Abstracts on Sustainable Agriculture

Compiled by Jürgen Carls

VOLUME 2

1989

Deutsches Zentrum für Entwicklungstechnologien – GATE

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PREFACE

This is the second GTZ publication to bear the title "Abstracts on Sustainable Agriculture".

These abstracts are more comprehensive than the usual type of annotated bibliography but they cannot substitute the original publication. For details we advise the reader to refer to the original.

We hope that the abstracts have a valuable role to play as part of the external input in the drafting of extension programmes. They make no claim however to offer tailor-made solutions. The responsibility for adapting the abstracts to suit local conditions rests with the reader.

Readers interested in the abstracts are asked to address their request to:

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Eschborn, June 1990

Jürgen Carls
Editor

Contents

GUIDE TO READERS

Selection of literature for the abstracts has been based on the following criteria:

- Ecological Aspects
  - . Sustainability
  - . Resource stability
  - . Soil fertility
  - . Diversity

- Socioeconomic Factors
  - . Promotion of smallholders
  - . Integrated systems (Animal-Man-Plant)
  - . Transfer of knowledge
  - . Low-external-input agriculture
  - . Sociocultural aspects

- Locational Factors
  - . Regional- and site-specific
  - . Practice-oriented
  - . Alternative uses

The abstracts are set up in the following way:

(1) Abstract number.

(2) Principal key-word: traditional land-use systems, cropping systems, agroecology, agroforestry, farming systems research and development etc.

(3) Key-words: if relevant, the geographical demarcation (continent, country) or the agroecological zone is given; the key words "review", "field trial", "field study" or "farm survey" indicate the nature of the paper; common names of field crops, soil fertility, pests, diseases, socioeconomic aspects etc. are used.

(4) Author's name.

(5) Title in the original language.

The subject index, based on the key-words, and the geographical indices are intended to help the reader to quickly find abstracts on specific aspects or areas of sustainable agriculture. The index of authors is intended to help the reader to find all publications by a particular author.

I. TRADITIONAL LAND-USE SYSTEMS

251 89 - 1/21

Traditional land-use systems
Review, traditional agriculture, sustainability, ecology, farming practices, appraisal
WOLF, E.C.
Mimicking nature.

Ceres No. 115, 20, 1, 1987, 20-24

Over the next 13 years, the world's population will increase from today's 5 billion to over 6 billion. Few analysts expect a significant increase in cultivated land by then. Merely maintaining current consumption levels will require a 26 per cent increase in the world's average grain yields. And by 2020, feeding the projected population of 7,8 billion will require grain yields 56 per cent higher than 1985 levels. Unlike past spectacular yield increases achieved under favourable cropping conditions, future improvements in average yields must come from raising the productivity of traditional farmers who cultivate unimproved crops under marginal conditions perhaps the most demanding challenge that national governments and the international development community have faced.
Subsistence farms around the world have certain common features. Farmers often mix different crops in the same fields to reduce the risk if a particular crop fails; they grow a variety of staple crops and vegetables to meet family food needs; and they rarely purchase artificial fertilizers or pesticides. It is not surprising that highyielding varieties of wheat and rice have been introduced to less than a third of the 423 million hectares planted to cereal grains in the Third World. For members of the 230 million rural households in Africa, Asia, and Latin America who use farming methods little different from those of their ancestors, green-revolution approaches will only be part of the answer.
Few researchers recognized the ecological and agronomic strenghts of traditional pratices that had allowed farmers over the centuries to maintain their land's fertility. In pursuit of higher productivity, many agricultural scientists overlooked the need for long-term sustainability.
Agricultural scientists have recently begun to recognize that many farming systems that have persisted for millennia exemplify careful management of soil, water, and nutrients, precisely the methods required to make high-input farming practices sustainable. This overdue reappraisal stems in part from the need to use inputs more efficiently, and in part from the growing interest in biological technologies. The complex challenge of Africa's food crisis in the early 1980s forced scientists to reexamine what peasant farmers were already doing. Many researchers today seek to improve existing farming systems rather than attempting to transform them in a major way.

Traditional farming systems face real agronomic limits and can rarely compete with high-input modern methods. It is important to recognize these limitations, in order to determine both how traditional practices can be modified and what such practices can contribute to the effort to raise agricultural productivity.
Traditional agriculture practised under biological and physical limitations often breaks down under growing population pressure. As rural populations grow, farmers try to squeeze more production from existing fields, often accelerating the loss of fertility. Or they may cultivate new, often marginal or sloping, land that is vulnerable to soil erosion and unsuited to farming.
None the less, traditional methods can make an important contribution to efforts to raise agricultural productivity. They use few external inputs, accumulate and cycle natural nutrients effectively, protect soils, and rely on genetic diversity.
The challenge for agricultural research is to improve agriculture in ways that retain the strenghts of traditional agriculture while meeting the needs of changing times.
Intercropping, agroforestry, shifting cultivation, and other traditional farming methods mimic natural ecological processes, and the sustainability of many traditional practices lies in the ecological models they follow. This use of natural analogies suggests principles for the design of agricultural systems to make the most of sunlight, soil nutrients, and rainfall.

252 89 - 1/22

Traditional land-use systems
Central America, Mexico, lowlands, traditional agriculture, ecology, subsistence farming, shifting cultivation, development
ALTIERI, M.A.
The modular systems in the Tabaşcan lowlands.

In: Agroecology - The Scientific Basis of Alternative Agriculture; Agroecology, 1050 San Pablo Ave., Albany, CA 94706, 1986, pp. 56-59

Various forms of subsistence farming are known to have been employed by the original Indian inhabitants of Tabasco, Mexico, and are thought to have achieved highly productive levels. Slash and burn agriculture was used for basic grain production (corn, beans), whereas extensive use of kitchen gardens (huertos familiares), composed primarily of tree crops and their associated understorey herbs, shrubs and vines, added great variety to the local diet. Cacao was produced as an understorey element in these kitchen garden systems and this crop has been expanded considerably using a plantation system which makes extensive use of legume shade trees.
In recent years the emphasis in agriculture in the Tabascan lowlands has been away from subsistence agriculture and towards commercial farming and stock-raising. Accompanying this shift towards commercial activities, a gradual abandonment of, traditional agricultural practices and varieties has taken place.

As part of a program to attempt once again to achieve the diversity and stability of productivity originally characteristic of the traditional agroecosystems of the region, production units were installed, referred to here as modular systems, whose primary focus centers around the application of ecological principles to agriculture with the incorporation of considerable empirical knowledge present in the region.
Each production unit consists of 5-15 ha controlled by several family units as part of their other agriculture activities. Depending on the social structure of the community, the families may actually live within each module or in a nearby community (ejido) and work in the module during the day. Thus production from each module would either be consumed directly by the families living there, or the products would be distributed to the members of the ejido. Any excess in production would be available for sale or exchange.
Each production unit has as part of its basic structural design an outermost band of vegetation consisting primarily of second growth species present naturally in the region. This band serves simultaneously as a windbreak, a source of natural predators and parasites for biological control, as well as a source of firewood and building materials. At the same time these shelter belts serve as biological reserves or germplasm banks for part of the great diversity of plants and animals normally present in tropical ecosystems. By selective species enrichment with forest and fruit tree species, it is possible to apply agro-silvicultural management practices, increasing the long term value of the shelter belt.
The interior part of each modular unit is constructed on the basis of the topographic diversity existent at each site. In cases where the lowest part of the module can be centrally located, large tanks are constructed which serve as catchments for all runoff from the production unit to collect dissolved nutrients and particles of soil and organic matter. Fish, ducks, and other aquatic animals are being produced in the tanks, with the aquatic plants and sediments being used as fertilizer in other parts of the module. Frequently small canals are built, radiating out from the central tank in order to further aid in the capture of excessive runoff. To avoid total inundation of the site, a principal canal can be built to eliminate excess water from the site, or in some cases, serve as a means of adding water in times of low rainfall.
Located around the central tank or along the edges of the water courses raised platforms (from 2,5 to 10 m wide and up to 100 m long) are constructed, often with the same material extracted from the catchment basins, forming a system of "tropical chinampas" for intensive vegetable production. The "chinampa" ist an ancient food production system extensively used by the Aztecs in the Valley of Mexico and by the Mayans in Southeast Mexico to exploit the swamplands bordering the local lakes. These systems still exist in many parts of Mexico. The Aztecs built chinampas up to a height of 0,5-0,7 m above water level and they reinforced the sides by posts interwoven with branches and by willow trees planted along the edges. The soil of the chinampas ist constantly enriched with

organic matter from the bottom of the reservoirs. Animals kept in small corrals, such as pigs, chickens, or ducks, are fed the excess or waste produce from the chinampas, as well as from other parts of the module, in order that manures can be incorporated back into the platforms for added productivity.
Around the areas of chinampas, the major part of the production of basic food crops traditional in the region is concentrated. According to the distribution of soil types, drainage, topography, and other physical characteristics of each site, a wide variety of annual and perennial crops are planted following the planting methods and combinations recommended by the peasants. This includes such systems as the local corn/bean/squash polyculture, cassava/corn/papaya, and fruit trees associated with various cover crops, shrubs, or vines.

253 89 - 1/23

Traditional land-use systems
South America, Chile, land-use, traditional farming systems, small scale systems, semi-commercial systems, crops, integrated systems
ALTIERI, M.A.
Traditional farming systems of Mediterranean Chile.

In: Agroecology - The Scientific Basis of Alternative Agriculture; Agroecology, 1050 San Pablo Ave., Albany, CA 94706, 1986,pp. 52-55

The farming systems of the small farmers (campesinos) of Mediterranean Chile are diversified systems. In these systems, the critical factor in the efficient use of scarce resources is diversity. Thus, campesinos assemble crops, animals and other farm resources to optimize production efficiency, nutrient cycling, crop protection, etc.
Although the manner in which campesinos assemble a particular set of farm resources varies from site to site, farming systems can be divided into two major groups: 1) small-scale intensive systems und 2) more extensive semi-commercial enterprises.
Small Scale Intensive Systems:
These systems rarely exceed 1 ha in size and the limited land area generally does not provide for all the food family requires. All items produced tend to be used for on-farm consumption. Missing resources have to be purchased with earnings from off-farm work. On these farms, campesinos typically produce a great variety of crops and animals, and it is not unusual to find as many as 10 tree crops, 10-15 annual crops and 3 to 4 animal species on a single farm.
The physical layout of these farms varies, but often they include, in addition to the tree and annual food crops, a sort of grapes ("parron") to provide shade, and fruit, herbs, medicinal plants and flowers. The typical animals of these farms are free ranging chickens and ducks, rabbits and occasionally a few pigs feeding on kitchen waste and crop residue. Intensified annual cropping usually involves the use of simple crop patterns (i.e., growing a set of annual crops only during the spring and summer), or more

typically crop sequencing (planting a second crop after the harvest of the first). In both crop patterns, campesinos may practice intercropping. Common intercropping systems include corn and beans, garlic and/or onion mixed with lettuce und cabbage, and corn-potatoes.
Extensive Semi-Commercial Systems:
The farms range between 5-20 ha in size. These systems are also diversified, but the crop and animal combinations are designed to increase production to yield a marketable surplus. With a larger area of land to work with, the campesino devotes much of it to more extensive activities such as pasture for livestock and grain cultivation. The additional land also affords more space for wood producing trees. In this way, nearly all of the household requirements are provided for on the farm.
Typically, the campesino grows crops preferred by the local community for commercial purposes. These crops, however, may entail relatively high risks. He hedges against this risk by growing several less valued and/or risky crops. Growing of beans, squash, potato or corn between rows of high value fruit trees (peaches, cherries, apples, etc.) is a good example.
The design of a 12 hectare farm about 10 km east of Temuco, in south Chile, is discussed where the campesino balanced his farm enterprises to provide for the needs of food, clothing, housing and capital. The farm consisted of an interplanted area of annual crops and fruit trees, a mixed orchard of fruit trees with rows of bee hives between the trees, approximately 5 ha of pasture, 2-3 ha of wheat and a stand of pine. From 26 bee hives he harvested 280 kg of honey/year, obtained 10-12 liters of milk per day from 3 cows, collected 10-11 eggs per day from his chickens, and from the wheat, supplied all of his flour for making bread. Pine trees were planted to provide for his wood requirements. The fast-burning wood was made into charcoal for cooking and heating and was also used in the construction of the house and barns. Guano from his animals and crop residues were collected in a compost pile for later use in crop fertilization.

254 89 - 1/24

Traditional land-use systems
Africa, review, traditional farming systems, Food plant
OKIGBO, B.N.
Broadening the food base in Africa: The potential of traditional food plants.

Food and Nutrition, 12, No.1, 1986, pp. 5-17

This paper reviews the potential for exploitation of African traditional food plants, in the context of traditional farming systems, the changes they have undergone, means to increase food production and appropriate measures to be taken, including international cooperation.
One important and widely accepted idea is that Africa developed two agricultural complexes: a seed agricultural complex,

characteristic of the savanna and involving the cultivation of grains and seed-bearing crops in open-field systems; and a "vegecultural" complex, peculiar to the forest regions and involving the growing of roots, tubers and cuttings in gardens rather than in fields.

Most tropical African livestock species were domesticated elsewhere or were introduced from North Africa and South-Eastern Asia. They include goats, sheep, chickens, pigs and ducks. Certain animals became adapted to specific ecological zones.

A simplistic model of traditional farms in tropical Africa consists of a pattern of fields at different distances and in different directions from the compound and/or homestead garden. Different methods of soil management and fertility maintenance are practised on each of the fields and in the homestead garden. The methods usually include fallows, clearance systems and production systems for varying numbers of crops and/or livestock according to prevailing practices, customs and the needs of the farmer. Each traditional farm is a complex of units or subsystems differentiated according to characteristic aspects of the production process.

The farm may be an enterprise and provide a livelihood for one or more individuals, but it usually supports a family unit in which some or all members may participate part or most of the time in farm work.

Farms are small: over 60 per cent range in size between 0.10 and 3.00 hectares. Farm size in savanna areas is usually larger than in the rainforest zone, perhaps as a result of high labour requirements in the latter for clearing, weeding and related tasks.

A diversity of farming systems exists, ranging from true shifting cultivation and nomadic herding to permanent settlement and intensive livestock production, such as modern poultry and dairy production.

In general, most of the traditional and transitional farming systems consist of shifting cultivation and related forest, secondary bush, woodland, thick and grassland fallows in respect of which varying periods of cultivation (two to five years) are followed by equally variable periods of fallow.

The second half of this paper discusses those changes which adversely affect food security and nutritional status in terms of increasing malnutrition in Sub-Saharan Africa. It also considers strategies for attaining meaningful levels of food self-sufficiency which should help to minimize that proportion of the food requirements that must be met through purchase with farm and/or non-farm incomes or through food aid.

Broadening the food base through greater utilization of indigenous food crops is one of the promising ways of increasing agricultural and food production in Africa within the strategies of increasing production per unit area and efficiency in the utilization of forest products and resources. Some indigenous food crops with developmental potential in the context of this paper are listed in a accompanying panel.

255 89 - 1/25

Traditional land-use systems
Central America, Mexico, sandy pits, study, traditional cultivation system
DEL AMO, R.S. et al.
The Tecallis: A traditional cultivation system.
In: Global Perspectives on Agroecology and Sustainable Agricultural Systems, Proc. of the 6th Int. Sc. Conf. of the Int. Fed. of Org. Agric. Movements, Univ of California, Santa Cruz, USA, 1988, pp. 433-443

As the sustainability of modern agriculture being increasingly questioned, studying and analyzing traditional cultivation systems has become more important. This paper describes a newly discovered cultivation system used along the banks of the middle Balsas River (Mezcala). Known as the Tecallis System (which means "holes" or Arenales (which means "sand culture"), this method is based upon efficient soil and water management, organic fertilizer, and intensive labour. The Tecallis System is an agriculture strategy developed for the dry season. The system is based on a high percentage of hand labour and represents a highly productive type of intensive agriculture.

In traditional Mesoamerican agriculture, two kinds of irrigation systems can be distinguished: those which require a hydraulic infrastructure and those which do not (the latter are termed "humidity cultivation" systems). In humidity cultivation, irrigation is accomplished through ditches and canal systems.

The basis of the agriculture system described in this study is the exploitation of the sandy soils that remain when the Balsas River level drops in the dry season (November to April). This system complements the other agricultural systems of these people in the following ways:

- During the rainy season, farmers cultivate maize and sesame seed fields on higher ground
- During the dry season communities carry out the arenales cultivation, which offers a subsistence base completely different from the maize-sesame seed system and includes vegetables, fruit, and flowers.
- Fruit tree orchards are tended in some sandy areas on the river bank.
- Tierra de sereno (night-dew culture), which uses moisture condensed during the night, is practiced during the months of September and October. This is developed on the lowlands of the river banks with maize sown for a second crop and watermelons grown between the maize plants.

The Tecallis System is ecologically sound because it efficiently uses water, natural fertilizers, space, and time; it does not rely on external inputs, and is based on diversity. The system facilitates intensive use of the environment through diversification in production and the profitable use of a seasonally specific and previously unexploited habitat. Diversity, soil protection, water conservation, and combination of species with different life cycles and from different habitats are

characteristics of the Tecallis System which integrate effectively into the natural ecosystem.
The Tecallis System has several socioeconomic advantages: farming occurs in the dry season when no other agricultural work is ongoing; certain crop species yield two or three harvests in one season; the system is highly appropriate for populations living in marginal river areas; while most food produced is consumed by the farmer's household, some surplus production is generated for barter or cash; and finally, this system provides food during the dry season, contributing to a stable year-round food supply in a region which is isolated from commercial large-scale food distribution.
Tecallis cultivation can be seen as a hydroponic system in that plants are cultivated in sand containing few nutrients to which natural fertilizers are applied. The rediscovery of techniques such as tecallis, a historical antecedent of hydroponics in ancient Mexico, is thus of great importance. Moreover, this system's advantage over modern and commercial hydroponics is that it does not entail any initial investment cost.

256 89 -1/26

Traditional land-use-systems
Africa, Nigeria, survey, agroforestry, homegarden, compound farm, germplasm conservation, tree improvement, land-use
OKAFOR, J.C. and E.C.M. FERNANDES
Compound farms of southeastern Nigeria: A predominant agroforestry homegarden system with crops and small livestock

Agroforestry Systems, 5, 1987, 153-168

This paper identifies the major components of compound farms and describes their uses, environmental variation, interactions and management practices. Prospects for and the implications of improvements to the system are examined.
Compound farms are a traditional land-use system that appear to have evolved with the shifting cultivation and bush fallow systems. Recent observations indicate the spontaneous establishment of compound farms by shifting cultivation seeking to establish land tenure alongside new roads.
Compound farms are found within the vicinity of homesteads and comprise numerous multipurpose woody species in intimate multistoried associations with annual crops and small livestock. The multistoried structure and species diversity allow almost complete coverage of the soil by plant canopies, thereby promoting soil conservation. Soil fertility is maintained by the use of household refuse, crop residues and animal manures.
The system has been recognized as a potentially sustainable form of land-use with possible applications for the entire humid tropics.
Several trees and shrubs are deliberately planted and managed on the compound farms for a variety of products or functions.

Goats, sheep and poultry are commonly kept for meat for sale or home consumption. Other animals occasionally kept include cattle and pigs. Livestock is fed with fodder from trees and shrubs, crop residues, grasses and herbaceous species growing in the compound farms or near fields. The animals are either confined in pens and stall-fed or tethered in fields. Trypanosomiasis is a major constraint to livestock rearing.
The number of crops decreases as the distance from the house increases. The highest diversity occurs on the compound farms and the lowest on the outlying fields. This minimizes the time spent visiting distant fields.
Vertically, several relatively distinct strata (canopy layers) can be distinguished in the compound farms. The lowest zone (0-1,5 m) comprises food crops like cocoyam, beans, cucurbits, okra and regeneration of overstorey trees and shrubs. The next zone (1,5-3 m) consists of cassava, maize, yams (on stakes) and castor. Next is the plantain/banana layer (3-6 m). Above this comes the fruit/vegetable tree layer (6-30 m +) comprising species for timber, fuelwood and cultural uses.
Due to different maturity periods, crop species are invariably planted and harvested at different times. Yams, for example, are planted before the onset of the rains, while maize and millet are planted a few months after the rainy season has begun. Cassava ist planted about four weeks after maize and harvested the following year. This diversified and continuous production of food is important not only nutritionally, but also because storage is difficult and post-harvest losses are high.
Numerous advantages are inherent in the multispecies, multistoried cropping systems like the compound farms. These include diversified production, risk minimization, enhanced labour efficiency, continuous production thereby minimizing post-harvest losses due to poor storage facilities, better nutrient cycling and nutrient use efficiency than in monocropping systems and good soil conservation due to continuous ground cover.
The biggest constraint of the compound farm or homegarden type of system is that it is perceived as a primitive form of subsistence land use. These view is common both on international and local levels of landuse policy and decision making and has resulted in little, if any, resources being devoted to the study and improvement of the system as a whole.
It is important that a well co-ordinated and systematic research programme is undertaken to obtain information relevant to enhancing the productivity and sustainability of the compound farms.

257 89 - 1/27

Traditional land-use systems
Africa, Rwanda, land-use, ecological farming, sustainability, gross margins, comparative study, economics
BENNETT, J. and R. PREISSLER
Traditioneller und Standortgerechter Landbau im Gebiet des Projet Agro-Pastoral Nyabisindu. Ein betriebswirtschaftlicher Vergleich der beiden Systeme.
(Traditional cropping and ecological farming in the area of the Agro-Pastoral Project of Nyabisindu. An economic comparison of the two systems.)

Projet Agro-Pastoral de Nyabisindu; Etudes et Experiences No. 10; GTZ Projet Agro-Pastoral de Nyabisindu, B.P. 70, Nyabisindu, Rwanda, 1987

The shortage of resources in many developing countries as well as the problems of a "high external input" agriculture, have led to an intensive search for ecologically sound land-use systems.
A model of land-use has been developed in the Agro-Pastoral Project of Nyabisindu, Rwanda which is more recognized not only within Rwanda but world-wide. In search for an alternative to the conventional European agriculture, methods of self-sustaining autochthon land-use systems have been combined with results of agricultural economy-research and adjusted to the local conditions of Rwanda.
Most important elements of methods are:
- Land contouring by integration of hedges, forage grasses and trees against erosion.
- Crop rotation with periodically returning green manuring,
- Manuring with compost, manure and mulch,
- Mixed cropping and
- Integrated livestock raising with fodder growing.

The activities have been tested on the experimental fields ("fermettes") of Nyabisindu and in model farms in the project area. First results and successes in the realization by the extension service give reason to believe that the way taken is the correct one.
The results of these tests accentuate the importance of a more intensive occupation with the economic aspects of ecological farming.
The present work tries to demonstrate the essential points for the economic evaluation of ecological farming by means of case studies received hitherto in Nyabisindu. The methodical main point of this work is to be seen in the expression and comparative interpretation of gross margins for traditional production methods as well as for those of ecological farming.
The data and calculating results used could serve as guide-lines for individual farm planning until the basis of research for ecological farming has been broadened.

258 89 - 1/28

Traditional land-use systems
Review, agriculture, sustainability, concept, traditional land-use, ecological farming, low-input systems, integrated pest management, alternative agriculture, environment, research needs
CARTER, H.O.
The agricultural sustainability issue: an overview and research assessment.

In: The Changing Dynamics of Global Agriculture; A seminar on Res. Policy Impl. for NARS; ISNAR/DSE/CTA, Feldafing, FRG, 1988, pp. 115-135

There is a growing and diverse literature based on agricultural sustainability - concerning its meaning, relevance as a concept in agriculture and development, and applicability for research planning and extension activities. Some confusion comes from the fact that the term has intellectual roots from different disciplines where it is used in a variety of contexts.
The term sustainable has long been used by resource managers with reference to the maximum harvesting of forests or fisheries consistent with the maintenance of a constantly renewable stock. Sustainability is the steady state when what is being used (harvested) is continually replaced.
Sustainability has been defined by some in terms of carrying capacity - the maximum population size that the environment can support on a continuing basis.
Other terms for agricultural sustainability include alternative, regenerative, low-input, ecological, environmentally sound, and organic agriculture. These terms are used by people interested primarily in alternative systems of farming that will feed expanding populations while minimizing potential negative effects, whatever they might be. Defining the negative effects essentially separates or categorizes the various proponents of sustainable agricultural systems. Some groups put primary emphasis on minimizing environmental damage and degradation. Sustainability becomes almost synonymous with stewardship of the earth.
Others want mainly to perpetuate a rural community system; community sustainability or maintaining viable rural communities becomes almost a goal in itself. Still others equate agricultural sustainability with food self-sufficiency while minimizing costs. Many advocate an energy-conservation agriculture - so much so that efficiency of the system is measured exclusively in terms of energy use. People require both safe food and water, which in turn, proponents argue, require an agricultural system that can operate ad infinitum with only meager dependence on external inputs. Thus, just as the term sustainability has differing dimensions in various contexts, the agricultural counterpart has social, ecological, economic, and emotional implications.
Summarizing, the paper discusses several meanings of agricultural sustainability, followed by a look at the current agricultural system and what the impetus is to change it. Then, the state of the art in research on low-input, sustainable farming systems is

discussed, what impediments there are for farmers to change from current agricultural production systems. Finally, change is more likely to be gradual than abrupt.

259 89 - 1/29

Traditional land-use systems
Africa, review, survey, semi-arid zones, natural resource management, forestry, range management, FAO
NIAMIR, M.
Traditional african range managment.

ILEIA, 5, 2, 1989, pp. 28-29

The pastoralist in Africa has developed principles and strategies for managing the natural resources in agreement with his variable physical environment and his social needs. Recently his situation had to face external pressures, such as crop expansion into high quality rangelands, nationalization of land by governments, population increase, indiscriminate water development, and a series of droughts, all of which have contributed to pasture shortages and land degradation.
In many areas the traditional system of management is no longer able to cope with the shortage of pasture, and instead is adding to the problem of land degradation. In addition, the traditional management knowledge is gradually being lost as more of the younger generation of pastoralists are attracted to urban areas. Yet the traditional system has developed an intimate knowledge of the environment and many successful techniques that could still be of use today.
A literature survey was commissioned by the Food and Agriculture Organization (FAO) of the United Nations, to collect details on traditional African natural resource management, and to evaluate the survival of traditional techniques and their potential for development in Africa. The study concentrates on four aspects: 1) the descriptive knwoledge of the physical environment (e.g. names of plants and soil types), 2) daily natural resource management techniques (e.g. which tree or pasture to use, when and why), 3) the social controls and organization of daily management (e.g. grazing controls), and 4) the socio-political structure of resource management (e.g. resource tenure issues). This article covers daily range and herd management techniques and the social controls on daily management.
Today many techniques are still in use, either in the original or a modified form, and can be incorporated into development projects. Development personnel in the field need to first consider whether the traditional techniques are still alive, for which they need the active assistance of the pastoralists in the planning, design and execution of the projects. In addition, these techniques cannot be revived without clarification of national land tenure laws, checks on crop expansion, official recognition of traditional socio-political organizations, greater incentives to young herders to stay on the range, greater sensitivity by

government officials and extension workers to the value of traditional knowledge, and a common, coherent national policy on the decentralization of natural resource management.

260 89 - 1/30

Traditional land-use systems
Latin America, Mexico, traditional farming, highlands, agro-ecosystem, mixed cropping, low-input system, sustainability, modern practices, integrated systems
BOROWITZ, S.
Lessons from a traditional agroecosystem.
The Cultivar, 7, 1, 1989, pp. 1-4

Increasing population pressures led the people of Tlaxcala, Mexico to expand their agricultural fields to include hillsides.
The farmers developed a unique agricultural system - canals associated with the terraced fields. Using this system - which incorporates nutrient cycling, crop diversity, and careful soil management - Tlaxcalan farmers have maintained the agricultural productivity of much of their soil without chemical pesticides or fertilizers.
Despite the long-term success of their traditional practices many Tlaxcalan farmers are abandoning them in favour of modern inputs and techniques, including synthetic pesticides and fertilizers, heavy machinery, and monocropping. This transition from a low-input, regionally adapted system to practices which do not emphasize the maintenance of soil structure and fertility threatens to deplete the area's fragile resource base and diminish the long-term sustainability of the system.
Traditional Practices:
The Tlaxcala region, located in the volcanic highlands 200 kilometers east of Mexico City, features intermittent, heavy rainfall, and alternating layers of clay soils covered by a thin protective layer of topsoil. Stripped of the topsoil, the underlying becomes hard and unworkable.
To control the runoff from the heavy rains Tlaxcalan farmers have developed a carefully designed system of sloping terraced fields, and built canals divided into catchment tanks, or cajetes, at the base of the terraces.
The cajetes, with an average capacity of 168.5 cubic meters per hectare, can trap up to 16.85 mm (0.65 in) of rain. As much as 24 mm (0.95 in) can fall in less than half an hour in this region, but the fields can also absorb some of the moisture.
The cajetes act as compost pits, trapping soil and leaf litter washed from upslope. Each year, the farmers dig out the cajetes and return the captured soil and composted vegetation to the terraced fields. Combined with manure from livestock and humans, as well as rotations of legumes, the soil and compost from the cajetes have provided a good portion of the nutrients and organic matter necessary for the system to remain productive over three thousand years of cultivation.

The diversity of both crop and non-crop plants plays a major role in maintaining the system. To meet their dietary needs, Tlaxcalan farmers traditionally plant intercrops, emphasizing corn/bean/squash. This kind of mixed cropping has been shown to use both soil nutrients and solar energy more efficiently, as well as suppress weeds and discourage pests, leading to a greater total harvest. In addition, farmers plant several seed varieties of each crop to insure success of at least one of each type in the variable climate. Through this traditional practice of seed selection, seeds especially adapted to regional conditions have developed.
The typical practice of leaving the areas around cajetes as permanent border space, where agave, cactus, fruit trees, native shrubs, and a variety of annuals thrive, ensures that regional plant diversity is also maintained.
The border plants provide food, fuelwood, and fodder, and provide food and shelter for beneficial insects that prey on and parasitize harmful insects. Trees along the border also control wind erosion and circulate nutrients from the deeper soil strata; nutrients are transferred to leaves, which eventually decompose and make nutrients available to crop plants.

<u>The Impacts of Modern Practices:</u>

Although the terrace/cajete system has traditionally produced more than enough food for the community, farmers are beginning to abandon it, due in part to pressures from a variety of sources - including government, banks, agribusiness interests, and export organizations - which promote modern high-input methods. To raise national production levels, Mexican agricultural policy encourages standard input-intensive systems using tractors, hybrid seeds, and synthetic chemical fertilizers and pesticides.
The scenario on Tlaxcalan farms has begun to change. To receive government aid and bank loans, farmers must monocrop using seeds produced under "ideal" conditions. These seeds, developed on farms with precise irrigation and fertilizers, and protection from wind and pests, are not appropriate for highland conditions. Monocropping leaves the crops vulnerable. To compensate, farmers begin to rely on government-subsidized pesticides.
To provide fields for the growing population, the government also subsizides the construction of tractor-built terraces. Existing fields are combined into larger plots, and new terraces are created on land that may be inappropriate for long-term agricultural use. Since these new terraces lack cajetes, which would collect nutrients, farmers find they need synthetic fertilizers to maintain soil fertility.
Even though high-input methods are a faster and less labor-intensive way to raise production in the short term, they cost more money, require more energy from fossil fuels, and can degrade the ecosystem.

<u>Integrating Traditional and Modern Practices:</u>

Mexican agricultural policy could promote proven traditional agricultural practices, such as those of the Tlaxcalans', in addition to appropriate "Green Revolution" methods. That's where development projects should begin."

The Mexican government could developed seeds selected for local conditions, and could encourage diversity, rather than monocropping. New terraces could allow for tractor access yet still include cajetes. And instead of subsidizing fertilizers and chemical pesticides, the government could use the same money to buy animals to provide not only manure, but meat and milk.
The Tlaxcalan methods can apply to most slope agriculture where soil and water conservation is essential.
A combination of resource-conserving, traditional methods and current scientific knowledge may provide increased productivity while still protecting the natural resource base.

261 89 - 1/31

Traditional land-use systems
Africa, Sub-Sahara, review, traditional systems, rotations, shifting cultivation, cropping systems, farming systems, ecology, sustainbility
OKIGBO, B.N.
Cropping systems and rotations development for improving shifting cultivation and related intermittent production systems in tropical Africa.
In: Improved Product. Systems as an Alternative to Shifting Cultivation, FAO Soils Bulletin 53, ISBN 92-5-102 121-X, Rome, Italy, 1984, pp. 121-140

This paper considers criteria for selecting suitable farming systems for different ecological zones and suggests more efficient cropping systems and rotations by integrating traditional with new technologies. It also presents examples of improved cropping systems with recommendations for integrating them into planned rational land use supported by research.
Traditionally, Africa has not been a major food importer; the food self-sufficiency ratio was much higher in the 1960s (98%) than in 1981 (88%). Yields per hectare are lower in Sub-Saharan Africa than elsewhere and whereas yields elsewhere have increased during the last decade, in Africa they have generally either been decreasing or have remained constant. It is, therefore, not surprising that studies agree on the poor performance of agriculture and on a gloomy future for food production in Sub-Saharan Africa.
In efforts to solve this problem, traditional farming systems have become increasingly outmoded because of such modernization pressures as rapid population growth, high rates of urbanization, rising incomes, and a demand for convenience foods produced outside Africa.
To overcome these low production rates in tropical Africa the following recommendations are given:
- The highest priority should be given to cooperative international and regional efforts to help African countries develop their own research especially that seeking alternatives to shifting cultivation and related fallow systems.
- Land development and soil management benchmark and technology

transfer activities of the IARCS and other international institutional efforts should be strengthened financially and in their national and regional manpower development programmes.
- Although some improvement is being made in the design and development of management principles for cropping systems in drier areas, progress in solving similar problems in the humid and subhumid tropics has been very slow. Crops there include several species not yet affected by the Green Revolution; more serious effort should be devoted to designing cropping systems and developing management principles for the humid tropics.
- In countries of tropical Africa which are not producing enough food to meet current demand, high priority should be given to: (a) strategies to increase productivity through more efficient cropping systems and rotations, (b) ways to maximize irrigation benefits including watershed development, especially in the drier areas, and (c) significant increases in the use of valley bottoms and hydromorphic soils especially in rice production for which a possible two million hectares is potentially in tropical Africa.
- Most African countries faced with problems in food production are giving priority to achieving self-sufficiency and to producing food commodities that are currently being imported. In all these efforts, primary emphasis should be placed on those resources, crops, soils, etc. which will give maximum returns per unit input; those of medium potential should be developed secondarily and lastly those with low or marginal potential. In tropical Africa this is not the case, where much effort and many resources are being devoted to production in marginal areas.

262 89 - 1/32

Traditional land-use systems
Tropics, developing countries, review, traditional systems, small-scale farmers, diversity, ecology, sustainability, nutrient cycling, diseases, pests, weeds, productivity, agroforestry
ALTIERI, M.A.
The significance of diversity in the maintenance of the sustainability of traditional agroecosystems.

ILEIA, 3, 2, 1987, 3-7

The ethnobotanical knowledge of certain traditional farmers is so elaborate that the Tzeltals, P'urepechas and Yucatan's Mayans of Mexico can recognize more than 1200, 900 and 500 plant species respectively.
Hanunoo swidden cultivators in the Philippines can distinguish over 1600 plant species.
Therefore a striking feature of traditional farming systems is their degree of plant diversity in time and space in the form of polyculture and/or agroforestry patterns.
Peasants knowledge about soils, climates, vegetation, animals and ecosystems usually results in multidimensional productive strategies which generate, within certain ecological and technical

limits, the food self-sufficiency of farmers in a region. For agroecologists interested in the development of sustainable agricultural systems, there are several factors of traditional agriculture as well as aspects of traditional knowledge that are relevant. By understanding the features of traditional agriculture, such as the ability to bear risk, biological folk classifications, the production efficiencies of symbiotic crop mixtures, etc., it is possible to obtain important information which may be used for developing appropriate agricultural strategies more sensitive to the complexities of agroecological and socio-economic processes, tailored to the needs of specific peasant groups and regional agroecosystems. It is difficult to separate the study of traditional agricultural systems from the study of the cultures that feed them. For this reason researchers must deal with both the complexity of the production systems as well as with the sophistication of the knowledge of the people that manage them. Such complex studies require the participation of social scientists interacting with agronomists and other biologists.
In this paper the roles of diversity in agroecosystem function is discussed:
- diversity and nutrient cycling
- diversity and insect populations
- diversity and plant diseases
- diversity and weed populations
- diversity and productivity
- diversity and sustainability

In essence, the performance of the total system is dependent upon the level of interactions between the various farm components. Systemdriving interactions are those direct interactions where products or outputs of one component are used in the production of another component.
The subsidizing of a peasant agricultural system with external resources (pesticides, fertilizers, irrigation water) can bring high levels of productivity through dominance of the production system, but these systems are sustainable only at high external costs and depend on the uninterrupted availability of commercial inputs. An agricultural strategy based on a diversity of plants and cropping systems can bring moderate to high levels of productivity through manipulation and exploitation of the resources internal to the farm and can be sustainable at a much lower cost and for a longer period.

263 89 - 1/33

Traditional land-use systems
Latin America, Mexico, study, agroecosystems, traditional agriculture, productivity, crops, soil fertility, plant protection, sustainable agriculture, ecology, research needs
JIMÉNEZ-OSORNIO and SILVA DEL AMO R.
An intensiive mexican traditional agroecosystem: The Chinampa

In: Proc. of 6th Int. Conf. of IFOAM, California, USA, 1988, pp. 451-462

This paper describes a study of the chinampas in San Andrés Mixquic, Méxcico D.F. The objectives of the study were to: describe the current status of the chinampas; determine changes in the basic elements and practices of the peasants from 1971 (the date of the oldest records) to the present; recover and understand the ecological basis and interactions involved in the chinampa system in order to utilize them in the design of sustainable agroecosystems; and propose research areas necessary to understand the ecological mechanisms and interactions involved in the system.
Traditional agriculture in Mexico has led to the development of complex agroecosystems characterized by high levels of production. The chinampa agricultural system, represents the pinnacle of Pre-Hispanic - technology in Mesoamerica and still functions today. The word chinampa, meaning "net of branches," is derived from the Nahuatl language. Both the Nahua and the chinampas were once part of the Aztec empire.
A chinampa is essentially a long narrow strip of land surrounded on at least three sides by water. The basic elements of the chinampa agricultural system are water, soil fertility, energy cycling, seed beds, and use of noncrop plants. The ample supply of water which characterizes the chinampas is important. Canals are used for transport, and the abundant water enables peasants to cultivate their land all year, instead of only during the rainy season. Chinampa soils have traditionally been managed intensively. Soil fertility is continuously renewed with organic amendments such as canal muck, aquatic plants, crop and weed residues, and animal manure.
The chinampa agricultural system is self-sufficient due to continuous recycling of energy and materials. Human labour is intensive, cultural practices are well adapted to the environment of the chinampas, and external inputs of materials are minimal under ideal conditions. This system is an example of how natural resources can be successfully managed without long-term depletion or destruction.
An essential element in the chinampa system is the technique for preparing the starter seedbeds, which are called almacigos.
Habitat and plot microclimate are controlled with the use of noncrop plants. The willow tree (Salix bomplandiana H.B.K.) is an important element and is planted around the perimeter of the plot at 3- to 5-meter intervals. Tree roots stabilize plot edges and draw moisture directly from the water table, thus enhancing water management in the field. Rows of willow trees reduce wind and are

an excellent habitat for some beneficial organisms such as birds and entomophagous insects. The branches of the willow tree along with other noncrop plants such as grasses and aquatic plants protect seed beds from heavy rains, frosts, and excessive drying. Almost all weeds are used as forage and fertilizer.
Although government projects have been designed to protect the ecology of this area, they have failed to recognize two important factors in the survival of the chinampas: water and the chinamperos. Future government projects need to recognize that water is a major component of the chinampas and that any change to the water supply affects the entire chinampa agroecosystem.
Family and social organization have been important factors in the survival of the chinampas. The decline of the chinampas has affected the social structure and cultural characteristics of the people living on them. Cooperative work on the canals has declined, for instance, as has the tradition of families working together within a chinampa. Younger generations look to the city for employment rather than to farming. The decline of the chinampas signals not only the loss of a production system, but a cultural system as well. Projects aimed at protecting and encouraging the chinampas' production system should protect and utilize its sociocultural attributes.
Since the chinampas are still functioning, studying the ecological mechanisms and interactions involved in the extraordinary and seemingly perpetual productivity of this system could provide useful information in the development of a sustainable agriculture. Research questions should include:
- What are the ecological roles and benefits of the noncrop plants?
- Why is the silt of certain canals incorporated in seedbeds?
- Does the system have mechanisms of pest control built in? If so, what are they?
- What are the allelopathic interactions involved in the system and how important are they?
- Are there plant species in the system that can be managed and incorporated into other agricultural systems?
- What are the nutrient dynamics and how are they affected by fertilizer usage?

Although these questions are focused on ecological factors the chinampa agricultural system includes ecological, technological, and social factors. Multidisciplinary study is therefore required.

264 89 - 1/34

Traditional land-use systems
Africa, tropics, review, book, Terres et Vie, CTA, agriculture, sustainability, sociology, traditional systems, diversification, ecology, farmers, crops, water resources, land managment, agroforestry, trees, soil fertility, cultural practices, economics
DUPRIEZ, H. and P.DE LEENER
Agriculture tropicale en milieu paysan african (Agriculturel in African Rural Communities).

MacMillan Publ. Ltd, London and Terres et Vie, Nivelles, Belgium and CTA, Netherlands; ISBN 0-333-44595-3, 1988, pp. 292 + ix

Agriculture in African Rural Communities is a basic introduction to principles of crop physiology and practices of crop husbandry. The book recognises the realities of traditional subsistence farming but introduces improved methods. As well as details of plant requirements and the importance of soil and water, it describes environmental, climatic, cultural, social, managerial and economic factors.
This book is about tropical agriculture in general, although stockraising and the keeping of poultry and small animals are not covered. The book does not overemphasize how best the grower might improve his or her farming methods. The reader must draw his own conclusions about the practical steps to be taken. It is more important to understand and think over one's farming methods than to imitate. Therefore a careful examination of the illustrations is needed. They show ways of working the land. Whether these ways are appropriate for a particular farmer, only the farmer can decide.
Each of the forty-nine lessons in this book are each on a different subject, but they form an interrelated whole.
This book does not treat agriculture simply as a technical activity which needs only specialists trained in institutes of higher education.
The "Land and Life Series" is aimed at practitioners and students of agriculture and rural development and associated vocational and technical skills. The books in the series treat topics according to appropriate, smallscale and affordable technology taking into account traditional ways but adding relevant modern improvements. For training, they can be used in secondary schools and vocational training centres and colleges up to diploma and degree level, but they are chiefly meant to be used in the field, in practice. They are ideal for self-help, adult education and rural extension projects. They are written in a clear and highly illustrative style and thus can be used equally by those for whom English is a second language and by non-specialists. All the titles in the series are designed and produced as low-cost editions. Although based on African practice, the books are relevant to similar climatic regions in other continents.

265 89 - 1/35

Traditional land-use systems
Africa, Ghana, report, cocoa, traditional practices farming, cropping systems, intercropping
ANABAH, S.
Traditional cocoa farming in Ghana.

IFOAM, 3, 1988, pp. 11

Cocoa is produced in Ghana by traditional organic methods, dating from 1879. It is grown in the tropical rainforest in the southern parts of the country by smallholders using traditional techniques. The recent adoption of intensive farming practices and the establishment of commercial farms in some parts of Ghana has not displaced these smallholders. Their cultural practices have prevented devastation of forests, helped in the maintenance and build-up of humus rich top soils, and prevented landslides and soil erosion on the hill tops and slopes where cocoa is grown.
The establishment of a cocoa farm starts with the clearing of jungle followed by judicious and selective felling of forest trees by axe. Many trees are retained to provide permanent shade for the cocoa plants. Most farm operations are done manually, although some farmers now use chain saws and motorised spraying machines. The debris is burned to open up the area for planting, to sterilise the soil, provide potash and destroy weed seeds. Once established, there is no further burning.
Weeds are clearing by hand twice a year just before the commencement of each of the two rainy seasons. They are left on the soil to decompose and build up the humus.
Artificial fertilizers and herbicides are not applied on the cocoa plants or on the staple food crops (cocoyam, plantain and cassava) intercropping with the young cocoa seedlings. These crops provide shade for the young plants and also biodynamic organic food for the farmer's family. Intercropping ceases when the cocoa overshadows the food crops and starts bearing pods about three years after planting. A well-maintained cocoa farm is always naturally covered with litter of cocoa leaves, which perpetually mulch and preserve soil moisture. This also accelerates the decomposition process.
Cocoa trees infected with swollen shoot disease caused by mealy bugs are cut out to arrest the spread of infection. Black pod fungus is also treated by removing diseased pods; and judicious pruning and reduction of shade brings it under control. Capsid beetles are very often a menace when there are flushes of new growth, and a pyrethrum base insecticide is sprayed twice a year. Another troublesome common pest establishing itself all over Ghana is the grasshopper, which feeds on nearly all green vegetation. Fortunately it perishes with the heavy rains, so is not a major problem.
The golden pods of cocoa are harvested and usually broken open by the communal efforts of neighbouring farmers in order to get the beans ready in time to allow for successful fermentation. The fresh cocoa beans are piled up on banana and plantain leaves and

covered up for a few days to ferment without chemical additives. After this period, the beans are sun-dried and sold.
Traditional cocoa farmers' wives burn sun-dried cocoa husk into potash, and together with palm oil they manufacture organic soap. So the traditional cocoa farmers of Ghana wash with organic soap, eat organic food, cure diseases with medicinal herbs growing around them, and brush their teeth with chewing sticks and sponges gathered from the forest.

266 89 - 1/36

Traditional land-use systems
Latin America, Amazon Basin, humid tropics, traditional agriculture, appropriate technology, migratory agriculture, acid soils, ecology, ecosystem, cropping systems, soil fertility, farmer, economics, low-input system, pasture, agroforestry
NICHOLAIDES, J.J. et al.
From migratory to continuous agriculture in the Amazon Basin.

In: FAO Soils Bulletin No. 53, ISBN 92-5-102121-x, 1984, pp. 141-168

Appropriate technologies for changing migratory agriculture to continuous agriculture in some parts of the Amazon Basin have been developed. These agronomically sound, scale-neutral technologies are beginning to be used on some of the Amazon Basin's acid and infertile soils normally subjected to shifting cultivation.
Two types of farmers are involved in the clearing of the Amazon Basin. Shifting cultivators are responsible for most of the clearing in the western part of the Basin, while ranchers trying to develop pastures are the primary cause for the clearing of the seasonal semi-evergreen forest in most of the Brazilian or eastern portions of the Basin.
Acid and infertile soils (Oxisols and Ultisols) occupy almost 75% of the Amazon Basin. These red or yellow soils are deficient in most nutrients, usually welldrained, and have generally favourable physical properties.
Most shifting cultivators in the Basin use the slash and burn technique. In this system, the larger trees and shrubs are cut by axe, machete, or chain saws during periods of low rainfall, are allowed to dry for at least 10-14 days and are then burned either in place or in piles with smaller trees and shrubs. Other shifting cultivators, such as those in the very high rainfall areas of Ecuador's Amazon Basin, practise "slash and mulch" by broadcasting the crop seed in the forest, cutting the undergrowth and using that vegetation as mulch instead of burning. Still yet another variation of shifting cultivation is in the Xingu River Basin in the centre of Brazil's Amazon Basin by the Indians who plant their root crops in the cleared forest prior to burning. Then, with the burn, the root crops lose their green material, but not the vitality of the underground root system which absorbs nutrients leached from the ash when the rains begin.

The Basin's shifting cultivators most commonly plant some combination of rice, bean, maize, cassava, sweet potato, and plantain among the ashed debris using a stick to make the hole into which seed or vegetative portions of the crops are planted. Cassava and banana are often planted before rice in many areas of the Basin and it has been reported that cassava is planted to 90% of the Basin's cultivated fields.
After one or two crops, especially on the acid and infertile soils, yields decline so drastically due to soil fertility depletion and consequent greater weed competition that the land is then abandoned to a forest fallow. This fallow usually lasts for 14-21 years during which the fertility of the soil is regenerated by nutrient cycling of the forest growth and litter. The land is cleared once again, cropped and returned to fallow after one or two more crops.
With the opening of the Trans-Amazon highway and feeder roads, there is consequent increased population pressure, shortening of the forest fallow period and the soil fertility regeneration process, and a subsequent conversion of an ecologically sound cropping system into an unstable, unproductive one which creates ecological disaster. The effect of this shortened fallow is especially pronounced on the more infertile soils which make up three-quarters of the Basin.
In Yurimaguas, Peru, continuous cropping systems for the acid, infertile soils of the Amazon Basin and other similar agro-ecological areas have been developed. The results of these research efforts are felt to offer attractive alternatives for shifting cultivators in the Amazon Basin and in similar soil-crop climatic areas.
Important components of the continuous cropping included determining the most important crops, their nutritional needs, best sequences and changes in soil properties with time of cultivation.
Included in the Yurimaguas research are various rotations and combinations of rice, maize, soybean, groundnut, cassava, cowpea, sweet potato and plantain.
The improved Yurimaguas technologies offer an agronomically, economically and ecologically attractive alternative to that scene for certain areas of the Amazon Basin.

267 89 - 1/37

Traditional land-use systems
Reviev, Africa, Sahel, book, technical notes, land-use, traditional systems, ecological approach
UNESCO
The Sahel: ecological approaches to land-use.

MAB Technical Notes, UNESCO, 7 Place de Fontenoy, 75700 Paris, France, ISBN 92-3-101237-1, 1979, pp. 99

The official reports of MAB published to date in the "MAB Report Series" number some 30 issues. These reports contain the

proceedings of the different types of meetings which have marked the planning phase of the programme. While these reports are above all of a logistic nature, it is evident that they have been established on the basis of the present state of ecological knowledge, as described and summarized in documents prepared by specialists and presented to each meeting.
It has been decided to publish such documents (in English, French and if necessary, Spanish) in a new series, entiled "MAB Technical Notes". These technical notes will provide reviews of scientific knowledge relating to the ecological bases of, and new techniques for the management and exploitation of natural resources. Eventually, the series will contain reviews or the results of the operational phase of the programme.
The present volume is devoted to the Sahel.
After an introduction to the problem, the book contains the following articles:
- The Sahel: climate and soils, by L. Berry
- Remote sensing potentials for ecological research and training in the Sahel, by N.H. MacLeod
- Plant cover and pastures of the Sahel, by H. Gillet
- Pastures and livestock in the Sahel, by G. Boudet
- The improvement of pastoral economy in the Sahel: research trends, by G. Boudet and H. Gillet
- Animal production and health in the Sahelian zone, by H.S.H. Seifert
- Studies on pastoral nomadism in the Sahelian zone: bibliographic review, by E. Bernus
- Human geography in the Sahelian zone, by E. Bernus
- The status of pastoral nomadism in the Sahelian zone, by D.L. Johnson
- Improvement of pasture and livestock exploitation in the Sahel: proposals for management and land use, by G. Boudet

These basic information documents, enriched and amended by discussions, constitute a useful body of information for a larger public, for use in research, planning or teaching.

268 89 - 1/38

Traditional land-use systems
Latin America, Chile, subtropical zone, slopes, survey, interviews, small farmers, agroecology, cropping systems, cultural techniques, sustainability, socioeconomy, productivity, soil conservation, appropriate technology, rapid rural appraisal
RODRIGUEZ, J.A. et al.
Agroecological typification of traditional farming systems in Central Chile.

In: Proc. of the 6th Int. Sc. Conf. of IFOAM, Santa Cruz, California, 1988, pp. 463-468 + Annex

Under prevalent conditions of economic uncertainty in Chile, attempts to improve rural life and income must emerge from rural

development strategies that minimize dependence on purchased inputs and industrial technology, improve the efficiency of the use of local resources are used, emphasize self-sufficiency in production and consumption, and favour the organization of peasants to enhance their capacity for economic and social survival. The approach must be based on people's goals, indigenous knowledge, autochthonous technologies, local resources and social organization, so that it becomes a village-based effort with the active participation of all peasants.
A typical agroecosystem of the described area rarely exceeds 2.5 ha and is composed of the household, a kitchen garden, a chicken house, a mixed fruit orchard, a pasture with grazing animals, and the cropping systems which include tobacco, corn/bean polycultures, potatoes, vegetables and a fallow section. Most farmers devote about 25% of their land to tobacco. Crop growing seasons are concentrated between October and March, with virtually no cropping activities during late spring and winter months.
Tabacco and traditional crops compete during the growing season for the same land, scarce labour, and/or cash resources. At present farmers devote more effort to tobacco because it provides secure cash when grown under contract with the National Tobacco Company of Chile. Although yields of traditional crops exhibit a decreasing trend, farmers still plant them to secure subsistence food. Risk avoidance is expressed through crop diversification and/or early planting to provide an early source of food.
After evaluating the information derived from a survey it has been decided to concentrate the technical efforts in three main areas: reorganization of production space, soil conservation practices, and use of appropriate technologies.
Reorganization of Production Space:
A proposed design of a model farming system deviates from the traditional model in various ways:
- it includes raised beds for biointensive year-round vegetable production using organic residues and wastes; medicinal herbs are also emphasized in these units;
- includes a cow "corral" built close to the compost pile;
- bee hives are placed between the mixed orchard and the annual cropping system area;
- it includes a portable chicken house to distribute manure in otherwise unused spaces; and
- it includes a crop rotation system designed to preserve the soil and to assure constant diversified production by dividing the land into 6 small fields of fairly equal productive capacity. The rotation is designed to produce the minimum variety of a basic crops, including winter crops such as fava beans, lentils, barley, and wheat, taking advantage of the soil-restoring properties of the legumes.

Soil Conservation Practices:
This includes simple recommendations such as plowing in contour, minimal tillage techniques, use of terraces and hedgerows, and cereal/legume rotations as well as improved management of fallow periods. It also involves construction of fences for better grazing rotation and cattle management.

An important technique for marginal areas on the slopes is the design of agroforestry systems.
Use of Appropriate Technologies:
This takes advantage of several techniques and tools like solar drying, greenhouse construction, solar heaters and ovens, basic food cooking recipes, home building techniques, etc., which would enable farmers to conserve energy, food, and other materials.

269 89 - 1/39

Traditional land-use systems
Pacific, Polynesia, Micronesia, review, book, traditional agriculture, subsistence agriculture, environment, ecology, sustainability, sociology, economics, vegetable, food plants, extension, education.
BARRAU, J.
Subsistence Agriculture in Polynesia and Micronesia.
Bernice P. Bishop Museum Bulletin, 223, Publ. Kraus Reprint Co., Millwood, New York, 1976, pp. 85

From a geological viewpoint, roughly three principal types of island are found in the south Pacific: (1) Coral islands, which are atolls or raised reefs. (2) Volcanic islands, whose rock formation may belong to one of two distinct mineralogical types.
(3) Continental islands consisting of plutonic and metamorphic rocks, particularly common in Melanesia but also found in Micronesia, as well as in the Fijian-Tongan group on the fringes of Polynesia.
The deterioration of the vegetation in a number of high islands in both Micronesia and Polynesia is due, at least partially, to the techniques of primitive agricultural systems. Often, such degradation is accompanied by the large-scale development of certain introduced weeds.
Traditionally, the Polynesian family was the owner of the land. The family, in the local and very wide interpretation of the term, included the whole group of descendants of a common ancestor under the authority of the most direct descendant, who was responsible for the administration of family land. Households and even some individuals of the group were entitled to a section of the family property, which was not transferable without the consent of the community and its chief. For instance, in the Samoas, where this traditional system has been retained, the head of the family, or matai, enjoys undeniable authority. It is not unusual for him to receive the wages earned by members of his family from their European employers, as well as the profits obtained from the sale of agricultural produce. The matai, in turn, is expected to provide each of the members of his family with sufficient means for subsistence. This system, intended for a strictly subsistence economy, has been the object of severe criticism in this modern era which began with European colonization. Nowadays, it is accused of paralyzing all personal initiative and retarding economic development.
In regions of the Pacific, the wooden digging stick was the most

frequently used agricultural implement, and it still has considerable use in some of the high islands of Polynesia where taro is grown in low-lying swamps. A variant of the digging stick is an enormous club, which is used for making a wide, regular, cylindrical hole in the mud, thus providing the tuber with a container in which it can develop freely. Nowadays, metal hand tools of European manufacture are increasingly common.
The time when Polynesia and Micronesia had a purely subsistence economy is past. Today, account must be taken of new economic factors resulting from the presence of Europeans, whose influence has varied in degree depending upon the area involved.
This social and economic classification permits the general observation that European influence, although varying in degree from one area to another, is considerable throughout Polynesia and Micronesia. All of the islands have been submitted to missionary activity; all are engaged today in cash-producing enterprises, and all have benefited, with European settlement, from the introduction of food plants. In short, few Polynesian or Micronesian islands have conserved their traditional subsistence economy intact.

270 89 - 1/40

Traditional land-use systems
Africa, Cameroon, survey, traditional farming, postharvest technology, root crop, tubers
NUMFOR, F.A. and S.N. LYONGA
Traditional postharvest technologies of root and tuber crops in Cameroon: Status and prospects for improvement.
In: Proced. of the 3rd Triennial Symp. of the Int. Soc. for Trop. Root Crops, Nigeria, 1986, pp. 135-139

Important tropical root and tuber crops in Cameroon include cassava (*Manihot Esculenta* Crantz), cocoyams (*Xanthosoma sagittifolium and Colocasia* esculenta), yams (*Dioscorea* spp.), and sweet potatoes (*Ipomoea batatas). The other* root and tuber crops either have been recently introduced or are of limited, local importance. This survey looks at root and tuber crops as staple foods; those of medicinal or pharmacological importance are excluded.
Postharvest losses of root crops in Cameroon involve losses in the quantity or quality of the produce caused by physical, physiological, and pathological factors. Losses occur at various postharvest stages: harvesting, gathering, transportation, storage, processing, culinary preparation, and consumption.
Traditional African societies have developed simple technologies for reducing postharvest losses. Because of rapid population growth and shortened handling and preparation times, however, these apparently ingenious methods are inadequate for current needs. Consequently, consumers prefer foreign-processed foods.
Available research results on postharvest technologies of root crops in Cameroon are crop specific and do not comprehensively assess traditional postharvest technologies. To fill this gap, the

existing traditional methods of processing and preservation were surveyed. The goal was to formulate future research priorities in the postharvest technology of root and tuber crops in Cameroon.
This survey indicates that postharvest technology research should focus on the following aspects. Simple storage techniques and structures must be developed. The production of root and tuber crops is indirectly constrained by the lack of effective storage techniques and structures. Most farmers are easily discouraged when, after a bumper harvest, most of the crop is lost during storage. With the growth of cities and the higher demand for food in the rural areas, any effective techniques and structures for the storage of root and tuber crops will promote increased production.
Improved handling and processing techniques must be developed with emphasis on nutrition, hygiene, and quality standards. There is a wide range of traditional skill for handling and processing root and tuber crops; however, these techniques need improvement. As people become aware of nutrition, hygiene, and quality standards, traditionally processed foods tend to be less desirable than imported foods. The emphasis, therefore, should be on developing existing local technologies.
Root crops could serve as raw materials for the development of industrial products. Cassava, for example, is a source of good-quality starch for the pharmaceutical, textile, and food industries, and the aroids contain chemicals that are important in medicine.
New, competitive, fast-food products should be developed. Most traditional products require a lot of time to prepare. Therefore, the general tendency is to buy imported foods that are easier to prepare. Root and tuber crops, show good base for the development of fast-food products.
Animal feeds must be developed. Root and tuber crops, particularly their shoots, offer useful material for animal feeds. Traditionally, the shoots of these plants have been used minimally, although they are rich in good-quality proteins and vitamins.
Basic data on root and tuber crops are required. Some information exists on the approximate composition of root crops. More information is needed, however, on the variability of these data with crop variety, environment, age, and storage and processing. Nutritional studies are also needed.

II FARMING SYSTEMS RESEARCH AND DEVELOPMENT

271 89 - 2/31

Farming systems research and development
Africa, Kenya, farming systems, strategies, subsistence, marginal area, beekeeping, livestock, crops
ABELLA, J.C. et al.
The farming system in Tharaka: Strategies for subsistence in a marginal area of Kenya.

ICRA, Bulletin 15, 1984, 55 p.

The study aims to identify and evaluate development options and research recommendations which are likely to meet the objectives of both the farmers and the Government in the Tharaka region.
The study area comprises 80% of the total 370,000 acres 150,000 ha of Tharaka Division, making up the arid and semi-arid parts of the Division.
The physical and natural resources of Tharaka present an unsuitable environment for arable farming, but the density of population makes mixed farming inevitable.
Population growth in Tharaka is around 3,3% per year (1969-1984). If this growth rate continues, it will result in a decrease of landholdings from 20 acres at the moment to 10 acres per household by the year 2005, far too small to support a household if the land is predominantly cultivated under a bush fallow system with fallow lenghts of mainly 2-5 years.
Labour is almost entirely provided by family members. Cash is required in certain periods to buy food and make up for a poor harvest. It is also needed for school fees, especially for secondary education. Small amounts of cash are also required for domestic needs. The economy in Tharaka is still largely run without cash. Sales match purchases in a way that is only a short step from a barter economy. Goats almost function as commodity money.
Cropping is undertaken in a situation of severe erosion and decreasing fertility of soils because the measures undertaken to prevent erosion are very poor. 83% of the cultivated area is devoted to food crops, mainly millet, sorghum, green gram and cowpeas. The remaining 17% is devoted to the cash crops, cotton and sunflower. Some farmers occasionally use ox ploughs but handtools are mainly used in cropping.
Livestock (sheep, goats and cattle) are owned by 85% of the farmers surveyed for a variety of socio-economic reasons. They are regarded as a source of wealth and prestige.
Beekeeping is the most promising way of earning money other than from sale of crops and/or livestock. More sales of honey or wax could provide a significant increase in income for a wide range of farmers. There is very little prospect of charcoal-burning, basket-making or other income-earning activities being able to make a significant impact in Tharaka.

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II FARMING SYSTEMS RESEARCH AND DEVELOPMENT

271 89 - 2/31

Farming systems research and development
Africa, Kenya, farming systems, strategies, subsistence, marginal area, beekeeping, livestock, crops
ABELLA, J.C. et al.
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Beekeeping is the most promising way of earning money other than from sale of crops and/or livestock. More sales of honey or wax could provide a significant increase in income for a wide range of farmers. There is very little prospect of charcoal-burning, basket-making or other income-earning activities being able to make a significant impact in Tharaka.

For arable agriculture the emphasis is on reducing risk. Proposals are directed to soil and water conservation measures in order to maximize the use of rainfall and minimize soil and water losses; to the introduction of more reliable cropping patterns; to more efficient use of labour; and to food insurance through specific measures to improve the marketing systems. Research recommendations concentrate on improving the reliability of crop yields.
The recommendations for livestock are directed less to research than to institutional and organizational developments. The most appropriate solution to the problem of over-grazing is seen as the establishment of small group ranches. The encouragement of cooperatives is proposed to act as a channel for improved health services and husbandry advice and to provide a more reliable external outlet for livestock sales. The only recommendation for additional research relating to livestock is to evaluate the browse and grazing in the area.
While marginal improvements can be made at the moment the basic problems of populations growth and the limiting agro-ecological circumstances remain.

272 89 - 2/32

Farming systems research and development
Africa, Nigeria, farming systems, yam, smallholder
DIEHL, L.
Smallholder farming systems with yam in the Southern Guinea Savannah of Nigeria.

Schriftenreihe, GTZ, 1982, 226 pp., ISBN 3-88085-135-2, 36,- DM

Yam is traditionally the most important food-crop in much of Africa. Yet, detailed knowledge about the large variation of production systems and their respective economics has been scarce. The present study examines smallholder farming systems with yam in Nigeria.
The study's hypothesis assumes that yam production is bound to decline due to unfavourable input/output relations and in particular low return to labour when compared with other crops.
This hypothesis is investigated on the basis of an intensive socio-economic survey including 68 yam producing farms in three locations of Nigeria's Middle Belt. During a period of 14 months all agricultural activities on the farm were enumerated in 2-3 interviews per week. Agricultural inputs and outputs were recorded, samples of local units being weighted and cultivated farm land being measured.
By means of statistical analysis on the farm as well as on the enterprise level similarities and differences among groups of farms in respect to resource endowment, factor allocation and income were investigated. The studied farms being subdivided into according to ethnological differences and varying distances between their farming locations and the village. Factor productivity on the enterprise level was analysed by budgeting,

enterprises being grouped into crop mixtures with and without yam and hydromorphic or well drained soil types.
The husbandry practices and cropping principles of the studied farms are described and explained in detail, emphasis being laid on the agronomy of yam. The interactions between yam and other crops have been analysed with particular respect to labour requirements over time.
Defining yam production enterprises it is important to differentiate between upland- and lowland-yam systems. The comparison of crop mixtures including yam with non-yam mixtures reveals the following characteristics of yam production:
- labour input to yam production is fairly stable and on an average amounts to 1300 man-hours per hectare in upland-yam systems and 2100 man-hours per hectare in lowland-yam systems,
- labour input to non-yam mixtures is extremely variable and on an average ranges from 660 to 1300 man-hours per hectare,
- yam production requires high capital inputs in the form of planting material due to extremely unfavourable physical input/output relations which range from ½ to ¼ in the survey area.

In spite of these unfavourable characteristics the analysis of factor productivity reveals that yam is by far the most profitable crop grown in the survey area as:
- the gross margins per hectare achieved in yam production are 4-6 times higher than those of non-yam mixtures,
- the gross margins per hectare of lowland-yam enterprises are 2060% higher than those of upland-yam enterprises,
- the returns per man-hour of labour input are between 2-6 times higher in yam production than in non-yam-mixtures. They are lower in lowland-yam systems than in upland-yam systems.

In spite of high requirements, labour was not a constraint to yam production due to the complementary distribution of labour requirements over time among yam and non-yam systems.
Yam production is, however, seriously constrained by:
- a physical shortage of planting material, and
- an increasing scarcity of suitable land.

The availability of yam sets is not only limited by the low rate of reproduction but also by the households' subsistence demands as yam makes significant and vital contributions to the food supplies and cash incomes of the farm households.
Symptoms of an acute shortage of fertile farm land were observed in four of the five distinguished strata in spite of the generally low population density in the survey area. The constraints on the availability of farm land are imposed by:
- the topographical limitations to arable land, and
- the clustering of farming in road-side locations due to social and economic advantages.

The observed scarcity of land has led to an intensification of farming. This process may well reflect the generally expected development of farming systems in the tropics, being characterised by:
- higher plant densities,
- increased diversity of land use,

- higher labour inputs, and
- higher inputs of cash for hired labour as well as fertilizer.

In this development of the farming systems yam production will gain rather than lose importance as it is tailored to the envisaged development of smallholder farming towards labour and capital intensive farming with high returns to land and labour.
The economic superiority of yam production is based on the present farmprice-relations. This situation is fairly stable unless major changes in these price relations occur. Such changes would imply marked alterations in the composition of production costs or the structure of demand for agricultural commodities. Both, however, are not to be expected in the near future.
The possible development of yam production technology and the implications of agricultural research show that yam may well maintain its position in the farming systems of the future. The yield potential of this crop as well as the possibilities of breeding and agronomic improvements are far from being exploited. Therefore more research is needed in respect to yam production. Any significant improvement of the input/output relation in particular is likely to have a drastic and lasting impact on the income of a large number of smallholder farms in much of West Africa.
Author's summary, amended

273 89 2/33

Farming systems research and development
Africa, Ghana, dry savannah, farming systems, compound farms, bush farm, livestock, crops, soil fertility, socio-economic analysis
PANIN, A.
Hoe and bullock farming systems in Northern Ghana.

Nyankpala Agric. Res. Report 1, 1988, 182 p. + Ann. ISBN 3-8236-1128-3, GTZ-Project Nyankpala, Ghana; Distributor: Triops, Raiffeisenstr. 24, D-6070 Langen, FR Germany

The use of bullock traction technology for crop cultivation in some areas in Northern Ghana has a long history which dates back to the early 1930's. Yet its overall impact on the farming systems in the area is not known. This study was therefore undertaken to assess the impact of the technology on the farming systems of the rural communities.
Following the main objective of this study, the analysis is based on the following hypotheses:
- Bullock farmers are more endowed with land, capital, and labour capacity than hoe farmers.
- The bullock traction technology is superior to handhoe technique in turning out increased food and cash crops per unit of land in the dryland farming systems. This is attributable to the increases in the productivity of labour and land that characterise the bullock traction technology.
- Bullock farmers realise higher net income and greater security of subsistence than their hoe counterparts.

- The rise in the factor productivity of bullock farmers is positively related to the experience in the use of the technology. These hypotheses are investigated on the basis of an intensive socio economic survey of 42 households selected from three villages in one part of Northern Ghana. During a period of one year from April 1982 to March 1983, data on various aspects of farm households activities were collected.

The selected households studied were stratified into two main groups:
- farmers who use the hoe as a major tool for cultivation and
- those using bullock traction as a method of cultivation.

The major findings of the analysis of the two farming systems (hoe and bullock) are summarily presented as follows:
Resource endowments: Bullock farmers are better equipped with land, labour capacity, and livestock than hoe farmers. But whether or not the higher resource endowment is partly the product of using bullock traction technology could not be established. The heads of bullock households were far older than their counterparts in the hoe households.
Land use:
- Effects on cultivated area: There was an increase of 4 percent in total area cultivated per active worker for bullock farmers compared to hoe farmers. But among the bullock households, the area cultivated per active worker was inversely related with years of bullock traction experience.
- Effects on cropping emphasis: The effects of bullock traction on the cropping systems were very small. The area allocated to the major food crops by hoe and bullock households accounted for 80 and 74 percent of their respective total cultivated areas. The overall shift to cash crop cultivation was therefore very slight, with bullock farmers growing slightly more cash crops than hoe farmers. However, there were remarkable changes in the cropping systems of the various bullock subsamples. These changes took the form of systematic shifts from the production of major food crops to cash crops as the years of traction experience increased.
- Effects on mixed cropping systems: Bullock traction technology led to increases in the number of different types of crops in the mixed cropping systems. Among the bullock subsamples however, these increases were negatively related to the years of bullock traction experience.
- Effects on crop yields: There were substantially higher yields per hectare from all the major cropping patterns for bullock farmers except one. Yield increases ranging from 16 to 35 percent were found among the bullock farmers. Total output of all crops per hectare was also considerably higher for bullock than hoe farming. According to the results of the production function analysis, bullock traction technology has a positive effect on total crop yield.

Effects on labour use:
- Labour use per hectare: The average labour input per hectare for all major farming operations together increased with the introduction of bullock traction technology. The increase in labour input per hectare was also positively related to the

years of bullock traction experience. As regards labour requirements per hectare for individual farming operations, the use of bullock traction technology increased those of clearing, weeding and harvesting, while those of ridging and planting were reduced. Moreover, in terms of labour use for the respective cropping patterns, bullock traction had different effects. Whereas it raised the labour intensity for some crop mixtures (e.g. groundnut-grains), it reduced it for others (e.g. cornmillet-beans).

- Seasonal variations in labour inputs: Survey data indicate that farming in the area is highly seasonal for both hoe and bullock households. The seasonal constraints are extreme, as agriculture is virtuallly impossible during the slack season in the year. Data indicated that the current use of the traction technology did not make any impact on the distribution of labour over the year.
- Labour input by household members: Survey data indicate a reduction in annual field labour use for small children of 6-9 years (both male and female), adult women, on heads of households in bullock households. But at the same time, annual labour input for field work contributed by boys, male adults, and both elderly women and men increased with the adoption of bullock traction technology. Further, there was an increase in labour input per man equivalent of household labour for bullock households.

Effects on income and production costs

- Net farm income: Based on either income per man equivalent of household labour or per active worker, the income effect of bullock traction technology was great. A substantial increase in net farm income of 32 and 40 percent per man equivalent of household labour and per active worker respectively was found for bullock farmers. The respective increase is attributable to increased crop production, on which the use of bullock traction has a positive significant impact.
- Annual cash income: The study indicates substantially higher disposable annual cash income among bullock households than hoe households. An increase of 151 percent in net annual cash income per household member was found for bullock households. The use of bullock traction contributed substantially to this increase through increased crop production and revenue from contract ridging.
- Farm investment analysis: The general performance of bullock traction technology (ridging) at the individual farm level as shown by the ten-year income projections is substantial. Over the ten-year investment period, bullock ridging produces an internal rate of return (IRR) of 65,5% which is quite appreciable. Further, it provides substantial increases of 17,5% and 16,8% of the net present worth (NPW) of the incremental net benefits respectively, before and after financing over the NPW of income from hoe farming.

Finally, the analysis shows that the performance potential of bullock ridging sets in quickly, and hence, the investment does not pose any severe problem on the cash flow positions of the adoptive farmer.

The findings of this analysis confirm the validity of the study hypotheses. For the analysis has shown that there were substantial increases in total crop production under the bullock farming systems. This was possible through the increase in factor productivity. Further, the net incomes of bullock farmers were high relative to those of hoe farmers, thus enabling the former to achieve greater security. Finally, the analysis revealed that bullock farmers were better endowed with resources than their hoe counterparts.

In conclusion, bullock traction technology offers a clear solution to the problem of low productivity which characterizes agriculture in the study area.

Although its use was limited to ridging only, the bullock household were able to realise higher crop production, higher income and a generally higher living standard compared to hoe households.

Therefore, if the use of the technology is expanded to cover all the major farming operations, the benefits to bullock households will increase even further. These benefits will then spread among the farming population, if the number of farmers using the technology increases.

Author's summary

274 89 - 2/34

Farming systems research and development
Africa, Botswana, study, farming systems research, crop production
JONES, R.B.
Crop production systems in Ngamiland West, Botswana.

Farming Systems Newsletter, CIMMYT, 1987, 17-31

The Republic of Botswana is a landlocked country in the centre of the Southern African Plateau.

An important aspect of the country is the harsh climatic environment, often described as semi-arid.

Precipitation occurs almost entirely in the summer months from November through to April and is unreliable, in that the annual total and seasonal distribution vary, and is of poor quality in that it usually falls in heavy showers of short duration leading to runoff and erosion. As a consequence of this, arable agriculture is a risky undertaking, the country being better suited for extensive grazing by ruminant livestock.

Although this paper focuses on crop production systems it is important to realize that livestock systems cannot be ignored because the two types of production are linked together. Livestock is essential for the provision of draft power and also play an important role in the cycling of nutrients.

It should be realized that production systems not only evolve in response to physical and environmental constraints but also in response to government policies.

Molapo Farming System:
Three major ecotypes have been distinguished in the Okavango Delta according to their lack or abundance of water.
A complex land tenure system has developed which takes into account the necessity to shift cultivation in response to the changing flood regime. With the drying up of the Thagoe River the areas available for molapo cultivation have become scarse with the result that the overall productivity from the area has declined. Molapo fields need several seasons of cultivation with the traditional ox-drawn mouldboard plough before weeds are controlled and smooth even seedbed is produced. Without this, germination is patchy reducing yields and making weed control almost impossible.
During the same period livestock numbers have increased drammatically due to campaigns carried out by the veterinary services, which provid free vaccinations against the major livestock diseases, and the control of tsetse fly. Conflicts between the two production systems have increased because both are competing for areas with more favourable conditions.
Dryland Farming System:
The Hambukushu grow millet, their staple food crop, together with sorghum, maize, mellons, groundnuts and a variety of beans on the soils which surround the Okavango Delta.
Farmers clear land burning the brusch but leaving stumps in the ground. Areas with dense vegetation are chosen with preference for clearing as they are considered to be more fertile. However after approximately 10 years the fields are abandoned and new lands cleared. At the beginning of the cropping season any remaining crop residues which have not been grazed by cattle in the field are collected an burnt. Land preparation and planting is done either by single furrow moulboard plough or by hand hoe. Plough teams are composed of only two oxen with donkeys being used very occasionally. Planting takes place by dropping seeds in every other furrow at carefully spaced intervals of 50-100 cm. Planting is done into both dry and moist soil although the latter is preferred. Often farmers will separate planting and ploughing preferring to plant into the ploughed seedbed when moisture conditions are optimal either using a hand hoe or the feet to knock over the ridge of the furrow thereby covering the seeds. If oxen are not being used land preparation is carried out by clearing an area of weeds using a hoe followed by planting at carefully spaced intervals.

275 89 2/35

Farming systems research and development
Africa, Liberia, tropical rainforest climate, survey, farming systems research, smallholders, labour, socio-economics, project, monitoring and evaluation
WESTPHAL, U. et al.
Baseline survey on smallholders in Nimba County to facilitate decision taking in project planning.

Schriftenreihe des FB Int. Agrarentwicklung (FIA) Nr. 109, SLE, 1987, 187 p.+ C1-C6, ISBN 3-924333-66-1, DM 19,-, Verlag J. Markgraf, Postf. 105, D-6992 Weikersheim, F.R.G.

The purpose of the study was to gain information about smallholders in Nimba County, placing emphasis on labour requirements and socio-economic data in order to facilitate further decision taking in project planning. It should also create a basis, in the form of indicators, for the monitoring and evaluation unit to measure the impact of project activities.
- The results of the baseline survey led to criteria in order to facilitate decision taking in project planning. The criteria cover the subjects of socio-economics, labour and ecology.

In order to demonstrate the use of criteria seven proposals for project activities have been developed. The proposals include programmes already practised but have been supplemented with components neglected so far. These proposals have been ranked according to more positive or negative aspects in regard to the criteria.
For the proposals which were rated feasible in comparison to the others M & E indicators have been developed.

276 89 2/36

Farming systems research and development
Africa, Ghana, study, dry savannah, farming systems, farm households, agronomic practices, cropping systems, yields, farm income, socioeconomic parameters
RUNGE-METZGER, A.
Variability in agronomic practices and allocative efficiency among farm households in Northern Ghana - a case study in on-farm research.

Nyankpala Agric. Res. Report, 2, 1988, p. 121, ISBN 3-8236-1134-8; CRI/GTZ Joint Project, Tamale, Ghana; Distributor: Verlag J. Markgraf, Postfach 105, D-6992 Weikersheim, F.R. Germany

Agricultural production in the Guinea Savannah in Northern Ghana is mainly done by small farmers. The high population growth of 3,6% p.a. in this region basically increases the pressure on arable land.
In the past, farmers of Wantugu, the study village which is located close to the regional capital, Tamale, tended to prefer

the first two solutions, so that ratio between cropping period and the length of the whole cultivation cycle decreased steadily. But recently farmers also extend their farms into virgin areas, which indicates that the soils located around the villages are exhausted. Farmers did not establish measures which could efficiently prevent soil mining.
Morever the destabilization of the fragile agroecosystems is accelerated by the increasing demand for firewood and the annual recurrence of burning the bush. In the long run soil fertility will further decrease so that self-sufficiency will become uncertain.
Consequently, the goal of the Nyankpala Agricultural Experiment Station is to develop sustainable cropping systems giving higher yields and improving soil fertility, so that also in future farm incomes will cover at least the basic needs of the family members.
This is followed up with two research strategies:
- On-station research for identifying the effects of improved agronomic practices and for identifying new varieties.
- On-farm research for testing the recommended practices and for developing new technologies in close cooperation with the farmers.

The disadvantage of both approaches is that they are very time consuming. Therefore a study which follows another approach was conducted in 1984.
The study was undertaken with the main aim to test a methodology for investigating the variability of agronomic practices and of factor allocation and their influence on yields and farm income. Therefore, farm sizes and other data were not selected to be representative for the whole region.
Furthermore the results of the agronomic analysis are strictly derived from on-farm observations. They are not an outcome of an on-station experiment where environment can normally be better controlled. Hence, the results have to be interpreted facing this empirical background.
In general, the results of the study show that the method of investigating the variability of the current farming system is a possible way to provide appropriate solutions for smallholder farm families to increase yields and incomes in a short period of time. Another advantage of this approach is that this method could easily be taken up by the extension services in order to generate extension messages in the field. This bottom-up approach promises to be more successful than the top-down oriented approach which is still widely practised in West Africa. The latter seems to fail in these countries where the research network is obviously too wide. This implies that agricultural research is not able to cover the whole range of ecological systems of a single country.
Therefore the bottom-up approach is recommended which comprises two steps. Firstly the actual socioeconomic situation of a household should be analyzed, while in a second step it should be looked for adequate technical innovations. Necessarily the extension agents have to be educated extensively in the techniques of data collection and microeconomic data analysis of small scale farm households.

277 89 - 2/37

Farming systems research and development
Developing countries, farming systems research, review
DOROGI, J. and R. RICHTER
Farming system research in developing countries.

Beiträge trop. Landw. Vetrinärmed. 26, 1, 1988, pp. 5-9

The role of the FSR is based on the recognition that farmers use farming systems which are researchable and can be improved at the farm, cropping, or crop system level. The FSR is essentially a multi-disciplinary activity, and it is envisaged that the programme will have both upstream and downstream roles. The upstream activities comprise the analysis of resources, the politico-socio-economic environment, and existing farming systems. This will improve the understanding of the natural resource base, farm producers' skill and production methods, and of reasons for the wide gap between the results demonstrated at the research stations and those obtained at the farms. Further, these investigations will enable users to identify major constraints in production, priority technical problems, and policy issues limiting the production and income. In a downstream context, the FSR programme will be an important complement to crop improvement and other discipline-oriented research programmes and would provide structures for fitting new findings into production systems and evaluating these under realistic farm conditions. The primary objective of FSR is to improve the well-being of individual farm families by increasing the overall productivity in the context of the entire range of private and social goals and given the potential and constraints imposed by the technical and human elements which determine the existing farming systems.
FSR can be divided into four stages:

the descriptive and diagnostic stage
The objective of this stage is to understand the farming systems practised in the target area. This enables the FSR team to determine the constraints that the decision-making households face and the flexibility that exists in the current farming system - timing, skill, slack resources etc.

the design stage
In this stage, improved technologies thought to be relevant to overcoming or avoiding the constraints identified in the fist stage are specified.

the testing stage
The objective of the testing stage is to evaluate a few of the more promising technologies arising from the design stage on farmers' fields.

the extension stage
In this stage, technologies found during the design and testing stages to best overcome the constraints outlined in the descriptive and diagnostic stage are widely extended to other farmers. Problems in the extension stage should be monitored - perhaps accompanied by a new round of descriptive

and diagnostic work. This process is dynamic and iterative because there is a frequent return to previous stages.
The distribution between the stages is not sharply defined as there is much overlap, and several stages are tackled simultaneously. The process is flexible and adaptable to many circumstances and different problems.
The essence of the FSR's methodology is that it analyses and assesses the original situation, the present level and results of production, and in this way learns in the constraints and elaborates alternatives of development. It is necessary to test these alternatives and chose the most suitable. After introducing the new system, or system components, it is necessary to test and compare the new system's level and results with the original one.
FSR can be the first step of an important development, but it must not be conceived in an isolated way. It should then be part of an agricultural policy which includes the necessary social and economic reforms. A farming system is not only a summary of crops and animals to which one can apply this or that input and expect immediate results. Rather, it is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs, and environmental influences. The farmer's understanding of his environment, both natural and socio-economic, affects his farm system.

278 89 - 2/38

Farming systems research and development
Review, book, developing countries, food security, poverty, policy study
THE WORLD BANK
Poverty and hunger: Issues and options for food security in developing countries.

The World Bank, 1986, pp. 69 + xi, USD 7.50 (softcover)

A publication as important as this by the World Bank has to be viewed in the context of the Bank's shift over the last six years to a much more conservative outlook. A lot has been heard from the Bank about "getting prices right", allowing market forces to have a free hand and so on, and much less of the talk heard during the 1970s about direct measures to eradicate poverty. Given the political climate in the Bank, this is an exceptional document; given what needs to be done about reducing poverty and hunger by improved food security.
Such chapter headings as "National measures to reduce chronic food insecurity" and "International support for food security" create the impression that insufficient attention has been given to household and community level factors and how those should be taken into consideration in designing food security policy. The document is one which can form the basis for promoting the argument that issues of national economic growth and equity can and do overlap in improving food security.

The policy study is essentially split into three parts. After a definition of terms and an overview, there is a discussion of whether food security is a problem of supply or purchasing power. That is reviewed by reference to two aspects - chronic and transitory food insecurity. The former is defined as continously inadequate diet caused by the inability to acquire food; the latter is a temporary decline in a household's access to enough food, resulting from instability in food prices, food production or household incomes. Inadequate production, household purchasing power and unstable world and domestic prices are all reviewed as causative factors.
The second part discusses national measures to reduce both chronic and transitory food insecurity. The former includes increasing the food supply (by trade interventions, production subsidies), subsidizing food prices (by targeted subsidies, marketwide subsidies) and augmenting incomes. The national measures to reduce transitory food insecurity are given as stabilizing domestic food supply (production, buffer stocks, trade), stabilizing domestic demand and protecting vulnerable population groups. The third section concentrates on international measures: external finance including food aid and international trade.
They should be tried to take household characteristics and priorities and see how those can be built up into national programmes that are technically, and politically, feasible. Many projects and policy studies have failed because inadequate attention was paid to the target group itself.

279 89 - 2/39

Farming systems research and development
Asia, Philippines, study, technology transfer, farmers, rice, language differences, IRRI,
CABANILLA, V.L. and T.R. HARGROVE
The Effectiveness Among Farmers of a Farmer's Primer on Growing Rice in two Philippine Dialects.

IRPS No. 127, 1987, pp. 11

Language differences inhibit the flow of agriculture information not only among scientists but even more so from research institutions to farmers, the ultimate users of technology. To alleviate the language barrier in technology transfer, the International Rice Research Institute (IRRI) has developed its copublication program - cooperative ventures with national agencies and private publishers in which the cooperator translates IRRI books and handles most distribution. IRRI designs certain publications to make them easy and inexpensive for cooperators to copublish.
The Tagalog and Hiligaynon editions of "A farmers's primer on growing rice", which is published in 30 languages, were evaluated for their effectiveness in transferring rice technology information to 84 farmers in Cavite and Negros Occidental, two provinces in the Philippines. Relationship among farmers'

sociodemographic characteristics, communication variables, and the Primer's effectiveness in terms of knowledge gain were also tested.
A 73-item test was used to measure initial knowledge level. The farmers were then given copies of the Primer in Tagalog (Cavite farmers) or Hiligaynon (Negros farmers). A post-test was given 45 days later to measure knowledge gain.
On both tests, farmers who answered less than 50% of the test questions correctly were defined as having "low"levels of knowledge, and those with 50% or more correct answers as having "high"knowledge. Only 4% of the farmers had high knowledge in the pretest, but 46% had high scores after reading the book. The t-test also showed that, although farmers who finished the book and those who did not were not significantly different in initial rice knowledge, the difference in post-test scores was highly significant. The farmers' knowledge gain concerning fertilizer was highest. In the pretest, only 15% knew the meaning of "24-12-12" on a fertilizer sack, but half knew after the treatment. Of 14 independent variables tested, only 4 were significantly related to knowledge gain: previous participation in rice training courses, land tenure, number of years in rice farming, and exposure to newspapers. The Cavite and Negros farmers generally matched well in most variables.
Farmers evaluated the Primer's design, packaging, and message content favorably but suggested improvement to increase its effectiveness, such as the deletion or substitution of abstractions and symbols that they found confusing or hard to understand.
IRRI is using the findings of this study to make forthcoming publications, designed on the Primer concept, more effective.

280 89 - 2/40

Farming systems research and developing
Latin America, Mexico, livestock, crops, smallholders
ALUJA, A. et al.
Decision making by livestock/crop smallholders in the state of Veracruz, Mexico
Cornell international agriculture mimeograph, 105, 1984, pp. 44

Prior to proposed agricultural development program in the Mexico State of Veracruz, 13 farms were surveyed in an effort to identify and quantify factors in farmer's decisionmaking. Data were collected in physical resources, (land, facilities and equipment, cropping), livestock, pasture management (grazing systems, pastures, quality of forages, supplementary feeding), milk output, livestock reproductive performance, animal health, selected indicators of livestock performance, marketing, labor, and economic factors. It was found that the farmers'decisionmaking in regard to both crop and livestock systems was rational. Farmers appreciated that to increase animal and milk production from modest to high levels would not be supportable under present marketing conditions. It is concluded that the government should

recognize that farms in Veracruz State are supplying local needs through low inputs and contribute to state and regional food supplies than is generally recognized. A 3-page bibliography (1955-84) is appended.
Abstract from FSR

281 89 - 2/41

Farming systems research and development
Africa, Zambia, adaptive research, farmers, scientists, farming systems research
KEAN, S.A.
Developing a partnership between farmers and scientists: The example of Zambia's Adaptive Research Planning Team.

Expl. Agric., 24, 1988, pp. 289-299

This paper is based on the experiences of the Adaptive Research Planning Team in Luapula Province (ARPT-LP), which is one of the nine provincial ARPT teams conducting farming systems research (FSR) in Zambia. The ARPTs form a section within the Research Branch of the Ministry of Agriculture and Water Development. The Research Branch also includes 16 Commodity and Specialist Research Teams (CSRTs), who conduct research mainly at the provincial research stations. This paper shows how a government-operated national agricultural research system has attempted to involve farmers in the process of research and technology generation.
When ARPT was established in 1980 one of its primary function was to involve farmers, especially small scale farmers, more fully in the technology generation process. However, only a few evaluations of ARPT and the Research Branch have seriously considered what progress has been made in involving farmers as partners in research. This paper makes such an assessment.
ARPT started working in Luapula Province in 1982 and since then has become increasingly concerned to involve the farmers in both planning and implementing the team's research programme. The team has used several formal and informal opportunities to interact with farmers and involve them in decision making. These opportunities and several key factors affecting the evolution of this interaction are examined here.
The information was collected as part of a larger study, covering the work of ARPT in Zambia as a whole, and is being published in a nine country comparative study of organization and management of on-farm client oriented research by the International Service for National Agricultural Research.
Even though ARPT has a mandate to work with farmers, the experience of ARPT-LP indicates that it is easy to underestimate the amount of time and effort needed to explain the purpose of the team's work and its specific activities, and to build an effective partnership with farmers. It is very easy for scientists conducting farming systems research to regard farmers simply as recipients of new technologies rather than as partners and initiators in the research process.

Research priorities should be set taking great care to use information derived from surveys and discussions with farmers. Farmers' ability to suggest topics for research can be enhanced over the long term if scientists explain clearly the range of technological options available to meet a particular need. They should therefore have some basic training in communication skills. Informal opportunities for discussion between scientists and farmers have been as important as formal occasions. However, care has had to be taken to ensure that comments made by farmers have been properly recorded.
Various factors likely to enhance the level of farmer participation include involvement of local leaders, use of extension workers or scientist with experience of extension work, selection of farmers in close proximity to one another, and emphasis on greater farmer participation by senior research managers.
Monitoring the level of farmer involvement in decision making in a national research system is difficult because there can be many informal, as well as formal occasions when information and opinions can be passed from farmers to scientists. It is also difficult because it is usually possible for scientists to justify decisions they have made by referring to survey results or comments made by farmers on some occasion. But if research organizations or sections have been given specific mandates to involve farmers in the research process, it is important that such mandates are included in the monitoring and evaluation of the research system.

282

89 - 2/42

Farming systems research and development
Discussion, workshop paper, farming sytems research, socioeconomic models, ICRISAT, small farmers
ANDERSON, J.R. et al.
Socio-economic modelling of farming systems.

FSR Workshop, Richmond, New South Wales, 1985, 30 pp.

The types and role of socioeconomic models in FSR are discussed in this non-technical workshop paper. In basic type, models are either descriptive or optimizing; the latter are defined as those which incorporate an algorithm which directly generates a solution for a specified function in the model. Among the variants of these two types, budgeting and mathematical programming stand out respectively; the latter's relative advantage in eliminating bias is exemplified during an excursus on the experiences of one of the authors in an FSR program conducted by ICRISAT. Socioeconomic modeling permits detailed evaluation of the performance of a given farming system and identification of its strong and weak points and helps assess the viability of a proposed technology. Problems involved in the use of socioeconomic models include the difficulty of striking a suitable balance between data gathering, model building, and model exploitation, the physical and/or cultural

remoteness of modelers from farmers (or, by contrast, an excessively anthropological approach), and various sins of omission, of which the most serious is failure to recognize the crucial role of female farmers. A concluding section stresses the need for greater sensitivity to the ideas and needs of small farmers. A 4-page bibliography (1970-86) is appended.
Abstract from FSR

283

89 - 2/43

Farming systems research and development
Asia, Pakistan, sustainability, development, agroecosystem zoning, farming systems survey,rapid rural appraisal
CONWAY, G.R. et al.
Rapid rural appraisal for sustainable development: experiences from the northern areas of Pakistan.

Presentation to the IIED's Conf. on Sustainable Development, London, Earthscan, 1987, 30 pp.

The challenge for the designers and managers of development projects is to find ways of analysing situations that are rapid and cheap and that ensure their recommendations will lead to sustainable development. This paper describes several methods that go some way to meeting the challenge and how they are being applied in development project in the Northern Areas of Pakistan.
Rapid rural appraisal (RRA) aims to provide enough structure to the observation and analysis to ensure a relatively high degree of accuracy, without incurring lengthy or costly studies. RRA is also a response to dissatisfaction with many conventional socio-economic and agricultural surveys. Experience suggests that in addition to being time consuming and expensive they often do not ask the key questions or obtain the critical data. RRA recognises that the context of the data may be as important as the data themselves, and that variations may be more revealing than the averages that are often the sole output of conventional surveys. Above all, RRA is intended as a highly iterative process. Learning takes place in the field as part of a dialogue with the farmers and the other members of the RRA team. Accuracy is achived by triangulation, i.e. by repeated cross-checking of information from several different directions using different techniques. It follows that RRA is primarily a process of generating and refining hypotheses about rural development.
There is no single, standardised methodology for RRA. In each situation this depends on the objectives, local conditions, skills and resources. However there is a suite of techniques in existence which can be used in various combinations to produce appropriate RRA methods. The suite includes:

- Secondary data review
- Direct observation
- Conceptual tools
- Semi-structured interviews
- Analytical workshops.

Secondary data consist of reports, maps, aerial photographs etc. that already exist and are relevant to the project. The review process involves searching for relevant data and summarising these in diagrammatic models, simple tables and brief abstracts.
The aim is to be sceptical and critical and to look out for what has been missed, but not to spend time here that could be better spent in the field. **Direct observation** includes measurement and recording of objects, events, and processes in the field, either because they are important in their own right or because they are surrogates for other variables that are important. **Conceptual tools** consist of a wide variety of simple techniques for summarising information. An important set of such tools are diagrammatic models, including maps, transects, seasonal calendars, flow diagrams, bar diagrams, decision trees and venn diagrams.
One of the most important of RRA techniques is **semi-structured interviewing**, which is a form of guided interviewing where only some of the questions are predetermined and new questions or lines of questioning arise during the conduct of the interview, in response to answers from those interviewed. The information is thus derived from the interaction between the knowledge and experience of the interviewer and the interviewee(s). The latter may be groups, for example of village leaders, or key informants, such as school teachers or local government officals, or the farmers themselves, selected on one or more criteria.
The final RRA technique is the **analytical workshop**. This takes place very soon after field visits, is semi-structured and provides an opportunity for intensive multidisciplinary analysis of the information acquired in the field.
Over the past two years these various RRA techniques have been explored as means of determining priorities for the next phase of development in the Northern Areas of Pakistan. The outcome has been a series of RRA methods under the headings of agroecosystem zoning, agroecosystem analysis, topical rapid rural appraisal and farming systems survey. In practice they have been developed and refined and it is only recently that their logical relationship to one another, as presented in this paper, has become apparent.
Underlying the use of these appraisal methods are a number of basic concepts that provide a framework for analysis. The first is that agricultural land use in the Northern Areas of Pakistan can be represented as a set of more or less distinct agroecosystems, typically arranged in a hierarchic fashion. An agroecosystem can be defined as an ecological system partly modified by humans for the purpose of food or fibre production. The wheat field is an example of such a system.
Each agroecosystem has a characteristic behaviour that may be summarised by four interconnected properties:
Productivity, which is the output of valued product per unit of resource input (e.g. land, labour, energy or capital) and is commonly measured as annual yield or net income per hectare or per agroecosystem, or per man hour or unit of investment.
Stability, which is the constancy of productivity about its long term trend in the face of small disturbing forces arising from the normal fluctuations and cycles in the surrounding environment, for

example in the climate, or in the economic conditions of the market. Such forces affect the variability of production but leave the long term trend unchanged. Stability is most conveniently measured by the coefficient of variation in productivity.
Sustainability, which can be defined as the ability of an agroecosystem to maintain its productivity when subject to stress or shock. A stress is here defined as a frequent, sometimes continuous, relatively small and predictable disturbing force which has a large cumulative effect, for example salinity, toxicity, indebtedness or declining market demand. A shock, by contrast, is an irregular, infrequent, relatively large and unpredictable disturbing force, such as a rare drought or flood or a new pest or the sudden rise of an input price. Stresses and shocks have the potential of causing lower, or declining trends in production or even collapse.
Equitability, which is a measure of how evenly the productivity of the agroecosystem is distributed among its human beneficiaries. The more equitable the system the more evenly are the products, the food or the income, shared among the population of the farm, village, region or nation. It can be represented by a statistical distribution or by a measure such as the Gini coefficient.
These four properties are essentially descriptive in nature, summarising the status of the agroecosystem. But they can also be used in a normative fashion, as indicators of performance, both in the design of agricultural innovation and in its subsequent evaluation. Experience shows that in agricultural development there is almost inevitably some degree of trade-off between these different properties and the challenge for rapid rural appraisal is to accurately foresee these trade-offs and ensure they are taken into account in project planning and management.

89 - 2/44

284

Farming systems research and development
Review, tropics, developing countries, technology transfer, farmers, modelling system, decision support system, appropriate technology, data requirement, future outlook
UEHARA, G.
Technology transfer in the tropics.

Outlook on Agriculture, 18, 1, 1989, pp. 38-42

The purpose of this paper is to examine factors that govern technology transfer and describe how these factors can be incorporated into new efforts to accelerate agricultural technology transfer in the tropics.
There is a growing sense that a technology is appropriate only in the eye of the beholder. The certainty that only farmers can recognize appropriate technology has generated strong opposition to researcher-designed technology packages and has given rise to arguments that agricultural research should be conducted with farmers, for farmers' fields.

Most researchers concede that the user must participate in the selection, design, and testing of a new technology, but in practice few farmers are involved in technology assessment. The problem with the well-intentioned aim of involving farmers in technology development is that it is too slow, too expensive, and unreliable.
It is not so easy to propose a better method. But it is abundantly clear that the current methods must be supplemented with a fresh approach.
An international group of agricultural and systems scientists met to design a decision support system for agrotechnology transfer (DSSAT). The participants were asked to focus on systems analysis and crop simulation models as the primary means to match crop requirements to land characteristics. The aim was to develop a solid foundation for dealing with the soil-plant-atmosphere continuum so that strong links between the biophysical and socioeconomic processes could be later forged. The scope of work was limited to ten food crops including four cereals (maize, rice, sorghum, and wheat); the grain legumes (dry beans, groundnut, and soybean); and three root crops (aroid, cassava, and potato). The first approximation of the minimum data set needed to stimulate crop performance was prepared. This report has since undergone two revisions and continues to serve as a guide to design field experiments for model validation and refinement.
The DSSAT is microcomputer software designed to provide users with easy access to soil, weather, crop, and experimental data as well as simulation models and expert systems to simulate outcomes of alternative management strategies. The system now includes a weather generator which provides the model with daily weather data to stimulate crop performance for 10 to 50 years. The weather generator uses historical weather data to compute coefficients with which to reproduce statistically similar weather data.
This paper is based on the experiences of an international team of agricultural and systems scientists which has been involved in the development and validation of a DSSAT. More information about the software and users' guide can be obtained from:
IBSNAT Project, Department of Agronomy & Soil Science, 2500 Dole Street, Krauss Hall 22, University of Hawaii, Honolulu, Hawaii 96822, USA.

285 89 - 2/45

Farming systems research and development
Review, humid tropics, IITA, farming systems development, models, ecosystems, conservation, utilization, food needs, sustainable farming systems
JUO, A.S.R.
New farming systems development in the wetter tropics.

Expl. Agric., 25, 1989, pp. 145-163

This paper highlights some of the unique features of the tropical forest environment and assesses some promising technologies that

may lead to the development of new farming systems in the wetter tropics.
Except for some densely populated urban areas in the coastal regions of south Asia and west Africa, the supply of basic foods has not been a real problem in the wetter tropics. Rice, cassava, sweet potato, cocoyams, small ruminants and a wide range of forest products have provided nearly all the basic needs of the indigenous population.
In tropical forest regions, most soils, for example, are inherently less fertile; the climate is continuously hot and humid; and the average farm worker is less well educated and less skilled.
Farming systems may be devided into three simplified models: the irrigated paddy-rice multistorey homestead garden complex of Asia, the tree and cash crop plantations of Latin America, and the mixed root-bush fallow systems of Africa.
Farming systems in the wetter tropics may be illustrated by simplified models, the main features of which reflect their natural resource base, their cultural and social characteristics and, above all, the path of agricultural development taken during past centuries.
An overriding factor guiding future agricultural development in the wetter tropics is probably the fragility of its upland ecosystems, particularly in areas where acid and kaolinitic or lateritic soils predominate. Agricultural development in the region should, therefore, be based on long-term environmental stability rather than short-term economic returns. Thus, high priority should be given to developing ecologically sustainable mixed systems involving annual food crops, trees and perennials on small family farms. Achieving household security for food and nutritions would remain the most important goal in such systems; family income would be derived mainly from cash crops and off-farm activities.
However, new farming system development does not explicitly imply inventing new systems or component technologies. To prevent further destruction of the earth's remaining tropical forests, there is an urgent need to develop or introduce new farming systems that are more in harmony with natural ecosystems and better suited to be cultural heritage of the indigenous societies in the wetter tropics:
- Multistorey homestead gardens
- Alley cropping
- Rotation with cover crops
- Food crop improvement
- Tree and perennial crop plantations
- Livestock range farming
- Farm units along a toposequence

Because of the fragility of the natural resource base, sustainable farming systems in the wetter tropics rest on a delicate balance between conservation and utilization. Much more research is needed to understand the dynamics of tropical forest ecosystems better and to assess their biological potential for future agricultural development. The current knowledge clearly indicates that predominantly acid and nutrient-depleted soils in the low altitude

wet tropics are unsuited to energy-intensive and market-oriented food crop agriculture. However, to meet the food and nutritional needs of the indigenous population, there is enormous potential for the development of more productive and stable multistorey homestead gardens and mixed systems including tree, perennial and annual crops.
The principle and practice of "alley cropping" provide an ecologically sound basis for future farming systems research and development in the wet tropics.

286 89 - 2/46

Farming systems research and development
Review, tropics, developing countries, farming systems, on-farm research, requirements, framework, design, execution
CAMEOENS, J.K.
Farming systems and their on-farm research requirements.

In: Proc. of on-farm animal research/extension and its economic analysis, Los Baños, Laguna, Philippines, 1987, pp. 19-24 + app., Distr.: Winrock Int. Inst. for Agric. Development, Petit Jean Mountain, Route 3, Morrilton, AR 72110, USA

A historical perspective tracing the development and application of on-farm research is presented.
The historical setting permits the classification of on-farm research needs into five broad categories: human, technical/technological, production economics, marketing linkages.
For purposes of identifying on-farm research needs, ten types of agricultural systems can be described:
- swidden agriculture
- shifting cultivation
- nomadic herding
- transhumant farming
- rainfed agriculture
- irrigated agriculture
- plantation farming
- contract farming
- commercial livestock production
- nontraditional livestock farming

Major characteristics of these systems are presented in this paper.
On-farm research should be planned, designed, executed, and analyzed within the framework of some important operational principles:
- Principle one: (Ask-the Farmer). Find out what the farmers are doing and design research to help them do it a little better.
- Principle two: Assemble on-farm resource data; determine their quantities; analyze on-farm resources' allocative efficiency; program on-farm research to optimize resource allocation and test the results for repeatability.
- Principle three: Determine the value of the research to the farmer and to the national economy.

- Principle four: Do not implement the change until the success of the research can be demonstrated as being repeatable.
  Principle five : On-farm research could awake the slumbering tiger. Beware of the consequences!

On-farm research is expensive and is becoming more difficult to fund because so much previous research was unsuccessful, and because it employs highly qualified scientists. Over 75% of research budgets are for personal payments. It is a luxury for developing countries; hence, it must be practiced with utmost care and economy, it must demonstrate a favorable benefit cost ratio, and its results must have effects in the shortest possible time. No scientist must yield to the temptation of doing research for its own sake, for the sake of a publication, or to add another decimal point to a statistic. On-farm research must have the farmer at its aim. Its objectives are to find out what the farmer is doing, help him do it a little better, and enhance the farm and national economies.

287 89 - 2/47

Farming systems research and development
Review, on-farm research, IITA, farming systems research, research procedures, farmer, productivity
MUTSAERS, H.J.W. and D.S.C. SPENCER
On-farm research - a necessary tool in the development of innovations.

entwicklung + ländlicher raum, 22,3, 1988, pp. 10-12

This article reviews some of IITA's recent experiences with on-farm research (OFR) as well as its current thrust in this area.
OFR is rightly considered as primarily a function of national research institutes. International institutes should develop prototype technologies to be adapted and tested for local conditions by national institutes.
Prototype innovations cannot be effectively developed without direct exposure to farmers conditions, particularly in Africa where national research institutes are weaker than in Asia or Latin America. Scientists in the International Agricultural Research Centers (IARC's) need direct contact with the farmers to test how realistic their ideas really are. Furthermore, there is a strong demand from national institutes for training in OFR. It is inconceivable for IARC's to respond to such training demands unless they have first-hand experience in OFR.
One important element of OFR in which it differs from conventional extension demonstration methods is its adoption of a stepwise approach. Farmers have often been found to resist the adoption of multielement packages as they are commonly offered by extension agencies. New crop varieties for example, are often introduced with a set of recommended practices attached such as sole cropping, row planting, recommended fertilizer, timely weeding etc. This requires a large number of changes in farmers' habits all at the same time, which they are unlikely to make.

The OFR - approach would break down the package into its constituents and test them one or two at a time while leaving everything else unchanged. This not only allows the researchers to observe their technologies under more realistic conditions but it also enables them to study the farmers' current practices and how they affect their yields. This is almost impossible when complete packages are tested: farmers will quickly leave everything to the researchers and even loose interest when the innovations are too different from their usual practices. The "one-farm trials" then degenerate into replicas of station trials.
In order to illustrate these points the paper briefly reviews some of the experiences with the introduction of a new maize variety and a moderate dose of fertilizer in farmers' conventional maize + cassava intercrop system and with alley cropping.
The paper concludes that IITA is becoming increasingly involved in OFR, both in its outreach projects and from its Ibadan main station. It enables to expose the technologies to realistic conditions which is a necessary step in the development of prototype technologies. It also provides with an opportunity to observe farmers' constraints and problems at first hand. Finally, it provides a field laboratory for the further development of appropriate OFR methods.

288 89 - 2/48

Farming systems research and development
Review, tropics, Asia, farming systems research, economics, measurement methods
BARLOW, C. and S.K. JAYASURIYA
Improving the economic impact of farming systems research.

Agricultural Systems, 22, 1986, pp. 109-125

Improvements in the economic impact of farming systems research are considered in this paper in two main and related senses. One sense concerns measurement of the extent to which a new technology affects in the incomes and resource use of farmers, and thus has wider economics and social significance at regional and higher levels. The other sense involves adjustment of farming systems research per se.
The focus of this paper is on what are judged to be key practical issues in each of these senses of impact analysis. Wider aspects of such analysis are already well covered in other literature, to which due reference is made. The concentration is on farming systems research in its commonest application on national sites, where the aim is to secure new technologies directly improving the economic viability of local agriculture. This is often termed "downstream" research, in contrast to the less direct "upstream" work undertaken by some international and regional centres. The prime concern is with the Southeast Asian area where are today several hundred crop and livestock sites. The rapid spread of such sites, with their usually fragile resources, emphasizes the need

to recognize limits on research possibilities, and, within these, to pinpoint ways of maximizing the value of what is done.
Some practical issues in the measurement of impact at the three stages of farming systems research are discussed. While most issues are seemingly obvious, the fact that they persist as serious deficiencies in so many research contexts indicates that they deserve important consideration.
With the ex ante stage the needs of securing representativeness of the target area and of benchmarking the wider initial situation, including economic, social and agroclimatic features, are emphasized. With the ongoing stage, the importance of using suitable partial budgeting techniques is stressed. With the ex post stage, an assessment of wider technological and economic effects is called for, together with the identification of enabling factors and constraints in technological progress.
The adjustment of the farming systems research process itself is finally considered, and the desirability of simplifying the process, further training junior field-level researchers and securing better interaction between workers at the various research levels, is highlighted.
The theme in this paper is that the effectiveness of such research could be substantially improved through a revised analysis of the impact of designed and actual new technologies, supported by certain adjustments to the farming systems research arrangements per se. The essential argument is for a broader analysis of technology effects, where the "total" environment, theoretically recognized as pertinent to farming systems studies, is better taken into account at successive stages. Achieving this goal is difficult under the poorly endowed conditions of most research sites, and will demand substantial revision of the current approaches of junior economic staff, accompanied by improved training and much better interaction with senior researchers.
The goal of this paper is to pinpoint deficiencies in current analysis, in the hope that an already valuable study technique may be thereby enhanced.

289 89 - 2/49

Farming systems research and development
Review, sustainable development, institution building, farmer organization, organizational structures, investments, agricultural development, project, socio-cultural compatibility, development strategies, social action, methodologies
CERNA, M.M.
Farmer organizations and institution building for sustainable development.

In: Sustainability Issues in Agricultural Development - Proc. of the Seventh Agric. Sector Symp., The World Bank, Washington, D.C., Eds. T.I. Davis and I.A. Schirmer, ISBN 0-8213-0909-9

This paper reports and discusses the findings of a recent systematic analysis of the correlation between the sustainability

of development projects and several factors assumed to affect it, including institutional and organizational factors. The analysis covered 25 largescale development projects financed by the World Bank. It sheds light on the premises of sustainability and, conversely, on the causes of non-sustainable development interventions.
The sections of the paper (i) present the empirical findings produced by the study, (ii) discusse implications of these findings, and (iii) define some issues and lessons relevant for designing strategies for sustainable development, particularly in agriculture. The issues refer to specific organization building and engineering approaches required in development programs and to the social science research and applied work needed for their realization.
The experience of many unsuccessful, or marginally effective, development projects has shown that the long-term sustainability or non-sustainability of such projects cannot be attributed only to factors of an economic and/or technological nature, but is related to institutional and organizational factors as well. The research devoted to this topic has been chronically insufficient.
The concept of sustainability of development interventions, while not new, is recently acquiring high visibility. Sustainability should be a sine-qua-non of every financially induced development program. Without the building bricks of sustainability, much financing is condemned to inducing only short-lived "development spurts".
The concern for sustainability is being powerfully reinforced now by the international debt crisis, which has thrown light on a profound paradox of both nationally and internationally financed development programs. Such programs are undertaken with the expectation that their benefits will not only allow recovering the investments and repaying the loans that made them possible, but will also generate a net surplus. However, if such projects do not foster sustainable development, then instead of surplus benefits the borrowing party ends up increasing its accumulated debts. In part, the international debt crisis is a product of repeated investments in non-sustainable development programs.
The definition of sustainability used was essentially an economic definition. Project sustainability over time was defined as the maintenance of an acceptable net flow of benefits from the project's investment after its completition, i.e. after the project ceased to receive Bank financial and technical support. The actual economic rate of return (ERR) was recalculated at the time of the in-depth impact evaluation studies (IES). The standard for determining economic sustainability has been to assess whether the ERR was equal to, or greater than the opportunity cost of capital.
The analysis concluded that 12 out of the 25 projects appeared to have successfully achieved long-term sustainability, while 13 did not. In 5 of the 12 successful projects, the flow of benefits at impact evaluation time was even significantly higher than the level of returns at completion time, while in the other 7 projects the level stayed constant. By area, the highest success durability rate was in East Asia (6 projects) and Latin America (4 projects);

the lowest rate was in East Africa and West Africa, with only 2 out of 15 projects able to sustain their initial good results.
The remaining 13 projects failed to sustain the minimum flow of benefits to qualify for an assessment of continued, lasting success. At the time of project completion, the rate of return projections for these 13 projects had been satisfactory and ranged between 15 percent and 30 percent. However, at impact evaluation they had all declined to less than 10 percent and in two projects the ERR had turned negative. The average rate of return assessed for these 13 projects at impact evaluation time was as low as 2.7 percent; this rate reflects the inability to sustain project activities in the post-completion period.
These are serious findings, even if they cannot be extrapolated, to the Bank's overall agricultural experience. Such a high number of unsustainable projects was certainly not expected.
Five main factors or sets of factors were found to have a decisive bearing on the sustainability of the 25 projects analyzed. These elements were derived by contrasting the experiences of the projects which performed significantly above expectations at audit against those which performed worst:
- institutional build-up and participation of beneficiaries;
- technological improvements;
- socio-economic compatibility;
- favourable policy environment;
- recurrent cost financing/recovery.

290 89 - 2/50

Farming systems research and development
Review, book, study, project maintaining, evaluation, agriculture, IFAD, FAO, WORLD BANK
CASLEY, D.J. and K. KUMAR
Project monitoring and evaluation in agriculture.

The Johns Hopkins University Press, Baltimore, Maryland 21211, USA; published for The World Bank, Washington, D.C., a joint study of the World Bank, IFAD and FAO; ISBN 0-8018-3615-8, 1987, 157 pp.

The accumulating experience and the growing consensus regarding concepts and definitions led the World Bank and IFAD in collaboration with the FAO to agree to produce a set of technical publications on the monitoring and evaluation of agriculture investment projects which would provide the basis for training programs at the regional and national levels.
This book provides a conceptual framework. A companion volume provides specific methodological guidance.
This book is based on the Task Force Guiding Principles and provides monitoring and evaluation concepts and definitions in the particular context of agriculture investment projects.

The book contains the following chapters:
1 Monitoring and Evaluation: A Management Perspective
2 Monitoring and the Management Information System
3 Monitoring of Physical and Financial Progress
4 Beneficiary Contact Monitoring
5 Follow-up Diagnostic Studies for Monitoring
6 Communicating Information
7 Evaluation: Substantive Focus and Types
8 Measurement of Production Increases: Methods and Limitations
9 Special Topics in Impact Evaluation
Suggested Readings
Index

Examples of actual monitoring and evaluation problems are interspersed in the text to illustrate significant points. These narratives have been edited and in some cases sharpened to dramatize the point being made. A full reference is given if the source document is available. In many cases, however, the source document is restricted and only the agency name is given.
It is necessary to stress what this book and its companion are not. This book does not deal with monitoring and evaluation of national programs and policies.
The framework proposed is put forward solely in the context of the monitoring and evaluation of agriculture and rural development investment projects, which are defined as interrelated and coordinated activities formulated and financed to achieve specific sets of objectives within a limited span of time and operated by an identifiable and formally responsible management team.
The primary intended audience comprises those in the developing world responsible for the design and implementation of monitoring and evaluation systems. Project managers may also benefit from this volume. It is hoped that this publication will be useful to those who provide training courses in this subject and to all who are interested in the issue of judging the success of the development effort in rural economies.

291 89 2/51

Farming systems research and development
Asia, Pakistan, study, rapid agroecosystem zoning, project, development strategies
PRETTY, J.N.
Rapid agroecosystem zoning of Alpuri sub-division, Swat District, North West Frontier Province, Pakistan.

Report of Malakand Fruit and Vegetable Development Project, MFVDP, Mingora, Pakistan and International Institute for Environment and Development, London, 1988, 67 pp.

At the request of Intercooperation (Switzerland) and the Pakistan-Swiss Malakand Fruit and Vegetable Development Project, an exercise in Rapid Agroecosystem Zoning and Rapid Rural Appraisal was conducted in Alpuri Sub-Division, Swat District, in July 1988.

The objectives were twofold: firstly to test the applicability of rapid zoning techniques to the work of the MFVDP and to identify different zones within Alpuri; secondly to produce a series of strategies for fruit and vegetable development and key questions for investigation in the identified zones of Alpuri Sub-Division.
This report has been written by the workshop participants and compiled and edited by Jules N. Pretty.
The dynamics of agroecosystems can also be described in terms of four interconnected properties - productivity, stability, sustainability and equitability.
These terms are defined as follows:
Productivity is the output of valued product of the zone per unit of resource input.
Stability is the constancy of production of the zone in the face of small disturbing forces arising from the normal fluctuations and cycles in the surrounding environment.
Sustainability is the ability of the zone to maintain production when subject to stress or shock. Stresses and shocks have the potential of causing declining trends in production of even collapse.
Equitability is the evenness of distribution of the production of the zone amongst the people.
These four properties are essentially descriptive in nature, but they can also be used as indicators of performance both in the design and evaluation of innovations. Experience has shown that in agricultural development there is almost inevitably some degree of trade-off between these different properties. The challenge for Agroecosystem Zoning is to foresee acurately these trade-offs and ensure they are taken into account during planning and subsequent management.
Methodology of Rapid Agroecosystem Zoning (RAZ):
The methodology makes use of a number of important techniques falling within the rubric of Rapid Rural Appraisal (RRA).
The key features of an RRA are as follows:
- it is iterative and involves "learning-as-you-go", enabling processes and decisions to be changed in the light of new generated information of analyses.
- it uses the farmers' perspectives to help define differences in field conditions.
- it is partly structured, flexible and adaptable,
- it reduces complexity to a few key problems and opportunities,
- it uses small teams of mixed disciplines and a system perspective to make communication easy,
- it is quick and relatively cheap,
- it emphasises not only productivity, but also other agroecosystem properties and the critical trade-offs between them.

This zoning of Alpuri used a number of important techniques of RRA, namely secondary data review, direct observation in the field, semi-structured interviews, drawing of diagrams, analytical games, portraits and stories and analytical workshops.
Secondary data and information are published or unpublished data, acquired by other people at an earlier time, that are relevant to the topic or target of the RRA. Time spent on quickly reviewing

and summarising secondary data can help avoid time wasted in repeating studies and, by revealing gaps or biases in the existing data, it can also stimulate ideas and suggest paths of investigation. Nonetheless it is important not to spend time on what could be better spent in the field.
Direct observation is relatively straightforward and encompasses any direct observation of field objects, events, processes, relationships or people that is recorded by the team in note or diagrammatic form. Innovative forms of direct observation rely on carefully chosen indicators. These are events, processes or relationships which are easily observed or measured but can be used as an indicator of some other variable that is more difficult or impossible to observe.
Semi-structured interviewing or semi-structured learning is probably the most powerful of RRA techniques. It takes place in informal,guided interview sessions.
Diagrams are simple, schematic devices which present information in a readily understandable visual form.
Analytical games are such techniques as ranking which are used as a quick means of finding out an individual's or group's list of priorities and preferences.
Portraits and stories are short, colourful descriptions situations encountered by the team in the field or stories recounted by people met there.
Analytical Workshops are means of bringing people together to participate actively in reviewing, analysing and evaluating the information gathered.
Throughout the RRA, whilst in the field or in the workshop, the team focussed on understanding the problems and opportunities particular to fruit and vegetables in each village or area under study. During field visits the team learnt from farmers of the important factors which characterised different zones.
The RAZ took a total of 11 days, alternating betwen analytical workshop sessions and visits to the field.
The Alpuri Sub-Division has been divided into 16 zones. These can be regarded, for planning purposes, as the basis for General Recommendation Domains. Each domain is characterised as having biophysical and socio-economic features sufficiently in common that a menu of diverse innovations and interventions can be appropriately recommended throughout the domain.
The zones were drawn up after considering a wide range of biophysical and socio-economic factors, both in the field and in an analytical workshop. Rapid agroecosystem zoning is, however, an iterative excercise, and boundaries for zones are expected to change in future as more information and knowledge on Alpuri is gathered.

292 89 - 2/52

Farming systems research and development
Study, Philippines, Peru, Mali, GTZ, ODI, participatory technology development, ecologically-oriented agriculture, sustainability, techniques, methods working models, institutions
WATERS-BAYER, A.
Participatory technology development in ecologically-oriented agriculture: Some approaches and tools.

Network Paper 7 of the Overseas Development Institute, Agric. Administr. Unit, Regent's College, Inner Circle, Regent's Park, London NW1 4NS, England, ISSN 0951-1873, 1989, pp. 62 + ii

This paper is an abridged version of a manuscript which was commissioned by the German Agency for Technical Cooperation (GTZ) and which is under review for publication as a "GTZ Working Paper for Rural Development".
Ecologically-oriented agriculture, organic farming, sustainable agriculture, alternative agriculture - the terms vary, but they all have some basic aims in common:
- developing land-use systems appropriate to site-specific physical, biological and socioeconomic conditions;
- making optimal use of locally available resources, and thus minimising dependence on external inputs;
- achieving productive, long-term sustainability. For the sake of brevity, this type of agriculture will be referred to here as "ecofarming".

The concern here is with the efforts of smallholders in the tropics to maintain and develop their farming systems and with the efforts of outsiders - agricultural researchers, extensionists, development project staff (nationals and expatriates) - to help them do so. As these outsiders have been trained in methods of formal agricultural science and are regarded by practical farmers as representatives of this science, they will all be referred to here as "scientists". The term "smallholders" refers to resource-poor farmers, i.e. persons who derive their livelihood mainly from agriculture and have very limited access to land and capital. They will usually be referred to here simply as "farmers". The central concept of this paper is "participatory technology development (PTD)": specifically, how farmers and scientists are collaborating to generate new ecofarming techniques and knowledge in Asia, Africa and Latin America.
The primary target group of this paper comprises planners and advisers in aid agencies or non-governmental organisations (NGOs) who are trying to help farmers improve their systems of land use and agricultural production. The aim is to increase awareness of how cooperation between scientists and farmers can lead to the development of farming techniques which are ecologically sustainable, economically feasible and socioculturally acceptable.
Specific aims are:
- to explain the concept of PTD and encourage incorporation of participatory methods into agricultural research and development (R & D);

- to indicate the place of PTD in the overall R & D process;
- to give concrete examples of PTD;
- to introduce tools which can be used to increase farmers' contribution to technology development in R & D programmes;
- to provide sources of further information so that those who recognise the potential of scientist-farmer collaboration in R & D can gain ideas and encouragement.

The focus is on the development of agricultural production technology. Although innovations in socioeconomic organisation on the village and regional levels are vital for "embedding" the new technology, i.e. for ensuring that smallholders can continue to apply and adapt it in response to changing conditions, the promotion of organisational innovation is not considered in detail here.

Emphasis is on the evolution of existing farming systems in areas of long-established land use by man. Here, resource-poor farmers are likely to regard completely new integrated ecofarming systems as too risky to adopt wholesale. They are more likely to try out small changes or new components which fit into and improve their existing farming systems, just as they have done in the past to evolve their present systems.

This paper is primarily concerned with actions which have been taken or are presently underway. The sources of information are the authors' own experience in a multidisciplinary research team which worked together with livestock-keepers in central Nigeria, reports on PTD given in two recent workshops on this theme, and personal contacts with scientists who attended these workshops and are/were directly involved in participatory R &D programmes.

The paper reviews the origins of participatory technology development, seeking ways in which conventional and participatory R & D can complement each other. Case studies are drawn from the Philippines, Peru and Mali. The bulk of the paper is allocated to a discussion of techniques for initial orientation (including village brainstorming, investigating indigenous innovations, studying farmers' informal trials, diagramming, crop histories, board games and preference ranking) for technology development (including participation in trial design, experimentation with working models, innovative workshops and group scoring) and dissemination (including farmer-to-farmer workshops, community video and farmers'field days). The final sections contain useful lists of institutions and individuals working in participatory technology development.

Author's Abstract, extended

89 - 2/53

293

Farming systems research and development
Asia, Philippines, systems-problem research, participatory method, marginal uplands, rehabilitation
LIGHTFOOT, C. et al.
A participatory method for systems-problem research: Rehabilitating marginal uplands in the Philippines.

Expl. Agric., 24, 1988, pp. 301-309

To improve the adoption of research findings by resource-poor farmers, "farming systems research" and its variants "farmer-first-and last" and "farmer-back-to-farmer" provide an alternative approach.

Rapid diagnostic methods have been developed but do not use systems tools to link biological and socio-economic relationships. Systems tools are especially important to FSR because farmers' problems are systems problems. They usually involve many components of the whole farm system.

Methodological questions remain on how exactly one goes about identifying farmer systems-problems, how these systems problems can be analysed and how this understanding leads to experiments.

The experiments developed first identified farmer systems-problems, second, analysed a key problem, and third, elaborated experimental hypotheses. Farmers participated throughout.

Initially, farmers were self-selected but later on random selection was used. While the methods are presented as three stages, in practice they flowed uninterrupted.

The research was carried out in three villages in the Philippines. These villages, whose combined population does not exceed 150 households, are located among rolling hills of infertile Alfisols. These brown acid soils are very poor in organic matter (3.0%) and phosphorus (29 ppm). Although the annual rainfall reaches 3000 mm an irregular dry season occurs between January and June. Between valleys of bunded rice, small plots of upland rice, corn, cassava, sweet-potato, coconut and banana break up the hills that are otherwise dominated by *Imperata cyclindrica,* locally known as cogon.

An informal random sample survey, guided by topics of inquiry and biological measurements that employed systems analytical tools, was used to obtain a farmers' perception of "systems-problems". Systems diagrams also provided a framework for searching and screening solutions. A sequence of vining legumes was tested in rehabiliting the marginal uplands. For this experiment farmers elaborated hypotheses on control of Imperata, recovery of soil fertility, and reduced labour costs in re-cultivation. Extensive research activity among the farmers indicates the value of this participatory method.

The method used encourages farmer participation. It also encourages the use of systems logic in identifying systems-problems, analysing systems, and elaborating experiments. Consequently, these experiments are very different from typical

cropping pattern trials which place priority on maximizing crop grain yield per hectare with high cash inputs.
The priority lies in the long term rehabilitation of cogonal land and in saving labour.
A more holistic systems logic also leads to differences compared to conventional cropping pattern trials.
A wider view of upland farming systems reveals that upland farmers not only cultivate many agroecological zones, but they do so on a crop-fallow rotation. Thus farmers are interested in the management of cogonal fallow land and not just the cropped areas.
More participation and a wider systems view than in conventional cropping pattern research undoubtedly produced important differences in both research topic and orientation of intervention.
Participatory methods that use farmer knowledge and systems logic are now solving problems that conventional cropping pattern research was incapable of addressing.

294 89 - 2/54

Farming systems research and development
Review, book, ILO, rural women, developing countries, development, status, domestic role, policy
FETHEROLF LOUTFI, M.
Rural women unequal partners in development.

Publ. of the Int. Labour Organization (ILO), CH-1211 Geneva 22, Switzerland, ISBN 92-2-102389-3, 1987, pp. 75 + ix

Rural women are the most silent participants in the economic life of developing countries. Women in the lowest classes and castes are deprived by their poverty, illiteracy and ill health of the means to escape from a short life of drudgery and fatigue. A majority of the poor is female.
To achieve substantial growth in production depends partly on women, and progress toward more just societies must include greater equality for women. Any acceptable definition of development should include both material improvement and greater equity.
What it is aimed to highlight in this study is the nature of forces and of interventions that can facilitate an upward progression of women in their roles as workers and managers wherever the location in the spectrum of socio-economic-political change and development.
Yet, in general, women still posses less education and training than men, and what they do have is less suited to the labour market. Average earnings still tend to be lower: occupations with a high proportion of women offer lower average earnings. This creates inequities not only between men and women as individuals, but also between female-headed and other households. In virtually all societies women work longer hours than men for smaller rewards, and a great many women accept and even defend the systems that ensure their dependence and even exploitation. But Third

World rural women in the lower classes and castes are the most disadvantaged in that their work is the hardest and yet the least rewarded. Some of the factors which sustain this, and those which could sustain an improved reality, are the subject of this study.
The first step is to examine the nature of rural women's work in developing countries. Perceptions of status are then reviewed and discussed with a view toward their interrelationship with and impact on rural women's work. The importance for benefiting women of looking beyond the household to the individuals inside is explained. Then the effects of official policies on rural women are highlighted. Where governments intend to attack rural poverty, the neglected necessity of taking particular account of the strains on female-headed households is observed. Possible constructive policies in various sectors are mentioned, as is the role of food-for-work. The urgency of providing opportunities for increased cash earnings along with reducing work burdens is stressed. And the dependence of effective policies on the participation of rural women is explained. Finally, a more abstract view of some general realities applicable to all countries with respect to the dynamics sustaining unequal wage and occupational structures and those that could sustain equality is taken.
This monograph draws together the principal themes arising with respect to rural women's work, while also discussing some general realities concerning women in all societies. It aims to place official policies in perspective as well as indicate constructive directions. The emphasis on the participation and organisation of poor rural women is characteristic of the programme on rural employment in general.

295 89 - 2/55

Farming systems research and development
Latin America, Brazil, Asia, Indonesia, Thailand, CEBEMO, RTI, study, review, self-help promotion, objectives, methodology, promotion instruments, economics, holistic development approach
VERHAGEN, K.
Self-help promotion.

Royal Trop. Institute, Amsterdam/Cebemo, Oegstgeest, ISBN 90 6832019 X, 1987, pp. 152, Distributer: Foris Publications, P.O.B. 509, 3000 AM Dordrecht, The Netherlands

This publication is an integrated report of a study conducted by three nongovernmental organizations in Brazil, Indonesia and Thailand, coordinated by CEBEMO, on the promotion of economic activities in rural areas.
Cebemo is a Dutch organization for development co-operation, which, on behalf of the Dutch Catholic Community, acts as a channel of the joint financing programme of the Dutch Government. Cebemo finances initiatives of a developmental nature at grassroot level.

The basis of the activities of the Royal Tropical Institute is the collection and dissemination of knowledge in tropical countries, concentrated in three main programmes: rural development, tropical hygiene and transfer of knowledge. The relevant development projects in these fields are carried out preferably in combination with scientific research, education and training.
The study was carried by local NGO's partner-organizations of Cebemo, which in the present study have been termed Self-Help Promotion Institutions (SHPIs).
Promotion refers to the development task these SHPIs have set themselves, namely to facilitate the emergence and foster the functioning of cooperative-type organizations at grassroots level, known as Self-Help Organizations (SHOs).
Since the rural poor have become too numerous to be helped from outside, "self-help" has emerged as a new paradigm for combating rural poverty, and "self-help promotion" as the main orientation for local NGOs in developing countries.
Two key elements in this approach are fundamental:
- building upon what the rural poor have, rather than what they lack;
- Facilitating and promoting their organization.

The study is divided in two parts and 10 chapters:

This book is the result of a lot of research, reflection and discussion. It should therefore be studied by all those interested in rural development in general and self-help promotion in special.

296 89 - 2/56

Farming systems research and development
Africa, Rwanda, farming systems improvement project, problem analysis, trials, field day, information transfer, cover crops, organic farming systems, soil fertility, leguminous shrubs
YAMOAH, C.F. and R. GROSZ
Linking on-station research with on-farm testing: The case of agroforestry and organic matter-based cropping systems for the Rwanda farming systems improvement project.

Agroforestry Systems, 6, 1988, pp. 271-281

The Rwanda Farming Systems Improvement Project (FSIP) is located in the Ruhengeri Province in the northwestern highlands of the country. This area is noted for its high potential in agricultural production. It is one of the most densely inhabited areas in the country, with about 372 people per square kilometer.
Hillside farming with its attendant erosion and decline in soil fertility is commonplace in the area served by the Farming Systems Improvement Project. The project is designing landuse systems that check erosion, increase soil organic matter and restore soil fertility.
Agroforestry and organic matter-based cropping systems, using leguminous plants, are some of the promising interventions recommended to deal with accelerated soil degradation problems on sloping lands.
This paper reports the approach used by the Rwanda FSIP to involve farmers in the entire research process.
Problems were identified through review of secondary data, exploratory surveys with farm families, consultations with scientists who have Rwanda experience and direct communication with local administrators and key informants.
The interventions suggested were:
- tillage (zero and minimum)
- mulch systems (live and in-situ)
- manures and composts
- agroforestry systems
- inorganic fertilizers

Farmers were exposed for the first time to technologies such as alley cropping, green manure and mulch systems using various cover crops.
This event was also an opportunity to show communal extension agents how to use a field day as an effective communication tool to integrate farmers into their activities. It was, thus, a learning experience and a linking event for all three partners in the FSR/E approach, researchers, farmers and extension agents.
The use of leguminous shrubs and cover crops as nutrient sources are options that land-use experts think might solve the problem. There is a dearth of knowledge about the biological feasibility of these interventions in the project area.

297 89 - 2/57

Farming systems research and development
Latin America, national programs, cassava, on-farm research, intercropping, evaluation, production constraints, small-scale farmers
CIAT
El programma de yuca amplia la investigación en fincas. (Cassava program expands on-farm research).

In: Informe CIAT 1988, Centro Internaciónal de Agricultura Tropical, Aportado Aéro 6713, Cali, Colombia, ISSN 01120-3169, pp. 35-38

Cassava in terms of calories is the fourth most important crop grown in the tropics after rice, sugarcane, and maize. Social and technological changes and the developments in recent decades make it desirable and possible for cassava to be used in nontraditional ways. CIAT's Cassava Program, in response to these changes, aims to exploit the staple's potential by developing ways to increase its production and to refine its processing and marketing.
In Latin America cassava is a small-farmer crop and is produced under a wide range of cropping systems of varying complexity. Understanding production constraints and what factors influence the adoption of new cassava technology, requires appraisal of the entire production system.
The Cassava Program has intensified its collaboration with national programs in onfarm research in selected areas in Latin America. The research is conducted in the areas where production, use, and marketing pilot projects are operating.
For example CIAT and the Colombian Agricultural Institute (CCA) are working with farmers to simultaneously evaluate new varieties of both cassava and maize. They are looking at how they perform when they are intercropped, as well as testing ways to improve the selection, treatment, and storage of the cassava planting stakes. Promising cassava varieties are routinely evaluated with farmers within their production systems. The farmers' participation helps scientists identify factors that influence the adoption of new technology.
Three years on on-farm testing have shown that cassava yields are greater when intercropped with the new ICA maize varieties than when grown with traditional maize types. Maize yields, too, are higher when intercropped with new cassava varieties than with old.
In Panama, CIAT is conducting with IDIAP's (Instituto de Investigaciónes Agropecúarias de Panamá) on-farm research. A cassava production package was developed which, in addition to adapted varieties, had recommendations on weed control, soil management, and fertilization. Because the crop has proved to be economically successful, the Banco de Desarrollo Agropecúario de Panama is using this package as the basis for loans to cassava growers in specific areas.
In an ecological study made with CIAT, Paraguay's SEAG (Secretaria de Estado de Agricultura y Ganadería) identified the main cassava production systems at Paraguari and Caaguazu. Analysis of the

production constraints showed that onfarm research should focus on soil management at Paraguari and on intercropping with maize at Caaguazu.
These examples show that in on-farm studies the evaluation of intercropping systems and the understanding of production constraints are inseparable if new technology is to be successfully adopted by small-scale farmers. CIAT and national programs see the need to conduct further research if efficiency of currently practiced intercropping systems is to be improved.

298 89 - 2/58

Farming systems research and development
Review, handbook, extension, theory, practice, methods, developing countries, GTZ, BMZ, CTA
Manuel de vulgarisation agricole - bases théoriques et méthodes (Handbook for agricultural extension - Vol. 1 - Theoretical bases and methods).

BMZ/GTZ/CTA-Publication, 1989; available at CTA, Postbus 380, 6700 A.J. Wageningen, Netherlands

The handbook is aimed at all professionals who try to improve agricultural advisory services through appropriate developing measures. "Manuels de développement rural" is a series published by the German Ministery of Cooperation (BMZ) and the German Agency of Technical Cooperation (GTZ).
"The handbook of agricultural advisory instructions" appeared in French with the help of CTA. It is the first of a serial collection which attempts to give short and precise informations about practical technical help. Based on acquired experiences, Vol. 1 gives theoretical informations about agricultural extension, how to plan and realize it.
Far from being a "book of recipes", this manual doesn't give instructions, but informs about ways leading to solutions. It aims in a practical way at filling a gap, i.e. the lack of information and advisory publications for smallholders.
Vol. 2 which consists in working documents is not yet available in French.
Abstract from SPORE

299 89 - 2/59

Farming systems research and development
Africa, Ethopia, farming systems research, on-station research, extension, appropriate technologies, small farmers, methodology, socio-economic condition
GEDENO, G.
Farming systems research linkages with on-station research and with extension at Bako, Western Ethiopia.

Farming Systems Newsletter, 33, 1988, pp. 10-25

Farming systems research and extension (FSR/E) is used to develop and adapt appropriate agricultural technologies for small farmers in order to increase their productivity.
The major reason for ineffectiveness of conventional, station based agricultural research is its reliance on a top-down approach which neglects the socio-economic conditions of small farmers.
Farmers in Ethiopia are often found to be reluctant to accept most of the technologies offered. The body of knowledge available from on-station research is useful for FSR/E. Some of the findings can be used with only slight modifications.
This paper describes the integration of OFR/E with on-station research and with extension, as they relate to Bako, Western Ethiopia.
The FSR/E programme's surveys and on-farm experiments have produced useful feed back for the on-station research programme and the on-station researchers are responding to the problems identified. From the on-farm experimentation there is a new recommendation available on fertilizer rate for maize and a tentative recommendation on intercropping forage crops with maize and sorghum varieties for producers' cooperatives. These recommendations were only possible due to on-station research results. Without a strong on-station research programme effective on-farm experimentation is not possible.
The collaboration and understanding between FSR/E and on-station researchers is progressively improving. For further improvement, the suggestions made to improve the integration of FSR/E with the on-centre research and extension should be given due attention. In contrast the progress made in FSR/E and extension linkage is limited.
The staff of the two organizations are physically separated and have their own programmes to follow. The organizations should develop a common interest and reconsider the importance of a strong institutional linkage to work out the problems.

300 89 - 2/60

Farming systems research and development
Report, farming systems research, extension, implementation, monitoring, women's contribution, subsistence farming, agricultural productivity
STRING, A.
Trials and errors: using farming systems research to reach farmers who are often neglected.

In: Farming Systems Reseach, Vol. III, No. 079, 1986, pp. 21

Although a large percentage of subsistence farming is conducted by women, agricultural extension and training programs have traditionally neglected them. This report suggests that because FSR is farmer-based, it may help researchers to recognize and nurture women's contributions to overall agricultural productivity.

In-depth analysis is made of soybean demonstrations and farmer trials in Malawi, where 50-70 of all smallholder farm operations are conducted by women, to determine whether the acceptance of new technologies is gender-related. Farmers were instructed in soybean cultivation techniques, and the level of acceptance and effects of the new technology were assessed. Constraints such as poorly adapted seeds and ineffective inoculants were not gender-related and affected all farmers equally; however, women had poorer crop yields than male farmers due, it is argued, to the lack of agronomic training given to women. The soybean project demonstrated: (1) that women are agriculturalists and interested in new technologies; (2) the importance of interaction between research and extension, farmer-oriented technical information, and an instruction methodology involving demonstrations and corrections; and (3) that further work is needed to include female farmers in agricultural development and training programs and to improve working relationships between female farmers and extension agents.

III INTEGRATED SYSTEMS

301 89 - 3/30
Integrated systems
Asia, Indonesia, review, home gardens, agro-ecosystem, plants, animals, agro-ecosystem
SOEMARWOTO, O. et al.
The Javanese home-garden as an integrated agro-ecosystem.

Sep. Print of the Int. Congr. of Scientists on the Human Environment, Japan, 1985, pp. 10

In the countryside of Java, the existence of a village is indicated by a goup of dense vegetation amidst rice fields. The houses are almost completely concealed by this dense vegetation.
This is particularly true in Central-Java. In West-Java many times the houses are clustered together with hardly any open space in between, while the gardens surround this cluster of houses. The village may also be fenced by a hedge of bamboo or other plant species.
The structure of the home-garden varies from place to place as influenced by ecological factors, like climatic, edaphic and social-cultural factors.
A salient facture of the home-garden is that it is planted with many kinds of plant species. For example, in the two adjacent subdistricts Cinangka and Padarincang in Banten, West-Java, 179 cultivated plant species were found in the home-gardens which included annuals and perennials of different hights varying from those creeping on the ground to trees of about 25 m. But not all species were found in every garden.
In addition, 62 weed species are found. But the term "weed" should be used with extreme care, since the people were using many weed species for one or other purpose. From a preliminary survey it was known that of these 62 species, 18 species were used for herbal medicine, one specie for roofing and fodder, four species for vegetable and almost all grass species for fedder. It is expected that more in-depth studies were likely to reveal that more weed species were actually used by the people in different ways.
Animals are raised by the villagers in home-gardens. The poor family may have a few chickens only and the rich one a few water buffaloes or cows, while goats and sheep are owned by people at the intermediate level. Other animals commonly found are horses, ducks, rabbits, guinea pigs, besides of course, pet animals, such as dogs, cats and birds.
In West-Java, particularly in the Priangan Region, fish ponds are a common part of the home-garden system. Kitchen waste form part of the fish food. The fish ponds are also fertilized by animal and human wastes, for which purpose the home stable and the bathroom-toilet are built above the fish pond.
From the description given above, it is clear that a village with its home-gardens is not merely a dwelling place, but also an important agro-ecosystem. It is an integrated unit in which the solar energy is channeled through the plants to animals and man,

and matter is cycled and recycled. This cycling and recycling process, together with the storied plant cover, effectively protects the soil of the home-garden from exhaustion, leaching and soil erosion.
Home-garden plants are also an important source of building materials and fire wood, supplemented by wood from forests.
Since home-gardens are still undeveloped, the potentials for increasing their production and economic value are still great. But their development should be carried out with care and with a full appreciation of ecological principles underlying their existence, including the social-economic aspects. Many of the plants and animals can still be improved by selection from the local varieties, followed later on by a hybridization program. In this respect the high diversity of the home-garden provides a rich genetic resource.
Since the villagers are poor und the unemployment rate is high, the need is for simple labour-intensive technologies. But even these technologies could displace people and disrupt the social structure of income distribution. The introduction of economic plants, which theoretically would give high economic returns, could become disastrous, if it would increase the need for capital investments, such as for the purchase of expensive seedlings, fertilizers and pesticides, and the daily income and food supply would be disturbed, since it might drive the people into the hands of money-lenders. Economic plants would also have the disadvantage of being sensitive to fluctuation of market demands and prices. Therefore, in the development process, it is essential that the introduction of economic plants in the home-gardens, should not eliminate plants and animals, which are essential to support the subsistence of the people. This means that the diversity of the home-garden will have to be high which is also important for its stability, thus reducing the need for energy subsidies. Consequently the technologies needed to improve the living standards of the people should be geared to an ecosystem of high diversity and not to that of a monoculture. It is also essential to develop an effectiv credit system in order to prevent the villagers from becoming victim of money-lenders.

302 89 -3/31

Integrated systems
Asia, Thailand, rice, fish, sustainability, stability, ecosystem, research, pests, diseases, yields, economics, productivity, equitability, smallholdings
MACKAY, K.T. et al.
Rice-Fish culture in Northeast Thailand: Stability and Sustainability.

In: Proc. of the 6th Int. Sc. Conf. IFOAM, UC, Santa Cruz, California, USA, 1988, pp. 355-369

The small-scale farmers of northeast Thailand are the poorest in the country. One crop of rice is grown during the rainy season.

Upland crops (e.g., peanuts and corn) are often grown in rain-fed areas during the dry season, while either an upland crop or a second crop of rice is grown during the dry season in irrigated areas. Traditional and locally improved varieties are used. Soils are poor, fertilizer levels are low, and some pesticides are used. Fish have recently been introduced to rice paddies and it is hypothesized that this increase in diversity will increase income, decrease fertilizer and pesticide use; and increase system stability and sustainability. This paper describes both the farming systems methodology used to test these hypotheses and the preliminary results.
Fish are nutritionally and economically important to many small farmers in Asia. The fish harvested from rice paddies are often the farmers' main protein source. Fish in rice paddies are also important economically, and benefits are often greater to tenant farmers than to owners. However, fish production in paddy fields has declined sharply in the past 20 years. Indications from Indonesia and Malaysia are that the introduction of double and triple rice cropping along with increased fertilizer and pesticide use have been the contributing causes. Similar decreases have also occurred in China and Thailand.
Recent research in rice-fish culture has concentrated on developing techniques to integrate fish back into rice production. These management techniques involve minimizing the harmful effects of fertilizer and pesticides on fish.
In northeast Thailand, rice-fish production is now increasing. Reports from various rural development workers indicate a rapid expansion of the fish production in rice paddies. What is unique about this development is that it is occurring spontaneously among farmers. Mixed rice-fish culture is not being pushed by any development programm but is being aided by a number of government and nongovernment development organizations. The causes of the expansion are not completely known although some are discussed in this paper.
Since 1984, the Farming Systems Research Institute, Department of Agriculture, Thailand, and CUSO Fisheries cooperative have been conducting on-farm research with rice-fish farmers in northeast Thailand. This research is designed to test the hypothesis that introducing fish into farming systems of this region will increase diversity, resulting in greater stability and sustainability, both ecologically and economically.
This paper reports selected results from larger studies of rice-fish culture. These studies are part of programs to increase farmers' income through improved and diversified agricultural production. These studies have focused on current farmers' practices, research in association with farmers, and extension to other farmers.
Due to the short timeframe of the study, it is not possible to measure changes in stability and sustainability. Indicators of stability are, however, examined: farm productivity, farm income, incidence of pests and diseases, requirements for chemical inputs, and farmers' perceptions of the system.
While the data from these on-farm experiments are incomplete and problematic with regard to statistical analysis, it suggests that

increased agroecosystem diversity increases productivity. The addition of fish to rice paddies appears to increase both rice yields and fish production, thus increasing total yields and economic returns.
The introduction of fish into the rice system offers additional food and income sources, decreases pest incidences, may reduce fertilizer requirements (i.e., increases linkages in ecological terms), and should increase ecosystem stability.
It is not possible to quantify sustainability of the rice-fish system. There are, however, certain features of this farming system which suggest sustainability: (1) chemical and other external inputs are reduced, (2) it is adapted to the social environment, and (3) there are reinforcing synergistic effects on other aspects of the farming system.

89 - 3/32

303

Integrated systems
Review, workshops, sustainability, agriculture, diversification, economics, agricultural policy, research needs
WINKELMANN, D.L.
Diversification, sustainability and economics.

In: Proc. of the Seventh Agric. Sector Symposium - Sustainability Issues in Agricultural Development -. Ed. T.J. Davis and I.A. Schirmer, The World Bank, Washington D.C., ISBN 0-8213-0909-9, 1987, pp. 295-304

The theme of the workshop was sustainability in agriculture. The author of this article referres to diversification and sustainability.
This article is concerning sustaining productivity in agriculture, with little attention to issues related to other domains and even without going much into spillover effects beyond agriculture per se., e.g., ground water and down-stream pollution. Then this article focuses on the land, the water, and the germplasm employed in agriculture.
In detail the article starts with sustainability, technology, then relates diversification to sustainability, agricultural policy, and mentiones some research issues.
History gives examples of the fates suffered by civilizations whose agricultural production could no longer be maintained. For the most part, however, the more dramatic cases seem to be related to changes in climates.
The concern is less with long-term trends in climate, but more with maintaining production in the face of the acts of man. Some particularly telling examples are in the overgrazed areas of the Sahel and in the heavily eroded areas of central Mexico. But whether man or climate, the consequences of declining productivity can be staggering.
Much more research is needed which relates current output to the question of sustainability. Doing so will imply a much longer research horizon than most currently apply. Given the way much

research in the tropics and subtropics is financed and implemented. It is especially important that development assistance agencies lengthen their own horizons, at least with respect to topics related to sustainability. And, of course, before initiating such efforts the research of the past should be carefully reviewed.
Research should incorporate "natural farming" as one of its elements. This research, too, will require long horizons.
Such research must include not only biology but other circumstances of farmers as well.
The connections among diversification, sustainable agriculture, and practice run through biology, economics, and institutions. Much is known about selected facets of those interactions, far too little about most. Much research needs to be reviewed, much research remains to be done and a good portion of this research must have long horizons. Development assistance agencies concerned with sustainability should hasten to encourage, foster, and promote such research.

304 89 - 3/33

Integrated systems
Review, agricultural development, integrated approach, integrated plant production, organic farming methods, agricultural policy, IFOAM, EC
SCHÜLER, C.
"Integration" - the future for agricultural development?!

IFOAM, 5, 1988, pp. 3-5

Three possible paths of agricutural development are discussed:
- "High-Tech-Farming" with widespread use of gene-technology
- further pursuit of the presently prevailing "Modern Agriculture"
- environmentally sound forms of agriculture such as "Integrated Plant Production" (Integrierter Pflanzenbau) or organic farming, the latter point being strongly favoured by the majority of representatives of organic farming in such discussions.

If we, the representatives of organic farming methods, intend to rise up and met the laid out standards, which in this dispute are taken more and more seriously, then the following questions have to be answered:
- Does "Integrated Plant Production" allow a development towards environmentally sound agriculture or is it merely an ecological touch to continuing conventional farming practices?
- Do organic farming methods provide a sound alternative to conventional farming which can be integrated into agricultural policy and hence cover the entire farming community in West-Germany or even the EC?

Both concepts of integrated plant production and organic farming including the historical development and the present-day state are briefly sketched and followed by an evaluation of their future potential in consideration of the questions raised above.

305 89 - 3/34

Integrated systems
Asia, Thailand, study, integrated farming, subsystems, vegetables, pigs, duck, fish, economic analysis, farming systems, scenarios
EDWARDS, P. et al.
Pilot small-scale crop/livestock/fish integrated farm.

Asian Institute of Technology Report No. 184, P.O.B. 2754, Bangkok 10501, Thailand, 1986, pp. 88 +vii

The pilot small-scale integrated farm operated by a farmer and his family was set up to gain quantitative biological and economic data to assess its relevance for improving the lot of the small-scale farmer. The 4,000 m² farm comprised vegetable, pig, duck and fish subsystems. Vegetables were raised continuously, four batches of pigs were fattened, one batch of egg laying ducks was reared, and two crops of fish were harvested in the 2 year project. The vegetable, pig and duck subsystems functioned independently to a large extent using off-farm inputs but the fish subsystem depended totally on wastes or by-products from the other three subsystems, mainly pig manure, but also duck manure and waste vegetables. The disposable income for the 2 year operation of the farm was only about 50% of the minimum wage for the area, mainly due to overcapitalization of the pig sty and to a poor yield of marketable sized fish in the first fish crop. A series of hypothetical modifications were made related to both technical and economic data derived from the actual operation of the farm. In Scenario 1 with the basic modifications, the monthly disposable income was 56% higher than the minimum wage, with only 69% of the farmer's time devoted to farming activities. The project demonstrate the feasibility of a small-scale integrated farm of only 0.4 ha to maintain a rural farming family. The vegetable subsystem was the only labour intensive activity on the farm and could be expanded to more fully utilize the working day and generate more disposable income as indicated in Scenario 2. Since the operating costs for the pig subsystem were 59% of the total, the farmer should attempt to substitute labour for relatively expensive feed which would lead to substantial improvements in labour income. Labour should also be directed to increase the nutritional inputs to the fish pond to optimize its use since it is a fixed asset of relatively high capital cost.
Sequencing of labour requirements would need to be considered if the small-scale integrated farm were developed on a traditional rice farm, the most likely way for a widespread development of integrated farming to occur. Since considerable skill is required to manage an integrated farm, it would have to be developed in a step by step way. Marketing may provide a greater constraint to the widespread dissemination of integrated farming systems than the need to adopt a variety of technological innovations.
Author's summary

306 89 - 3/35

Integrated systems
Asia, Malaysia, study, integrated agriculture, fish farming
TAN, E.S.P. and K.H. KHOO
The integration of fish farming with agriculture in Malaysia.

In: Proc. of the ICLARM-SEARCA Conf. on Integrated Agriculture Farming Systems, Manila, Philippines, 1979, Eds. R.S.V. Pullin and Z.H. Shehadeh, Rep. 1986, ISSN 0115-4389, pp. 175-187

The objectives of this paper are to outline the status of freshwater aquaculture in Malaysia, the forms of integration of such practices, other farming activities and to describe the results of specific case studies of integrated farming systems involving fish culture.
In Malaysia, agricultural activities dominate the life of the rural population. If aquaculture is to be introduced to the rural areas, it follows that some form of integration of aquaculture with agriculture is essential, at least during the early phases of development, so that the potential value of aquaculture, not only as a reliable source of food protein but also regular income, is gradually realized by the rural population. Such a strategy would enable financial assistance to be channelled to the rural poor directly. As these communities are located away from the sea, freshwater aquaculture using both fish and crustaceans is appropriate.
The status of freshwater aquaculture in Malaysia is reviewed with special reference to integrated farming. Case studies of pig-fruit-vegetable-fish, pig-fish and pig-poultry-fish farms are described in detail and the kampung style integrated farms (smallholding involving rice, fruit, vegetable, livestock and fish production) are discussed.
Integrated farming systems aim to optimize food production from limited land and water space. In practice, they maximize utilization of the farmer's time, with or without the efficient recycling of wastes. The recycling of animal wastes in fish production, as observed in pig-fish farms, is important in providing additional income for the farm.
The utilization of disused mining pools for fish farming in Malaysia requires minimal capital costs. As a commercial enterprise, it is very profitable provided that adequate fertilizers, both inorganic and organic, are used. This provision can be met by channelling animal wastes, especially pig manure, into the pools. There is, however, little control of the quantity of wastes being drained into these pools and excessive quantities can cause mass mortality of fish by entrophication and oxygen depletion. Further studies are required to determine the appropriate amount of various animal wastes required for a defined water space and the recommended stocking densities of fish so as to maximize production.
Fish yields in ponds in Malaysia are low and could be improved by better management techniques. Intensive fish farming techniques have yet to be practiced commercially in Malaysia, though their

potential should be investigated in view of the increasing competition for the utilization of land.
Unlike the commercially-operated integrated farms which are profit-oriented, fish culture in small ponds operated by smallholders at the kampung level is relatively recent. As an additional activity for small subsistence integrated farms, it involves minimal operating costs yet provides a valuable source of animal protein. It also provides practical experience in fish culture which offsets the rather poor initial yields and offers a way of directly assisting the rural inhabitants. With proper training, farmers should be able to increase the yields which would generate further interest in aquaculture at the kampung level. Ultimately, improved methods for fish culture must be formulated to make it more commercially viable.

307 89 - 3/36

Integrated systems
Asia, case studies, workshop, on-farm research, animals, extension, economic analysis, farming systems
AMIR. P. and H. KNIPSCHEER
On-farm animal research/extension and its economic analysis.

Proc. of a Workshop - On-farm animal research/extension and its economic analysis, Los Baños, Laguna, Philippines, sponsored by Winrock Int. Institute for Agric. Development, USA, 1987, pp. 113

During the last decade increasing attention has been called to developing strategies for increasing the productivity of small farm animals. While rapid increases from the green revolution have been a mixed blessing for some groups, countries facing stiff competition in the commodity export market are anxious to diversify agriculture. Improving animal productivity appears to be one viable alternative.
While discipinary scientists are good at designing broad-spectrum technology, these improvements seldom reach the doorstep of the average farmer. Acceptance is now growing for the idea that researchers should participate in all stages of technology generation: problem description, diagnosis, design and testing, and evaluation. This approach requires an interdisciplinary focus.
This book contains 14 papers presented at a workshop in the Philippines: Devendra's paper discusses the need for on-farm animal research in Asia, outlining areas of concern and future directions. Camoens'paper looks at on-farm research from the perspectives of 10 farming systems.
Five papers document country experiences with on-farm animal research: Dickey's paper discusses the potential for using bioeconomic models to diagnose problems, using Bangladesh as a case study. Singh presents development strategy followed by the National Dairy Research Institute in India, giving special attention to economic analysis of different sized dairy units maintained on small farm. Hanjra's paper looks at dairy-improvement strategies in Pakistan, with special emphasis on the

cost of milk production. Papers by Calub and Ranjhan deal with the methodological and institutional problems in designing and conducting on-farm research. Calub's paper uses the Santa Barbara cattle fattening project as a case study, while Ranjhan's paper documents buffalo development in the Philippines and India.
Arboleda's paper stresses the need to design on-farm research with some consideration to statistical rigor.
Dawson's paper addresses the soil-pasture-animal ecosystem by looking at the use of animal manure and its long-term residual effects. Saadullah's paper describes present efforts in Bangladesh to develop better strategies for dealing with animal problems - he stresses the need to make graduate curricula more relevant to farmers' needs and to involve students in on-farm experimentation.
Papers by Lai and Prucsasri illustrate economic analyses of on-farm animal research in Malaysia and Thailand. Amir's paper provides a comparative micro study of the performance of large ruminants in Pakistan and India, giving special attention to the influences of policy and farmer preferences on the productivity of farm animals. Rañola's paper highlights marketing and policy factors that must be kept in mind when making widespread technology recommendations.
The workshop ended with some general recommendations for improving the training material. The consensus was that opportunities for disseminating information pertaining to on-farm animal research should be identified. National programs showed keen interest in participating in and hosting such workshops and courses. The group suggested holding a similar workshop in 3 to 4 years to review the progress of on-farm research in selected national programs. Specific proposals for networking between national programs were also discussed. In summary, this workshop proved beneficial in updating participants about future directions of on-farm research in Asia and strengthening linkages among country programs.
Eds. Abstract, shortened

308 89 - 3/37

Integrated systems
Asia, review, animal production, farming systems, animal resources, non-continental feeds, strategies
DEVENDRA, C.
Non-conventional feeds: Potential value for animals in the Asian region.

Outlook on Agriculture, 18, No. 2, 1989, pp. 58-63

The availability of feeds and efficiency in their utilization represents the principal constraint to animal production in the Asian region. The constraint is serious in that imcomplete use of the available feed resources is associated with inefficient feeding systems, resulting in continuious low productivity from animals. Between ruminants and non-ruminants, the contribution of the former is especially low, due to inadequate exploitation of their attributes and wider use of the indigenous breeds available.

This has in turn raised questions about the efficiency of existing ruminant production systems, and more particularly about potential possibilities of increasing the current level of output from the animal resources.
Animal feeds, including crop residues, agro-industrial by-products, and non-conventional feeds provide a link between crops and animals. In most parts of Asia, mixed cropping is the main pattern in agriculture, so that the relevance of ensuring efficiency in feed utilization is not only imperative but also contributes to the stability of farming systems.
Among the nutrients, dietary protein is the main limiting factor, but variations in the supply of energy, minerals, and vitamins are also implicated. The problem of inadequate feed supplies is particularly acute in all countries in South Asia (Pakistan, Nepal, Bhutan, India, Bangladesh, and Sri Lanka). Additionally, there is also competition between animal species for the utilization of the feed resources, and also with humans for cereals and cereal by-products. These aspects are further exacerbated by limitations in the availability of land and inadequate production of feeds to meet the annual requirements of animals.
Elsewhere in the more humid parts of South East Asia, such as Malaysia and the Philippines, feed availability is relatively greater and the major limitation is inadequate and inefficient utilization of the quantities potentially available. Theoretical calculations suggest that the feed availability in these countries is often in excess of current animal requirements, emphasizing that considerable opportunities exist for further increasing numbers and improving animal production.
Development strategies that can alleviate prevailing circumstances, overcome current limitations and ensure more complete utilization of the available feeds, are therefore especially important. These constitute a means to increase the overall contribution from animals. In this context, the potential value of non-conventional feeds deserves increased attention, together with more intensive use of other crop residues and agro-industrial by-products. The approach is to take advantage of these feeds and identify clearly utilization with the objectives of production through the development of innovative feeding that can support all-year-round management systems.
This article considers how far traditional feeds can be effectively supplemented by non-conventional ones such as crop residues and agro-industrial by-products.

309 89 - 3/38

Integrated systems
Review, book, Africa, tropics, beekeeping
VILLIÈRES, B.
L'apiculture en Afrique tropicale (Beekeeping in tropical Africa).

Gret-Le point Sur, n.11, 1987, 250 p., available at GRET, 213 Rue Lafayette, 75010 Paris, France

In spite of its extensive character as well as the lack of professionals specialised in this activity, beekeeping is of some interest for Africa. On the one hand, honey is an appreciated product and its price is high. An important potential market thus exists, which is far from being saturated through national production. On the other hand, being an activity of dry season, beekeeping does not get into concurrence with field work; furthermore, it can contribute to a complementary source of income at quite an opportune moment of the year, filling so a gap in farmers' activities.
The African bee is productive. Concerning the traditional beekeeping practices, they are most efficient considering the fact that the costs are practically non existent. Therefore, improvements should prevail over changes in African beekeeping.
Characteristics of the African bees, apiarian practices, how to valorize beekeeping, a list of materials'suppliers and places where to find informations, as well as an exhaustive bibliography, make this book the reference work (in French) of African apiculture.
Abstract from Agricultures actualité

310 89 - 3/39

Integrated systems
Asia, Nepal, study, integrated farming systems, agriculture, animal husbandry economics
RAJBANSHI, K.G. and M.B. SHRESTHA
A case study on the economics of integrated farming systems: Agriculture, aquaculture and animal husbandry in Nepal.

In: Proc. of the ICLARM-SEARCA Conf. on Integrated Agriculture - Aquaculture Farming Systems, Manila, Philippines, Repr. 1986, ISSN 0115-4389, pp. 195-208

Although multicrop and integrated production systems have a long history in Nepal, there is a lack of scientific information on their methodology, management and economic viability. The objectives of this case study were to develop reliable, quantitative management guidelines and economically viable production methods for integrated farming systems combining agriculture, aquaculture and animal husbandry, with modifications appropriate to local conditions.
A two-year economic case study is presented of a small Nepali farm 14 km east of Kathmandu. In the first year the farmer concentrated on cereal crops while in the second year he added a piggery, combined duck raising with fish culture and used improved varieties of cereals.
The case study shows some of the important factors which have helped the farmer to increase his production of various crops with the limited resources of land, labour and other inputs. The increased production of various crops using an integrated farming system has increased his income too.

The direct benefits of an integrated farming system of agriculture, aquaculture and animal husbandry compared to agriculture alone can be summarized as follows:
- The labour requirement for intensification of agriculture decreased by 39% while the production of agricultural crops alone increased by 56%. Also, the move to integrated farming system which requires the addition of a 5% increase in labour compared to agriculture alone has given a 19% increase in income.
- The use of waste materials from one operation has reduced expenditure on inputs and helped to raise production for other operations.
- The move to integrated farming yields fish, ducks and pig meat which are considered as cash crops by the farmer. These are much more valuable than cereals alone and help raise the economy of the rural farmer above the subsistence or near subsistence level.
- The production of animal protein in the form of fish, ducks and pig meat improves the diet of the farmer.

The input:output ratio for aquaculture and animal husbandry is low compared to crop farming which reflects the farmer's limited resources for such capital intensive operations and his lack of technical knowledge which must be remedied by technical assistance.
This study was carried out with a single farmer. Environmental, social and other factors may vary from place to place but the authors feel that the study indicates the attractions of integrated farming systems to assist the rural farmers according to their requirements and conditions. In this study, pigs were included in the integration of livestock, but in certain parts of the country farmers may hesitate or refuse to accept these on social and religious grounds. Therefore, there is a need to study integrated farming using dairy or beefcattle or buffalo as well as pigs so that integration of livestock with agriculture and aquaculture can easily be tailored to the choke of the rural farmer.
With the possible combinations of cattle or pig and even poultry, there is also room for domestic biogas production in integrated systems when processing the available manure for field use. Biogas operation would give the rural farmers who are deprived of hydroelectric power the benefits of gas lighting and gas fuel for domestic use. It would also help to reduce public health hazards in the villages, protect the farmers from the effects of unprocessed wastes, and help to reduce the expense of waste disposal.
In addition to all these recommended developments, a detailed resource study has to be carried out to determine availability of land for the various crop combinations to optimize production and maximize the income of the rural farmer.

311 89 - 3/40

Integrated systems
Africa, Nigeria, study, crop/livestock production systems, germplasm, soil fertility, ILCA, fodder, alley farming
ATTA-KRAH, A.N. and J.E. SUMBERG
Studies with *Gliricidia sepium* for crop/livestock production systems in West Africa.

Agroforestry Systems, 6, 1988, pp. 97-118

Forage research at ILCA concentrates very heavily on the identification, selection and improvement of fodder trees and their development and integration into farming systems of the zone. The emphysis on fodder trees is a result of the general potential of trees, and their common occurrence in farms, fallow lands and compounds in the tropics. Their relative ease of establishment and management (compared to that of herbaceous legumes) and potential of their integration into local farming systems makes fodder trees, rather than forage legumes and grasses, the base for developing integrated fodder production systems for small farmers in the zone.
This paper gives a broad discussion of the potential of *Gliricidia* and describes research conducted, in the development of fodder tree-based production systems for the improvement and integration of crop and livestock production in humid and sub-humid West Africa. Relevant research on the species by some other workers in the zone are also cited.
It examines the biological characteristics of the species, with respect to growth, flowering and seed production, and analyses its potential for improving crop production (through soil fertility maintenance) and livestock production (through production of improved fodder). Integration of *Gliricidia* into cropping systems is necessary for optimum realisation of its crop improvement quality. The alley farming system is presented in the paper as one means of achieving sustainability in crop production through integration of trees, such as *Gliricidia*, into cropping systems. The use of *Gliricidia* in Intensive Feed Gardens, for production of leguminous fodder is also described as an alternative production system. The paper finally reports on experiences with local farmers in on-farm research and development for the integration of *Gliricidia* and *Leucaena* into local farming systems. It ends with a suggestion for more research, targetted specifically at improvement of the species and its utilisation.
The various studies and observations discussed in this paper, show very clearly that *Gliricidia* does not just grow 'tall for nothing'. The species is useful both for maintenance of soil fertility in cropping fields and for improving livestock production through the use of its high-protein foliage, as feed. Its fast growth and nitrogen-fixing qualities are two characteristics that make it comparable to *Leucaena leucocephala* in cropping systems. Like *Leucaena* it offers a way of integrating crop and livestock production, and has a potential for improving

the overall productivity of farmers in the humid and sub-humid zones of West Africa.
There is a need to improve the awareness of local farmers on the potential uses of the species, as well as encouraging and promoting more research targetted specifically at its improvement (through breeding), its management in various farming systems and its utilisation for improved crop and livestock production.

89 - 3/41

312

Integrated systems
Review, bibliography, catalogue, tropics, agriculture
RTI/CTA
Tropical agriculture - selected handbooks -.

Royal Trop. Institute and Technical Centre for Agric. and Rural Cooperation (CTA), Netherlands, ISBN 90-6832-627-9, 1988, pp. 114 + XI

This catalogue is a guide to English-language books on agriculture and rural development (farming, animal husbandry, fisheries, post-harvest operations and related activities) in the tropics and subtropics, with emphasis on Africa, the Caribbean and the Pacific.
It is a compilation of 405 standard reference works which are still in print and available from publishers. As such, it is a practical buying guide for students, educational staff, researchers, extension officers, librarians and others.
Many outstanding handbooks on various aspects of rural development are out of print and, therefore, not included in this catalogue. Some of these titles can be found in the bibliographies and lists of references mentioned in the catalogue. Copies of out-of-print books are still available in many libraries.
The principal aims of this bibliograpy are:
- to provide a guide to reference works on tropical agriculture for research workers, extension staff, planners and decision makers;
- to create an awareness of the rich sources of information on tropical agriculture in the English language;
- to assist agricultural librarians in creating well balanced collections of textbooks, reference works and manuals in this field.

The catalogue is divided into categories and sub-categories. Within these groups the entries are arranged by subject. Entries with a broad scope are categorized by their main subject. There is one abstract for each book.
The catalogue is supplemented by an author index, with codes referring to the entry number. Bibliographic data provided in the descriptions of the books include: title, author(s); place of publication; publisher; year of publication; number of pages; figures, drawing and maps ('figs'); tables; number of references ('ref'); bibliography (for books which contain more than 100

references); name of series and volume number (in parentheses); ISBN; the price of the book (in Dutch guilders) and the abstract. Book selection, abstracting, editing and production were carried out by the Information and Documentation Department (Evert C. van't Sant and Wiebe de Boer) and the Publications Bureau (Keith Addison) of the Royal Tropical Institute.

313

89 - 3/42

Integrated systems
Review, booklet, tropics, rabbit farming, small-scale, practical approach, animals, reproduction, raising, housing, feed, diseases, administration
AGROMISA
Backyard rabbit farming in the tropics.

Agrodok 20, Agromisa, P.O.B. 41, 6700 aa Wageningen, The Netherlands, 1989, pp. 68, price DM 15,--

The popularity of the rabbit in the tropics is on the increase. A national rabbit compaign in Ghana receives much attention; the Indonesian Government is also importing rabbits and stimulating interest in rabbit raising. Certainly other countries have similar programs, or private organizations like churches, schools and youthclubs all over the world have their rabbit projects.
People keep rabbits for many different reasons. The main aim of this booklet is to give some reasons for small farmers, low income families or children, and to discuss management, breeding, nutrition, veterinary, and other problems for this type of backyard farming.
The booklet contains the following chapters:

1. GENERAL INTRODUCTION
   - Some reasons for keeping rabbits
   - Some disadvantages of keeping rabbits
   - General husbandry, an introduction to the following chapters
2. TYPES OF ANIMALS (BREEDS)
   - Fancy and fur breeds
   - Meat breeds
3. SELECTING YOUR ANIMALS (BREEDING STOCK)
   - Health
   - Sex
   - Risks
4. MATING AND KINDLING (REPRODUCTION)
   - The male
   - The female
   - Mating of ram and doe
   - Pregnancy control
   - Kindling and mothercare
   - When to mate the doe again
5. RAISING THE KITTENS

6. HOUSING
   - Introduction
   - General advice before you start building
   - The stable
   - The individual hutches
   - The maternity hutch and the nest box
7. WHAT FEED TO GIVE
   - Introduction
   - Water requirements
   - Feedstuffs to feed
   - Growth rates of rabbits
   - Some practical remarks
8. THE SICK ANIMALS
   - Introduction
   - Prevention of rabbit-diseases
   - The main diseases
     Intestinal problems
     Problems of the respirational tract
     Parasites
     Other diseases and health problems
9. PROPER ADMINISTRATION
   - Introduction
   - Identification methods
   - The record-book
   - The calendar
10. PRODUCTS OF RABBIT BREEDING
11. GLOSSARY
12. RECOMMENDED LITERATURE
13. QUESTIONNAIRE

APPENDIX 1 Nutrient requirements of rabbits fed ad libitum
APPENDIX 2 List of common diseases of rabbits, their symptoms, causes, treatments and control
APPENDIX 3 The process of tanning

This book ist not meant to be comprehensive and on purpose it is kept very simple. The basics for "tropical backyard rabbit farming" are included. Only those things which can be understood by common sense and which require no specialised knowledge, laboratory work etc. are discussed.
The literature list gives some details of the most important publications which are easily available. In the text no reference has been made to specific literature sources. In the appendix interesting information is given which could not easily be fitted into the other chapters of this booklet.
This booklet is very useful for all those keeping rabbits or have the idea to do so.

314

89 - 3/43

Integrated systems
Discussion, integrated approach, tropics, temperate zones, livestock, earthworms, soil fertility, biotechnology, management, slurry, organic waste
HARTENSTEIN, R. and M.S. BISESI
Use of earthworm biotechnology for the management of effluents from intensively housed livestock.

Outlook on Agriculture, 18, 2, 1989, pp. 72-76

This article discusses how organic waste can be effectively disposed of on a large scale, by systematically managing the destructive and productive activities of earthworms.
The objective of this article, accordingly, is to describe a procedure by which animal wastes can be (i) managed at minimal cost: (ii) on minimal land; (iii) with minimum damage to the environment; and (iv) with the production of a coomodity from the waste material. Several species of earthworms are required if these goals are to be achieved. The species recommended are normally found mainly in the temperate zones of the world. The procedure called for, however, will lend itself to their use in the tropics as well.
With a rapidly expanding world population, growing use of intensive animal husbandry, and increasingly stringent waste disposal legislation, the problem of disposing of livestock effluent is already severe.
In relation to livestock that can be intensively housed, 0.30 cattle were available per person in 1975, 0.26 in 1984; 1,56 poultry per person in 1975; 1.52 in 1984; and 0.17 pigs per person throughout 1975-84.
The success of intensive management of effluents from intensively housed livestock hinges on a continuous peturbation of the soil in which the animal wastes are to become humified. Earthworms will pertub the system through tunnelling; through mixing various microbial species during digestion; through the creation of internal soil surface beneath the external soil surface; by establishing conditions through which nematodes, potworms, oribatid mites, springtail insects, terrestrial isopods, snails, slugs, millipedes, and predators of these animals - including mesostigmatid mites and centipedes - are brought into the system. Additional activity results from exposing an enormous surface to rain which carries acids, hydrogen peroxide, and various other oxidants such as the perhydroxyl radical, hydroxyl radicals, and superoxide anions into the soil.
It can be concluded by saying that the system outlined can also be applied to the management of slurry from intensively housed humans. By 2024, regardless of how many humans are on Earth, probably more than 90 per cent will be urbanized. In the event that doubling of the human population from 1984 could occur, in accord with the present inherent rate of population increase, more than one million dry tons of body wastes will be in need of management daily.

315

89 - 3/44

Integrated systems
Asia, Thailand, integrated approach, agriculture, aquaculture, farming systems, chicken-fish farming
KACHORNSAK WETCHAGARUN
Integrated agriculture-aquaculture farming studies in Thailand with a case study on chicken-fish farming.

In: Proc. of the ICLARM-SEARCA Conf. on Integrated Agriculture - Aquaculture Farming Systems, Manila, Philippines, 1979; ISSN 0115-4389, Repr. 1986, pp. 243-249

There are many possible approaches to increasing agricultural production and income, including diversification and integrated farming. The idea of integrated farming is not new. It has been in existence in Thailand for centuries and can be seen in most farm households in the rural areas which combine animal and fowl husbandry with crop raising. These activities are mainly for home consumption and gifts within the community, but not for sale as an additional source of income. They could, however, become an additional source of income if given adequate attention. Integrated agriculture-aquaculture operations can include combinations of fish farming with animal and fowl husbandry or with crop raising.
There was, however, no follow up study until 1968-1969 when the Agroeconomic Unit, Central Office, Chainat Province, carried out a systematic study on income and expenditure in farms of various sizes in the Chaophyra Irrigation Project. The main study involved the selection of representative farms and the injection of slightly improved management techniques and some basicnew technology which the average farmer could absorb and follow. This revealed that farms of the sizes studied could yield annual profits of 8,522; 18,679, and 26,212 baht, respectively, profit being defined in this paper as net return over variable costs. Moreover, a farm of 6 rai with all activities reorganized as an integrated farm (e.g., crops, vegetables, rice, fish ponds, livestock, etc.) would yield an annual profit of up to 24,770 baht compared with only 6,500 baht from rice cultivation alone. Thus, compared to the slight improvements mentioned which give a profit of 31% higher than normal, a reorganized integrated farm shows a 3-fold increase. This study shows clearly that increases in farm income are possible without corresponding increases in the amount of agricultural land. To achieve this, however, farm management techniques and modern technology must combine to fully utilize limited natural resources.
Most of the current integrated farms in Thailand are operated in the traditional way - without proper planning, modern technology or modern farm management techniques - and rely on personal experience. Marketing is therefore a recurrent problem except in very good years. Fish diseases constitute a further major problem which the farmers cannot solve by themselves since they have

inadequate experience and knowledge, and such knowledge is not as readily accessible as with other farm animals where feed manufactures or veterinary supply companies offer services to assist farmers in many cases. A further problem for farmers is the shortage of credit and working capital, which forces them to contract their produce sales to middlemen, usually at unfavorable prices.
Although integrated farming has proved to be highly profitable, its practice remains very limited in scale. This is because the relevant scientific and technological information on diversification of methods is unavailable to farmers. To remedy this, there must be a bridge between in information sources and the farmers, perhaps through extension services. A multidisciplinary approach is needed, including technological, economic, social and political aspects which are interrelated. Any approach must, however, be relevant to national economic, social and environmental conditions and to the farmers' needs. A systematic study on a pilot farm is recommended, including all the aspects mentioned above.
A case study shows that integrated chicken-fish farming can yield a very high profit. A comparison of the variable costs of production of an egg (0.63 baht), its farm-gate sales price (0.86 baht), and its retail market price (1.25 baht) shows that the farmer's profit per egg is 36.0%, whereas that of the middleman is 45%. This is considered to be an equitable arrangement.
The turnover and total profit are both very high for such a small farm, and should enable the farmer to make adequate savings for his working capital, considering his cost and standard of living. An interview with the farmers revealed, however, a continuing shortage of working capital and the consequential unfavourable credit arrangements with feed suppliers.

316 89 - 3/45

Integrated systems
Africa, Burkina Faso, project, agrosylvo-pastoralism, soil fertility, reforestation, mixed cropping, livestock, integrated approach
GIRARD, H.
Zoramba nataaba: projet du centre agro-écologique de Guie. (Zoramba nataaba: project of the agro-ecologic centre of Guie).

Centre Agro-écologique, 1988, 70 p., available at the author's address, 76 route de Guise, F-59550 Landrecies, France

This abstract describes a project situated in Burkina Faso. It is based on agrosylvo-pastoralism and comprises 3 sections:
- Section "Improvement of arable soils" with the aim of rehabilitation the soil fertility through the composting method of Jean Pain on one hand (very simple method requiring brushwood and water); on the other hand, by building up lots of tiny anti-erosive walls in the fields.

- Section "Reforestation": creation of nurseries, of anti-erosive quickset hedges with thorny species (preventing damages through animals), mixed cropping with trees (*Acacia albida* for example) promoting soil fertility.
- Section "Control of cattle dissemination": efforts are being made to reduce ovine livestock, keeping donkeys, bovine livestock, pigs and poultry. Bee keeping is also considered. An eyperiment has been made with beehive (on the soil), allowing better honey harvest and less hive loss.

To reduce the exodus of young people to the Ivory Coast, the Centre will open a class for practical and theoretical formation of the youth. Short-term training courses will be organised for adults. Furthermore, in the villages around the Centre, rural activities will take place, to sensibilize already existing groups to the problems of deforestation (villagers, women, chief authorities).
Abstract from Agricultures actualité

317 89 - 3/46

Integrated systems
Review, manual, FAO, mushroom cultivation, indoor cultivation, field cultivation
RAMBELLI, A.
Manual on mushroom cultivation.

FAO Plant Production and Protection Paper No. 43, 1985, pp. 65

This manual is an attempt to present all that is currently known on the cultivation of mushrooms, at both small-scale level and industrial level. The techniques described involve the use of laboratories specializing in production of the most important species concerned. Laboratories, however, are insufficient in developing countries which stand to benefit most from this new source of income, nutrition, and investment. It is hoped that the development of laboratories will become a priority so that cultivation of mushrooms can be encouraged and undertaken. In the meantime, the possibility of successfully producing mushrooms exists both in developing countries and elsewhere, using the techniques described in the first part of this manual, and adapting them to suit prevailing local conditions.
A beneficial and convenient use of fungi in agronomy is the cultivation of mushrooms for nutrition. New growing techniques, in addition to the old traditional method of mushrooms beds, guarantee an increased and selected production. Mushrooms have always been appreciated more as a delicacy than for their nutritional and therapeutic properties.
As well as the industrial production of mushrooms, the small-scale farmer can make a profitable sideline from their cultivation. Unused stalls, sheds, greenhouses, cellars, etc. can be economically transformed without an excessive outlay of capital, and mushrooms can be grown and sold either fresh or preserved. The income to be earned from the specialization in selection and

preservation of mushrooms compares very favourably with the production and sale of similar farm produce.
As well as indoor cultivation, farmers on both small-scale and family-run farms can round out their agricultural earnings with the outdoor cultivation of mushrooms.
Although a great deal of research on many aspects of mushrooms cultivation remains to be carried out, the actual state of scientific knowledge at present available, combined with the practical experience and observations gained over the years by the small farmer and cultivator, provides an excellent and interesting approach to this type of investment.
Tropical forests undoubtedly offer great possibilities for the development of mushroom production, but so far very little is known of these regions, either from a mycological point of view or as a source of species for possible artificial cultivation. Many plants from tropical forests could probably be incorporated in agriculture to supply an income together with eventual mycorrhizal-fungi production, used for nutrition. A great amount of research must be performed in this field, which seems very promising.

318 89 - 3/47

Integrated systems
Central America, Honduras, case study, integrated approach, development program
BUNCH, R.
Guinope - an integrated development program in Honduras -.

Publ. of World Neighbors, 5116 North Portland Avenue, Oklahoma City, Oklahoma 73112, USA, 1989, 17 pp.

The Guinope Integrated Development Program was initiated in January, 1981, as a tripartite effort between World Neighbors, the Honduran Ministry of Natural Resources and the Association for the Coordination of Development Resources (ACORDR).
By and large, the Ministry has provided legal papers, tax-free status and occasional logistics; ACORDR has offered a series of ecologically sound agricultural technologies, plus administrative support, and World Neighbors has supplied the program personnel, financial support and general orientation as to development strategies and philosphy.
The obvious root problem in the area was severe soil deterioration caused by erosion and the continual monocropping of corn. Much of the area's topsoil was gone, with the results that average yields were extremely low; many farmers were walking for hours or taking buses to other parts of the country to find arable land, while others had left permanently for the slums in Tegucigalpa, the nation's capital, and malnutrition among those who stayed was increasing noticeably. Empty houses scattered throughout the town were mute testimony to Guinope's declining economic fortunes.
The key factors in the program's success, which as experience has shown can be applied to programs in most of the Third World, are:

- All forms of paternalism should be avoided, including giving things away or subsidizing farmer activities. All work should be accomplished for the sole reason that villagers want to achieve it for themselves.
- Programs should start small and slowly, so that local people can participate from the beginning.
- The program must use a limited technology, so that villagers can learn and teach it as soon as possible and so that a maximum number of villagers will be reached. In this way, great socioeconomic differences are not created among the population, and efforts can be concentrated on a few ideas in order to assure success.
- The technology should be appropriate to the local area, and the first lesson taught should deal with traditional food crops. Technologies should be simple to learn and inexpensive. They should use locally-available resources and provide rapid successes.
- Farmers should not have to risk too much to learn. Therefore, the technology should be taught through a system of small-scale experimentation. The teachers should be village farmers who already have had success with the same technology in their own fields. Training should be done in one or two day sessions in the farmers' villages, with at least 70 percent of the class time in the fields.
- A multiplier effect must be an important component of any agricultural extension program, so that successful villager farmers become the trainers in the program, eventually taking it over completely.
- Programs do best by gradually responding to other fields of the community's farm family, including health, family planning, participation in the political system, environmental improvement.

One additional factor of success has been that of using small farmer adapted green manure cover crops as a major method of retaining soil fertility. Green manure cover crops can be grown with virtually no expense, with very little labour and without using any land on which other crops could be planted. They can be planted in association with basic grains, during the dry season, on land already abandoned because of depleted fertility, under fruit trees or along soil conservation infrastructures.
The per-hectare grain production of the 1,200 families in the program has tripled, assuring them ample basic grain supplies for the ensuing year. This has been achieved at an average cost of $212 per family (based on the $254,000 cost above). Absolutely all the costs of agricultural production are carried by the farmer. Thus, except for a small revolving fund used to buy and sell necessary equipment (hand sprayers and pitch forks, for instance), the program makes no expenditures for labour, equipment or raw materials, Since technologies are kept simple and locally replicable, there are no import requirements, nor is there any need for replacement parts or maintenance that is not locally available and easily afforded by local farmers.

Probably the major problem in the Guinope Program has been that of marketing cash crops. The area around Guinope has no traditional vegetable marketing structure. Thus, before the farmers could produce any major amount of vegetables, a marketing structure had to be built.
Farmers became more experienced as to what quality would be accepted. The program's nutrition classes helped to stimulate the growth of a local market, and farmers competed to deliver the best quality so as to receive repeat orders. All of this helped ameliorate the problem of quality control, although there will probably always be complaints.
The last problem is how to phase out the program's involvement in the store, which finally became profitable, but nevertheless is extremely complex.
Prices fluctuate rapidly, and setting prices that are competitive, yet fair to the farmer, is a constant challenge. A tremendous amount of information must be learned in order to meet customer preferences regarding appearance of produce layout of the store, conditions of the washroom, etc.
The break-even point for this store is approximately $15,000 total sales per month, an astronomical sum for villagers to handle. All sorts of cheating is possible in a system where market-bought products are never sold with receipts, and vegetables rot or lose weight over time.
The best possibility would be that other middlemen and retailers should begin to buy vegetables from the Guinope area. Thus, the store could be phased out altogether. A second, more difficult alternative is that the store be sold to Guinope's farmers or to an entrepreneur.
The goal of this program is not so much to sustain itself indefinitely, but rather to "work itself out of a job". By using small-scale experimentation, keeping simple accounts of their experiments and sharing results with each other, large numbers of small farmers can continue to develop their own agriculture long after the program has closed its doors.
The program has no plans for institutional sustainability of the agricultural extension program. What will be sustained is a loose-knit federation of village-level agricultural clubs, which will coordinate experiments each year and share results. The vegetable producers' association eventually will run the vegetable store in the event that alternative marketing channels do not grow around Guinope's now proven record of high-quality vegetable production.

89 - 3/48

319

Integrated systems
Africa, Zimbabwe, integrated approach, study, livestock development, mixed farming systems, smallholder
STEINFELD, H.
Livestock development in mixed farming systems: A study of smallholder livestock production systems in Zimbabwe.

Farming Systems and Resource Economics in the Tropics, 3, Wissenschaftsverlag Vauk, Kiel KG, Postf. 4403, 2300 Kiel 1, FRG, ISBN 3-8175-0030-0, 1988, 239 pp

In this series farming systems approach is understood to mean the analysis and planning of the farm and the household as a complex system. This includes an holistic concept, an interdisciplinary approach and the dynamics of systems. Cropping or livestock systems are, therefore, subsystems within the farming systems complex. The international and external relationships of this system are of special interest in the fields of physical, technical, economic, social, socio-cultural, administrative and institutional impacts. In resource economics special emphasis is given to resource availability, use and long-term stabilization from a micro, regional and macro-economic point of view. It is here where the relations between farms, regions/projects and national sectors are of greatest economic relevance.
The aim of this study has been to determine the type and extent of livestock contributions within mixed farming systems and to indicate if and how livestock development can be instrumental in agricultural development. This has been done by analysing smallholder livestock production systems in Zimbabwe, employing a farming system perspective. Analysis and elaboration of development implications are carried out with regard to the resource base, the management practices applied, livestock output and the functions that livestock fulfil. On the basis of a comparative analysis and on both normative and positive grounds, development approaches are identified and assessed and future trends outlined.
The prevailing farming system in the Communal Areas is based on smallholder mixed farming using animal draught power and a minimum of purchased inputs. Livestock are essential for cropping in that they provide work and manure, and their outputs such as milk and meat contribute to household consumption and income. At the same time, livestock constitute the only significant asset in terms of security and wealth.
This study on "Livestock Development in Mixed Farming Systems" concentrates on the integration of the livestock component in agricultural farms. The type and extent of livestock contributions within mixed farming systems in smallholdings in Zimbabwe is analysed by employing the farming systems perspective. Based on this, the results show how livestock development can be instrumental in agricultural development. Special attention is given to the resource base, the management practices, livestock output and the functions that livestock fulfils.

It is the aim of the study to contribute to a better understanding of the role and development possibilities of livestock in mixed farming systems. Livestock, particularly cattle, are at the base of the farming system both as a means of production and as products. They are the capital investment and they provide consumables and inputs to the farming system. The role of livestock is characterised by a multiplicity of linkages connecting both the resource and the product level of the livestock production system to the other sub-units of the farming system and the outside economy. The approach applied in this study in analysing and planning the development of the livestock production system follows a farming system methodology in which a three-phase procedure, viz. resources, livestock management and production, and livestock functions, is adopted. At the same time, these phases constitute the tactical and strategic points of intervention and levels at which change can be monitored. This enhances the validity of the chosen approach for livestock development. Priority in development planning must be given to flow products in order to strengthen livestock functions that concur directly with the farmer's rational needs and that induce agricultural development through their direct and indirect effects. This major conclusion is applicable to a wide range of mixed farming systems in similar environments. The validity of the "flow product approach" is given

- where communal grazing land and individually held livestock coincide with (at least occasional) cash surpluses from crops, livestock, remittances or off-farm employment and lack of financial facilities; and
- where a high degree of farm integration (both within the farming and the livestock production system) interacts with high human population pressure.

It is expected, that many of the findings and conclusions drawn from the analysis and planning considerations apply to a whole range of mixed farming systems in Africa. This becomes evident because the focus of this study has been on trends and on comparisons between species, different sizes of holdings and different agro-ecological zones, which are the major determining factors of both livestock production potential and constraints. It is in this context that the main development implications found for smallholder mixed farming systems in Zimbabwe have a wider applicability since they are based on strata comparison as well as on general dynamics of change and development paths.

Author's summary

320 89 - 3/49

Integrated systems
Review, book, tropics, water buffalo, animals, integrated approach, meat, milk, work, environmental tolerance, nutrition, reproduction, management, research needs
BOSTID
The water buffalo: new prospects for an underutilized animal.

National Academy Press, Washington, D.C., Library of Congress Cat. No. 81-83416 - Repr. 1984, 115 pp.

The water buffalo is an animal resource whose potential seems to have been barely recognized or examined outside of Asia. Throughout the world there are proponents and enthusiasts for the various breeds of cattle; the water buffalo, however, is not a cow and it has been neglected. Nevertheless, this symbol of Asian life and endurance has performed notably well in recent trials in such diverse places as the United States, Australia, Papua New Guinea, Trinidad, Costa Rica, Venezuela, and Brazil. In Italy and Egypt as well as Bulgaria and other Balkan states the water buffalo has been an important part of animal husbandry for centuries. In each of these places certain herds of water buffalo appear to have equaled or surpassed the local cattle in growth, environmental tolerance, health, and the production of meat and calves.
Although these are empirical observations lacking painstaking, detailed experimentation, they do seem to indicate that the water buffalo could become an important resource in tropical, subtropical, and warm temperate zones in developing and developed countries.
If this is the case, then it is clear that many countries should begin water buffalo research. Serious attention by scientists could help dispel the misperceptions and uncertainties surrounding the animal and encourage its true qualities to emerge.
This report describes the water buffalo's attributes as perceived by several animal scientists. It is designed to present the apparent strengths of buffaloes compared with those of cattle, to introduce researchers and administrators to the animal's potential, and to identify priorities for buffalo research and testing.
The present report is an introduction to the water buffalo and its potential. It is written particularly for decision makers, as well as scholars or students, in the hope that it will stimulate their interest in the animal and thereby increase the appreciation of, and funding for, buffalo research. The report includes much empirical observation, largely from the panel members. Some of these observations may, in the long rund, prove not to be universally applicable. Much benchmark information needs to be obtained.

321 89 -3/50

Integrated systems
Africa, humid zones, subhumid zones, tree crops, plantation, livestock integration, integrated approach, sociology, ecology, economics, viability
FAO
Integrating crops and livestock in West Africa.

In: FAO Animal Production and Health Paper No. 41, ISBN 92-5-101443-4, Repr. 1985, pp. 69-74

This publication attempts to bring together existing information relating to prospects for developing closer integration of crop and livestock production in West Africa and to present this in a format useful to senior professionals and technical administrators concerned with improving efficiency of land use in those parts of the subregion where increasing population density makes this necessary. Its focus is mainly on the subhumid and humid zones since these offer greatest scope for intensification and integration of crop and animal production.
Technical Feasibility:
The factors included are soil and climate, the size of the plantation, the number of animals it can support, the availability of fodder, its quantity and quality and whether these can meet the nutritional requirements of the stock for economic growth and performance, the effect of livestock on the performance of the plantation crop, nutrient (especially minerals) deprivation due to forage growth and consumption by the livestock, and direct damage to the crop by livestock.
The acquisition of land for the establishment of plantations and the right to use the land during the economic life of the plantation, which could be as long as 40-50 years for oil palms and 60 for coconuts, may be difficult to negotiate. Plantations established in grazing land can evoke tenurial problems.
If not correctly managed forage may compete with the plantation trees for nutrients and make the harvest of the crops difficult, e.g. creeping grasses and legumes like Giant Star Grass (*Cynodon plectostachyus)* and *Centrosema* growing up young trees or crowding out other useful grasses and legumes; on the other hand the grazing may be killed by shade if the canopy closes.
Lack of forage due to failure of rains or closed canopies will severely affect the supporting capacity under tree crops.
Damage to tree crops can be a limiting factor to crop/livestock integration. Apart from young trees being trampled and broken, livestock debark the trunks and expose roots of citrus, cashew, rubber, cocoa and mahogany. Cattle damage leaf tips of palm and eat ripe fruit bunches of oil palms when the trees are small and young; sheep pick and eat young cocoa pods and on heavy soils livestock can cause compaction. In high rainfall areas grazing and confinement at night cause puddling of the soil and adversely affect the root system of oil palms.

Economic Viability:
Inputs like fertilizer for crops and forage, drugs for animals, tranportation for movement of staff, produce and livestock need to be available.
Operations like land clearing, plantation and cover crop establishment, purchase of livestock, drugs and fertilizer will require credit. Most small plantations are established by an individual helped by relatives, usually without the help of outside labour.
There are a large variety of food and cash crops such as cowpeas, cassava, plantains, maize, sunflower, peanuts, banana, etc., that are interplanted with tree crops to provide income while the major crop is becoming established. Decision has to be made on whether to interplant crops or to undersow plantations with forage for livestock.
Due to the remoteness of some plantations, regular cattle markets may not be available and stock owners may be forced to sell animals for low prices. This factor should be taken into account when assessing the economic alternatives of interplanting crops or integrating livestock.
Social Feasibility:
Attempts at settling pastoralists in the wetter areas of Nigeria and Ivory coast have run into problems because of the inability of pastoralists ot obtain land to cultivate food crops. It is possible, however, that pastoralists would like to establish plantations which could provide forage for their livestock, or that they could graze their animals under plantations for a fee.
The fact that the content is derived heavily from Nigerian experience is attributable to the location of two highly relevant internationally sponsored research programmes in that country. Nigeria encompasses all of the West African ecological zones from mangrove swamp to Sahel, and its national development plan supports small farmer development, pastoralist sedentarization and development of parastatal and private farming enterprises.
It is expected therefore that the Nigerian experience will have increasing relevance and value for other West African countries over the next few decades.

322 89 - 3/51

Integrated systems
Review, tropics, integrated approach, aquatic macrophyte, problems, productivity, composition, research needs, food potential
EDWARDS,. P.
Food potential of aquatic macrophytes.

ICLARM Studies and Reviews 5 ISSN 0115-4389, ICLARM, P.O.B. 1501, Makati, Metro Manila, Philipines, Repr. 1984, 51 pp.

The present paper reviews critically the various aspects in which aquatic macrophytes may be used in food production. The term "weed", to refer to aquatic macrophytes, has been purposefully

avoided as far as possible, since, as pointed out by certain authors, involving them in the food production process may be a far more effective control method than their mere destruction. Furthermore, several species have considerable potential in their own right and warrent detailed study. Indeed, considerable benefit would accrue in the field of aquaculture in general, if botanical aspects of the subject were given due attention.

The prolific growth of several species of aquatic macrophytes in certain water bodies leads to a multitude of problems. Because of the adverse effects of such dense vegetation, there is a voluminous literature on the control of aquatic macrophytes, with emphasis on their destruction. There is also the paradox of food shortages coexisting with large expanses of aquatic vegetation in many developing countries, where the utilization of these plants as food would convert a weed problem into a valuable crop.

An attempt is made in this review to identify ways in which aquatic macrophytes may be used in the food production process. A schema is presented which outlines strategies in which aquatic macrophytes are presently involved, or could become involved, in food production. Those strategies which may have the greatest value or potential are identified.

Because a certain strategy is recommended as worthy of attention, it does not necessarily mean that it should be implemented in a given locality, but rather that it should be considered against all other alternative uses of the aquatic macrophyte and/or utilization of the available space and energy inputs available. The final choice is likely to be influenced by a variety of factors including the physical environment, the climate, the degree of development of the area, marketing facilities, and local customs.

Aquatic macrophytes may be involved in the food production process, directly as human food, as livestock fodder, as fertilizer (mulch and manure, ash, green manure, compost, biogas slurry), and as food for aquatic herbivores, such as fish, turtles, rodents and manatees. An attempt is made to identify the strategies which may have the greatest potential at present. The following research areas are suggested as worthy of attention: protein content and yield of *Ipomoea aquatica* and *Neptunia oleracea*, two vegetables which grow year round in the tropics and can be propagated from cuttings; protein content and yield of various types of duckweed in the tropics as a function of different concentrations of various organic wastes; *Azolla* and filamentous blue green algae as biofertilizers; composting aquatic macrophytes and the use of the compost as an organic fertilizer in fish ponds; aquatic macrophytes in biogas production and the use of the slurry as an organic fertilizer in fish ponds, and the feasibility of stocking herbivorous fish in irrigation systems with large aquatic macrophyte populations.

The intention of this paper is to indicate the role of aquatic macrophytes in food production, and the author hopes that the research recommendations may be of use in focusing future studies on these underexploited plants.

89 - 3/52

323

Integrated systems
Africa, Nigeria, socioeconomic study, case studies, subhumid zone, ILCA, farming systems, integrated approach, research, pastoralism, dairy production, development, household, women, economics, smallholder
WATERS-BAYER, A.
Dairying by settled Fulani agropastoralists in Central Nigeria - The role of women and implications for dairy development -.

Farming Systems and Resource Economics in the Tropics Vol. 4; Wissenschaftsverlag Vauk, Kiel, Postf. 4403, 2300 Kiel 1, ISBN 3-8175-0033-5, 1988, 317 pp.

Over 95% of milk produced within Nigeria is derived from the traditional livestock sector. The dairy herds are kept primarily by pastoral Fulani families, which process the milk before selling. Milk production, processing and marketing are thus combined within numerous small independent dairy enterprises. This study is an attempt to describe and analyse the present situation of dairying by Fulani who have settled in an area of Nigeria thought by development consultants and planners to have a high potential for animal production, particularly dairying - the subhumid Middle Belt. The study is limited to the household level of dairy production and marketing. The marketing structure is depicted from the smale-scale producers' point of view. Where sales which do not go directly to consumers but rather via intermediaries, the description goes no further than the point when the milk products leavesthe hands of the Fulani producers and sellers.

The study formed part of a wider programme of Livestock Systems Research (LSR) conducted in central Nigeria by the International Livestock Centre for Africa (ILCA). The aim of this programme is to gain sufficient understanding of the existing livestock production systems to be able to develop appropriate, improved technologies to increase productivity. The case study approach and combination of qualitative and quantitative methods used are described and assessed so as to illuminate possibilities of development-oriented socioeconomic research within an interdisciplinary LSR team.

The thesis is divided into three parts: Part one (pp. 1-75) describes the methods on investigation, research objectives, the local setting of the study and the wider national context of dairy development and livestock industry in Nigeria. System approach has been used in order to 'study the existing livestock production systems as a whole, identifying and testing possible innovations and defining priority areas for more intensive research'. Part two (pp. 75-208) is devoted to the presentation of the material collected by the author, and the research findings. It represents the core of the study with detailed and rich first-hand field work material and results. Part three (207-328) refers to the planning implications of the study for milk-collection schemes, small holder milk production, dairy extension and training, small-scale

dairy processing groups and the relevance of all of that to rural and urban nutrition, on the one hand, and for Fulani women, on the other.

324 89 - 3/53

Integrated systems
Africa, Mali, livestock production, economics, productivity indices, agro-pastoral system, ILCA, production traits, traditional system, cattle
WILSON, R.T.
Livestock production in central Mali: economic characters and productivity indices for Sudanese Fulani cattle in the agro-pastoral system.

Trop. Agric. (Trinidad), Vol. 66, No. 1, 1989, pp. 49-53

Most data relating to the productivity of African indigenous cattle come from modern production systems. Relatively few literature reports relate to productivity of native cattle under traditional African ownership.
It is probable that more than 90% of all cattle output in inter-tropical Africa comes from traditional systems. The constraints met in them and the actual productivity from their cattle should be understood before attempts to improve them are made. The results presented in this paper are a part of a study on one such traditional system carried out by the International Livestock Centre for Africa in central Mali.
Data relating to traditionally managed cattle for 1978-1984 were analyzed.
Calving interval (725 days) was not significantly affected by any variable. Cow postpartum weight (219 kg) was significantly affected by the management unit, the season and year of calving and by parity ($P<0.001$). 365-day calf weight (78,3 kg) was significantly influenced by the management unit ($P<0.01$) and by year of birth ($P<0.05$). Mortality to 365 days (17.4%) was significantly affected by system ($P<0.05$) and by year ($P<0.01$). The index, weight of young produced cow $^{-1}$, year $^{-1}$ (36.0 kg) was affected significantly ($P<0.01$) by parity but the values of the other indices (167 g kg $^{-1}$ and 718 g kg $^{-0.73}$) were not significantly affected by any of the variables. Significant correlations between calving interval, 365-day weight and mortality and all three indices indicated that some progress might be achieved in improving the indices. Lack of significant effects of the different variables on the indices themselves precluded easy construction of appropriate improvement paths such as have been proposed for goats and sheep in this environment.
Results of productivity studies on the same type of cattle under the controlled conditions of a livestock station in the same area in which the current research was carried out indicate that Sudanese Fulani cattle are capable of achieving outputs similar to those of other African indigenous breeds. Improvement of cattle productivity could perhaps best be attempted through improving the

feed supply by planting of forages or by intercropping them with staple cereals, by increasing the effectiveness of the veterinary services, by training in management skills of owners and herders, and perhaps by tackling the sensitive issue of total livestock numbers. The introduction of exotic breeds with high response capability to improved levels of inputs - a "solution" which is often proposed by politicians and developers - should not be attempted until the adaptive features of indigenous zebu cattle have been identified and exploited to the full.

325 89 - 3/54

Integrated systems
Review, report, developing countries, tropical highlands, Latin America, Colombia, Africa, Rwanda, Tanzania, low-external-input, sustainability, ecology, development projects, multiple cropping, fruit trees, green manure, shrub legume fallow, agroforestry, fodder, erosion control, GTZ, EC, BMZ
KOTSCHI, J. et al.
Methods of ecologically oriented agriculture under low-external-input conditions in agricultural development projects.

Synthesis Report of a Res. Programme, No. TSD-A-070, The Commission of the European Communities (CEC), Brussels, Belgium and GTZ, Eschborn, F.R.G., 1988, 71 pp.

Smallholders in Third World countries constitute at least two thirds of the rural population. Most of them face problems of land scarcity, low fertility status of the soil, and limited availability of external inputs (e.g. mineral fertilizers).
The objective of the present research programme is to develop methods of ecologically sound agriculture which make use of few external inputs and are suitable for the conditions of smallholders. The most important measures to achieve this aim are:
- agroforestry or multistorey farming
- multiple cropping (sequential cropping and intercropping)
- intensive gardening and vegetable growing
- green manuring
- biological nitrogen fixation (cultivation of legumes, blue algae, azolla, etc.)
- manure and compost application
- mulching
- integration of livestock and crops within the farming system (e.g. by forage cropping, stall-keeping, using fodder trees and shrubs, and combining pastures with tree crops)
- pond aquaculture.

These measures are considered of primary importance because all of them either contribute to a higher production of biomass and/or an increase in organic matter content in the soil. Both the production of biomass and organic matter are most important parameters in a system designed to sustain soil fertility and to make more efficient use of basic resources like nutrients, water and light.

The approach taken to meet this objective has been to initiate several small-scale programmes of applied research in existing development projects supported by the GTZ (German Agency for Technical Cooperation). Close cooperation is sought with extension workers and farm families. Accordingly, less emphasis is laid on conducting agronomic trials on research stations and greater emphasis on trials in village demonstration plots and farmers' fields. In this way, a high degree of applicability of research results can be achieved.
Six GTZ projects initially applied for research support. Only four subprogrammes eventually came into being:
- intercropping and agroforestry research in the Caja Popular Project in Tunja, Colombia
- green manuring research in the Agro-Pastoral Project in Nyabisindu, Rwanda
- research on agroforestry and livestock-crop integration within a farming system, in the Soil Erosion Control and Agroforestry Project in Lushoto, Tanzania
- research on livestock-crop integration within a farming system, in the TAD project in Samarinda, East Kalimantan, Indonesia.

These four subprogrammes were jointly financed by the European Community (EC), the German Federal Ministry of Economic Cooperation (BMZ) and the German Agency for Technical Cooperation (GTZ). The different subprogrammes commenced work between January 1985 and February 1986, and not all of them have yet been completed. The work in Indonesia had to be discontinued and the preliminary results are not reported here.
This "Synthesis Report" presents the initial results of the research subprogrammes in Colombia, Rwanda and Tanzania. A description of each research location is followed by a brief problem analysis and - based upon this - an outline of the main aims of the research and the methods applied. The discussion of results is limited to the main findings, which already indicate the perspectives for future research. Deeper analyses of the data are still underway and final results will be presented in more detailed publications.
Abstract from author's introduction, amended

326

89 - 3/55

Integrated systems
Africa, Nigeria, review, subhumid zone, ILCA, wet season, dry season, pastoralism, integrated approach, crops production, livestock production, agropastoralism, pastoral settlement, cattle, land-use, national policy, animal diseases, tenure, inputs, credit, research needs
FAO
The progression from pastoralism to integrated crop and livestock production.

In: Integrating Crops and Livestock in West Africa, FAO Animal Production and Health Paper No 41, Rome, Italy, Repr. 1985, pp. 13-32

It has been pointed out that the settlement of arable farmers and pastoralists are spatially, economically and socially related. Although West African arable farmers are disinclined to herd cattle, even if they own them, they appreciate cattle food products and the manure, draught and transport benefits which cattle provide; pastoralists also appreciate the benefits of convenient markets for livestock products and access to crop residues. Many pastoralists are becoming agropastoralists by including subsistence crops in their farming systems. Thus, apart from seeking the same social amenities like schools and health facilities as the arable farmers, many now have the same ecological and market needs which result in their settlement within, or on the periphery of, arable farming communities.
Pastoral women sell sour milk and butter along with prepared millet or sorghum which is mixed with the sour milk at the time of sale. This can bring about a partnership between the pastoral and the arable communities to trade their different products to the same consumers.
In the arid zones crop/livestock integration is limited by climate. As average annual rainfall rises above 400 mm, crop production becomes more important and is increasing in area in response to growth in human population; in the southern pastoral zone of Niger the influx of farmers into areas that were dry-season grazing reserves for semi-nomadic pastoralists started in 1948. This expansion was not interrupted by the drought of 1968 during which Hausa merchants continued to plant grain but depended on trade profits for the purchase of food. The provision of permanent water has permitted the establishment of large resident cattle populations. The combination of permanent farmers, resident cattle and dry years has so damaged land resources that migrating Tuareg farmers are being forced to settle. This sequence is common in many of the drier areas in West Africa.
The proximity of farming and pastoral communities is indicative of historical interdependence between the two groups. Deferred grazing of the pastoralists' own crop residues and the coralling of cattle on their fields as instances of deliberate integration of the two production systems are cited. The advantages of settlement are analyzed and concluded that settled pastoralists having crop residues were more likely to be able to supply their herds' nutritional requirements than nomads.
In this paper the following topics are discussed in detail :
- Pastoral settlement and the adoption of agropastoralism
- Agropastoral livestock production
- Agropastoral crop production
- Reduction in trypanosomiasis risk
- Cattle distribution within the subhumid zone
- Livestock national policies
- Impediments to integration
- Related research

The paper concludes that there is very little information that extension services can offer traditional agropastoralists who are adopting integrated crop/livestock systems.

327 89 - 3/56

Integrated systems
Latin America, Ecuador, farming systems, cassava, shrimp farming, tide, pond, feed, subsistence crop, farmer
CIAT
Rising tide in Ecuador for cassava shrimp farming.

CIAT International, 7, No. 2, October 1988, pp. 3-6

Shrimp farming is a booming business in Ecuador's coastal Manabi Province. In the last decade, this industry has gone from a near novelty to a major contributor to the economy of this Andean country. Ecuador has become the world's largest exporter of pond-raised shrimp with pond area approaching 100.000 hectares. Fresh and frozen shrimp exports bring the country more than US$ 300 million a year and the demand is growing.
One of the components which is contributing to the development of the industry is cassava: new ways to process the root are providing an essential agglutinant for shrimp feed. This technology is making what had been principally a subsistence crop a key component of an international food marketing business.
Cassava is being used in shrimp feed because of its high content of elongated starch granules that give it its sticking properties. Used as an agglutinant to hold the feed pellets together, it is replacing imported, reportedly toxic, agglutinants. Shrimp growers cannot get enough cassava to fill production needs.
The system worked well and in just a few months the associations produced 50 tons of dried cassava in an initial test of the technology. Success was contagious as more farmer associations sprang up. By 1986, the amount of cassava dried doubled to 100 tons a year. The next year it was up to 500 tons, and in 1988, the year's output will be more than 1000 tons. There are presently 20 farmer associations with around 400 members.
This amount, though impressive for the initial phase of a project, meets only a fraction of the demand. Animal feed manufactures are eager to substitute even more cassava for maize and sorghum, particularly since grain prices are escalating and some grain is imported. With the discovery that dried cassava can be used as shrimp feed, the need for the crop has taken a dramatic upswing.
The feed, compressed in the form of pellets, contains high amounts of protein from fish meal or soybean meal to which vitamins and minerals are added. The pellets need to be sufficiently durable to remain undissolved in water for up to six hours, yet not so hard that the prawns cannot eat them. The crustaceans used their front claws to hold the pellet pieces while they eat them.
Most Ecuadorian manufacturers of feed concentrate for shrimp have used European-made, expensive, chemical glues based on formaldehyde that give the pellet its consistency. These chemical binders are no longer available. Cassava starch, on the other hand, can be used to produce a natural glue effect that is both inexpensive and non-toxic. An additional advantage of using

cassava for this purpose is that it can be produced locally and it generates jobs.
The demand of the burgeoning shrimp industry is not the only area of the market that is growing. Consumers in Guayaquil and surrounding areas are buying fresh cassava conveniently packaged. It is being sold by the farmer associations using CIAT-developed technology to conserve the root. Freshly harvested cassava is put into plastic bags, sprayed with thiabendazole (a chemical with fungicidal properties), and sealed. This retards deterioration and keeps it fresh for up to two weeks. Without such treatment, physiological changes begin within 24-48 hours after harvest and microbial deterioration often starts within 5-7 days.
Some big changes are taking place in the lives of several hundred farm families in Ecuador. Many farmers, who on the average have less than five hectares of land, are making a subsistence crop the basis for a profitable business. This was undreamed of only three years ago.
Agricultural officials, scientists, farmers, and industrialists are clearly optimistic about the future of cassava growing in Ecuador and have taken positive steps toward the integration of research, extension, farmer organization, and marketing.

328 89 - 3/57

Integrated systems
Latin America, Peru, project, report, study, aquaculture, wastewater, natural resources, World Bank, GTZ, water supply, urban development, fish, prawns, sustainability
COINTREAU, S.J.
Aquaculture with treated wastewater: A status report on studies conducted in Lima, Peru.

Technical Note No. 3 of the Integrated Resource Recovery Project; The World Bank - Water Supply and Urban Development Department, Washington D.C., 1987, 54 pp.

In 1981, a global research, development, and demonstration project on integrated resource recovery was undertaken by the World Bank as executing agency for the United Nations Development Programme. The goals of the project are to achieve economic and environmental benefits through sustainable and replicable resource recovery and recycling of liquid and solid wastes from municipal and commercial sources.
A major goal of the project is to develop and encourage resource recovery as a means of offsetting some of the costs of community sanitation, which may account for more than 50% of total expenditures. Aquaculture in higher-level wastewater treatment (polishing) laggons offers one method of partially or totally offsetting these costs. This would not only make it possible to achieve high quality standards for effluent discharge for environmental improvement but would also enhance the opportunities for effluent reuse.

This note documents research, development, and demonstration studies on fish and prawn culture was conducted at the San Juan Laggons in Lima, Peru. Potential public health risks of fish consumption were examined through microbiological analyses of both raw and processed fish. Financial support was provided by the United Nations Development Programme, Global and Interregional Projects Division. Additional financial support came from the German Agency for Technical Cooperation (GTZ).

This study has shown that significant quantities of protein for either human consumption or livestock feed could be produced from wastewater-based aquaculture, which could be integrated with sewage stabilization lagoon systems. Reuse of treated sewage to fertilize the microbial food chain for aquaculture presents one of the most economic resource recovery options for cities in developing countries.

Fish and prawns were cultured in wastewater stabilization lagoons operating as polishing lagoons in series with primary and secondary ponds. Some of the fish ponds were operated as batch-type (receiving make-up water only) rather than flow-through ponds. The fish fed on the natural food chain fertilized by the nutrients in the treated wastewater; no supplemental feed was added.

The hypothesis being tested was that fish and prawns would grow in wastewater-based ponds and be acceptable for human consumption either directly or indirectly (for example, fish may be used as a protein source for livestock or a second generation of fish ponds). It was found that the environmental conditions in the ponds were satisfactory for the survival and growth of tilapia and carps, particularly in the cycle-end polishing ponds. Although the prawns grew satisfactorily, they did not survive unanticipated large fluctuations in water quality due to shock loadings, which may be common under uncontrolled conditions. The experience in Lima indicates that ammonia is a key water quality constraint for fish growth and production, and that total ammonia should not exceed 2.0 mg-N/l.

Raw fish examined in this study had no parasites on the gills or skin, or in the muscle. Furthermore, the bacteria load of the muscle portion of raw fish was acceptable for human consumption. However, higher bacteria levels within the digestive tract and peritoneal fluid could lead to contamination of food preparation areas during fish cleaning. Experiments in processing the fish through salting and smoking promise as a means of minimizing public health risks to consumers. Indirect consumption through crushing the fish and disbursing them to other fish ponds or for use as livestock feed has not been tested.

329 89 - 3/58

Integrated systems
Review, book, tropics, goat, sheep, breeds, reproduction, feeds, diseases, parasites, management, productivity, processing, marketing
PAYNE, W.J.A. et al.
Goat and sheep production in the tropics.

Intermediate Tropical Agriculture Series; Longman Scientific and Technical, Longman Group UK Ltd., Essex CM 20 2JE, England; ISBN 0-582-60935-6, Repr. 1987, 264 pp.

Goats and sheep are important domestic animals in tropical livestock production systems. In the subsistence sector pastoralists and agriculturists often depend on them for much of their livelihood.

Both goats and sheep are widely distributed, from arid semi-desert to humid rainforest regions, and represent 20·2 and 28·9 per cent, respectively, of the total populations of ruminant livestock in the tropics and sub-tropics. Although the total number of sheep is greater than that of goats, sheep in the tropics represent a lower proportion of the total world population. The largest concentration of goats are in Africa and in the Indian sub-continent. India, with 71 million, is the country with the largest goat population. Africa also has a large sheep population as does Western Asia and South America.

Data on changes in the goat and sheep populations between 1970 and 1979 show that goats and sheep increased at the rates of 2·2 and 0·4 per cent, respectively. These rates are well below the rate of increase of the human population in the same area. In the Indian sub-continent and in South America the rate of increase of the goat population was greater than that of the sheep population whilst in Africa and Western Asia the reverse was the case.

This book describes goat and sheep husbandry in the tropics and suggests ways in which these domestic species can be exploited for the benefit of tropical peoples. There are regions in Africa and Western Asia that are located outside the geographical tropics, but where problems of goat and sheep husbandry, and even the breeds, are similar to those encountered in the tropics. There will, therefore, be some mention of breeds and husbandry systems that are not, by the strictest definition, tropical.

The book presents knowledge in a compact and easily available form and suggests ways of overcoming the limitations of goat and sheep production by the application of developments in technology.

Parts 1 and 2 discuss in some detail various aspects of goat and sheep production. Part 3 considers the important topic of potential production and aims to stimulate further interest in both species. Various possibilities for the achievement of maximum productivity, both technical and non-technical, are discussed. Terms which may be unfamiliar to readers are defined in the glossary.

The practical approach to husbandry gives a comprehensive and reliable knowledge of how to rear and maintain healthy, productive goats and sheep in a tropical environment.
Students of agriculture at schools and colleges will find the book of use, as well as teachers, farmers, agricultural extension workers, planners and administrators.

330 89 - 3/59

Integrated systems
Africa, Tanzania, Kenya, Botswana, tropics, developing countries, apiculture, agroforestry, farmers, sustainability, beekeeping, ICRAF

PAWLICK, T.
The underexploited bee.

Agroforestry Today, Vol. 1, No. 2, 1989, pp. 8-10

Apiculture, as an ancient craft using traditional hives, has been present in rural African life from time immemorial. So have a whole series of handicaps that make life difficult for those who harvest honey - obstacles which agroforestry could play a significant role in overcoming.
Typical African beekeeping problems include 'random occupation of hives; swarming, migration and absconding, and defensive (aggressive) behavior'.
The potential rewards of beekeeping are as great as the challenges Africa poses for it. Not only is there a market for honey - whose current average world retail price hovers around $10 per litre. Beeswax is also in demand, along with a whole host of honey or wax-based secondary products, from processed sweets and condiments to cosmetics. Perhaps equally important, particularly in an agroforestry context, is the effect bees have on both tree and field crops.
The potential has barely begun to be tapped in Africa. In Tanzania, for instance, it has been estimated that beeswax exports could be increased tenhold, if the country's forests and woodlands were properly exploited. For Africa as a whole, whose exports of beeswax are measured in hundreds of tonnes, the export figure could potentially rise above 3,000 tonnes if resources were fully utilized (of course, this assumes honey harvesting has been well established, so the removal of wax from hives does not cause too great percentage of bees to leave off honey-making in order to make up the wax deficit). A 1985 study noted Tanzania's crop of export quality honey totalled only 467 tonnes, while the potential yield could be as high as 184,000 tonnes per year.
Agroforestry, offers some solutions, based on the symbiotic relationships between bees, field crops and trees. Woody perennials are important sources of nectar and/or pollen for honeybees, and bees are important as pollinators. A system that combines apiculture and agroforestry - apiforestry, in other words - is therefore likely to improve the quality of life and the

revenue of many small farmers who would harvest hive products and would also probably have better yields from their trees as a result of better pollination.
By growing appropriate trees, the period when nectar and pollen are available can be extended. Woody plants are generally preferred to herbaceous species for this purpose because they are less affected by moderate climatic variations. This is especially important in arid of semiarid zones.
Best results are achieved by planting trees which are actually somewhat ill-suited to their environment. Those which are not at their ecological optimum, which are slightly marginal to local conditions, will often produce their flowers at a different moment than their neighbors. Some trees under these conditions even react by producing more flowers than normal.
For example, *Eucalyptus gomphocephala* gives better results in some places in North Africa than on its native sandy plains of southwestern Australia. There are tens of thousands of flowers on an adult eucalyptus, and each one of them provides work for several bees over several months. Even one tree thus represents a considerable source of nourishment for a bee colony. The popular agroforestry species *Grevillea robusta* is also known as a prolific producer of honey-yielding-flowers.
A tree of a great potential for dryland beekeepers is the so-called Apple-Ring Acacia, *Faidherbia albida*, also called *Acacia albida*.
Planting melliferous (honey-yielding) species could do much to alleviate some of Africa's chronic apicultural handicaps. Providing a water supply is present, extending the period when flowers are available as bee forage could significantly reduce colony migrations, as well as the need for bees to consume their own honey during periods of food scarcity. At the same time, it would boost the total honey output of the colonies affected.
Realizing the potential involved, the International Bee Research Association (IBRA) has made a survey of world honey sources, and has published a Directory of Important World Honey Sources. The directory includes hundreds of plants, many of them multipurpose trees capable of yielding timber, animal fodder, fruit or other products.
The IBRA's directory, which is stored on a computerized database, lists many such species. Programmed searches can be made for them on the basis of such economic uses as fuel, timer, hedges, afforestation, amenity planting, soil benefit, erosion control and soil enrichment.
For further information contact: Information Officer for Tropical Apiculture, International Bee Research Association (IBRA), Hill House, Gerrards Cross, Bucks, SL9 ONR, U.K..

IV CROPPING SYSTEMS

331 89 - 4/34

Cropping systems
North America, USA, experiment, temperate climate zone, cropping system, conventional agriculture, low-input system
LIEBHARDT, W.C. et al.
Crop production during conversion from conventional to low-input methods.

Agron. J. 81, 1989, pp. 150-159

Alternatives to conventional agricultural methods range over a wide spectrum. As used in this paper, the term "low-input" emphasizes the use of international resources generated on-farm rather than purchased resources produced externally. Pest control is achieved mainly through cultural and biological methods, such as mechanical cultivation and crop rotation, and nutrients are supplied primarily by animal and green manures.
A fundamental difference between low-input and conventional systems is the use of more diverse crop rotations in low-input systems. Continuous cropping of corn, or corn and soybeans, cannot be sustained without substantial additions of fertilizer and pesticides. Many studies demonstrate reduced yields in continuous corn compared to corn following hay or small grains.
Another important component of low-input farming systems is the use of animal manures, green manures, and cover crops. These soil amendments provide nutrients and organic matter, the benefits of which have been discussed elsewhere.
Very few replicated experiments have been conducted comparing low-input and conventional systems.
A 5-yr cropping system experiment was initiated in 1981 to study transition from a conventional agricultural system using pesticides and fertilizers to a low-input system. Three 5 yr rotations were compared. A conventional corn (*Zea mays* L.)-soybean [*Glycine max* (L.) Merr.] rotation (designated "conventional") was compared to two low-input rotations which utilized oat (*Avena sativa* L.), red clover (*Trifolium pratense* L.) and winter wheat (*Triticum aestivum* L.), in addition to corn and soybean. One low-input rotation used cattle manure as a nutrient source and produced forage crops in addition to cash crops (designated "low-input/livestock"), while the other used legume crops as a nutrient source and produced a cash crop every year (designated "low-input/cash grain"). Corn grain yields in the low-input systems were 75% of conventional in 1981 to 1984, but yields were not significantly different in 1985. Weed competition and insufficient N limited low-input corn yields during the first 4yrs. Soybean yields in the low-input systems were equal to or greater than conventional all 5 yrs. It is concluded that a favourable transition from input-intensive cropping to low-input systems is feasible, but only if crop rotations are used which include crops that demand less N and are competitive with weeds, such as small

grain, soybean, or legume hay. Corn should be avoided for the first 3 to 4 yrs.
A farmer might choose to facilitate the transition by reducing pesticide and fertilizer inputs gradually. Herbicides could be banded in the row at a reduced rate and supplemented by cultivation. If corn must be grown during the first 3 to 4 years, low rates of N fertilizer could be applied to supplement N derived from manure or legumes.
In the conversion from conventional to low-input farming methods, weed and nutrient problems may result if herbicides and fertilizers are withdrawn without designing the system to function without these inputs. Management skills are a key factor in designing systems to make this transition successful. The primary management decisions in this experiment were related to weed control, and the production and availability of N. Future work will concentrate on refining low-input systems to further improve weed control and N availability, as well as to reduce soil erosion and nitrate leaching.

332 89 - 4/35

Cropping systems
Asia, India, experiment, sole cropping, intercropping, rice, mungbean, soybean, peanut, blackgram
MANDAL, B.K.
Effect of intercropping on the yield components of rice, mungbean, soybean, peanut and blackgram.

J. Agr. & Crop Science, 162, 1989, pp. 30-34

Due to the bottleneck of availability of cultivable land, the scope for horizontal expansion for increasing foodgrain production in India is gradually becoming limited, but there is a good scope for vertical expansion through intensified cropping. Intercropping is one of such approaches. Rice (*Oryza sativa* L.) enjoys second position among the cereal crops in the world. The crop is also adapted to diverse agroclimatic conditions. In West Bengal, rice is the predominant crop, being grown in more than 70 per cent of the cultivated land. Pulses are the chief sources of dietary proteins in India. Well equipped with the unique property of fertility restoration, they have been considered to be the backbone of Indian agriculture. Among the pulses mungbean, blackgram and soybean occupy an important position in West Bengal. Among the oilseed crops, groundnut holds a dominant position in India.
An investigation was carried out to study the feasibility of growing different leguminous crops as intercrop with rice.
The soil was alluvial, sandy loam in texture with 0,063% N, 15.88 kg available phosphorus, 80.40 kg available K/ha and a pH of 7.6.
The 14 cropping systems were: sole rice, sole mungbean, sole soybean, sole peanut, sole blackgram, rice + mungbean (4:1), rice + mungbean (2:1), rice + soybean (2:1), rice + soybean 4:1), rice

+ soybean deferred (2:1), rice + peanut (2:1), rice + peanut (4:1), rice + blackgram (4:1) and rice + blackgram (2:1). Sole crop of rice always recorded higher number of effective tillers/m², however, it was observed that legumes had an influence on the number of filled grains per panicle in rice + legume combinations. Among legumes, pure crops of soybean and peanut always gave rise to increased number of yield components in comparison to the other crops grown in association with rice. In case of mungbean, number of pods per plant and thousand kernel weight was higher in pure crops, though number of seeds per pod was more with rice + mungbean combination. Blackgram in association with rice yielded greater number of seeds per pod and thousand kernel weight though sole crop of blackgram significantly produced higher number of pods per plant.

333 89 - 4/36

Cropping systems
Fed. Rep. of Germany, greenhouse trials, sandy soil, missed cropping, sole cropping, wheat, barley, persian clover, salinity, soil water regime, soil temperature, nutrient uptake, protein content
HOSSIEN, Y.K.
Einfluß der Faktoren NaCl-Versalzung, Boden-Wasserregime und Bodentemperatur auf Wachstum, Nährstoffaufnahme und Proteingehalt von Weizen und Gerste in Reinkultur und in Mischkultur mit Perserklee.- (Influence of the factors NaCl salinity, soil water regime and soil temperature on growth, nutrient uptake and protein content of wheat and barley in single cultivation and in mixed cultivation with persian clover).

Göttinger Beiträge zur Land- u. Forstw. i.d. Tropen und Subtropen, 30, 1987, 289 + Annex.

The present experiments were intended to give information on the influence of NaCl salinity, water regime, and soil temperature on growth, nutrient uptake, and protein fractions of different convars or varieties of wheat and barley grown either singly or mixed with Persian clover (*Trifolium resupinatum* L.) on marginal sandy soils. The experiments were carried out in a temperate or an untemperate greenhouse. The results are presented in the following sections according to the four main factors.

NaCl salinity

Salinity has been tested with wheat and barley in single- and mixed cropping in the temperate and in the untemperate greenhouse.
- Low salt content of the soil (o,05% NaCl) had generally no negative but frequently often a positive effect on growth (shoot dry weight) and seed weight.
- Higher salinity reduced shoot and root dry weight and seed weight.
- Barley proved to be more tolerant to salinity stress than wheat.
- The wheat cv. Ralle and the barley cv. Carina showed an average tolerance to salinity compared to some local varieties tested.

- Soil salinity led to a higher TCA-soluble protein fraction in the seeds.
- Mineral uptake was disturbed by soil salinity: uptake of N, P, K, Ca, and Mg was reduced whereas Na and Cl uptake was increased. Hence the Na/K ratio was increased.
- Seeds, in general, had lower content and uptake of Ca, Mg, Na, and Cl.
- High salinity in the soil led to a decrease of total water uptake, whereas relative water uptake (water uptake/dry matter of shoots) was increased.
- Application of gypsum ($CaSO_4 \cdot 2 H_2O$) to salinized soil (0,2% NaCl) caused slightly better growth and slight increases of N, K, Ca and Mg in the plants. Na in this case was reduced only in barley.

Water regime

The water regimes were tested with wheat and barley grown in single- and mixed cropping in the temperate and in the untemperate greenhouse.
- Water regime of 20% led to depressions of growth with both wheat and barley. Already low soil salinity reduced growth additionally under these dry conditions.
- Increase of watering increased growth shoot dry weight, ear weight, number and weight of seeds. Root dry weight was increased as well and also water consumption.
- TCA-soluble protein fractions were decreased when plants were watered at higher levels.
- Higher water regimes reduced the concentrations of N, P, K, Ca, Mg, Na, and Cl in the plants, Na and Cl more than those of the nutrient elements. The total uptake of N, P, K, Ca, and Mg was increased, whereas Na and Cl uptake decreased at higher water levels. Na/K- and Na/Cl ratios were reduced as well.
- Under economical considerations the water regime of 55% showed the best results increasing growth on the one hand and reducing relative water consumption on the other hand.

Soil temperature

Different soil temperatures were applied to wheat and barley only in single cultivation and in the temperate greenhouse.
- Under the given conditions high shoot dry weights were achieved at the soil temperature of 20° C.
- Increase of the soil temperature reduced growth of barley and wheat. Barley showed to be more tolerant than wheat up to a temperature of 30° C.
- High soil temperatures disturbed the nutrient balance of wheat and barley; the concentrations of N, P, K, and Ca were reduced, those Na and Cl were increased. High soil temperature intensified the negative effect of increasing salinity.

Mixed cropping

Wheat and barley were grown alone or in mixed systems with clover either inoculated with *Rhizobium trifolii* or not inoculated in the untemperate greenhouse.
- Wheat and barley in mixed cultivation with uninoculated clover showed a high tolerance ot salinity stress and yielded high shoot dry weights.
- Mixed cropping of wheat and barley with inoculated clover produced low shoot dry weights.

- Clover - both inoculated and uninoculated - had higher shoot dry weights when grown alone than in mixed cultivation with either wheat or barley.
- Generally, wheat and barley had high nutrient concentrations as well as high nutrient uptakes when grown together with uninoculated clover.
- Salinity reduced contents and uptake of N, P, K, Ca, and Mg of clover, whereas it increased these values of Na and Cl.
- Uninoculated clover in mixed cultivation with either wheat or barley as preceding crop had a positive effect on the growth of the following crops, wheat or barley grown singly.
- Single clover as preceding crop improved the growth of single clover as following crop.

Author's summary

334 89 - 4/37

Cropping systems
Asia, Philippines, IRRI, cropping pattern, small farms, dryland, rice, methodology
GARRITY, D.P. et al.
Determining superior cropping patterns for small farms in a dryland rice environment: test of a methodology.

IRRI Res. Paper Series, 33, 1989, 13 pp.

Strategies for increasing farm productivity that focus on introducing technical changes within a single-crop enterprise are often rejected by farmers because of unforeseen negative effects on productivity or resource utilization. Cropping systems research approaches this problem by determining the effects of potential technical changes on the entire system. This paper discusses the methodology for cropping systems research for dryland rice-based systems in the Philippines. Test patterns are grown on a portion of each cooperating farm under joint farmer-research team management. This methodology involves the farmer actively in the research process, thus facilitating early detection of some of the constraints to adoption at the farm level. The potential for increased crop productivity was tested in the Batanga region where the predominant cropping pattern involves dryland rice followed by field corn. Alternative cropping was tested, including: following rice with alternative field crops that may offer advantages over corn; following rice with two crops to extend cropping further into the dry season; and following rice with intercrop patterns to replace monoculture corn. Alternative crops included soybean, peanut, mungbean, and cowpea. After 3 years of testing, it was found that adoption of an improved corn variety could increase productivity in the dryland rice-corn system studied. Soybean and sorghum appeared to be outstanding alternative crops. However, because neither is currently grown in the area, their acceptation would represent a substantial change in the system. New infrastructural support, markets, and threshers would be required. Intercropping of corn shows the potential of substantially raising

land productivity, but lack of labour appears to be a potential constraint. Cropping patterns with three crops per year were shown to be feasible and profitable.

89 - 4/38

335

Cropping systems
Australia, high altitude, experiment, soybean, cassava, yield, intercropping, sowing time
TSAY, J.S. et al.
Effects of relative sowing time of soybean on growth and yield of cassava in cassava/soybean intercropping.

Field Crops Res., 19, 1988, pp. 227-239

Cassava (*Manihot esculenta* Crantz.) is a major root crop in the wet tropics and subtropics. There is a widespread practice of cassava intercropping in these regions using many different species. Grain legumes are among the crops most often used, this combination providing a better-balanced human diet in respect of protein and carbohydrate. Legumes may also help to minimize the decline of soil fertility, which is a serious problem under continuous cropping with sole cassava. A previous study showed that quick-maturing, short-statured soybean appears to be suitable as an intercrop in the subtropical regions where the growing season is limited to 9 months by low temperature in winter. When intercropped with soybean at 0,9 or 2,7 m row spacings of cassava, there was a large reduction in total biomass production, but tuber yield was not affected, because the harvest index increased.
In intercropping, the relative times of planting of the component crops have both biological and practical implications because they change the relative competitive ability and hence the yield of component crops and the combined yield. It is known that a small difference in relative planting times can cause a large difference in final economic yield, as for example shown for a maize/cowpea intercrop.
A study was made of the development of yield in cassava/soybean intercrops to examine physiological reasons for high harvest index of cassava in intercropping and to identify the optimum time for sowing soybeans. This paper describes the performance of the cassava component, while another paper described that of the soybean component and of sole-soybean crops.
The development of yield in cassava, either as a sole crop or intercropped with quick-maturing soybean sown 1,5 or 9 weeks after cassava planting, or a succession of two soybean sowings 14 weeks after planting, was followed at a high latitude (27°S) where the cassava growing season is limited to 9 months by winter temperatures. Competition, at least largely for nitrogen, restricted the growth of cassava. After soybean harvest, leaf-area increased in such a way that there was little difference in interception of radiation among crops. Consequently growth rates and amounts of assimilates potentially available for tuber growth were similar. Competition from earlier-sown-soybean greatly

reduced branching by cassava. The reduced number of branches were sufficient to provide adequate leaf-area index, but were a reduced sink for assimilates during the main period of tuber growth. The slightly reduced assimilate supply available in early intercropped cassava was offset by the increased partitioning to tubers. As a result, soybean intercropping did not reduce tuber yield, except slightly in the case of double-intercropped cassava, but provided an additional yield of grain. Land equivalent ratio was particularly high at about 1,6 when soybean was sown within 5 weeks of cassava planting. When soybean was sown 9 weeks after cassava planting, land equivalent ratio was reduced to about 1,3 as a result of lower soybean yield.

336 89 - 4/39

Cropping systems
Australia, experiments, subtropical region, cassava, soybean, cultivars, intercropping, evaluation
TSAY, J.S. et al.
Intercropping cassava with soybean cultivars of varying maturities.

Field Crops Res., 19, 1988, pp. 211-225

Short-statured, early maturing soybean (85 days to mature) is suitable as an intercrop with cassava (*Manihot esculenta* Crantz) in the subtropical regions where the growing season of cassava is limited to 9 months by low temperature in winter. It was observed that competition restricted the growth of cassava, but after soybean harvest there was sufficient time for cassava to attain full light interception and to produce high total biomass. Distribution of assimilates to tubers was increased, as a result of reduced branching of cassava and hence competition for assimilates. In consequence, tuber yield was not reduced by the soybean intercrop. Nevertheless, total biomass and grain yield of the soybean were low. Increased crop duration with the use of a late-maturing cultivar may provide higher grain yield but, commonly, cassava tuber yield is adversely affected by long-duration legum crops.
As the duration of a legume crop increases, competition for light becomes more severe. When other environmental and soil factors are not limiting, light becomes the factor determining the productivity of intercrops. Dry-matter growth of an intercrop can be studied in terms of total light interception (LI) and efficiency of conversion (EC) of the intercepted light to plant dry matter. Crop yield then can be expressed as LI x EC x HI, where HI is harvest index. Such an analysis for a sorghum/pigeonpea intercrop indicated slight advantages of the intercrop in all these terms. This type of analysis was adopted for the work reported here in which the effects of soybean cultivars of differing maturity on the growth and economic yield of each component crop were examined in cassava/soybean intercropping. The objective of this study was to identify the

most suitable maturity type of soybean in cassava/soybean intercropping, and to examine which term(s) in the above analysis contributed to the superior productivity of the intercrop.
All soybean cultivars dominated intercropped cassava, and their dry-matter growth and seed yield were not affected by competition with cassava. Growth of cassava was, on the other hand, severely restricted by intercropped soybean, particularly by late-maturing types. After removal of early-maturing soybean, cassava recovered quickly to produce high leaf-area and effectively intercepted solar radiation. Consequential high total dry-matter production, combined with high assimilate allocation to tubers, resulted in tuber yield at the final harvest similar to that in sole cassava. After the removal of late-maturing soybean, however, recovery was poor, and with a short growing season remaining, tuber yields were only 50-60% of that of sole cassava.
In addition to their adverse effect on cassave growth, late-maturing cultivars were not suitable as an intercrop because of low harvest indices and low light-conversion efficiency (dry matter produced per unit intercepted radiation), although total light interception during the whole growth of cassava/soybean intercrop was similar to that of sole cassava. The low overall light-conversion efficiency in intercropping with late-maturing cultivars was due to very low dry-matter production of soybean during pod-filling when light interception was still high.

337 89 4/40

Cropping systems
Asia, IRRI, experiments, cropping systems, subsistence farmers, multidisciplinary approach
HOQUE, M.Z. et al.
Need for long-term cropping systems experiments.

Report (11th) of the Cropping Systems Working Group Meeting, IRRI, 1981, pp. 327-331;

Crop intensification may be necessary to the survival of subsistence farmers in Asia. Because the validity of intensive multiple cropping systems (i.e., effects on the soil, labour utilization) is still being questioned, the authors of this report suggest that long-term trials be designed and implemented before the farmers' situation worsens. The objectives of long-term trials include identifying soil and crop management methods which can be used to ensure high crop yields while protecting the environment and developing a data base for future guidance and research programs. A list of recommendations for planning and implementing long-term cropping systems trials is provided; these include, inter alia, conducting the trials on experiment stations rather than in farmers' fields, focusing the purpose of the trials on the generation of component technology over time, and using a multidisciplinary approach. Attention is briefly given to the types of experiments to be conducted, experimental design, and the

types of data which should be collected and analyzed. An implementation plan for the proposed programm is suggested.
(Abstract from FSR)

338 89 -4/41

Cropping systems
Australia, experiment, cassava, soybean, intercropping, nitrogen
TSAY, J.S. et al.
Growth and yield of cassava as influenced by intercropped soybean and by nitrogen application.

Field Crops Res., 21, 1989, 83-94

In sole cropping, application of N at planting enhanced leaf area and dry-matter production during early stages of growth, but the effects did not persist until the final harvest. Dry-matter partitioning to tubers was reduced, and in consequence tuber yield tended to be less in this treatment than in the no-N control, although not significantly. N-application at day 85 had negligible effects on dry-matter production and partitioning.
The adverse effect of soybean on the growth and morphology of intercropped cassava was similar, but more severe than that of the no-N application in sole crop. Total dry-matter of intercropped cassava was always less than that of sole cassava in any N treatment. Lateral branch production and leaf turnover were reduced by the presence of soybean, and the consequent reduction in shoot demand for assimilates resulted in an increased proportion of assimilates transferred to tubers. When N was applied at planting, harvest index was higher in intercropped than in sole cassava, and tuber yield was similar in the two crops.
Intercropping under no N-application made only a slight improvement in harvest-index over the corresponding sole cassava, while severely reducing total dry-matter production. It appears, therefore, that the tuber yield advantage of cassava/soybean intercropping is likely to be small under low availability of soil N.

339 89 - 4/42

Cropping systems
USA, study, humid tropics, ecosystems, CATIE, plant communities, leaf area, light transmission, roots, damage
GLIESSMAN, S. et al.
Leaf area, light transmission, roots and leaf damage in nine tropical plant communities.

Agro-Ecosystem, 7, 1982, 305-326

The efficiency of resource utilization and resistance to pest attack are two key issues in agriculture, especially as fertilizers and pesticides increase in cost. This is particularly

true in the humid tropics, where year-round growth permits rapid pest and disease build-ups, high rainfall promotes nutrient leaching, and weeds invade agressively. Structurally, diverse multiple-crop tropical agroecosystems might reduce these problems more than the monocultures now often used.
To find out if structurally complex ecosystems make better use of resources and experience less herbivory than do simple systems, nine varied agricultural and successional ecosystems were studied, ranging from simple to diverse, herbaceous to woody, short to tall, and young to old. The study concentrated on a few study areas to reduce variation due solely to geographic variables. Measurements included: leaf area index (LAI) by height and by species and optical density of the canopy, both indicators of a system's light-capture ability; root biomass by depth and diameter class, an indicator of ability to exploit root-zone resources; and leaf damage (caused primarily by herbivorous insects) by species, and indicator of resistance to pest attack.
Six of the nine ecosystems were on the grounds of the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica.
The other three study sites were in the state of Tabasco, Mexico.
Leaf area index ranged from 1,0 in young maize to 5,1 in natural succesion and the gmelina plantation. The vertical distribution of leaves was most uniform in diverse ecosystems, and most clumped in species ecosystems. Light transmission was impoverished inversely proportional to leaf area, and two dense-canopied monocultures (sweet potato and gmelina) were nearly as effective at light capture as were some of the more diverse ecosystems. Optical density of the canopy ranged from <0,5 (35% transmission) in the young maize to >2,0(<1% transmission) in the natural succession.
Large roots (>5 mm diameter) accounted for most root biomass in the older ecosystems at soil depth of 5-25 cm, and fine roots (< 5 mm diameter) were most important in the surface 5 cm in all ecosystems. The range of values for root biomass (39 to 422 g m^{-2} to a depth of 25 cm) were similar to the range of values for leaf biomass (33 to 345 g m^{-2}) and, with the exception of two monocultures, ecosystems with high leaf biomass also had high root biomass. The surface area of the fine roots was lower than leaf area, abd ranged from 0,5 to > 2,0 m^2 m^{-2} of ground. Total root surface area increased with age and diversity, and the monocultures - even those effective at light capture - had low root surface area.
Herbivore damage on leaves of 35 species ranged from <2 to > 16% of leaf area. Heavily damaged species contributed less to total ecosystem leaf area than did species damaged less than average. Ecosystem-level damage was not well correlated with age or diversity. Leaf damage in all ecosystems ranged from about 2 to 10% of leaf area, or <2 to > 25 gm^{-2} of ecosystem.
Young monocultures do not necessarily capture less light, provide less soil cover, and experience more herbivory than older, more diverse ecosystems. However, root surface area (and therefore possible nutrient-capture ability) is high only in ecosystems that are diverse or old, and this is an important design consideration for agroecosystems appropriate for the humid tropical lowlands.

340 89 4/43

Cropping systems
Africa, Nigeria, study, IITA, humid tropics, cassava, maize, okra, egusi melon, plant mixtures, intercropping, productivity
IKEORGU, J.E.G. et al.
Productivity of species in cassava/maize, okra/egusi melon complex mixtures in Nigeria.

Field Crops Res., 21, 1989, 1-7

In Nigeria, cassava (*Manihot esculenta* Crantz) and maize (*Zea mays* L) are dominant components of many traditional complex mixtures. The cassava/maize package developed to small-scale farmers was not readily adopted because of the non-inclusion of minor crops which, in traditional mixed-cropping systems, are as important as the base crops. Some of the minor crops frequently grown with cassava and maize are egusi melon (*Citrullus lanatus* Thunb.) okra (*Abelmoschus esculentus* Moench) and fluted pumpkin (*Telfairia occidentalis* L). It is now being realised that small-scale farmers will not adopt any technology that excludes these essential minor crops. Apart from preliminary work on cassava/egusi melon and cassava/okra mixtures at IITA, little attempt has been made to determine the productivity of major root-crop-based complex mixtures. The study was carried out to determine whether, under technologically improved conditions, the inclusion of egusi melon and/or okra in cassava/maize intercrops actually improves total productivity. Information from this work will reveal the strengths and weaknesses of the cassava/maize recommendation.
The crop combinations investigated, along with their sole crops, were: (1) cassava/maize/okra/egusi melon; (2) cassava/maize/okra; (3) cassava/maize/egusi melon; (4) cassava/maize; (5) cassava/okra; (6) cassava/egusi melon; (7) cassava/okra/egusi melon; (8) maize/egusi melon; and (10) maize/okra/egusi melon.
In cassava/okra and cassava/egusi melon mixtures, cassava yield did not differ from that of sole cassava. Maize depressed the yield of cassava by about 28% in cassava/maize mixture, even though the maize population used was only 50% of the optimum for sole maize. Inclusion of either okra or egusi melon or both okra and egusi melon to the cassava/maize intercrops still gave cassava tuber yields comparable to that from cassava/maize. This indicates that the farmer could still produce as much cassava in cassava/maize/vegetables as in cassava/maize alone.
Intercropping did not depress the grain yields of maize. Maize grain-yield in maize/cassava intercrops was 26% more than in sole maize at equivalent populations. Sole maize yield at optimum population (40 000 plants/ha) was 3.6 to/ha.
It was interesting to note that maize yield remained high irrespective of companion crop type.
Intercropping reduced yield of okra by more than 50%. Unlike egusi melon which spreads very fast, okra grows slowly and hence a

slight shading by a higher-canopy crop would reduce fruit yield. It is probable that tall-growing okra varieties may be more suitable for intercropping than dwarf types, though probably at the expense of other components species.
As was observed for okra, intercropping reduced seed yield of egusi melon by more than 50%. Egusi melon appears to be more compatible with cassava/maize intercrops than okra. For example, egusi melon yielded 49% of sole-crop yield in egusi- melon/cassava and egusi-melon/maize intercrops, respectively, while okra yielded only 28% and 14% with the same companion crops. Also, in egusi-melon/cassava/maize intercrops, seed yield of egusi melon was depressed by 76% while in okra/cassava/maize, okra fruit yield was depressed by 90%.
The various LER and calorie yields obtained from intercropping systems involving cassava, maize, okra and egusi melon are shown in a table: The cassava/maize system is highly productive in terms of calorie yield per unit area per unit time. Inclusion of okra and egusi melon into the cassava/maize system did not further improve calorie yields. The four-crop mixture had slightly lower calorie yields but higher LER than cassava/maize intercrops. This means that although okra and egusi melon did not improve the calorie yields of cassava and maize-based complex mixture, they could improve total productivity per unit area of land. The cassava/maize recommendation could have been based on the high-calorie productivity of the cassava/maize intercrops.
The data of this experiment seem to provide an explanation for the persistence of traditional practice. While dietary requirements are better satisfied, the farmer also saves more land by including vegetables in cassava/maize intercrops.

341 89 - 4/44

Cropping systems
Asia, India, experiments, rainy season, loam soil, lowlands, nitrogen fixation, nodulation, yield, soybean, nitrogen-harvest-index, mineral nitrogen equivalent
CHANDEL, A.S. et al.
Symbiotic nitrogen fixation and nitrogen benefits by nodulated soybean (*Glycine* max (L.) Merrill) to interplanted crops in Northern India.

Trop. Agric. (Trinidad), 66, 1, 1989, 73-77

Simultaneous cropping or mixed cropping is important in Indian agriculture. Intercropping is a variant of this system in which crops are planted in rows.
The merits of mixed cropping relative to sole cropping have been evaluated in sorghum (*Sorghum bicolor* (L.) Moench), millet (*Panicum miliaceum* L.), maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* (L.) Walp.). There are many reports on the beneficial effect of grain legumes such as soybean (*Glycine max* (L.) Merrill) by virtue of their ability to fix atmospheric N_2 and leave the soil enriched. There is, however, a dearth of precise information

on how much benefit cereals and legumes derive from mixed cropping in terms of mineral nitrogen equivalents, nitrogen uptake and grain yield. Benefits were quantified by growing *Eleusine coracana* (L.) Gaertn. and non-nodulated soybean as intercrops with nodulated soybean.
Experiments were conducted to study the effect of nodulation of the soybean (*Glycine max* (L.) Merrill) on plant dry matter, grain yield and nitrogen benefits in terms of mineral nitrogen equivalent (MNE), nitrogen uptake and nitrogen-harvest-index (NHE) in interplanted ragi (*Eleusine coracana* (L.) Gaertn. cv. PES-176 and non-nodulated soybean cv. Lee. Symbiotically fixed N_2 by nodulated soybean was also determined. Nodulated soybean significantly increased plant dry matter and grain yield of interplanted crops. The average beneficial effect in terms of mineral-nitrogen-equivalent, was 41.1 and 82.4 kg N ha^{-1} from non-nodulated soybean and 43.2 and 78.6 kg N ha^{-1} for ragi, respectively, associated with one and two rows of nodulated soybean between the intercrops. Average nitrogen benefit in terms of N-uptake was 61.8 and 73.1 N ha^{-1} for non-nodulated soybean and 32.0 and 45.1 kg N ha^{-1} for ragi associated with one and two rows of nodulated soybean, respectively. Application of N at a greater rate than 20 kg ha^{-1} decreased nitrogen-harvest-index in both interplanted crops. Nodulated soybean, however, slightly improved nitrogen-harvest-index. The quantity of symbiotic N_2 fixed by nodulated soybean cv. Shilajeet was estimated to be 128.1 kg N ha^{-1}.

Cropping systems
USA, experiment, cowpea, forage, planting sequence, nitrogen, intercropping, yield
BRYAN, W.B. and S.A. PEPRAH
Effect of planting sequence and time, and nitrogen on maize legume intercrop yield.

J. Agron. and Crop Sc., 161, 1988, 17-22

Increasing costs of land and energy have stimulated renewed interest in intercropping since growing two or more crops simultaneously may enhance land productivity compared to monocropping. Intercropping reduces risk of crop failure, increases availability of N when a legume is one of the intercrop components, and may increase crop nutritive value. Major difficulties with intercropping include mechanization of cultural practices, and fertilizer and herbicide applications.
Maize (Zea mays L.) and bean (*Phaseolus spp.*) and cowpea (*Vigna unguiculata* (L.) Walp.) are widely intercropped in the tropics for grain production. Some work has also been carried out on the use of the intercrops for forage. Little research has been carried out on maize/legume intercrops for forage in temperate areas. The effects of planting sequence and time on yields are unclear. Thus, an experiment was conduced to compare forage and grain production

of maize/polebean and maize/cowpea intercrops planted in different sequences and at different times. Two levels of N fertilization (0 and 160 kg ha^{-1}) were also included in the experiment.
Intercropping (average of all treatments) reduced maize grain and forage yields compared to maize in monoculture but had no effect on total forage production. However, total forage production was greatest when the seeding sequence was maize intercropped at the same time or before cowpea. Cowpea never produced grain, but forage production was almost twice that of polebean. Maize produced most forage when seeded before the legumes, and the legumes produced most forage when seeded before maize. Early planting increased maize production and decreased legume production. Nitrogen increased maize grain, maize forage, and total forage yields but had not effect on legume forage production.
Results of these experiments show that intercropping maize and legumes has promise for increasing forage production in temperate climates. Although intercropping may reduce yield of individual components, total forage yield was not lower than monocropped maize in this experiment. In fact, total forage production tended to be greater where maize and cowpea were intercropped either by seeding on the same date or by seeding cowpea after maize. Cowpea is more promising than polebean as an intercrop with maize. Both legumes affected maize production equally, however, cowpea produced almost twice as much dry matter as polebean.
More research is needed both on production criteria such as intercrop planting times and densities, weed control, planting and harvesting mechanization, and on economic and management aspects of forage production from intercropping.

Cropping systems
Africa, Sahel, experiments, ICRISAT, cowpea, pearl millet, cultivars, intercropping
NTARE, B.R.
Evaluation of cowpea cultivars for intercropping with pearl millet in the Sahelian zone of West Africa.

Field Crops Res., 20, 1989, 31-40

This study was made to examine the performance of contrasting cowpea cultivars intercropped with millet, to determine the relationship between performance in sole-crop and intercrop. The study also examined the effectiveness of selection for intercropped cowpea.
Field trials were conducted at ICRISAT Sahelian Centre, Niger, to examine the performance of contrasting cowpea cultivars intercropped with pearl millet. Significant effects ($P \leq 0.05$) of cropping system and cultivars were observed for cowpea grain yield. Cultivar X cropping system interaction was significant only for fodder yield. Intercropping reduced cowpea yields significantly but the degree of reduction varied among cultivars.

Early-maturing erect cultivars exhibited greater yield reduction than the indeterminate spreading types and had the least effect on millet yields. Indeterminate spreading cultivars produced greater grain and fodder yield than erect types and caused the greatest millet yield reduction.
The relationship between the yield of cowpea cultivars and millet when intercropped was negative. Linear correlations between yield of cowpea in sole and intercrop were positive and significant ($P < 0.01$) with r values ranging from 0.45 to 0.91. However, a small proportion of the biggest and least-yielding cowpea cultivars in intercropping would have been selected and rejected respectively, on the basis of sole-crop grain-yield. It was concluded that selection of cowpea cultivars for intercropping with millet based on their grain yield in sole-crop may have limited success. Selection based on fodder yield favoured late-maturing cultivars. Selection of cowpea cultivars for intercropping should be based on their intercropped performance, paying special attention to other agronomic factors. An appropriate cowpea cultivar for intercropping with millet would be one that is less competitive with millet and yields both grain and fodder.
Drought-stress is a major concern particularly at the end of the season. Early-maturing cultivars to escape drought would minimize the probability of all components being equally affected. They should not be erect and extraearly, and not too leafy to be too competitive with the millet. An appropriate cowpea cultivar for intercropping with millet would be the one that is less competitive and yields both grain and fodder.
The relationships between cowpea yields in sole and intercropping were positive and significant, indicating that evaluation in sole-crop gave a reasonable prediction of cowpea performance in intercropping. The ranking of cultivars in the two cropping systems revealed that a small proportion of the highest-yielding cultivars in intercrop would have been selected from sole-crop. Similarly, a small porportion of the lowest-yielding cultivars in intercrop would have been rejected based on their sole-crop performance. These results suggest that selection of cowpea cultivars for intercropping with millet based on their grain yield in sole-cropping may have limited success. Since sole and intercropped performance were reasonably related, selection for simply inherited traits such as resistance to diseases and insects, plant type and maturity could be done in segregating populations in sole-crop. The final selection for intercropping should be based on intercropped performance of advanced breeding lines.

344 89 - 4/47

Cropping systems
Australia, semi-arid zone, monsoon climate, field trials, maize, sorghum, pearl millet, yield, productivity
MUCHOW, R.C.
Comparative Productivity of Maize, Sorghum and Pearl Millet in a Semi-Arid Tropical Environment. I. Yield Potential.

Field Crops Res., 20, 1989, pp., 191-205

The primary objective of the work reported here is to analyze the environmental limitations of the productivity of maize, sorghum and millet in the semi-arid tropics as a basis for the selection of appropriate crops for these regions.
Few studies have been conducted in which the yield-determining processes of maize, sorghum and millet have been compared in the same experiment under similar agronomic and environmental conditions. Accordingly, a field study was undertaken in the semi-arid tropics of northern Australia with the objective of comparing the productivity of these cereals under different radiation, temperature and water regimes. This paper examines the potential productivity of high-yielding F_1 hybrids of maize, sorghum and pearl millet grown under the fully irrigated and high-fertility conditions of the experiment. Different sowing-dates were used to assess the impact of varying radiation and temperature regimes on yield.
The varying radiation and temperature regimes sowing during affected biomass at maturity in maize and millet, but not in sorghum. Variation in biomass depending on sowing dates was associated more with differences in the amount of radiation intercepted than in radiation-use efficiency. In contrast, grain yield was relatively stable across sowing dates in maize, but it varied with sowing date in sorghum and millet. Here, differences in grain-yield were related more to variation in harvest index. Overall, variation in grain yield across sowing dates within species was small relative to that among other species.
Average grain yields over the three sowing dates were 9.2 t ha^{-1} for maize, 5.6 t ha^{-1} for sorghum and 2.9 t ha^{-1} for millet. High yield was associated with high biomass production both at maturity and during grain-filling, high harvest index, and an increase in stover weight during grain-filling. High biomass accumulation was associated with long growth duration, especially the duration of grain-filling and thus high cumulative radiation interception, and with high radiation-use efficiency.
It was concluded that crops growing in the semi-arid tropics rarely reach their potential, owing to water shortage, poor nutrition, incidence of pests and diseases and poor crop husbandry. One of these limiting factors, namely the consequences of water shortage, is considered in the companion paper.

345 89 - 4/48

Cropping systems
Australia, semi-arid zone, study, maize, sorghum, pearl millet, water deficit
MUCHOW, R.C.
Comparative Productivity of Maize, Sorghum and Pearl Millet in a Semi-Arid Tropical Environment II. Effect of Water Deficits.

Field Crops Res., 20, 1989, 207-219

This paper is the second in the series examining the effect of water regime on the comparative productivity of maize, sorghum and pearl millet in semi-arid tropical Australia.
This paper examines the productivity of maize, sorghum and pearl millet under both short-term water deficit at different stages of growth and prolonged water deficit during grain-filling. The effect of water deficit on radiation interception (RI) and radiation-use efficiency (RUE) and thus on biomass accumulation, on harvest index (HI) and, therefore, on grain yield in the different cereals, is described. This information is used to define those environments in which maize, sorghum and millet are best suited.
Maize out-yielded sorghum and millet under water deficit where maize grain-yield was at least 6 t ha^{-1}, whereas sorghum yielded more than millet and maize where maize yield ranged from 1 t to 2 t ha^{-1}. Only where maize produced no grain under water deficit did millet yield the same as sorghum. In millet, grain-yield was more stable than biomass in response to water shortage, but in maize and sorghum biomass was more stable. The decrease in biomass in response to water deficit was associated more with a reduction in radiation-use efficiency than with a decrease in radiation interception, except when the water deficit was imposed during early vegetative growth, when the opposite was the case. Mobilization of pre-anthesis assimilate to grain occurred in sorghum and millet but not in maize. Where water shortage occurred, harvest index was more conservative than biomass accumulation; harvest index was reduced only when water deficits severely decreased grain-yield.
This study has highlighted the importance of biomass accumulation in determining grain-yield in these species. Water deficit reduced biomass and grain-yield in several treatments, but did not decrease HI, which decreased only where water deficit severely reduced grain-yield. Given the relatively high temperature in this semi-arid tropical environment and the consequent rapid canopy development, intermittent water deficit is more likely to have a larger impact on RUE than on RI. Further work is required to identify factors contributing to differences in RUE in response to water regime, both among and within species.

346 89 - 4/49

Cropping systems
Asia, India, groundnuts, experiments, split-plot design, Alfisol, plant density, cultivars, yield, ICRISAT, irrigation
RATTUNDE, H.F. et al.
Cultivar Mixtures: a Means of Exploiting Morpho-Developmental Differences among Cultivated Groundnuts.

Field Crops Res., 19, 1988, 201-210

Crop yield is determined by the effectiveness with which the community of crop plants exploits its environmental resources for growth. This suggests crop yields would be maximized by using heterogeneous populations that contain several genotypes whose demands for environmental factors differ in space or time, thus encouraging a complementary and fuller exploitation of available environmental resources.
The objectives of these experiments were to determine (1) whether by sowing groundnut cultivars in mixed stands, synergistic interactions among cultivars could be exploited to increase yield of pods, kernels, or haulms relative to those of the sole crops, and (2) whether certain combinations of growth patterns produce a greater frequency of overcompensatory reactions than do others.
Two genotypes were used from each of four growth-habit classes (Spanish, Valencia, Virginia bunch, and Virginia runner) to form two cultivar (1:1) mixtures representing diverse maturity and growth-habit combinations. The mixtures, 12 in the 1983-1984 dry season, and 28 in the 1984 rainy season, were sown at three and two plant densities, respectively. Land Equivalent Ratios (LER) of mixtures showed that overcompensation was more frequent than undercompensation. The largest LERs were 1.23 for pod yield, 1.29 for kernel yield, and 1.18 for haulm yield average over planting densities in the rainy season. Intersubspecific combinations that gave diversity for both maturity and growth habit exhibited synergistic interactions most frequently. However, this intergenotypic interaction was specific to the genotypes involved. Investigation of cultivar mixtures in groundnuts should focus on stability rather than maximization of yield since no mixture yield surpassed that of the highest-yielding variety.

347 89 - 4/50

Cropping systems
Africa, Nigeria, humid zone, glasshouse experiment, cowpea, luffa, pre-planting, plant density, mixed planting, lateritic soil
OKUSANYA, O.T. et al.
Effects of pre-planting, mixed planting and planting density of *Vigna unguiculata* (L.) Walp. on the growth of *Luffa aegyptiaca* Mill. in humic and red lateritic soils.

Trop. Agric. (Trinidad), 65, 3, 1988, 241-244

Luffa aegyptiaca Mill. (=*L. cylindrica* (L.) Roem.) (Cucurbitaceae) is an annual tendril climber, mainly tropical and subtropical. It is of economic importance in West Africa because of the edibility of the young fruits and the use of the dried fibrous interior as a sponge. This latter use is increasing so that not enough is being harvested from the wild and from back-gardens; the need for large-scale cultivation and high production of the species arises.
In this investigation, two glasshouse experiments were carried out to determine the effects on the growth of *L. aegyptiaca* of (i) planting it in soils which had been pre-planted with a legume and (ii) mixed planting with the legume. At the same time the effect of sowing density was also determined.
For these experiments, *Vigna unguiculata* (L.) Walp. was chosen as legume because, like many other members of the Leguminosae, it is also of economic importance as a cash crop. It is an annual herbaceous erect plant. The Ife-Brown variety, commonly available and a favourite of farmers, was used.
Two soil types, humic and red lateritic, were collected from areas where two populations of *L. aegyptiaca* grow naturally. These two soil types not only have contrasting chemical and physical characteristics but the *L. aegyptiaca* populations growing in them also show marked differences.
The effects of pre-planting, mixed planting and planting density of *Vigna unguiculata* (L.) Walp. on the growth of *Luffa aegyptiaca* Mill. in humic and red lateritic soils were determined in the glasshouse. Pre-planting of *V. unguiculata* in the soils which were subsequently used to grow *L. aegyptiaca* resulted in increased growth.
The results show clearly that the density of sowing of the species is an important factor for growth. Decrease in weight as planting density increased shows the effect of intraspecific competition; space, light and nutrients are likely factors for competition. Individuals of the same species will have the same ecological requirements; if these are in short supply, intraspecific competition would set in and appears to have happened in this experiment.
Competition for nutrients appears to be very important in the lateritic soil as it is poorer in nutrients than the humic soil; consequently, the mean dry weights of either the pre-planted *V. unguiculata* or the *L. aegyptiaca* which was planted after *V. unguiculata*, were lower than those for the humic soils. The effect of the poor nutrient status of red earth becomes more marked in the mixed planting experiment.
The results of the pre-planting experiments, which simulate the system of crop rotation, suggest that pre-planting of *V. unguiculata* in soils to be used for growing *L. aegyptiaca* would enhance the growth of *L. aegyptiaca*, and that the higher the density of *V. unguiculata* pre-planted the better would the growth of L. aegyptiaca be. The pre-planting of a legume appears to be a good method for increasing the productivity of *L. aegyptiaca*, more especially in humic than in red earth soils. This result supports the generally accepted view that legumes improve soil fertility and consequently the productivity of crops grown after them.

The results of mixed planting experiments in humic soil suggest that it would not be agriculturally and ecologically sound to grow the two species in mixed culture; similarly for red earth. When the results of the pre-planting and mixed planting experiments are compared, it is aboundantly clear that for the improved growth of *L. aegyptiaca*, pre-planting with *V. unguiculata* or possibly any legume rather than mixed planting is preferable.

348 89 - 4/51

Cropping systems
Asia, India, highland, monsoon climate, sandy loam soil, randomized block, experiment, legumes, oilseeds, cereal, pigeonpea, intercropping, yield, land-equivalent ratio
RAFFEY, A. and U.K. VERMA
Production potential of legumes, oilseeds and cereal in intercropping system with pigeonpea (*Cajanus cajan*).

Ind. J. of Agr. Sc., 58, (2), 1988, pp. 433-436

The upland soils of Bihar plateau are Alfisols, light-textured, with low water-holding capacity. The area is traditionally monocropped with upland rice (*Oryza sativa* Linn.), finger millet or ragi [*Eleusine coracana* (Linn.) Gaertn.], other millets and pulses in the rainy season. Due to low irrigation potential and low water-holding capacity (100-150 mm/m depth), double cropping is not possible. The only way to increase cropping intensity and to improve resource utilization is intercropping system.
The experiment was laid out in randomized block design with 11 treatments replicated thrice. Treatments 7-11 were in additive series. The treatments were (i) 'BR 65' sole pigeonpea, (ii) 'Sunaina' greengram, (iii) 'T 9' blackgram, (iv) 'AK 12-24'groundnut, (v) 'Birsa Soybean 1'soybean, (vi) 'BR 19-23' rice, (vii)pigeonpea + greengram, (viii) pigeonpea + blackgram, (ix) pigeonpea + groundnut, (x) pigeonpea + soybean, and (xi) pigeonpea + rice.
There was annual variation in pigeonpea yield. Yield of pigeonpea both as a sole crop and as intercrop was better in 1983 and 1984 than in 1982 owing to rain in September-October, whereas in 1982 there was practically no rain after 16 September. Irrespective of the intercrop, the yield of pigeonpea was always higher in sole stand than in intercropping system. This might have been due to competition with intercrops.
Yield of all crops decreased under intercropping system compared with their respective sole-crop yield. However, the extent of reduction was less in soybean (300 kg/ha in pooled mean).
All intercropping systems proved efficient with land-equivalent ratios of more than 1. Pigeonpea + soybean gave the highest LER value, because reduction in their yield was lesser than of other intercropping systems, whereas pigeonpea + greengram gave the lowest yield. Pigeonpea + groundnut, pigeonpea + blackgram and pigeonpea + rice gave the same LER values.

Sole groundnut and pigeonpea + groundnut gave the maximum pigeonpea-equivalent yields of 2,187 and 2,253 kg/ha, respectively, and were significantly superior to all other treatments. These 2 treatments were on a par with each other, and sole pigeonpea, pigeonpea + blackgram, pigeonpea + soybean and pigeonpea + rice were also on a par among themselves. Pigeonpea + greengram system gave the lowest pigeonpea-equivalent yield.
Amongst the sole crops, greengram was the least profitable, followed by soybean. Sole pigeonpea was superior to the others, except groundnut.

349 89 - 4/52

Cropping systems
USA, experiment, maize, soybean, leaf removal, randomized block design, yield stability, sole crop, intercropping
KELLEY, T.G. and J.A. JACOBS
Yield stability of sole-crop and intercrop planting systems.

In: Soybean in Trop. and Subtrop. Cropping Systems: Proc. of a Symp., Japan; AVRDC, 1986, pp. 49-56

The objective of the study reported here was to test the "risk-aversion hypothesis," often stated as a primary reason for mixed plantings under subsistence conditions. The hypothesis maintains that mixed plantings, intercrops, or random mixtures are less susceptible to the yield losses that result from adverse climatic or environmental conditions than are corresponding sole-crops. The measure used for testing the stability of a cropping system in this experiment was the ability of a crop to perform or yield well under adverse conditions. By subjecting a mixed crop of maize (*Zea mays*) and soybean (*Glycine max*) and corresponding sole-crops to simulated insect and disease defoliations, a measure of the relative degree of production stability was derived for each system.
The effect of defoliation on maize and soybean grown under both sole-crop and intercrop systems was studied in an experiment. A mid-season maize cultivar, FR 632 x FR 16, and soybean cultivar Williams 80 were each subjected to varying degrees of leaf removal at different times in the season.
A randomized block design consisting of treatments in a factorial combination of five levels of defoliation (0, 25, 50, 75, and 100%) at three dates (25, 45, and 60 days after seeding (DAS)) was used. Within each of the fifteen factorial treatment combinations (Main plots), a split-split plot design was arranged. Subplots consisted of either sole-cropping or intercropping. Each subplot specified the crop to be defoliated. There were three replications.
Under both sole-crop stands of maize and soybean, defoliation treatments depressed grain yields in relation to severity and time of defoliation. The results obtained here are in general agreement with earlier studies on defoliation for both crops. Yield reductions followed a negative linear trend with respect to rate

and time of defoliation. Exceptions were observed for maize defoliated at the earliest date, the 8-leaf stage, and when maize was defoliated at the 25% rate for all dates. In these cases a yield increase of up to 9% was observed.
Yield reductions in defoliated, intercropped maize and soybean were more acute than in the defoliated sole-crops. This was presumably due to the presence of the competing companion crop which was able to increase its yield as a result of the other's injury. This effect was more pronounced under maize-defoliated conditions than under soybean-defoliated conditions. Soybean intercrop yields increased in proportion to the degree and time of maize defoliation. Maize intercrop yields under defoliated-soybean were higher than the control (undefoliated treatment), but did not show increasing trends in proportion to the degree and time of soybean defoliation. The reason for this phenomenon is not clear, but the unavailability of light may have limited yields in the soybean intercrop. Removing (partially or fully) the maize plants allowed more light to reach the soybean canopy and thereby increased yields. Maize, being a taller crop, may not have benefited to the same degree from soybean leaf removal. No light meter readings were taken, however, so this hypothesis cannot be substantiated.
Defoliation, either in maize or soybean, caused greater proportional yield reductions when the defoliated crop was intercropped rather than planted in solid stands. Therefore, in order for an intercrop system to suffer lower losses due to defoliation, yield compensation from the non-defoliated crop must exceed the difference in loss between the intercrop and sole-crop defoliation. There are obvious problems in comparing yield compensation values of one crop to crop yield losses in another. For this analysis an assumption was made in order to equalize the productivity between a hectare of sole-crop maize and the productivity of a hectare of sole-crop soybean, so that a conversion factor of 2.1 t of maize is equivalent to 1.0 t of soybean. Accordingly, after the conversion adjustment, direct comparisons between sole-crop yields and intercrop yields could be made on the basis of total combined grain yields for each of the defoliation treatments. Under normal conditions (undefoliated), an intercropping system, maize + soybean, was 8.7% more productive than the corresponding sole plantings of the same crops. Under maize-defoliated conditions, maize + soybean was an average of 8.1% more productive than the corresponding sole-crop plantings. The value increased under conditions of more severe defoliation, reaching 26.3% at the at the rate of 75% of defoliation on the last date. For the soybean defoliation treatments, intercrops were an average of 4.9% more productive than the maize and soybean sole-crops. There was no trend for either increase or decrease in this value as defoliation severity increased.
In regard to production stability, maize + soybean intercrop provided higher "highest-returns", higher "average-returns," and higher "minimum returns" than corresponding maize and soybean sole-crops. The yield returns for maize- and soybean-defoliated conditions under single sole-cropping, two sole-crops, and intercropping are presented. Under maize-defoliated conditions the

intercrop system had an average return of 7.9 t/ha, with a range of 0.8 t/ha between highest and lowest returns. For the single crop planting, an average value of 7.1 t/ha and a range of 3.6 t/ha between highest and lowest returns were observed. This implies that as the cropping system moved away from diversity (intercropping) and towards homogeneity (sole-cropping), average returns were lower, range of yield values increased, and, most importantly, possibilities for very low returns increased - a concern of top priority for small farmers operating at or near the minimum subsistence level. Hence the data suggest that the risk-aversion principle for intercropping applies to maize-defoliated conditions.
The picture changes for soybean-defoliated treatments. Average grain yield for intercropping, two sole-crop plantings, and single sole-crop planting, were 7.8, 7.4, and 7.1 t/ha, respectively - a much closer margin than that observed unde maize-defoliated conditions. Under soybean-defoliated conditions, which were generally not as sensitive to yield losses as the maize-defoliated treatments, the risk-aversion hypotheses would not be a valid justification for intercropping, since minimum yield returns from the two sole-crop plantings and intercrop plantings were about the same. Justification for intercropping by risk-aversion would require higher minimum returns rather than just comparable minimum returns. Still, average returns and highest returns were higher in the intercrop treatment than in either of the sole-crop systems.
It appears that intercropping does offer a measure of risk aversion based on the treatments tested in this experiment. Lowest grain yield (excluding 100% defoliation) was found in the single sole-crop planting (4.7 t/ha from 75% maize defoliation on last date) followed by the two sole-crop planting system (6.2 t/ha from 75% defoliation on the last date). Lowest grain yield for the intercrop (6.7 t/ha for soybean defoliation on the last date) was over 0.5 t/ha higher than the two sole-crop plantings.
A complete loss in one crop is not uncommon, but because of the alternative for replantings - especially under sole-crop conditions - it is difficult to assess the real advantage of intercrops over sole-crops in this situation. If, however, the assumption is made that a replant situation is not feasible (too late in the growing season or labor shortages early in the season) the intercrop system is markedly superior to sole-cropping. The difference is most dramatic under maize-defoliated conditions. Yields of intercropped soybeans where maize was completely defoliated averaged 87% of sole-cropped soybean yields. The earlier the maize was removed from the intercrop the more soybean yields increased.

350 89 - 4/53

Cropping systems
Africa, Ghana, savannah zone, land-use, experiments, crop rotation, split plot design, maize, groundnut, yam, sorghum
SCHMIDT, G. and E. FREY
Crop Rotation Effects in Savannah Soil.

Nyankpala Agric. Res. Report, 4, 1988, pp. 37, Distr.: Verlag J. Markgraf, FRG, ISBN 3-8236-1159-3, DM 19,--

In crop sequence experiments carried out at the Nyankpala Agricultural Experiment Station (Guinea savannah zone of Northern Ghana) maize proved to be very responsive to preceding crops. Grain legumes (groundnut, cowpea, pigeon pea) and yam were very favourable preceding crops for maize.
Yields were lower where maize followed maize and lowest where maize followed sorghum. Intercropping of maize with various grain legumes (alternating rows of maize and legumes) led to subsequent maize yields which were close to those obtained after sole crop maize.
Maize also responded strongly to nitrogen fertilizer application. This applied to all combinations with previous crops. In a long term crop sequence trial (1981-1986) nitrogen fertilizer efficiency (60 kg N/ha) for maize tended to be highest after yam. In this experiment, protein contents of maize grain and nitrogen contents of maize stover were generally extremely low indicating a very poor plant and soil nitrogen status. The application of 60 kg N/ha brought about only a slight increase in these contents whereas preceding crops had either little or no distinct influence. As a result the quantity of nitrogen contained in grain and stover was mainly determined by crop yields.
The nitrogen uptake of maize varied greatly depending on the weather conditions. In dry seasons the uptake of soil and fertilizer nitrogen was low. The highest recovery of fertilizer nitrogen was observed in two seasons with a favourable rainfall distribution (1984 and 1985). During the same seasons as well as in a third season with high stover yields (1982) the difference between nitrogen uptake after groundnut and after maize, largely attributable to biological N-fixation, was also the highest (27-32 kg N/ha). This difference was minimal in two dry seasons.
Tall local sorghum was less responsive to preceding crops than maize. During the first two years of the long term crop sequence trial no distinct influence of preceding crops could be observed. From the third year groundnut turned out to be the best preceding crop followed by maize-groundnut intercropping and/or yam. Sorghum after maize tended to be less productive and sorghum after sorghum gave the lowest yields. Nitrogen fertilizer (60 kg N/ha) increased sorghum yields during 4 of the 5 test seasons, but sorghum responded less than maize. In two seasons nitrogen fertilizer did not show any appreciable effect on sorghum cultivated after groundnut or maize-groundnut intercropping.
Groundnut yields were little influenced by preceding crops. In three seasons yields tended to be low after groundnut or maize-

groundnut intercropping indicating self-intolerance. However, during extended drought in another season groundnut after groundnut wilted less than groundnut after sorghum. This may have been the reason for higher kernel yields after groundnut or maize-groundnut intercropping than after sorghum. Nitrogen fertilizer mostly depressed groundnut yields.
Yam yields were hardly or not influenced by either preceding crops or nitrogen fertilizer application. A tendency of low yam yield after yam reached the level of significance only once in 5 years. In the last season (1986), previous sole crop groundnut cultivation or maize-groundnut intercropping increased yields as compared with previous cereal or yam cultivation. After groundnut yam did not respond to nitrogen fertilizer or responded less than after other crops, in particular sorghum.
In an ideal rotation, maize which is most responsive to previous crops and fertilizer should be grown after grain legumes. Phosphate fertilizer for a whole rotation is concentrated on this crop, which also has a high nitrogen fertilizer requirement (recommended minimum dose: 60 kg N/ha). Maize is followed by yam or again grain legumes, crops not affected by the N-hunger period during the decomposition of cereal residues of extremely low nitrogen content and ideal preceding crops for sorghum. Sorghum should not be followed by cereals.

351 89 - 4/54

Cropping systems
Asia, Sri Lanka, experiments, humid tropics, Ultisol, mixed cropping, mungbean, annual crops, perennial crops, yield, alley cropping, AVRDC
SANGAKKARA, U.R.
Mungbean as a component of annual mixed cropping system.

In: Mungbean - Proc. of the 2nd Int. Symp., Bangkok, Thailand, AVRDC, Shanhua, Tainan, Taiwan, 1988, pp. 406-411

Grain legume production in Sri Lanka is centered around cowpea (*Vigna unguiculata* (L.) Walp.) and mungbean (*Vigna radiata* (L.) Wilczek), although others are produced on a smaller scale.
The production of food crops in Sri Lanka is based on the smallholder agricultural sector, in which land holdings range between 0.5 and 1 ha. Due to the constraints of land size, mixed cropping is recommended for these small holdings both in the traditional lands and in new settlement schemes opened up under the development programs. Traditional small-holder farms in Sri Lanka produce rice in the lowlands and legumes, cereals, condiments (chilies) or root crops in the highlands. Upland crops are generally mixed, and the combinations consist of a legume with one or two of the other economic species. Studies, both in Sri Lanka and abroad, have shown the versatility of mungbean for mixed cropping in such systems, especially with cereals. In addition mungbean is recommended for dryland cultivation, especially under alley and agroforestry farming systems.

A study was carried out to evaluate the comparative performance of mungbean when planted in binary mixtures with three companion crops which have different crop canopy structures and growth patterns during the rainy season in the midelevation region (1500 to 2000 m above sea level) of Sri Lanka. Another study evaluated the comparative performance of mungbean under two alley crops (*Leucaena* and *Gliricidia*) and in open-farming conditions found in the traditional systems of the dry zone of Sri Lanka. These are primarily intended to test the versatility of mungbean under different conditions found in small-holder farming systems.
The selected main crop treatments were: cassava (*Manihot esculenta* Crantz) variety CARI 555; corn (*Zea mays* L.) variety Thai composite; and sweet potato (*Ipomoea batatas* (L.) Lam.) variety C 26.
These were planted in rows at 1 m spacing. The spacing between plants within rows was 1, 20 and 50 cm for cassava, corn and sweet potato, respectively.
The main crop was intercropped with mungbean variety MI 5 in rows at 25 cm spacing between the main crops and at an interrow spacing of 10 cm. In addition a mungbean monocrop was established at similar spacing.
Annual Mixed Cropping System:
The results show that the plant heights of mungbean are marginally taller when intercropped with a tall companion crop. This could be associated with the available light for mungbean. Corn, and to a lesser extent cassava, intercept a proportion of incident light depriving intercrop of the maximum available radiation. This shading effect can be considered the mechanism of increased plant height of intercropped mungbean compared to its monocult or plants grown with a short companion crop.
No significant differences were observed between mungbean plants in terms of flower and pod set, when intercropped. Thus, shading has minimal effects on the number. of flowers and pods per plant in mungbean. Temperature is reported to have a greater effect on these parameters than light.
Seed development in legumes is generally associated with available radiation. A table shows that the number of seeds per pod and 100-seed weight of mungbean are affected by intercropping. The lowest seed number per pod and 100-seed weight is recorded when mungbean is intercropped with corn, which intercepts a greater percentage of light than the other companion crops tested. Since cassava permits greater light penetration, these seed parameters are affected to a lesser extent. As there is no shading effect when mungbean is associated with sweet potato, these yield components are similar to those of the monocrop.
Per plant and per hectare yields reflect the effects of intercropping on yield components. Corn has the greatest effect on mungbean yields. However, yields of mungbean are depressed when intercropped. The measurements taken in this study indicate the detrimental effect of shading, especially when grown with a taller crop. The mechanisms of yield reduction when mungbean is intercropped with sweet potato, although not elucidated in this study, have been reported as interactions between the root systems for nutrients. This conclusion is based on the availability of

adequate light for mungbean when grown with the shorter crop, and the production of the highest yield among the intercrops under conditions of no competition for light.

Alley-Cropped Trial:

The lopping of branches at the beginning of the wet season allowed ample light penetration into the contours that were intercropped. In addition the prevalent rainfall in this season was conducive to mungbean even under conditions of open farming. Thus, yield components and yield of mungbean within the alley-cropped region and traditional open-farming conditions show no significant differences.

In contrast *Leucaena leucocephala* and, to a lesser extent, *Gliricidia sepium* intercept light during the dry season. Shading has a beneficial effect on the microclimate of the alleys, reducing temperature and increasing water retention when compared with open-farming conditions. The improvement of growth conditions under alley crops in the yala season helps better growth of mungbean when compared to the open-farming conditions. All yield components are increased when mungbean is alley cropped in the yala season. When comparing the alley crops, *L. leucocephala*, due to its dense canopy, appears to have a greater beneficial impact on mungbean than *G. sepium*. Thus, mungbean can be considered a useful component for alley crops, especially in the yala season under rainfed conditions, where no agricultural practices are undertaken in traditional farmer lands.

The results of this study show the feasibility of growing mungbean as an intercrop with both annual and perennial species. Although mungbean yields are significantly reduced when intercropped with taller annual species, as reported in most grain legumes, they have the capacity to increase the productivity of land by producing a crop, from a region hitherto left uncultivated within a short period of time. If associated with a short companion crop and proper culture practices are adopted, yield reduction could be minimal.

The results suggest that competition for light is one of the factors causing yield reduction in the intercropped mungbean. When such competition is absent, yield reductions are low. However, the presence of root competition cannot be ignored and this area warrants further research.

The value of mungbean under alley cropping, especially in the yala season when no successful agriculture is possible due to very low rainfall, is shown in this study. While optimal yields are not obtained, the results reveal that when mungbean is cropped under perennial species, especially *L. leucocephala*, in the yala season its yield can double over that obtained in other conditions. Its value is further enhanced due to its short duration, which enables it to use the available soil moisture efficiently. However, no increase in yield is obtained when mungbean is alley cropped in the maha season, due to the availability of water.

89 - 4/55

352

Cropping systems
Asia, India, experiments, Alfisol, intercropping, mungbean, pigeon pea, sorghum leaf area index, grain yield, dry matter
SUBRAMANIAN, V.B. and D.G. RAO
Intercropping effects on yield components of dryland sorghum, pigeon pea and mung bean.

Trop. Agric. (Trinidad), 65, 2, 1988, pp. 145-149

The present paper reports the results of field experiments on two intercropping systems: sorghum + pigeon pea and sorghum + mung bean. The objective was to compare the effect of intercropping on the three crops to identify intercropping-sensitive yield components.

Two contrasting intercropping systems, sorghum + pigeon pea and sorghum + mung bean, were compared for the effects of intercropping on leaf area index, grain yield, yield components and total dry matter.

Both component crops of the sorghum + pigeon pea system yielded less grain and dry matter than did the respective sole crops. In the sorghum + mung bean system, grain yield and dry matter of the sole and intercrop sorghum were not significantly different but the yields of intercrop mung bean were only some 20% of that of the sole crop. In comparison with the sole crops, harvest index was more than two-fold in pigeon pea, was decreased in mung bean and was not affected in sorghum.

The grain yield components of sole and intercrops of sorghum, pigeon pea and mung bean are compared. Except the intercrop sorghum + mung bean system, all the intercrops had fewer grains m^{-2} than did the respective sole crops. In pigeon pea, the reduction in number of grains was due to reduction in number of pods m^{-2}, whereas in mung bean, both number of pods m^{-2} and number of grains pod^{-1} were affected. Intercropping did not influence the average grain size (1000 grain weight).

Data on dry matter accumulation in plant parts and leaf area index at anthesis of sole and intercrop sorghum are presented. In the sorghum + pigeon pea system, intercropping resulted in reduction in total dry matter production and leaf area index of sorghum. Accumulation of dry matter was relatively less affected in the stem than in leaf and ear. In the sorghum + mung bean system, leaf area index in sole and intercrop sorghum were not significantly different.

Dry matter m^{-2} increased progressively in both the sole and intercrop pigeon pea during the late vegetative and early reproductive stages. After the commencement of flowering, the rate of increase in dry matter accumulation slowed, more so in the steam. The absolute amount of dry matter in the intercrop was only 50% of the sole crop. The reduction due to intercropping in dry matter accumulation was slightly but consistently more in leaves than in stem. The stem of the intercrop pigeon pea was thinner. The height and node number on the main stem at which the first branch was borne was higher in the intercrop than in the sole

crop. The number of nodes and primary branches plant^{-1} were also less. At maturity, the reduction due to intercropping in number of secondary branches plant^{-1} was more than that of primary branches. In the sorghum + mung bean system, dry matter in the intercrop mung bean at flowering was about 33% of that of the sole crop. As with sorghum and pigeon pea, leaf dry matter accumulation was relatively more affected by intercropping. Both leaf area index and leaf weight ratio were significantly less in the intercrop than in the sole crop.

353 89 - 4/56

Cropping systems
Asia, India, experiment, field trial, sandy loam soil, irrigation, nitrogen, maize, cowpea, intercropping, intercrop competition, fodder crop
AGRARWAL, G.C. and A.S.SIDHU
Effect of irrigation and nitrogen on maize-cowpea fodder intercropping at Ludhiana, India: advantages and intercrop competition.

Field Crops Res., 18, 1988, pp. 177-184

This study was undertaken to examine: (1) the effect of nitrogen and irrigation on maize (*Zea mays* L.) and cowpea (*Vigna sinensis*) fodder intercropping advantages and intercrop competition; (2) the residual effect of such intercropping on a succeeding pearl millet (*Pennisetum americanum* L.) fodder crop; and (3) relationships among different measures used for evaluating intercrop competition.
The effects of three variables, crop system, nitrogen level, and irrigation level, were studied.
For further evaluation of the intercrop system, the residual effect on a following pearl millet crop, sown after harvesting, was also studied. Irrigation treatments became replications for the succeeding pearl millet experiment. Basal doses of 26.2 kg P/ha and 24.9 kg K/ha, but no nitrogen, were applied.
A yield advantage of intercropping over sole cropping was observed at all N and irrigation levels, with LER of 1.09 averaged over all treatments. However, differences in LER values at different levels of N and irrigation were non-significant. Although the relative fodder yield advantage of the intercrop was consistent at all N levels, the relative contribution to yield from maize increased with N level.
Irrigation frequency did not affect LER. This agrees with other findings that moisture availability has no observable effect on LER.
Intercrop competition was affected by both nitrogen and irrigation. LER for cowpea decreased and that for maize increased with increase in nitrogen.
Evaluated in terms of relativ crowding coefficients as well as aggressiveness, cowpea changed from a dominant species at lower N levels to a dominated species at higher N. The behaviour of maize

was the reverse of cowpea. The competitive ability of maize was almost equal to that of cowpea. For quantifying competition between competing crops at different irrigation and nitrogen levels the competitive ratio was computed, as other measures have some limitations. Nitrogen increased the competitive ability of the maize, increasing from 0.80 at zero N to 1.46 at 120 kg N/ha. Since the competitive ratio values of the two crops are the reciprocal they are presented for only one of the crops. The results show that cowpea is more competitive than maize only when grown under N and irrigation constraints.
Sole maize gave the highest fodder yields except at N_0, and sole cowpea the least. Sole cowpea significantly responded to N up to 40 kg N/ha only, whereas increases in yields of sole maize and of the maize-cowpea intercrop were significant up to 120 kg N/ha. However, the contribution of cowpea in intercrop yield decreased with increase in N.
Both the preceding cropping system and applied N at 120 kg/ha had significant effects on the succeeding pearl millet fodder yield. Pearl millet fodder yield was the highest when grown after cowpea. Averaged over all N treatments, pearl millet grown after the intercrop yielded 42% more than after maize.
It was found that N uptake by pearl millet (25.5 kg/ha) following the intercrop was 1.3 times more than after maize.
Yields of cereal-legume intercrops have, generally, been found to be less than those of cereal crops, and the results of this study supports this. Consequently, intercropping has been advocated either for balanced food production or other specific considerations. That approach ignores the beneficial residual effect of intercropping. A rational evaluation of cereal-legume intercropping should be based on crop-sequence yields. The total crop sequence fodder yield of the intercrop system was comparable to yield of the sole-crop sequence. Higher crop-sequence yields from intercropping at low inputs indicate that intercropping is more beneficial under N and irrigation constraints.

354 89 - 4/57

Cropping systems
Africa, Mozambique, experiments, intercropping, groundnut, maize, ICRISAT, IDRC
RAMANAIAH, K.V. et al.
Groundnut/Maize Intercropping in Mozambique.

In: Trop. of the 2nd Reg. Groundnut Workshop for Southern Africa, Harare, Zimbabwe, 1986, pp. 119-123

In Mozambique, groundnut is usually intercropped with cassava, maize, beans, sorghum, etc., depending upon the locality and season. Some combinations have advantages during drought years. This study was conducted on a research station and on farmers' fields to determine the best geometry of planting groundnut/maize intercrops, and to compare the results obtained on research stations with those obtained under farming conditions.

The yield of maize was greatly reduced when intercropped with groundnut . Line planting facilitated easier weeding than the zig-zag- pattern. Line planting took more labour than the zig-zag method at the time of sowing. This is very important for the farmer as he has to plant as much area as possible to capture the available moisture before it escapes from the ground. In some places where rats and birds are a problem, line planting was disadvantageous because they can easily pick up seeds if they are in a line.
Difficulties in achieving standard moisture contents resulted in the omission of some data. The results reflect the variable nature of each farm and the non-uniform rainfall pattern.
In general, intercropping groundnut with maize is not advantageous. The maize crop, when associated with groundnut, was short in height, pale yellow in foliage colour (nitrogen deficiency) and was infected with stem borers. Many of the cooperating farmers were of the opinion that it is better to select crops like cassava, sorghum, and beans rather than maize. Similarly, these farmers are now of the opinion that maize should be grown as a sole crop or intercropped with beans.
Intercropping of groundnut with maize is not always advantageous, especially in a dry year. Maize suffers if it is intercropped with groundnut.
Although farmers are convinced by the results, some still intercrop groundnut with maize because they need both maize and groundnut for consumption. If sufficient land is available they prefer to grow groundnut as a sole crop, but maize is always grown with some other crop such as beans, cassava, etc..

355 89 - 4/58

Cropping systems
Asia, India, experiment, field trial, cocoa, arecanut, mixed cropping, bivariate analysis, spacing, manure, economic evaluation
BHAGAVAN, S. and SHAMA BHAT K.
An Appraisal of a Mixed Cropping Trial on Arecanut and Cocoa.

J. of Plantation Crops 17, (1), 1989, pp. 10-17

Increased production and efficient use of resources can best be achieved through mixed cropping systems. It has been outlined how cocoa can effectively be grown in combination with either coconut or arecanut palms to increase the returns per unit area. In such mixed cropping trials, testing the response of crops to treatments imposed is difficult when two or more crops are involved.
There are complex interactions that occur in intercropping, depending on various combinations of the effect of plant species, plant density and spacing, planting patterns, canopy types, root systems, differential demands on environmental factors at different growth stages and so on. There are various functions such as Relative Crowding Coefficient, Competition Index, Aggressiveness, Reciprocity, Land Equivalent Ratio, Land Utilization, Gross Returns, Net Returns, Diversity Index, Multiple

Cropping Index, Harvest Diversity Index, Simultaneous Cropping Index, Cultivated Land Utilization Index and Crop Intensity Index which expresses competitive abilities of components and or yield advantages for a given crop model. Each of these methodologies have advantage of their own in testing predefined objective but none of these can be used satisfactorily for assessing the efficacy of a given cropping model with due consideration to individual crop performance and that too when perennial crops are involved. This is because in perennial crop mixture
- the growth pattern and yield of each crops are highly interdependent;
- the extent of competition and other interactions among the crops vary substantially as the year advances and
- the prices of each crop will be fluctuating over years.

Such an insight of assessing individual crop performance in addition to testing the efficacy of the given crop model can best be made by bivariate/ multivariate analysis after eliminating the interdependency among the crops.
In the present study, data from an arecanut-cocoa mixed cropping experiment was used. Apart from economic evaluation of different spacings based on gross returns per hectare, a bivariate analysis has been attempted in order to evaluate the treatment effects. This method has following advantages:
- it brings out the extent of interdependency existing between two crops
- it considers both the crop yields as two variates instead of combining the two yields as one index and
- it assesses the performance of treatments for the mixed cropping system as a whole.

It was found that yield per plant was higher when arecanut was spaced at 2.7 m x 2,7 and cocoa at 5.4 x 5.4 m. However, when both the crops were planted at a spacing of 2.7 m x 2.7 m, eventhough there was a decrease in yield of individual plants, yield per unit area was significantly higher due to higher population density. The economic evaluation based on gross returns also highlights the efficacy of 2.7 m x 2.7 m spacing for both the crops with average gross returns of Rs. 82.830 per hectare.
In fact any increase in spacing from the recommended spacing for the arecanut, viz,, 2.7 m x 2.7 m gives significantly poorer returns as the major portion (nearly 2/3 rd) of returns is realised from this crop.
From the analysis it is evident that cocoa can effectively be grown in the areca gardens in recommended spacing with cocoa trees spaced at 2.7 m x 2.7 m and if the cost of cultivation of cocoa is found to be high, the next best spacing viz. cocoa spaced at 2.7 x 5.4 m may be preferable for realising good returns.

356 89 - 4/59

Cropping systems
Asia, tropics, developing countries, IRRI, cropping systems research, multiple cropping, small farmers, crop intensification, on-farm research, sustainability, future programes, evaluation
PENDLETON, J.W. and GREENLAND, D.J.
Cropping systems research program of IRRI.

In: Summary Procedings of an Experts Meeting, ICRISAT, India and UNEP, Kenya, 1986, pp. 25-27

The aim of cropping systems research at IRRI is to identify productive ricebased rainfed cropping systems acceptable to small farmers in specific regions. This paper presents the evolution, development, present research areas and achievements, and future challenges in cropping systems research by IRRI.
The six essential components of the methodology are site selection, site description, design of improved cropping systems, site testing, preproduction testing, and the production program. The last one, that is the production program, is the ultimate objective - to provide government decisionmakers with sufficient information to make firm decisions about supporting improved cropping systems programs and technology that will lead to greater food production and better family welfare for small Asian rice farmers. The CSR team helps prepare the recommendations for production programs with extension staff or government policymakers.
The program accomplishments are:
- The development of a methodology for designing, testing, and transferring improved technology for increasing food production.
- The formation of the Asian Cropping Systems Network and its continued growth and development.
- Specialized training at IRRI in cropping systems to trainees from many countries who return to be program leaders.

Future challenges exist primarily in the following areas:
- Variety improvement: Varieties that are tough enough to withstand stresses of too much water or too little water, that is the ability to produce relatively stable yields, are needed. Improvement of dryland crop varieties for rice-based cropping systems has been identified as the long-term objective. It is agreed that both the empirical and the physiological approaches should be utilized. Cultivars with low sensitivity to both temperature and photoperiod are needed.
- Management and tillage: For most soils, the conversion from puddled to well aggregated, well aerated soil conditions is expensive, time-consuming, and wasteful in terms of residual soil moisture. The transition period of as much as 1-2 months can be avoided by seeding the following crop in the uncultivated drained paddy field. Recent trials show promising results from this technique.
- Fertilizers: Maintenance of soil fertility and efficient fertilizer use in intensive cropping systems is beginning to

receive attention. Collaboration in long-term fertility trials and studies on controlled-release nitrogen carriers, to generate more information about tailoring fertilizer practices to fit rice-based cropping systems. Research on systems where organic and inorganic fertilizers are used in a complementary manner. Symbiotic nitrogen fixation must continue to receive attention for all legume types. Trials have shown that a green manure crop before rice can contribute the equivalent of 30 kg ha^{-1} of fertilizer N.
- Environment: Agrometeorological and land capability studies will receive more attention as a means of identifying areas where present cropping systems might be intensified. Basic rice growth modeling for rainfed rice will continue. Better information on the physical environment should assist us in understanding and controlling pest outbreaks. Closer identification of critical soil moisture levels for component crops is needed.
Socioeconomic variables are much harder to measure than physical parameters and simpler, faster methods are needed.
One of the future challenges for IRRI is how best to serve the increasing demands of national programs that have recently evolved from cropping systems programs dealing with only the cropping component of farming systems programs. It remains necessary to integrate livestock, agroforestry, aquaculture, and other components of farmers' production into the system. This will receive increasing collaborative attention.

357 89 - 4/60

Cropping systems
Africa, semi-arid tropics, review,ICRISAT, pearl millet, yield stability, management practices, soil fertility, production systems, plant nutrition, soil management, water-use-efficiency, tillage systems, animal traction, cultivars, cultural practices, crop associations, agroforestry
FUSSELL, L.K. et al.
Practiques de culture visant à augmenter et à stabiliser le rendement en Afrique. (Management Practices to Increase Yield and Yield Stability of Pearl Millet in Africa.).

In: Proc. of the Int. Pearl Millet Workshop, ICRISAT, India, Patancheru, A.P. 502 324, ISBN 92-9066-134-8, 1987, pp. 255-268

Pearl millet (*Pennisetum americanum*) is a staple cereal best adapted to the low fertility soils and frequently drought-prone semi-arid tropics of Africa and India. It is grown on an estimated 27 million ha in these two regions, with 56% of the production in Africa. In Africa, major pearl millet growing areas are in West Africa (83%) and the Sudan (8%), in the Sahelian (300-600 mm annual rainfall) and the Sudanian (600-900 mm) bioclimatic zones. Of the 14 million ha grown in West Africa, Nigeria (28%) is the largest producer, followed by Niger (22%), and Mali (10%). The discussion in this paper is confined to implications for these principal millet-growing regions of Africa.

Of all the regions of Sub-Saharan Africa (SSA), West Africa has shown the slowest growth rate for total food production, mainly due to the very low production rate of the major staples, sorghum and millet, and the decline in the groundnut cash crop production. The small increase in total food production has been almost exclusively due to increases in cultivated area. The new land tends to be in poorer, marginal cropping areas. The technological change has had little impact on food production in general, and millet production in particular. FAO statistics indicate for Africa to meet its food needs in the year 2000, increased production will have to come from increased yield per hectare (51%), rather than from expanded cultivated areas (27%), or from more than one crop per year on the same land (22%).
Millet is traditionally reserved for light, sandy, low fertility soils in areas where rainfall is low and drought common. Few yield-increasing inputs are used. Management strategies, using mainly hand labour, are extensive rather than intensive. The crop is grown with low plant populations, normally in association with other crops, particularly cowpeas (*Vigna unguiculata* [L.] Walp.) and Sorghum bicolor [L.] Moench). Millet grain is used primarily for human consumption, however the straw is important for construction and as standing dry fodder for animal production system.
Improved millet production in the West African semi-arid tropics (WASAT) should rely on management practices that increase yields, when possible, while improving production stability in both good and poor rainfall years. Farmers' production can be stabilized through a reduction in yield variation from year-to-year, and by insuring a carryover of grain from good to poor years.
The principal factors limiting millet yields in WASAT to be, in order of priority: (1) inherent loss of soil fertility, (2) limited and untimely cultural practice, and (3) the frequent occurrence of drought periods. The first two factors are more limiting than moisture in most years. In years when rainfall is inadequate, water-use efficiency and yields can be improved by inputs that address these two factors. The improvement of millet production will rely on management practices that overcome these limitations, while insuring yield stability and maintenance or improvement of the production resource base. Inputs, by necessity, will have to be available to the resource-poor farmer.

358

89 - 4/61

Cropping systems
Asia, India, field trials, intercropping, pigeonpea, plant populations, maize, green gram, sesame, upland rice
MOINBASHA, S. and R.A. SINGH
Land-Equivalent Ratios of Pigeonpea-Based Intercropping Systems at Different Plant Populations.

International Pigeonpea Newsletter (IPN),Nr.7, 1988, pp. 18-20

Field experiments were conducted during the cropping seasons of 1982/83 and 1983/84 at the Agricultural Research Station of Banaras Hindu University, Barkachha-Mirzapur, Uttar Pradesh, to develop compatible intercropping systems with pigeonpea for Ultisols (Vindhyan Red Loams) of eastern Uttar Pradesh, India. The experiments were laid out in randomized-block design with three replications. There were five intercropping plant populations factorially combined with green gram cv T44 (65 days to maturity), maize cv Diara Composite (75 days), sesame cv T12 (85 days), and upland rice cv Akashi (100 days; only in the 2nd year). Plant populations in intercropping were maintained by changing within-row plant to plant distance. Sole-crop treatments of all crops used in the intercropping experiment were grown at their respective optimum populations, i.e.: pigeonpea 50.000 plants ha^{-1}, maize 75.000 plant ha^{-1}, sesame 100.000 plants ha^{-1}, and mungbean 200.000 plants ha^{-1} and upland rice at 80 kg seed ha^{-1}.
Pigeonpea intercropping in additive combinations with either green gram, maize, or sesame was consistently more productive than when grown separately, as total LER values were greater than 1.0 for these treatments. However, the LERs of intercropping systems under replacement populations were close to 1.0 indicating no advantage of intercropping. Upland rice did not show any compatibility with pigonpea even when it was maintained at 150% of sole stand. Perhaps the taller-growing pigeonpeas shaded the rice canopy and reduced dry-matter partitioning to grain.
Intercropping of pigeonpea with low-growing green gram caused pigeonpea yield to be virtually identical to that of the control pigeonpea at each population pressure. The average response of total grain LERs of pigeonpea and green gram intercropping was superior and highly compatible when pigeonpea was alternated with three green gram rows at 30 cm. When intercropped with maize, partial LERs for pigeonpea were less than for pigeonpea grown alone. This indicates suppression of pigeonpea growth by maize. It is interesting to note that in intercropping, both pigeonpea and maize LERs for grain were affected when the maize plant population was increased any more than its sole optimum. Nevertheless, the response to total dry matter LER of maize was considerably higher and it did entail sacrifice in grain yield of pigeonpea. Thus the overall efficiency of the pigeonpea/maize intercropping system was optimum with a maize plant density at the sole maize optimum (75.000 plants ha^{-1}) but a pigeonpea density at 1.5 times (i.e., 75.000 plants ha^{-1}).
In conclusion, it has not been found any compatibility in intercropping upland rice with pigeonpea (at least with the row arrangements tried), but green gram maize and sesame were highly compatible and it would be more profitable to grow them as intercrops with pigeonpea than as sole crops.

359 89 - 4/62

Cropping systems
Africa, savanna, agroecological zones, experiments, cowpeas, varieties, cropping systems, small-scale farmers, potential
IITA
Cowpea varieties for different agro-ecological zones and cropping systems.

IITA Ann. Report and Research Highlights 1987/88, ISSN 03311-4340, 1988, pp. 76-81

Cowpeas - an important food legume produced in several countries around the world - are adapted to a wide array of soils and moisture regime. Because this crop is versatile and fits in with different cropping systems, rotational niches, and marginal lands unsuitable for some of the major crops, it has expansion potential and offers opportunities for small-scale farmers to practice intensive cropping on their farms.
The most limiting constraint is damage by insects because the plant is vulnerable to pests from seedling to harvest stage and in storage. In spite of this and some other constraints, the cowpea production area has maintained a stable position, but any expansion will depend on alleviating the insect pest problems which are more severe in Africa than in Latin America and Asia.
Cowpeas are grown in different agro-ecological zones of sub-Saharan Africa, but primarily in the drier regions of West Africa in mixture with millets and sorghum without any chemical protection. Insecticides are essential for pure or sole crop cowpeas.
IITA-bred varieties are being adopted in several countries of Africa, Central and South America, and Asia. Popularity of the varieties is based on superior performance, maturity, and seed type. For example, VITA-1, VITA-3, and VITA-7, popular in Central and South America, are not in other regions. For example, the preferred seed types in West Africa are large white or brown with a rough seed coat texture, but in Central and South America and East Africa cowpeas are used as a substitute for beans so consumers prefer red and brown seeds with a smooth coat.
Among the varieties TVx-3236 was the first to combine a moderate level of resistance to thrips and to receive wide acceptance in several ecological zones in Africa. It was then used as a parent for further incorporation of resistance to aphids and buchids, resulting in a new cowpea line - IT84S-2246-4. It has a high yield potential and moderate resistance to diseases and to aphids, bruchids, and thrips.
Because of a wide range in maturity and plant types available in cowpea germplasm, scientists developed erect, early-maturing cowpea varieties and evaluated them in maize-based, cassava-based, yam-based, and rice-based cropping systems.
Cowpea varieties adapted to different agroecological zones in various West African countries are listed in this paper.
IITA research on cowpeas in the years ahead will focus on plant resistance to insects and diseases and on breeding varieties

especially suited to mixed cropping with sorghum and millet in the moist and dry savanna zones in West and Central Africa. Here the need is for new varieties with stability of yield rather than high yielding cowpeas that require insecticides and fertilizers which small farmers cannot afford.
Pearl millet and cowpeas are grown extensively as intercrops in the dry savanna regions of West Africa.
Spreading and indeterminate types are important factors influencing cowpea yield in both sole and intercrop systems. Therefore, research efforts are aimed at developing spreading plant types suitable for the millet-based systems and having resistance to the various stresses that limit production.

360 89 - 4/63

Cropping systems
Africa, Kenya, semi-arid and arid zones, experiments, ecophysiology, land-use patterns, legumes, tepary bean, bambarra groundnut, drought resistance
HORNETZ, B.
Ökophysiologische Experimente zur Verbesserung der Landnutzung im Trockengrenzbereich SE-Kenyas mit trockenadaptierten Leguminosen (Tepary-Bohnen, Bambarra-Erderbsen). (Ecophysiological Experiments for Improving Land-duse Patterns in the Dryland of Southeast Kenya by Means of Drought Resistant Leguminous Crops (Tepary Beans, Bambarra Groundnuts).

Der Tropenlandwirt, 89, 1988, pp. 107-129

Pressure inducted by increased population of as much as about 4% per year has led to a dramatical shortage of arable land in the smallholder farming areas of Kenya, especially in the so called "high potential areas".
People either have to optimize their agricultural systems in these high potential areas by expensive investments or - as most of them leave their homes and try to settle in uncultivated areas, predominantly marginal agricultural lands of the semi-arid and arid drylands.
Though it can be observed that in the wetter parts of the drylands smallholders have started to cultivate drought resistant leguminous crops like pigeon peas (*Cajanus cajan*) and cowpeas (*Vigna unguiculata*), there is a lack of ecologically adapted crops in the potential cropping areas.
This study deals with potential cultivation of the "minor pulses" of tepary beans (*Phaseolus acutifolius*) and bambarra groundnuts (*Voandzeia/Vigna subterranea*) with special reference to their ecophysiological demand.
The aim of this research is to supplement actual land-use patterns in those areas recently dominated by integrated systems of crop cultivation and livestock production with ecological adapted leguminous crops of high nutritional values. This would subsequently reduce the risk of crop failure, food crises, and soil degradation (mainly by means of nitrogen fixation).

Newly constructed growth containers gave possibilities to stimulate different durations and intensities of water stress under controlled environmental conditions in climatic chamber experiments.
It was observed and recorded that teparies and bambarras possess different mechanisms of morphological and physiological adaptation to high temperature and water stress. This apparently includes the ability of osmotic adjustment. The patterns of adaptation to water stress are combined with defined hydrature periods closely connected with the reduction of soil moisture.
The computations resulted in a spatial differentiation of potential cultivation patterns of tepary beans and bambarra groundnuts. Short-cycle teparies can be cultivated in all areas of the analyzed geographical area. Successful cropping with a probability of about 67% is even confined to the more humid rainy seasons in the drier parts of the agroecological zone.
The tested variety of bambarra groundnuts turned out to need at least 75 days of sufficient water supply during the agrohumid period (AHP) to receive the water requirements for obtaining minimum yields in two out of three years.

V AGROECOLOGY

361 89 - 5/28

Agroecology
Review, environment, agriculture, economics, eco-development, holistic approach, nonmonetary principles, house-keeping, policy
SÖDERBAUM, P.
Agriculture, economics, and eco-development.

In: Proc. of the 6th Int. Sc. Conf., IFOAM, UC, Santa Cruz, California, USA, 1988, pp. 93-102

In this paper it is suggested that the meaning of economics is not necessarily a simple and clearcut one. There may be many kinds of economics, just as there are many kinds of agriculture. And what is more interesting, perhaps, is that there are important similarities with respect to philosophy between some forms of nonconventional economics and organic farming as a case of nonconventional agriculture. In a similar way, the links between conventional economics and conventional farming are worth studying.
When asked about the meaning of economics, many people tend to think primarily of monetary aspects such as the price "mechanism" and the use of money as an instrument in our societies.
Problems related to development and environment are certainly complex in many respects and any desire to simplify things is perfectly understandable. Some simplification is also necessary. But the process of reducing complex development and environmental phenomena to one-dimensional terms involves losses in relevance which make the whole approach dubious. It is oversimplification.
Economics has to be understood in an broad sense, in which a parallel study of nonmonetary and monetary processes as impacts is recommended. Management of health resources or natural resources like ecosystems will seldom be made any wiser by attempts to put monetary prices on everything. On the contrary, there is a risk that our understanding of the nonmonetary processes involved will diminish.
The tendency among economists and others to think of economics as mainly related to monetary resources and monetary aspects of other resources should be counteracted.
In addition to the holistic and multidimensional idea of economics and resources and positional thinking, positional analysis is characterized by systems thinking, i.e., an effort to identify all the diverse systems that will be affected differently, depending upon the alternative chosen in a specific decision situation. This is essentially a way of broadening the analysis from one-sector thinking to multi-sector analyses.
The first part of the word economics comes from oikos, meaning house. Economics, therefore, could be seen as dealing with housekeeping in a broad sense. The "holistic" conception of economics implies that any tendency to regard things as "more economic" when a monetary price has been put on them should be

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Economics has to be understood in an broad sense, in which a parallel study of nonmonetary and monetary processes as impacts is recommended. Management of health resources or natural resources like ecosystems will seldom be made any wiser by attempts to put monetary prices on everything. On the contrary, there is a risk that our understanding of the nonmonetary processes involved will diminish.
The tendency among economists and others to think of economics as mainly related to monetary resources and monetary aspects of other resources should be counteracted.
In addition to the holistic and multidimensional idea of economics and resources and positional thinking, positional analysis is characterized by systems thinking, i.e., an effort to identify all the diverse systems that will be affected differently, depending upon the alternative chosen in a specific decision situation. This is essentially a way of broadening the analysis from one-sector thinking to multi-sector analyses.
The first part of the word economics comes from oikos, meaning house. Economics, therefore, could be seen as dealing with housekeeping in a broad sense. The "holistic" conception of economics implies that any tendency to regard things as "more economic" when a monetary price has been put on them should be

counteracted. Money is certainly a very important and useful instrument in facilitating transactions and monetary incentives may be very powerful in influencing the course of development of the economy. But principles of housekeeping or management of resources may be nonmonetary as well as monetary. And nonmonetary principles are not "less economic" than monetary ones.

The search for useful principles of housekeeping should therefore be directed as much towards nonmonetary as towards monetary factors and variables. Productivity estimates connecting the outputs and inputs of specific industrial or agricultural activities are relevant in this context. The endeavor to increase productivity in terms of yields per hectare or milk per cow from one period to another is certainly a nonmonetary principle of housekeeping. But it is narrow in the sense that there are many kinds of outputs (some of which, like pollution, are negatively valued) and many kinds of inputs in a given agricultural activity, and thus many possible output-input ratios. To get a many sided picture of the development over time of a given farm activity, a set of productivity estimates and also a description of changes in resource positions with respect to soil, groundwater, human health, etc. is needed.

Agricultural practices which conform to a specific definition of organic farming will certainly not mean that all environmental problems have been eliminated, but such practices are likely to perform better according to environmental criteria. This is not unexpected, however, since the philosophy behind organic farming incorporates long-run considerations of what is good for ecosystems, human beings, and society at large. Or, to put it in the terminology the theory behind organic farming involves a holistic rather than reductionistic concept of economics and housekeeping. Monetary criteria are relevant for the organic farmer too, but the relative role of monetary success criteria in relation to environmental and social criteria seems to be different.

Money and monetary incentives can play a significant role in efforts to transform present agriculture to practices which are environmentally sound. There are nonmonetary incentives in addition to the monetary ones. And beyond prices and perceptions of supply and demand, there are always human beings and often social relationships rather than mechanical forces. Social pressure within a bussiness community can certainly give considerable scope to unrestricted egoism and be destructive. On the other hand, to the extent that business leaders think and behave according to judgements of social and environmental responsibility, they will play a more constructive role in building a future sustainable society.

89-5/29

362

Agroecology
Review, sustainability, developing countries, human development, agricultural sector, training, economy theory, systems approach, holistic thinking
WOODS, B.M.
Human development and sustainability.

In: Proc. of the Seventh Agric. Sector Symposium - Sustainability Issues in Agricultural Development -; The World Bank, 1818 H Street, N.W. Washington, D.C. 20433, U.S.A., 1987, pp. 80-91

Sustainable development requires the necessary human skills, attitudes, motivation, understanding, leadership, organizations, policies, plans, and administrative and financial systems for whatever activities are involved - as well as the necessary infrastructure, funds, and physical inputs.

Despite all the resources and dedication that have been applied to development, shortcomings in "institution building" and "human resource development" remain, and a great many well-intended projects and programs have failed to be sustainable as a result.

The problem is well known, but its solution continues to exist.

A better understanding of the reasons for this persistent difficulty in development would be half way to its solution.

This paper addresses this issue and draws together the separate conclusions of authorities in a variety of relevant fields. They show the reason to be simple, but the solution to affect some of the underlying assumptions and philosophies on which development assistance has been based.

The paper considers findings in the agricultural sector; it touches on economic theory; examines the learning process on which human development depends, and how this has been approached in "development"; and it describes an underlying cause of a pervasive problem.

The paper summarizes that one can view the human development required for sustainability first in the context of what is needed within the agricultural sector, and in the context of what is needed for the total universe of learning on which development depends and then concludes within agricultural sector:

- that the staff profile, skills, language, and perceived role of the sector have led to great emphasis on the technical/physical, an economic/financial dimensions of agricultural development, but excluded equal attention to the human dimension;
- that development has to be effective in the human dimension to achieve sustainability, but prevailing conventional wisdom and the mental programming of most development planners and practitioners which derive from traditional education systems currently prevent wide success in that dimension;
- that the imbalance between the three dimensions through "reprogramming" of those involved in the sector can be corrected;

- that there is a need to focus on the root cause of the problem which lies in the reductionism of traditional educational systems, and in agricultural education especially.

Byond the agricultural sector there are other essentials, but missing, ingredients of sustainable development on which the sustainability of agricultural development depends. These include particularly the extent to which development approaches deriving from the technical sectors now in place are unable to deal with the whole spectrum of adult learning needed for development. The addition of the organizational structures, expertise and resources needed to achieve this whole spectrum of adult learning offers new opportunities for investment and for success in development. But it calls for a move toward holistic systems approaches and away from the reductionist thinking styles which have dominated development assistance to date.

363 89-5/30

Agroecology
Review, sustainability, definition, development, environmental management, ecology, sociology, economy, energy, global concept, indicators, policy making
BROWN, B.J. et al.
Global sustainability: toward definition.

Environmental Management, 11, No. 6, 1987, pp. 713-719

Sustainability is clearly becoming a popular word in the environmental policy and research arena. "Sustainable development","sustained use of the biosphere," and "ecological sustainability" are terms increasingly used by institutions and individuals concerned with the relationships between humans and the global environment.
In recent years, much attention of the scientific and policy-making community has become focused on global sustainability. For example, the Man and the Biosphere Program of UNESCO is concerned with integrated approaches to global natural resources management, particularly in and around designated biosphere reserves.
Sustainability is raidly becoming one of those transcendent terms, like "appropriate technology" or "environmental quality," which are cornerstones of environmental policy and research, but difficult to measure and rarely defined explicitly.
In this article, the concept of sustainability is examine, some of the ways in which it has been defined, and the use of the terms sustainable, sustained, and sustainability in the global context are clarified.
There are obviously many ways of defining sustainability. The common themes that emerge include:
- The continued support of human life on earth
- Long-term maintenance of the stock of biological resources and the productivity of agricultural systems
- Stable human populations
- Limited growth economies

- An emphasis on small-scale and self-reliance
- Continued quality in the environment and ecosystems.

If one accepts an anthropocentric view of sustainability, with the focus being on indefinite and global sustainability, then there is a range of ways in which to construct a definition from the essential elements.
In the narrowest-sense, global sustainability means the indefinite survival of the human species across all regions of the world.
A broader sense of the meaning specifies that virtually all humans, once born, live to adulthood and that their lives have quality beyond mere biological survival.
The broadest sense of global sustainability includes the persistence of all components of the biosphere, even those with no apparent benefit to humanity.
The emphasis in agriculture is gradually shifting from a goal of maximizing production in the short term to a perspective that also considers long-term maintenance (that is, sustainability) of production.
Sustainable agriculture must conserve the land resource base without degradation and must be economically viable and socially acceptable as well. Recent volumes on sustainable agriculture discuss the importance of soil and water conservation, genetic diversity, and appropriate technologies in insuring a continued supply of food, a reasonable quality of rural life, and a healthy environment.
The meaning of the term is strongly dependent on the context in which it is applied and on whether its use is based on a social , economic, or ecological perspective. Sustainability may be defined broadly or narrowly, but a useful definition must specify explicitly the context as well as the temporal and spatial scales being considered.
Setting the priorities for sustaining or being sustained, and at what costs, is a process that can only be accomplished within the context of a clearly stated definition of sustainability. Deciding what actions and policies should be taken to achieve sustainability can only be accomplished with appropriate measures and indicators of sustainability.

364 89-5/31

Agroecology
Review, environment, agriculture practices, pre-industrial impact, shifting cultivation, permanent agriculture, hunters, gatherers, pastoralism
SIMMONS, J.G.
The environmental impact of pre-industrial agriculture.

Outlook on Agriculture, 17, No. 3, 1988, pp. 90-95

The growing impact of changing agricultural practices on the environment is a matter of general concern, but it is generally supposed to date largely from the introduction of machinery and agrochemicals. In fact, the impact was substantial long before

this, and can be tracted back to hunter-gatherers like the Australian aborigines who, without actively cultivating the land nevertheless deliberately controlled their local environment - as by burning or simple water management - in order to conserve the wild life on which they depended.
The purpose of this paper is to give an idea about some of the ways in which agriculturalists changed the maps of their regions even in the days before they had access to the products of industrialisation.
The paper deals, therefore, with the period between the emergence of the first plant and animal domesticated in the 9th-7th millennia BC and about 1890 AD when the products of the iron- and chemical-based industrial revolution began to affect farming practice in a way which has undoubted environmental significance. The terminal date is also arbitrary in the sense that the agriculture of many Third World countries today has not experienced the full impact of industrialization, so that process is incomplete. But to demarcate any period of history is to acknowledge that one cannot entirely sever it from what went before and what comes after, and so one needs to sandwich the main theme with some account of the predecessors of pre-industrial farmers as well as with a few remarks concerning perspective now afforded by about 150 years of the industrialised way of life.

365 89-5/32

Agroecology
Discussion, developing countries, ecological agriculture, environmental problems, calamity approach, conservation strategy, agriculture strategy, small-scale farmer
GERRITS, R.
Environmental problems and the role of ecological agriculture in the Third World.

In: Global Perspectives on Agroecology and Sustainable Agricultural Systems, Proc. of the Sixth Int. Sc. Conf. of the IFOAM, Ed. Patricia Allen and D. van Dusen; The Agroecology Program, Univ. of California, Santa Cruz, CA 95064; 1988, pp. 153-158

This paper discusses the concept of ecological agriculture within the Third World as a means to overcome some of the adverse effects brought about by increased use of Green Revolution techniques. Major environmental problems associated with agriculture are described as well as some global alternatives suggested by the World Conservation Strategy and the World Commission on Environment and Development.
Today the world faces environmental problems that are both serious and complex. Generally stated, these include:
- Soil erosion.
- Air/water/land pollution.
- Loss of genetic resources.
- Deforestation.

- Desertification.
- Population.
Until now the principal way of dealing with global environmental issues has been the so-called "calamity approach." That is, whenever a global ecological problem reaches the level at which calamities occur, politicians tend to do the minimum necessary to avoid growth of the problem, be it a short-term solution or long-term containment. Military defense and economic growth are the top priorities, while global environmental issues still have a low priority within most governments.
Unique ecosystems are being destroyed - quickly and thoroughly. Due to the delayed "development" of the Third World and its high genetic diversity, ecosystems destruction is today worse in the Third World than in the First World. There is more to destroy, the Third World still has the better part of the world's genetic diversity scattered over countless unique ecosystems, while the First World has already lost most of its own ecological heritage. In slowing and stopping this destruction, ecological agriculture clearly has a role to play as a sound environmental-management counterstrategy to the Green Revolution.
Ecological agriculture can be a sound strategy for solving the ecological problems of increased pesticide use, population growth, erosion, deforestation, and desertification. With ecological agriculture, chemical pesticide use is minimized or avoided completely; biological and integrated plant protection is utilized. Mulching and composting are necessary since they add to the organic content of the soil. Humus is an essential factor for soil fertility with positive effects on soil structure, air, water, nutrient interactions, and soil health. Together with multicropping, biological nitrogen fixation, agroforestry and combinations of animal husbandry and crop farming, ecological agriculture is also a form of erosion control.
Ecologically oriented agriculture aims at establishing high and lasting soil productivity, thereby conserving or re-establishing a well balanced ecological environment to enable the future existence of humanity within sound ecological systems.
Most promotion of ecological agriculture in developing countries will need to take place at a grassroots level with the help of local and foreign nongovernmental organizations. The principal target group will be Third World men and women, small-scale farmers who produce food for their own consumption or for local markets.

366 89 - 5/33

Agroecology
Review, book, developing countries, GTZ, ILEIA, AGRECOL, ecofarming, agricultural development, technical cooperation, techniques, principles, traditional practices, participatory research and development, training, sustainability, low-external-input
KOTSCHI, J. et al.
Ecofarming in agricultural development.

Verlag J. Markgraf, Mühlstr. 9,P.O.B. 105, D-6992 Weikersheim, F.R.G. and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, F.R.G.; ISBN 3-8236-1163-1, 1989, 131 pp.

"Ecofarming in agricultural development" contributes to the discussion of the principles and methods of sustainable agricultural development, and its importance for the development of smallholder agriculture in the tropics.
The book contains a definition of ecofarming (sustainable agriculture with low levels of external inputs), and an outline of the major ecofarming techniques from the point of view of formal agricultural science, the major results of a GTZ survey of ecofarming development activities, and a commentary on the state-of-the-art of ecofarming development within technical cooperation.
The book takes a close look at indigenous agricultural knowledge and ecofarming practices in the tropics, and the possibilities of collaboration between local farmers and agricultural scientists in developing site-appropriate techniques of sustainable agriculture. This leads on to a consideration of the implications of this approach for project and advisory work, professional training, research emphases, and the planning and organization of technical cooperation.
In detail the book deals with the following aspects:

1. Why "ecofarming"?
   - What is ecofarming?
   - Why is the promotion of ecofarming necessary?
2. Ecofarming in Technical Cooperation
   - Major techniques and principles of ecofarming
     Vegetation design: multiple cropping and agroforestry
     Use of biological symbionts
     Green manuring
     Mulching
     Composting
     Integrated plant protection
     Integration of livestock
     Integration od aquaculture
   - Current research activities and development approach
     Ecofarming research activities
     Prevailing approach to ecofarming development

3. An underutilized resource: Indigenous ecofarming knowledge
   - Indigenous ecofarming practices
     Vegetation design and manipulation
     Soil fertility enhancement
     Crop-livestock integration
     Plant protection
   - Indigenous experimentation
4. Toward scientist-farmer cooperation in ecofarming development
   - Participatory research and development
     Situation analysis
     Innovation design, testing and evaluation
     Spreading the ideas
   - The challenge for Technical Cooperation
     Form and content of project and advisory work
     Training of professionals in agricultural development
     Priorities in terms of regions and activities
     Planning and organization of Technical Cooperation
5. References

Annex 1: GTZ survey of ecofarming activities in Technical Cooperation
Annex 2: List of contact addresses
Annex 3: List of relevant GTZ projects

The authors welcome reports from additional individuals, groups and institutions involved in ecofarming research and development, to permit more detailed and up-to-date documentation of activities and wider dissemination of information between interested parties. Furthermore it is hoped that this volume will stimulate further thought and discussion among development workers in the field as well as in the head offices of Technical Cooperation agencies.
Numerous development institutes and concerned individuals provided information and ideas for this study; most of them are mentioned in the address list or references.

367 89 - 5/34

Agroecology
Review, compendium, subhumid zones, arid zones, sustainability, erosion control, water management, pastoralism, integrated systems, agroforestry, extension, training, participatory approach
ARRIGNON, J.
Agro-écologie des zone arides et sub-humides.
(Agro-ecology of arid and sub-humid zones).

Maison neuve et Larose - ACCT, 1987, 283 pp., available ACCT, 13 Quai André Citroën, 75015 Paris, France

This work is a compendium of short notes, taken by the author during 30 years work as a tropical agronomist. It doesn't claim to be exhaustive nor to be a pedagogic book; its wealth is elsewhere: it gives the reader the experience of a "field man" hints tricks, facts in numbers, sketches etc. And that all about a subject, which is more spoken of, than precisely referred to.

Following attentively the author's plan, one learns that agro-ecology concerns many fields such as: erosion control, water management, pastoralism, integrated production, agroforestry and other technologies. The logic is not always evident, and the reader is obliged to consider many cross-references through the chapters.
The "spirit" of the book is: more ecological management in arid and sub-humid zones. The compendium closes with 2 methodological chapters considering problems of sensibilization, popularization, formation, participation of the population and external intervention.
Abstract from Agricultures actualité

368 89 - 5/35

Agroecology
Review, humid tropics, case studies, economic development, agricultural projects, applied ecology, agroecological approach, research needs, integrated agroecosystems, weed management, sustainability
GLIESSMAN, S.R.
The role of applied acology and agroecology in the design of agricultural projects for the humid tropics.

Paper from the Workshop "Application of Ecology to Enhancing Economic Development in the Humid Tropics"; 38th AIBS-Annual Meeting, Ohio State University, Columbus, 1987, 29 pp.

The term sustainability has become the topic of considerable discussion and concern among a broad spectrum of people involved in the multiple components of the production, processing and distribution of food, feed, and fiber around the globe.
This is especially true for those people working in agriculture in the humid tropics.
A focus on managing agricultural resources in the tropics needs to be developed that both reduces the dependence on costly, non-renewable inputs, and ameliorates the impacts that current practices are having on the environment. By applying an ecological element to the design and management of agricultural projects, as well as developing an analytical model that allows for the incorporation of longer-term aspects of sustainability, prospects for the future of agriculture in the tropics can be greatly improved.
Agroecology is the application of ecological concepts and principles to the design and management of sustainable agricultural systems. It has as a goal the development of agroecosystems that depend on low external-inputs, function more on the use of locally available and renewable resources, have benign impacts on the environment, and are built upon the knowledge and culture of the local inhabitants of the region. The agroecosystem is the basic unit of analysis of any particular production system, and to a certain extent, can be analyzed using systems methodology common in most economic analysis.

In detail the following aspects are discussed in this paper:
- Agroecological approach
- Agroecological research focus: case studies
- Integrated agroecosystems
- Agroecological approach to weed management
- Future research needs

In the final chapter "future research needs", the author states that an agroecological focus on tropical agriculture goes much beyond crop yields, delving deeply into the complex set of factors that make up the agroecosystem. Local, indigenous agroecosystems that have evolved under the diverse and often limiting conditions of the tropical environment, are adapted to this set of factors. They have evolved through time as low external-input systems, with a greater reliance on renewable resources and on ecological-based management strategies. A research focus in agriculture that can take advantage of this knowledge and experience permits to explore the multiple bases upon which sustainability rests. It represents the blending of knowledge gained by ecologists studying the dynamics and stability of natural tropical ecosystems with the knowledge of farmers and agronomists on how to manage the complexities of food producing agroecosystems. From this can become the sustainability in the production base so critical for the long-term cropping of farmlands in the tropics. Therefore, it becomes critical that one has found ways to combine the short-term demand that economic models place on agricultural development with the need to project the long-term ecological models of sustainability generations into the future. This can only be done by demonstrating the absolute need to link ecological knowledge with long-term economic viability and environmental quality.

369 89 - 5/36

Agroecology
Review, book, Africa, Sub-Sahara, food production technology, nutrition, women's role, agriculture, labour use, support systems, food policy, development strategies, assistance strategies
MELLOR, J.W. et al.
Accelerating food production in sub-Saharan Africa.

The Johns Hopkins University Press, 701 West 40th Street, Baltimore, Maryland 21211; published for the Int. Food Policy Res. Institute, ISBN 0-8018-3390-6, 1987, 343 +xvii pp.

Sub-Saharan Africa is an enormous region comprising 39 countries with a combined area of more than 22 million square kilometers. It represents nearly three-quarters of the African continent and about 15 percent of the land mass of the entire world. The population in mid-1979 numbered about 344 million, slightly more than three-quarters of the total for all of Africa and 8 percent of the global total.
The climates in these regions range from tropical rain forest to arid desert. The question arises as to whether agriculture can in fact reasonably be expected to fulfill its required role.

This book provides up-to-date definitions of the food and nutrition problems that face us now and in the medium-term future. The book also deals with the policy needs for promoting growth of food production.
The book examines food policy in the context of national development strategies.
Several chapters in this volume, written by representatives from both sub-Saharan Africa and donor countries and agencies, analyze past experiences and suggest aid strategies for accelerating agricultural growth in oll part of the world. Several stress the point that the aid most urgently required is that which would assist our region in greater utilization of its agricultural base in order to increase overall production and lessen dependence on food aid.
The papers provide a wide-ranging, up-to-date, and varied approach to key issues, which reflect the diverse physical, cultural, economic, and political environment of Africa.
Perhaps the most telling message of the book is the urgent need for immediate action.

370 89 - 5/37

Agroecology
Europe, France, regions, study, marketing structures, biological agriculture
GRÉGOIRE, M.C. and ROCQ, S.
Quel développement pour l'agriculture biologique?
(Biological agriculture and its development?).

Nature et Progrès, 1988, 54 pp., available at: Nature et Progrès, Service Librairie, 142 rue de la Gravière, F-30460 Lasalle, France

This a thorough study of marketing structures in biological agriculture in three regions: Rhône-Alpes, Franche-Comté et Provence-Alpes-Côte d'Azur.
The biological agriculture has often preferred short circuits (direct sales) to long ones (markets dependent from transport = expedition marketing); the study begins with this statement, gives reasons and motivations for this fact.
Since few years, marketing structures arise in the investigated regions, some disappear or are transformed, other develop and become slowly professional.
What are the hindrance to a real development of the "expedition market" of biological products? Be it cereals, fruits or vegetables which have to be transported, the producer/wholesaler should concentrate exclusively on organizing themselves to plan the production and the sales. The main problem is thereby the quantity and regularity in production; another problem arises from a certain incapacity to offer a satisfactory range of products to the wholesaler, i.e. to the potential consumer.
Furthermore, other obstacles are: the lack of technical knowledge (in tree cultivation for example, where the schedules of conditions are sometimes too constraining); the insufficient

results in research (varieties not adapted to the market, lack of information about bio-pesticides), which all slow down the professional penetration of the market.
On the whole, the authors note that most of the problems could be solved, if the farms were better organized.
At the end of the study, it is striking to understand that the development of the biological agriculture is closely bound to an increasing exchange of technical and economical information and to better market commodities. But this development depends also on a change of mentality for a better integration of these new concepts into the methods and structures of conventional agriculture.
Abstract from Agricultures actualité

371 89 - 5/38

Agroecology
Review, book, developing countries, case studies, Pakistan, Peru, Sudan, humid tropics, arid and semi-arid zones, mountain zones, rural development, ecological resources, preservation, DSE, BMZ, GTZ, RF
KLENNERT, K.
Rural 'development and preservation of natural resources: challenge: or contradiction?

Report of a Conference of the German Foundation for International Development (DSE), 1983, 124 pp.

In view of the decline in food availability per capita and the rapid increase in (imported) food requirements in the developing countries, the need for an increase in food production in these countries is so massive that it would even exceed the growth rates achieved in the 1960s and 1970s. At the same time, natural resources are being placed under such strain that the objective of ensuring food production levels in the countries of the Third World, which are least adequate in terms of quantity and quality, can be achieved only by means of a major effort on the part of both researchers and those engaged in the field.
This report on an international seminar organized by the Food and Agriculture Development Centre of the German Foundation for International Development on the subject of "Rural Development and Careful Utilization of Resources" looks at case studies from Pakistan, Peru and Sudan. The report examines the specific conditions in various regions and production systems of these countries, but its results should also be applicable to neighbouring countries with similar ecological and socio-economic structures.
The basic assumption underlying the Conference was that rural development should be accorded highest priority in all future development efforts, this in the interest of ensuring that the development process as a whole should remain well balanced.

The most important development objectives in this connection are the following:
- improving food and energy supplies by means of an increase in agricultural and forestry production and adjustment of the production structures;
- securing from such measures the greatest possible employment and income effects for the broad mass of the populations;
- long-term protection of natural resources.

The task at hand was to develop strategies which would give due consideration to this entire package of objectives. Since the individual objectives are interdependent in the long term, overly pronounced emphasis of one of them would ultimately prevent a self-sustaining development process. Of extraordinary importance in this connection was an analysis of the reciprocal dependencies between natural, technical and social factors in their significance with respect to goal attainment.

372

89 - 5/39

Agroecology
Review, book, developing countries, development, international cooperation, microprojects, NGO's, accountability, improverishment, pragmatic approaches, economics, sociology, Club of Rome
VILLON, A.F.
The barefoot revolution.

Intermediate Technology Publications, 9 King Street, London WCZE 8 HW, UK, ISBN 0-946688-19-2, 1988, 245 pp.

A new pattern of development is taking shape at community and village level in rural areas of the Third World. In a spirit of self-reliance, numerous "grassroots" groups have decided to take charge of their own development in rural villages throughout Latin America, Africa, and Asia.
This book is based on the results of surveys of 93 small-scale development projects carried out by six teams of researchers in nineteen countries of Latin America, Africa, and Asia from September 1983 to January 1985. Each team was made up of two professionals, one from the social sciences - sociologist, anthropologist, historian - the other an economist, agronomist, or experienced development field-worker. Each team spent an average of a week to ten days at the project site, interviewing its participants, beneficiaries, NGO workers, villagers, officials, religious leaders, local organizations. The teams also sought out people in neighbouring villages and areas to determine the local impact of the project and how it was perceived by outsiders.
The field surveys were followed up by a documentary study of a further 227 small-scale projects primarily supported by organizations in the developed world. Appendix I outlines the methodology of the entire project.

In detail the book contains the following chapters:
PART ONE
- Twenty years of misguided development
- Microprojects - a new world-wide development
- Development of the Third World - a continual concern of the Club of Rome

PART TWO
- First aid, then development
- Factors of impoverishment

PART THREE
- Factors of development
- NGOs: a new world phenomenon
- NGOs in the field
- The significance of NGO activity around the world
- Accountability

PART FOUR
- Can NGOs limit the factors of impoverishment?
- Can NGOs create factors of development?
- Obstacles and limits to NGO action

PART FIVE
- Economic and social achievements
- A new approach to development

Conclusion
Appendix I: Methodology of the study
Appendix II: List of projects visited
Appendix III: The Club of Rome
The purpose, was to identify and measure the impact of small-scale operations on the severe problems affecting rural areas in the Third World.
In order to ensure lasting social and economic progress, the communities had to achieve a certain degree of self-reliance and regain the initiative, choice, and responsibility for their own development. The ultimate aim of the study was to determine whether small rural development projects really offer a valid development alternative for the Third World.
The importance and urgency of the so called "barefoot revolution" require from governments, international institutions, and non-governmental organizations new thinking and novel approaches, closer co-operation and greater responsiveness to the growing expectations of rural communities. Failing such a response, the quiet revolution might very well grow more radical and fall prey to the temptations of violence.
NGOs are beginning to emerge as a significant force for development.

373 89 - 5/40

Agroecology
Review, sustainability, policy, natural resources, institutions, World Bank
HOPPER, W.D.
Sustainability, policies, natural resources and institutions.

Proc. of the Seventh Agricult. Sect. Symposium on Sustainability Issues in Agricultural Development, Eds. T.J. Davis and I.A. Schirmer; The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A.; ISBN 0-8213-0909-9, 1987, pp. 5-16

The author of this paper is focussing on the term sustainability and tries to forge a tie between it and a core definition of social and cultural institutions.
After a definition of the term sustainability, the paper is dealing with agricultural projects in the context of the core issues of development change.
Based on practical examples the implication of sustainability, natural resources and institutions are discussed.
Finally the paper is closing on the question of sustainability by referring to South Asia's green revolution story.
In laying the groundwork for massive change in agricultural practices there was a firm assumption that farmers would adopt new techniques if they were profitable and if the required behavior was in conformity with the cultural traditions of village society. For the diffusion of the high yielding crop varieties, these assumptions proved valid. More difficult was the organization of farmer cooperation. The competitive structure of village kinship groupings has made and will continue to make farmer cooperation a difficult social innovation. Health practices, changes in social organization, legal system reforms, etc., will be much more difficult to engineer without significant and continuous pressure on the structure of traditional social and cultural values and institutions. Obviously if project execution is faulty due to poor management even those activities that do mesh with the basic cultural framework of the society will have little impact and even less duration. And if the economic, social or administrative infrastructure of support for the project and its several components is not in place, the likelihood of later finding much of a residual of the project vision will be very small indeed. Education, training and an understanding of how cultures evolve, how practices within a culture, within a society interact and evolve and alter are keys to the sustainability of the endeavours we seek to initiate and nourish to completion.

374 89 - 5/41

Agroecology
Review, sustainable development, IIED, water resources, land resources, planning, management, pesticide losses, nutrient losses, soil erosion, integrated approach, partnership
PRETTY, J.N.
Planning and management for water and land resources: partnerships for sustainable development.

Paper from Development Interregional Seminar on Water Quality Management in Developing Countries; International Institute for Environment and Development - Sustainable Agriculture Programme -; 1989, 27 pp.

This paper summarises the impact of agricultural activity on natural resources and, in particular, on the water environment.
For most of its history agriculture has been environmentally benign. Crop residues were incorporated into the soil or fed to livestock, and manures returned to the land in amounts that could be absorbed and utilised. This kind of traditional mixed farming system was closed and sustainable, generating few external impacts and using few external resources.
But this has changed over recent years. Increasing pressures for food production growth to feed expanding populations have resulted in the production and distribution of externalities, and consequent costs, that affect both the human and natural environment. These increased social costs principally arise from the intensification of land use, often involving the use and overuse of fertilisers and pesticides.
The impact of agriculture activity on natural resources and in particular on the water environment can be widespread and severe, though not always due to agriculture alone. Given a continued need for growth in food production, the evidence indicates a likely increase in contamination for the future years.
This contamination constitutes a widespread social cost. It also threatens the sustainability of natural resources and compromises the ability of future generations to meet their needs. Quite clearly approaches must be found that will enable a satisfactory resolution of this key trade off between production and sustainability. These include approaches for integrating pest management, nutrient conservation and soil and water conservation. But the challenge still remains to extend such integrated approaches to farmers and rural people themselves. Greatest advances are currently being made where rural people are involved in the process of planning and management in a partnership with research scientists, developers and extension workers. Only through joint analysis will these conflicts over development goals be avoided, and natural resources sustained to meet the needs of future generations.
In detail the paper deals with the following aspects:
- Impact of nutrient losses from fertilisers and livestock manures
- Impact of pesticide losses on water resources
- Soil erosion

- Future trends in contamination
- Conflicting development goals
- Integrated approaches to management
- Partnership in planning

Management of agricultural and natural resources must resolve the conflicts between production goals and those relating to equity and sustainability. This can only be achieved by extending finetuned and integrated approaches to farmers which, if they are to be adopted in sufficient numbers to make a significant impact, must be planned in partnership with the rural people themselves.

375 89 - 5/42

Agroecology
Review, tropics, ecosystems, Africa, Rwanda, GTZ, ecofarming, ecology, sustainability, shifting cultivation, ecological intensification, diversity, site specific compatibility, stability, integrated approach, low-external-input agriculture
EGGER, K.
Ecofarming in the tropics.

IFOAM, 6, 1988, pp. 3-6

In the industrialized nations, ecofarming has developed in opposition to extreme intensification. Fertilizers and pesticides contaminate the food of human beings and animals, endanger the environment and lead to overproduction. In the developing countries of the tropical area, ecofarming is based on a "lack". It is the soil exhaustion along with an intensive exploitation that destroys the ecological basis and creates insufficient provision, and even hunger. Thus, an intensification is still useful, but: Certain criteria are therefore necessary regarding an ecofarming in the tropics ensuring sustainance and variety with little help from outside (sustainability - diversity - low external input).
In this paper the author refers to the following aspects:
- Shifting cultivation
- The Green-revolution-strategy
- Ecological consequences
- Autochthonous "Ecofarming"
- Permanent agroforestry
- Organic farming
- Intercropping, relay cropping
- Intensive fallow
- Goals of ecofarming
- Stability
- Diversity
- Site specific ecosystems
- Stability
- Diversity
- Site specific compatibility
- Ecofarming in Rwanda - the concept of ecological intensification
- Integration of trees = Agroforestry

- Integration of animals
- Intensive bush fallow/green manuring/compost
- Water retention, hedgeline, terracing/-complex
- Intercropping, rotation
- Modern technical inputs (tools, fertilizer, pesticides)
- Extension and transfer of ecofarming

The paper concludes that an internationally spread network of centres, where ecofarming is practised and shown, should be aimed. The great research centres cannot play this role - they are conceptionally dominated by other interests. It should be an alternative network. This is an important task for IFOAM, to publicize the underlying beginnings, to report about them and to stimulate the exchange of experiences between them. The centres have to be distributed in such a way that they cover the most important climatic zones and can be reached easily.
The GTZ-project in Nyabisindu/Rwanda played the role of such a centre, but it can only do that in the future, if the GTZ continues to carry on the concept.
At present, the research and development centre IPIASP in Mugusa/Rwanda, which is financed by the Land of Baden-Württemberg and by private partnerships, is prepared to admit persons interested in ecofarming. A lot of groups carried by NGOs make use of this offer.

376 89 - 5/43

Agroecology
Africa, Nigeria, study, NGO, pioneer project, results, illiteracy, motivation, sociology, integrated approach
AKOMOLAFE OLATUNJI
The limits of ecological agriculture in Nigeria.

IFOAM, 8, 1989, pp. 7-8

The various research projects carried out by the Village Pioneer Project (VPP), Ajue, Nigeria, are discussed in this paper. The VPP observations of the factors hindering ecological awareness are mentioned.
All ecologists agree that ecological awareness is a product of general awareness. The farmers and people in Nigeria are probably only as ecologically aware as they are scientifically and economically aware.
Advancement of technology and innovation have been failing in Nigeria because of the conservative attitude of the people. Most people are traditionally fixed to a particular way of doing things and would hardly accept any ecological improvement, no matter how well this may be intended.
The most difficult but important aspect of ecological agriculture is integrated agriculture, that is, the combination of animal and crop production.
The integration is as yet very limited in Nigeria, where the animals are roaming about without a specifically controlled confinement. The research in the Village Pioneer Project, Ajue in

Ondo-State of Nigeria confirmed: "That while the production of pigs, rabbits, and poultry makes mixed-farming possible for the small farmers, the goat production requires a very large area of farmland, which the farmers with small plot holdings cannot afford". Research further confirmed that the mere integration of plants and animals would not wholly solve the problems of ecological agriculture without an integral knowledge of the utilization of all possible local resources.
It is understood that Nigeria poisons itself continuously by its ignorance, in spite of the knowledge the scientists acquired, which is of no practical use for Nigeria. The new eco-tactics now developed by the ecologically advanced countries would not produce any effect in Nigeria if the Nigerians are to remain stagnant in the understanding of the essence of ecological awareness required in protecting their environments. The government of Nigeria cannot achieve any tangible development in her agricultural programmes if sufficient encouragements are not given to the eco-farmers in order for them to be able to expand their productions.
The ecological balance which the Village Pioneer Project anticipates would not be restricted to teachers and educationalists but would also include religious leaders in their places of worship. Nigeria would then reserve much more time for eco-campaigns than preaching in the parks. The effectiveness of the above mentioned solutions would depend on an integral education from the smallest school of thought, the kindergarten, to the highest institute of learning.
Village Pioneer Project
c/o Revd. Bishop Goonigi,
P.O. Box 1622, Akure,
Nigeria.
Information integrated agriculture can be obtained from Village Pioneer Project in Nigeria. The VPP is fully prepared to enter into partnership whit any person or the organisations on the road to improve agro-allied training and ecological self-sufficiency.

377 89 - 5/44

Agroecology
Review, book, report, Africa, natural resources, sustainable development, human environment, agriculture, food, climate, soil, water, forest, wildlife, pasture, livestock, fishery, genetic resources, environmental problems, erosion, soil degradation, deforestation, desertification, land utilization, pollution problems
FAO
Natural resources and the human environment for food and agriculture in Africa.
FAO Environment and Energy Paper No.6, ISBN 92-5-102354-9, 83pp.

The productive capacity of most of Africa's natural resources for food and agricultural production depends on delicate physical and biological balances that are not yet fully understood. Man's capability of disturbing these balances has vastly increased.

Whenever a resource is used beyond its productive capacity, it is degraded and depleted, often beyond the possibility of recovery, for many generations to come.
The report surveys the state of the principal natural resources for food and agricultural production in Africa, and some of the more critical problems that have arisen from man's growing demands on these resources. The greater part of the report consists of an overview of present knowledge of the extent, state and potential of natural resources for food and agricultural production (including fisheries and forestry) in Africa, and of related environmental issues. It includes a brief account of the mineral resources for fertilizer production. A main conclusion of the survey concerns the need for a better database and for its use for the regular assessment and monitoring of the use and the state of natural resources for food and agricultural production in Africa. A further conclusion is that, while Africa as a whole appears to be endowed with natural resources that are abundant enough to feed a greatly expanded population, these resources are very unevenly distributed. This applies especially to the quantity and quality of soil and water resources, to agroclimatic suitability, and to forest and marine fishery resources. Most of the action that is needed, both for the proper management of natural resources and for the prevention of pollution, must be at the national level. In some cases, such as the management of watersheds, river basins and fish stocks crossing international boundaries, as well as the conservation of some genetic resources, intergovernmental cooperation is also necessary.
The final part of the report attempts to draw some preliminary general conclusions on the state of the natural resources for food and agricultural production in Africa, and on some of the requirements for their better assessment and management.
As far as possible, the report covers the whole of the developing continent of Africa (i.e. excluding South Africa). In some cases, however, information is only available on a limited basis. Since Africa is a very diverse continent, different sub-regional groupings are used where appropriate.

378 89 - 5/45

Agroecology
Discussion, low external-input agriculture, community ecology, species interaction, nonrenewable sources, intercropping, polyculture systems, pest, diseases, cover crops, environment changes
GLIESSMAN, S.R.
Species interactions and community ecology in low external-input agriculture.

American J. of Alternative Agriculture, II, No. 4, 1987, pp. 160

External production inputs have contributed greatly to the remarkable increases in crop yields achieved during the past several decades. These inputs take many forms, including

fertilizers, pesticides, irrigation water, various soil amendments, machinery and labour. Most of these inputs have been developed to both stimulate farm system output as well as replace materials that have been removed with the harvest. Limited concern has been given to the long-term availability of these inputs as long as farming produced a net profit. Relatively little attention was paid to understanding the biological and ecological bases of interactions occuring within the cropping system as long as such interactions were not considered detrimental to yields. But today agriculture is confronted with the need to assess the long-term sustainability of its production practices. It must consider the availability and cost of inputs and the impacts of conventional practices on the environment, food safety, and the quality of life for the people involved in food production and consumption. In essence it is now as or more important to understand agroecosystems processes that promote productivity in the short term and sustain it over the long term than it is to concentrate on how much is produced.
Agricultural productivity is being examined through the study of such ecosystem characteristics as biotic interactions in species mixtures, nutrient cycling mechanisms, habitat management for pest and disease population regulation, multi-trophic level species dynamics, and application of recent developments in mutualism and competition theory. Establishing an ecological basis for low external-input agriculture builds upon the ability to capitalize on knowledge gained from the study of species interactions at the level of the crop community.
Polyculture systems can be managed for nutrient cycling efficiency and pest and disease regulation using knowledge of multi-trophic level interactions and application of recent developments in mutualism and competition theory. A mechanistic model of additive and removal reactions on the environment is proposed as a means of studying species interactions.
The agroecosystem can be examined as a complex set of species assemblages with many levels of organization that build upon the basic understanding of the ecology of interactions at the individual organism level, emerging at the ecosystem level to understand the dynamics of what makes the entire system function. This is especially important as the understanding of ecosystem level processes of sustainable agriculture then interface with yet more complex aspects of the social and economic systems within which agroecosystems function. Eventually such an integration of social system and ecological system knowledge about agricultural processes will not only lead to a reduction in external inputs used for maintaining productivity, but will also permit the evaluation of such emergent qualities of agroecosystems on long-term environmental quality, the importance of the human element to production, the long-term effects of different farm input/output strategies, and the relationship between economic and ecological components of sustainable agroecosystem management.
It is time to redirect a large portion of the resources that have generated all of the knowledge about single-species cropping systems towards the integration of both ecological and agronomic knowledge, with a broader goal of developing the ability to

quantify the ultimate emergent quality of the agroecosystem - its sustainability. This is an extremely complex process, requiring a systems-level approah and the interaction of many disciplines, but with the outcome of being able to understand where and how effective change in agriculture can come about.

379 89 - 5/46

Agroecology
Review, Europe, France, F.R.G., Holland, Asia, Japan, EEC, biological agriculture, producers, products, cooperation groups
GHESQUI`ERE PH., D.P.
L'agriculture biologique à l'étranger.
(Biological agriculture abroad).

Nature et Progrès, 105, 1988, pp. 11-23

This document illustrates the meaning of biological agriculture in Europen and in Japan.
As introduction, a summary of a EEC study gives the essential points of reference: description of different producers' groups and their development, a list of the products concerned, label types and other important items.
Two more in depth studies follow concerning the situation both in Holland and W. Germany, two countries where production and networks are well structured. Which lessons can be drawn from these countries? First that Holland has more satisfactory results than France and the record of a very efficient marketing organisation in W. Germany, promoting the development of biological production. Two other countries are also briefly mentioned: Italy and Japan, where the notion of "biological" label does not exist, as the very active cooperation producer/consumer is based on selfcontrol and selfhelp.
On the whole, an excellent introduction to "bio" in Europe which should also contribute to the preparation of what will be the agreement of the EEC in 1992. For more detailed informations, contact FNAB, 9 rue Cels, F-75014 Paris, which will send following documents for each country: "Bilan des connaissances... (Statement about the actual stand of knowledge and implementations of biological agriculture as well as the interest results for community agriculture).
Abstract Agricultures actualité

380 89 - 5/47

Agroecology
Review, book, holistic agriculture, scientific approach, soil, cultivation, fertilizer, pest and diseases, rotation, crops, grassland management, seed, animal husbandry, yield, profitability, food quality, energy utilization, pollution, labour usage
WIDDOWSON, R.W.
Towards holistic agriculture: a scientific approach.

Pergamon Press, Headington Hill Hall, Oxford, OX3 OBW, UK, IBSN 0-08-034211-6, Hardcover, 1987, 194 pp. US$ 22,95

This book explains the use of an ecological way of farming, with modern practical applications, to make the fullest use of land resources and the best utilization of available capital and labour. In analyzing the vital relationship between soil, plant, animal and man, the author discusses the best care of land itself, its components, grassland management and the most efficient use of crops to maximize yield, food quality and profitability without the extensive use of chemicals and without damaging the ecology. Widdowson also covers the holistic approach to animal farming, the welfare and health of poultry, cattle, sheep and goats, their nutritional needs through the various stages of their lives, and the best way to balance their diets.
For all those interested in organic farming and its implications for modern agricultural practices.
Author's abstract

381 89 - 5/48

Agroecology
Review, register, working paper, book, Europe, Germany, Switzerland, sustainable agriculture, technical cooperation, developing countries rural development, DGA, Helvetas, GTZ
HOESLE, U. and OPITZ, M.
Sustainable agriculture in German and Swiss Technical Cooperation.

GTZ Working Papers for Rural Development No. 15, 1989; available at Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ), Departm. 4210, Eschborn, Postf. 5180, 6236 Eschborn 1, FRG

Practical questions, which come up so often in talks with field staff has led to the compilation of the third edition of a register of projects working in the field of sustainable agriculture.
The register itself cannot of course provide an answer to these questions, and neither is it intended to. It aims to assist and improve the inter-project exchange of concrete experience gained and information available on the topic "sustainable agriculture".

The questionaire for this third edition met with a good response, as did those sent out for the first and second editions of the register.
The first edition, published in 1986 listed 67 projects. By the time the second edition went to print, this number had already rocketed to 102, while this third edition covers an impressive total of 117 projects and features various other improvements over the previous editions.
This edition includes projects run by the Swiss organisations DGA and Helvetas for the first time. This expansion can only further a wide-scale exchange among experts. There exists the intention to include other appropriate institutions in future editions.
The register will in future be published in English, to enable the counterparts to work with it without difficulty.
The principal part of the register comprises the project descriptions, divided into countries. At the top of each description one finds the project address, details about the counterpart organisation, term of the project and the status enjoyed by sustainable agricultural within the agricultural policy of the partner country. To give a better overview of the location topographical and climatological data along with the geographic information are included. This is followed by a brief description of the target group.
After the project description the key words used to characterise project activities are indicated, arranged firstly by topic, and then the most important ones also alphabetically. To find the projects which particularly interest more rapidly one can find the fourdigit code allocated to the project in the key word list.
The following system to classify topographic and pedological characteristics and the status of project activities are used:
(1) shows that there is primarily one type of country or soil quality or one priority activity
(2) shows that a certain topographic or pedological characteristic can also be found or that a certain activity is also carried out, but that it is not the primary land form/activity
(0) no details available.
Where there are no data on specific aspects of a project the spaces are kept blanc pertaining to this data.
This third edition carries forward the tradition of the two previous works of giving contact addresses and the names of contact persons working in the field of sustainable agriculture at GTZ head office and outside.
Although the register has been expanded it does not claim to be an exhaustive overview of the activities of each of the projects included, nor does it give a detailed description of the location of the individual projects.
The authors would like to use thie opportunity to ask all to continue to help update and improve this work.
Author's summary, amended

382 89 - 5/49

Agroecology
Review, developing countries, ACP-States, ISNAR, DSE, CTA, Africa, Caribbean, Pacific Islands Lomé Conventions, sustainability, physical factors, climate, soil, research implications, organizational aspects, agricultural policy, agricultural cooperation
TREITZ, W. and T.M. NARAIN
Conservation and management of the environment and natural resources in developing countries - policy implications for ACP States.

In: Proc. of a ISNAR/DSE/CTA-Seminar/Workshop on Res. Policy Implications for Nat. Agric. Res. Systems - "The changing dynamics of global agriculture" -, Eds. E. Javier and U. Renborg, Feldafing, F.R.G., 1988, pp. 137-150

The authors of this paper point out that definitions of sustainability in standard reference books are inadequate. Only in specific recent publications is the problem of sustainability dealt with more comprehensively with a more precise definition.
The Brundtland report explained sustainability:
Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
TAC's definition is that:
Sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources.
The concern about sustainability is that during the last decades considerable changes have taken place. Most developing countries have experienced a rapid population increase. As a result, the pressure on the land has increased at a rate never before known. Millions of hectares of tropical forests have been cleared for food production, in most cases without consideration for ecologically sound agricultural practises after deforestation. The results are frightening: land degradation, erosion, silting of rivers and lakes, to name only a few. The stocking rate of animal populations has been augmented at a rate which in many countries exceeds the carrying capacity of the land. Shifting cultivation, which does not allow the soil to recover after its exploitation, is taking place at an ever-increasing rate due to land shortages.
On a global basis, the most serious problem during the next century will be to feed people without destroying the natural resources. In other words, to implement systems of sustained agriculture.
The physical factors of the ACP-States (Africa, Caribbean, Pacific) related to the term sustainability are discussed in this paper.
From the experiences of 20-25 years of international agricultural research the authors draw some general principles for research priorities:

More attention to special situations. International agriculture must give more attention to regions with special constraints due to extreme climatic conditions, poor soils, weak infrastructure, and high population pressure, which among other problems, leads to indiscriminate forest clearing for food production, followed by desertification.
Food crops. Food crops other than wheat and rice also improving the soil should be given higher priority. Improved cultivars of cassava, cowpeas, and potatoes are already available, but need to be introduced more widely through national agricultural research systems (NARS). Research on other crops that improve the soil is being conducted, but these activities should be intensified. Research on other traditional crops should also be pursued.
Soil research. Research on soil conservation, maintenance, and improved soil fertility has to be strengthened, even at the cost of crop research. The development of appropriate agricultural technologies to be used after forest clearing is of the highest priority, and land-use patterns for agroforestry have to be developed.
Fertilizers. Optimal utilization of manures and inorganic fertilizers is of great significance both for sustainable agricultural systems as well as for meeting the needs of small farmers and regions with special constraints.
Trypanosomiasis research. Research on this livestock disease is required for sustainable agricultural production systems, especially to introduce animal traction in specific regions of Africa.
Water use. Optimal water utilization for both irrigated and rainfed agriculture is an important factor for sustainable agriculture, and needs a higher priority from both IARCs and NARS.
Breeding for resistance. In view of the damage to the environment caused by pesticides, as well as their high cost, breeding for resistance should be given more attention, even to the detriment of yield. Conservation of plant and animal genetic resources is fundamental for sustained agricultural production.
On-farm research. Socioeconomic and on-farm research of farming systems or technologies, especially for ACP countries, is required for studies of sustainability.

The authors refer then to organizational aspects for research and state that research aiming for sustainable agriculture is complex and difficult because it must be location specific.
This considerations has implications for the future organization of international agricultural research. Because of the more complex and location-specific problems, IARCs may have to relocate more research from the centres to different locations.
Furthermore, much more research will be needed where the farmer is not an object of research, but rather an active participant. If farmers are actively involved in research projects for sustained agriculture, expensive experiments without much probability for success can be avoided.
With respect to the agricultural policies the authors point out that in order to achieve sustainability, priorities have to be set for national laws and regulations, as well as in agreements, or

even treaties, drawn up for regional and international cooperation. There are a number of activities that can be launched without serious budget implications, but other activities require a reallocation of funds from less important projects to programmes of sustained agriculture. In donor-funded programmes, sustainability should be given the highest priority. Developing countries should be assisted, especially in areas, such as conservation of plant and animal genetic resources, that serve the international community as a whole.
Questions of dissemination of scientific and technical information for sustainability are discussed in which CTA is playing a leading role.
Finally the Lomé Convention with respect to sustainability is mentioned.
Concluding the authors point out that the development of sustainability in agriculture is essential for two reasons:
- to allow the necessary increase of food production to feed a rapidly growing population;
- to protect and develop the productive potential of soils, water, and genetic resources;

Research for such harmonious development should be an on-going process and must be location-specific. NARS have to play a more central role in such a venture. Networking of research and the dissemination of its findings through scientific and technical information are becoming more and more important in the development of sustainable agricultural systems.

383 89 - 5/50

Agroecology
Review, Latin America, Chile, Mexico, Bolivia, alternative agricultural systems, small farmers, sustainability, developing countries, ecological basis, traditional systems, rural development, agroecological approaches, peasant assistance programs, recommendations
ALTIERI, M.A. and M.K. ANDERSON
An ecological basis for the development of alternative agricultural systems for small farmers in the Third World.

IFOAM, 3, 1988, pp. 3-8

Promotion of a large scale agriculture based on uniform crop varieties and farming techniques has largely ignored the heterogeneity, both environmental and socioeconomic, that characterizes small farming systems. Consequently, agricultural development has not been matched with the needs and potentials of local peasants.
As a result, the development and extension of appropriate technology for peasants is being re-examined and it is slowly becoming recognized that technologies developed for small farmers in developing countries must fit the socioeconomic and agroecological features of small farming systems.

Examples of sustainable traditional farming systems are discussed:
- Paddy rice culture
- Shifting cultivation
- Raised field agriculture

In Latin America, several assistance programs for peasants are directed at meeting their subsistence needs. The general approach is to take existing peasant production systems and to use modern agricultural science to improve their productivity, progressively and carefully. The programs have a definite ecological orientation and rely on resource-conserving and yield-sustaining production technologies. They emphasize an ecological engineering approach in which the various components of agroecosystems including crops, trees, soils, and animals interact in a way that enhances use of internal resources, recycling of nutrients and organic matter, and trophic relationships among plants, insects, pathogens and weeds that foster biological control. Three levels of interactions are discussed in this paper:
- Temporal interactions at the cropping system level
- Spatial interactions at the cropping system level
- Farming systems interactions

Positive peasant assistance programs in Latin America are described.
In summary, the few examples of grassroots, bottom-up rural development programs described here suggest that development and diffusion of appropriate technologies for peasants must meet four criteria: that it be based on a knowledge of peasant needs as they are perceived by peasants; that it uses autochthonous technologies; that it be a village-based effort with the active participation of peasants; and that it emphasizes local and indigenous resources.

384 89 - 5/51

Agroecology
Review, alternative agriculture, sustainability, scientific approach, grassroot approach, data processing method, participative method, social science, natural science, image-building approach, emphasis on growth, system imbalance, rethinking growth
VAN MANSVELT, J.D.
Basic concepts of alternative agriculture.

In: Proc. of the Sixth Int. Sc. Conf. of the IFOAM, Eds. P Allen and D. van Dusen; Univ. of California, Santa Cruz, USA, 1988, pp. 135-145

The theoretical and the practical approaches to agriculture are based upon an overemphasis on a particle-interaction concept. To balance this abstract modeling trend in agriculture, in this paper a concrete imaging approach will be proposed, illustrated, and discussed.
Studying agriculture on any level relies on "pictures" of crops, fields, cattle, farms, countrysides, etc. These pictures are

partly based on observation (perception) and partly on theoretical modeling (conception). Over time, the interaction of perceptive and conceptive activities brings about an image (in researchers as well as in practitioners) of agriculture in which the two are strongly interwoven. Because they are so deeply embeded in our concept of agriculture, these images or pictures tend to be taken for granted, even if contradictory experiences accumulate.
The author summarizes the contents of the paper with images and ecological agriculture. Emphasis on direct observation of the full range of authentic agroecosystem phenomena can serve as a methodological tool to:
- restore and enlarge the essential contact between the observer (farmer, researcher) and the observed, which has been narrowed or even broken by reduction and abstraction;
- extend the corresponding concepts and images of the observed subjects toward a deeper and more whole understanding;
- adjust the gauging marks for appropriate quality judgements, serving the joint health of consumers, producers, and their common environment;
- complement necessary analytical and reductionist steps with a frame of reference appropriate to an understanding of the object's full, long-term significance for the subject and vice versa.

Images of agriculture structure the attitudes and actions of farmers, researchers, consumers, and politicians. In a general sense we all share the notion that we each function within and are responsible for a holistic, globally connected environment. Yet the conceptual bits and pieces we have abstracted and reduced from our agricultural reality often appear to be incoherent and certainly not congruent with a more generalized, holistic conception of reality. Without a conscious, explicit revision of the images of reality held by those participating in agriculture, discussions of what is evident, necessary, desirable, healthy, or even economically sound in agriculture will be unproductive. These images must be adjusted toward holism if ecologically sound agriculture is ever to become as normative as conventional agriculture is today.
Author's summary

385

89 - 5/52

Agroecology
Review, Africa, savannah soils, agroecology, soil fertility, soil management, practices, development projects, low-external input, minimal fertilization
PIERI, CH.
Fertilité des terres de savanes. (Fertility of savannah soils).

CIRAD-IRAT, Service des éditions, BP 5035, F-34082 Montpellier Cedex 1, France, 1989, 448 pp.

The crucial question arising in the Westafrican agriculture is: how to suppress fallows and increase yields to meet with demographic growth without causing soil degradation? Soil studies

carried out since 30 years show systematically that the higher the population density, the better soil fertility is preserved. In the contrary, where migrants start exploiting "new soils" (with low population density), they practice an extensive agriculture favourising erosion and soil impoverishment.
Among the "classical" methods of soil-fertility management, a certain number of them appear to be unsuitable for African Savannah zones. So for example the "artificialised" agricultural management.
The mineral fertilization would be the most efficient solution - at least for short term - to prevent the African soils' degradation, if the costs for the fertilizers wouldn't be out of reach for the farmers. So after all, it is the organic fertilization, propagated through advisors of many countries, which seems to be best adapted to spread rapidly. Last not least, two low-cost solutions deserve to be rehabilitated or propagated: on the one hand the use of trees in agriculture, which have a very positive effect on the undercrops, particularly if they are leguminous trees; on the other hand the development of appropriate crop rotations. This last method, so important in practical agriculture, has been often "forgotten".
Nearly 30 years of research results on soil fertility in Westafrica and its management have been quoted and analysed here. This work is of great value, because it is objective and describes successes and failures of development projects carried out by French experts since decades in this region.

386

89 -5/53

Agroecology
Review, sustainability, natural resources management, developing countries, rangelands, semi-arid areas, desertification, soil erosion, upland areas, tropical forests, biological diversity, institution building, policy opportunities, World Bank, World Resources Institute
REPETTO, R.
Managing natural resources for sustainability.

In: Proc. of the Seventh Agric. Sector Symp. - Sustainability Issues in Agricultural Development -, Eds. T.J. Davis and A. Schirmer; The World Bank, Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 167-179

After an introduction the paper deals with the following aspects:
- Deterioration of natural resource assets in Third World countries
- Rangelands and semi-arid areas: desertification
- Watershed and upland areas: soil erosion
- Irrigated lands: waterlogging and salinization
- Depletion of tropical forests and biological diversity
- Atmospheric concerns

- Strengthening natural resource management
- Institutional strengthening
- Policy opportunities

The paper concludes that the broader policy question of sustainability is whether the framework of agricultural incentives, taken as a whole, does not bias the evolution and adoption of farming systems. The author refers to the widespread direct and indirect subsidization of fertilizers, pesticides, water, machinery, and credit - and the equally widespread implicit taxes on farm production. Impositions on agricultural output reduce the benefits of investment in soil conservation and land improvement. Subsidies reduce the costs of external inputs to the farm, including fertilizers to restore soil fertility, and heavily discriminate against alternative agricultural systems that rely on nutrient recycling, inter-species population balancing, and labour inputs for sustained productivity. Even in the United States and other industrial countries where purchased inputs are relatively cheap, farms using alternative "regenerative" technologies are close to commercial viability, and would probably be competitive were the external costs of chemical run-off and soil erosion internalized into farm production costs. In the Third World, the World Bank has helped to develop and demonstrate alternative farming systems involving multiple cropping and integrated animal, tree, and crop production that are capable of sustained high productivity with fewer external inputs. However, even if such an alternative approach were more productive and sustainable over the long run, will it emerge in the face of the overwhelming policy-induced bias in incentive against it?

As natural resources are increasingly stressed by the pressures of growing demands, it would be surprising if mismanaging them could be good economics. Generally, it is not. Numerous government policies not only fail to reflect the true opportunity cost of resource use, they perversely encourage more rapid and extensive degradation of soils, water, and biota than market forces alone would. Many current policies - subsidies, fiscal incentives, and market interventions - artificially increase the profitability of activities that result in serious resource deterioration. Changing these policies would often raise current welfare by reducing economic distortions, and also reduce long-term environmental damage. Typically, these changes would also reduce fiscal burdens on government and eliminate important sources of inequity within the economy as well.

Eliminating these perverse incentives has large payoffs. They are important issues for policy dialogue with borrowing countries, and for policy-based lending. Like other policy changes that reallocate resources significantly, they arouse political opposition from interests that have captured the benefits of existing arrangements.

387 89 - 5/54

Agroecology
Review, book, agroecology, food production, ecofarming
KICKUTH, R.
Die ökologische Landwirtschaft. (Ecological agriculture).

Alternative Konzepte 40, 3. Auflage, Karlsruhe, ISBN 3-7880-9746-9, 1987, 207 pp.

The book tries to give a scientific answer to numerous questions being more and more important not only for the agricultural producer but also for the consumer. One can find fundamental ideas referring to the complex of subjects as agriculture and ecology, economy, toxicology as well as biological cropping and world food programme with particular details of: ecological-biological and energetic farm analysis, soil biological questions, behaviour research in the productive livestock farming, consequences of the large-scale livestock farming and realization of the eco-cultivation in the tropics.

Three practice reports - one of them about a farm successfully running for 58 years in a biological-dynamical way - are proving that eco-farming is reality. Well known experts give concrete evidence based on research work. Practicable experiences give an account of realistic possibilities and prospects of an ecological orientated food production.

In the annex one can find characteristic features of eco-farming, important addresses in Germany, Austria and Switzerland as well as valuable references of literature.

388 89 -5/55

Agroecology
Review, paper, sustained agricultural development, institutional requirements
RUTTAN, V.W.
Institutional requirements for sustained agricultural development.

In: Proc. of the Seventh Agric. Sector Symp.: Sustainability Issues in Agricultural Development; Eds. P.J. Davis and I.A. Schirmer, The World Bank, Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 57-74

In this paper the author elaborates a theory of institutional innovation in which shifts in the demand for institutional change are induced by changes in relative resource endowments and by technical change. There discusses the seemingly contradictory export promotion and import substitution policies followed with respect to industry and agriculture in East Asia to illustrate the effect of changing resource endowments and changes in the economic environment are discussed. Then the author turns to a review of the efforts by the World Bank and other members of the donor community to build institutions to sustain agricultural

development in Pakistan. In a final section an attempt is made to see if one can draw any lessons from the theory and the experience. Finally, a more inclusive framework within which the attempt to understand the process of institutional innovation is suggested.

389

89 - 5/56

Agroecology
Review, humid tropics, ecology, soils, population, diseases, work capacity, climate, development model, sustained growth, land-use-ecological constraints
WALLER, P.P.
The ecological handicap of the tropics.

Intereconomics, 19, 1984, pp. 137-142

The three main ecological handicaps of the humid tropics are infertile soils, which may only sustain a system of shifting cultivation and low population densities, high incidence of human and animal disease, and lower work capacity because of daily and seasonal high temperatures. Economists have tended to assume that these could be overcome by modern technology and have tended to neglect the very high capital investment which agricultural development under those conditions involves. The traditional development model, sustained increase of work output in agriculture and transfer of agricultural surplus to develop other sectors, does not work under these conditions, especially with an increasing scarcity of land. In many such countries rural areas must be net receivers of capital if they are to have any hope of survival. The opposite policy, which has been followed particularly by some African countries, has led them into an economic crisis threatening their basis of existence. Appropriate forms of land use (shifting cultivation with adequate fallow periods, irrigated rice cultivation, some tree crops, agro-forestry) in different areas should produce small surpluses and meet subsistence needs of the rural population. It is important to realize that the ecological handicap of the tropics constitutes a complex and substantial development threshold which it will not be easy to surpass.
Abstract from CAB

390

89 - 5/57

Agroecology
Review, agricultural sustainability, development programmes, projects, rural development, USAID
BLAKE, R.O.
Sustainability in agricultural development programmes: The approach of USAID.

Gatekeeper Series No. SA 15, Int. Inst. for Environment and Development (IIED) - Sust. Agric. Programme - ; Endsleigh Street, London, WC1H ODD, UK, 1989, 15 pp.

This paper is a summary of recent testimony by the Chairman of the Committee on Agricultural Sustainability to the House Committee on Foreign Affairs, Washington, March 1989.
Recently great progress has been made in the United States over collaboration between leading environmental organisations, private voluntary organisations, research and academic groups and individual scientists and experts on the topic of agricultural sustainability for developing countries.
There are two critical reasons why AID should help developing countries achieve sustainability in their agricultural development. First, sustainability is a powerful political paradigm. Secondly, AID's having to apply the test of sustainability adds an element of very desirable rigor to both initial and continuing evaluations of AID's agricultural (and other) programmes and projects.
Agricultural sustainability does not depend only on environmental sustainability. Sustainability cannot be achieved in agriculture or any other area except by also assuring economic, political, sociological, and institutional sustainability. If concerned groups tend to emphasize the environmental and ecological facets of this problem, it is because these aspects have too often not been given enough attention by development agencies including AID.

The paper concludes with some prescriptive measures for the 1990s:
The central purpose of development assistance should be to promote environmentally sustainable broad-based economic growth. Efforts must be focused on a small number of key objectives, one of which must be sustainable agricultural development. New legislation should place primary emphasis on helping farmers (and governments) make this transition to sustainable agricultural systems. AID's efforts in this regard should also encompass better management of sustaining non-agricultural natural systems (forests, watersheds and water resources, for example) as well as associated energy systems.
The highest value should be placed on AID's continuing support to developing countries'family planning programmes, upon which the ultimate success of all that we advocate depends.
In working towards agricultural sustainability the greatest emphasis should be placed on developing human resources at all levels of agricultural effort, on training and motivating people who can help energize the small farmer, as well as the researcher

in agronomy and the government planner. Development assistance organisations should make special use of the developed countries' comparative advantage in science and technology through the expansion of collaborative and cooperative relationships in agriculture, including efforts that involve people from the advanced developing and newly industrialized countries. In addition these agencies should be countinuing strong support for the international agriculture research centres.
In all these efforts strong reliance should be placed on utilizing the talents represented by US universities and scientific institutions. Ways must be found to recreate and sustain the links between US universities and agricultural experts which were so strong and mutually beneficial in 50's and 60's but which are now eroding.
On another level, continuing efforts to strengthen the position of the small farmer and the landless and to reinforce equity within farming communities should be sought. Combating rural poverty is essential to environmentally sound rural development. The United States must remain the strong advocate of "bottom up" agricultural development.
Slimmed down US economic assistance should, with a few exceptions where major US financial leverage will continue to exist, continue to play only a supporting role in global programmes of structural adjustment. Finance should be restricted to only relatively small agricultural infra-structural programmes.
Finally giving aid-giving organizations more flexibility in the use of funds, but only within congressionally established guidelines, would ensure a focused, balanced approach which will provide continuity of purpose and programme.

VI AGROMETEOROLOGY

391 89 - 6/8

Agrometeorology
Review, book, Africa, drought, hunger, development, cooperation, climatology, economy, politics, food, self-sufficiency, sociology
GLANTZ, M.H.
Drought and hunger in Africa: Denying famine a future.

Cambridge Univ. Press., Cambridge, UK, ISBN 0-521-32679-6, hardcover, £ 37.50/USD 49.50, 1987, 457 pp.

This is an interesting book, and many of the contributions raise serious issues on the African development process as a whole for which there are no simple answers. It is primarily an American perspective on the African problem.
In this foreword, Bradford Morse, the former Administrator of the United Nations Development Programme, points out that drought itself is not the fundamental problem in sub-Saharan Africa since drought prevails in many parts of the world, and when properly managed need not be more than a nuisance. Drought in Africa has triggered a crisis of development, since the efforts underway have been badly disrupted. Morse acknowledges that much of the development assistance provided for sub-Saharan Africa in the past has not produced the anticipated results, a main reason for which is the inadequate consideration and understanding of agro-climatic conditions and socio-cultural frameworks of the African countries.
The book is divided into four parts. Part 1 deals with physical and social setting, and contains four papers. The main emphasis in this section is on climatological aspects of drought, which is very well covered. It would have been helpful to the readers if corresponding emphasis could have been placed on water resources and land-use aspects as they related to drought and agricultural production. Much of this part provides a general review of the works of various climatologists and some selected development specialists. The paper on some aspects of meteorological drought in Ethiopia is the only paper in the book by a scientists from Africa.
The second part, consisting of four papers, examines the internal-external perspectives. Among the subjects covered are the decline of African agriculture, internal factors that affect famine, political economy of the crisis, and economic externalities and the persistence of destitution and famine. Together these four papers attempt to review the multitude of external and internal factors that could transform food production shortfalls into famine. Two broad schools of thought on the causes and potential remedies for Africa's agricultural crises are identified internalists and externalists. Internalists argue that the basic reasons for the crisis can be found by the constraints imposed by the policies pursued by the recent governments, a point that was also alluded to by Morse earlier. Externalists believe that the

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VI AGROMETEOROLOGY

391 89 - 6/8

Agrometeorology
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main reason is the international economic environment which adversely affects the economies of the individual countries.
The third part, which is on case studies, constitutes nearly half of the book. The seven papers in this part discuss various problems from different parts of Africa. Among the subjects discussed are the following impact of drought, environment and food security on peasants, pastoralists and "commoditization" in dryland West Africa; drought, food and social organization of small farmers in Zimbabwe; social impact of drought in Ethiopia; Kenyan experience on the role of government in combating food shortages; social impacts of planned settlement in Burkina Faso; evolution of food rationing systems with reference to African group farms in the context of drought; the role of non-government organizations in famine relief and prevention.
The final part deals with the lessons for the future. Liebenow discusses the reasons not only for Malawi's food self-sufficienca but also its ability to export substantial quantities of agricultural products to its neighbours suffering from food shortages. Two chapters deal with famine relief policies in India and China and their potential transfer to Africa. The reviewers, however, will point out that in depth analyses indicate that many of the policies and agricultural technologies that have succeeded in India, when transferred to Africa, have proved either to be marginally successful or failures due to a variety of socio-economic, institutional and technical reasons. South-south transfer of policies and technologies appear to be more difficult than many of its proponents believe.
Understanding the complexities of drought and associated hunger in Africa is a difficult process under the best of circumstances. The problem is further complicated by the fact that physical, social, economic, institutional and political systems often vary from one country to another, and thus what may be an acceptable solution in one part may not be appropriate for another. Overall, the book is a useful contribution to the ongoing debate on the African crisis.
Abstract by M.R.BISWAS and A.K. BISWAS, UK

392 89 - 6/9

Agrometeorology
Africa, Ghana, humid tropics, lowland, review, agrometeorology, plant protection, farmers, rainfall, temperature, humidity, solar radiation, sunshine duration, wind speed, soil temperatures
USSHER, A.K.E.
Agrometeorological Activities for Plant Protection.

In: Proc. of the Seminar on: Agrometeorology and crop protection in the lowland humid and sub-humid tropics, Cotonou, Benin, 1987, pp. 229-230

In Ghana a monthly Agrometeorological Bulletin containing agrometeorological data and their departure from long term average values is published and disseminated to the authorities at the Ministry of Agriculture and other related agencies for their

information and action in formulating plant protection advice for farmers and agencies engaged in agriculture. Listed data include rainfall, temperatures, humidity, solar radiation and sunshine duration, wind speed and direction, and soil and earth temperatures.
Excessively high temperatures have been known to be detrimental to young crops especially in absence of adequate moisture. Therefore, occasions of temperatures above 30°C in the screen are reported immediately to the agricultural authorities. Shading is recommended for the months of February and March if planting is done, since highest temperatures occur during these months.
Bright sunshine hours range from a minimum of about 2.5 hours in August to about 10 hours in November/December with radiation levels ranging from about 280 cals/cm²/day in August to about 570 cal/cm²/day in February/March. This latter period coincides with the beginning of the rainy season in the southern parts of the country. Tender grain crops are usually adversely affected by the intense heat especially when the rains are late or initial amounts are rather low. This situation is taken into consideration when determining the onset of the rainy season so as to minimise crop losses and the need for replanting.
The early rains are associated with high winds leading to battering and flattening of plaintain and banana plants as well as young grain plants. The meteorological service therefore gives warnings of approaching squall lines on the radio.
Heavy rains damage tender crops by either breaking the stems or eroding whole planted areas. Intensity-duration data have therefore been prepared and are supplied to agriculturists on request to enable them select viable areas for farming activities.
For irrigation, evaporation data from Penman's method are available.
Winds associated with squall lines usually cause damage to plants especially plantain, banana, corn, millet, and sorghum. by battering and flattening, as mentioned earlier. Data on highest wind gusts have been compiled. The construction of wind breaks have been suggested to the agricultural authorities, as a means of reducing damage. Spraying of cocoa are carried out in months of low wind speeds and in the mornings or evenings mainly.
Warnings of the risk of bushfires are given in the news media when excessively low humidities prevail, especially in the dry season.
A study to attempt to forecast drought years is in progress. Monthly rainfall data are being analysed to augment studies on annual rainfall data.
Plant protection activities require agrometeorological information on:
- Onset of crop pests and diseases
- Air pollution
- Agroclimatological surveys
- Crop production and yield relationships with meteorological information

All these data give an idea of the agrometeorological activities recorded in Ghana.

393 89 - 6/10

Agrometeorology
Africa, Nigeria, case study, smallholder, cropping systems, agricultural production, rainfall, solar radiation, relative humidity
NWEKE, F.I.
Weather Constraints on the Smallholder Cropping System of Southeastern Nigeria: A Case study of Two Villages in Anambra State.

Agricultural Meteorology, 23, 1981, pp. 309-315

In Enugu in southeastern Nigeria there are two climate seasons, the dry season from November to April and the rainy season from May to October which is interrupted by a drier spell in July-August. In the rainy season, the rainfall is adequate for most crops grown in the area. However, the rainy season is associated with high humidity and low solar radiation with the consequence that available moisture at this period is not used to the best advantage by farm crops. In the dry season, humidity is low and solar radiation relatively high, but it is so dry that most crops would not grow without irrigation water. Moreover, the timing of the rainy season with respect to the beginning and end of the rains, as well as the timing of the drought, is irregular.
A random sample of 20 farmers was selected in two villages from a list of 205 compiled on request by the agricultural extension officer in Ogboji, and also from a list of 151 compiled on request by the village chief in Ndubia. Information on available farm land and cropping practices was obtained from the sample farmers.
The above analysis suggests that although aggregate annual rainfall could be adequate for food crop production in southeastern Nigeria, irregularities in timing of the rainfall, and in month-to-month distributions of rainfall, relative humidity and solar radiation, are in fact limitations on food crop production expansion and that the use of supplementary irrigation water to grow food grains in the dry season would enhance food crop production in the area. However, experience in some tropical African countries, such as Ghana, has shown that investment in irrigation development could have high costs and low returns, partly because of high overheads and partly because the change from rain-fed farming to irrigation farming takes time to accomplish. It may be possible to achieve the same objective at a lower cost by investment in research in the development of short duration foodgrain varieties which can be planted in August or September to grow when the humidity is not too high or solar radiation too low.
Still another alternative, especially for maize, is the development of drying facilities. Before the Nigerian Civil War centralized grain silos for drying and storing maize were being erected in various locations for farmers throughout the former Eastern Region (most of southeastern Nigeria) with the assistance of the United States Agency for International Development. Since the War no attempt has been made to re-introduce them. At present,

however, the International Institute of Tropical Agriculture, Ibadan, is working on a small and simple drying and storage facility which could be purchased by a small farmer. It is possible that such a facility coupled with an available market for maize would encourage the smallholders to grow maize. This in turn could encourage them to use and possible employ mechnaical equipment in maize production.

394 89 - 6/11

Agrometeorology
USA, study, climate, management practices, crop water requirements, soybean, sandy soil, model, evaporation, transpiration
JAGTAP, S.S. and J.W. JONES
Stability of crop coefficients under different climate and irrigation management practices.

Irrig. Sci., 10, 1989, pp 231-244

In many parts of the world where water holding capacity of the soil is low and precipitation is inadequate during the growing season, irrigation is practised to avoid drought-caused yield losses. A critical problem in irrigation is to determine just when, how, and how much water to apply. Irrigation scheduling using evapotranspiration (ET) estimated from climatic data is appealing because this approach is relatively simple compared to on-site measurements. One such approach makes use of crop coefficients to relate actual ET of a disease free crop grown in a large field adequately supplied with water to a reference crop.
Using principles of heat and mass balance, a comprehensive evapotranspiration model was developed. This model referred to as the Jagtap model, predicts water use, soil evaporation, transpiration, and microclimate of a well irrigated developing crop where the soil may go through cycles of wetting and drying.
The specific objectives of this paper were to use the mechanistic model developed to:
- Determine the effects of variation in irrigation interval and climatic variables such as temperature, vapour pressure, radiation, and wind speed on water use and coefficients.
- Determine the effect of planting date, crop development rate, and length of the growing season on water use and coefficients for a soybean crop grown in sandy soil and actual weather data in humid Florida climate.
- Discuss corrective procedures when applying crop coefficients developed at one site under a given environment to other sites with different climate and agronomic conditions.

It was found that seasonal errors could be as high as 190 mm when crop coefficients developed under one set of conditions were used under different climate and management conditions. The largest error in ET occurred when vapour pressure was reduced from 26 mb to 14 mb; next in importance were site differences in wind speed,

radiation, irrigation interval, temperature and planting date. Correction factors needed to adjust crop coefficients to those site specific conditions ranged from 0.73 to 1.30 depending on the time of season and climate or management variable that was changed. When the overall crop coefficient was divided into a plant specific and a soil specific coefficients, the plant coefficient was relatively stable compared to soil coefficients. The results of this study can help establish a practical range of conditions over which crop coefficients developed at one site can be used to compute the appropriate values for sites where measurements have not been made.

395 89 - 6/12

Agrometeorology
Africa, Nigeria, IITA, study, weather, insect population, sweet potato weevil, planting time, control strategy
LEMA, K.M.
Effects of Weather Conditions on Insect Populations with Particular Reference to the Sweet Potato Weevils (Cylas spp.) and Time of Planting as Control Strategy.

In: Proc. of the Seminar on Agrometeorology and crop Protection in the lowland humid and sub-humid tropics, Cotonou, Benin, 1987, pp. 223-227.

Empirical observations reveal that populations of the sweet potato weevils, Cylas spp., are affected by weather conditions in Africa. The weevils are the most destructive pests of sweet potato (*Ipomoea batata*) in the tropics. Losses of tubers generally range between 10% and 50% but losses of up to 90% have been reported.
Throughout Africa these insects are scarce in the rainy season but their populations rapidly build up to damaging levels during the dry season. In this paper direct and indirect effects of weather on insect populations are discussed with special reference to Cylas spp. and the manipulation of time of planting as a control strategy.
The annual averages of climatic components, temperature, humidity, rainfall, etc.,(or climate) do not affect insect populations but rather the day-to-day changes of the components (weather). Weather may affect directly insect populations.
The results confirm that early planting and early harvesting is effective against the sweet potato weevils. Sweet potato is a relatively short cycle crop (about four months). If planted early enough in the rainy season, the crop can be harvested before the weevil populations increase to damaging levels.
Unfavourable weather has an adverse impact that may determine a period of reduced activity or low populations for some insects. This weak point in the biology of such insects can be used as the basis for the manipulation of planting time recommended as control strategy. This strategy effectively controls Cylas spp.. However, this method alone may not be readily implemented by the farmers who generally grow a variety of crops. Sweet potatoes (where they

are not che main crop) are planted late in the rainy season after the main crop (yams, cassava, beans, etc.) has been planted. An integrated pest management program against the weevils may alleviate this problem. Such a program is being developed at IITA. It combines use of sweet potato lines with moderate resistance to the weevils, early planting and early harvesting and re-ridging (or earthing up the plants).

396 89 - 6/13

Agrometeorology
Review, book, technical note, humid tropics, monsoon climate, cold seasonal climate, land-use, management practice, recommendations
World Meteorological Organization (WMO)
Land-use and agrosystem management under severe climatic condition.

Techn. Note No. 184 of the World Met. Organization, Geneva, Switzerland, ISBN 92-63-10633-9, softcover, SwFr. 25 (surface mail), Sw Fr. 40 (airmail), 1986, 161 pp.

This technical note is the product of a working group established by the Commission for Agricultural Meteorology to study the interactions between changing climate and land-use and to make recommendations for improved management practice in areas of severe climate. The publication of this book is clearly most timely while there is considerable global awareness of climate-related crop failures and starvation in areas of marginal agriculture.
The book describes the macroclimate and agrosystems in a range of severe environments from regions which are hot and arid through to monsoon regions, the humid tropics and regions dominated by the cold seasonal climate. Five chapters describe the climatic envelopes of these particular regions, followed by a resumé of the range of agricultural practices in the particular climatic zone and generally ending with some recommendations for improving agricultural methods. Each selected macroclimate extends beyond national barriers and so it is most interesting to learn of the different agricultural techniques which are employed in different countries.
The first two chapters provide general introductory detail on the methods for describing and classifying climate. The methods which are employed in these chapters and throughout the book are strongly based on those developed by Köppen in 1931. The effectiveness of ten such systems of classification in predicting global vegetation from climatic factors is also assessed in Chapter 2. The smallest error of prediction for the major global biomas was 39% for the best system increasing to a worst case of 64%. Such a poor success in prediction must be a major concern when providing climatic classifications of areas which are suitable for a particular type of agriculture. In this respect it is surprising that there has been no attempt in this volume to apply more mechanistic models of evapotranspiration, such as the

Penman-Monteith equation, and to tie such models in with known physiological limits to survival, e.g. chilling and frost sensitivity. Agricultural research has, over the years, provided a large data set of such information for a wide range of crops and so limited data sets are not the primary obstacle.
The limitations of the models used in the chapters are noted in Chapter 6, by Molion, who notes when discussing some idealized models of energy transfer in ecosystems that "There is an urgent need to establish pilot projects with special emphasis on the energy and water balances and sediment transport rates, so that the sketches ... can be replaced by actual numbers".
This volume clearly indicates the problems of agriculture in areas of severe climate, however, there is a need for more work to quantify the interface of climate and agriculture.
Abstract by F.I. Woodward, UK

VII AGROFORESTRY

397 89 - 7/21

Agroforestry
Africa, Nigeria, humid zone, economic analysis, alley farming, small ruminants, models
SUMBERG, J.E. et al.
Economic analysis of alley farming with small ruminants.

ILCA Bulletin 28, 1987, 2-6

Several evaluations of the economics of alley cropping have been conducted. None of these analyses have considered livestock. While alley cropping was conceived primarily for crop production, it offers considerable potential for integrating crop and livestock production by supplying mulch for crops and high-quality fodder for animals.
In humid West Africa, sheep and goat production is generally a minor enterprise using few inputs. Production is limited by a viral disease.
However, realisation of the potential of small ruminants, following disease control, may eventually be constrained by feed resources.
Alley farming, which is the addition of animals to an alley cropping system, offers the opportunity to realise this potential by producing high-quality feed year round.
In this paper alley farming models are evaluated with small ruminants, based on field and experimental data from southwest Nigeria, and compare them with basic alley cropping and with fallow systems. The analysis is used to define key management areas within alley farming, as well as areas where further information is needed.
These models indicate that under conditions found in southwest Nigeria maize production with alley cropping is more profitable than with a 3-year fallow system. While alley cropping requires more labour than the fallow system, this is more than offset by the increased maize yields, and relative profitability of alley cropping is insensitive to changes in labour requirements.
The amount of tree foliages and the method of mulching affect alley cropping profitability. The models assume a low tree foliage yield of 3000 kg/ha/year based on difficulties of obtaining good tree stands in village conditions. Low foliage yields reflect farmers' hesitancy to plant densely to obtain high populations. Better methods of tree establishment (or better instructional methods) that assure good stands would therefore add to the overall attractiveness of alley cropping. Mulch incorporation, particularly if done at tillage or weeding times and thus not requiring additional labour, can increase the profitability of alley cropping.
With control of viral diseases particularly for goats, increases in net output of 20 to 30% per dam from 25% supplementary feeding are needed to make small ruminant feeding competitive with maize

Penman-Monteith equation, and to tie such models in with known physiological limits to survival, e.g. chilling and frost sensitivity. Agricultural research has, over the years, provided a large data set of such information for a wide range of crops and so limited data sets are not the primary obstacle.
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However, realisation of the potential of small ruminants, following disease control, may eventually be constrained by feed resources.
Alley farming, which is the addition of animals to an alley cropping system, offers the opportunity to realise this potential by producing high-quality feed year round.
In this paper alley farming models are evaluated with small ruminants, based on field and experimental data from southwest Nigeria, and compare them with basic alley cropping and with fallow systems. The analysis is used to define key management areas within alley farming, as well as areas where further information is needed.
These models indicate that under conditions found in southwest Nigeria maize production with alley cropping is more profitable than with a 3-year fallow system. While alley cropping requires more labour than the fallow system, this is more than offset by the increased maize yields, and relative profitability of alley cropping is insensitive to changes in labour requirements.
The amount of tree foliages and the method of mulching affect alley cropping profitability. The models assume a low tree foliage yield of 3000 kg/ha/year based on difficulties of obtaining good tree stands in village conditions. Low foliage yields reflect farmers' hesitancy to plant densely to obtain high populations. Better methods of tree establishment (or better instructional methods) that assure good stands would therefore add to the overall attractiveness of alley cropping. Mulch incorporation, particularly if done at tillage or weeding times and thus not requiring additional labour, can increase the profitability of alley cropping.
With control of viral diseases particularly for goats, increases in net output of 20 to 30% per dam from 25% supplementary feeding are needed to make small ruminant feeding competitive with maize

production. The reproductive potential of West African dwarf goats and sheep has been well documented; the principal goal of future research must be to demonstrate that supplementary feeding of high-quality fodder species such as leucaena and gliricidia is effective in realising this potential.

398 89 - 7/22

Agroforestry
Agroforestry, data base, principles, information,ecology
YOUNG, A.
An environmental data base for agroforestry.

ICRAF Working Paper No.5, 1985, 32 pp.

Agroforestry is based on plants: trees, crops and grasses. Plant growth is dependent on the physical environment; different crops are suited to particular environmental conditions, and multi-purpose tree species will respond in different ways to variations in climatic conditions, soils and drainage. The choice of plant species suited to the environmental conditions of an area is fundamental to the success of any agroforestry practice. Equally there are environmental influences upon agroforestry practices which involve livestock, acting both directly on the animals and indirectly through effects on the growth of pastures.
There is a second, equally important, aspect: the effects of agroforestry on the environment. Such effects can be either positive (i.e. beneficial) or negative. Frequently, they involve interaction between two or more components of an agroforestry system, e.g. trees and crops. Such interactions do not take place directly, but through the medium of climate and soil, modifying, for example, the microclimate and the soil moisture, organic matter and nutrient content.
Hence many types of information in the science of agroforestry are environment-specific: what grows well, or interacts effectively, under one set of physical conditions may not do so under another. This applies very obviously at the broad scale of major climatic zones, e.g. the humid tropics or rain forest zone, the subhumid tropics or savannas, and the semi-arid land. At more detailed scales also there will be differences between efficient agroforestry designs on, for example, sandy soils as compared with clays, or on steeply-sloping lands as compared with gentle slopes.
An environmental data base has the function of relating different kinds of information in agroforestry research to a common basis of environmental information. The paper outlines the principles and structure of the data base, the information contained within it, and its potential uses. Information is included on geology, landforms, climate, hydrology, soils, vegetation, fauna and disease, and land-use, including agroforestry practices. There are three levels of detail: a Summary Level, an Intermediate Level 1, and Level 2 containing detailed information. Data are transferred from an input form to computerized storage, using the data base management system. Potential uses of the data base include, first,

the collection, storage and selective retrieval of information on individual aspects of agroforestry: multipurpose trees, agricultural crops, agroforestry systems, and agroforestry experimental work. Secondly, it may be used for synthesis of these different kinds of information, as in land evaluation, diagnostic and design studies, and advisory work.
This paper is intended primarily for those working permanently or temporarily with ICRAF, that is, the scientific staff together with research fellows, trainees, and others who join the organization for short periods. It may also assist individuals and organizations who make use of the results of ICRAF studies by providing an explanation of the basis and terminology employed for environmental information.

399 89 -7/23

Agroforestry
Review, developing countries, marginal lands, food, trees, agroforestry systems, GTZ, ICRAF,
VON MAYDELL, H.J.
Food from multipurpose trees on marginal lands.

Highlights of German Research Projects in the Tropics and Subtropics; IJT - International Cooperation and Transfer GmbH, Berlin in Coop. with ATSAF, Bonn, 1988, pp. 63-68

Multipurpose trees are those which are deliberately grown or kept and managed for more than one intended use, especially in agroforestry systems.
The various potential uses of such trees on marginal lands as found in the Sahel Zone of Africa have been classified into broad categories as follows:
- Food
- Energy
- Raw materials
- Environment
- Socio-economic benefits

Food supply is one of the main concerns of development policy. More than ninety per cent of all living biomass of the globe lies in the forests, and the area covered by trees and shrubs, especially in the tropics, is still very large.
Therefore, it may rightfully be expected that forests and woody species growing outside forest lands contribute more to human nutrition than previously assumed. This can be achieved by increasing the production of food, (primarily fruit and leaves) and through the protective and soil and water balance improving functions. Both can be realized by applying agroforestry practices on a variety of sites (including those otherwise not suitable for growing food crops) and should therefore be seen as a challenge and opportunity for a future-oriented tropical forest management.
In the various tropical and subtropical marginal regions there may be many hundreds of wild trees and shrubs suitable for food production. They are supplying food, either permanently,

seasonally or in times of need, often important enough to sustain the very existence of the people. These species provide fruit, seeds, nuts and oil, and various other products: spices and food supplements and medicines which are widely used in the area. The collection of leaves, buds and young shoots as vegetables is of relatively great importance, particularly in dry areas where fresh vegetables are otherwise difficult to obtain. The abundance and variety of such tree and shrub produce that are helpful to nutrition in the widest sense is amazing and the rural population is extremely well-informed on how to produce and use it in various forms.
There are hardly any statistical records available on the quantities and value of food products obtained from the woody vegetation of a region as for example the Sahel. Thus, the overall importance of such food has been - and still is - seriously underestimated.
An evaluation of food production from multipurpose trees should be done according to checklist given in the paper.
Besides improving food supplies from woody perennials by quantity and quality through biological and technical research, a multitude of system-related questions will have to be answered. Only three of them shall be mentioned here.
- Diversity:
Under marginal site conditions the number of species is generally reduced. As the amount of marginal lands in the tropics is high by nature and increasing through human interference, the loss of diversity is creating increasingly more concern, both with regard to the environment (including genetic resources) and to meeting human demands. On the other hand, many tropical regions still offer outstanding facilities for diversity of production, unparalleled by other regions off the world. This is why, with a view to food production from trees and shrubs, the management of more species and the extension to different uses from one species ("multipurpose") should be investigated.
- Reduction of risks:
This may, in some tropical regions, prove to be even more important than increased yields. Risks include the natural (e.g. pests, diseases, floods, fire, drought, etc.) as well as the socio-economic (markets, tenural rights, agricultural policies, management, etc.) sphere. Long-lasting (as compared with annual crops) woody plants may prove to be less flexible ("resilient") but more reliable and resistant ("persistent"). The interaction of both "strategies" appears to be of importance for long-and medium-term land use planning.
- Sustainability:
Forestry is often said to be "the" sustainable land use, which may be true in specific situations. However, under increasing pressure, due to population growth and environmental degradation, ways will have to be found to maintain or even increase the overall carrying capacity of a given region. Better use of more sites (including those which were considered unsuitable for agricultural crops and livestock) by food-tree management and the introdution of multi-storey systems are ways in which agroforestry has already proven to be a successful land-use system. More

knowledge, based on hard facts is needed to define indicators of sustainability of such integrated land-use systems, to evaluate their applicability both ecologically and economically, and to optimize tropical rural development by incorporating the hitherto somewhat neglected and thus underutilized potential of trees and shrubs for food production.

400 89 - 7/24

Agroforestry
Review, tropics, subtropics, land-use systems, agroforestry, practices, associated crops, woody perenniala, animals, spatial mixture, temporal sequence, ecology, economics, sociology, sustainability, potential, future role
STEPPLER, H.A. and B.O. LUNDGREN
Agroforestry: Now and in the Future.

Outlook on Agriculture, 17, 4, 1988, pp. 146-151

In this paper current status and the future of agroforestry is discussed. Included are the aspects of social acceptability and sustainability.
Agroforestry is a collective name for all land use systems and practices where woody perennials are deliberately grown on the same land management unit as agricultural crops and/or animals, either in spatial mixture or in temporal sequence. There must be insignificant ecological and economic interactions between the woody and non-woody components.
The information provided on the various systems is largely descriptive. There is relatively little rigorous production data arising from controlled measurement - much could even be labelled as anecdotal. This does not invalidate the systems inventory; rather, it underlines the need for research to understand and to quantify the performance of these systems. Advice to farmers, development projects, etc., on choice of system and expected impact/outputs is of necessity based on such information. Production performance is available only for tree crops and alley-cropping and, in this latter case, in a limited humid zone in West Africa.
The unique feature of agroforestry which distinguishes it from all agriculture systems is the deliberate introduction of trees into the landscape. These are not the conventional timber-producing trees of forestry but, rather, the MPT's of agroforestry.
None of the genotypes of economic crops currently being tested in agroforestry systems has been specifically bred for a mixed cropping system.
The integration of the animal with the woody perennial and the crop component becomes of high priority.
There is an urgent need for quantified information on animal production in agroforestry systems and for the development of research methodologies, in particular experimental designs, appropriate for such studies.

Social acceptability implies that the technology, in this case some agroforestry systems, will not create any social problems and might even be socially desirable. Thus, there should not be any labour demands which are in conflict with current practices.
Sustainability of agriculture production is a key issue as one looks at the impact of increasing population pressure and the movement of agriculture into less favourable areas. The issue, however, is not merely sustainability, but, hopefully, sustainability at higher levels of productivity.
For a system to be sustained, there will be costs depending on the level of production which one wishes to maintain. The prevention of leakage from the system, recycling of nutrients, enhancement of nutrient status by biological activity, are all ways of attaining sustainability but by no means exhaustive of the means. While there has been in very recent times a significant increase of interest in sustainability, there have to date been few objective data published on the subject.
With population expected to reach 10 billion early in the next century and with increasing expectation for better nutrition, the demand will continue to grow. Agricultural enterprises have to move into more marginal areas and in more intensive management of currently used areas. A critical concern of all faced with the problem is that the systems shall be sustainable; not just capable of maintaining the status quo, but dynamic and capable of meeting the increasing demands while still avoiding environmental degradation.

401 89 - 7/25

Agroforestry
Review, tropics, subtropics, developing countries, land-use systems, traditional systems, agrosilvopastoral systems, homegardens, plantation, farm forestry, marginal lands, constraints, ecology, sustainability, future trends
SWAMINATHAN, M.S.
The promise of agroforestry for ecological and nutritional security.

In: Agroforestry - a decade of development. Eds. Steppler, H.A. and P.K.R. Nair, ICRAF, Nairobi, Kenya, 1987, pp. 25-41

This paper gives a brief account of agroforestry systems, some recent successes, and the potential of these systems for increasing food and environmental security.
Sustainable food security is a major human goal.
Enduring food and nutrition security can be built only on the foundation of ecological security, i.e. the security of the basic life-support systems of land, water, flora, fauna, and the atmosphere. It is in this context to assess the role of agroforestry systems in helping to achieve sustainable nutritional and ecological security.
It is predicted that between 1980 and 2000, world population will increase by 1.7 billion. Ninety percent of this growth will occur

in developing countries. This tremendous increase will require at least 50-60 percent greater agricultural output than in 1980.
Any increase in food production has to come primarily from raising the productivity of currently tilled soils rather than from bringing new land resources into farming. In fact, a large portion of currently tilled marginal areas will have to be phased out of agriculture for economic and ecological reasons. Land for agriculture is a shrinking resource, because some land is being taken out of production all the time and diverted to uses such as roads, housing, and industry.
Modern agricultural production technology has raised the hope that hunger can be eliminated and the carrying capacity of the land increased through better use of soil, water, and air. Nevertheless, the ecological sustainability and economic viability of new technologies are increasingly at stake. The rising populations of humans and animals, with their ever expanding food, fodder, and feed needs, exerts great pressure on the stabilizing elements of agro-ecosystems. As productive land becomes scarce, marginal farmers are pushed into fragile crop lands and forest areas unsuitable for modern agriculture. If the present trend of population growth persists, forest and pasture lands will be further reduced.
A major cause of soil erosion is deforestation. The World Resources Institute has estimated that 160 million hectares of upland watershed in the Himalayas and Andean range, and in the Central American, Ethiopian and Chinese highlands, have been seriously degraded due to human interference.
It is obvious that the maintenance of tree cover is of utmost importance for ecological and economic sustainability of food-production systems. Agroforestry involving the integrated cultivation of woody perennials, crops, and animals provides one answer to the problem. A typical agroforestry system allows symbiotic economic and ecological interactions between the woody components to increase, sustain, and diversify the total land output. Some of the dominant agroforestry systems are: (a) shifting cultivation, (b) taungya afforestation, (c) homegardens, (d) silvopastoral, (e) agrisilvicultural, and (f) windbreaks and live fences. Farming systems that incorporate perennial trees and shrubs have the advantage of producing fuelwood, fruit, fodder, and other products along with annual crops. In addition, they decrease the farmer's exposure to seasonal environmental variations and, over the long-term, maintain and improve soil health.

402 89 - 7/26

Agroforestry
Review, tropics, subtropics, developing countries, land-use systems, land-tenure, shifting cultivation, sustainable agriculture, marginal lands, fallows, alley cropping, intercropping, trees, agropastoral systems, mixed farming
RAINTREE, J.B.
Agroforestry pathways: Land tenure, shifting cultivation and sustainable agriculture.

Unasylva 154, 38, 4, 1986, pp. 2-15

From a project standpoint there are two fundamental ways of arriving at agroforestry: by integrating trees into farming systems or by integrating farmers into forests.
Appropriately selected woody components may contribute to both the productivity and sustainability of farming systems on marginal land in several ways: by enhancing the production of organic matter; by maintaining soil fertility; by reducing erosion; by conserving water; and, by creating a more favourable microclimate for associated crops and livestock. These "service roles" are above and beyond the direct "production roles" trees can also play in supplying food, fodder, fuelwood, building materials and other raw materials for rural industries. In traditional land-use practices, agroforestry is also important in maximizing and diversifying the productivity of even highly fertile lands. Intensive agroforestry systems are most commonly found in areas with a long history of population pressure, indicating their general efficiency as a land-use system.
All tropical land-use systems exhibit varying degrees of "leakiness" with respect to the cycling of nutrients held in the soil-vegetation complex, although systems such as irrigated rice paddies, permanent tree crops and forests are inherently more sustainable than others. It is a fundamental contention of agroforestry that trees have good prospects for plugging many of the holes in tropical farming systems. The degree of "infilling" can vary from slight to virtually complete. Essentially, the decision as to how many and which kind of trees it is profitable to add to the existing pattern of land-use depends on what useful niches for trees can be identified. An agroforestry "niche" in this sense has three components: a functional role within the land-use system; a place within the landscape; and a time within the life cycle of a particular land-use system.
Although many of the recent research thrusts in agroforestry have been directed toward the integration of trees into farming systems, agroforestry also has a role to play in the preservation of forests and the improvement of forest management systems. By providing farmers with a means of producing fuelwood, timber, building poles and other forest products on farmland, agroforestry can significantly reduce the demand on forests and natural woodlands. By doing this in ways that enhance and sustain agricultural productivity, agroforestry can also alleviate some of the pressure for the conversion of forest land into farmland.

Moreover, the integration of farmers into forest management schemes through the use of "compromise" land-use systems based on agroforestry may be one of the few realistic ways of sustaining forestry production on agriculturally pressured forest land.
The purpose of this article is to provide some mental images of the scope and potential role of agroforestry to serve as a background to the discussion of tenure issues. The main assumption is that the interactions between agroforestry and tenure issues are basically of two types: first, tenure factors may pose constraints to the realization of the potential ecological and socio-economic benefits of agroforestry in many land-use systems; and second, agroforestry may offer ways of resolving some existing tenure problems. Tenure issues are far more varied and complex than are reflected here. However, attention is focussed on some of the major changes in tenure that arise in conjunction with the main developmental trends in tropical land-use. These changes are then viewed in ecological and evolutionary perspectives.
Agroforestry can perhaps provide a simple, equitable, all-round solution in developing countries to the related problems of biomass energy supply, decentralization of rural industry, and the participation of pastoralists in national development.
The purpose of this article has been to raise some questions and provide some images for a positive approach to tenure questions in agroforestry.

403 89 - 7/27

Agroforestry
Central America, Costa Rica, CATIE, review, coffee, cacao, laurel, *Erythrina poeppigiana*, litterfall, nitrogen fixing, nutrient cycling, shade trees
BEER, J.
Litter production and nutrient cycling in coffee (*Coffea arabica*) or cacao (*Theobroma cacao*) plantations with shade trees.

Agroforestry Systems, 7, 1988, pp. 103-114

This paper reviews the published data on litter production, nutrient cycling and nitrogen fixation in shaded coffee or cacao plantations, in order to discuss the relative importance of these possible benefits of the shade trees.
High crop production levels from unshaded coffee (*Coffea* spp. L.) and cacao (*Theobroma cacao* L.) plantations can be obtained on fertile soils given intensive management. Many possible advantages of using the so called "shade trees" have convinced most farmers in Central America to continue to manage these crops under a partial tree canopy. Obviously shade itself is not always necessary.
In Central America some of the best known shade trees are *Erythrina* spp. and *Cordia alliodora* (R + P) Oken, which are used individually or in combination. An obvious reason for including *C. alliodora* is the production of high value timber. In contrast the *Erythrina* spp. give no commercialized products.

In Costa Rica it seems significant that farmers who have encouraged natural regeneration of *C. alliodora* in coffee or cacao plantations do not eliminate the existing *Erythrina* spp. which suggests that the latter possesses desirable characteristics which are not provided by the former. The Rhizobium associated with the roots of leguminous shade trees such as *Erythrina* or *Inga* spp. can fix 35-60 kg N/ha/a. This is sufficient to replace the N exported in crop harvests, from plantations where no or little inorganic fertilizers are applied, assuming that all the fixed N becomes available to the coffee. Many partially shaded coffee plantations in Costa Rica are heavily fertilized at rates of up to 270 kg. N, 60 kg P and 150 kg K/ha/a. Thus it seems improbable that N fixation is the reason why these coffee farmers have continued to use *Erythrina* spp.
Comparisons are made between the leguminous shade tree *Erythrina poeppigiana* and the non-leguminous timber tree *Cordia alliodora*. The former, when pruned 2 or 3 times/a, can return to the litter layer the same amount of nutrients that are applied to coffee plantations via inorganic fertilizers, even at the highest recommended rates for Costa Rica of 270 kg.N, 60 kg.P, 150 kg.K/ha/a. The annual nutrient return in this litterfall represents 90-100 percent of the nutrient stored in above-ground biomass of *E. poeppigiana*, and hence the consequences of competition with the crop should not be a serious limitation. In the case of *C. alliodora*, which is not pruned, nutrient storage in the tree stems, especially of K, is a potential limiting factor to both crop and tree productivity.
These trees contribute 5.000-10.000 kg organic material/ha/a.
It is concluded that, in fertilized plantations of cacao and coffee, litter productivity is a more important shade tree characteristic than N fixation.

404 89 - 7/28

Agroforestry
Review, book, ecological zones, dissertation, land-use systems, marginal lands, deforestation, food security, grazing, desertification, ecology, sustainability, agroforestry systems, agriculture, education, environment
BOEHNERT, J.
Agroforestry in agricultural education with a focus on the practical implementation.

Tropical Agriculture 2, 1988, 182 pp.; Verlag J. Markgraf, Eichendorffstr. 9, D-8074, Gaimersheim, ISBN 3-8236-1117-8, price DM 49,- USD 29,-

The world wide destruction of natural environment which is the base of life and that of future generations, is calling urgently for practical solutions. In this respect agroforestry has a great deal of potential to offer, but it is far from being a panacea. Other political, economical and educational solutions have to come

first before a natural sound way of farming like agroforestry can show its full potential.
As long as farmers in the developing countries are encouraged to mono cash crop production on land that should be used for growing locally needed food, to pay back the debts of their countries and to satisfy their urban elite, and as long as environmental education and conservation is regarded as an "unnecessary luxury" - the world wide destruction of natural resources will continue.
There are indications for hope. The world wide growing interest in agroforestry is one. The author hopes that this dissertation will contribute to the further extension and education in agroforestry.
The main objective of this publication is to study and to identify ways in which agroforestry can become a vital part of agricultural education and a sustainable way of farming for school and college farms.
Methods of the study include a review of existing literature on the subject (Chapter 1), knowledge gained from a study course and the writer's experience gained from working on a Teacher Training College (Agriculture Department) in Zambia and for over two years in a Agroforestry Project in the semi-arid areas of Kenya, as well as journeys in South America and Africa.
Chapter two attempts to present agroforestry systems as a possible "solution" to most of the problems mentioned in chapter one. The chapter will go into detail about the possibilities and potentials of agroforestry.
Chapter three is focussed on three potential "Fields of Expansion" for agroforestry: the tropical and sub-tropical regions, the semi-arid to arid regions and the temperate regions of the world.
Chapter four is devoted to a study of formal and non-formal education and training in agroforestry. This chapter is suggesting a detailed agroforestry training programme,its concepts and objectives.
Finally the study attempts to make suggestions on the practical implementation, management and utilisation on agroforestry-systems for school and college farms.
The main point is not layed on a particular country, climatic region or continent, but all climatic regions of the world are included in the study with preference towards tropical and sub-tropical regions.

405 89 - 7/29

Agroforestry
Asia, India, semi-arid tropics, studies, agroforestry systems, cropping systems, sustainability, alley cropping, intercropping, economics, annual crops, Alfisol, Vertic Inceptisol, land equivalent ratio
ICRISAT
Assessing sustainability - agroforestry - .

ICRISAT Annual Report 1988, pp. 184-185; ICRISAT, Patancheru, Andhra Pradesh 502 324, India, 1989

Agroforestry experiments with *Leucaena leucocephala* began at ICRISAT Center in 1984 in conjunction with a study funded by the Ford Foundation to examine the potential role of agroforestry in the semi-arid tropics (SAT). The findings of the Ford Foundation study, highlighted two major constraints to the introduction of agroforestry and alley cropping in SAT India. First, trees compete strongly with crops, a fact that has subsequently been shown to be due to competition for water. Second, the close association of trees and crops does not have the positive interactions often observed in conventional intercropping. Indeed, many agroforestry combinations may be economically inferior to combinations of annual crops in the SAT, but data to demonstrate this are lacking.
There is now sufficient information on alley-cropping systems based on leucaena to allow to examine: (1) the evidence for positive interactions, especially in terms of productivity and microclimate amelioration, and (2) the economic comparison of alley cropping and annual cropping over a large range of fodder prices. The hypotheses that alley cropping is less productive than sole leucaena in terms of biomass was explored previously by measuring the total amount of solar radiation intercepted by leucaena hedgerows and three cropping systems on a Vertic Inceptisol. These calculations showed that when sole leucaena was managed optimally, the total land equivalent ratio (LER) of the alley crop reached 0.58. None of the sole leucaena treatments was managed optimally for biomass production because they were pruned in the rainy season even when there was no demand for fodder, but they provide a comparison of an alley-cropping system where prunings are used as green manure during the rainy season.
A multidisciplinary experiment was started on shallow Alfisols to determine the advantage of incorporating prunings of leucaena (cv Cunningham) into annual cropping systems and the consequences on runoff and yield. Leucaena in paired rows at alley spacings of 3.0 and 5.4 m, and pruned hedges regularly was grown. Annual crops were pearl millet /pigeonpea intercrop in 1984 and 1986, castor in 1985, and groundnut in 1987. Sole leucaena spaced at 1.2 m x 0.25 m which was optimal for canopy development and dry matter production.
Incorporation of prunings per annum had a negligible effect on crop production, so results for both mulched and non-mulched treatments were combined. This observation is consistent with the bulk of the evidence in SAT India. Dry matter production in 1984 and 1985 was poor in all three treatments, probably because of exceptionally low rainfall. With more rain during 1986 and 1987, the biomass production of all treatments during these years increased markedly. Over the 4 year period, sole leucaena still produced the greatest amount of biomass per unit field area, closely followed by the yields in alley cropping. The annual crop treatment produced 66% of the sole leucaena over the same period. The superiority of the sole leucaena stand over the alley crop was clearer during the off-season from January to early June, when the demand for fodder is greatest. Calculations of LER show no advantage at 5.4 m and at 3.0 m spacings. The values of LER is insufficient to compensate for the loss in economic return from grain yield at 3.0 m. This finding supports the hypotheses that

alley cropping based on leucaena is not more productive than sole leucaena even when leucaena is not managed optimally. A similar conclusion was drawn from an alley cropping trial of leucaena/sorghum/pigeonpea on Vertic Inceptisols reported previously, in which the highest LER was 1.14, using the best annual crop treatment as a base.
An economic comparison of the most remunerative alley- and annual crops was carried out over a wide range of prices for leucaena dry fodder for both the Alfisol and Vertic Inceptisols trials. The best alley crop treatments were the widest spacings in both trials, 5.4 m for the Alfisol and 5.55 m for the Vertic Inceptisol. Both trials revealed that the economic superiority of alley cropping was small and was confined to the price range of Rs 0.8-1.6 kg^{-1}. Below this price range, the annual crop gave the best economic returns, and sole leucaena dominated above Rs 1.6 kg^{-1}. The poor comparative performance of alley cropping on the Alfisol was partly due to the lack of response to mulching, but even if response to both mulching and fertilizer were significant, applying more fertilizer to annual crops will always be economically preferable to sacrificing land to leucaena hedgerows.

89 - 7/30

406

Agroforestry
Europe, Spain, study, highlands, mediterranean region, land-use system, dehesa, oak trees, agrosilvopastoral system, soil fertility, animal integration
JOFFRE, R. et al.
The dehesa: an agrosilvopastoral system of the Mediterranean region with special reference to the Sierra Morena area of Spain.

Agroforestry Systems, 6, 1988, pp. 71-76

The various characteristics of the dehesa system are described and evaluated in this paper based on the results of a six year study undertaken at Sierra Norte area, north of Sevilla, Western Andalusia, Spain.
In South Western Spain the word "dehesa" is used to denote the land-use system in rural areas, mainly rangelands, which are occupied by scattered oak trees (*Quercus rotundifolia, Q. suber, Q. faginea*). The system has been known for many centuries for its multiple, mainly silvopastoral, use of renewable resources, and its strong linkages of recurrent cereal cropping in rangelands.
There are many bibliographical references to the past importance of the oaks producing sweet acorns both for human food consumption and to feed domestic animals such as pigs. Early livestock farmers of the South Western Spain had legal rights for the use of grazing resources belonging to rural areas "with trees". These indicate the long history of land-use systems involving oak trees in the appropriation of rural areas in the Iberic Peninsula.
The scattered tree layer dominated by sweet-acorn-oaks has a strong link with animal husbandry and, as such, the dehesa could basically be considered as an orchard system which produces feed-

stuff for domestic animals. But looking more carefully, one can say that this orchard-like system is also a producer of forestry resources, such as timber for various uses, charcoal, tannin, cork (*Q. suber*) etc. Besides, it plays a very important role in improving soil conditions, and also in giving shelter for grazing animals; the system also contributes to the comprehensive ecological equilibrium of the rural area and to its environmental quality and stability, both at regional and very local levels.
Considering on the one hand the very rapid ecological change during the last two decades, and the powerful techniques available today to contribute to these changes on the other, the dehesas become a very sensitive agrosystem and also a subject of controversial judgement and evaluation. Looking at the ecological advantages, in terms of biological productivity and metastability, it can be said that some positive synergic effects could be observed and measured when scattered oak trees are associated with various components of grassland vegetation, unless management practices favour mainly tree and perennial grasses associations. Still, much more research is required in order to give substantive data to decision-makers, managers and farmers.
The dehesa-like systems could be considered for adoption as potential multiple use agro-ecosystems for all the fragile areas of Mediterranean region, from semi-arid to sub-humid conditions. This concerns millions of hectares in the countries bordering the Mediterranean Basin, as well as other millions of hectares in countries of the rest of the world where mediterranean climates occur. For instance in Chile the dehesa-like system of *Acacia caven* in semi-arid and sub-humid regions has the same ecological and socio-economic role as of oak dehesas of the Old World. Positive synergic effects between tree canopy cover of *A. caven* (a legume tree) and the best grassland conditions (*Lolium multiflorum*) have been demonstrated in farm systems, with sheep and cattle.
More experiments at farm level need to be undertaken with management practices applicable to the complex of the dehesas, both for the benefit of the environmental conservation and of the farmers and the countries concerned. New package of management techniques must be implemented.
Adoption of management techniques could lead to better conservation of renewable resources, land, water and genetic pools. The socio-economic benefits from such a programme should be considered on the basis of long-term benefits for the whole society.

407 89 - 7/31

Agroforestry
Review, land-use systems, sociology, land tenure, conservation, labour, nutrition, marketing, organisation
HOSKINS, M.W.
Agroforestry and the social milieu.

In: Agroforestry - a decade of development; Edts H.A. Steppler and P.K.R. Nair, ICRAF, Nairobi, Kenya, 1987, pp. 191-203

This paper deals with the following issues: local uses and knowledge, tenure, organization, conservation, landlessness/distance, enterprises and marketing, labour, nutrition, and gender/age.
Much agroforestry research has been based on topics selected through an expanded farming systems type approach, the diagnosis and design (D&D) methods. D&D uses a multidisciplinary problem-solving focus originating from the perspective of farmers. Establishing research priorities from within the social milieu in this manner promises to put agroforestry research results ahead of much traditional forestry and agricultural research in being of great relevance to farmers. However, the methods of making new innovations available to farmers are not yet clear.
The uniqueness of the socio-economic factors involved in tree promotion is important to examine and to work with extension and development ministries and agents already in place. Probably agroforestry awareness and training will be needed for various extension agents dealing with farmers. However, if methods commonly used in agricultural promotion programmes are adopted without careful modification for use with agroforestry they may indeed defeat the promotion of farmer adoption, causing such programmes to come to a dead end, if they begin at all.
It is not easy to select and describe the crucial socio-economic variables in a universal way: situations differ depending on the locality, environment and the major traditional production activities; issues overlap and are not easily considered in isolation. Variables will need to be studied case by case. However, examples of common issues, even if incomplete, may serve to highlight some of the questions which should be raised in order to tailor agroforestry promotion policies and the training of promoters in an effective manner.
Agroforestry helps focus agriculture on sustainable practices and on ways to make smaller parcels of land produce the range of plant and animal products required for subsistance or for market. It offers hope where land pressure has made traditional agriculture and herding practice unviable. When well designed, it can provide a more diverse production system thereby reducing risks. However, when not designed to respond to the social milieu, the benefits can completely miss the poor.
It will be a challenge to develop testing methods easily understood and used by farmers in developing realistic but rapid ways to examine plant inter-relationships in the context of their own objectives. This must become a two-way process because only

through farmer management and adoptation of these suggested new approaches will the real socio-economic aspects of agroforestry be more fully understood. This final step needs to be designed to complete the information circle, giving data back to the on-station researchers. If attention is given to plan the full cycle of research and trials and the effective information flow, the speed of providing socially appropriate agroforestry interventions and their adoption will be greatly enhanced. It is only through this testing of methods and information that technical and social scientists can refine their tools and interventions to be, in fact, relevant. Trainers of extensionists are going to have to stay abreast of this dynamic field as more is learned about tree specific issue in different settings. Agroforestry extension agents will need to be trained to approach extension as a service which makes information available and encourages farmers themselves to experiment and to actively participate in the adaption of research results to fit their needs.
The use of agroforestry in the overall development context needs to be critically assessed. Agroforestry cannot become the development tool of choice only when poor land-use practices by commercial loggers or by poorly designed irrigation or other large-scale agricultural schemes have left denuded hillsides or salt marshes. Policies need to be designed to support agroforestry as an integral part of better land-use planning and to strengthen access to these new technologies for the poor not only on wasted lands.
Agroforestry offers solutions to many problems. Its promises are extremely encouraging and attractive. However, as a development tool, agroforestry will be helpful only if it can be put effectively into the hands of men and women farmers, and if the political decisionmakers see this as a tool for achieving equity in development.

408 89 - 7/32

Agroforestry
Asia, India, review, rural development, tree planting, non-governmental organizations
SHAH, S.A.
Tree Planting for Rural People-Involvement of Non-Governmental Organizations.

The Int. Tree Crops Journal, 4, 1987. pp. 195-207

Rural tree planting differs from conventional planting in recognised forest areas in being extremely sensitive to local social and economic conditions, and designed to meet local needs rather than commercial requirements, usually in a multiple land use context. Thus, rotations are short, multiple-use trees are planted instead of timber trees, the involvement of local people is essential and the distribution of benefits to economically and socially backward people, who largely follow a non-monetarised economy, has the highest priority.

This paper reviews the experiences, assesses the requirements for improved performance and suggests ways by which these needs may be met.
Only since 1980 have international organizations perceived the need for and accorded a high priority to social forestry in India. Progress in aided project development has been phenomenal.
There is a great need for improvement. As a result of application of a poor technology package, enthusiasm and motivation suffer a set-back. A few NGOs have made a beginning in organising training programmes. But they leave much to be desired. The course content is not properly identified and the training material not developed adequately. The trainers are field personnel who themselves need training.
Almost all the NGOs find it difficult to procure quality seed and planting material. Some of them are exploited by unscrupulous traders in this matter. Similarly, quite a few of them who are involved in nurseries find it difficult to dispose of the seedlings raised by them. As such, a tie up with the consumers is essential.
Tree planting activity needs continuous and sustained attention. This requirement demands strong local institution support.
A few NGOs find it difficult to deal with Governments to ensure a timely and a steady delivery of inputs they are eligible for, such as planting material etc..
Tree planting activities should start with education strongly supported by audio-visual aids. It is this which should secure full commitment of the local groups and NGOs. Forest Science Centres should be established to develop and provide appropriate literature, conduct tours to demonstration areas, organise discussions, screen suitable films, etc. Care should be taken to ensure that women and children take full advantage of the programmes. Backyard planting is one of the most attractive and appealing components of tree planting. It is women who need to be motivated. Nursery raising is another activity very well suited to women. Greater progress is achieved if a village-level forester is accessible to the local group all the time.
Establishment of a village level institution is a priority. It is essential that the local group entrusted with the planting responsibility be highly motivated. The NGO should provide managerial support to the local groups and will need to build up its own capabilities and evolve a suitable structure, as and when its activity expands laterally, so that it is able to guide, oversee and monitor the activity. None of the existing NGOs has developed such a structure so far. Very few farmers' tree societies or cooperatives have been formed. Cooperatives are needed for timely delivery of inputs and financial assistance, securing loans and sharing equipment.
Training will have to be designed for different target groups. A few NGOs and state governments have made efforts to design suitable courses but a lot remains to be done. There is a great deficiency of training materials and competent trainers. All NGOs suffer from inadequacy of trained personnel. Regional, state and national seminars would bring NGOs together and ensure better coordination and cooperation.

409 89 -7/33

Agroforestry
Asia, India, ICRISAT, semi-arid tropics, report, agroforestry research, recommendations
VAN DEN BELDT, R.J.
Agroforestry research in the semi-arid tropics.

ICRISAT, India, A report on the working group meeting, ISBN-92-9066-116-x, 1986, 55 pp.

The genuine needs of the poor for fuel and fodder, the needs of subsistence farming, and neglect of soil and water conservation principles in these fragile environments have all contributed to the rapid decline of forest cover in India.
Inappropriate agricultural and forestry production systems and population growth (animal and human) outstripping production lead to land degradation. The problem is severe in the tropics, where the presure of population is high, ecosystems fragile, and exploitation of forest cover ruthless. The consequence is that wood supplies are dwindling.
The effects trees have on crop production call for intensive scientific studies. The competitive effect for moisture, nutrients, and light in a mixed crop and tree culture, the problems of pests, diseases, and birds, and the effects -- long and short term -- on soil and water conservation are all important aspects, which assume great importance in agroforestry studies especially under the rainfed conditions of the SAT.
Agroforestry research should emphasize: (1) increasing productivity of marginal lands in both the dry and wet-dry SAT, wastelands (or wasted lands), and land affected by salinity and alkalinity; (2) monitoring nutrient recycling and nutrient and moisture depletion from soil profiles by agroforestry mixes; and (3) developing systems relevant to farmers and adaptable by them.
A workshop was held at ICRISAT Center on 5 and 6 August 1985, with discussions designed to assist in exploring the potential of agroforestry in the semi-arid tropics.
The workshop brought together participants from Indian industries, research institutes, universities, and nongovernment organizations (NGOs), as well as representatives from foreign aid missions, ICRISAT, and the International Council for Research on Agroforestry (ICRAF, Nairobi) to share ideas, methodologies, and results on agroforestry research.
The objectives of the workshop were:
- To review agroforestry research under way in India.
- To foster dialogue between the various sectors, in order to facilitate development in the semi-arid tropics.
- to prepare broad guidelines on priorities for agroforestry research in the semi-arid tropics.

The contents of this report are:
- Foreword
- Preface

- Position Papers
  . Agroforestry Research - An Introduction
  . Making Agroforestry Research Relevant to the Needs of Small Farmers
  . International Funding Agencies and Agroforestry Research
- Working Group Recommendations
  . Bioscientific Research
  . Socioeconomic Research
- The Indian Program
- The ICAR Program
- The Role of Industry
- The Role of Nongovernment Organizations
- ICRISAT's Program
- Collaboration and Linkages
- Appendix: List of Participants

Although the workshop was traditionally structured, with topical sessions, discussions, working groups, and plenary sessions, this volume does not closely follow that structure. As such, it is not a proceedings but rather a report on the workshop.
No formal papers as such were presented; rather, summaries of research methodologies and objectives of the various institutions were outlined. In preparing this report, therefore, more emphasis has been placed on the content of the papers rather than on authorship.

410 89 - 7/34

Agroforestry
Tropics, sub-tropics, agroforestry systems, nitrogen fixing, legumes, actinomycete associations, shrubs, crops, animals, fodder, green manure, fuelwood, pulp, timber, shade, windbreak, soil amelioration, multiperpose trees, deforestation
BREWBAKER, J.L.
Significant nitrogen fixing trees in agroforestry systems.

In: Agroforestry: Realities, possibilities and potentials; Ed. H.L. Gholz, Martinus Nijhoff Publishers in association with ICRAF, ISBN 90-247-3591-2 (paperback), 1987, pp. 31-45

N-fixation characterizes most legumes (over 90% of mimosoids and papilionoids, and 34% of caesalpinioids). At least 90% of these represent tropical centers of origin. Selected genera in 9 other plant families also fix nitrogen: *Betulaceae, Casuarinaceae, Coriariaceae, Cycadaceae, Elaeganaceae, Myricaceae, Rhamnaceae* and *Ulmaceae*. Legume N-fixing nodules are rhizobially infected, while those of the other families involve actionomycetes of the genus Frankia. Nitrogen fixation characterizes about 650 known tree species and several thousand suspected ones.
The list of potential NFT species for use in agroforestry is expanded greatly if one generously includes all plants from which wood is an economic product. Many N-fixing species are shrubs or secondary forests and grasslands. They often lend themselves

better to crop- and animal-based agroforestry systems than the premier forest trees do. In this paper NFT are divided in:
- Fodder trees:
- Alley farming and nurse trees:
- Fuelwood and charcoal trees:
- Food and medicinal trees:
- Windbreak and fence row trees:
- Pulpwood and roundwood trees:

These groups of NFT are discussed in detail.

411 89 -7/35

Agroforestry
Asia, Thailand, land-use systems, forst village, reforestation, taungya method
WATANABE, H. et al.
Combinations of trees and crops in the taungya method as applied in Thailand.

Agroforestry Systems, 6, 1988, pp. 169-177

Agroforestry systems, particularly those using the taungya method, have been initiated to rehabilitate large land areas abandoned after over-use (i.e., shifting cultivation or overlogging), in southeast asian countries. The taungya method has been applied to regions where it was never traditionally practiced. It is usually defined as a reforestation method in which trees and agricultural crops are simultaneously planted at the initial stage of reforestation and later only trees are left to complete reforestation.
In Thailand a government enterprise, began establishing Forest Villages to accelerate reforestation efforts in 1967, and the taungya method has been introduced as the primary reforestation method. At present, forty one Forest Villages have been established throughout the country.
The objectives of the Forest Village Programme are to resettle landless people and establish sustainable agriculture in each forest unit. Each family member is allotted a 10 rai (1.6 ha) plot of land in a reforestation area to raise their crops simultaneously with tree planting and another 1 rai (0.16 ha) in a forest village on which to live, build a house and establish a backyard garden. All lands allotted belong to the Forest Industry Organization but cultivators can use the land without cost within the specified time limit.
In addition to growing agricultural crops as a source of income, labour for forestry work is recruited from the villages to ensure continuous employment for additional income. Therefore, this system is called a "modified taungya system" in Thailand.
Since the establishment of the programme, many trials of introductions of exotic trees and agricultural crops have been conducted, and various combinations of trees and crops have been tried. As a result, the remarkably fast growth rates of several trees species, such as *Eucalyptus camaldulensis*, have been

selected, and these are widely recommended for planting throughout the country. Planting of eucalyptus is an effective measure to recover green as quick as possible, however, when trees attain age of cutting, it is doubtful whether enough demand is there.
The combinations of trees and crops in the taungya method which have been practiced in the Forest Village Programme differ from village to village, and even more so from region to region due to the differences in climate, soil fertility, market demand, and skills or preferences of the cultivators involved.
Combinations of trees and crops in the taungya method are probably best classified into the following four main types reflecting the differences in climatic conditions, though there are various other combinations of trees and later crops on a lesser scale:
Type A: Teak (*Tectona grandis*) - Upland rice - Vegetables
Type B: Fast-growing trees - Cassava
Type C: Fast-growing trees - Maize
Type D: Para-rubber (*Hevea brasiliensis*) - Fruit trees/coffee
Fast-growing trees *Dipterocarpus alatus*
In the taungya method practiced in Thailand, one main tree species and one main crop, namely, cereals like upland rice, maize, sorghum, or cash crops like cassava and fruit trees are usually inter-planted in a given area. Additionally, beneath the cereals or fruit trees, various kinds of vegetable subcrops (e.g. pumpkin, chili and beans) or other cash crops (e.g. pineapple, mungbean or castor bean) are often inter-planted.
Tree and crop combinations are changed depending on the season. Maize is usually cultivated in the rainy season, from May to August. After the maize is harvested, sorghum is planted where the maize was grown in reforestation areas in the west region. Sorghum is more tolerant to drought. Occasionally, maize and sorghum are mix-planted on the same land in the northern region.
Vegetables like beans, pumpkins and sesame, are not normally inter-planted with tall cereals, such as maize or sorghum, because those vegetables would be too shaded to yield a large enough harvest. However, vegetables are occasionally inter-planted with maize and sorghum in cases where the latter two have been sparsely planted.
The interaction between trees and crops, particularly advantages and disadvantages as a whole, should be further clarified to find much productive and stable combinations.

412 89 - 7/36

Agroforestry
Latin America, Costa Rica, CATIE, land-use systems, living fences, fuelwood, fodder, food, windbreaks, wildlife protection, trees, sustainability, ecology, cultural practices
BUDOWSKI, G.
Living fences in tropical America, a widespread agroforestry practice.

In: Agroforestry: Realities, possibilities and potentials, Ed. H.L. Gholz, Martinus Nijhoff Publ. in Cooperation with ICRAF, ISBN 90-247-3591-2 (paperback), 1987, pp. 169-177

Living fence posts are a characteristic feature of the landscape of many tropical American countries from sea level to well above 2500 meters, and from relatively dry environments to some of the very wettest areas (over 4000 mm annual rainfall). As here described and analyzed, living fences refer only to those that are established by planting large cuttings (usually about 2.5 m long and from 8-20 cm in diameter), that easily produce roots and on which several strings (usually 3) of barbed wire are attached with the obvious purpose of keeping livestock in or out. Besides fencing, many other possible benefits are derived from the trees, including the production of various goods and services. Although publications in this area are few, a pioneer research effort has been carried out in recent years at the Tropical Agricultural Center for Research and Training (CATIE) in Turrialba, Costa Rica. More recently, studies on the best frequency of pruning *Gliricidia sepium* for fodder and current management practices of farmers for preparing *Gliricidia* cuttings and planting showed other promising lines of research. Moreover, various CATIE staff members have been producing information on species selection, productivity, socio-economic implications, advantages and drawbacks of live fences compared with "dead" fences.
Besides holding wire, live fences produce fuelwood, fodder, and food, and act as windbreaks and protection for wildlife, but the greatest benefit is derived from the use of branches to establish more fences or to "fill in" old fences. Many trees are used, depending on ecological zones, availability of large cuttings for planting, and special needs dictated by preferences and beliefs of the farmers. Planting practices, studied in detail in Costa Rica, also vary.
With a decreasing supply of naturally resistant wooden posts, formerly cheap and easily available, and the prohibitively high cost of artificially treated posts, living fences are bound to become more common. If one adds the other secondary products that can be derived, this appears to be a remarkable instrument for improving the quality of life of low-income farmers.
To this must be added the fact that very little effort has been made to genetically improve the most desirable fence post species for vigor, biomass production, pruning response, nitrogen fixation, form, and so on. An important factor that lends itself to genetic selection is the relationship between wood and leaves,

which could be modified depending on whether stakes, fuelwood or a large amount of leaves are desired.
This paper attempts to summarize the present information.
Advantages and drawbacks of living compared to non-living wood fences are discussed. Some speculations of future prospects and the possible involvement of scientists are advanced.

413 89 - 7/37

Agroforestry
Latin America, Peru, humid tropics, land-use systems, ecology, swidden-fallow, management practices, fallow utilization, site nutrient recovery
UNRUH, J.D.
Ecological aspects of site recovery under swidden-fallow management in the Peruvian Amazon.

Agroforestry Systems, 7, 1988, pp. 161-184

Mechanized farming does not necessarily provide permanently greater agricultural yields in energy-limited tropical countries. This has re-focused scientific interest on traditional subsistence farming systems which are able to provide sustained yields.
Recent research attests to the ecological viability of swidden (cyclic, or slash and burn) agriculture at appropriate levels of population. In fact much attention is currently being placed on improving shifting cultivation - in order to cope with increasing population pressure rather than trying to replace it.
A problem with fallowing as a means to overcome agriculture difficulties in the cropping cycle, is that it requires a great deal of time; time that is traditionally spent in an unproductive state.
This paper discusses the ecological "fit" of an existing fallow utilization scheme in Peruvian Amazon in the context of the changes in plant succession and nutrient dynamics which result in a favourable site nutrient recovery.
Following a brief description of the fallow management scheme, information is drawn from the author's observations in the Iquitos region of Peru and from the ecological literature to explain how management practices interact with specific aspects of swidden ecology - from the point at which the field is cleared, through the phases of burning, cultivation, harvesting, site abandonment, and distinct stages of succession - to allow a variety of economic fallow plants to thrive while setting the stage for continued favourable re-use of managed sites.
The ecologic attributes involved in promoting site recovery primarily include:
- Less destruction of the nutrient cycling root-mat in the swidden cycle, and its quicker re-formation in the fallow cycle.
- Discouraging the establishment of exotic weeds and grasses such as imperata, while encouraging the colonization of local, early successional species.

- Encouraging the earlier establishment of woody plants in abandoned swiddens.
- A natural litterfall higher in nutrients than in unmanaged fallows.
- Additions of "slash" litterfall higher in nutrient content than natural litterfall in the proximity of valuable managed plants.
- The increased capacity of the managed stand to limit nutrients such as N and P from, and leach unneeded quantities of non-limiting nutrients such as K, Ca and Mg to, thoughfall.
- Increasing the alkalinity, possibly resulting in less soil cation leaching in managed fallows.
- Staggering seed production, germination and maturation times of the rapid nutrient cycling softwood trees.
- Increasing the spontaneously occuring abundance of valuable fallow plants with management of successive fallow cycles, thereby possibly reducing the labour requirement, and increasing the value of this agroforestry scheme over time.

Development of the techniques of swidden-fallow management into a workable agroforestry system necessitates consideration of the ecologic relationships between the productive managed fallow and the productive swidden. The fallow period serves to reduce problems of soil impoverishment, diseases and weeds. Utilization of the fallow cycle ideally should either enhance or maintain the natural ability of the fallow to overcome these agricultural problems.

414 89 - 7/38

Agroforestry
Latin America, Brazil, semiarid woodlands, clearcutting, goat, sheep, nutrition, leaf litter production, herbage production, herbage chemical composition
KIRMSE, R.D. et al.
Clearcutting Brazilian caatinga: assessment of a traditional forest grazing management practice.

Agroforestry Systems, 5, 1987, pp. 429-441

Caatinga is the name of the vegetation growing in the semiarid portion of northeastern Brazil. This vegetation type covers approximately 830,000 km² of the region referred to the Northeast and constitutes about 10 percent of the total surface area of Brazil. Generally, caatinga is composed of trees and shrubs with an understory of annual herbs. Production of sheep and goats under extensive grazing programs is an integral component of the mixed-farming system of the Northeast and provides a source of dietary protein and cash reserve for subsistence farmers. Sheep and goats are dependent on caatinga vegetation for survival and production. The seasonality of rainfall and periodic droughts, however, place severe constraints on the dry season forage supply and resultant production of these small ruminants.
Clearcutting, a common practice for removing woody vegetation in the semiarid tropics of northeast Brazil is currently promoted at

state and national levels. The prevalent belief is that clearing increases the capacity to support livestock by increasing production of herbaceous vegetation. Little empirical evidence exists, however, to support this belief. African and Australian researchers report impressive increases in herbaceous yields after reducing overstorey canopies.
In northeast Brazil, increasing herbaceous production during the wet season, a time when forage quantity and nutritional quality are not generally limiting, may not enhance livestock production during the dry season, a time when forage quantity and nutritional quality are often limiting. In addition, leaf litter from trees is an important forage reserve during the dry season. Conversely, coppice produced by most tree species in this area following cutting still contributes, although to a lesser degree, to dry season forage reserves. Furthermore, many trees may enhance livestock production, provided the foliage is both palatable and nutritious.
The overall objective of the research program is to assess the validity of clearcutting as a means for increasing livestock production in caatinga woodlands. The study investigated the effects of clearcutting on forage production and quality throughout the year for small ruminants in the semiarid tropics of northeast Brazil. Specific objectives were to determine the effects of clearing on (1) herbage standing crop and chemical composition; (2) nutritive value of the vegetation to goats and sheep; and (3) botanical composition of the diets of goats and sheep.
It has been found that biomass of herbaceous species increased sixfold following cutting of trees, but much of this increase was in the form of poorly palatable stem. The large supply of leaf litter from woody species that was typical of uncleared areas during the dry season was replaced by persistent green foliage on cropping trees the year following clearing. This green foliage may enhance the nutritional quality of the diets of sheep and goats during the dry season.
Additional research is needed to determine whether or not the nutritional quality of trees that coppice is adequate for meeting small ruminant requirements during the dry season and whether or not palatability can be increased, perhaps through repeated cutting or fertilization or both. While this study attempted to assess the value of clearcutting to small ruminant nutrition in caatinga woodland, it did not attempt to address the question of ecological changes (e.g. water, soils, plants) that may or may not accompany clearcutting. That is an important next step prior to designing national grazing management policy in northeast Brazil.

415 89 - 7/39

Agroforestry
Review, humid and subhumid tropics, ILCA, IITA, alley cropping, land-use systems, soil management, soil fertility, planted fallow, sustainable crop production, farming systems, outlook
KANG, B.T. and G.F. WILSON
The development of alley cropping as a promising agroforestry technology.

In: Agroforestry - a decade of development, Eds. H.A. Steppler and P.K.R. Nair, ICRAF, Nairobi, Kenya, 1987, pp. 227-243

To meet the ever-increasing demand for food in the tropical and subtropical (developing) countries, more land must be brought under cultivation. This is feasible for much of Africa and Latin America where only 18 and 19 percent, respectively, of the potentially-arable lands are under cultivation. This will, however, provide only a temporary solution to the food-production problem if it is not followed up by viable and sustainable food-production technologies.
In alley cropping, arable crops are grown between hedgerows of planted shrubs and trees, preferably leguminous species, which are periodically pruned to prevent shading the companion crop(s). The shrubs and trees grown in the hedgerows retain the same functions of recycling nutrients, suppressing weeds, and controlling erosion on sloping land as those in the bush fallow. Prunings from the trees and shrubs are a source of mulch and green manure. Leguminous woody species also add fixed nitrogen to the system. The alley cropping technique can, therefore, be regarded as an improved bush-fallow system with the following advantages:
- Cropping and fallow phases are combined;
- Longer cropping period and increased land-use intensity;
- Rapid effective soil fertility regeneration with more efficient plant species;
- Reduced requirements for external inputs; and
- The system is scale-neutral, being flexible enough for use by small-scale farmers and for large mechanized production.

By integrating small-ruminant production with alley cropping, the International Livestock Centre for Africa (ILCA) project in Ibadan, Nigeria, has developed the alley-farming concept in which prunings from the hedgerows provide high-quality supplementary fodder. So alley farming can be defined as the planting of arable crops between hedgerows of woody species that can be used for producing mulch and green manure to improve soil fertility and produce high-quality fodder.
Various field trials were carried out by IITA scientists over the past ten years on strongly acid soils (Ultisols) and slightly acid soils (Alfisols) in the humid and subhumid regions of Nigeria to test the suitability and benefits of alley cropping.
On Alfisols and associated soils *Leucaena leucocephala* and *Gliricidia sepium* were the most promising woody species for alley cropping and alley farming. They can be established by direct seeding in association with a growing crop. Once established, the

hedgerows can be repeatedly pruned to produce large amounts of biomass that can be used as green manure, mulch or fodder.
Even on degraded land, *L. leucocephala* and *G. sepium* prunings had higher nutrient yields than those of some widely used native fallow species such as *Acioa barterii* or *Alchornea cordifolia*. The high nutrient yields are maintained when prunings are added to the soil. However, under a cut-and-carry system where prunings are continuously removed as fodder, the soil can also become improverished unless nutrients from other sources are added.
The performance of maize, cassava and cowpea in alley cropping with *L. leucocephala* and *G. sepium* has been studied. Higher maize and cassava yields were obtained when alley cropped than in control plots. It is estimated that *L. leucocephala* can contribute about 40 kg N ha^{-1} to the companion maize crop. Cowpea yield, however, showed either no increase or reduction in yield when alley cropped with *L. leucocephala*. Upland rice alley cropped with *L. leucocephala* does not respond to added fertilizer nitrogen, but the control plot (not alley cropped) responded to 30 kg of applied nitrogen per hectare.
An important aspect of alley cropping is how it affects yield sustainability. Under long-term observations on a sandy soil, maize yields were significantly higher when alley cropped with *L. leucocephala* than in control plots with or without applied nitrogen. Similar results were observed in long-term alley cropping trials on degraded Alfisols. With or without applied nitrogen, maize yielded more when alley cropped. This trial also showed that, in addition to nitrogen, improved soil conditions resulting from alley cropping had a positive effect on maize yields.
Results of long-term studies showed significant improvement in soil properties under alley cropping. These soils had higher soil organic matter and nutrient status than in soils receiving no prunings. Prunings added as mulch also substantially increased moisture retention in the topsoil.
The development of a sustainable production system suitable for large parts of the subhumid and humid regions, particularly in Africa, will have the additional benefit of reducing the land area needed for food production. Expanded alley cropping could help to arrest rapid deforestation.

416 89 - 7/40

Agroforestry
Africa, humid regions, ILCA, agroforesty, alley farming, hedgerow intercropping, *Leucaena*, evaluation
SUMBERG, J.E. and A.N. ATTA-KRAH
The potential of alley farming in humid West Africa - a re-evaluation.

Agroforestry Systems, 6, 1988, 163-168

A previously published paper examined the potential of a *Leucaena leucocephala*/maize alley farming system (hedgerow intercropping)

for the lowland humid tropics. Using data from the literature, the potential nitrogen and firewood contributions from the Leucaena hedgerows and the productivity effects on maize yields were estimated for a range of alley widths (between-row spacing of Leucaena) and maize yield environments. With the assumption that a 30% increase in maize productivity would be needed to motivate farmers to adopt a new technology such as alley farming, the paper concluded that alley farming would be acceptable only where existing maize production levels are lower than 1500 kg ha^{-1}. In addition, alleys wider than approximately 3 m would probably not be acceptable where existing maize production levels are greater than 1000 kg ha^{-1}.

This analysis suggests that alley farming is a potentially valuable crop production technology over a broad range of conditions in humid West Africa.

The central assumptions of the alley farming approach that the trees can draw and recycle nutrients from the lower levels of the soil profile, and that the trees can be managed in a way that minimizes competition with the crop have now been reasonably well documented. Further research and development with alley farming should be focussed on adapting this approach to local crop production conditions. It is ultimately of little value, for example, to investigate various pruning regimes which attempt to maximize the amount of mulch produced, when under farm conditions time and frequency of pruning are determined rather ridigly by the need to minimize shading of the crop. Similarly, height of pruning will probably be determined more by considerations of ease and speed than by pruning effects on re-growth and the life of the tree.

ILCA's experience in West Africa indicates that the work of adapting alley farming to local conditions can probably be done most effectively by the farmers themselves. The potential of alley farming can be realized through true "adaptive research", where farmers and researchers, working together, attempt to adapt a loosely defined technology to suit a range of farmers' needs and production environments.

VIII HOMEGARDENS

417 89 - 8/15

Homegardens
Review, developing countries, homegardens, household garden, CIP, garden types, ecology, sustainability, socioeconomy, practical approaches, policy
NIÑEZ, V.K.
The household garden as a lifeboat.
Ceres, 19, 112, 1986, pp. 31-36

Home garden programmes aimed at nutritional improvement of low-income groups in developing countries have been launched repeatedly during the past 25 years.

Failure to transfer model gardens was blamed on the clients' lack of interest rather than on the project's shortcomings. This "start and stop" pattern finally caused gardens to be discredited as a valuable food and nutrition strategy for developing countries.

Recently, interest in small-scale food production has come up, and advocates of the home garden strategy are looking for new avenues to make it work.

Household gardens have come to address many pressing development concerns. They help overcome seasonal or chronic food shortage, distribution bottlenecks, and high food costs. Low-technology and resource-wise production methods save energy and help reduce dependence on food imports. Native food gardens represent truly appropriate technology, a highly personalized self-help measure and a vital mechanism in the preservation of underexploited species. Furthermore, as gardens traditionally exist in space that is marginal and not in competition with large-scale field production, they help confront the problem of increasingly scarce new land ecologically sound for agricultural exploitation.

The tropical garden, is marked by high species density arranged in several vegetation "layers". This gives tropical homesteads the unkempt appearance that often misleads temperate gardeners to undue prejudice. Layering, in fact, is highly functional in tropical ecosystems: it prevents soil erosion, nutrient washing, and sun baking; it provides for beneficial plant symbiotic relationships (support, nutrient exchange, disease control), and it supplies a great variety of foods.

Household gardens differ depending on the type of household economy they serve. Subsistence farming households derive the bulk of their food from permanent or shifting field cultivation nutritionally complemented by mixed garden and field margin plantings. Garden staples often replicate field staples (in the case of maize, starchy roots, and tubers), but may be planted at different times and for immediate consumption.

Garden production supplements wage earnings for urban and rural labourers and helps stretch family income through savings. In Lima, Peru, for example, urban budget gardens produce the equivalent of 10 per cent of monthly wage earnings for low-income

for the lowland humid tropics. Using data from the literature, the potential nitrogen and firewood contributions from the Leucaena hedgerows and the productivity effects on maize yields were estimated for a range of alley widths (between-row spacing of Leucaena) and maize yield environments. With the assumption that a 30% increase in maize productivity would be needed to motivate farmers to adopt a new technology such as alley farming, the paper concluded that alley farming would be acceptable only where existing maize production levels are lower than 1500 kg ha^{-1}. In addition, alleys wider than approximately 3 m would probably not be acceptable where existing maize production levels are greater than 1000 kg ha^{-1}.

This analysis suggests that alley farming is a potentially valuable crop production technology over a broad range of conditions in humid West Africa.

The central assumptions of the alley farming approach that the trees can draw and recycle nutrients from the lower levels of the soil profile, and that the trees can be managed in a way that minimizes competition with the crop have now been reasonably well documented. Further research and development with alley farming should be focussed on adapting this approach to local crop production conditions. It is ultimately of little value, for example, to investigate various pruning regimes which attempt to maximize the amount of mulch produced, when under farm conditions time and frequency of pruning are determined rather ridigly by the need to minimize shading of the crop. Similarly, height of pruning will probably be determined more by considerations of ease and speed than by pruning effects on re-growth and the life of the tree.

ILCA's experience in West Africa indicates that the work of adapting alley farming to local conditions can probably be done most effectively by the farmers themselves. The potential of alley farming can be realized through true "adaptive research", where farmers and researchers, working together, attempt to adapt a loosely defined technology to suit a range of farmers' needs and production environments.

VIII HOMEGARDENS

417 89 - 8/15

Homegardens
Review, developing countries, homegardens, household garden, CIP, garden types, ecology, sustainability, socioeconomy, practical approaches, policy
NIÑEZ, V.K.
The household garden as a lifeboat.
Ceres, 19, 112, 1986, pp. 31-36

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Household gardens have come to address many pressing development concerns. They help overcome seasonal or chronic food shortage, distribution bottlenecks, and high food costs. Low-technology and resource-wise production methods save energy and help reduce dependence on food imports. Native food gardens represent truly appropriate technology, a highly personalized self-help measure and a vital mechanism in the preservation of underexploited species. Furthermore, as gardens traditionally exist in space that is marginal and not in competition with large-scale field production, they help confront the problem of increasingly scarce new land ecologically sound for agricultural exploitation.

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Garden production supplements wage earnings for urban and rural labourers and helps stretch family income through savings. In Lima, Peru, for example, urban budget gardens produce the equivalent of 10 per cent of monthly wage earnings for low-income

households. Only if earnings are high and retail markets close, can gardening become a hobby not necessary for household survival. Consequently, garden cropping lists were compiled utilizing Eurasian vegetables for which nutritional analyses and field horticultural technology existed. Often, no attempt was made to investigate locally grown or collected fruits and vegetables. Northern Hemisphere gardening techniques and inputs frequently not available in target areas were exported as a package.
Serious efforts for formulating successful, long-term programmes must consider the following guiding principles:
- Household food production must be given higher priority and must be treated as a serious development objective in its own right. To be successful, household food production has to be understood in its full complexity involving production, processing, storage, preparation, and consumption all performed by the same unit. Home garden programmes, therefore, must be carried beyond often spontaneously organized women's clubs and children's groups and given better preparation and longer project duration, addressing individual household units.
- Project objectives must be clear and simple. Specific approaches cannot expect general results while a general approach (food production) may bring about specific results. Thus, the major focus of promotional campaigns should be food production.
- Existing garden infrastructures must be researched. If water, soil, inputs (seed, chemical), time, or space are not available or affordable, "pushing" a garden project makes little sense in the long run. What might be considered by Third World governments is an allotment policy - similar to the European experience which offers garden space and infrastructure on long-term leases at low cost.
- Ecological, economic, and cultural feasibility of cultivars must be considered. Species selection and programme design must take into consideration household needs and objectives. A basic principle for producers, whether small or large, is: if it costs it has to earn. Vegetables that require costly inputs (so-called urban vegetables) may be sold rather than consumed at home, leading to neglect local species, which as a rule have greater overall nutritional value with lower production cost and established processing, storage, and consumption patterns.
- Appeal, extension, and advertising must be priority elements in project design. Home garden promotion should not limit its audience to "the poorest" or temporary disaster situations but should appeal to wider social strata on a permanent basis. Extension efforts must be structured to meet the educational level and interest of population segments addressed.
Though often limited in supplying all household needs, gardening is still vital for the survival of resource-poor households throughout the developing world. As a cost-effective approach for development agencies and clients alike, household food production is one of the best strategies at disposal.

418 89 - 8/16

Homegardens
Asia, Philippines, developing countries, case study, vegetable production, farming systems research, upstream research
CALDWELL, J.S.
Assessing Rainy Season Vegetables Production Alternatives: a Case Study in "Upstream" Farming Systems Research".

Trop. Vegetable Inf. Service, Techn. Bulletin No. 16, AVRDC Publ. No. 86-260, ISBN 92-9058-0024-3, 1986, pp. 30

Within FSR/E, a distinction is made between "upstream" and "downstream" FSR/E. "Upstream" FSR/E refers to crop and/or animal research based on diagnosis of farm conditions, but done on-station. It is designed to generate prototype solutions that can be further adapted to each recommendation domain in the target region where the diagnostic work is done. "Downstream" FSR/E, on the other hand, refers to crop and/or animal research done on-farm. In many cases, diagnosis can lead directly into "downstream" research, if available technology from previous station matches farm family priorities and constraints. Where such station technology is not available, however, "upstream" research may be needed to provide technology alternatives for "downstream" on-farm testing.
For the past 10 years, the Asian Vegetable Research and Development Center (AVRDC) has worked to expand the range of technology alternatives for vegetable crops in Southeast Asia. In a very broad sense, all of AVRDC's work could be called a type of "upstream" research for Southeast Asia as a whole.
AVRDC research is aimed at two different types of clientele. The first type is specialized vegetable producers, usually located either in highland areas or around large urban centers in Southeast Asia. These producers are highly commercialized and can readily utilize new, advanced technology. There is less need to take a system' approach to the introduction of new technology for these specialized producers.
The other type of clientele served by AVRDC are diversified, small-scale producers. These farm families grow vegetables as one component of a complex mix of activities, including staple crops, fruits, animals, fuelwood plots, and non-agricultural activities. Their objectives in growing vegetables include both sale and home consumption.
For these clientele, a systems approach is essential, in order to target opportunities for technology development most likely to be compatible with all the diverse activities and goals that comprise their farming systems.
The study reported here is one part of the AVRDC Development Program effort. It built on the earlier work by Calkins and colleagues in Taiwan, and sought to expand its scope, both in methodology and in target area. The study was conducted with the goal of developing a methodology for integrating surveys of vegetable production, consumption, and marketing with experiments based on AVRDC crop managment research. The target area was two

municipalities in Ilocos Norte, Philippines. The study had begun in 1978 with the stated objective of assessing the potential for increased rainy season vegetable production within the context of the "farmer's system".
The case study is presented with three objectives. First, it documents one way in which AVRDC has sought to develop farming systems methodology for its diversified clientele. Second, it provides an example of the application of some of the tools of farming systems analysis to a vegetable-centered problem. Third, it illustrates the importance of policy and infrastructure support.
The problem was limited availability of vegetables in the rainy season, in an area where vegetables are important in the diet. Survey data and observations were combined with rainfall pattern data and previous crop management research to select four crops for "upstream" production experiments. The four crops were common cabbage, tomato, mungbean, and sweet potato.
The survey techniques used in this study had strengths and weaknesses. Their strengths were in the use of secondary data, both environmental and market. Their weaknesses were over-reliance on formal methods and inadequate use of more open-ended questioning. Open-ended questioning within an interview guide format allows better insight into farm family member perceptions, while retaining a useful degree of structure and comparability.
This study focused on the main farmer of each household. With the exception of a few female-headed households, this meant only the male "farmer". The term used at the conception of this study, "farmer's system", reflected that focus.
The economic analysis of this study is an example of what is now called "ex ante" analysis in FSR/E. That is, the economic analysis is done "ex ante" (meaning "prior to") a program of on-farm trials.

419 89 - 8/17

Homegardens
Asia, Southeast Asia, study, vegetable production, permanent compost beds, soil fertility, sustainability, low-input system
STEARN, W.C. and CHEN, L.C.
Feasibility Studies on the Use of Permanent Composting Beds for Intensive Vegetable Production in Southeast Asian Countries.

In: AVRDC Publ. No. 87-273, ISBN 92-9058-028-3, AVRDC, Shanhua, Tainan, Taiwan, 1988, pp. 40-47

The addition of composted organic matter to the soil has long been recognized as an essential component of any good cropping system to maintain good soil tilth, release plant nutrients over the growing season, maximize yield, retain soil moisture, etc.
Composting is done on a commercial scale in Taiwan for mushroom growing, and to a lesser extent for agricultural use. The more traditional labour intensive methods are being replaced with inorganic chemical fertilizers, pesticides, and herbicides.

Traditional methods, however, are still being practiced on subsistence type farms.
Realizing the importance of maintaining organic matter, especially in the tropics, a composting component was initated in the Garden Program at the Asian Vegetable Research and Development Center (AVRDC) in Tainan, Taiwan.
This component was eventually dropped due to the unfamiliarity with the process of composting as well as the lack of enthusiasm for turning piles in the hot tropical sun.
A modified sheet composting method was designed to eliminate the intensive labour requirement usually associated with more traditional composting methods. The objectives of this project were to determine the feasibility, cost, water requirements and impact of this type of sheet composting within the Home Garden Project objectives.
The compost-growing beds were designed to be constructed once and then maintained with the addition of organic household or agricultural waste materials.
Some of the general concepts employed came from traditional sheet composting methodology, layering composting techniques as well as methods described by Permaculture movement in Tasmania.
Results showed that compost-beds allow tremendous root penetration and proliferation, thus, allowing optimal nutrient feeding. Generally, the composting/planting bed concept, with reduced labour input, potentially reduced watering requirements (due to the high organic matter content), gave good yield, better insect and disease resistance, and the ability to plant high density crops year-round, appears to have potential for tropical areas. The evaluation of this type of growing bed, however, is still in the early stages and overall recommendations cannot be made yet.

420 89 - 8/18

Homegardens
Review, handbook, tropics, vegetable production, homegardens, garden tools, type of garden, cultivation practices, soil fertility, propagation methods, seeds, watering, crops, diseases, pests
AGROMISA
The vegetable garden in the tropics - with special reference to Africa.

Agrodok 9, pp. 54, Agromisa, P.O.B. 41, 6700 AA Wageningen, The Netherlands

Agromisa is a volunteer organization of students and graduates of the Agricultural University Wageningen, the Netherlands.
Agromisa aims at improving the position of socially and economically underprivileged groups in developing countries by transferring agricultural knowledge to those organizations and persons who are working for the benefit of these groups.

Agromisa co-operates with the TOOL Foundation, the Dutch umbrella organization whose participating groups together cover the fields of tropical agriculture, technology and health.

The booklet mentioned above contains the following chapters:
- Why gardening?
- Fruits and vegetables in the diet
- Which type of garden?
- Garden tools
- Preparing the site
- The best site for a garden
- Size and design of the garden
- Clearing the site
- Cultivation of the soil
- Preparing the beds
- Fences
- Soil improvement
- Soil conditioning
- Plant nutrients
- Organic manure
- Chemical fertilizers
- Crop rotation
- Sowing and propagation by cuttings
- Seeds
- Sowing in situ
- Sowing in a nursery
- Transplanting
- Taking cuttings
- From sowing to harvest: techniques of cultivation
- Watering
- Control of diseases, insects and other pests
- Other techniques of cultivation
- Choosing the right crops
- Bibliography

This booklet does not pretend to be an original work. It is an anthology of the literature mentioned in the bibliography. Especially "Le jardin en zone tropicale" is quoted frequently.
The main objective of this Agrodok is to serve as a general manual for those who practise or teach gardening in developing countries.

421 89 - 8/19

Homegardens
Asia, Philippines, China, developing countries, food production, sustainability, small-scale households, low-input system, recycling, space-intensive, labour-intensive, water conservation, appropriate technology, nutrition, pest control, genetic resources, ecology
GONSALVES, J.F.
Characteristics of the Bio-intensive Approach to Small-scale Household Food Production.

AVRDC Publ. No. 87-273, Proc. of the Vegetable Improvement Gardening Workshop; AVRDC, Shanhua, Tainan, Taiwan, ISBN 92-9058-028-3, 1988, pp. 93-99

The bio-intensive approach, as the name suggests, is a biological (as opposed to chemical) form of agriculture in which a small area of land is intensively cultivated with the use of nature's own ingredients to rebuild and then maintain the soil's productivity. At the heart of the approach is the effort to improve the soils capability to nurture and sustain plant life. What a bio-intensive gardener tries to do on his small plot is to stimulate or replicate a natural forest (with the constant recycling of nutrients and maintenance of soil, moisture, and microbial conditions). Many countries of the world (and China is particularly notable) have farmed biologically for thousands of years and have been able to sustain output levels over those years. In sharp contrast the "efficient" but short-sighted approaches being used in many Western and Third World countries have often been disruptive of the natural resource base.
Farmers in many parts of the world are experiencing the fact that they have to use steadily increasing quantities of fertilizers and pesticides to sustain previous yield levels.
In the bio-intensive approach being recommended here for small-scale plots, the soil is gradually enhanced and the composition of beneficial microbial life actually improves from season to season. The soil structure and humus content is also supported. The nutrient content of the soil is built up, rather than depleted, after each crop. A healthy soil means a healthy stand of plants, and that means less insects and diseases. In the bio-intensive approach, yields continue to rise for the first few years and then tend to stabilize at an overall higher yield. Such systems and the outputs (i.e. yields) are easily sustained at that level for many years with unchanging or even reduced levels of material and labour inputs.
The bio-intensive system is characterized by a greatly reduced dependence on expensive inputs that are generally used in conventional food production approaches. Many of these nonrenewable inputs, such as chemical fertilizers and pesticides, are produced at high energy costs (usually petroleum-based). Instead of chemicals, plant and animal wastes and natural mineral substitutes are used. In the methods being advocated here, the

inputs required are bones, wood ash, eggshells, compost, ipil-ipil leaf meal or fish meal.
Locally available seeds are advocated rather than hybrid and other imported substitutes. Experience suggests that it is feasible to achieve a 100% self-reliance in recurring input needs. Other than hand tools, all material inputs are usually available locally or within easy access. This reduces significantly or eliminates the need for cash outlays. It also provides the producers with a sense of control over the required production resources. Finally, by emphasizing the use of local and biological resources, rather than energy-intensive, fossil-fuel-based chemical imports, a small step is being made in the direction of conserving the world's nonrenewable resources.
The bio-intensive approach to food production at the household level differs considerably from the conventionally introduced gardening systems because of its stress on deep-bed preparation, nutrient recycling, building up of the soil's biological base, diversified cropping, and a balanced and integrated ecosystem.

422 89 - 8/20

Homegardens
Review, handbook, tropics, vegetable gardening, tools, equipment, planning, cultural practices, crops
AGUSIOBO, O.N.
Vegetable gardening.

Macmillan Publ. Ltd., London, UK, ISBN 0-333-34472-3, 1984, pp. 57

In human nutrition, vegetables are an essential protective food containing vitamins and minerals. Any balanced diet should include vegetables and fruits for this reason. The proportion of vegetables required in a balanced diet per capita per meal is of the order of 45% of the total volume of the food.
In addition to growing vegetables in gardens, it is possible to produce some in boxes, or in large pots. In some parts of the world vegetables are grown in water, without soil. This method of growing plants is called hydroponics. It requires special equipment.
This book seeks to introduce all those interested to the improved production of vegetables. This will provide greater profits for the farmer, and better produce for the domestic vegetable grower.
The author bases his writing on his considerable experience in instructing students in vegetable garden practices, and on the results of successful experiments conducted on growing vegetables in the tropics.
Simple tools for use in vegetable production are discussed, as are methods of land preparation, seed-bed preparation, storage and the cultivation of specific vegetables.
"Vegetable Gardening" is one of a series of inexpensive books which have been designed to treat a variety of individual agricultural topics in greater depth than could be expected in a general textbook. They are particularly of interest to students

and teachers in Schools of Agriculture and to students in their preliminary year at University.

423 89 - 8/21

Homegardens
Asia, Indonesia, review, historical view, homegardens, traditional system, agroforestry, soil erosion, structure, composition
SOEMARWOTO, O.
Homegardens: a traditional agroforestry system with a promising future.

In: Agroforestry - a decade of development, Eds. H.A. Steppler and P.K.R. Nair, 1988, pp. 157-169

Homegardens may have originated in prehistoric times when hunters and gatherers deliberately or accidentally dispersed seeds of highly valued fruit trees in the vicinity or their camp sites.
These ancient gardens may have originated as early as the seventh millenium BC. They were attached to temples, palaces, elite residences and the homes of the common people. The homegarden was mentioned in an old Javanese charter of AD 860.
From this very brief historical sketch there is evidence that homegardening is a very old tradition which may have evolved over a long time from the practices of the hunters/gatherers and continued in the ancient civilizations up to modern times.
This paper is not intended to present a literature review of homegardens, but rather to discuss their features, based on the author's experience in Indonesia, as related to their potential and opportunities for future development, and the associated constraints and pitfalls.
The term agroforestry denotes land-use systems consisting of a mixture of perennials and annuals, and often also animals. A major concern in agroforestry research is sustainability. It is determined by the structure of the system, its ecological functions and its continued ability to fulfil the socio-economic needs of the people. Thus, as is implied by the term, homegardens as an agroforestry system should ideally combine the ecological functions of forests with those of providing the socio-economic needs of the people. The ecological functions of forests include hydrologic benefits, microclimatic modification and soil erosion control, and genetic-resource conservation.
A prominent structural characteristic of the homegarden is the great diversity of species with many life forms varying from those creeping on the ground, such as the sweet potato, to tall trees of ten metres and more, e.g. the coconut palm, and vines climbing on bamboo poles and trees. These create the forest-like multistorey canopy structure of many homegardens.
The socio-cultural functions of homegardens have not received much attention so far. In many areas products for religious rituals and ceremonies are very important, e.g., in Bali and Thailand.
Studies in villages in West Java have shown that homegardens are an important social-status symbol. People who do not have a

homegarden and hence, have to build their house on someone else's homegarden, are considered of low status. In traditional Indonesian villages, people can freely enter homegardens, e.g., to get water from a well, or just to pass through them. Although there may be fences around them, they are seldom completely closed nor are there locked gates. The concept of trespassing does not exist. Those who close off their gardens completely are considered conceited. Fruits and other products are traditionally shared with relatives and neighbours, and products for religious or traditional ceremonies and medicine are given away freely when requested. However, this equitable social situation is now gradually changing.

Animals in homegardens are important elements in the cycling of matter. In West Javanese villages, plants, goats, sheep, horses, chicken and fish, and also man, are components of the recycling of wastes. In non-Muslim regions the pig plays the role of fish. Thus man is an integral part of the trophic system from which he obtains nutrients and income. Naturally, there is a health hazard attached to this recycling system. Therefore, although the recycling of wastes does present an excellent opportunity for the efficient use of resources and helps in the maintenance of soil fertility, it should not be accepted uncritically.

Since homegardens are a part of the total agro-ecosystem and linkages exist between them and the other parts of the system, i.e., the rice and the dry fields, their development cannot be considered in isolation.

In conclusion one can say that homegardens do have a promising future. However, while it is relatively easy to increase yields and income, there are difficult problems in achieving long-term sustainability. These difficulties are both in the biophysical and in the socio-economic realm. It is recommended to look into these problems and stimulate research to seek appropriate solutions.

424 89 - 8/22

Homegardens
Developing countries, LDC's, homegardens, activities, constraints, funding strategies, research, extension, AVRDC
GERSHON, J.
Funding of Gardening Activities in LDC's: Thoughts and Suggestions.

AVRDC Publ. No. 87-273, ISBN 92-9058-028-3, Shanhua, Tainan, Taiwan, 1988, pp. 111-116

Gardening is often one of the activities of development projects in less developed countries (LDC's) generally started by national programs in response to national needs. Support for such projects often initially comes from the national programs. Once this commitment is made and a particular development project shows feasibility, additional support is often obtained from donor agencies under their international development founds.

Gardening as a project component has not yet attracted additional funds from donor agencies. This is partly due to lack of proper technology development and testing, poor transfer of the technologies to recipients, and inadequate assessment of the impact of gardening. In the past three years, AVRDC has addressed itself to these constraints, producing good gardening technologies, designing ways of transferring the technologies to LDCs, and developing methodologies for assessing impact. The AVRDC-type gardens established in Thailand, show good promise. Published reports on these garden activities may assist Thailand in obtaining future support. It is now time to look into that possibility, not only for Thailand, but for all LDC's.

This paper examines some of the problems and prospects of gardening activities in LDCs and offer some suggestions. It attempts to address itself to one general question: can technical collaboration with AVRDC help national programs attract additional donor-agency support for development projects containing gardening components?

In order to obtain funding for garden-related activities in less developed countries (LDC's), these activities should be promoted within the context of projects that are of interest to donor agencies. It might best attract funds if the activity is part of an international development project.

A number of constraints have contributed to this problem in funding. Among them are the lack of information, planting materials, research, training for extension workers, evaluation, impact. etc.

One funding strategy is to utilize existing AVRDC outreach programs which are linked to national programs. A second possibility is to link AVRDC garden programs directly to an in-country institution. The third is to seek funds for gardening technology development and transfer to specific projects, such as the northeast rainfed project in Thailand, transmigration project in Indonesia, homestead food production projects in Bangladesh, and cropping systems projects in the Philippines.

A collaborative effort with AVRDC might assist national programs in achieving funding goals.

425 89 - 8/23

Homegardens
Africa, Nigeria, leaf vegetables, homegardens, backyard crops, nutritional value, potential, crop management, preservation, cultural practices
LUCAS, E.O.
The Potential of Leaf Vegetables in Nigeria.

Outlook on Agriculture, 17, 4, 1988, pp. 163-168

The term vegetable is frequently used to refer to soft leafy plants whose leaves or shoots may be eaten raw as salads or cooked in stews. In preparing them as food they may require considerable seasoning and salting. In Nigeria's farming systems, as well as in

other farming systems in West Africa, leaf vegetables are usually regarded as "backyard crops" which are given little or no cultural attention. In the few areas where there is sustained production, the production of leaf vegetables is through peasant agriculture in which a relatively small area of land is cultivated and the vegetables are usually intercropped with one or two staple food crops, such as cereals and root crops. In drier parts of the country, leaf vegetable production is restricted to those types that are hardy, drought-resistant, and of easy cultivation.
The country abounds with a large number of plant species which are used by the people as leaf vegetables. Very few of them have been brought into proper cultivation and the majority are still in the wild, used only by the people who know and can recognize their value. This article aims at highlighting the potentials of the very few of these vegetables that have come under some measure of research studies in Nigeria.

426 89 - 8/24

Homegardens
Asia, Southeast Asia, review, survey, AVRDC, vegetable research, training, funds, time allocation, literature, research facilities
TSOU, S.C.S. and J.T.S. TSAY
Vegetable Research in Southeast Asia - An Overview.

AVRDC Publ. No. 88-303, ISBN 92-9058-034-8, Shanhua, Tainan, Taiwan, 1988, pp. 119-132

Vegetables are the major source of vitamins and minerals in the Asian diet. In 1983 the per caput supply of vegetables varied from 35 to 123 g per day in this region. There are between 60 and 100 crops consumed as vegetables in various diets, and vegetables also serve as important cash for Asian farmers. Although vegetables are receiving increasing attention from the national governments and scientific communities, information on the research environment, support, major interests, and constraints is still lacking.
In order to augment the country reports presented in this Workshop, a survey of Vegetable Research Scientists in Southeast Asia was conducted.
The specific interests of individual scientists are investigated in the survey. The main constraints or problems of selected crops are listed. The problems reported can be classified into 10 groups. Diseases receive the most concern of all problems in all the countries; this was expected to be one of the most important constraints limiting vegetable production in humid tropical Asia. Various approaches are undertaken to resolve these constraints. The types of approaches used are listed. Breeding is the most popular approach to relieve various constraints.
This survey revealed that there are active research programs on 55 vegetables at various institutes in this region. A literature survey also shows that at least 63 vegetables have been studied by the scientific community since 1975. However, the survey result also indicates that most of the research resources are

concentrated on a few vegetables. More than 76% of the publications are on 10 vegetables and 93% of the available publications are for the top 20 vegetables.
The survey on vegetable research scientists indicated that 132 respondents are working on the 10 most popular crops, namely tomato, peppers, common cabbage, mungbean, soybean, potato, sweet potato, legumes, common bean and eggplant. Among the ten crops, the first five crops have breeding programs for various objectives in all four countries. Cassava, soybean, mungbean, corn, potato, sweet potato and legumes are vegetables which are recognized as a calorie and protein source. The important vegetables for vitamins and minerals are tomato, common cabbage, onion, common bean, eggplant, pepper and garlic. Among them there is only one leafy vegetable, common cabbage, which is not a really nutritious dark green vegetable. This clearly suggests that the leafy vegetables, especially the tropical vegetables, are neglected by the scientific community in this region.
In order to use the limited resources effectively, two types of research networks seem to be needed; one concentrates on the major vegetables such as breeding efforts on tomato, peppers, cabbage, etc. to improve the research efficiency of ongoing research programs. The resources saved from improvement of efficiency should be shifted to vegetable crops which are important, yet have been neglected in the past. A collaborative test network to determine performances of those vegetables under various tropical environments could be an effective way to distribute accumulated experiences from each country to other corners of the region.

427 89 - 8/25

Homegardens
Developing countries, urban families, urban garden, pot garden, nutrition, children
AVRDC
Urban garden and 45-pot garden.

AVRDC Progress Report 88-305, Shanhua, Tainan, Taiwan, ISSN 0258-3089, 1988, pp. 349-353

Urban migration to large cities in developing countries has resulted in shifts of population and has created large urban areas. The people live in somewhat cramped quarters with little in the way of land to grow even a small 4 x 4 m^2 home garden. Growing vegetables in boxes or pots could be a way for these people to provide their small children with needed micronutrients on a daily basis.
The project aims to determine daily yields of box and pot gardens, and to measure the percentage for selected nutrients that the gardens can provide for preschool children.
A small selection of crops was planted in two city gardens - an urban garden and a 45-pot garden. The urban garden crops were planted in eight wooden boxes, 115 cm x 35 cm high. The total planting area of the eight boxes is 3.2 m^2. Boxes were stacked in

stepwise fashion on a metal frame to receive equal and maximum sunlight and still utilize a small area of land. Each box was harvested 1 to 9 times and then replanted with another crop when the box was completely harvested.
The 45-pot garden is designed for city areas where there are a number of small sunny places around a house or apartment but no single area in which to plant the urban-type garden. Rooftops, window ledges, edges of walkways or stairways, or outside walls can all be used for pot gardening. Forty-five pots were chosen because that is the minimum number of pots to use to ensure a harvest each day if one desires a reasonable variety of crops. The pot size is 12 cm x 12 cm x 20 cm high. As each pot was harvested, it was replanted with a different nutritious vegetable.
The same agricultural procedures were practiced in the boxes and pots as in the larger home garden, such as the use of compost for fertilizer, hand-weeding, hand insect removal, the use of rice straw as mulch, and the use of mosquito-net screening over boxes during the early stages of growth. The yield of the city gardens was not expected to be high enough to contribute significantly to a family of five persons. But these gardens could make a contribution to the RDA of the two preschool children (between ages 1 and 6) in the family of five. The city gardens were evaluated as such. The number of times harvested was also recorded for each seasonal period.
The yields and nutritional output of the crops grown throughout the year in the urban home gardens are summarized. This garden produced an average of 0.3 kg/day of nutritious vegetables with something to harvest 273 times during the year. The nutritional contribution for the two preschool children is good for protein and calcium, and more than adequate for iron and vitamins A and C.
Average daily yields were 0.2 kg/day with something to harvest 342 time during the year. Nutritional output was excellent for vitamins A and C and good for iron.
Both of the city gardens show that something nutritious can be harvested throughout the year. The gardens can also make significant contributions to the nutrition of two preschool children in terms of vitamins A and C.

428 89 -8/26

Homegardens
Europe, France, experiment, urban compost, vegetable production
CTIFL
L'Emploi de Composts Urbains et de Composts de Boues de Station d'Epuration en Cultures Legumières. (Utilization of Urban Composts and Mud Composts from Purification Stations for Vegetable Crops.).

C.T.I.F.L. Lahier No. 18, 1985, pp. 67; available at CITFL, 22 Rue de Bergère, F-75009, Paris, France

This publication describes an experiment on the effect of its differents composts on yield and quality of vegetables cultivated under controlled conditions and in the field. No significant

results came out concerning specific accumulation of trace elements or of heavy metals in the soil.
The examination of the composts themselves has given on the whole equivalent results, casually varying according to the crops. Only cattle dung was found to be slightly superior at equal proportion.
This document gives numerous technical data and will be of interest to those utilizing or intending to utilize urban composts.
Abstract from Alternatives actualité

IX SEED PRODUCTION

429 89 - 9/8

Review, cassava, seed multiplication
CIAT
Promisoria la uca sembrada por semilla (Seed-grown cassava shows promise).

CIAT Report 1987, pp. 31-33

Throughout history cassava has been vegetatively propagated that is, farmers have grown new plants from stakes or cuttings that are planted into the ground and left to root. CIAT cassava scientists believe there are advantages in growing the crop from seeds and that commercial production from seed may be a promising alternative for the future.
Producing cassava from seed offers several advantages over the vegetative method of growing the crop. For example, in vegetatively propagated plants viruses build up over generations and can cause major yield losses. Since cassava seed are not known to transfer viruses this problem is averted.
Storing stakes for the next crop also produces problems. Most farmers have to store planting material for the next crop over time, that is, from a few weeks to several months. Loss of nutrients during storage reduce germination and planting vigor, resulting in lower yields. This does not happen with cassava seed which can be stored for a year or more without such losses.
The dependence on the availability of enough stakes to increase the area sown to cassava or to introduce a new variety is another constraint on production. This could be avoided if seeds were used because their multiplication rate is higher than that of stakes. It is estimated that there could be at least a 1:100 multiplication rate for seed compared to about 1:10 for vegetative propagation.
Seed are less costly to transport than stakes and they make management of the planting process easier.
However, commercial production from seed cannot begin immediately because both knowledge and technology need refining. There are problems in the areas of genetics and management. There is optimism that many of the genetic problems can be eventually solved. The management-related problems are, on the whole, similar to those of other seed crops.
The biggest question relates to the potential productivity of seed-derived plants. Stakes produces plants with higher initial vigor because of the larger carbohydrate reserves they contain. Research at CIAT has shown that the production of seed-derived plants can equal that of stake-derived plants under favourable conditions. A recent study shows that there is potential for achieving even higher yields with seed by using higher plant densities.

It is expected that in the future, farmers can look forward to using a combination of vegetative and seed propagation to obtain the best advantages of both methods.

430 89 - 9/9

Seed production
Developing countries, climates, Vietnam, Peru, Burundi, Philippines, daylenghts, seed technology, true potato seed, clones, tubers, cuttings, seedlings
CIP
Seed technology.

CIP Annual Report, Lima, Peru, 1988, pp. 24-26

The major focus of the true potato seed (TPS) breeding work was on testing advanced progeny selections for tuber yields under a wide variety of locations with different climates and daylenghts. Clones AVRDC-1287.19;377964.5 and LT-8 were good combiners for wide adaptation in TPS crosses and most crosses had a high degree of adaptation to short-day conditions. Twenty six crosses were found to have an acceptable tolerance to early blight and late blight diseases during seedling screening.
An index criteria for acceptable TPS vigor was developed, using both the coefficient of velocity of emergence calculated from daily counts after sowing and seedling dry weight. Data showed that seedling vigor evaluations among different TPS crosses must be conducted using nondormant seed. Although the standard treatment with gibberellic acid (GA) was shown to promote final emergence in dormant TPS, seedling vigor was impaired by GA. Priming TPS in solutions of low-water potential was found to be the most effective presowing treatment for optimizing seed vigor in nondormant TPS.
In two crosses, the optimal stage of TPS maturity at harvest was 10 to 12 weeks post pollination. Nevertheless, the maturity of berries from the cross, Atlantic x LT-7, could not be extended beyond nine weeks. Seedling vigor in this cross was superior to the other crosses tested. The importance of proper storage conditions for preserving vigor prior to testing was clearly demonstrated in all seed tests. Eight open-pollinated progenies were identified with acceptable performance in a large scale screening test for germination at high temperatures. Pollen selection and seed size separation techniques were found promising in certain crosses for the enhancement of progeny uniformity characteristics.
Continuing international TPS trials have resulted in the identification of several new progenies for use by national programs. Three TPS progenitors C83.199, 377964.5, and Maine 28- were introduced into the seed program for clean up. Following several testing cycles, two new potato progenitors, 377250.7 and C83.551, are now ready for clean up. All of these progenitors transmit yield, earliness, and tuber uniformity. Ten TPS progenies that maintain a stable yield from the F_1 generation through four

generations of successive open-pollination have been identified. This will facilitate the use of TPS by farmers, since they will be able to produce needed TPS from open pollinated berries produced in their own fields.
The superiority of raised bed systems for seedling transplanting was confirmed this year with respect to yield advantages. The application of a layer of gypsum to the soil surface during seedling tuber production in beds increased tuber yields and acted as an effective tuber moth control system.
The most important pathogens causing damping off in seedlings are in the AG-3 group or race of R. solani. These organisms were shown to be present only in cool areas while the more pathogenec AG-4 group was found in the warmer areas.
Potato flowering was increased with a four-hour night interruption of the night period under short-day environments. Factors involved in reducing TPS yields generally included increasing stem densities and berry loads per plant, as well as producing the berries at the end of the flowering period (in lower order inflorescences). The collaborative project between INIA in Chile and CIP on commercial scale TPS production determined that the average costs of non-emasculated TPS were US$ 246 per kilogram, ranging from $ 128 to $ 307 depending on the cross. Pollination tasks - especially labour and technical management costs - were the most expensive inputs in TPS production. The collaboration between CIP and INIA will continue for a fourth season, but a foreign commercial seed company is interested in contracting large-scale TPS production by farmers. This will probably start in 1988-89 with several hectares of production.
It was shown that warm climate-produced seeds (tubers, cuttings, and TPS seedlings) are likely to yield lower than those produced in cooler areas. The production efficiency of cuttings was lower than that of seed tubers, but the larger size of tubers produced from cuttings still makes this alternative suitable for direct production of consumer potatoes.
A case study conducted in the Philippines showed that institutional and nontechnical factors are closely associated with the level of success of a seed potato program. In Burundi, the basic seed production programm has redesigned the strategy to eliminate latent bacterial wilt disease. This new system is based on in-vitro micropropagation methods with subsequent transplanting of plantlets to large plastic bags for production of small tubers. The use of sprout cuttings for planting materials is now well advanced in Vietnam.

431 89 - 9/10

Seed production
world, review, germplasm conservation, crops, livestock, genetic erosion, management, germplasm system, genetic resources collections, economics, sustainability
PINO, J.A. and M.S. STRAUSS
The Preservation of Germplasm.

In: Proc. of the Seventh Agric. Sector Symposium: Sustainability Issues in Agricultural Development, The World Bank, Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 252-269

Some people consider germplasm to be the world's most valuable natural resource, yet its great value remains largely unrecognized.
In its simplest sense, agricultural germplasm is nothing more than the plants or animals from which modern agriculture has derived present-day varieties and breeds. Germplasm, although applied to whole organisms or their parts (e.g., seeds, tubers, pollen, semen), also refers to their genetic composition. In essence, the term germplasm refers to the genetic variability within a population.
Natural habitats for many wild species are disappearing and indigenous agricultural systems are giving way to the practices and varieties of modern agriculture. The preservation of wild species and landraces in their environments (in situ) is becoming increasingly difficult. Most nations have not taken this matter seriously and there has been a lack of creative thinking about how traditional agroecosystems and natural environments of wild crop relatives could be preserved.
Germplasm used in crop and livestock development has been most frequently and efficiently maintained in ex-situ collections - collections of plants or animals stored outside of their natural habitat. Preservation of genetic resources as seed or live vegetative materials originated with the collections maintained by plant breeders, botanists, or botanical garden curators.
Collection and maintenance of germplasm today includes in-situ conservation of natural habitats or planted pure stands in the place of origin; and ex-situ conservation by cold storage, tissue culture, or field collections of plants. In the future it may be possible to maintain germplasm as DNA-libraries from which plants or animals could be reconstructed or specific traits selected.
Increased interest in the managment of genetic resources is based on several general concerns. First, there is a growing awareness worldwide that species of plants and animals are being lost both due to and in spite of development efforts. Second, the emergence of biotechnology and its potentials for crop and livestock development have left many nations, particularly those in the developing world, with concerns about their future ability to compete scientifically on a global scale. Third, a political has arisen over proprietary rights to germplasm and the crop varieties derived from it. Along with these specific concerns has been a frequently stated unsureness about how well present systems for

collection, maintenance, and management of crop and livestock germplasm are functioning.
Since the beginning of scientific plant breeding there has been a decline in both the number of crop species and the genetic variation within species. The range of genetic diversity of the world's major crops may well be declining rapidly. The drive to develop high-yielding, uniform crops has significantly increased production, but at the expense of sharply reducing the genetic base (particularly in terms of loss of landraces) on which these crops are founded. As use of these improved varieties has spread, they have accelerated the loss of the genetically diverse traditional landraces through displacement. The result is increased risk of vulnerability to disease and pest losses due to increased genetic uniformity and the loss of the broad genetic base (variation) necessary for continued crop improvement.
One rational argument for preserving genetic diversity is that it is insurance against future agricultural catastrophe, investment for future needs, and a matter of moral principle. Plant breeders have drawn extensively on the genetic diversity of crop germplasm to achieve the tremendous gains seen in the past two decades. Future gains, however, will require the continued availability of such materials and the expansion of existing collections.
The major needs and issues associated with the collection, maintenance, evaluation, and use of crop and livestock germplasm are divided in this paper into four general categories: Scientific or technical, management, regulatory, and resources.
In conclusion the collection and maintenance of genetic resources in all nations has progressed considerably in the past decade. The advances in developing nations have largely been due to the efforts of international agencies and technical assistance from researchers, institutions, and foundations in the developed world. Although significant international collections exist for the crops of major importance to global agriculture, considerable work remains to be done in establishing national and regional programs for many minor but important food crops, livestock, forages, and forest species as well as those of purely esthetic value. Perhaps most important is the need for many of these nations to develop a germplasm maintenance and plant breeding infrastructure that will lay a foundation for their own food security. The primary constraints to this development are human and financial resources.

432 89 - 9/11

Seed production
Review, study guide, audiotutorial unit, handbook, CIAT, developing countries, tropics, subtropics, bean seed, management, ecology, production, harvest, standards, activities, evaluation
DOUGLAS, J. et al.
Good Quality Bean Seed.

Study Guide, CIAT, Apartado Aéreo 6713, Cali, Colombia; Series 04EB-12.03,1981, 36 pp.

An effective seed program comprises many and diverse elements and activities which must be coordinated to attain the principal objective: produce and distribute good quality seed of improved varieties. Therefore, the success of a seed program is founded on producing and providing a sufficient quantity of good quality seed, at the required time, at a reasonable cost, and at a location where it is needed, so that the majority of the farmers can enjoy the benefits provided by using this seed.
This study guide is complementary material to the audiotutorial unit "Good-Quality Bean Seed". Its principal objective is to provide useful information relating to the practices of production, quality control and processing of bean seed.
The audiotutorial unit is a translation of the Spanish unit entitled "Semilla de Fríjol de Buena Calidad" which was produced by CIAT through a special project on the development and utilization of training materials on improved agricultural production technology.
The handbook contains the following chapters:
- Objectives
- Introduction
- What is Good Quality Seed?
  . Varietal purity
  . Physical purity
  . Good germination
  . Freedom from seed-borne diseases
- Why is Good Quality Bean Seed important?
- What is Needed to produce Good Quality Bean Seed?
  . Varietal pure seed
  . Freedom from seed-borne diseases
  . A site that provides an unsuitable environment for development of pathogenic organisms
  . A suitable field
  . Special management of the crop
  . Removal of foreign, off-type and diseased plants
  . Harvest of the seed
- Steps to follow after harvesting Good Quality Seed
  . Drying
  . Cleaning
  . Treatment
  . Sampling
  . Evaluation
  . Storage
  . Transport
- Activities of Different Groups in Obtaining Good Quality Seed
  . Seed certification authorities
  . Research programs
  . Seed growers, seed enterprises and marketing groups
- EVALUATION
- BIBLIOGRAPHIE

This handbook together with the audiotutorial unit provides useful information for the practice of quality bean production.

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432 89 - 9/11

Seed production
Review, study guide, audiotutorial unit, handbook, CIAT, developing countries, tropics, subtropics, bean seed, management, ecology, production, harvest, standards, activities, evaluation
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This handbook together with the audiotutorial unit provides useful information for the practice of quality bean production.

433 89 - 9/12

Seed production
Developing countries, review, seed supply, food crops, traditional systems
LINNEMANN, A.R. and G.H. DE BRUYN
Traditional seed supply for food crops.

ILEIA, 3, No. 2, 1987, pp. 10-11

In this paper some aspects of traditional seed supply systems are discussed.
Seed supply systems in developing countries can be subdivided into traditional and modern systems. In traditional systems it is common practice that the farmer produces his own seed, or gets some or all of it from other farmers, locally or in the region. In modern systems a part or all of the seed is bought from seed producers. These systems are characterized by a high degree of specialization. Seeds are produced for the market and often there is an ample use of hired labour and inputs such as fertilizers and pesticides. Combinations of both systems exist as well; some farmers use traditional and modern systems on their farm, either or not for different crops.
At least 80 percent of the planted seed of the main crops is produced by the farmers themselves.
Thus, the contribution of the modern sector to the seed supply of food crops in most developing countries is restricted to 20 percent at the most.
Small farmers need varieties with a good yield which is reliable and stable through the years, also when the environmental conditions are adverse. For this purpose, they often use a mixture of varieties. These varieties must by compatible with their farming systems.
This could mean that a variety must be adapted to intercropping and staggered harvesting for instance, and that it should fit into the labour pattern. Subsistence farmers also attach much importance to a specific taste and culinary quality, while byproducts that can be used as forage, building material, etc., are appreciated too. As a result, seeds of their own varieties that are carefully selected by the farmers themselves during generations for the properties mentioned above and also for characteristics such as healthiness, shape, size and appearance are more likely to suit their individual wishes than seed of modern varieties, which is produced for a large group of customers.
The way in which farmers produce and select their seed varies enormously. Most farmers take a part of their grain of bean crop after the harvest as seed, while others make their choice in the field. Farmers who select after harvesting may just put aside part of their harvest, but they can also make a careful selection for a particular seed appearance. Also in selection before harvest several methods are applied. In a few cases, farmers walk through their fields and mark the plants they will use for next year's crop, while other farmers grow the plants that will give the seed

for the next season on a separate plot at some distance of the main crop. They pay extra attention to this plot by applying manure or fertilizer, discarding off-types and keeping it free of weeds, pests and diseases. Careful visual selection gives farmers the opportunity to compose a seed mixture that will satisfy their needs. Thus, they strive for a uniform crop, but they can also choose to maintain a certain variation in earliness, shape, colour and taste of the product. In many cases farmers have successfully developed their own methods to produce and select their seeds.
Farmers may have different reasons for buying seed instead of using a part of their own production. These reasons are often associated with necessity and/or economic aspects. Necessity to buy seeds arises when erratic rains repeatedly lead to failures of a crop. In general, farmers save enough seed to resow at least twice. However, in drought-prone areas farmers run out of seeds and come to depend on seed from other sources. It is also necessary to buy seeds of those crops for which farmers can not adequately store the seeds. For instance, in areas with merely one short growing season each year, farmers are forced to get fresh seed from elsewhere.
Economic considerations play a major role in the decision by farmers to buy seeds or to use their own produce. As a rule, farmers invest more in their cash crops than in their food crops. In cash crops a somewhat higher yield is directly reflected in higher monetary returns. Moreover, specific taste preference are of less importance than in a food crop. Finally, the most obvious motive for farmers to purchase seed is of course the conviction that this material satisfies their demands better than their own produced seed, but often farmers are not convinced of this. They prefer their own seed for its adaptation of their farming system.
Although a slow change from traditional seed production to modern seed production may be foreseen, the extent of the area which is planted with farmer-produced seeds and the diversity in the wishes and needs of the majority of the farmers with regard to the characteristics of their crops, call for a strengthening of farmerbased seed supply at community level, rather than just a focus on the modern, commercial sector. Results can be expected from even minor improvements in traditional seed production practices such as selection in the field and better drying, protection and storage. It seems worthwhile to stimulate experienced farmers to specialize in seed production for their region.

434 89 - 9/13

Seed production
Africa, tropics, developing countries, review IITA, seed production, sweet potato, yam, cocoyam
ALVAREZ, M.N. and S.K. HAHN
Seed Production in Sweet Potato, Yam, and Cocoyam at IITA.
In: Proc. of a Global Workshop on Root and Tuber Crops Propagation, CIAT, Cali, Colombia, ISBN 84-89206-53-8, 1986 pp. 219-224

This paper describes the process of seed production for sweet potato, yam, and cocoyam (cassava is excluded) as practiced at IITA in Abadan. In contrast with sweet potato, it is only recently that yam and cocoyam seed production has been intensified and problems are yet to be adequately researched.
The Root and Tuber Improvement Program at IITA has as its main objectives: (1) to improve yield and quality characteristics of cassava, yams, sweet potatos, and cocoyams, including disease resistance and storage ability; and (2) to provide seeds from various regions to national programs for selection.
In conclusion, it is clear that there has been progress in seed production of these crops due to the efforts of the many scientists and breeders who have worked on them. However, there is continued need for superior cultivars with disease resistance. Because of the narrow germplasm base in some of these crops, new plant explorations to collect species are needed.
IITA's strategy in fulfilling its responsibility for crop improvement is to generate improved genotypes and introduce them to national programs, predominantly as true seeds, but also in tissue culture form. The systems described and employed at IITA have given satisfactory results for seed production in all these root crops except *D. alata*. Ways of stabilizing seed production in yams will receive special attention in the future along with efforts that are, at present, underway to investigate methods of improving seed production and quality generally.

Seed production
Review, tropics, CIAT, developing countries, cassava, propagation, rapid multiplication techniques, multiple shoot system
COCK, J.H.
Rapid propagation techniques for cassava.
In: Proc. of a Workshop on Root and Tuber Crops Propagation, CIAT, Cali, Colombia, ISBN 84-89206-53-8, 1986, pp. 109-116

The inherently slow propagation rate of cassava delays the testing of new varieties and their subsequent release to farmers. Over the years a number of more rapid techniques for propagation have been developed.
CIAT has refined these methods and developed two basic rapid propagation techniques. The first of these, multiple shoot production from two-node cuttings, is moderately rapid and can be carried out with a minimum of infrastructure. The second technique, using the axillary buds of green stems, is considerably faster but requires better infrastructure and more skillful handling of the plant material. Nevertheless, both systems are simple and require no highly sophisticated equipment for their operation. The two systems are described in detail.

The two methods described greatly increase propagation rates. Starting from a mature mother plant, it is possible to produce

12,000-24,000 commercial stakes in one year with the multiple shoot method, as compared to 100-400 using traditional methods. The axillary bud method is even more rapid, producing 100,000-300,000 commercial cuttings from a 3-4 month old mother plant.
The systems described here have been used successfully under the conditions of CIAT-Palmira. Modifications may be necessary under different conditions. For example, when average temperatures are less than 20°C, rooting will be much delayed, and when average temperatures are above about 25°C, it may be necessary to shade the propagation and rooting chambers.

X PLANT PROTECTION

436 89 - 10/23

Plant protection
Africa, Sub-Sahara, IITA, review, biological control, cassava pests
IITA
Working with Nature: Progress in Biological Control of Cassava Pests in Sub-Saharan Africa.

IITA Annual Report and Research Highlights 1987/88, Ibadan, Nigeria, ISSN 03311-4340, 1988, pp. 30-38

Not only does cassava mealybug (*Phenacoccus manihoti*) cause substantial yield losses of a basic food for millions of Africans but another pest - cassava green mite (*Mononychellus tanajoa*) - adds its big share to the damage. Together they can cause yield losses as high as 80%, with an average 30% considered a conservative figure.
Any sizable loss can be catastrophic because cassava (*Manihot esculenta*) grown on an estimated 10 million ha, is a staple food for approximately 200 million people in sub-Saharan Africa. It is a prime source of carbohydrates from the underground roots and proteins and vitamins from the leaves. Of all the food crops in tropical Africa, cassava - a drought tolerant crop - is the greatest source of food energy.
A two-pronged attack, which has become the world's largest biological pest control program, was launched against the two cassava pests by IITA with help of many collaborators and donors in Africa and in other parts of the world.
The size of the threat demanded a rapid solution over an area larger than the United States. The biological control option using natural enemies for control of the two pests was chosen as the fastest, safest, and most appropriate method and a special Africa-wide Biological Control Program (ABCP) was established.
Analyses from several sources illustrate the advantages of working with nature. Checks and balances have evolved in natural systems that keep the proportions of species within narrow ranges during any given period.
Although the cassava mealybug (CM) and the cassava green mite (CGM) can be controlled with frequent applications of highly toxic pesticides, this approach is both ecologically and socially unsound, as well as too expensive.
Successful results with biological control of CM using the parasitic wasp *Epidino carsis lopezi* show this environmental-conscious approach to be a practical strategy for control of the mealybug, especially in sub-Saharan Africa agriculture that is oriented towards low-input, sustainable production of food crops and the maintenance and protection of agro-ecological zones devoid of widespread use of pesticides.
By the end of 1987, the two pests had spread to 31 of 35 countries in the African cassava belt. They are found together in 24

countries and will probably cover all cassava-growing areas within the next two or three years. Originally the CM was considered to be the more important of the two pests, causing devastating damage in Central and West Africa. It has recently moved over the Rift Valley into East and Southern Africa causing great concern. But in the past three years the CGM has been reported as an increasingly serious problem.
Biological control of the CGM - first observed in Uganda in 1971 - is proving to be more difficult and may require consistent, long-term efforts. The complex of efficient natural enemies of the green mite is almost restricted to predatory mites. Because of different behavior and ecological needs of these biological control agents, the introduction of predatory mites from South America and their establishment in African countries appears to be more difficult than of mealybug antagonists.
Because cassava - the main natural host of CM in Africa - was introduced from South America and the genera *Manihot* and *Phenacoccus* are particularly rich in species in that part of the world, the search for natural enemies started there in 1980 as a follow-up of the efforts initiated by the CAB International Institute of Biological Control (CIBC/England).
The exploration has resulted in the identification of more than 60 natural enemies of the two pests, 14 of which have been released in Africa.
However, to date only one parasitoid - *E. lopezi* - has proven to be effective against the mealybug using both aerial and ground releases in many ecological situations. This parasitic wasp has been established in 18 countries over areas of about 1.5 million km². It is estimated that cassava crop losses due to the CM in these areas have already been reduced by half and both IITA and national scientists expect that losses will continue to decrease since *E. lopezi* is known to keep CM population low only after the second year following its establishment.
On the other hand, none of the releases of cassava green mite predators has led to proven establishment. Therefore, CGM research, including rearing of host mites for natural enemies, mass rearing the natural enemies, and experimental releases, is being stepped up.
E. lopezi was discovered quickly and inexpensively, could be mass-reared by techniques developed by research, appears to be capable of permanent establishment over nearly all (if not all) of the cassava belt, disperses effectively and rapidly, and provides good control under a wide variety of conditions. Furthermore, farmers do not have to decide to adopt the technology and it requires neither investment nor maintenance by them.
An integrated problemsolving approach that includes research, training, and development of national programs has been used. Rather than being concentrated only on the pests and their natural enemies, research has included the plant and its environment. Through intensive field and laboratory studies and computer simulation, the cassava agro-ecosystem is analyzed and the impact of manipulations assessed.
National biological control programs are being established in 35 countries of the African cassava belt.

Because biological control is area-wide, it can spread from one country to another. Thus, there is a critical need for African countries sharing similar climatic conditions by the Inter-African Phytosanitary Commission, FAO, and ABCP. In addition, it was emphasized that an authority responsible for the application of these regulations should be established.

437 89 - 10/24

Plant protection
Africa, review, crop protection, small-scale farmers, farming systems, intercropping, research, weed control, striga, yield, pesticides, practical approach
PRINSLEY, R.T. and P.J. TERRY
Crop protection for small-scale farms in East- and Central Africa - a review.

Commonwealth Science Council, Marlborough House, Pall Mall, London SW 15 HX, UK, ISBN 0-85092-3331 X, 1988, £ 6.00

In most countries of Eastern and Central Africa, agricultural production is carried out mainly on small-scale farms; small-scale farming families account for the majority of the population in these countries. On many of these farms, a single family provides the only labour available, and inputs such as pesticides and machinery are not affordable. However, in many of these countries there is an urgent need to improve the productivity of food crops, despite these constraints. For example, extensive yield losses are inflicted upon these crops on small-scale farms by insects, weeds, diseases and nematodes, and improvement of crop protection practices is therefore seen as an important means of raising yields.
"Crop Protection for Small-Scale Farms in Eastern and Central Africa - a Review", is a book devoted to the consideration of this question; it was published by the Commonwealth Science Council in 1988. It was based on an analysis of the farming systems in the Embu district of Kenya and on a workshop held in Embu, which combined systems analysis techniques with farm visits and a detailed study of the area. As a result a coordinated collaborative regional research project was recommended, and further developed at a project planning meeting in Harare in March 1988.
This volume represents a compilation of the review papers presented at this meeting. It is intended as a handbook for the scientists involved in the research programme but will also be of interest to other scientists involved in crop protection for small-scale farms. It provides an extensive review of intercropping and its relation to crop protection; it recommends appropriate research; it discusses major weed control problems in the region and, in particular, looks at potential control methods for Striga: it also looks at intercropping practices.
The available information on yield losses in maize due to maize stalk borer are reviewed and the need for further information

using standardized and quantitative procedures are identified. The final chapters discuss pesticide safety, management and storage, the need to learn from farmers of their approaches to crop protection, and in general terms, how their farming systems work.

438 89 - 10/25

Plant protection
Central America, Mexico, experiment, bean, agroecosystem, fall armyworm, predators, population
RUIZ-ROSADO, O. et al.
Tropical corn-bean agroecosystems: management for insect pest and disease control.

In: Proc. of the 6th Int. Sc. Conf. of IFOAM, California, USA, 1988, pp. 525-531

Tropical ecosystems have long been considered the most productive systems of the world, but their productivity decreases when they are converted into agroecosystems. Following 3 to 4 years of agricultural use, these systems suffer nutrient and soil losses accompanied by weed, insect pest, and disease invasion.
The objective of the field work reported here was to study the population fluctuation of the fall armyworm, *Spodoptera frugiperda*, and its natural predators. The fall armyworm is the primary insect pest in maize monoculture and when associated with a black bean crop. How herbivore insects and disease affect bean pods was also analyzed. Observations were recorded from fields on existing farms managed by the peasants (campesinos).
The intercrop was tested under both traditional and modern conventional management systems. In the conventional system, land was prepared by double discing 30 cm deep; corn and black beans were mixed with BHC (concentrated at 80% of active ingredient) at sowing time to protect them from soil insect pests. In order to control fall armyworm larvae on maize plants, methyl parathion insecticide was sprayed when the crop was 28 days old and the insecticide phoxim was sprayed at 34 days. Maize ears were harvested by hand.
In maize sampling, *S. frugiperda larvae* were recorded without differentiating larval stages. Data were reported by plant and compared under a t-test using paired-sampled hypotheses.
Pest Presence and Damage in Maize:
S. frugiperda larvae presence was one week earlier in the traditionally managed system than in the modern one. Larvae presence followed similar trends in each system. When the maize crop was 33 days old, fall armyworm larvae numbers per plant were lower (0.44) in the traditional system than in the modern system (7.6), with a statistically significant difference at the .01 level. In part, the fall armyworm larvae reduction in the traditional system was due to the larval cannibalism characteristic of this insect species and to the predatory activity of its natural enemies. Families of predatory insects colonized crop plants at different times and attacked *S.*

frugiperda at different larval stages. The presence of predatory insect families in the traditional system remained constant from 33 days to 49 days after crop germination. In the modern system predatory insect populations were initially lower but increased steadily in that time period. At 49 days, numbers of predatory insects in both systems increased; populations in the modern system rose sharply until 57 days, and then decreased to equal the maximum value of the traditional system. When families of predatory insects were analyzed separately, there was no statistically significant difference in numbers of insects in the two systems. But when families were analyzed altogether, there were more insects per plant (9.4) in the traditional system at 57 days than in the modern system (6.4).

The reasons for reducted *S. frugiperda* larvae were different for the traditional and modern systems. In the latter, reduction was mainly due to the methyl parathion and phoxim insecticides applied when the crop was 28 to 34 days old. But the reduction of *S. frugiperda* larvae without insecticides in the traditional system suggests that sprays may not be necessary under traditional management strategies, thus saving campesino farmers money and protecting the environment.

At the beginning of the study, *S. frugiperda* larvae were more numerous in the traditional system than in the modern one, which may have been due to the fact that residue from the previous crop was not burned in the traditional system. The dried crop residue may have protected *S. frugiperda* pupae from natural enemies. In contrast, double discing used in the modern system would have exposed pupae to the sun and to natural enemies. Thus, insect pest infestations may be affected by different soil preparation methods. This may account for the presence of S. frugiperda one week later in the modern system than in the traditional one.

Pest Presence and Damage in Black Beans:

Although beans in the modern system generally produced more pods per plant than those in the traditional system, the difference was not statistically significant. Insect damage to bean pods at 65 days after germination was due primarily to Coleoptera of the Chrysomelidae family and was lower in the modern system than in the traditional system (statistically significant at the .05 level).At 65 days there was no sign of damage by anthracnose, *Colletrotichum lindemuthianum*. Continuous foggy mornings, however, increased relative humidity, stimulating optimal growth and dispersion conditions for anthracnose. At 82 days, damage from anthracnose was observed; in the modern system 35.7% of pods were damaged as compared to only 1.1% in the traditional system (statistically significant at the .01 level). In addition to dispersion by the wind, anthracnose spores may have been spread by herbivore insects visiting and feeding on healthy pods after feeding on infected pods. The percentage of pods damaged by herbivore insects between 65 and 82 days increased by 375% in the modern system and by 17.2% in the traditional one (statistically significant at the .o1 level). Although yield was higher in the modern system than in the traditional, there were more healthy pods per plant in the traditional than in the modern system. Herbivore insect damage in the modern system reached a much higher

level than in the traditional system; it may be that high damage levels stimulated yields in the modern system.

439 89 - 10/26

Plant protection
Latin America, Chile, study, rice, weeds, phenológical development
SAN MARTIN, J. et al.
Estudios fenologicas en malezas de arrozales cultivados en Chile Central. (Phenological studies of rice field weeds in Central Chile.)

Turrialba, 38, 1, 1988, pp. 23-30

Rice fields of Central Chile suffer the invasion of large numbers of aquatic and marsh weeds, which diminish yields. This study compares the phenological development of the most important rice field weeds with that of a rice crop during the 1982-1983 growing season in the region of Pelarco (Talca province, Chile). Cultivation began in August and September with plowing and forming of the rice fields. Rice sowing took place in November. The phenological development of rice as well as the phenological development of 13 weeds in the fields was controlled weekly, for five individuals of each species. The phenophases studied were: emergence, growth, flowering, fruiting and senescence. Several weeds sprouted before the rice, showing a faster development. After rice sprouting, *Carex canescence, Cyperus haspan, Polygonum persicaria, P. aviculare, Ammannia coccinea* and *Typha angustifolia* emerged. *Typha angustifolia*, does not flower in the field. Most weeds flowered before rice. Some are able to set fruit before anthesis of rice occurs. Such is the case for *Echinocloa crusgalli, Cyperus haspan, Lythrum hissopifolia, Polygonum persicaria, P. aviculare, Ammannia coccinea* and *Paspalum distichum*. Five of these weeds were able to flower and set fruit for a second time during the rice growing season, this time in unison with the crop. *Myosotis laxa* ends its life cycle before rice flowering. Almost all weeds produce diaspores before or together with the cultivated plant as a way of ensuring their permanence in the field.

440 89 - 10/27

Plant protection
USA, experiments, study, broccoli, cultivars, cabbage aphid
ALTIERI, M. and L.L. SCHMIDT
Mixing broccoli cultivars reduces cabbage aphid numbers.

California Agriculture, 1987, pp. 25-26

Opportunistic pathogens and insect pests with high adaptability and a wide genetic variability have become an increasing problem in modern, genetically uniform, agricultural systems.

Among the available options, mixing cultivars of different resistances (variety mixtures or multilines) has been found to reduce disease levels (especially rusts) in several grain production systems.
The use of this strategy in insect control has been virtually unexplored.
The presence of resistant plants impedes pathogen spread by increasing the separation between susceptible plants. It is possible that, depending on the degree to which insect pests discriminate between resistant and susceptible cultivars, the intensity of insect attack could be reduced in a field with a wide array of crop cultivars.
The effects of varietal diversity in the field on the population response of the cabbage aphid, *Brevicoryne brassicae* (L.) were examined. Stands of broccoli, *Brassica oleracea botrytis* (L.), composed of a single cultivar or mixed cultivars were used to determine how aphid population densities were affected by variety mixtures, variety proportions, planting arrangements, and planting times of different broccoli varieties. The main objective was to test whether increased cultivar diversity in crops reduces pest populations.
The study consisted of three experiments conducted during 1985-86 at the University of California, Berkeley's Gill Tract in Albany. All plots (5 by 6 meters each) were planted with 80 greenhouse-grown broccoli plants (12 cm tall). Treatments were replicated either three or five times. Each plot had eight rows with 10 plants each, 60 cm between rows, and 50 cm between plants. A 1-meter space between plots was kept free of vegetation by frequent rototilling. Broccoli varieties used were Asgrow's Futura (var.A),, Orion (var.B), Apollo (var.C), and Gem (var.D). This selection was based on the varieties' suitability to environmental conditions at Albany. The densities of winged and wingless aphids on the plants were estimated weekly by counting the numbers on five randomly selected plants of each variety in each plot for eight weeks. The number of aphids, and height and number of leaves of each broccoli plant were also recorded. At harvest time, all sampled plants were cut at soil level to estimate total number of aphids, mummies, plant biomass, and fresh weight of broccoli heads. Plant height and biomass were measured throughout the experiment. Statistical analyses to compare aphid densities between treatments were performed, and so separate significantly different densities resulting from varying cultivar diversity in the field were studied.
Mixing broccoli varieties in various space and time designs resulted in fewer cabbage aphids per plot and per plant than planting a single broccoli variety (Futura, Variety A). Aphid numbers decreased in plots as varietal diversity increased and as the proportion of variety A decreased. Planting of a preferred variety as a border row 15 days earlier than variety A gave significant protection to variety A from aphids.
The observations seem to confirm that increased crop cultivar diversity in a field can result in fewer pests.
While it is difficult to explain the ways in which aphids responded to increased cultivar diversity, it is known that plant

quality differences among closely related varieties can affect aphid population development. It it possible that differences in chemical or visual stimuli emanating from the varieties played a role. Data from the first and second experiments, however, suggest physical differences were important, since the dispersion of short varieties among tall plants restricted aphid settling on short plants. Taller varieties seemed to be more easily located by aphids, and functioned as a protective barrier or trap crop. This "physical interference" was apparent when the taller variety B was planted earlier as borders around variety A plants.
These results are encouraging and need to be studied further in larger plots more representative of farmers' fields.

441 89 - 10/28

Plant protection
Asia, Bangladesh, experiment, neem seed kernel, pulse beetle, storage pest
DAS, G.P and M.A. KARIM
Effectiveness of Neem Seed Kernel Oil as Surface Protectant Against the Pulse Beetle.

Trop. Grain Legume Bull., 33, 1986, pp. 30-33

Pulse beetle, *Callosobruchus chinensis* Linn. is a serious pest of stored pulses whose cicular holes in the seeds make them almost unfit for human consumption. Neem (*Azadirachta indica* A. Juss) leaf and seed kernel powder have been reported by different workers to be effective in reducing the insect pest attack of stored grains.
The present investigation was initiated to test the efficacy of traditionally extracted neem seed kernel oil as surface protectant for three popular pulses of Bangladesh,viz. grasspea (*Lathyrus sativus* L.)., lentil (*Lens culinaris* Medik)., and chickpea (*Cicer arietinum* L.) against the pulse beetle.
Well-dried seeds of grasspea, lentil, and chickpea were kept for eight days in a deep-freeze in sealed bags to destroy any hidden infestation. The moisture contents of the test legumes were 12.1% for grasspea, 12.5% for lentil and 12.3% for chickpea. Matured neem fruits that had dropped from the trees after ripening were collected and dried. They were then decorticated to get the kernels. The kernels were passed through a bullock-drawn, locally designed, wooden oil expeller (locally called "ghani") to give off the neem seed kernel oil. Portions of 400 g seeds of each pulse well-mixed with 4 ml neem seed kernel oil and equal quantities of untreated pulse seeds were kept in individual glass jars (15,5 cm x 13,0 cm as controls). All treatments were replicated three times. Three pairs of newly emerged *C. chinensis* adults were introduced in each glass jar. The top of each jar was covered with cloth to facilitate aeration, but to prevent escape of the insects or entry of other insects from outside. The jars were kept in the laboratory with a temperature of 30 ± 2°C and 80 ± 5% R.H. After 5 months of storage, the total height of the seeds in each glass jar

was divided into three equal portions by visual observation and marking on the glass jar. These three portions were then carefully poured separately on pieces of paper. Seed samples from each of the above three layers of seeds were obtained and the samples mixed after which a portion of seeds was randomly selected. Seed damage was determined by the number of infested (seeds with feeding holes) and noninfested seeds. The viability of treated and untreated (control) seeds was tested by germinating 100 randomly selected seeds from each jar in large petri dishes using moist cotton as a substrate.
Infestation by *C.chinensis* in neem seed kernel oil-treated seeds was zero as compared to 91.00%. 77.33% and 90.33% infestations in untreated seeds of the above three pulses, respectively, after 5 months of storage.
The exact mechanism of protection is not clear but it may result from physical and chemical factors. There was no adverse effect on the germination of seeds treated with seed kernel oil.
From the above results, it is clear that commonly available and cheap neem seed kernel oil can be used as surface protectant of seeds of stored pulses to effectively control pulse beetle infestations with no risk of hazards.

442 89 - 10/29

Plant protection
Asia, India, SAT, study, traditional pest control
BHASKAR RAO, V. and R.A.E. MUELLER
Some traditional pest control practices of SAT farmers.

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India, 1986, pp. 15

Agriculture production in the tropics is exposed to considerable stress from insect pests. Traditional agriculture has coevolved with the insect pests and cropping systems have unfolded that are adapted to local conditions and that benefit farmers. Traditional pest control methods are one manifestation of the coevolution between agricultural production and its environment. These methods have not been designed and recommended by non-farmers, such as researchers or extention agents, but are simply used by farmers with the intention to reduce or eliminate insect pest damage in crops.
This paper serves three purposes. Firstly, pest control practices are likely to change considerably on the small farms in SAT India. Rapid adoption of chemical control has occured in some crops and locations. Many traditional practices will, therefore, soon be part of history and forgotten if not recorded. Because one can only learn about the process of technical change by studying its history, and because one cannot study history without documents, our record of traditional pest control practices may be of use to students of technical change in pest control. Secondly, orthodox entomologists and plant protection specialists, who design and develop protection methods only on experiment stations, may want

to know with which methods their recommended methods may have to compete. The third purpose of this account is to assist pest protection specialists who approach their subject with a farming systems perspective. Various authors have recently emphasized the importance of close and detailed examinations of traditional pest control practices as the basis for research on improved pest control adoptable by small farmers. The study of traditional pest control practices by scientists obviously requires that the scientists know what practices there are. Several accounts of traditional agricultural practices are available for India and the contribution can, therefore, only be marginal in this regard. The intention is not to add to the literature but to complement the very detailed farm and village information that has been assembled for three villages over ten years by ICRISAT's village-level studies.
The data for this note were obtained from two sources. The first source was the recollections and experiences of four ICRISAT village investigators. They had been stationed in four villages and observed farmers' production methods in six villages in three agroclimatic zones of SAT India.
The authors do not believe that any of the traditional pest controls reported here offers an important crystallizing point for further adaptive research. They believe that many of the traditional practices are not very effective and could not compete with judicious chemical control. Perhaps the biggest advantage of the traditional practices, the pseudo-controls in particular, is that they do not cause control resistance building up in the insect population. This characteristic may occassionally be exploited in pest control recommendations. Just like a patient with an undiagnosed illness is best treated with placebos, harmless pseudo-control practices may be suitable for farmers who insist on carrying out some pest control, when actually no authentic pest control can be recommended.
Some of the traditional pest controls require materials that are collected from plants growing on common property land. With increasing population density such lands are gradually vanishing and continously overexploited. With the reduced availability of natural materials the costs of traditional pest control methods are rising and alternative protection measures, such as biological or cultural control, and varietal resistance, should become more economically attractive.

443 89 - 10/30

Plant protection
Latin America, study, cassava, cultivation, weeds, weeding, intercropping, biological balance, purple nutsedge
LEIHNER, D.E. et al.

El coquito (*Cyperus rotundus*) en el cultivo de yuca: interacciones y control. (Purple nutsedge (Cyperus rotundus) in cassava: interactions and control.).

Revista COMALFI, 7, (3-4), 1980, 3-20

Recent information on the biological balance between purple nutsedge (*Cyperus rotundus*) and cassava is analyzed; the possibilities of influencing this balance to favor cassava are also studied. The slow initial growth of cassava highly favors the development and propagation of *C. rotundus*, resulting in competition between the 2 species during the 1st part of the cassava growth cycle. While competition for light may be of little importance, the allelopathic effect and the large consumption of water and nutrients by the weed may be responsible for cassava production losses. In cassava, mechanical control of *C. rotundus* continues to be the most common practice; however, this can aggravate the problem instead of reducing it. Only mechanical control during the dry season shows some promise. Pre-emergence herbicides or pre-planting incorporated products currently used in cassava are of limited and erratic effectiveness against *C. rotundus*, but chemicals with improved effectiveness have been identified. In the area of postemergence herbicides, glyphosate continues to be the most effective. Since there is still no ideal control system, simple practice, or single herbicide to control and finally erradicate *C. rotundus*, investigation has focussed on integrated control measures that combine mechanical, chemical, and cultural practices. Future investigations will try to establish practical and economical integrated control systems and at the same time determine the factors responsible for yield and quality losses in cassava due to *C. rotundus*, such as allelopathy and competition for water and nutrients..
Author's summary

444 89 - 10/31

Plant protection
Africa, Sahel, pearl millet, insect plant management, FAO, CILSS, USAID
GAHUKAR, R.T.
Problems and perspectives of pest management in the Sahel: a case study of pearl millet.

Trop. Pest Management, 34, 1988, pp. 35-38

Pearl or Bulrush millet (*Pennisetum americanum* (L.) Leeke) is widely grown, along with sorghum, covering over 13 million ha in the sub-saharan region of West Africa. This region is characterized by annual rainfall below 500 mm with its unequal distribution during the crop seasons and droughts are common. Pearl millet is a major food crop. The average yield per ha is about 450 kg, but yields up to 2 tonnes have been obtained through improvement of local or introduced genotypes.
Generally, drought is a major constraint, but weeds, plant diseases, insects and birds cause considerable damage to the crop. In order to reduce yield losses, pest management studies began in 1980-81 under an Integrated Pest Management Project (FAO/CILSS/USAID) in member countries of the CILSS (Comité Permanent Inter-Etats pour la Lutte contre la Sécheresse dans le Sahel).
The present paper reviews the pest complex of pearl millet and discusses pest management strategies in the context of subsistence farming.
In the present situation, chemical control appears impractical and costly, and alternative measures need to be considered. Partial burning of green stems for use in fencing and roofing, destruction of crop residues before the rains, planting of resistant varieties intercropped with grain legumes is recommended for stem borer control. Midge populations may be limited by destruction of infested spikes, avoiding delayed planting and by encouraging larval pupal parasites. Traditional methods applied on varieties with bristles is suggested for the control of blister beetles. Insecticide applications should be used to control sporadic attacks and epidemics of pests. However, the economic injury level should be determined in relation to the grain price, farmers' preferences, the scarcity of food, purchasing power etc. In order to examine the benefits of above recommendations and some of the socio-economic problems, pilot projects have been initiated in Burkina Faso, Senegal, Mali, Gambia and Niger.
Millet is a subsistence crop and the production cost is often unknown. Therefore any cost involved in IPM might be unacceptable to farmers. Extension workers should demonstrate the advantages of IPM and its ability to achieve acceptable results. The IPM system should be modified as government policy, varieties released and pest incidence changed. However, extension technical assistance and finance are necessary for the continuity and adequate progress in IPM. A combination of efficient pest forecasting and monitoring with IPM should help the Sahelian farmer to reduce yield losses in pearl millet and increase the crop production.

445 89 - 10/32

Plant protection
Asia, India, field study, upland rice, crop, weed, competition
SINGH, G. et al.
Crop/weed competition studies in upland rice.

Trop. Pest Management, 33, 1987, 19-21

Direct seeding by broadcasting or drilling (in upland rice) is a common practice of rice cultivation in India. A large area (22·5 million ha) under rice is still occupied by upland rice where yields are extremely low, and it is on account of the upland rice that the average yield of rice has not much increased.
Yield losses due to uncontrolled weeds in upland rice have been reported to be as high as 40-80%, and in many cases, there have been complete crop failures due to severe weed infestation.
The existing practice of manual weeding has to continue since there is no herbicide available which can be used effectively, safely and economically for weed control in upland rice under Indian conditions. Under these circumstances, it is necessary to identify the critical period of weed control in upland rice to make the practice of manual weed control more effective and economical.
The field study was carried out during monsoon seasons from 1981 to 1983. The soil was loam in texture (38,4% sand, 45,2% silt and 16,4% clay), medium in organic carbon (0,58%), very high in available phosphorus (109 kg P/ha) and medium in potassium (201 kg K/ha) content with pH 7,7.
The experiment was laid out in randomized complete block design with four replications in 1981 and three replications in 1982 and 1983 crop seasons. Treatments consisted of weedy conditions for the first 15, 30, 45, 60, 75 days after sowing (d.a.s.) and up to harvesting, and weed-free conditions for the first 15, 30, 45, 60, 75 d.a.s. and up to harvest. Rice cv. Pusa 2-21 was sown in the last week of June every year with a fertiseed-drill at 100 kg seed/ha and a row spacing of 23 cm. Recommended cultural practices were followed to maintain optimum crop growth.
Echinochloa colonum, Scirpus grossus, Dactyloctenium aegyptium, Cyperus rotundus, C. iria and *Trianthema monogyna* were the major weed species. Competition from weeds during the first 15 days after sowing (d.a.s.) had no significant effect on the grain yield of rice. Competition beyond 15 d.a.s. caused drastic reduction in the grain yield. Grain yield of rice increased significantly with the increase in the duration of weed-free period up to 45 d.a.s. during two years. However, further increase in the weed-free period up to 60 d.a.s. caused significant improvement in the grain yield of rice in only one year. Weeds emerging after 45 d.a.s. were lower in density and their growth was suppressed by the crop. Density of weeds emerging between 15 and 30 d.a.s. was high and could compete with the crop resulting in reduced grain yields. The period during 15 to 45 d.a.s. was found to be the most important for crop/weed competition.

446 89 - 10/33

Plant protection
Canada, experiments, fababeans, organic farming, weeds, aphid infestation, intercropping, nitrogen
PATRIQUIN, D.G. et al.
Aphid Infestation of Fababeans on an Organic Farm in Relation to Weeds, Intercrops and added Nitrogen.

Agriculture, Ecosystem and Environment, 20, 1988, 279-288

Intercropping or weedy culture of crops commonly results in reduced numbers of insect pests in comparison with crops grown in strict monoculture. Such reductions have been attributed to higher levels of natural enemies in the diversified systems, non-harvested intercrops or weeds diverting pests from harvested crops, repellent properties of intercrops or weeds, and to effects of intercrops or weeds on visual attractiveness of crops to pests. Pest infestations are affected also by the nitrogen status of the host. Growth and fecundity of insects are commonly stimulated by high levels of protein amino acids, and are inhibited by certain non-protein amino acids. Fertilizing crops with inorganic fertilizers, use of certain pesticides and other stresses on plants may make crops more susceptible to pests through their effects on crop nitrogen metabolism. Organic methods of fertilization may be less damaging.
The possibility that weeds or intercrops might reduce pest infestation by affecting the nitrogen metabolism of crops has apparently not been addressed. Evidence for this sort of interaction was obtained during studies of weed-crop interactions on an organic farm in 1985 and 1986 in Canada.
To test the hypotheses that low levels of soil N contribute to the effective natural control of *Aphis fabae* on fababeans on an organic farm, large plots in a fababean field were fertilized with urea. Aphids settled and/or proliferated differentially in differently treated plots of this experiment, and also in those of experiments set up for other purposes in 1985 and 1986. Aphids were more numerous in fertilized than in unfertilized plots, in weeded than in unweeded plots, and in plots without intercrops than in plots with them; in one experiment in which N and weeding were combined factorially, weeding resulted in increasing numbers of aphids, but addition of N did not. Leaf N, measured in two experiments, was highest in treatments with highest numbers of aphids. It is suggested that in addition to enhancing control of pests through their effects on natural enemies, weeds or intercrops can reduce susceptibility of the host to pests by consuming soil N and restricting luxury uptake of N by the crop.

447

89 - 10/34

Plant protection
Review, insects, diseases, weeds, pesticides, chemical control, alternatives, risks
CTA
Pesticides: une arme à double tranchant (Pesticides: a two-edged sword).

SPORE, 19, 1989, pp. 1-4

Insects, diseases, and weeds account for 40% of the annual crop and harvest losses in the ACP-countries. But the use of pesticides, the most commonly adopted remedy against these problems, has its dangers both for man and environment.
The use of pesticides is considerably lower in developing countries than in industrialized nations, but is rising continuously. Africa still accounts for only 5% of world pesticide use but has increased consumption ninefold in a decade or so. However, Third World countries have a poor safety record, and therefore agrochemicals are frequently condemned and referred to as "Third World poisons".
Lack of care in handling and applying pesticides often causes serious accidents and illegal uses such as fishing and poaching, or even criminal purposes (poisoning, suicide, abortion) all too often increase the mortality figures.
As with any chemical product, the use of pesticides requires precautions to ensure the protection of those applying them, the safety of the consumers of the treated crops, and the preservation of the environment. Storing sacks of pesticides next to foodstuffs in poorly-ventilated depots, handling torn sacks or leaking drums without gloves, and spraying with faulty equipment are some of the most frequent causes of poisoning. The many risks of contamination demand that the basic rules of safety should be followed implicitly. Simple precautions and procedures which are not always put into practice include not checking wind direction and strenghth and washing hands after application. This sort of attitude is sometimes accompanied by careless application.
It is imperative that manufacturer's instructions should be followed exactly. A product that kills locust larvae may not necessarily be the right thing to apply to tomato plants and, when a farmer treats his fields with the product he has at hand or that is available on the market, he risks poisoning himself or others with the crops and vegetables from his farm and garden. Such practices which are too common and difficult to control, can have disastrous consequences on the health of consumers by contaminating food products and polluting water supplies.
Furthermore, farmers do not always get the desired results from products which have to be applied at a precise dose and at a certain growth stage of crop or pest in order to be effective against target species. Herbicides, which are now more commonly used, must be applied at a certain stage in the development of the weed for it to be killed. Usually cash crops are treated with appropriate pesticides whereas food crops, all too often have to

do with products originally intended for other crops grown for export. Farmers themselves are not always primarily responsible for this hazardous state of affairs; they are poorly educated, they do not always know how to use these toxic substances, and often have expectations of performance and safety based on exaggerated claims made by salesmen and even extension staff.
The first pesticides to appear in the 1940s, of which DDT is the best known, are now prohibited almost world-wide. Very long-lasting, they can cause lasting damage to the environment and to human beings. The carbamates and organo-phosphorus compounds were the second generation. They were widely used in agriculture and although these were more easily degradable, they were nonetheless toxic to people and mammals. But it is the third generation insecticides, synthetic pyrethroids, which came on the market in 1975 which are now most widely used. These products are harmless to man and beast and to the environment, and at the same time extremely effective against crop pests, especially *Lepidoptera*. Even though less toxic, they need to be applied at low dose rates: were 1 kg DDT or 400 g parathion were once necessary, now only 10 g of deltamethrine would be required. Unfortunately, repeated use of these pyrethroids induces resistance to them in insects so the selection of insecticides must be varied to extend their span of time. A fourth range of compounds is about to come onto the market. These are growth regulators which act on an insect's metabolism and disturb their development. These are very selective, toxic to their target organisms only, and are effective at a very small dosage. Thus a promising new insecticide, which modifies the transformation mechanism in locust larvae, seems likely to replace the controversial organo-chlorine, dieldrin. But the cost of producing these complex molecules is high, and it will still be several years before their use becomes general in developing countries. Other types of products mimic natural substances and may be used in order to avoid causing serious ecological imbalances. For instance it is possible to synthesize the chemical messages which determine insect's sexual instincts (pheromones), which attract pests to certain plants or which repel them.
Microbiological warfare is being developed on many other fronts: bacteria, viruses and fungi, to which insects are naturally victim, are being formulated and sprayed on crops like chemical pesticides. Their use - as yet not fully developed - will allow the reduction of substition for chemical pesticides. Both biotechnology and using other insects which are hostile to pest species are also possibilities which can be considered in addition to the treatments outlined.
With this wide range of weaponry available to farmers to fight pests, the «all-chemical solution» is no longer the only option. An integrated campaign which combines complementary techniques of chemical and biological control seems to be the solution for the future.

448 89 - 10/35

Plant protection
Review, book, pesticides, traditional methods, pestcontrol, sustainable agriculture
GIPS, T.
Breaking the pesticide habit - Alternatives to 12 hazardous pesticides.

Int. Alliance for Sustainable Agriculture, Newman Center at the Univ. of Minnesota, 1701 Univ. Ave. SE., 55414, USA, 1987,372 pp., US$ 14,95

In 1985, The Pesticide Action Network (PAN), launched a public information campaign against 12 of the world's most hazardous pesticides, the "Dirty Dozen": "the Drins" (Aldrin, Dieldrin and Endrin), EDB, Chlordane/Heptachlor, Parathion, Paraquat, 2.4.5-T, Chlordimeform, DBCP, HCH/Lindane, Camphechlor and PCP.
To bridge the lack of documentation on safe alternatives for the specific pesticides the International Alliance conducted a broad research effort of both chemical and nonchemical alternatives for all of the major uses of the Dirty Dozen, from agriculture to public health. This includes an extensive literature review, as well as a survey of more than two thousand leading scientists, extension officials, farmers and groups worldwide. A Scientific Panel was created with distinguished scientists to help review the work. The conclusion of this research is that alternatives are available for nearly every use of the 12 pesticides. A range of beneficial insects, plants, fish, fowl, fungi, and other natural-occuring organisms can be successfully combined with an array of creative management strategies such as ridge tillage, trap crops, and composting, to manage pests. The proper combination of traditional approaches and modern discoveries can provide an historic opportunity to develop sustainable agriculture and pest control systems worldwide. The book provides a thorough review of the evolution of pest control, the concepts of sustainable agriculture and the impact, status and alternatives of the 12 pesticides. Besides this, recommendations for action by Governments, Research and Extension Institutions, International Agencies and Business and Industries are given. This research must not be seen as a source for quick or even nonchemical replacements, but rather, as the basis for a properly designed, holistic and sustainable agriculture. Alternatives are not alternative products but alternative value systems and associated ways of thinking and behaving. Convincing and inspiring, a must for anyone active in agriculture, policy, business, research or extension, worldwide!
Abstract from ILEIA

449 89 - 10/36

Plant Protection
Central America, Costa Rica, field trial, cassava, weed groundcover, white grub, losses
HRUSKA, A.J.
Weedy groundcover increases damage to cassava by white grubs in Costa Rica.

Trop. Agric. (Trinidad), 64, 3, 1987, 212-215

White grubs, the larvae of *Phyllophaga* spp. (*Coleoptera: Scarabaeidae*), are important pests of temperate and tropical crops and natural grasslands. The beetle larvae of this genus inhabit soil and feed on roots and bark of plants for as long as four years before pupating. This damage can cause complete crop loss, especially if attack occurs when plants are young.
In Costa Rica, white grubs cause economic damage to virtually all important crops, including coffee, sugar cane, rice, maize, sorghum, potatoes, cucurbits, legumes, peanuts, onions, lettuce and cassava. The grubs are pests of cassava wherever it is grown.
Research in temperate regions indicates that rainfall and the extent of weedy groundcover can greatly influence grub population levels. Groundcover may lead to an increase in the white grub population levels by: (1) increasing oviposition by adult beetles, (2) increasing survivorship of eggs, larvae and pupae and/or (3) decreasing egg and larval parasitism and predation.
Chemical control of larvae, once they are in high abundance, is often necessary. Thus there is a growing body of research investigating environmental parameters that could be manipulated for cultural control of white grubs. There is also growing interest in natural enemies of the grubs for use in biological control.
This study, conducted in Costa Rica, examines the relationship between groundcover and cassava plant damage caused by white grubs. It also investigates how plant damage is affected by interactions among weeds and (1) cyanogenic glycoside content of the cassava, (2) plant population density and (3) inter-row variety mixtures.
The damage to cassava was due to root-feeding by white grubs. A significant correlation ($P<0.05$) was found between the amount of groundcover and plant damage due to grub feeding at two plant population densities. The correlations were highly significant ($P>0.01$) in pure stands of either of two varieties of cassava, but were not significant in mixed stands. Possible biological mechanisms responsible for the results are discussed.

450 89 - 10/37

Plant protection
Review, plant diseases, air pollutants, epidemics, examples, logistic model, limitations, computer simulation
MADDEN, L.V. and CAMPBELL, C.L.
Potential Effects of Air Pollutants on Epidemics of Plant Diseases.

Agriculture, Ecosystems and Environment, 18, 1987, 251-262

Usually, plant epidemics consist of an increase in disease intensity with time in a population of plants (i.e., crops) in a greenhouse, field or forest. This definition does not agree with the common lay-person's concept of an epidemic, being the rapid development of a large amount of disease over large areas or in large populations. Occasionally, plant disease epidemics will reach such a high level, but this is the exception rather than the rule; plant epidemics usually develop over an entire growing season for field crops or over a period of years in a stand of trees. Disease levels can stay relatively low, but even low levels of many crop diseases result in substantial yield losses and are important economically.
A plant disease epidemic will not occur unless there is a susceptible host, a virulent pathogen, and a favourable environment. This is known as the disease triangle. Air pollutants could be considered pathogens, but for this purpose, only biotic pathogens (e.g., fungi, viruses, bacteria, nematodes) are considered. Pollutants will be considered as part of the environment, which also includes weather and all other biotic and abiotic factors that influence the dynamic interaction of host and pathogen. With epidemics, time must also be considered; conceptually, the disease triangle can be expanded to a disease pyramid.
Little work has been done on determining the effects of pollutants on disease progression. To understand the potential effect of pollutants or other environmental variables on epidemics, a description of an epidemic more quantitative than the disease pyramid is necessary. A theoretical description of an epidemic using mathematics, based on published results, is given to represent an epidemic with well-defined parameters and variables. A discussion of how pollutants can affect epidemics is then given in the context of the mathematical treatment.
Nonconstancy of the characteristics, due either to changing environment or inherent variability of the population, generally requires computer simulation for a thorough understanding. Spatial variability and pathogen dispersal further complicate the effect of pollutants on plant disease epidemics. Some reported examples of the effects of O_3, SO_2, and acid deposition on epidemic characteristics are discussed.

451 89 - 10/38

Plant protection
USA, experiment, biological control, snap bean, grey mold, *Trichoderma hamatum*
NELSON, M.E. and M.L. POWELSON
Biological Control of Grey Mold of Snap Beans by *Trichoderma hamatum*.

Plant Disease, 1988, pp. 727-729

Grey mold, caused by *Botrytis cinerea* Pers. ex Fr., can be found on all aerial portions of the snap bean *(Phaseolus vulgaris* L.) plant. Economic loss, however, is due primarily to pod rot, which reduces quality and increases processing costs. When conditions are cool and moist, losses from pod rot may be substantial. At the present time, grey mold is managed primarily by application of fungicides. In some cases, however, the application of a fungicide may actually increase the severity of *Botrytis*-caused diseases. This increase is presumably due to the presence of fungicide-resistant strains of *Botrytis* and suppression of natural antagonists by the fungicide. The development of strains of *B. cinerea* resistant to fungicides, coupled with the difficulty of registering new fungicides, has stimulated an interest in biological control.
Grey mold on strawberries was reduced in the field with applications of several species of *Trichoderma*, beginning at early bloom. Other workers also have inhibited grey mold on grapes in the field by applying suspensions of *Trichoderma* spp., *Cladosporium* sp., and *Aureobasidium* sp. beginning at flowering. This study examined the potential of *Trichoderma* spp. recovered from snap bean foliage to suppress grey mold of snap beans.
Isolates of *Trichoderma* spp. from snap bean foliage were tested for their capacity to suppress grey mold of snap bean pods caused by *Botrytis cinerea*. In a detached blossom-pod assay, an isolate of *Trichoderma hamatum* reduced pod rot by 94% compared with the nontreated control, which was comparable to that obtained with a fungicide. Forty-two colony-forming units (cfu) of *T. hamatum* per blossom reduced pod rot by 77% compared with the nontreated control. Control was 97% when 233 cfu per blossom were applied. Grey mold was reduced only when spores of *T. hamatum* were appllied to blossoms before, or simultaneously, with application of conidia of *B. cinerea*. Volatile compounds produced by one isolate of *T. hamatum* reduced mean radial growth of *B. cinerea* to 0.6 mm on potato-dextrose agar, while growth on nontreated plates averaged 23.6 mm. These results suggest the production of inhibitory volatiles as one possible mechanism of biocontrol.

452

89 - 10/39

Plant protection
Africa, Nigeria, trials, tropical rainforst, cassava, maize, intercropping, integrated weed management
UNAMMA, R.P.A. et al.
Integrated weed management for cassava intercropped with maize.

Weed Research, 26, 1986, pp. 9-17

Under the non-mechanized cropping systems of south-eastern Nigeria, intercropping cassava and maize is highly productive and gives better land utilization efficiency and more convenient spread of harvest than sole cropping either of the two crops. This crop combination is widely grown by the farmers of southern Nigeria. Weed control in the mixed cropping systems as practised by farmers is labour intensive, uneconomical and more difficult than weed control in either of the sole crops. About 32% of the farmer's time is expended in hand-hoeing either sole cassava or cassava/maize intercrop. The methods adopted by the farmers have been found to be ineffective mainly because of the problem of untimely weeding. Some herbicides have been used to control weeds effectively and economically in cassava/maize intercrop in some parts of Nigeria. A preliminary investigation had suggested the use of low growing crops in combination with herbicides for effective weed control in cassava/maize intercrop.
Whichever method is adopted for controlling the weeds in cassava/maize intercrop, it is critical to keep the weeds suppressed during the first 8 weeks after planting. Current research aims at developing systems of managing weeds whereby the crop is encouraged to exert such pressure that crop growth is favoured at the expense of the weeds. In this way, relying heavily on herbicides for weed control in cassava/maize intercrop weeds may be minimized by the application of more than one kind of technology in a mutually supportive manner. The objectives of the present work are: (i) to evaluate weed control methods involving manual weeding, herbicides, low growing crops and integrated techniques involving the use of herbicide and low growing crop in cassava/maize intercrop; and (ii) to assess the effect of intercropping cassava and maize on their respective yields.
Trials were conducted in the tropical rainforest zone to compare manual weeding with chemical and integrated weed control systems in cassava (*Manihot esculenta* Krantz)/maize (*Zea mays* L.) intercrop. Uncontrolled weeds reduced cassava and maize component yields by 2-year averages of 49 and 62% respectively; and their combined energy yield by 53% compared with 30.572 kcal ha^{-1} obtained from the control plots hand-hoed at 3 and 8 weeks after planting.
Highest economic returns were obtained from using cowpea (*Vigna unguiculata* (L.) Walp) or Egusi melon (*Colocynthis citrullus* (L.) O.Ktze) which gave 2-year average net returns of ₦ 2843 ha^{-1} and 2944 ha^{-1} compared with ₦ 1598 ha^{-1} generated from the control that received two hand-hoeings. Integrated use of cowpea and pre-emergence application of alachlor at 2·0 or chloremben at 3·4 kg

ai ha^{-1} and pre-emergence application of either fluometuron or chloramben at 2·5 and 3·4 kg ai ha^{-1} respectively or their mixture gave more economic net returns than two hand-hoeings. Under similar management level, intercropping cassava and maize resulted in 36-43% more land being made available to the farmer for other uses than sole cropping.

453

89 - 10/40

Plant protection
USA, trials, field beans, insect incidence, relay intercropping, monoculture
TINGEY, W.M.
Insect abundance in field beans altered by intercropping.

Bull. Ent. Res., 78, 1988, pp. 527-535

Intercropping provides several significant advantages over monoculture including a greater total land productivity as well as insurance against failure or unstable market value of any single crop. In addition, crops grown in an intercropping system are sometimes less prone to outbreaks of insect and disease pests than are those grown in monoculture.
In the USA, where monoculture is widely practiced, double cropping systems have attracted considerable interest in recent years. In double cropping systems, a second crop, usually soybeans, maize, or sorghum is planted immediately following harvest of an earlier crop, usually a cereal grain. Consistent success in double cropping requires a minimal delay between harvest of the first crop and planting of the second crop.
Northern latitudes are subject to the danger that the second crop may be immature at the time of the first killing frost. For these areas, relay intercropping may be more advantageous since two or more crops can be grown together for part of the life-cycle of each. This modification provides buffering against failure of the second crop due to unfavourable soil moisture or early frost.
The objective of the present study was to determine the effect of relay intercropping field beans, *Phaseolus vulgaris*, and winter wheat, *Triticum aestivum*, on the abundance of four insect pests (potato leafhopper, *Empoasca fabae* (Harris); bean aphid, *Aphis fabae* Scopoli; tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), and red headed flea beetle, *Systena frontalis* (F.)) on beans.
Densities of four herbivorous insect species were compared on field beans (*Phaseolus vulgaris*) grown in monoculture and those grown in relay intercropping with winter wheat. In three years of study in New York State, population densities of *Empoasca fabae* (Harris) and *Aphis fabae* Scopoli were significantly less in plots intercropped with winter wheat than in those grown in monoculture. In contrast, intercropping was associated with greater densities of *Lygus lineolaris* (Palisot de Beauvois) and *Systena frontalis* (F.). An increased density of *L. lineolaris* may be an economic risk factor in beans intercropped with wheat because only this

species of the four studied feeds exclusively on the flowers and developing seed pods.

454 89 - 10/41

Plant protection
Review, book, ecological approach, integrated pest management, economic injury level, insect-plant interaction, predators, biological control, plant resistance
HORN, D.J.
Ecolocical Approach to Pest Management.

Guildford Press, 200 Park Avenue South, New York, NY 10003, USA, 1988, pp. 275 + xi, $ 36.00

Ecological approach to pest management is a professional-level overview of the relationships between current ecological theory and practical insect pest management. Principles of sampling theory, population modelling and community ecology are developed and related to current advances in integrated pest management programs. Concepts discussed include: economic injury level, analyses of demographic factors, and insect-plant-predator interactions. Insecticides, biological control, plant resistance, genetic manipulations, and cultural/physical control are discussed separately and then integrated to illustrate applications to agricultural, forest, and urban settings. This book will be useful to all those studying pest management and plant protection and to professionals in agricultural and environmental sciences.
The book contains the following chapters:
1. Introduction. Background. Administration of applied entomology. Professional societies. 2. Insect Pests and Economic Decisions. Economic injury level. Expansion of time frame. Role of entomological research. How insects become pests. 3. Sampling Populations. Theoretical considerations. Practical considerations. Appendix. 4. Single-Species Populations. Simple population models. Stochastic models. Population structure. Utility of life tables. Genetic systems. Responses to environment. 5. Insects in Ecological Communities. Interspecific interactions. Synoptic model of insect population dynamics. Theoretical and ecological islands. Synoptic model with K-strategy. Diversity and stability.
6. Insect-Plant Interactions. Insect impact on plants. Plant effects on insects: nutrion. Plant effects on insects: defense. Plant spacing and insect density. Texture and community stability. 7. Broad-Spectrum Chemical Insecticides. Classification of insecticides. Formulation. Development and testing. Side effects of insecticide application. Using insecticides in ecological pest management. 8. Narrow-Spectrum "Biorational" Management. Microbial insecticides. Insect growth regulators. 9. Biological Control. Importation. Evaluation. Attributes of "ideal" agents. Single versus multiple introductions. Augmentation. Compatibility. Major biocontrol agents. Conclusions. 10. Plant Resistance. Introduction. Mechanisms of resistance. Development of resistance varieties. Application of resistance. 11. Genetic, Cultural, and

Physical Control: Quarantines. Genetic manipulations. Cultural management techniques. Sanitation. Physical controls. Quarantines. 12. Integrated Insect Pest Management. Application of pest management models. Alfalfa: successful development of management models. Cotton pests: developed versus developing economy. Forest insect pest management. Suburban household: subjectivity and aesthetic injury levels. Conclusions and future prospects. Index.

455 89 - 10/42

Plant protection
Africa, Nigeria, experiment, cowpea, insect damage, weeds, weeding, flower thrips, pests, IITA
EZUEH, M.I. and L.O. AMUSAN
Cowpea Insect Damage as Influenced by the Presence of Weeds.

Agriculture, Ecosystems and Environment, 21, 1988, pp. 255-263

Weeds constitute a major constraint in crop production in the tropical and sub-tropical regions. They compete for light, water and nutrients, resulting in reduced crop yields. Crop losses in the tropics caused by weeds are 2-3 times greater than in the temperate zones. Average yield loss due to weeds in cowpeas was estimated at 53% at the International Institute of Tropical Agriculture, Ibadan.
In addition to their repressive effects owing to competition, weeds also act as reservoirs, or alternate hosts, for insects, diseases and nematodes. For example, when cowpea was not weeded, insect damage to developing seeds was reported to have increased by 15,3% compared with the weed-free plots. A greater build up of insects and diseases in cowpea under weed competition was reported.
This paper reports the effects of weed presence on the damage intensity of the major pests of cowpeas in the rainforest zone. The results and conclusions provide a necessary back-up for adequate recommendations on control of weeds and pests of cowpea for this geographic region.
The influence of weeds on insect damage of cowpea was studied using weeding treatments, with one treatment isolating the direct effects of weeds on the grain yield of the crops. Seventeen weed species were identified in the cowpea plots. The results of the study showed that the population of flower thrips *Megalurothrips sjostedti* Trybom and *hemipterous* pests increased significantly ($P<0.05$) in the presence of weeds. The effects of weeding frequency on pod damage by the pod-borers, *Maruca lestulalis* Geyer and *Cydia ptychora* Meyr were not consistent but the presence of weeds seemed to have increased the population of these pests. In the 1981 and 1982 experiments, there were positive correlations between the number of times of weeding and insect damage on seed ($r=0.85$ $P<0.05$; $r=0.99$ $P<0.01$, respectively). In 1986, the results showed a positive correlation between number of undamaged seeds per pod and mean grain yield ($r=0.92$ $P<0.01$). The presence of

weeds was therefore thought to have increased insect damage which led to a yield reduction of about 20% in cowpea.
The importance of keeping the cowpea crop weed free is emphasized by the results of this investigation. It offers practical insect-control possibilities especially at the low level of management prevalent amongst the peasant growers. Three weedings, at fortnightly intervals from date of planting, gave the pest results, in terms of pest reduction and yield increase. The major set-backs in manual weeding are the current cost of labour. However, if the use of herbicides, now proven to be effective for cowpea production is widely adopted, it will drastically reduce the intensity of labour inherent in the traditional hoe-weeding, and will therefore make cowpea production more profitable in the humid tropics by reducing heavy yield losses through adequate weed control.

456 89 - 10/43

Plant protection
USA, survey, apple, integrated pest management, pesticide use
KOVACH, J. and J.P. TETTE
A Survey of the Use of IPM by New York Apple Producers.

Agricult. Ecosystems and Environment, 20, 1988, 101-108

Integrated Pest Management (IPM) is one strategy practised by apple producers to manage the large and varied pest complex found in New York. The concept of an integrated approach is not new, having been used in apple orchards as early as 1942, when Nova Scotian growers developed a pest control program that de-emphasized costly insecticides and used "harmonized" control that relied on more natural pest population regulation and limited use of insecticides. This concept of bringing all pests (weeds, insects, diseases, etc.) into an integrated approach was suggested and implemented. In New York, the pilot project began in 1973, but demonstration of the concept to growers did not begin until 1976. Some states reported quick adoption of IPM concepts, but efforts in crops with high-quality standards have taken place at a slower rate. Some consider the slow rate of adoption to be largely the fault of crop protection scientists, but many of these scientists have been frustrated by their inability to foster change when new IPM methods have become available. To reduce this frustration and bring about increased grower acceptance of IPM, it is necessary to understand who uses IPM methods and to appreciate the differences that exist between IPM users and non-users.
This investigation had several purposes. The first was to determine the background and behavioral characteristics of apple producers who use IPM methods and compare them with those of non-IPM users. The second objective was to determine the major source of pest management information used by growers. The third objective was to determine the economic consequences of using IPM by monitoring pesticide use, cost and effect on fruit quality over an 11-year period.

Results showed that >80% of the apple producers in New York State incorporate some aspect of IPM into their pest control strategies. IPM users were younger and better educated and had less farm experience than non-users. However, agricultural sales persons were also considered useful by the growers for making pest management decisions. Growers that employed comprehensive IPM practises used 30% less insecticides, 47% less miticides and 10% less fungicides than growers that did not use IPM practises. This resulted in 235 kg active ingredient ha^{-1} not having to be absorbed by the environment and saved IPM apple growers an average of US$ 95.80 ha^{-1} $year^{-1}$ over an 11-year period (1976-1986) without significantly affecting fruit quality.

457 89 - 10/44

Plant protection
Africa, Burundi, experiments, potato, bacterial wilt, mixed cropping, disease development
AUTRIQUE, A. and M.J. POTTS
The influence of mixed cropping on the control of potato bacterial wilt (*Pseudomonas solanacearum*).

Ann. appl. Biol., 111, 1987, pp. 125-133

This paper describes an investigation to evaluate the effects of intercropping on disease control and the build-up of inoculum in the soil. The objective was to increase crop yield and also to permit a more efficient method of selection of plants for conservation of tubers as seed, in situations where roguing is not considered acceptable by farmers.
Two major sources of bacterial wilt inoculum exist: infected tubers and infected soil, either through the presence of free-living bacteria or through their presence on potato plant debris. Infected tubers, particularly where the infection is latent, are a major source of dissemination between fields and between seasons. Research into methods of controlling the disease have thus tended towards the investigations on the effect of latent infection of the tuber on the spread of the disease. Methods, such as selection of site, crop rotation and even roguing, are not practised on the very small, intensively cultivated farms of the area, where food is at a premium.
Until such time in which resistant or highly tolerant varieties become available, the use of clean seed, must be considered the principal method of reducing the level of infection. Such a philosophy depends upon the production of adequate quantities of clean seed, the establishment of a new tradition to ensure that only clean seed is planted and a low level of soil infestation. Whilst small quantities of clean seed are now available, it is always likely to be in limited quantities and at a price that farmers cannot afford each season. Thus, until the appropriate varieties become available, methods must be found to enable farmers to keep the inoculum potential in their land as low as possible and enable them to enhance their chances of selecting

clean seed. This suggests that more research is necessary on the spread of the disease within a crop.
Since roguing does not appear to be acceptable to farmers, an alternative method may be to intercrop potatoes with crops not susceptible to race 3 of *P. solanacearum*, since isolation of the potato plants, spatially and by the presence of immune species between them, should reduce root-to-root spread.
The experiments discussed here were carried out on a free draining sandy loam, situated at 2100 m above sea level. Mean temperatures range between 14° and 18°C (average mean maximum 20° to 24°C; mean minimum 10° to 13°C). Total precipitation in the range 1400 to 1700 mm per annum is bimodally distributed, with peaks in November and April, and a dry season from mid-May to mid-September.
The experiments with bacterial wilt (*Pseudomonas solanacearum*) race 3 showed that the practice of intercropping potato with maize or haricot beans markedly reduced the incidence and rate of disease development in the potato crop. This reduction in disease was considered to be an effect of the increased distances between individual potato plants, their spatial arrangement and the presence between potato plants of root systems of other plant species, all of which resulted in a reduction in plant-to-plant transmission, via the roots. The lower potato plant population associated with intercropping resulted in a slower rate of inoculum build-up in the soil and the presence of an intercrop further markedly reduced the inoculum build-up. Where farmers retain tubers for seed, but where roguing of diseased plants is not practised, the isolation of plants through intercropping was considered to facilitate an efficient selection of healthy tubers.

458 89 - 10/45

Plant protection
Africa, experiments, cotton, soybean, bambarra groundnut, Striga, trap crops, screenhouse, intercropping
PARKINSON, V. et al.
Cultures Pièges Permettant de Lutter Contre *Striga* en Afrique (Trap crops as a cultural measure in *Striga* control in Africa).

FAO Plant Prot. Bull., 35, 2, 1987, pp. 51-54

The effects of *Striga* infestation on crop losses in the savannahs of Africa cannot be over-emphasized. Yield losses in sorghum and millet have been estimated to range from 20 to 100 percent; total crop failures have in some cases resulted in relocation of villages. In maize yield reduction, even under good management, has been estimated at 20-90 percent.
These limitations to cereal yields have had serious socioeconomic consequences in many parts of Africa. The problem is further pronounced as new areas are brought under intensive cultivation and Striga seeds are dispersed both by grazing cattle in search of more fertile land and by contaminated crop seeds brought by farmers forced to migrate because of problems such as desertification.

Striga species produce several thousands of microscopic seeds which can remain viable in the soil for up to 20 years. Germination of these seeds takes place only in response to chemical compounds exuding from the host root. The germ tubes then make contact with and penetrate the host root cells, extracting nutrients and moisture from the host, which results in a pathological effect with serious yield loss.
In the absence of a vulnerable host root, the seeds die shortly. Several farmers interviewed during a survey of *Striga* species in Benin and Togo confirmed that the level of infestation was always lower in a cereal crop planted after cotton. In laboratory experiments, cotton seeds always stimulated seeds of the parasite to germinate in vitro, after which they were unable to penetrate and colonize the host root cells. In areas where it can be grown, cotton is thus a desirable crop for controlling *Striga*.
Another logical trap crop might be soybean. Soybean would be planted after and harvested before maize in many environments, and thus the labour requirements of the two crops are complementary. In addition, the maize yield following soybean may be increased because of residual nitrogen contributed by the soybean. Additionally, the high lysine in soybean complements the low lysine in maize. Thus, the two together produce a high-quality protein for both human nutrition and animal feed.
Most *Striga*-infested areas already have a high level of parasite seed in the soil. Yield loss is thus due to more than just the competition for environmental factors (nutrients, moisture, light) triggered by non-parasitic weeds. It is, therefore, essential to look at control measures that aim to reduce the level of *Striga* seed inoculum in the soil in areas where varieties with a level of tolerance to *Striga* are not yet available.
Studies of three methods for reducing the level of Striga inoculum in the soil are reported here, namely:
- screening of trap crops for use either in association or in rotation with cereals to reduce *Striga* seed population;
- field assessment to determine the effect on *Striga* of soybean intercropped with or in rotation with maize; and
- the effect of successive cropping of soybean for three years on the presence of a Striga in a subsequent maize crop.
Results indicated that these crops had the potential to reduce the Striga seed population in the soil. Three years'continuous cropping of soybean in plots originally heavily infested with Striga showed a reduction of the population of the parasite in a subsequent maize (*Zea mays*) crop. Finally, the *Striga* count in maize intercropped or rotated with soybean was much lower than in maize alone.
It now remains for these potential trap crops to be tested in other ecologies with different *Striga* species and morphotypes, and ultimately to be demonstrated to the farmers that this approach offers a solution to the problem.

459 89 - 10/46

Plant protection
Latin America, Honduras, study, sorghum, maize, cropping systems, fall armyworm, natural enemies
CASTRO, M.T. et al.
Populations of fall armyworm, *Spodoptera frugiperda* (J.E. Smith), larvae and associated natural enemies in sorghum and maize cropping systems in southern Honduras.

Trop. Agric. (Trinidad), 66, 3, 1989, pp. 259-263

Sorghum is generally intercropped with maize on small farms in Honduras because it tolerates an adverse environment characterized by erratic rainfall, high temperatures and low soil fertility. When the maize crop fails from drought, resource-scarce farmers often substitute sorghum grain for maize in making tortillas to feed themselves and their families; and the grain and crop residues are fed to livestock.
The intercropping of late maturing, photoperiod-sensitive sorghums with early-maturing maize varieties effectively utilizes the limited land available and soil moisture and nutrients by staggering the reproductive phase of the two crops to reduce competition between them during their respective growth and development.
The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is a principal constraint to sorghum and maize production in southern Honduras. It can cause yield loss by defoliation or as a cutworm by killing plants during the seedling growth stage. The larvae also feed on the grain, but on-farm observations in Honduras suggest that other lepidopterous species are more important as grain feeders. In most agricultural systems lower herbivore populations are observed when one crop species is interplanted with other crop species or intermingled with weed communities.
Since sorghum-maize intercropping is prevalent in Honduras and because maize is more attractive than sorghum to FAW moths for oviposition, the influence of component crops in spatial arrangements and in pure stand on FAW infestations was investigated. Fall armyworm infestations were measured in sorghum and maize in pure stands, sorghum-maize intercrops, pure stand sorghum with a maize trap crop to isolate larval infestations for spatially limited application of control measures, and in a weed-infested sorghum planting system to determine the influence of weeds on FAW infestations. Additionally, parasitization of FAW larvae was determined in the different sorghum and maize cropping systems in southern Honduras. Possible explanations for the observed results and proposals for future studies are presented.
A nematode (Mermithidae) was the most common parasite of the FAW in both years. Parasitization (up to 71%) of larvae by this endoparasitic nematode increased as rainfall increased; precipitation accounted for 93% of the variation in parasitization.

460 89 - 10/47

Plant protection
Latin America, Nicaragua, experiment, intercropping, cotton, maize, beans, weeds, oviposition, green lacewings
SCHULTZ, B.B.
Reduced Ovipositon by Green Lacewings (*Neuroptera: Chrysopidae*) on Cotton Intercropped with Corn, Beans, or Weeds in Nicaragua.

Environmental Entomology, 17, 2, 1988, pp. 229-232

Crop diversification is well known as a potential method for increasing beneficial insect populations in agroecosystems. Crop diversity may be increased by planting more than one crop species in alternate rows or hills within rows (i.e., intercropping, or polyculture), by planting in bands of several rows of each crop (i.e., strip cropping), or by reduced weed control. Entomophagus insect populations may thus be increased if the additional plant species provide them with additional food sources (e.g., alternative prey species, nectar, and pollen) or microhabitats, or both.
Populations of green lacewings (*Neuroptera: Chrysopidae*; mainly Chrysoperla spp.) have been increased in cotton strip cropped with sorghum, corn, or alfalfa. Relatively little work has been done with lacewings in intercrops, where the crop species are planted more closely together. Yet polycultures often offer additional advantages in terms of higher yields, greater stability in yields, and better use of labour and resources.
Nicaragua is currently seeking ways to optimize both the production of cotton and of basic grains (mainly corn, beans, and sorghum), and lacewings are often the most frequently observed natural enemy in these crops. There is also general interest in the potential advantages of reduced tillage, with more limited control of weeds, as well as in integrated pest management. In this paper, results of a study of lacewings populations, as measured by counts of eggs, on cotton planted in monoculture and in polycultures with corn, dry beans (*Phaseolus vulgaris*), or weeds, carried out near Managua, Nicaragua, are presented.
This study was conducted without irrigation during the 1985 rainy season at the Plantel, an experimental farm located near Tipitapa. Major crops in this area are cotton, sorghum, and corn. The rainy season in Nicaragua normally extends from May to November, with a short dry spell in late July and early August. One cycle of rain-fed cotton is usually planted in the Managua region in early July and harvested well after the dry season starts in December. Grain crops are grown from May to August or August to November, or both, and may be grown in the dry season under irrigation.
Significantly fewer eggs were found on cotton plants intercropped with corn and weeds than in cotton monocultures, but cotton plants tended to be smaller in intercrops. The lower egg numbers in cotton intercropped with corn or weeds were significant when adjusted for differences in leaf number per cotton plant and mean cotton leaf area, but not significantly lower on cotton intercropped with beans. Mechanisms are suggested to explain the

reduction in egg numbers in the intercrops, including a decrease in the numbers of prey (aphids) and the presence of other predators.
One potential drawback of this study was that the area between blocks was weedy. If there were any beneficial effects of plant diversity (in this case, weeds), vis-à-vis lacewings or other predators, such effects could have spilled into all plots, causing any advantages of polyculture treatment over monocultures to be overwhelmed and obscured. Thus large-scale polycultures might still be expected to show advantages over monocultures.

461 89 - 10/48

Plant protection
USA, study, integrated pest management, multiple pests, soybean, model, multiple stress factors
BARFIELD, C.S. et al.
Major problems with evaluting multiple stress factors in agriculture.

Trop. Pest Management, 33, (2), 1987, pp. 109-118

The purpose of this paper is to stimulate thought on several issues of relevance to modern crop protection scientists worldwide. First, it is known that diverse plant and animal stresses act in ecological concert in nature; yet, the discipline orientation of most scientists evades evaluation of simultaneously acting stresses. Many statistical analyses can rank stress effects but cannot capture the nuances so often providing ecological insight and, thus, more sustainable management strategies.
Despite advances in the use of modelling as a tool to gain biological insights, agriculturists remain virtually of any ability to evaluate the consequence of multiple stress factors, acting simultaneously, on crop systems. If readily available, ability to design management strategies for complexes of pests would be closer to reality.
Agriculture has made progress in abilities to design relevant and more sustainable pest management strategies. Yet, there remain major discrepancies between the principles and practices of IPM. Farmers still obtain crop protection advice along unilateral discipline lines.
This paper presents simulations run with the Soybean Integrated Crop Management (SICM) model under various combinations of pests, water availability, pesticide regime, value for economic threshold, scouting interval, and cost of management operation. These are relevant parameters for all pest management specialists, and apply regardless of culture or economic status of target farmers.
The physiologically-based, validated soybean plant growth model at the core of SICM has provided a framework for coupling effects of multiple stresses at a process level. Combined stress effects from water and three insect species are presented in real economic context relative to soybean growers. The framework is now in place

for adding stresses from weeds, foliar pathogens and nematodes. This approach offers insights into the experimental designs, analyses and potential uses of integrated pest management strategies developed by interdisciplinary scientists; yet, major problems exist in acquisition of model validation data. Conceptual and experimental dilemmas associated with these type efforts are outlined herein.
The ecological system being modeled is complex, not simple. To be serious about simultaneous evaluation of multiple stress factors means more, not less, ecological detail. Validation studies in any particular space and time may not be subjected to the broad range of stresses for which the model was built to cope. This literally means that validators must choose a variety of fields in space and time so that, in combination, they encompass the broad range of stresses and climatic conditions required by the model. In each such field, the above data sets would be required. It is not hard to understand why so few multistress, validated models exist as aids to farmer decision-making. Such requisites are enormous compared to nicely controlled experiments which lend themselves to routine statistical analyses. This is not a complaint; rather, it is a realization which has come from several years of present attempts, and it illustrates what others who profess to be working in interdisciplinary modes toward improved pest management strategies should be comtemplating.

462 89 - 10/49

Plant protection
Africa, Senegal, farmer, experiments, cowpea weevil control
PIERRARD, G.
Control of the cowpea weevil *Callosobruchus maculatus*, at the farmer level in Senegal.

Trop. Pest Management, 32, (3), 1986, pp. 197-200

In Senegal farmers grow cowpea as a food ingredient rather than as a staple. Therefore, the amount of seeds stored by each farmer is not high, about 100-200 kg, but the desired period for storage is very long, up to 10 months. This cannot normally be achieved due to heavy attacks by the cowpea weevil, *Callosobruchus maculatus*, which is the sole insect pest of this stored grain legume in Senegal and all over the Sahelian region. Damages caused by this insect are such that they tend to limit the development of cowpea growing as the grains rapidly become unsuitable for marketing and consumption.
The effectiveness of several insecticides has been tested in two experiments with cowpea samples, and the most effective among them underwent a pre-extension test in villages. Effectiveness controls were periodically made during the test. One of the obvious conditions for the use of the insecticide was that there should be no health hazards.
The groundnut oil treatment and the fumigant carbon tetrachloride failed to give control of this pest. Among eight tested active

ingredients commonly used to protect stored foodstuffs, the pest results were obtained with pirimiphos-methyl. This insecticide treatment at 12.5 ppm has been extended in two farmer pilot area of the Sahelian zone, and is efficacious for six months. In the future, resistant varieties and the use of local plant substances to control cowpea weevil could be alternative control methods or part of integrated pest management.

463 89 - 10/50

Plant protection
Africa, Uganda, experiments, beans, cowpeas, maize, bean flower thrips, planting density
KYAMANYWA, S. and E.M. TUKAHIRWA
Effect of Mixed Cropping Beans, Cowpeas and Maize on Population Densities of Bean Flower Thrips, *Megalurothrips sjostedti* (Trybom) (Thripidae).

Insect Sci. Applic., 9, 2, 1988, pp. 255-259

Entomological studies have indicated that some crop mixtures are characterized by a lower incidence of herbivorous insects compared to sole crops. These and other findings hold the promise that mixed cropping could become a component of integrated pest management (IPM) in tropical countries. This could reduce the trend of increasing dependence on insecticides which are environmental hazards. To fulfil this objective, however, crops to be mixed will have to be selected carefully in order to get combinations and cropping densities that significantly reduce insect abundance. As the authors point out, this will require detailed information on insect/crop interactions in order to indentify those crop combinations which are both agronomically and entomologically more advantageous than individual sole crops. A review of literature indicates that this information is generally lacking for the control of *M. sjostedti*, and the present paper deals with a study aimed at ascertaining crop combinations that significantly reduce pest populations, or indeed those crop combinations that increase the severity of pest damage on each other, and must therefore be excluded from any IPM strategies.
Mixtures of beans, cowpeas and maize were used because these are quite common particularly in Uganda where the work was carried out, but the mixtures are also widespread in the whole of East Africa. Throughout the region, *M. sjostedti* often becomes a major pest of cowpeas and beans, especially whenever their growth coincides with a dry spell.
The experiments were conducted at Makerere University Farm, Kabanyolo, and planting was timed to coincide with the rainy season so as to obviate the need for irrigation. Crop varieties used were those grown locally namely, Kawanda Composite Maize, Emma Cowpeas, and Nambale Beans.
The experimental design was a split plot of 18 subplots of 10 x 10 m each; the subplots carried mixtures of either cowpeas and beans, cowpeas and maize, beans and maize, cowpeas, beans and

maize, or sole-crops of either cowpeas or beans. Each treatment was thus replicated three times. Within the mixed crop plots, crop mixing was formed using the de Wit replacement series technique. For each crop mixture, three different intra-row planting densities were used.
The results show that the level of infestation by *M.sjostedti* in bean or cowpea crop in the cropping patterns used is influenced by the host plant density, and the presence and density of non-host plants. The higher the cropping density, the greater was the level of infestation. The explanation for this is probably simply that the more host plants there are per given area, the greater is the available resource for exploitation by thrips, and therefore the greater their density becomes. This reasoning would explain the lower pest densities recorded for planting densities lower than the optimum.
The results also indicate that the practice of mixed cropping beans with cowpeas, which is common in parts of Uganda, confers no advantage to either crop with respect to attack by *M. sjostedti*. On the contrary, the present data indicate that combining the two crops generated infestation levels similar to those produced by either crop grown in monoculture.
A good pest managment strategy for this pest, therefore, would appear to be the encouragement of non-host-plant-based mixtures of either the beans or cowpeas, and certainly to discourage the present practice of growing either crop in monoculture or combining the two in one stand. This strategy would not be unique to these particular crops and associated pests.
The results of this experiment show that *M. sjostedti* infestations tend to reach their peak during flowering. The crops at their flowering stages, therefore, obviously deserve maximum protection if a good yield is to be realised. This is then the stage when pesticide application can be most beneficial. In the context of IPM, therefore, it would appear that any insecticide applications to control *M. sjostedti* prior to the flowering stage of the crop would not only be less beneficial in increasing yield returns, but such a practice would also merely have adverse effects on the environment.

XI WATER MANAGEMENT

464 89 - 11/7

Water management
Review, article, water harvesting, traditional techniques
SPORE
Water harvesting: reviving ancient techniques.

Spore, 13, pp. 4-6, 1988

The two features common to all water harvesting systems, whether ancient, traditional or modern, are the catchment area and the storage area, or reservoir. Ideally the surface of the catchment area should be impervious to water to allow maximum run-off to occur. In some cases such catchments occur naturally, but in others the catchment surface is treated to improve run-off or an artificial surface may be used.
In less favourable situations run-off can be increased by smoothing and compacting the soil surface. An example is the roaded catchment system, widely used to collect water for livestock in Western Australia. Here road construction equipment is used to compact and camber the soil surface, to form a series of parallel roads measuring between 5 and 12m from crest to crest, on a stretch of sloping ground between 50 and 300 m long. Storm water collects in the furrows between the roads and flows into a channel at the lower end of the catchment, from where it is led into a reservoir.
Soil surfaces which have been compacted for other reasons, such as roads, airstrips and school playgrounds, can sometimes be exploited to provide run-off water for crops or livestock. Careful design and regular maintenance is necessary to avoid soil erosion with compacted catchments, although in some systems the washing down of soil can be beneficial by filling up small depressions in the catchment surface and building up soil fertility in the area where the crop is grown.
Run-off water once collected has to be stored. In most of the traditional systems described, where the water is used for growing crops, the storage area is the soil itself. Deep water-retentive soils are therefore ideal. But if the soil is very free-draining, evaporative losses are high, run-off is excessive or if the water is to be used for cattle or domestic purposes, then a surface reservoir is needed for storage.
Such reservoirs may range from simple pits dug in the ground, sealed by pudding with clay, to more substantial tanks and cisterns. Water losses as a result of evaporation can be reduced by covering the surface of the reservoir with materials such as wax, polystyrene or foamed rubber sheeting.
At the Desert Runoff Farm Unit in the Negev Desert, some of the ancient run-off farming systems have been carefully re-created and now serve as experimental farms. Here, where the scanty and unpredictable rainfall is less than 200 mm a year, a tremendous range of crops has been successfully grown using harvested water

alone. These include grasses and cereals (such as wheat, barley, sorghum and millet), legumes (lentils, chickpeas and novel varieties of beans), grape vines, soft fruit (logan berries) and fruit, nut and fuelwood trees (plums, apricots, peaches, pomegranates, cherries, apples, figs, olives, pistachios, Acacia, Prosopis, Leucaena and Eucalyptus).
In good years yields are comparable with crops grown in irrigated conditions but even in drought years there is usually some yield. Cereals, almonds, pistachios and olives do particularly well. Annual crops which are quick maturing (such as millet) or deep rooting (such as Sorghum) and perennials which can tolerate both drought and occasional inundation are those which do best.
Existing schemes show that water harvesting can do much to improve conditions in drought stricken areas.

465 89 - 11/8

Water management
Review, tropics, developing countries, rainfed agriculture, limitation, potentials, future development, traditional systems
BARROW, C.J.
The present position and future development of rain-fed agriculture in the tropics.

Outlook on Agriculture, 17, 3, 1988, pp. 113-119

Recent estimates suggest that 18 per cent of the world's cropland is irrigated: the rest is rain-fed, of which perhaps a fifth is under shifting cultivation.
Techniques which can be used to improve soil-moisture availability are listed in detail in this paper.
The goal of "direct" rain-fed cultivation is to capture the maximum amount of moisture in the soil and to retain it there for as long as possible to support crops. Rain-fed farming productivity depends heavily on crops that are suited to local rainfall conditions and on the careful timing of their cultivation.
Much of the world's cropland is sloping. Wherever this is the case and rainfall does not quickly infiltrate there is likely to be runoff - namely that portion of rainfall which is neither absorbed into the ground, nor stored on the surface, nor evaporated, but which flows over the land and may be collected from a larger area than that cropped or grazed. This concentration may result from natural conditions or deliberate action by farmers. A wide range of "indirect" rain-fed farming strategies rely upon catching runoff (rainfall collection).
Rain-fed cultivation is widely practised by small farmers, some may also use irigation: a common strategy is to subsist on irrigated rice and to grow a rainfed cash crop.
In Asia as a whole about 10 per cent of rice is rain-fed. Rain-fed rice seldom yields more than 700 kg/ha/y, and as irrigated rice often exceeds 3000 kg/ha/y, there is clearly much scope for improvement.

There has been considerable expansion of rain-fed cultivation since 1918 into tropical and subtropical "marginal lands", much in the form of large-scale, commercial, mechanized wheat and barley production. In many regions where rain-fed-cultivation is practised, crop yields are decreasing due to "development pressures" and, perhaps, environmental change. Not only are yields often decreasing, in many parts of the world the ability to sustain production is under threat because of land degradation (soil erosion, salinization, loss of fertility, etc.).
The maintenance of fertility of rainfed cropland is vital if cropping is to be sustained; also soils which have adequate organic content hold more moisture than degraded soils. Most of the fertilizer used in the tropics is used by irrigated agriculture. Appropriate artificial fertilizers and "green manures" (including the growing of nitrogen-fixing crops) and strategies for their use have to be developed for tropical rain-fed farming. In addition, there is scope for more integration of livestock production and rain-fed cropping.
It is probably worth developing rainfall collection agriculture in areas with at least 300 mm/y and, ideally, 500 to 600 mm/y rainfall.
Promising rain-fed cropping strategies are being developed. Agro-forestry and alley croping have great potential for maintaining soil fertility, reducing soil erosion, and, by creating a favourable microclimate, improving moisture availability.

466 89 - 11/9

Water management
Review, developing countries, irrigation systems, farmer, management, resources, public policy
COWARD, E.W. and E. MARTIN
Resource Mobilization in Farmer-Managed Irrigation Systems: Needs and Lessons.

In: Technical Papers from the Expert Consultation on Irrigation Water Charges Vol. I, FAO/USAID, Rome, Italy, 1987, pp. 177-190

There is presently widespread interest in the topic of appropriate government funding for irrigation development, including both the initial and continuing costs. With restricted budgets, and a worldwide ethos of reduced government involvement in various sectors, there is increased interest in inducing the mobilization of irrigation development resources in the private sector.
In most instances concern with mobilizing resources for irrigation development has focused exclusively on that sector of irrigated agriculture served by the hydraulic works owned and operated by the State.
There has been less attention to the matter of resources for the irrigation that lie outside the State sector and are managed by farmers themselves, the farmer-managed irrigation systems (FMIS).

In a number of countries, FMIS serve a very significant portion of the national irrigated command.
FMIS represent important cases of farmer mobilization of resources for both system development and system operation. In this paper two important public policy questions related to mobilizing resources for irrigation development have been explored. The first question deals with the matter of appropriate public policies in support of the resource mobilization processes that already occur in many FMIS. The importance of reexamining present public policies for assisting FMIS has been noted, some of which have the effect of discouraging continued resource mobilization by these groups. The second question dealt with is the relevance of resource mobilization processes in FMIS as a model for increasing resource mobilization in State-operated systems. On this point, it has been noted that farmers were likely to increase their mobilization only if they were granted more involvement in and control over both operations and maintenance activities, and in cases where construction is being planned, involvement in design and layout as well as construction activities. In short, increasing resource mobilization by farmers in State systems needs to be complemented by significant farmer control of selected activities of those systems.

467 89 - 11/10

Water management
Asia, India, irrigation systems, study, economics, semi-arid tropics, smallholder, farming systems research
ENGELHARDT T.
Economics of traditional smallholder irrigation systems in the semi-arid tropics of South India.

Diss. Institut für Agrar- und Sozialökonomie in den Tropen und Subtropen, Stuttgart-Hohenheim, 1984, 173 pp. + Annex

The climate of the semi-arid tropics of Southern India is characterized by highly erratic rainfall. Owing to transpiration, the crops' large water requirements, and the shallow soils with, little water-retention capacity, water is one of the restrictive factors for crop production on alfisols.
Irrigation may be capable of overcoming this constraint caused by limited water. The net income from rain-fed crops (sorghum mix) is only 16% of that from wetland crops (paddy). In addition to its effects upon production, irrigation also has a considerable impact upon employment: 1 ha of paddy requires 7.7 times as much labour input as 1 ha of rain-fed sorghum mixtures. The same area of irrigated dry crops (groundnuts) requires 4.3 times as much labour input as rain-fed sorghum mix but provides a net income which, on an average, is 4.5 times greater.
The traditional sources of irrigation in the hard rock regions of Southern India are open dug wells and surface reservoirs (tanks). The wells' water yield is sometimes improved by means of in-well bores. The area irrigated by tanks has been declining while that

irrigated by wells has increased considerably. Since 1950 the area under well irrigation has risen by 148% while the area under tank irrigation has fallen by 6%. The wells are usually rectangular. They are excavated manually and have an average volume of 772 m3. The water is generally raised by electric pumps. An open dug well may irrigate several hectares, depending upon the amount of available water, but the average area irrigated from open dug wells in the survey region is 2.5 ha per well. The cropping intensity with well irrigation is 114% with paddy as the main kharif crop (28%). During the rabi other crops, such as groundnuts, vegetables and wheat, are grown with paddy (19%) in the well command area. Paddy's total water requirements are 14 mm/day during the kharif and 19 mm/day during the rabi. The value of an open dug well is determined by its volume but averages 24,800 Rs (1982prices). Investment in wells is profitable for the farmers: using market prices for the costs and benefits, the IRR averages 14%.

Surface reservoirs (tanks) are not so popular with the farming community: they occupy valuable land and it is difficult to arrange equitable distribution of the water. Wasteful application of water is common. Surface reservoirs do, however, recharge the ground water; although the infiltration from reservoirs varies according to the ground water level, the filling and the water depth in the reservoir, it was possible to estimate from field survey data that traditional tanks have a seepage rate of 0-15 mm/day. Newly-built reservoirs may supply an average of 8-40 mm/day percolation water to the ground water.

Since the farmers greatly prefer open dug wells as a reliable and flexible source of water, the number of wells is rapidly increasing. The individual well-owner does not maximize the current value of the community-owned resource - ground water - over a period of time but uses the water as if its marginal value equals the variable cost of raising it. Consequently, ground water is overdrawn in various parts of Southern India and its level is falling at a disturbingly rapid rate. So water becomes more expensive to raise. Well-deepening requires additional investment and sometimes the wells run dry.

Surface reservoirs and wells should be regarded as a single unit for supplying irrigation water. This composite watershed management system makes it possible to combine the benefits of privately-owned open dug wells with the advantages of surface reservoirs (ground water recharge).

The complexity of the water balance and the reciprocal influence of irrigation, cropping pattern and the hydrological infrastructure in a region make it necessary to prepare a model for the system which combines all the important elements.

A discrete stochastic linear programming model was designed which permitted optimization of agricultural production in an alfisol watershed in the hard rock region of the SAT in Southern India.

The model results indicated that the profitability of artificial ground water recharge by means of percolation reservoirs depends to a very large extent upon how much ground water is drawn. With a low well density (e.g. 5 wells/100 ha) a composite watershed management system, as described in this study, has little effect

upon production and employment, but an increase in the well density, will make it profitable to build percolation tanks. An increase in production and in employment opportunities can be expected. It was possible to quantify the impact of artificial ground water recharge upon risk in an E-V context. Yet the cost of building percolation tanks should not exceed 3 Rs per m3 of storage volume; if it does, the opportunity cost of the submerged arable land plus the construction costs are greater than the benefit of additional ground water.

The system of percolation reservoirs combined with wells makes it possible to employ a simple management tool which may help to control over-drawings from the ground water. Since almost all the wells are operated by electricity, any increase in electricity prices should induce more judicious use of the water by the farmer. The model demonstrated that parametric changes in electricity prices within a realistic range causes a downward-sloping demand curve for water.

Watershed management should take account of the dynamic nature of a developing irrigated agricultural system. In the initial stages, private enterprise for well-digging could be encouraged and supported by employing scientific methods to search for ground water. Ground water recharging structures (percolation reservoirs) should not be built until the ground water becomes limited. If the well density is further increased and irrigable land rather than water becomes a major constraint, a rise in electricity prices combined with the consequent change in the cropping pattern from wet to dry crops should be envisaged.

Needless to say, some aspects of agricultural production - particularly the dynamics of ground water flow between the surface and the aquifer - could not be satisfactorily expressed in the model. Nor was it possible to include contraints such as crop rotations, labour availability, home consumption, etc. Consequently, the model results do not fully reflect the real situation and especially with regard to paddy production in lowlying areas. Further research could incorporate these constraints to give the model more actuality and to obtain more realistic results.

Discrete stochastic linear programming models offer the possibility of transforming pay-offs into suitable utility levels but this operation requires a utility function and thus knowledge of the decision-maker's risk preference. Analysis of a real farm decision (in-well boring) showed that most farmers are averse to risk with a partial risk aversion coefficient of 0.87062. The absolute risk aversion averaged 0.00016 with negative correlations to wealth, even though the coefficient was not significant.

Further research should endeavour to establish a utility function which is defined for losses and makes it possible to accomodate higher moments besides mean and variance. That utility function should then be incorporated in the model so that pay-offs can be transformed into utility measures.

A composite watershed management system seems to offer promising prospects if it is analysed by employing the discrete stochastic linear programming model developed in this study. It may, however, prove beneficial to combine agricultural optimization models with

hydrological simulation models which provide a more consistent definition of the hydrology and especially the water flow. In addition, on-going percolation tank construction programmes should also be monitored so that their effect upon the ground water and agricultural production, income and employment can be measured.
Author's summary

468 89 - 11/11

Water management
Asia, Thailand, study, technical paper, irrigation design, management, constraints, on-farm development
PLUQUELLEC, H.L. and T.WICKHAM
Irrigation Design and Management - Experience in Thailand and its General Applicability - .

World Bank Technical Paper No. 40, Washington, D.C., USA, ISBN 0-8213-0532-08, 1985, 68 pp. + maps

The degree of performance achieved in managing irrigation projects depends on a number of physical, social and institutional factors and to a large extent on the basic physical infrastructure provided. The first four chapters of this paper examine how these various factors affect the irrigation system performance in one country - Thailand - which has a long history of irrigation. The paper first briefly describes the physical characteristics of Thailand which affect irrigated agriculture, then gives an overview of Thailand's irrigation development and the objectives which have determined system design, and finally analyzes the various factors now constraining system performance throughout the country.
The concluding chapters explore the general topics of main system improvement and tertiary system development, and are implicitly aimed at the controversial question of whether irrigation performance can be improved solely through improved management or whether physical facilities need to be upgraded as well. This section of the report reviews the main approaches now available to improve canal system management in new and rehabilitated projects. It indicates that each approach has different managerial and financial requirements and should not be used indiscriminately. The paper goes on to examine the impact of design and management on water distribution at the farm level and the relation of the tertiary system to the main system. In general, the paper finds that management alone may not substantially improve irrigation performance but, if combined with physical improvements at a modest cost, it may have a major impact on performance.
The paper can be of interest to irrigation project planners, designers and managers since the lessons learned from the Thai experience are applicable to many countries, particularly those in the humid tropics. The paper also provides a general review of the technological and other options available to improve irrigation system performance and thus has widespread applicability.
Author's summary, amended

469 89 - 11/12

Water management
Africa, Nigeria, study, semi-arid zone, farming systems research, smallholder productivity, irrigation, agriculture, water supply, crops, yield
EZIAKOR, I.G.
Towards Improving Smallholder Productivity: The Case of Irrigated Agriculture in Bauchi State of Nigeria.

Agric., Admin. & Extension, 30, 1988, 269-279

Especially in the arid and semi-arid regions of Nigeria, the unreliability and erratic nature of rainfall patterns clearly demonstrate the imperativeness of providing supplementary water supplies for irrigation purposes. Although the supply of water is recognized as a fundamental prerequisite for crop production, studies show that the moisture demand for crop growth and development is not evenly spread over the length of the growing season. While consumptive use is low at the beginning of the growing season, it increases as plant foliage develops and expands as the days become warmer. But the demand for water by most arable crops reaches its peak during flowering and fruit formation, and rapidly declines again during ripening.
The overwhelming majority of the farming population in Bauchi State consists of small-scale, peasant farmers and their families whose accessibility to a variety of improved technologies and agricultural innovations is severely limited.
Since water supply has been identified as a limiting and usually costly production resource, especially in semi-arid and drought-prone areas of Bauchi State, it has become necessary to analyse the general strategies for planning irrigation for the maximization of crop yield per unit of water applied.
In general, the degree of accessibility of small farmers to supplementary water sources for irrigation is remarkably low, with less than 10 per cent of the sampled population having access to, and, therefore, utilizing, supplemental water supply for cropping. However, even though the farmers who applied irrigation realized consistently higher yields than those who did not irrigate their crops, the yield differences were not statistically significant at the 5 per cent level.
The following observations and recommendations are considered important:
- There is a substantial scope for increasing productivity and aggregate food production through the promotion of small-scale irrigation based on ground water development, utilizing either hand-operated or small-motor pumps.
- A profitable irrigation practice is one that is not only adapted to the nature of the crops(s) being grown, but is also integrated with the prevailling soil, climatic, and socio-economic conditions of the specified agro-ecological zone.
- In the semi-arid and drought-prone areas of Bauchi State where

water scarcity is usually a limiting production resource, it is essential to plan irrigation so as to maximize crop yield per unit of water applied. Thus irrigation water should be applied only at such times and in such precise quantities as to produce the desired crop growth and development.
- Proper irrigation practice cannot be seen as a substitute for, but only complementary to the provision of a package of improved production technologies (including improved seeds and crop varieties, fertilizers, herbicides and pesticides). Access to irrigation can only be beneficial to smallholders if other production constraints (such as access to credit, improved harvesting , storage, processing, transport, and marketing) are eliminated.

470 89 - 11/13

Water management
Review, manual, developing countries, irrigation schemes, smallholders, maintenance, operation, water distribution, on-farm, off-farm, drainage, health, management
STERN, P.H.
Operation and Maintenance of Small Irrigation Schemes.

Intermediate Techn. Publ. Ltd., 103/105 Southampton Row, London WC 1B 4 HH, UK, ISBN 0-946688-74-5, 1988, 36 pp.

Currently world-wide attention is being given to the poor performance of so many irrigation developments, including both well-established schemes and new projects.
The quality and organization of maintenance can be the single most important factor in the success of irrigation schemes. This short, practical manual deals with the problems of operation and maintenance at the source of supply and in the conveying of water in pipes or open channels. Water distribution is described both on- and off-farm and the maintenance of irrigation systems and devices - and advice is given on drainage, health and general management problems.
The book contains the following chapters:

This book has been written to supplement the author's "Small-scale Irrigation" which was first published in 1979, and is intended for those who are concerned with the development of irrigated cultivation on a small scale, with limited technical and financial resources.
This book will make some contribution to the success of small-scale irrigation.

471 89 - 11/14

Water management
Review, developing countries, tropics, irrigation, water management, agriculture, agroecology, basin irrigation, furrow irrigation, soils, cropping systems, sustainability
PLUSQUELLEC, H.
Crop Diversification in Irrigated Agriculture: Water Management Constraints.

In: World Bank 7th Agric. Sect. Symp.: Sustainability Issues in Agric. Developm., Washington, D.C., ISBN 0-8213-0909-9, 1987, pp. 313-321

This paper deals with the physical constraints imposed by the irrigation system both at the distribution level and a farm level. The issue of crop diversification will be limited to surface irrigation which is the predominant method used for more than 90

percent of the 275 million ha currently irrigated in the world. In the vast areas of lands irrigated in Asia surface irrigation methods are used almost exclusively for both paddy and upland crops. The scope for pressurized irrigation will remain limited to very high value crops in specific areas. Conversion to drip and sprinkler methods will progress slowly and where it will take place, diversification to non-paddy-crops will be irreversible. In sum, surface irrigation will remain dominant in the foreseeable future.
This paper reviews the different water requirements of paddy and upland crops and reviews the general technical features of the two dominant surface irrigation methods, basin and furrow irrigation used in developing countries. Then the paper discusses the issue of improving irrigation facilities to make possible the shift from paddy cultivation to other crops and/or the adoption of mixed cropping. This review will be limited to the aspects relevant to crop diversification and does not pretend to fully cover the above subjects even in a condensed form.
The issue of improvement/modernization of irrigation systems to permit crop diversification has been complicated by the sharp drop in projection rice prices that occured since 1982. The 1990 rice price projections dropped from about 600 US$ in 1982 to 339 US$ in 1984/85 and recently below 250 US$. Most of the rice irrigation project were viable in the early 80s including those for which all the infrastructure from storage or diversion works down to the on-farm water delivery works have to be built. Under the 1984/85 economic conditions, the viable investments in rice projects were those taking advantage of sunk costs in existing infrastructure.
The precise water control needed for diversified field crops requires in general extension of the tertiary networks, improvement and modernization of the main and distribution system, and in some areas improvement of the drainage and flood control conditions.
With the price projections, a detailed analysis of each project would be needed because of the sensitivity of the rate of return at these low rice prices. Investments required to improve the tertiary system together with improvement of the distribution system may no longer be jusified unless there is a substantial increase in yields (above 1 ton per ha/ and/or an increase in cropping intensity by making use of the water saved through more efficient operation). The conclusion is that in a number of cases the improvement of irrigation systems at both the tertiary and distribution level may not be economically justified for increasing rice production alone, without diversification to higher value crops. The investments required for crop diversification would have to be undertaken only when there is sufficient indication that all the other preconditions for crop diversification are met: market, marketing facilities, extension services, etc.

472 89 - 11/15

Water management
Africa, Subsahara, review, irrigation management, small-scale technology, NGO's, water use
VAN STEEKELENBURG, P.N.G.
Developments in Irrigation Management in Subsaharan Africa.

entwicklung und ländlicher raum, 2, 1989, pp. 20-21

In Sub-Saharan Africa where traditional rainfed production is in many countries becoming insufficient to feed the rapidly increasing population. Apart from agency-managed systems, the spontaneous development of small-scale simple technology irrigation is becoming a regular phenomenon. Non-governmental organizations are strongly involved in these self-managed operations. Presently, main themes are the emphasis on improving the results of existing schemes, the strengthening of water user associations, and efforts to reduce irrigation agencies' tasks and annual deficits.
As regards the management of these government-controlled irrigation systems, there is an increasing emphasis on self-management by the irrigators.
Very interesting results in delegating tasks to water co-operatives can be found in Niger, where delegation was preceded by political decision-making and farmer training. Increasing self-management is sought especially in the medium-sized and large irrigation systems where management problems are most evident (low yields, low intensity, low payment rates of water charges, rapid deterioration of the system, high annual costs to the government). One can say that at present attempts are being made to transfer the attractive concept of self-management, which was and still is successful in traditional and in small-scale systems, to large systems. One of the requirements is that the large system be converted into smaller-sized hydraulic units which can be fairly independently operated.
The main reason for this change is the soaring charge of recurrent costs to the government to keep the systems operating, and the low production levels. If farmers were to take more responsibilities while other tasks were delegated to the private sector, the generally large, overstaffed, bureaucratic Irrigation Agencies could become much lighter, could perform better the fewer tasks, and thus could become less expensive. If on top of that they could be converted from being static and mechanistic into being more customer-oriented and adaptive, the results in terms of effectiveness and reduced costs would even be better.
In recent years a quite spectacular growth of horticulture (especially vegetables) around capitals and other cities is to be noted. This "gardening" often starts as an off-season activity, and is mainly for urban supply with some for exports. This development has invariably started without any government initiative; very often non-governmental organizations (NGO) play an important role in such developments. "Gardening" is no longer limited to the immediate environment of cities: where enough water

and suitable soils can be brought together and as far as the transport infrastructure permits timely delivery to the markets, it can be found.
Many governments have come to realize that irrigation, as an increasingly important sector of the national economy, is in need of sector management and institutional co-ordination. In order to facilitate correct project selection, preparation, and scheme management, a policy is needed, and a planning framework has to be agreed upon and applied. This is one of the important steps needed to diminish the large number of external and internal insecurities and uncontrollable elements which irrigation management in Sub-Saharan Africa faces every day.

473 89 - 11/16

Water management
Asia, India, water conservation, soil conservation, research, contour farming, water collecting, recycling runoff, fuel-fodder plantation, technology transfer, ICRISAT, UNEP, sustained food production
DHRUVA NARAYANA, V.V,
Soil and Water Conservation Research in India.

In: Summ. Proc. of an Exp. Meeting, ICRISAT, India and UNEP, Kenya, ISBN 92-9066-115-1, 1986, pp. 23-24

In India, where population pressures on the land are high, rational utilization of soil resources assumes great importance for optimum and sustained food production. This involves proper land utilization, protecting the land from deterioration, building and maintaining soil fertility, conserving water for farm use, provision of proper drainage, flood protection and erosion control. Out of the 328 million ha of India's land area, nearly 175 million ha (whereas 140 million ha are under cultivation) are subject to soil erosion, out of which nearly 70 million ha suffer from serious hazards, such as sheet, gully, and hillside erosion. The Indian government has organized large-scale soil and water conservation programs. Beginning with contour-bunding programs in the early phases, the concepts of integrated land-use planning on a watershed basis were introduced through a chain of Soil Conservation Research Demonstration and Training Centres.
Soil and water conservation practices include: contour farming, mulching, intercropping, bunding, graded bunding and bench terracing on steep slopes, and the harvesting storage, and recycling of runoff water.
Soil loss from areas having slopes as high as 25% was reduced, for example, from 39 to 15 ha^{-1} when potato farming was done on contours. Some cultural practices that reduced soil loss were closer plant spacings, intercropping, and mulching.
On deep lateritic soils in high rainfall areas with average slopes of 25%, bench terraces with lengths of 100 m, longitudinal grades of 0.2 to 0.8%, and inward grades of 1%, conserved the soil and moisture relatively more efficiently and also produced higher yields of potato.
Collecting runoff is necessary and possible for the better utilization of rainfall, control of erosion, and the provision of life-saving irrigation during droughts and for growing a second crop. The development of seepage control techniques (especially important in alluvial soils) for farm ponds is still in the experimental stage. But the cost of lining small farm ponds with bricks and cement mortar, and cement concrete, appears to be justified, particularly in areas where there is no other source of irrigation water.
Establishment of vegetative cover is one of the effective ways of conserving soil and water. Growing trees helps in the interception of 14-26% of the precipitation, and reduces its impact on the soil surface.
Fuel-fodder requirements are progressively increasing in India. Experiments conducted at several locations with fuel-fodder plantations have been successful.
Ravine areas, which occupy nearly 4 million ha, require special soil conservation measures. Techniques have been developed for use in areas having gullies of varying depths. By closing the ravine lands to grazing and other biotic interferences, it was observed that poor and inconsequential annual plant species were replaced by more useful species. These ecological changes have also resulted in a natural reduction in runoff and soil loss from the area, along with improvement in the quantity and quality of grass yields.
The transfer of technology, based on the concept of watershed management, is important in soil conservation work.
Soil and water conservation practices are expected to generate three benefits in a watershed: (1) increased production of food, fodder, fuel, timber, etc.; (2) sedimentation control; and (3) a favourable water regime.
An economic analysis of each of the soil and water conservation measures in agricultural land, as well as their combined effect have shown that the benefit: cost (B:C) ratios range from 1.8 to 3.6. The highest B:C ratios are obtained for water storage and recycling in rainfed lands, thus emphasizing that adoption of soil and water conservation measures will not only protect a development area but increase its productivity.
The solution lies in the development of methods of land use that are both profitable to the local community and also give a better control of the flow-regime in the watershed, and to get these methods adopted by the local community.

474 89 - 11/17

Water management
Africa, tropics, ILCA, water supply, livestock, traditional methods, land-use, animal production, water management, research
SANDFORD, S.
Organisation and management of water supplies in tropical Africa.

ILCA Research Report No. 8, 1983, 46 pp.

This report, one of a series of three on livestock and water in Africa, defines the major agricultural production zones of tropical Africa with some account of the importance of land, livestock and water in each zone.
Organisation and management are elastic terms and in this report they are widely stretched to include not only formal organisational structures and the details of administrative procedures, but also people's behaviour and decisions and the factors which determine these. Although this report is mainly concerned with the drier zones of tropical Africa some attention is paid to other zones and their production systems, since comparisons can throw more light on the situation in the drier zones.
Chapter 1 starts with a brief definition of the major agricultural production zones of tropical Africa and of different kinds of water supplies, with some account of the endowment of land and livestock and of the importance of water supplies in each zone. This is followed by a section which distinguishes six livestock production systems of which three are of particular interest in terms of the need for and use of water.
Chapter 2 discusses the traditional strategies to overcome water shortage which have been adopted by societies in Africa without much access to external resources. The chapter distinguishes five main strategies and, focusing on these, briefly cites examples where they have been adopted.
Chapter 3 describes in detail the way in which particular human societies, selected to exemplify different livestock production systems, have sought to overcome water shortage, and this illustrates how strategies are adopted. The chapter ends with a discussion of the factors that determine which traditional strategies are adopted in different societies, systems and zones.
In chapter 4 modern strategies are discussed, which are defined as at least partially dependent on inputs originating outside Africa. Two principal strategies are discussed together with the factors which determine their adoption.
In chapter 5 the focus switches to the experience of programmes for the development of water supplies. The technical, administrative and environmental problems experienced in the past are discussed as well as the relationship between technology, equity, management and control.
Chapter 6 considers the implications of past experience for planning water development in the future. Attention is focused particularly on technology, on decisions about the appropriate

capacity and density of water points and on organisation and management.
Chapter 7 lists some proposals for more research in the future which could lead to the formulation of better policies and development programmes than in the past.
The appendix to the report recommends a nomenclature for different kinds of water resources which, if generally adopted, would lead to greater precision and clarity in discussion of water management.
Author's summary

475 89 - 11/18

Water management
Review, book, symposium, report, water conservation, soil conservation, history
HELMS, D. and S.L. FLADER
The history of soil and water conservation.

Univ. of California Press, Berkeley, Agriculture History, Vol. 59, No. 2, 1985, 242 pp.

The editors of this 242 pages symposium report provide the essentials of each of the 18 papers presented there in their introduction. A reviewer can therefore do two things: reduce their introduction again to the size of a book review or choose the electical method. The latter approach applies here because, in fact, the title of this publication is somewhat misleading. As much as 13 papers deal for the largest part with aspects of the history of soil and water conservation in the United States or part of it only. Certainly, the North-Americans were the innovators of organized modern soil conservation and every research scientists in this field working there should have this volume. Undeniably also others could learn from these experiences, but the location specificness is in most cases too high to attempt a review of what could be learned from these papers for outside the US conditions.
A notable expection is one of the conclusions of Kelly's paper on "Anthropology in the soil conservation service" where he demonstrates how the first comprehensive soil rehabilitation program on the badly overgrazed Navajo Indian reservation, more than fifty years ago "led to the realization that scientific and engineering good works could not succeed unless consideration was given to the people whose land was being saved and to the culture that predetermined their response to soil conservation". But this same conclusion can be drawn from Kay's more general introductional paper on "Preconditions of natural resource conservation", which on the other hand skillfully centers around the theme that if one wants to use environmental beliefs of people to explain their ecological impacts, the problem remains that human beliefs alone constitute only a small part of the factors that influence environmental change. To end up with the conclusion that until future research reveals the grand theme which ties

together the case studies, the best we can hope for are conservation strategies tailored for individual societies, taking into account their own environmental and cultural attributes. Which would be a perfect conclusion too for Stocking's paper "Soil conservation policy in colonial Africa" with respect to what we may hope for. The main lesson formulated in that paper is that soil conservation is as much a socio-cultural challenge as it is a technical exercise. From the considerations given at the end of the paper, this reviewer concludes that agroforestry as it is these days advocated certainly is among the few practices with soil conservation aspects that appear to have learned from history when it takes the local population directly involved centrally in its approach.
Subsequently, two more general technical papers ask for attention: "Soil erosion by water: the research experience" by Meyer and Moldenhauer and "Predicting and controlling wind erosion" by Lyles. Of these two the latter is far the most useful from a basic review point of view, because it puts less emphasis on (American) history and more on causes and effects. Moreover, techniques of wind protection appear in most cases more suitable for undapted transfer than those for prevention of soil erosion by water. This is due to the larger role differences of soil and climate and of scale and type of agronomic practices play in soil erosion by water and to a better understanding of the (somewhat simpler) initiating, transport and transport prevention mechanisms in wind erosion. There exist obvious differences such as in the role drought plays but the conservation attempts meet each other these days in a common interest in the beneficial role of conservation (i.e. minimum, mulch or no) tillage farming, of surface residues and cover, and of strip farming, including trees. From both papers it is clear that, because of mechanical farming becoming impossible in such cases, there is an obvious gap, in both conservation fields, with respect to knowledge on the mechanisms of scattered trees and bushes and woodlots as protection agents.
Finally this reviewer wants to pay attention to Hudson's closing paper "A world view of the development of soil conservation". Was is not for Stocking's and Lyles" papers referred to above, it was for this one I would have liked to obtain this booklet. After a surprising opening by cautioning against a historical trend of exaggeration of a situation which is already alarming enough by itself, the conclusions remain that:
- the devastations we see today are primarily man-made phenomena;
- the effective ingredient of counter-movements may well be the self-interest of a significant porportion of landowners;
- every one of a series of spelled out conditions that helped in a positive trend towards soil conservation in North America is reversed in developing tropical countries;
- there are few, if any, developing countries where up till now the anyway very recent conservation movement has been substantially transformed by external assistance;
- attempts to develop an alternative technology for the third world are hampered by the lack of money and trained personnel, so that some method of assessing the relative merits of programs is necessary.

To end with the general conclusion that progress in the development of soil conservation has been uneven, and less than satisfactory, largely as a result of the constraints and difficulties that beset soil conservation in developing countries.
Abstract by C.J. Stigter, shortened

476 89 - 11/19

Water management
Review, book, tropics, developing countries, water resources, agricultural development, water management, appropriate technology, water supply, groundwater, irrigation development
BARROW, Ch.
Water resources and agricultural development in the tropics.

Longman Scientific & Technical, Longman Group UK Ltd., Essex, England, ISBN 0-582-302137-8, 1987, 344 pp.

This book to provides a broad interdisciplinary introduction. The first five chapters consider background and principles, the character of tropical agriculture and water resource systems and broadly how they might be managed. Chapters 6 to 10 review the technology and practice of water resources and agricultural development in the tropics, concentrating on where water may be obtained, where savings might be made or moisture better used. Irrigation methods are briefly examined, especially those which may be adopted by farmers in developing countries, and the problems associated with water supply, conveyance, application and disposal are considered.
The book contains the following chapters:
- Part I Water Resources and Agricultural Development: Background and Principles
- Chapter 1 Factors affecting tropical agricultural development
- Chapter 2 The water resource management system
- Chapter 3 Water resources in the tropics
- Chapter 4 Systems of water management in the tropics
- Chapter 5 Assessment of water resource plans
- Part II: Water Resources and Agricultural Development: Technology and Practice
- Chapter 6 Using rainfall, runoff and floodwater, fog, mist and dew
- Chapter 7 Irrigation
- Chapter 8 Irrigation water supply: groundwater
- Chapter 9 Irrigation water supply: large impoundments and diversion of streamflow
- Chapter 10 The biogeophysical and human consequences of irrigation development.

This book has been written for students of geography, economics, development studies and agricultural management, administrators, planners and aid agency staff.

XII SOIL FERTILITY

477 89 - 12/15

Soil fertility
Africa, Burkina Faso, study, land-use, soil properties, land types
STOOP, W.A
Variation in soil properties along three toposequences in Burkina Faso and implication for the development of improved cropping systems.

Agric. Ecosystems and Environment, 19, 1987, 241-264

A large variability in crop stands and low average crop productivity are typical phenomena of farming in the West African semiarid tropics. Crop productivity tends to decrease along the toposequence from the valleys to the generally unfertile uplands, or from the more assured rainfall areas in the south to the low and erratic rainfall areas in the north.
Farmers, most of whom farm without mechanization, employ an ecological strategy in matching their major crops (millet, sorghum, maize, rice, cowpea and groundnuts) and cropping systems with different land types, thereby minimizing the risks of total crop failure and exploiting localized variations in soil fertility to a maximum. The use of fertilizer inputs and manure is minimal because of their high costs and relative scarcity. The pressures on these local systems are steadily increasing with the expanding human and livestock populations: fallow periods are shortened and marginal lands, generally the upper and mid-slopes, are taken into production at an increasing rate. These processes, in addition to a continuing decline in rainfall, have started the current accelerated land degradation around towns and on the densely populated Mossi-plateau.
However, vast upland areas throughout the Sudanian and Sahelian zones of West Africa are threatened in the same way, and a better understanding of the degradation and fertility problems is, therefore, important in developing more stable and sustainable systems of farming for this region.
Soil genesis and soil management factors responsible for the large soil variability in farmer's fields have been studied for three toposequences that are at various stages of degradation. The land types associated with these toposequences are common to large parts of the Sudanian zone and are easiliy recognized in the gently undulating landscape. Attention is given to the soil fertility and crop production aspects of these land types, in particular the fertility management of the upland, upper- and mid-slope soils, which at present are the most prone to degradation. Soil fertility problems, such as acidification and multiple nutrient deficiencies (N, P, K, Ca, Mg among others), are readily induced following intensification of agricultural production because of the low buffering capacities of these highly weathered sandy soils. In addition the serious labour and economic constraints under which farmers in the area are operating were

considered while formulating alternatives for cultural practices, including rotations of cereal/cereal with cereal/legume cropping systems. These alternatives, although aimed at increasing the sustainability of farming on upland soils, also have direct implications for the long-term land use of the lower land types.
Owing to their low initial fertility, most soils of uplands and upper and mid-slopes are prone to rapid degradation when cultivation is intensified and fallow periods are shortened due to growing populations and the presence of growing animal herds. Once the permanent vegetation has been removed, these soils tend to develop dense surface crusts which reduce moisture infiltration, therely increasing runoff and erosion as well as the risks of drought. By contrast, the soils of the lower slopes are more fertile and their moisture availability is more assured. The lowland soils are generally the most fertile but may suffer from occasional waterlogging. The local agriculture will often permanently occupy the lower slopes and lowland fields, whereas the higher fields will be in fallow systems. The cropping systems vary simultaneously among different land types. Based on the soil studies and crop adaption patterns to toposequence land types, certain modification to the present cropping systems and cultural practices are proposed to develop more stable and sustainable production systems for upland areas in particular.

478 89 - 12/16

Soil fertility
Africa, Egypt, appropriate technology, small-holdings, soil cultivation, equipment, ICT, ATSAF
ABO-HABAGA, M. and EICHHORN, H.
Test on the suitability of different types of soil cultivation equipment for farming on smallholdings in Egypt.

Highlights of German Res. Projects in the Tropics and Subtropics; ICT-International Cooperation and Transfer GmbH, Berlin in Coop. with ATSAF, Bonn, 1988, pp. 53-61

The insufficient supply of food available to the Egyptian population from domestic production necessitates further intensification of agriculture.
Depending on the crop rotation of the particular agricultural area, the natural and climatic conditions of the Nile Delta allows several growing periods with the help of irrigation. Normally there are already one and a half to two annual harvests, but an increase to three is necessary and possible. Because the interval between harvest and sowing the next crop is accordingly greatly reduced, the work cannot be carried out in the traditional ways.
It is possible, particularly in the field of sol tillage including methods of seed bed preparation, to achieve a considerable cost reduction using appropriate technology. Suitable solutions for this have been taken into account for the illustrated crop rotation proposal.

With regard to increased mechanization, the preservation of the fertility of the soil is a special problem requiring consideration. During the last ten years the soil has depeted alarmingly. The reasons for this are both manmade and natural. A natural influence arises from the country's position in relation to the Mediteranean Sea. The Nile Delta lies directly on the sea and because the soil rinsing effects through Nile flooding have caesed to exist since the Assuan Dam was built, the salt level in the Nile Delta is rising rapigly.
The other causes are the intensive cultivation of the land and the irrigation system which has been used in Egypt for many years to safeguard and increase the harvest. Farming does indeed reduce soil salinization in general, however only slightly increased concentrations are no longer tolerable for most cultivated plants.
The best way of obtaining reproducible results is by testing machines with various equipment in the field. Accordingly, experimental fields were laid out, in the form of long strip, at different locations in the Nile Delta to serve as the site for plant growing, pedological and microbiological experiments.
One can draw the conclusion from the described experiments that cultivating machinery can be improved and save time by only breaking, loosening and essentially surface crumbling in the special conditions of the Nile Delta. Under no circumstances should a mixing of the soil layers by striven for.
Therefore, feasible solutions for the future, even for small areas, will be combinations of broad cutting cultivators and power takeoff-driven rotary tined equipment to achieve a track covering cultivation.
The chisel plough is the most suitable equipment for soil cultivation in Egypt. Its implementation prevents salt concentration during cultivation. For secondary tillage the most suitable machines are the rotary tiller and the tined rotor in order to produce a sufficiently level seedbed.

479 89 - 12/17

Soil fertility
Review, tropics, soil fertility, acid soils, organic matter, low-input-systems
SANCHEZ, P.A. and R.H. MILLER
Organic matter and soil fertility management in acid soils of the tropics.

Paper XIII Congress of Int. Soc. of Soil Science, Hamburg, FRG, VI, 1986, pp., 609-625

The purpose of this paper is to review some aspects of practical organic matter management of acid soils of the tropics.
Although it has been established that plants grow normally in soils devoid of organic matter, the maintenance of soil organic matter (SOM) is a sound management objective in sustained agriculture. The known beneficial effects of SOM to crop production were summarized as follows: SOM is 1) a source of

inorganic nutrients to plants, 2) a substrate for microorganisms, 3) an ion exchange material, 4) a factor in soil aggregation and root development, and consequently 5) a factor in soil and water conservation.
Many of these favourable effects can be attained by producing high yielding crops with appropriate fertilization, liming, tillage and crop rotation practices that do not include organic inputs from outside the field. Such practices have maintained and increased SOM contents in temperate climates. This happens because the amounts of above-and below-ground inputs from crop residues equal or exceed SOM decomposition rates. A similar situation can be expected to occur in intensively managed, stable agricultural systems in the tropics where crop yields are high enough to return large quantities of above-ground and root residue to the soil. But many of the new lands in the tropics are likely to be initially managed with low-input systems due to the limited availability of fertilizers, farm machinery, credit and markets. In such cases, the management of SOM may have to be deliberate, and not just a consequence of intensive, fertilizer-based farming.
The management of organic inputs and soil organic matter (SOM) is of particular importance to low-input systems in the tropics. Considerable confusion exists about the value of the different practices, partly due to the misapplication of temperate region concepts developed primarily on high base status soils and partly from the lack of quantitative parameters that agronomists can manage. Soil organic matter contents differ little between tropical and temperate regions. Oxisols and Mollisols have similar SOM ranges. Fractionation of SOM into functional groupings may help evaluate the role of SOM on acid tropical soils as a nutrient source, and as a source of cation exchange. Quality or organic inputs affects the effectiveness of such materials not only in terms of N release but possibly in complexing Al.
The contribution of SOM to effective cation exchange capacity (ECEC) may be low in highly acid soils. Increasing ECEC is of questionable value in soils where Al is the dominant cation. Quantitative parameters for the practical management of organic inputs need to be developed to help agronomists in a similar way as parameters now in use for chemical fertilizer management. Joint research by soil biologists and soil fertility specialists could improve the understanding of the processes involved and thus help identify the needed parameters.

480 89 - 12/18

Soil fertility
USA, study, soil biotechnology, sustainable agricultural systems, economics, fertilization, soil analysis, growth factors, tillage methods, recycling nutrients, water management, mineral balance, soil temperature, on-farm research
STOUT, A.L.
The Potential of Soil Biotechnology in the Development of Profitable and Sustainable Agriculture Systems.

In: Proc. of the Sixth Int. Sc. Conf. of IFOAM, Santa Cruz, California, 1988, pp. 647-649

On-farm research has been conducted to analyze the effectiveness of biological soil enhancement products and the conditions affecting their action. Results have indicated that research in soil biotechnology to enhance beneficial biological functions in the soil could have great potential in the development of profitable and sustainable agricultural systems.
The research with biological fermentation products containing various vitamins, hormones, enzymes and other unidentified growth factors indicated that beneficial biological action can be stimulated in soils to increase the availability of soil and fertilizer nutrients; improve soil pH, tilth, water absorption, and retention; and reduce waste of water and fuel, as well as dependence on chemical fertilizers and other petrochemicals used in agriculture.
Soil analyses were performed. Paired sample data from the field trials were analyzed by using the paired-t correlation.
As the results show, soils treated with the biological vitamin-hormone preparation had higher nutrient levels which translate into reduced fertilizer requirements and/or increased yields. Soil hardness was reduced by treatments which often resulted in reduced power and fuel requirements in tillage. Better water infiltration occurred in soils treated with the biological preparation and resulted in reduced erosion, reduced water loss, and more efficient irrigation. Results in Arizona on cotton showed 45% reduced water requirement, saving approximately $125 per acre in irrigation costs and increasing yields by up to 30.8%.
In addition, biological treatments significantly enhanced crop-quality characteristics, including protein, test weight, oil content, and sugar content.
In many of the biologically treated soils it has been observed better weed control (even using reduced amounts of herbicide) and fewer insect and disease problems, resulting in reduced costs for weed, pest, and disease control. Although the overall significance of biological soil treatment was very positive using paired trials, the data revealed many variations and some negative results indicating specific limiting factors. Products of biotechnology are not and never will be a panacea which can replace good management practices; in fact, these products require good management if they are to be effective.

The major factors important to obtaining good results from soil biotechnology are listed below in the paper.
Further research and development in soil biotechnology comprises a positive step in the development of appropriate and sustainable agricultural technology.

481 89 - 12/19

Soil fertility
Review, tropics, developing countries, acid soils, phosphorus, fertilization, efficiency, soil tests, phosphate rocks, fertilizer application, lime, mycorrhiza, agricultural practices.
ARCA, M.
Efficient use of phosphorus fertilization in acid tropical soils.

In: Proc. of an IBSRAM Workshop on management of Acid Tropical Soils for Sustainable Agriculture, Bangkok, Thailand, ISBN 974-7614-39-1, 1987, pp. 179-186

Acid soils of the tropics are usually deficient in available P. This is the result of low P reserves and the dominance of occluded and organic forms over more active forms of P.
Fairly constant ratios are reported among the various forms of P for highly weathered tropical soils: active forms account for 10-20% of the total P; organic forms account for another 10-20%; and occluded forms account for 50-80%.
The potential for increasing P availability by water-soluble phosphate application is limited by the high P-fixing capacity of highly weathered soils of the tropics with topsoil of loamy or clayey textures. Although utilization of fixed P by plants, following P application, depends on the nature of the chemical and mineralogical species formed, it is generally accepted that "fixed"-P availability to plants is limited. Biological immobilization of P also occurs as a result of P incorporation into microbial bodies and parts of living plants, but this process is reversible and contributes to increased P availability upon decomposition.
Another factor that contributes to limited use by plants of P reserves in acid soils is the limited volume of soil explored by roots of nonacid-tolerant species. This is mainly the result of the practical difficulty of deep lime incorporation necessary for a good root system development. Moreover, due to high ambient temperature and udic soil moisture regimes often encountered in tropical environments, high crop growth rates cause high P requirements during part of the growth cycle. To meet the requirements of fast-growing crops, a rather large pool of soil P must be present, with a potential for fast rate of transfer of P from the soil surface to the soil solution.
Considering phosphate rocks as a nonrenewable resource of which there are limited reserves on earth, maximum efficiency in their use should be made in selecting the method of utilization.
Some phosphate rocks become more efficient with time, possibly being as efficient as superphosphate after 3 or 4 years.

In soils with high P-fixing capacity, banded application of P fertilizers has been recommended as a way to reduce P fixation. However, it has been shown that banded P fertilizer, applied on maize growing in extremely P-deficient Oxisols could reduce yield when soil water availability is limited. Combining broadcast and banded applications increased efficiency of low rates of P applied as ordinary superphosphate as well as phosphate rock as measured by soybean yield growing in Ceradi soils.
It has been suggested that mycorrhiza control the evolution of roots and that many crops cannot take up sufficient P from low-P soils unless their roots become infected with efficient strains of mycorrhiza. These fungi form an extensive system of external hyphae through which they absorb P from soil solution outside the P-depletion zone around roots.
Although the role of mycorrhiza fungi in improving uptake and plant growth in nutrient-deficient soils has been well established, the influence of edaphic factors on the mycorrhizal symbiosis is less well understood. The soil conditions most suitable for maximum mycorrhizal growth must be identified if plant growth response to mycorrhizal inoculation is to be predicted under field conditions.
Besides the improved efficiency in P uses that can be obtained by selecting the best sources and rates of P fertilizers and the most efficient method of application, considerable gains could be obtained by developing farming systems that make more efficient use of fertilizers.
Since the amount of P extracted from soil by most common crops is only a rather small amount of P applied, emphasis should be given to farming systems that better utilize residual fertilizers or provide opportunities for recycling of P in plant residues.
The use of perennial crops probably provides the best opportunity for P recycling in humid tropical environments as a result of the continued addition of plant residues to the soil and the consequent addition of P and other nutrients. In addition, grazed pastures can be expected to contribute to P recycling and efficient use of residual P fertilizers in both the humid tropics and acid savannas. Crop pasture rotations could offer good opportunities for better use of fertilizers previously applied to crops and the return of important quantities of P to soil by grazing animals or pasture plant residues.
Intercropping annuals and perennials or forest trees offers other alternatives for maximum efficiency of P fertilizer use.

482 89 - 12/20

Soil fertility
Africa, review, humid tropics, Savanna highlands, low altitudes, fertilization, alternative approaches, inoculation, research needs, IBSRAM
PIERI, C.
Management of Acid Tropical Soils in Africa.

In: Proc. of an IBSRAM Workshop of Management of Acid Tropical Soils for Sustainable Agriculture, Bangkok, Thailand, 1987, pp. 41-61

Acid soils in the humid tropical zones of Africa cover several hundred million hectares and most often support a marginal agriculture due to their natural low fertility. The coastal zone of the Benin Gulf, the Adamaoua Plateau of Cameroon, the Congo Basin, the high plateaus of Madagascar, and the highlands dividing the Congo and Nile basins support mainly shifting agriculture, although some areas (such as the Ivory Coast and Cameroon) also support large and intensive agro-industrial farms of perennial crops (oil palm, coffee, rubber, and pineapple, among others). These crops are more tolerant to acid soils than the majority of the staple food crops.
In West Africa, however, acidified Alfisols are more frequent than naturally acid soils (Oxisols and Ultisols). The process of soil acidification is common in the humid zone as well as in the semiarid zone of West Africa where sandy soils with low organic-matter content are dominant. Management of these low-buffered soils differs from that suitable for the acid soils.
Different technologies adapted to acid and acidified soils of Africa have been studied for many years by various research organizations. A review of what has been done for the last 20 years in the Francophone countries is partially presented in this paper, with emphasis on the management of soils under subsistence agriculture. The paper addresses the management of (1) acid soils in the humid tropics, (2) acid soils in the savannas, and (3) acidified soils.
Application of initial corective fertilization - using heavy rates of N, P, K - and lime, drastically increases the productivity of the acid soils from Africa. This productivity can be maintained under continuous cropping through annual fertilizer applications that match crop nutrient requirements. This technology - called "investment fertilization" or "maintenance fertilization" - although agronomically sound, is generally not adapted to African conditions, due to the high risks it induces for the small farmer in terms of erosion and potential nonprofitability.
This paper presents some low-input technologies and indicates the need for more research on evaluation of lime requirements, availability of P-fertilizer in high P-fixing soils, crop tolerance to Al in soil solution, and physical properties of the acid soils.
Low fertility sandy soils of western Africa are highly sensitive to acidification, as a consequence of current farming practices

that induce nutrient imbalance in the soils. The low levels of fertilization, erosion, leaching, and intensive organic-matter mineralization that occur in the semiarid zones are the main causes of soil degradation and acidification.
From the specific point of view of soil chemical fertility maintenance, the local socioeconomic conditions emphasize the need for more research not only on soil acidity as mentioned above, but also on the feasibility of the maintenance of nitrogen and organic-matter balance and other nutrient balance at the farmer's level. This can be achieved by:
- Promoting a more efficient recycling of crop residues,
- Increasing the nitrogen-fixation efficiency of legume crops,
- Improving the efficiency of mineral nitrogen fertilizers and local sources of rock phosphates.

Little will be achieved if agricultural policies are not consistently implemented in these countries where, most often, food crop production is limited by the weakness of marketing and credit organizations.

483

89 - 12/21

Soil fertility
Review, book, acid rain, acid soil, environment, ecology, air pollution, nitrogen, sulphur, ecosystems, nitric acids, sulphuric acids
KENNEDY, I.R.
Acid Soil and Acid Rain. The Impact on the Environment of Nitrogen and Sulphur Cycling.

Research Studies Press Ltd., Letchworth; Distributor J. Wiley & Sons, Chichester, hardcover, ISBN 0-471-91251-4, 1986, XV+ 234 pp.

This is an unusual book on a well-covered topic, and has a refreshing approach to the understanding of the significance of acid rain for the environment, not least, perhaps, because the author resides in Australia - a country that is not generally associated with air pollution problems. The book falls into two distinct entities, after a brief introductory chapter on the cycling of nitrogen and sulphur in ecosystems, which highlights some of the similarities in the chemical behaviour of these elements and their formation of nitric and sulphuric acids. The next seven chapters are concerned with the physical and chemical processes by which acidity is generated or consumed naturally within ecosystems, including at the physiological level. The general reader may find these rather heavy going, with their strong emphasis on thermodynamics and long lists of equations. Nevertheless, it is here that the real value of this book lies. A thorough understanding of natural acidification processes is vital for the elucidation of the changes induced in ecosystems by the deposition of acid pollutants. This section sets the scene for the remaining four chapters, which are concerned with the environmental impacts of acid deposition and draw heavily on the more fundamental information provided earlier. Unfortunately, as

perhaps might be expected from an author whose research interests clearly lie outside the field of air pollution, there are a number of important developments taking place in both Europe and North America which are omitted.
Chapter 2 is concerned with the characteristics of acidity and the properties of buffers with respect to their potential significance for the control of environmental acidity. This is followed by a longer chapter on the energetics of life processes, which places particular emphasis on considering the non-equilibrium states prevailing in nature and contrasting these with the fact that most studies on thermodynamics have been based on equilibrium conditions. The next two chapters are concerned with the biochemistry of nitrogen and sulphur utilisation, respectively. The similarities between the behaviour of nitrogen and sulphur in ecosystems is emphasised, together with the major role played by micro-organisms. Chapter 6 discusses the regulation of cell-pH and is biochemical in nature. It includes a fascinating (to me) list of foods which are either acidic or basic with respect to their metabolism in the human body and hints at the possibility of heart disease being associated with an excess of the former - an interesting addition to the long list of evil effects of acids in the world. The final chapter in the first section is concerned with ionic imbalances in plants, particularly with respect to those induced by uptake of nitrogen and sulphur compounds from the soil.
The first chapter in the concluding section is entitled "Acid Rain" and attempts to give an overview of the history, production and toxic effects of this phenomenon. It is obvious that the author is not really familiar with much of the relevant literature, e.g. the role of hydrocarbons in O_3-formation is not at all clear, while the concentrations of gaseous pollutants claimed to cause injury reflect the beliefs of 20 years ago. No mention is made of the work of Tamm and others which is now building up a picture of widespread long-term acidification of sensitive European soils. Chapter 9 is concerned specifically with acid soils and gives careful consideration to the various natural and anthropogenic processes leading to increases in acidity; the latter include Australian ley farming practices, where increased nitrogen levels, arising from fixation by clovers, are reducing soil pH and increasing its organic matter. Some consideration is given to the consequences of applying ammonium fertilisers to soil, but no mention is made of the increasing concern in certain parts of Europe over acidification problems arising from the deposition of NH_3 and its derivates from The atmosphere, originating from livestock production. the penultimate chapter is entitled "Neutralising Impacts of Nitrogen and Sulphur Cycling", which is somewhat ambiguous in a book on environmental acidity and turns out to be concerned with various ameliorative measures, such as liming and adjustment of cropping regimes. The last chapter describes methods for predicting the impacts on acidification of modifying nitrogen and sulphur cycles, and includes a number of case studies for different agricultural and forestry regimes. Perhaps the philosophy of this book can best be summed up in the author's statement in Chapter 8 that oxidation processes involving

nitrogen and sulphur are the prime causes of acidity and that, as such, oxygen should be considered a dangerous chemical which if newly manufactured would not pass environmental impact assessments! It is this lateral approach which makes this book a pleasure to read and which, despite some misgivings over the second section, I am happy to recommend.
Abstract by J.N.B. Bell, UK

484 89 - 12/22

Soil fertility
Review, tropics, socioeconomy, soil research, acid soils, people, plants, interaction, human behaviour, IBSRAM
MORAN, E.F.
Socioeconomic Considerations in Acid Tropical Soils Research.

In: Proc. of an IBSRAM workshop on management of acid tropical soils for sustainable agriculture, Bangkok, Thailand, 1987, 227-244

A growing number of social scientists, however, are defining their long-term research interests by studying the potential of the humid tropics for intensive agriculture. This potential has considerable significance for both agronomy and anthropology, for anthropology especially because much of the existing literature suggested that the humid tropics could not support human societies above the level of the small, isolated village.
This paper illustrates the value of attention to the interaction between people and the soils and plants they manage. This value lies not only in facilitating final acceptance of technological packages that might be proposed to farmers, but also in providing a faster flow of information from farmer to soil scientists that may be worth experimenting with.
Integral systems are those used by populations who for long periods of time held rights to land in an area that they had come to know with great preciseness of detail. In contrast, pioneer systems were those in which the populations were recent settlers and in which the social organization and integrity of cultural knowledge had been disrupted by either external or internal forces. Evidence for such disruption could be seen in the simplification of shifting cultivation practices, the shortening of fallows, and the declining rates of intercropping.
This distinction between integral and pioneer systems did not have much impact upon subsequent work in the social sciences. Anthropologists have tended to take the position that native people know their physical environment and that it is unnecessary to test the accuracy of native knowledge. Although still dominant, such a view is increasingly being questioned. Now it is seen that most native people's traditional forms of social organization, cultural knowledge, and familiarity with the environment have been disrupted by resettlement and adoption of nonnative knowledge and technology, which has resulted in the loss of traditional expertise.

Socioeconomic considerations are therefore relevant to the management of acid tropical soils, primarily because the term "management" refers to the behavior of farmers toward crops and soils. This behavior, in turn, is a function of (1) past behaviors, (2) current constraints of land, labour, capital, and technology, and (3) the opportunity costs of the individual household.
Pioneering systems in the first decade after resettlement tend to be characterized by subsistence agriculture because of poor infrastructure development, scarity of labour and capital, low yields, and the dominant role of the market for land. Thus, emphasis in the early years of frontier settlement ought to be on baseline research, both agricultural and socioeconomic, rather than on credit, extension, and crop commercialization. After the first decade, the area's potential is clearer, land speculation may decrease, and a growing number of farmers arrive to produce crops - a population more receptive to agricultural technology and production than the earlier one. These conclusions are based on a comparative analysis of the U.S. frontier in the 17th and 19th centuries, and on the Amazonian frontier of the past 2 decades. There is evidence that it may apply to Africa and Asia, but few cases from those areas have been analyzed.
The choices made by local populations about soils and crop choices are the result of a complex calculus that includes agronomic considerations, nutritional needs of the household, the need for cash in the household, and social/religious obligations. Thus, the selection of given soils or crop varieties in pre-market or areas poorly articulated to markets is rarely based on the primacy of yield and more on the need to get security of yield under existing constraints at the lowest possible labour cost. Thus, it is inappropriate to test native varieties against newly introduced varieties using yield as the measure. Rather, the proper measure should be how the two varieties perform in fulfilling these multiple needs of households at low levels of input - and perhaps moving the population toward greater security of income.
For example, the native Amazonians plant their fields 90% with cassava (*Manihot esculenta*) and they plant very small areas in maize and beans. Such a choice reflects the better performance of cassava in acid soils of the humid tropics and the well-known agronomic problems in achieving acceptable yields for maize and preventing disease and insect infestations in beans of the genus *Phaseolus*. The crops chosen also acknowledge the difficulties of providing fertilizers and lime at reasonable cost in most of the Amazon region.

485 89 - 12/23

Soil fertility
Review, tropics, developing countries, soil management, land development, sustainability, IBSRAM, IITA, ICRISAT, environmental degradation, low-input systems, small farmers
LATHAM, M.
Soil Management A Necessary Tool for Land Development in the Tropics

entwicklung + ländlicher raum, 22, 4, 1988, pp. 16-17

Successful technological packages have been adopted on most of the fertile soils in traditional agricultural areas. In less-favoured areas, the green revolution has usually had less impact. Yields have stagnated, and in turn a growing population has attempted to make a living from marginal lands. The agricultural problems and environmental degradation which usually follow the development of such infertile, fragile marginal environments poses a new challenge to agricultural and soil management research.
Soil conservation, soil physical aspects, and an extreme variability in the ecosystems often prevent the use of mechanized, high-input systems. Besides, the high inputs and modern technologies which would be necessary for these areas to achieve high production are not available to smallholders in developing countries due to cash limitations, badly organized credit facilities, and poor communications.
This being the case, there is a need for adapted technologies using low inputs. Some of them have recently proved successful.
Experiments on soil management conducted collaboratively by the National Agricultural Research Institute of Peru with the help of Tropsoils - an Association of US Universities - have shown that on Amazonian acid soils, a rice-cowpea system could be maintained, given proper soil management techniques, for three years without fertilizer. A total of 13.8 tons of grains were recorded in comparison to the 2.8 tons normally harvested by shifting cultivation.
Scientists of the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria have demonstrated that proper land-clearing methods using manual clearing and postclearing such as in situ mulch, live mulch, shrub fallows or alley cropping, soil management techniques can bring about a notable improvement in crop production on lateritic soils or Paleustalfs compared to traditional shifting cultivation practices, and make it more sustainable. These few examples and others show that some new technologies exist, but they need to be adapted to particular agroenvironments and promoted in the localities they are intended to serve.
Up to now, results of research on the discrete components affecting soil fertility have had little impact on farmers'practices. For example, slash-and-burn shifting cultivation is still the basic soil management practice of the humid tropics. Even though a good number of experiments have been

conducted on liming, fertilization, the use of new varieties, and the introduction of N-fixing legumes, there is still an urgent need to adapt and test the existing knowledge in various technological combinations in different agroenvironments.
It is now recognized that the major role of national research organizations should be to adapt on-farm soil management research. However, limited staff and financial resources are major constraints in conducting such operations - and it is precisely to minimize these constraints that the network concept has been put forward. Networks are initiated by informing the participating national organizations of existing knowledge and of the need for its adaption to local conditions. Networks lead to the sharing of new findings by collaborators working on the same problems, and help to coordinate development efforts. For this reason, the International Board for Soil Research and Management (IBSRAM) has encouraged the formation of soil management networks, and is continuing to promote network developments in various tropical regions.
These networks use a common methodology to test and validate different cropping systems in common-core experiments, where high and low cash input options are compared to the farmers' traditional practices. Particular attention is paid to the monitoring of sustainability. The different experiments are intended to asses erosion, soil fertility evolution, and the spreading of weeds or pests and diseases. This assessment is completed by monitoring socioeconomic factors such as the profitability of farmers. The experimental work will be followed by on-farm demonstrations in situations similar to those pertaining in the experimental site and by disseminating validated techniques to the farmers.
In conclusion, soil management research in the tropics is oriented towards the adaptation of improved and sustainable technologies to different agroenvironments. This procedure,which is already well advanced on fertile soils where the green revolution has taken place, has to be extended to more marginal soils, which are being increasingly utilized by poor farmers as a result of population pressure.

486 89 - 12/24

Soil fertility
Asia, India, experiments, biofertilizer, desert ecosystem, legumes, low-input system
RAO, A.V. and B. VENKATESWARLU
Use of Biofertilisers in the Desert Ecosystem.

Indian Farming, 4-1987, pp. 21-22

The Indian deserts spread over four states, Punjab, Haryana, Rajasthan and Gujarat. Most of it, that is about 61 per cent is in Rajasthan. It is characterised by low and erratic rainfall and high temperature coupled with intense solar radiation besides low soil fertility. The production of plant biomass in the desert

ecosystem is limited among other factors by the low available nutrient pool of the soils. The use of chemical fertilizers has not become popular largely due to the inherent risk in arid zone farming besides the high cost of fertilizers. Under such conditions the obvious alternative would be to use the biofertilizers, a low-cost input to supplement the nutrient deficiency.
Experiments were conducted to isolate strains of rhizobium that could suit crops like guar, moth bean, etc. grown in the region of Rajasthan. It has been found that the grain yield of guar can be increased by about 6 to 13 per cent by inoculation with different rhizobial strains. Similarly, very good results were achieved by inoculation in the case of moth and bean. Concluding, farmers in the desert region can enhance their crop yields by the use of biofertilisers.

487 89 - 12/25

Soil fertility
Asia, Philippines, field trial, IRRI, azolla, green manure, nitrogen fertilizer substitution, wetland soils
LALES, J.S. and R.S. MARTE
Long-Term Utilization of Azolla as Organic Fertilizer for Lowland Rice.
Phil. Agric., 69, 1986, pp. 459-464

Evidences accumulated through a number of short-term experiments show the possibility of reducing the commercial nitrogen fertilizer input for lowland rice by as much as 25 to 30% through the use of azolla as green manure in wetland soils. This implies reduction of production cost as well as less dependence upon fuel-based commercial nitrogen fertilizers.
Decomposition studies conducted at the International Rice Research Institute indicate that complete decomposition of azolla incorporated after transplanting may not be attained within the growing period of the rice crop. In about 8 weeks after flooding, only 73% of the organic nitrogen in azolla was mineralized. Continuous green manuring with azolla may therefore gradually increase the organic matter content of the soil which in due time might reach a level where the application of commercial nitrogen fertilizers becomes unnecessary.
This paper presents partial results of the long-term evaluation of the effects of continuous green manuring with azolla at varying levels on lowland rice yield and soil fertility.
For five consecutive cropping periods, replacing 50% of the total commercial nitrogen fertilizer input for lowland rice with azolla gave grain yield similar to that given by 90 kg N/ha from urea. Without any addition of inorganic nitrogen fertilizer, at least three azolla incorporations (equivalent to about 26 t fresh azolla/ha) during the entire cropping period were found necessary to attain grain yield comparable to that of the standard treatment. Slight increases in inorganic matter content of the soil have been observed at the end of each cropping period but

there was no significant change in soil inorganic matter content after six consecutive cropping seasons and continuous utilization of azolla as green manure.

89 - 12/26

488

Soil fertility
Pacific, Samoa, study, farming techniques, tillage methods, cowpea, no-tillage farming
TOFINGA, M.
Comparison of the No-tillage and Tillage Farming Techniques in the Production of Cowpea (*Vigna unguiculata* L.) in Western Samoa.

Alafua Agric. Bull., 10, (2), 1985, pp. 47-51

In the South Pacific region, the concept of no-tillage farming is not new. Many traditional crops such as taro (*Colocasia esculenta* (L.) have been grown successfully by farmers using the no-tillage technique. The farmer usually clears the forest of trees, shrubs and undergrowth, burns the dry debris and plants the taro by using a pointed stake ("oso") to make a hole large enough for planting the apex (tiapula") of the shoot.
The planting sites cleared from forests are, at this stage, free of weeds because there is a thick mulch deposited over the years. Farmers often face a serious weed problem when they plant successive crops on the same land, previously cleared of forest. The yields of the crops gradually decline. Earlier in time, this problem was solved by shifting to another site or allowing the forest to regenerate for a few years before cultivating it again. Recent increases in population make shifting cultivation and bush-fallow techniques impractical in relation to land shortage.
Farmers began to use imported chemicals, as herbicides, to control weeds before planting taro and found the results succesful. Tillage methods were also introduced and benefits, besides weed control, were the improvement of soil tilth, better soil aeration, and the more rapid availability of soil nutrients. Farmers began to adopt this practice and then found several adverse effects. The most important was the degradation of the soil and its loss through erosion.
Moreover, the high energy inputs with machinery are not easy to provide. Other inputs such as fertilizers and pesticides are costly, and are not readily available to most of the farmers in the tropics, particularly those in the South Pacific Islands. A need to compare tillage versus no-tillage techniques in the South Pacific countries was accordingly felt.
This study is a part of a long-term project aimed at comparing the tillage and no-tillage techniques on the production of cereals and pulses in suitable rotations. This paper reports the results with cowpea (*Vigna unguiculata* L.). Yield and weed dry weights of two successive crops of cowpea were assessed in this part of the study. Plot sizes, treatments, and husbandry practices were the same for both the crops.

For both the cowpea crops, the no-tillage treatments had advantage over the tillage treatments. No-tillage treatments gave higher yields and generally low weed dry weights.
It appears that the higher yields of the no-tillage treatments in comparison with the tillage treatments are related to the low weed infestation. Repeated tillage can be expected to promote the incidence and growth of weeds. No-tillage has the opposite effect reducing weeds thereby.
In this study, the additional advantage of the no-tillage treatments is the absence of the high energy input of using machinery which is expensive and commonly not available in the tropics. No-tillage also conserves the soil together with its physical and chemical properties from soil erosion and depletion.
The trials should be continued to confirm the results of the tillage and no-tillage treatments on the yield of crops, weed control and input requirements, as well as to determine the effects on the nutrient status of the soil. An economic assessment of the methods will also be considered.

489 89 - 12/27

Soil fertility
Latin America, Brazil, glasshouse experiment, mycorrhiza, maize, efficiency, phosphorus sources
DIEDERICHS, Ch.
Influenca de different fontes de fósfato na eficacia de different espécies de fungos micorrizicos no crescimento de milho. (Influence of different P sources on the efficiency of several tropical endomycorrhizal fungi on growth of *Zea mays* L.).

Turrialba, San José. Costa Rica, 1990, 20 pp.

The Cerrado region of the Central Plateau of Brazil is characterized by soil-related constraints which inhibit satisfactory crop production, unless expensive inputs such as mineral fertilizers are applied. Phosphorus is the most deficient plant nutrient in the Cerrado soils.
In addition to acidity and low-nutrient status, these soils also present high phosphate sorption capacities. Therefore, large amounts of P-fertilizer are indispensable to obtain adequate economic returns. The application of soluble P-fertilizers by local farmers, however, is seldom practiced, due to limited financial resources. In order to meet these limitations agricultural practices are being tested to improve the efficiency of applied P-fertilizers, viz: application of dolomitic lime to minimize phosphorus fixation, introduction of legumes into crop rotation, determination of the best P fertilizer rates and placement methods, and evaluation of local cheap P-sources (rock phosphate).
The purpose of the present research work was to examine the efficiency of various local and foreign endomycorrhizal fungi on growth of *Zea mays* fertilized with two P-fertilizers of different solubility.

The evaluation of fourteen endomycorhizal species belonging to the genera *Gigaspora, Scutellospora, Glomus, Acaulospora* and *Entrophospora* was conducted under glasshouse conditions in an unsterilized tropical virgin soil using two P-sources with different solubility. In both P-treatments indigenous mycorhiza species enhanced growth of *Zea mays*. Introducing other species modified the growth pattern of maize. Using a low-grade rock phosphate (Patos de Minas) from Brazil all endophytes with exception of *Gigaspora margarita, Scutellospora verrucosa, Scutellospora gregaria, Entrophospora colombiana* and *Glomus pallidum* enhanced shoot dry weight. In the treatment with single superphosphate, dry matter production was not significantly improved by *Gigaspora margarita, Gigaspora gigantea, Scutellospora verrucosa, Scutellospora reticulata, Scutellospora gilmorei* and *Glomus manihotis*. Root fresh weights were enhanced only by three endophytes when rock phosphate was added but in no case with single superphosphate. The percentage of P in shoots was almost equal in uninoculated and inoculated plants and yield responses did not always followed the pattern of P-uptake. Mycorhizal root infection was always highest in the treatment with single superphosphate and in most cases a correlation with plant growth was found. The present results show that different foreign introduced mycorhiza species differently promote growth of *Zea mays* according to their adaptability to the P-source and to their capability to compete with native VAM-endophytes.

490 89 - 12/28

Soil fertility
Latin America, Peru, humid tropics, Ultisols, experiment, rock phosphate, fertilization, tillage system, no-tillage system, low-input system
GICHURU, M.P. and P.A. SANCHEZ
Posphate Rock Fertilization in Tilled and No-Till Low-Input Systems in the Humid Tropics.

Agron.J., 80, 1988, pp. 943-947

The Ultisols of the Amazon basin of Peru are generally acidic and deficient in P, although soil fertility problems can be corrected by using liming.
Socioeconomic constraints often limit the application of fertilizer-based continuous crop production in areas where farmers still practice shifting cultivation. The low-input approach to food production is an alternative to shifting cultivation in areas where fallow periods are too short and continuous cultivation technology is limited by lack of market infrastructure. This approach is based on acid tolerant cultivars, minimum tillage, minimum use of purchased inputs and maximum nutrient receycling.
Application of phosphate rock is an attractive possibility for low-input systems because it is less expensive than superphosphates. The use of acid-tolerant crops may permit more efficient utilization of P from phosphate rock, because the plants

will grow under acid conditions that favor dissolution of apatite. In addition to reducing energy costs and promoting soil conservation, surface applications of P may also facilitate a gradual transition from shifting to continuous cultivation, while fertilizer incorporation is difficult in fields that still have fallen logs and tree stumps. Although surface application of P-fertilizers has been found to be comparable to incorporating them into nonacid soils, little information is available on surface application of phosphate rock to annual food crops under acid soil conditions.
The objective of this work was to determine the relationships between P-sources and tillage methods in a low-input systems using acid-tolerant crops.
The study was directed toward determining the effects of these two P-sources under no-till and rotovation tillage systems on crop production in a fine-loamy siliceous, isohyperthermic Typic Paleudult. A rotation of Al-tolerant cultivars of rice (*Oryza sativa* L.) and cowpea (*Vigna unguiculata*) was followed for seven consecutive harvests. Grain yields increased with rotovation in the first crop, were not affected by tillage methods during the second and third crops, but decreased with rotation from the third to the seventh crops. Phosphate rock at a soil pH of 4.5 was as effective as superphosphate in supplying available P.A total of 13.9 Mg ha^{-1} of rice and 2.5 M ha^{-1} of cowpea grain was produced in seven harvests in newly cleared fields without lime or P-application. There were significant responses to P-fertilization in one rice crop and in both cowpea crops. On the average, however, rice yield did not respond to P.A single application of 22 kg P ha^{-1} was sufficient to produce 85% of the maximum yield of cowpea for 2 years. The results with cowpea indicate that broadcast phosphate rock is a good source of P for low-input systems on acid soils where acid-tolerant cultivars are used.

491 89 - 12/29

Soil fertility
Asia, Indonesia, review, tropics, marginal lands, development, sustainability
CONWAY, G.R. et al.
The development of marginal lands in the tropics.

Nature, 304, 1983, pp. 392

The past decade has seen great progress in the agricultural development of the irrigable lands of the tropics, particularly in South-East Asia.
Attention is turning to the development of those lands which, on various criteria, are more marginal.
In Indonesia there are three major categories of marginal land: the tidal swamplands, primarily of Kalimantan and Sumatra (approximately 35 million ha); grasslands covered by alang-alang *(Imperata cylindrica*; about 15 million ha); and "critical" uplands, mostly on Java and Bali, which are defined as lands

suffering from severe degradation because of erosion (between 10 and 40 million ha).
In total these lands may cover as much as one-third of Indonesia's land surface, encompassing a wide range of ecological and socio-economic conditions. Thus whereas the development of the better-endowed lowlands has been achieved by disseminating widely adapted crop varieties and cropping techniques, the more diverse and severely constrained marginal lands require a more finely tuned approach.
The land should be zoned not only according to agroecological factors, but also in terms of socio-economic criteria. Alang-alang land, for example, should be characterized not only by climate, soil and topography but also by who owns or cultivates the land, their cultural and economic circumstance and, in particular, whether they view alang-alang as a weed to be eradicated or as an asset to be preserved.
Marginality arises partly from limiting factors, for example acid sulphate soils in the tidal swamps, low levels of soil nutrients in alang-alang land and steep slopes in the critical uplands; and partly from their inherent environmental instability. Tidal swamplands are subject to considerable seasonal and daily fluctuactions in levels of water and salinity. Alang-alang lands experience frequent burning and, in some areas, severe drought, while critical uplands suffer from periods of intensive rainfall.
Such variability tends to be viewed as a constraint, but it can also provide opportunities for development. For example, the critical problem in the tidal swamps is that excessive drainage leads to destruction of the surface peat layers followed by acidification of the underlying soil and the production of toxic aluminium. Expensive engineering works which carefully control the water level are one solution, but in Indonesia areas for rice production have been successfully opened using simple communally operated gates which permit tidal flows to flush away the acids yet retain sufficient water to prevent oxidation.
A similarly simple and inexpensive solution is the use of burning to manage alang-alang. Although often an indicator of degraded and apparently abandoned land, anthropologists argue that in many cases alang-alang is a productive resource. In South Kalimantan alang-alang is an essential part of a rice-fallow system; on Sumbawa island it supports productive game hunting - the deer being attracted by the regrowth after burning - and in Bali it is an important cash crop, providing the materials for traditional thatched roofs which are coming back into favour.
Many of these traditional agricultural systems, although not highly productive are sustainable. But under the demands of population pressure and economic necessity they may give way to less appropriate systems. The challenge is how to increase the productivity while retaining sustainability.
A particularly productive and apparently sustainable cropping system has been designed for the red-yellow podzolic soils which occupy about 15 per cent of Indonesia's land area. Traditional cultivation consists of a mixture of crops followed by a fallow of alang-alang. The new system developed comprises a more organized inter- and relay cropping, grown in a continuous cycle without a

fallow. About 1 ton per ha of burned limestone is applied initially, phosphorus is spread in the furrows, nitrogen and potassium are placed below and beside the seed, and all crop residues are returned as mulch. The benefits lie in the evenness of labour demand and the steady flow of produce and income. Five years of such continuous cropping have produced yields, in food calorie terms, of 12-25 tons per ha per year of paddy rice equivalent.
The development of sustainable systems for the critical uplands will be more difficult.
An alternative strategy is to develop and extend traditional agro-forestry systems, such as the home and forest gardens. These are typically multistoried and highly diverse cultivation systems with perennial tree crops and a rotation of mixed annuals underneath. They provide the farmer with a steady flow of food, fibre, wood and cash crops, and because of the high degree of nutrient recycling and the completeness of the ground cover they also conserve the soil even on fairly steep slopes.

492 89 - 12/30

Soil fertility
Review, booklet, tropics, subtropics, soils, composting, soil fertility, organic material
AGROMISA
The preparation and use of compost.

Agrodok 8, ISBN 90-72746-04-X, 1983, 20 pp.; Agromisa, P.O.B. 41, 6700 Wageningen, The Netherlands

One of the major problems of small farmers in tropical and subtropical countries is the maintenance of soil fertility. This has been a problem for centuries, but in the last decennia it has become more and more serious, as the growing population demands more from the soil, than ever before. As a result of the increasing demand for food, the soil has to yield a higher quantity of products.
Because of the fact, that fertile areas are scarce, people are forced to farm less fertile soils, which, once they are in use, degenerate quickly. Usually the poorest farmers have to grow their crops on the worst soils, and here the result of the degeneration of the soil is that they become even poorer. The question of how to handle the soil in such way that its fertility is maintained or improved is therefore a very essential one.
A step in the right direction is to try to make better use of things, that are already present,either at the farm or in the neighbourhood. All sorts of organic material, that are usually considered as waste, and may be thrown away or burnt, can be used to help improve the soil.
This booklet discussed here deals with composting. In fact composting is a method of turning all kinds of organic wastes into a substance that is beneficial to the soil, and therefore to the plants that grow there.

The main aim of all these different methods is to increase the amount of organic matter in the ground. The reason why organic matter is important to the soil, is explained in chapter 2. Chapter 3 deals with the principles of composting: what happens during the composting process, and which aspects are important?
In Chapter 4, the practice of composting is described step by step. It must be borne in mind, however, that a universal recipe for the ideal compost heap cannot be given. Differences in climate, available material, labour, implements and needs will result in different heaps. It takes experiences to find out, which is the most suitable way of your specific conditions, and the booklet can be no more than an indication.

493 89 - 12/31

Soil fertility
Asia, India, study, soil classification, farmers
ICRISAT
Soil classification by farmers.

ICRISAT Ann. Report, 1988, pp. 167-169

ICRISAT intensively examined indigenous systems of soil classification in three study villages of peninsular India. The indigenous classifications were drawn up solely from interviews with farmers and were based on their perceptions of edaphic characteristics in fields where input and production data had been collected since 1975.
Major differences in farmers' systems of soil clasification were evident between villages with red and black soils. In the Alfisol region, soil categories were very distinct and were organized nonhierarchically on multiple characteristics. In the two villages representative of Vertisol regions, the farmers' classification was based on the deviation form of an "ideal" soil type. Thus, farmers in the Vertisol areas viewed their soils as less distinct than farmers in the Alfisols region. These fundamental differences are reflected in variations in crop and soil management practices between fields within the village. This source of management variation can be summarized as an adjustment to central principles in the Vertisol tracts and as the targeting of cropping systems and groups of practices to the diverse soil types in the regions.
The laboratory analyses generally supported the farmers' way of thinking about their soils. In the red-soil village, all analyzed chemical and physical properties, with the exception of available P, were significantly different ($P<0.05$) for the five major soil groups. In the black-soil villages, differences in chemical and physical characteristics of major soil groups within a village were not as marked. In Shirapur the major soil groups differed significantly in available water and exchange cations (Ca, Mg, K, and Na). With the exception of exchangeable Ca, the problem soils ranked lowest for every trait. In Kanzara CEC, organic C, available P, and exchangeable K distinguished the main soil groups ($P<0.05$).

This classification system by farmers to the descriptive soil taxonomy used in the ICRISAT Village Lever Studies (VLS) was compared. Soil depth and colour figure prominently in the VLS soil classes, which are similar to those used to elaborate the 1968 Soil Map of India. In comparing the farmers' assessment to this more formal system of classifying soils, cross classification was generally inconsistent, i.e., fields within a major farmers' soil group were frequently placed in several of the VLS soil groups. Land perceived by farmers as having problem soils was often not identified as such by the VLS soil descriptors.
Summing up, the indigenous systems appear to provide an informative and compact base for indexing variation in land quality. Farmers' soil classification would also appear to have the potential to hasten the process of technology generation and transfer. Additional research is needed on the extent to which a farmers' system of classification from a representative village can be extrapolated to a larger area.

XIII EROSION CONTROL

494 89 - 13/13

Erosion and desertification control
Tropics, review, soil degradation, soil management, sustained productivity, soil fertility, yield stability, low input strategies, IITA
LAL, R.
Surface soil degradation and management strategies for sustained productivity in the tropics.

In: IBSRAM Proc. No. 2; Management of acid tropical soil for sustainable agriculture, Bangkok, Thailand; ISBN 974-7614-39-1, 1987, pp. 167-177

The tropics cover about 40% of the earth's surface, and land resources are sufficient to produce food for the present and future populations. Of the total potentially arable land area of 3419 million ha in the world, 789 million are in Africa and 819 million are in South America. Only about 231 and 15% of the potentially cultivable land area is currently being cultivated in Africa and South America, respectively. Considering the possibilities of multiple and double cropping, the gross arable land area is considerably higher.
The predominant soils of the tropics are Oxisols (23%), Ultisols (20%), Entisols (16%), Alfisols (15%), Inceptisols (14%), Vertisols (5%), and others (7%). Oxisols and Ultisols are leached acid soils of relatively low chemical fertility. Alfisols, in contrast, have better nutrient status but often poor physical properties. In general many Entisols and Inceptisols have favourable chemical fertility.
The results of soil degradation are the direct consequence of the degradative processes. Soil mismanagement results in a decline in soil organic-matter content and the effective cation-exchange capacity, reduction in water- and nutrient-holding capacity, overall soil compaction and decline in macroporosity and transmission pores, lack of oxygen in the root zone, and frequent occurence of moisture deficit. This degradation process is set in motion by man's intervention in his quest for producing more food and is further accentuated by accelerated erosion.
The soil degradation process is set in motion by the drastic change in soil and microclimatic factors caused by cultural practices that result in soil exposure and disturbance of the soil-vegetation-climate equilibrium. This implies that the protective native vegetation cover should be removed with the least possible disturbance. Furthermore, as the soil is protected when covered by the forest canopy, it should be continuously covered after the forest cover is removed and during the cultivation phase. This can be achieved by replacing the forest canopy with a low canopy cover that will protect the soil against impacting raindrops but not shade the seasonal crops. Furthermore, the soil should not be disturbed by mechanical manipulation.

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XIII EROSION CONTROL

494 89 - 13/13

Erosion and desertification control
Tropics, review, soil degradation, soil management, sustained productivity, soil fertility, yield stability, low input strategies, IITA
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active soil organic matter is an important factor
the fertility level of the soil, stabilizing soil
stimulating biological activity, including that of
is more effective to leave organic matter on the
than to incorporate it into the soil by plowing or
cal operations. Deep-rooted perennials should be
iation with the shallow-rooted annuals so that they
er and nutrients from different horizons. An orderly
annuals with perennials may help facilitate farm
crop management.
ie socioeconomic conditions and financial resources
ale farmers concerned, the emphasis is on low-input,
g, and ecologically compatible technologies. The
nd-use and soil management systems are those that
ic yields rather than those that produce only short-
irns. The objectives of soil surface management are
r restore and sustain soil productivity, maintain
ility, and optimize biophysical environments, by
to the specific soil environments.
nciple is the least disturbance of the soil-plant-
brium. This can be achieved by replacement of a
by a ground cover such as mulch or a cover crop,
mit food crop production without exposing the soil
s of the weather.
holders in the tropics and subtropics it is vital to
dependence on agrochemicals and other capital
ts. While it is true that high yields cannot be
ut these inputs, agronomic practices should be
can drastically reduce the fertilizer and chemical
esticides, etc.) needs and yet maintain good yields.
es have proven successful on research farms and
d on-farm plots. Their effectiveness needs to be
a wide range of ecologies by adaptive problem-
rch. Improved cultivars and chemicals are easily
ctive conservation measures are not adopted.
potentially useful agronomic techniques listed need
ed and adapted for a wide range of soils and
The best production potential of the tropics can be
od production can be dramatically increased.

89 - 13/14

sertification control
, report, NORAD, IUCN, UNEP, environmental
soil degradation, drought, ecology,
ecodevelopment, integrated strategy

This report has been produced by the Conservation for Development Centre of the International Union for Conservation of Nature and Natural Resources (IUCN).
The scope of this report is the Sahel and other drought-affected regions of Africa. In view of time and cost constraints it primarily covers the "climatic Sahel" but it is hoped that other regions of drought-affected Africa will receive a balanced treatment in the future.
This report has been written for the use of national, regional and international bodies, development assistance organizations, non-governmental organizations and IUCN's own constituent centres and commissions.
Environmental degradation ("desertification") is distinguished from cyclical successional change. Exploiting any ecosystems can cause changes to become non-cyclical. Rehabilitation is possible with time, resources and reduced exploitation, but is harder as thresholds are crossed. In dry zones loss of the herb layer is critical, even when reduced competition favours tree growth.
In the drought-affected regions of Africa, human livelihood security and environmental rehabilitation are inextricably linked. A dual strategy approach is required, to promote ecodevelopment at the local level and to address national, regional and international causes of environmental degradation:
- Linked ecodevelopment projects for local rural communities
- Promoting new styles of development at the national and international levels.

The Action Plan is intended to operate over the remaining 15 years of this century. This report outlines a framework for the first three years. The principal focus of the programme is a series of community based ecodevelopment projects aimed at conserving and better managing the living natural resources on which the communities depend. Starting with a small core of cooperating NGOS, with one serving as a focal point in each of the target countries, it is anticipated that, over the years, the number of partner NGOS, the number of projects supported and the range of ecodevelopment activities represented will grow.

496 89 - 13/15

Erosion and desertification control
Review, tropics, IITA, farmign systems, soil erosion, agroecology, sustainability, traditional systems, development
LAL, R.
Impact of farming systems on soil erosion in the tropics.

ıd and labour, both of which are becoming scarce.
ation and related bush fallow systems which rely
g forest fallow for soil fertility restorations are
t on purchased inputs. These systems have been
d-surplus economies. With mounting pressure on land
necessary to transform the resource-based systems
d systems. This transition phase has been marked by
ood deficit, particularly in tropical Africa. The
intensive landuse systems has also resulted in
tion of resources. A principal cause of soil
the tropics is accelerated soil erosion.
there are broadly two systems of land and soil
the traditional shifting cultivation system and
ming systems:

ivation and Related Bush Fallow Systems:

ming systems, based on natural fallow for fertility
e widely practiced in the Highlands of Northeastern
Thailand, Philippines, Outer Islands of Indonesia,
Africa and South America.
il erosion losses are generally low, if the
tems are based on short periods of cultivation
ng periods on natural fallow. Sediment and water
r, increase with increasing length of the
se because of the progressive degradation of the
ion properties of surface soil.
the duration of cultivation and fallow phases,
in traditional systems can be drastically high when
are cleared for slash-and-burn agriculture. Shallow
terrain in regions of torrential tropical rains,
hed away even during the first year of cultivation
w.
the erosion hazard, the resource-based extensive
s must be replaced by more productive and
ble farming systems. For the alternate farming
eed, it is imperative that soil erosion and
iminized.

rming Systems:

rming systems must achieve economic and sustained
oduction while preserving the resource base and
gh environmental quality. Some introduced systems,
sful elsewhere, have caused severe soil erosion
tropics. For example, mechanized forest clearing
ensive mechanized cultivation for grain crops cause
and erosion-induced soil degradation from

497 89 - 13/16

Erosion and desertification control
Review, book, soil erosion, conservation practices, psychology, physiology, biology, physics, population density, land-use, socioeconomic factors, guidelines
HALLWORTH, E.G.
Anatomy, physiology and psychology of erosion.

John Wiley & Sons, Chichester, hardcover, ISBN 0-471-91212-3, 1987, 176 pp.

In 1974, the International Federation of Institutes of Advanced Study (IFIAS) initiated a project to investigate the problem of soil degradation, especially that occuring in Third World countries. Professor Gordon Hallsworth, the author of this book, was project leader.
The major subjects covered include the following: the interaction of man and erosion; anatomy of erosion; physiology of erosion; the extracellular system; traditional soil conservation methods; the effects of the human component on erosion; the effects of extracellular system processes on intracellular ones; psychology of erosion; guidelines for the future. The content of some chapters, such as the anatomy and physiology of erosion and extracellular and intracellular system processes, is not self-evident. Thus, anatomy refers to the structure of soils and physiology deals with organic processes of the soil system. Extra- and intracellular aspects of erosion refer to factors affecting erosion and soil formation within a land system or those coming from areas external to the particular land system.
The three chapters devoted to the structure, biology and physics of soil erosion are outstanding in clarity and detail. However, when Hallsworth reports that an average soil erosion is 20 t ha^{-1} $year^{-1}$, the reader needs to understand the significance of such a loss. Given the fact that soil is reformed at a slow rate of about 1 t ha^{-1} $year^{-1}$, the magnitude of the loss is clear and emphasizes the need for action to curtail erosion.
The author presents convincing evidence that various soil conservation practices have been employed during the last 1000 years. One of the most commonly used practices through time is terracing. Other conservation technologies that have been used for centuries include: trenches; contour planting; mixing cropping; live fences; stone barriers and other types of barrier constructed on the contour to catch soil moving down the slope; mulching using vegetation (a form of no-till). Hallsworth currently emphasizes that vegetative cover is the most effective way of protecting soil

. conservation practices by farmers. Hallsworth
trained extension personnel play a major role in
use of conservation technology. In addition, he
e financial incentives and credits encourage and
in using needed conservation technologies. The
d that, based on his observations, "chap food"
vernments that exploit rural farmers tend to
land management practices. Based on field data
study team, literacy and the size of the farm had
erosion and employment of conservation.
several tangible barriers to the control of soil
hor also discusses several psychological factors,
ld beliefs, that are barriers to initiating
tices.
chapter on guidelines for the future, he concludes
be done to halt the rapid growth of the human
use it is associated with over-exploitation of
nd the concomitant reduction in vegetative cover,
are bound to increase. Thus, the only way for
rotect soil resources is to encourage farmers to
nservation practices in producing crops and

ggests that farmers will use soil conservation
nen they see it will provide them with profit and
ty. Hallsworth explains that the best way to
er to use soil conservation technology is to
value of conservation on his land. This means that
practice must be suitable for his land, his crops
. Clearly, getting the involvement of people at a
time and patience. It also requires sound plans
and effective extension agents. Most scientists
Hallsworth that no government in the world has
evise and implement a sound soil conservation
only hope that policy makers and agricultural
ionals will give priority to the eight guidelines
sworth to develop an effective soil conservation

e of this book and that of some of the chapters
misleading, the basic information on erosion
book is excellent. The author writes clearly,
ables to substantiate his explanations, and each
eferenced. Scientists, students and policy makers
biology, physics, sociology and politics of soil
rvation will find this book a valuable resource.
97% of the food of the human population is grown
vital that our soil resource and indeed our

498 89 - 13/17

Erosion and desertification control
Review, case studies, Ethiopia, Thailand, soil erosion, soil formation, ecosystem, soil loss, yield stability, sustainability, soil degradation ratio
HURNI, H.
L'érosion des sols et la formation de sols dans les systémes écologiques agraires: les cas de l'Ethiopie et de la Thailande septentrionale. (Soil Erosion and Soil Formation in Agricultural Ecosystems-Ethiopia and Northern Thailand-.)

Mountain Res. and Development, 3, No.2, 1983, pp. 131-142

The term soil erosion is generally used to describe the adverse effects of man's utilization of the soil, with soil being a precious, natural resource which is renewed extremely slowly.
Soil erosion is by definition a process induced by man's impact on a landscape, whether he acts to remove the forest cover, to cultivate, or to introduce his own structures. Soil erosion, however, is not restricted to the formation of gullies, badlands, and landslides, as is sometimes inferred. The most dangerous form of soil erosion is sheet and rill erosion, resulting in an almost invisible but steady degradation of large areas under cultivation. Also, soil erosion may not be negative in all cases, and man not necessarily destabilize an ecosystem irreversibly.
This paper emphasises the study of soil erosion effects on agricultural ecosystems which differ in terms of land-use practices, natural prerequisites, and human responses to soil erosion. Sheet and rill erosion is considered to be the most harmful of all soil erosion forms since it may be unnoticed or ignored by the peasant cultivating his land, yet it can result in damages which cannot be reversed. The assessment of soil loss rates alone, however, will not be sufficient for evaluation of the destabilizing effects of soil erosion. It is also necessary to define and describe all related terms, such as mean annual soil loss due to sheet and rill erosion, soil loss tolerance, soil formation rate, and soil degradation ratio.
Two case studies, one in the Ethiopian high mountains and one in the mountains of Northern Thailand, are used to demonstrate the role of the various factors that influence stability. Despite moderate erosion rates, the ecosystems in Ethiopia have suffered the greatest ecological damage through soil degradation processes. This threatens the food security of the present-day inhabitants. Reasons for this can be found in the inaccurate perception of soil erosion as a problem, and in the low soil loss tolerances of this

radation ratio, defined as the soil loss divided
tolerance, was found to be a practical method of
destabilizing potential of soil erosion in
stems.
ion ratio, D, of a cultivated slope, soil, or
defined as:

$$D = \frac{A}{T}$$

n soil loss ($t \cdot ha^{-1}$) for a defined period (e.g.,
.s the soil loss tolerance ($t \cdot ha^{-1}$ as a function
rates for the same period).
sure of the destabilizing effect of soil erosion
l ecosystem. High figures for D indicate more
tion.
an 1.0 indicate that a cultivated slope is being
oil conservation measures are required. D-values
nat the rapid soil formation processes act as a
considerable soil losses. If D equals 1.0, soil
led, but the resistance of the ecosystem in the
soil losses, such as will occur if population
reduction in the fallow period, is small.
ts for soil erosion studies, therefore, include
mean soil loss) F (soil formation) T (soil loss
soil degradation ratio) and at least one year of
ts for each watershed selected for study.

89 - 13/18

fication control
n, theory, stability of soil

on-preventive stability of soils.

s of the Int. Soc. of Soil Science, Hamburg, V,

function of five factors, namely, climate,
rties, parent and bedding rocks (in case of
etation and man economic activities. Effect of
erosion should be viewed from two angles:
volume and velocity depend to a large extent on
secondly, soil resistance to outwash seriously
ensity when the runoff has already been formed.
thstand the outwash action of the water flow or
of the water flow and

horizons of soils of different genetic types under a thick overgrowth of perennial and annual grasses have a scouring velocity of 30-50 cm sec^{-1} and more. A positive effect of vegetation is however most clearly expressed when the root density approaches 0.15%. Weakly developed grasses do not have noticeable influence.
Influence of various factors of erosion-preventive stability has been reflected in some degree in the proposed classification of soils according to their erosion-preventive stability.
Data are to be used in predicting water erosion of soils and in planning counter-erosive measures. A scouring velocity of the flow together with the velocity of water movement along the slope, are essential arguments in the formulas describing soil outwash.

500 89 - 13/19

Erosion and desertification control
Review, book, soil degradation, society, case studies, Nepal, North America, Indonesia, Pacific, China, India, Europe
BLAIKIE, P. and H. BROOKFIELD
Land degradation and society.

Univ. Paperbacks, Methuen, 11 New Fetter Lane, London EC4P 4EE, England, ISBN 0-416-40150-3, 1987, 296 pp. dfl. 50.40

Piers Blaikie has led a radical re-think of the issue of environmental degradation. In this volume, which reflects the useful collaboration he established with Brookfield and others at the Australian National University, his arguments become more realistic and, consequently, pessimistic.
The departure point of the book is that the environmental movement has had a marginal impact upon the continuing exploitation of nature for short-term gain. This volume argues that there is a need for a combination of natural and social science in order to address the problem of land degradation. In particular, the authors argue that social understanding of land degradation is poorly developed so much that the environment is frequently only considered as a stage, a passive background, to human action. The argument of the volume is that people produce nature through complex methods of land management. To capture the physical complexity of nature, the authors discuss the notion of sensitivity and resilience in land systems; sensitivity refers to to environmental damage and resilience refers to the ability of land to reproduce its capability after interference. The volume usefully summarises the frequency/magnitude problem in measurement and the issues of scale. In addition, there is a brief and clear

ngly antifundamentalist, not seeking to preserve
or the sake of the environment: it strongly
y is the cause of poor land management and poor
eepens the environmental crisis. Such a social
seful, if pessimistic, departure point for
issues of land degradation.
A

89 - 13/20

ification control
, farming systems, soil degradation, arid lands,
humid tropics

ming systems to prevent soil degradation.

of an Experts Meeting, ICRISAT Center, India,
02 324, 1986, ISBN 92-9066-115-1, pp. 7-8

includes physical, biological, and chemical
as decline in soil fertility, decline in
ion, erosion, adverse changes in salinity,
inity, and the effect of toxic chemical,
cessive inundation. It is estimated that 5-7
ltivated lands are being completely lost for
tion every year through soil degradation.
n developing countries, where most of the soil
ce, will double in the next 20-30 years. For
riod, the needed increase in agricultural
ve to come from the existing cultivated land,
ch are already subject to degradation. It is
op farming systems that permit greater food
the same time, enhance the potential of the
re food, fodder, fuel, and fiber. Many such
developed for the arid, semi-arid, and humid
al and international agricultural research
ent recommends improvements in farming systems
ions and describes areas in which further
It provides guidelines based on the improved
ble to be observed when it is planned to
stems on arable land in order to feed the
tion.

502 89 - 13/21

Erosion and desertification control
Africa, book, review, desertification, climate, CILSS, strategies, methods, rural participation
BONFILS, M.
Halte à la désertification: Guide méthodologique. (Stop desertification: A methodologic guide).

C.T.A. Karthala, 1988, 263 p., available at Ed. Karthala, 22-24 Bd. Arago, F-75013, Paris, France

A good half of West African territories are affected with desertification. More than a progression of desert,it is a landscape which degrades. The climatic factor (successive droughts) is one reason, but it is amazing to learn that the demographic factor, causing a soil overexploitation through men and animals, is much more responsible for this desertification: in fact, it is a degradation coming from inside and not from outside influence which makes an urgent solution necessary.
The different governments are conscious of this fact (e.g. CILSS, International Committee for Control of Drought in the Sahel) but they are still in a phase of wishes and sectorial activities than in a state of global and participative action. Strategies and techniques of control exist already, but methods are lacking: methodology in rural participation, governments' support, soil management etc.
Many pages about participation, but nothing very concrete, only general statements, except for one account about "participating activities in a village", which gives a real practical contribution on this subject.
In fact, there are very few new elements to be found. There are in the first part of this guide some references and comparative assessments of different techniques in desertification's control (protection, tree plantations, dune fixation, crops etc.).
The book ends with a sort of "credo" underlining three key principles: reduction of areas for traditional crops, intensification of cultural methods, and effort of rural communities in accepting changes.
Abstract from Agricultures actualité

Use: There are two types, one with bitter tasting fruits and the other with fruits which are not bitter. The green unripe fruit of both types is eaten raw or cooked.
Cultivation: In Zambia planting is done between August and September. The seed are broadcast and will germinate when the rain starts. The first fruits are harvested after 3 to 4 months before they become yellow.
Pests feed on all parts of the plant and leaf spot is common.
Green vegetables that are not mucilaginous are chopped finely before washing. Then the leaves are boiled in water. If the flavour of the type of vegetable is too strong or bitter the water is discarded. Generally, vegetables are cooked for a long time and groundnuts or cooking oil is added.
In the case of mucilaginous vegetables like cat's whiskers, they are cooked with soda and are not washed. No cooking oil is added but sometimes groundnuts are.
There are two disadvantages in preparing the food like this:
- Washing after cutting and prolonged cooking will cause a loss of watersoluble vitamins (Vit. C).
- Cooking with soda destroys much of the protein.

In spite of the obvious advantages of these vegetables they suffer several shortcomings:
- They are considered the food of the poor.
- Preparation methods are not always suitable for their full nutritional exploitation.
- Their market value is low and they are not exported.
- Many children do not especially like leafy vegetables.
- Some types are eaten by certain ethnical groups only and are not acceptable for others.
- Data on yields, nutritive value or antinutritive value are scarce.
- Little selection on local types has been done.

While much emphasis in research is directed towards the adaptation of exotic vegetables and fruits to tropical conditions, very little is done to improve those crops that are already adapted and liked by the majority of the people.
More detailed information is needed on their yields and the diseases affecting these crops. It would be worthwhile to compare local types of the same species in order to find out which are the most suitable for further promotion.

1. GEOGRAPHICAL INDEX

2. SUBJECT INDEX

Use: There are two types, one with bitter tasting fruits and the other with fruits which are not bitter. The green unripe fruit of both types is eaten raw or cooked.
Cultivation: In Zambia planting is done between August and September. The seed are broadcast and will germinate when the rain starts. The first fruits are harvested after 3 to 4 months before they become yellow.
Pests feed on all parts of the plant and leaf spot is common.
Green vegetables that are not mucilaginous are chopped finely before washing. Then the leaves are boiled in water. If the flavour of the type of vegetable is too strong or bitter the water is discarded. Generally, vegetables are cooked for a long time and groundnuts or cooking oil is added.
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3. AUTHOR INDEX

This is the second edition called "Abstracts on Sustainable Agriculture". In view of the good experience made with the "Abstracts on Intercropping", GTZ intends to continue making the documentation available. Intercropping remains an important aspect of the abstracts but will now be treated as an integral component of sustainable agriculture.

These abstracts are more comprehensive than the usual type of annotated bibliography but they cannot substitute the original publication. For details it is advisable to refer to the original.

The abstracts are divided into different sections, e. g. integrated systems, agroecology, homegardens, soil fertility, water management etc. The subject index, based on key-words, the geographical indices as well as the index of authors help the reader to find abstracts on specific aspects of sustainable agriculture easily.

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