1150 92 - 5/126

Agroecology
Asia, Pacific, review, book, environmental crisis, natural resources, food, agriculture, health, toxic wastes, people's movements, NGO's, environment network

SAM

ENVIRONMENTAL CRISIS IN ASIA-PACIFIC.

Publ. by SAHABAT ALAM Malaysia 37, Lorong Birch Penang, Malaysia, 1984, 52 pp.

This booklet summarizes the declaration and resolutions of a seminar on "Problems of Development, Environment and the Natural Resource Crisis in Asia-Pacific".
Countries all over Asia and the Pacific are beginning to be affected by the impact of development and environmental crisis in the region. The range of problems are similiar throughout.
In the Asian-Pacific Environment, a few major issues can be identified for special attention, taking into account the reality behind many of the problems that are affecting people in the rural and urban areas. These include:
- Food and agriculture
- Forests, land, wildlife and national parks
- Minerals and energy resources
- Human settlements and urban environment
- Industrial policies and environment
- Rural environment and effects of development
- Environmental education, media and non-governmental organisation

In Asia and the Pacific, as in Africa and Latin America, the best resources are being used for the benefit of the rich countries - exporting to them the energy, the fish, the raw materials and using labour resources to extract and export these materials and all at low prices and poor terms of trade.
The rich countries with 20 percent of the world's population are consuming and using up 80 percent of the world's resources.
Given this situation, one should not divorce environmental and development issues and priorities in this analysis, deliberations and suggestions. Development and the environment are inter-twined issues. Unjust economic relations lead to ecological disturbance, resource depletion and environmental degradation. These environmental crises in turn have a disastrous effect on the development efforts of the developing countries.
In this context many individuals and groups have got together in the Asia-Pacific region representing grass-roots action organisations, media institutions, United Nations agencies, and scientists and academics, to deliberate on the environmental crisis in the region.
The seminar was attended by participants from India, Sri Lanka, Bangladesh, Thailand, Malaysia, Indonesia, the Philippines, Hong Kong, Japan, Australia and the Pacific.

The participants had opportunity to identify the various common issues related to problems of development and the environment and the depletion of natural resources in the Asia-Pacific region.
Participants reviewed the role of regional environmental agencies, government agencies, research and education institutions, media and information agencies and non-governmental organisations in their efforts to fight environmental problems.
Specific recommendations and measures for action plans were formulated on environmental pollution and natural resource depletion problems, to cooperate with and among individuals, organisations and agencies in the region and plans to make representations on behalf of the people whenever and wherever needed on problems regarding the environment.
Participants also examined the need for an effective follow-up Coordination Programme of Links, Documentation and Action Network among the non-governmental organisations, research and educational institutions, the environmental agencies and the media in the region.

VI AGROMETEOROLOGY

1151 92 - 6/30

Agrometeorology
Review, article, industrialized countries, developing countries, agriculture, air pollution, pollutant impact, yield losses, environmental pollution

ASHMORE, M.R.

AIR POLLUTION AND AGRICULTURE.

Outlook on Agriculture, 20, 1991, 139-144

Air pollution has long been known to damage plants.
Up to the middle of this century, the problem was very largely restricted to urban and industrial regions of Europe and North America. Over the past two decades, however, it has become evident that pollutants can be transported over long distances, and hence their impact may be felt widely over rural regions. The rapid pace of industrial development and urbanization in many developing countries means that adverse impacts on agriculture are beginning to be felt in many parts of the world.
The major pollutants of concern in relation to agriculture are summarized in this article and some important sensitive crop species and the approximate concentration at which adverse effects are observed. The pollutants may conveniently be divided into primary pollutants, such as sulphur dioxide and ammonia, which are emitted directly into the atmosphere, and secondary pollutants, such as ozone, which are formed by subsequent chemical reactions in the atmosphere.
Although particulates act primarily by reducing light interception, certain particulates (e.g.cement dust) have chemical properties which may lead to more specific injury. Other particulates may contain high concentration of heavy metals, such as lead and zinc, which may contaminate foliage directly, or contribute to an increased soil burden. Other primary gaseous pollutants which may be of concern around industrial works include hydrogen chloride, chlorine and ammonia.
Apart from ozone, the most important secondary pollutants are acid mists and rain which contain high concentrations of nitrate and sulphate, produced from the oxidation and dissolution of nitrogen oxides and sulphur dioxide. Acid rain has been shown to cause soil and fresh-water acidification in areas with poorly buffered soils.
Ozone is undoubtedly the most important gaseous secondary pollutant in terms of impact on agriculture, but other gases have local impacts on sensitive crops too. These pollutants are photochemical and are produced in high concentrations under hot, sunny conditions.
National estimates indicate crop losses of about 5% in the USA and Netherlands, but these estimates do not take into account indirect effects, via altered pest and pathogen performance, which could

substantially alter the economic loss assessment. The greatest concern in the coming decades should be the impact of air pollution on food production in the developing countries. There is a need, in particular, for an objective assessment to identify the regions and pollutants of greatest concern; improved rural monitoring of pollutant concentrations; evaluation of the pollutant sensitivity of local crops and cultivars; and field experiments to quantify impacts of air pollution. A great contribution could be made to these needs by the governments and scientists of developed countries where agricultural impacts of air pollution are of less immediate relevance for the welfare of the population.

1152 92 - 6/31

Agrometeorology
Review, book, Europe, primary production, agriculture, greenhouse effect, climatic change, crop distribution

GOUDRIANN, J. et al

THE GREENHOUSE EFFECT AND PRIMARY PRODUCTIVITY IN EUROPEAN AGRO-ECOSYSTEMS.

PUDOC, Wageningen, The Netherlands, ISBN 90-220-1026-0, 1990, Dfl. 40, USD 23

This slim volume of 96 pages contains the proceedings of an international workshop on primary productivity of European agriculture and the greenhouse effect, held at Wageningen in April 1990. The synopses or abstracts of the 24 papers presented cover the results of recent work carried out since the Villach conference held in 1985. Several contributors discuss the effects of climatic change expected in the future on the basis of increased concentrations of atmospheric CO_2 and other gases giving rise to the 'greenhouse effect' with increasing temperatures, greater UV-radiation intensity and associated phenomena. Geographic distribution of crops is expected to change, making wheat and even maize production possible in hitherto marginal northern areas. Plant productivity is likely to increase through greater photosynthesis, but other aspects are less reassuring, notably accelerated development of winter cereals and possibly reduced growth periods, enhanced survival of weeds which would help pest and disease organisms to overwinter, increased weed growth due to better seed production and more life cycles, and inadequate mineral supply for increased plant growth. Crop and climate modellers have looked at possible trends, but there is a paucity of primary data and, up till now, inadequate dialogue between different groups of workers.
Several contributors discuss historical aspects and economic consequences of the greenhouse effect. There has been climatic change in the past, as shown for example by the cultivation of wheat in Iceland and of grapes in England and Belgium during the High Middle Ages, and thus a temperature rise limited to 1.5 to 2.0°C by 2050 is not considered disastrous. What is likely to be more important in Western Europe, quite apart from the cost of increased sea defences, is the likely prospect of even greater overproduction of agricultural produce which, in the face of a shrinking and ageing population, will lead to still greater surpluses of food. Future politicians will thus have to determine, how much longer local farmers can be protected and whether marginal land can be retained for agriculture or needs to revert to forest.
Many of these and other aspects were raised at the workshop, and it is valuable to have them recorded.
Abstract by R.H.M. Langer, shortened.

1153 92 - 6/32

Agrometeorology
Review, book, vegetation, atmosphere, principles, case studies, ecology, weather, soil, ecosystems, microclimate

MONTEITH, J.L.

**VEGETATION AND THE ATMOSPHERE:
VOL. 1 PRINCIPLES; VOL. 2 CASE STUDIES**

Academic Press, London, UK, 1975

In the post war period, especially after 1950, a deliberate effort has been made to achieve a better balance between weather and soil studies in the study of vegetation in relation to its environment, in which soil conditions had been privileged for a long time. Stimulus for this work comes from, among others, (tropical) ecologists concerned with changes in the microclimate that occur when the equilibrium of an ecosystem is disturbed. The two volumes have been prepared to take stock of current knowledge and to ask whether ecological science is getting the full benefit from all the information now available about physical processes and mechanisms in plant communities. The first volume, as the introductional chapter states, deals with the main contributions of micrometeorology to ecology in terms of a matrix where mechanisms, processes and states are used against air, plants and soil. This leads to review chapters on radiative transfer in plant communities, momentum, mass and heat exchange of plant communities, the hydrological cycle in vegetation, the movement of particles in plant communities, micrometeorological models and instruments and their exposure. In the first part of the second volume chapters on relatively heavily studied crops like temperate cereals, maize and rice, sugar beet and potatoes, sunflower and finally cotton show (and occasionally state in their conclusive chapters) that much is known on (consequences of) radiation characteristics, less on (consequences of) detailed heat and water balances, appreciably less on (consequences of) momentum balances and carbon dioxide balances, overall enough to try to use some of it in relatively simple but economically useful attempts of crop climate management and manipulation, but that a synthesizing attempt for that purpose is far from possible. Only in either a modelling approach, like in the chapter on townsville stylo, or in controlling certain confined aspects (frost, solar radiation) of the microclimate, like in the chapter on citrus orchards, such simple but useful attempts are actually exemplified. The chapter on coniferous forests is one of the earliest attempts to apply in detail the same approach as for the well studied crops. In less detail, because less is known, the same is done for deciduous forests. And still more limited in scope but rather unique is the micrometeorological work reported on tropical rain forest. The last three chapters, on swamps, grassland and tundras show how micrometeorological concepts can be applied to whole ecosystems. It is important for our purposes that the following ecological

topics are listed in which the potential contributions of micrometeorology have still to be realized: "measurements of states outside the temperate climates in which most micrometeorological groups have hitherto worked", "measurements of process rates over a whole growing season", "the description of plant communities as 2- or 3-dimensional systems: in particular, the application of micrometeorology to row crops and to systems of inter-cropping which are an integral part of traditional farming practice in many tropical areas; the micrometeorology of isolated trees or small groups of trees valuable for amenity or shelter; the measurement and specification of root systems", "analysis of the relation between weather and disease in terms of mechanisms, processes and states (including dispersal)", "the measurement of atmospheric pollutants in plant environments".

92 - 6/33

1154

Agrometeorology
Review, book, tropics, microclimate, environment, biometeorology, agronomic practices, yield

ROSENBERG, N.J. et al.

MICROCLIMATE: THE BIOLOGICAL ENVIRONMENT.

Wiley & Sons, New York, 1983, (2nd Ed.)

This book contains twelve chapters:
- on the radiation balance;
- soil heat flux and soil temperature;
- air temperature and sensible heat transfer;
- wind and turbulent transfer;
- atmospheric humidity and dew; modification of the soil temperature and moisture regimes;
- evaporation and evapotranspiration;
- field photosynthesis, respiration and the carbon balance;
- windbreaks and shelter effects;
- frost and frost control;
- water use efficiency in crop production;
- human and animal biometeorology.

This is a textbook close to the climate aims of understanding modification practice and potential. Especially microclimatic influences of different mulches and shelters and the manipulation of evaporation and frost climate are quantitatively dealt with. It is summarized that the literature of shelter effect is reasonably consistent in its conclusions that: shelter alters microclimate; shelter reduces potential evapotranspiration; shelter reduces actual evapotranspiration; shelter improves internal water relations, for example greater internal water potential, lower stomatal resistance; shelter provides improved opportunity for photosynthesis; shelter generally increases yield. On the one hand these benefits may be most dramatic in dry years or when moisture shortages are critical, but on the other hand the literature also suggests that benefits in terms of actual yields may be more consequential under irrigation than on dry lands. Scattered trees as shelter have not been dealt with. As methods of frost protection are treated: site selection; radiation interception; thermal insulation; air mixing; direct air and plant heating; application of water; chilling to prolong dormancy and soil manipulation. The book is full of very relevant tropical and other Third World examples from the experience of the authors and many other sources.

1155 92 - 6/34

Agrometeorology
Review, bibliography, project, microclimate management, traditional farmer, field reports

WILKEN, G.C.

MICROCLIMATE MANAGEMENT BY TRADITIONAL FARMERS.

Geogr. Rev. 62, 1972, pp. 544-566

This bibliography covers the only international project existing on "Traditional Techniques of Microclimate Improvement". The paper relies on field reports in its identification of farmers' reasons for using particular management practices and wants to produce sufficient evidence to justify the nomination of (micro)climate to that group of environmental factors over which traditional farmers exercise significant control. Two aspects of field microclimate are distinguished: preservation of desirable characteristics and generation of these characteristics within the crop zone. Examples of shade management, the manipulation of albedos, surface geometry and longwave transfers are separately dealt with. In a section on heat and moisture, tillage systems, surface mulches and dew are dealt with. Sections on wind, rain and hail and on maintaining microclimates close this valuable paper. In footnotes the widely scattered existing literature on basic concepts and examples is very adequately covered. The paper nevertheless concludes that its coverage is less than comprehensive, and for good reason. Crop climate management is so widespread and assumes so many forms that a complete catalogue of practices would fill volumes. Nor can extensive quantitative evaluation be attempted, since neither field nor laboratory research has produced much data on the results achieved by traditional methods. The paper concludes that traditional farmers employ an impressive array of climate-ameliorating techniques. But information on these practices comes mostly from scattered field observations, with few indications of the results achieved. Measurement of radiation, heat, and moisture fluxes under a variety of crop and field conditions are sorely needed to determine the effectiveness and extent of these climate-control measures. Questions as growing seasons and production are affected by these practices need to be dealt with.

1156 92 - 6/35

Agrometeorology
Review, book, plants, agriculture, environmental stress, ecology, drought, salinity, temperature, heat, frost

CHERRY, J.H.

ENVIRONMENTAL STRESS IN PLANTS.

Springer Verlag, NATO ASI Series G: Ecological Sc., 19, 1989, ISBN 3-540-18559-3, DM 188,-

Probably at no time in the past has there been a more concerted research effort aimed at improving understanding of fundamental mechanisms by which plants respond to their environment. 'Environmental Stress in Plants - Biochemical and Physiological Mechanisms' provides a recent summary of those efforts, the volume arising from a NATO-sponsored meeting held in Norwich, UK, in 1987.
The volume is divided into groups of chapters, each group dealing with a specific area of stress, namely: drought, salinity, anaerobic, low temperature and heat. Mineral nutrient deficiency and mechanical impedance are omitted but the coverage of the general area of stress in higher plants is otherwise comprehensive. Typically, each paper is brief, but well focussed, so that the reader is quickly in tune with the important issues that preoccupy investigators. Unfortunately, a few contributions comprise a single-page abstract, without references; such skimpy offerings detract from a volume that is otherwise carefully edited and printed to a high standard. It is also curious to find a paper on accumulation of metabolites by a prokaryote (*Salmonella typhimurium*) in a volume otherwise dedicated to higher plants - one questions its inclusion.
Although it can be argued that many of the presentations in this volume have appeared in reference journals, the value of this book is that it provides a useful collection in a single volume and reasonably current summaries of the field. The volume will be useful mainly to teachers, students and those working in other disciplines who wish to become acquainted quickly with this area of plant science; it is unlikely to appeal to the specialist researcher who is already current with the literature.

1157 92 - 6/36

Agrometeorology
Review, book, cold climate, semi-arid climate, climatic variations, agriculture, impact assessment, IIASA

PARRY, M.L. et al.

THE IMPACT OF CLIMATE VARIATIONS ON AGRICULTURE.
VOL. 1: ASSESSMENT IN COOL TEMPERATE AND COLD REGIONS.
VOL. 2: ASSESSMENT IN SEMI-ARID REGIONS.

Kluwer Academic Publishers, Dordrecht, 1988; Vol. 1: 876 pp., Paperback 220 Dfl.; Vol. 2: 764 pp., Hardback 200 Dfl.

These two substantial volumes arise from a project to investigate the impacts of climatic variations on the agricultural sector, carried out at the International Institute for Applied Systems Analysis (IIASA) in Austria, under the direction of Martin Parry, the leading editor.
The underlying idea, as set out in the preface, was that the impact assessments should be designed, conducted, and reported in a compatible manner even though they took place in different countries, with everything that implies in terms of economic, technical, and cultural diversity. Thus it should be possible to compare the results of one assessment with those of any other. The intention was not to look simply at the first-order (or direct) effects of climate on agriculture but also at the higher-order effects on regional and national economies.
Although the title of the book concerns climatic variations rather than climatic change, in fact much of the content, particularly in Volume 1, is devoted to impacts arising from the greenhouse effect. There are 11 case study regions altogether, with papers contributed by a team of 2-3 scientists in each. All the contributions were reviewed, and abstracts are given at the beginning of each section.
Volume 1 collects together the papers on cool temperate and cold regions: Saskatchewan, Iceland, Finland, subarctic USSR, and Japan. It opens with a set of background papers. These cover, on the one hand, discussion of regional climate scenarios for a high-CO_2 world and, on the other, impacts and first-order impact models. There are two papers applying the results of a climate scenario to estimate impacts on forest productivity in Northern Hemisphere high latitudes, and the higher-order effects on the world timber trade.
Volume 2 covers semi-arid regions in Kenya, Brazil, Ecuador, India, Australia, and European USSR. The background papers take only 120 pages as against 220 in Volume 1 and are of much less interest. One summarizes the results of the semi-arid case studies, one looks at first-order impact models, and one is a general essay on semi-arid climates.
There is a clear dislocation between the two volumes. The production of Volume 1 is much better, although potential purchasers might like to check for missing pages between 309 and

341. Volume 1 is oriented very much towards CO_2-related impacts whereas Volume 2 looks almost exclusively at present-day climatic variability. On this basis we may say that the project failed in its stated aim. However, the subject matter and quality of Volume 1 is such that I would recommend people to buy it.
Abstract by J. Palutikof

1158 92 - 6/37

Agrometeorology
Review, book, Afrika, Burkina Faso, Mali, Niger, Senegal, drought occurence, dry spells, crop variety, irrigation needs, crop water requirements

ICRISAT

DURÉE ET FRÉQUENCE DES PÉRIODES SÉCHES EN AFRIQUE DE L'OUEST. (DROUGHT SPELLS AND DROUGHT FREQUENCIES IN WESTAFRIKA).

ICRISAT Research Bulletin No. 13, ISBN 92-9066-182-8, 1991, Order Code RBE 013; LDCs: USD 14.31, HDCs: USD 33.11; Bilingual: English, French

This publication is bilingual (English and French). Recurring droughts and decreased agricultural productivity during the last two decades in West Africa have pointed to the need for a clearer understanding of the length of dry spells, their frequencies and probabilities. A comprehensive review of various definitions of droughts has been presented to develop the basis for analysis of droughts. Using the specific definition of onset of rains in each year as the sowing date, the length of dry spells was calculated from the historical rainfall data for 150 stations located in Burkina Faso, Mali, Niger, and Senegal. The relationships between mean annual rainfall and average frequency of dry spells for the selected locations in West Africa showed distinct patterns and permit the prediction of the frequency of dry spells from annual rainfall totals. Applications of dry-spell analysis for the choice of a crop/variety, supplemental irrigation, and crop water requirements have been described with examples.

1159 92 - 6/38

Agrometeorology
Syria, Israel, Netherlands, study, faba beans, climate change, temperature rise, CO_2 increase, yield stability, ecology

GRASHOFF, C. et al.

POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE ON COOL SEASON FOOD LEGUME PRODUCTIVITY

Publ. of the Dep. of Production Ecology, P.O.B. 430, 6700 AK Wageningen and Centre for Agrobiological Research, P.O. 14, 6700 AA Wageningen, Netherlands, 1992, 18 pp + Annex

In this paper a feasibility study of effects of climate change on growth and production of faba beans is described.
The increasing presence of atmospheric trace gases such as CO_2, CH_4 and N_2O due mainly to human activity, directly or indirectly, may influence the Earth's climate by transmitting incoming solar radiation, while partly blocking outgoing terrestial black body radiation. The increased "greenhouse" effect may cause temperature rise. This may affect the functioning of various agro-ecosystems in general and faba bean growing more specifically.
Different processes are influenced by various factors that are affected by climate change. CO_2-increase affects the stomatal conductance and increases photosynthesis rate and water use efficiency. Temperature rise may increase development rate of the crop, resulting in an adverse effect on crop production. Evaluation of the effects which work in contrary directions with direct qualitative or quantitative methods is difficult. Crop growth simulation models may be used for such an evaluation as the causal relations between rate variables and forcing variables is present in such models. The consequences of CO_2-increase and temperature rise may be evaluated with these models.
Climate change may have strong effects on faba bean growing, as this crop is very sensitive to water shortage and has a high yield variability at the present climate.
A simulation study was done with a well tested and validated model for crop growth and production of faba beans.
The used model was a version of SUCROS87, including a water balance.
For three locations differing in climate (Tel Hadya, Syria; Migda, Israel; Wageningen, Netherlands) at least 8 years with detailed weather data were used to simulate the consequences of temperature rise and increase of atmosheric CO_2 (based on assessment of the Intergovernmental Panel on Climate Change IPCC), separately and combined. It appears that temperature rise causes a decrease in seed yield of rain-fed crops in Wageningen and Migda, due to a shortening of the growing season. At Tel Hadya, seed yield of rain-fed crops increases, due to an accelerated start of the reproductive phase and consequently an 'escape' from water shortage later in the season. For fully irrigated crops, temperature rise causes at all locations a decrease in seed yield,

most in Migda, and smallest in Tel Hadya. CO_2-enrichment causes in all situations an increase in growth and production of faba beans, which compensates the decrease due to temperature rise. The effects are not completely additive at all locations. Yield increases due to CO_2-enrichment are much higher than the yield decrease due to temperature rise. In Wageningen, Tel Hadya and Migda the positive net effect of the two considered effects is respectively 12%, 68%, 28% for rain-fed crops and 5%, 16%, 13% for fully irrigated crops, assuming an increase of CO_2 concentration to 460 ppm and a temperature increase of 1.7°C. Fully irrigated crops show a remarkably smaller yield variability than rain-fed crops in all these assessments. In rain-fed crops, the variation in yield over the years stays the same or is somewhat reduced due to the reduced sensitivity to water shortage. Thus the net effects on productivity and stability due to the scenarios used for global climate change are at all locations positive. Other effects, such as for example morphological effects may overrule these physiological effects. Such effects are not taken into account in this study.

1160 92 - 6/39

Agrometeorology
Review, book, tropics, Asia rice, weather, project proceedings, workshop, physiological responses, biological stresses, cropping systems, deterministic models,

IRRI

WEATHER AND RICE.

Proc. of the Int. Workshop on the Impact of Weather Parameters on Growth and Yield of Rice; IRRI, Philippines, 1987, 320 pp. + annexes

Rice is the staple food of about half of mankind. At least 1.125 billion people, comprising 225 million rural families, depend on rice as their major crop; the majority of them are subsistence farmers.
Rice is cultivated under diverse climatic, hydrological, and edaphic conditions.
Its wide adaptability is illustrated by rice cultivation at latitudes from 40°S to 53°N at elevations ranging from below sea level to more than 2,000 m; under upland conditions with no accumulated surface water and lowland conditions with no accumulated surface water and lowland conditions with 5 m deep water. Temperatures and humidity also vary widely. The importance of studies to determine the impact of weather variables on rice crop performance is apparent.
The World Meteorological Organization has implemented a number of programs, including the World Climate Impact Studies (WCIP), to which the undertaking of this workshop is relevant.
In the Philippines, specifically in the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), a system to assess climate impact for agriculture started in January 1985. Its objective is to provide a reliable and timely, yet inexpensive, weather-based information system that will continuously monitor and assess the impact of weather (such as drought, floods, typhoons, etc.) on rainfed agriculture.
Summarizing the main recommendations of the workshop are:
- Weather and biological stresses:
  The extent to which information on the prevalence of rice pests under different cultural types and climatic conditions is quantitative or qualitative needs to be reviewed.
  Information on the current status of major pests in different rice-growing environments should be collected in a central data bank.
  Pest monitoring should be incorporated into studies on rice-weather relationships, including data on both research plots and adjacent farmers' fields.
  Provision for measuring or calculating leaf wetness, an important parameter in disease epidemiology, should be added to the basic data set. Continuous temperature and humidity records are desirable.

- Weather and rainfed rice:
  The constraints to upland rice production can be grouped as environmental, environment-dependent, and site-specific.
  The constraints to rainfed rice production include:
  . Climate: rainfall amount and variability, solar radiation, and temperature.
  . Technology: insect pests and diseases, weeds, and rats and birds; land preparation; planting methods; soil nutrient management; soil erosion and other physical problems; cropping patterns; and water conservation.
  . Genotype: seed dormancy and vigor, rooting characteristics, insect and disease resistance, resistance to temperature extremes, drought resistance, and crop duration.
  . Socioeconomic: production incentives, labor, markets, infrastruture, and credit.
  Most of these constraints can be related directly or indirectly to climatic factors or site characteristics.
  Water balance is the best tool for determining soil water availability or deficiency throughout the crop season.
  Because of the socioeconomic problems in rainfed rice regions and the complexities of environmental constraints on rainfed rice, international collaboration is the only avenue with the potential to contribute significantly to increased and stabilized production.
- Rice modeling:
  Several recommendations to rice modeling were made.

Because of the importance of the impact of weather on the rice crop, the major importance of the crop, and the success of the UNDP-funded Rice-Weather Project in initiating the collection of essential basic information on weather and rice crop yields, and noting that the project has already established a basis for prediction models for rice yield and shows potential for developing forecasting models for pest outbreaks, the workshop recommends that appropriate donor agencies make funds available to IRRI to continue the rice-weather project, encompassing as far as possible the recommendations of the working groups.

VII AGROFORESTRY

1161 92 - 7/75

Agroforestry
Review, Africa, Asia, agroecosystems, tree products, economics, policy issues, household inputs, agricultural inputs, employment, income, natural resources, social forestry, tree management, farmer, tenure

ARNOLD, J.E.M.

TREE PRODUCTS IN AGROECOSYSTEMS: ECONOMIC AND POLICY ISSUES.

GATEKEEPER Series No. 28; IIED London, UK, 1991, 21 p.

This paper reviews trends in the use of, and rural reliance on, forest products; it examines the role of common property resources (PRs) as a source of these products; and characterises trends in the growing and management of trees in farming systems. Throughout, the impact of national policies and of programme and project interventions on these two sectors is examined in the respective sections.
Trees are planted and managed in the farming system, and in the neighbour wood to provide inputs needed in order to complement those available from on-farm resources. These non-forest sources of production are becoming increasingly important with the growing decline and degradation of nearby forests and the increase in demand for fuel, fodder, and other products.
There are three broad categories of use of forest products: direct use by the household as fuel, food, etc; inputs into the agricultural system such as fodder and mulch; and sources of rural household income and employment. These categories are discussed in detail in this paper.
Rural people draw much of their forest products from areas of forest, woodland and 'waste' land to which they have access as common property resources (CPRs). These outputs often constitute a major component of the overall agricultural system - filling gaps in the resource and income flows from other resources, and providing complementary inputs often critical to the continued functioning of agricultural and household systems.
The nature and magnitude of the relationship varies with the characteristics of the surrounding ecological and agricultural systems.
Examples from Asia and Africa are outlined.
Social forestry woodlots and joint management on forest land are explained.
In recent times farmers everywhere have sought to shift the production of outputs of value on to their own land by protecting, planting and managing trees of selected species. In many situations farmers now depend on their own tree stocks for some products, and on common property resource sources for others. The process of adding trees to farming systems has been accelerated or

transformed by the growing commoditisation of fuelwood and other tree products, and the consequent emergence of the growing of trees as a cash crop. Examples in which tree planting occur in Asia and Africa are mentioned.
Within a particular agroecosystem, farmer involvement in tree growing appears to be largely related to changes in the availability and employment of land, labour and capital, and to the progressive commoditisation of tree products such as fuelwood and poles. Variations in tree growing patterns seem to reflect variations in the efficiency of operation of factor markets, different stages in the process of agrarian transition, and different patterns of tenure.
Concluding the author outlines implications for future policy considerations.

1162 92 - 7/76

Agroforestry
Latin America, Asia, Africa, lowland tropics, plantation forestry, tree species, genotype environment interaction, tree breeding, tree yields, DESFIL

EVANS, J.

SUSTAINABLE USE OF PLANTATION FORESTRY IN THE LOWLAND TROPICS.

In: Proc. of the Humid Trop. Lowlands Conference, Panama City, Panama, 1991, pp. 55-68

This paper lays down the principles governing successful plantation forestry in the lowland, humid tropics and seeks to address the issues which underpin sustainability: land capability, species choice, and management. Relevant examples are drawn from across the tropics.
While plantation forestry is often associated with industrial plantations the enormous expansion in social forestry is not neglected.
Accurate data for areas of tropical plantations are notoriously difficult to obtain. Gathering information from just over 100, mainly developing countries inevitably leads to a variety of definitions, confusion over units, optimism by some of equating seedlings supplied or planted with plantation established, lack of proper inventory, and so on. Nevertheless, from the available data, it seems clear that some 20 million ha of forest plantations of various forms have been established throughout the tropics and hotter subtropics in the last 10 years to give a global figure in excess of 40 million ha.
The virtual doubling of plantation forest area in the last 10 years arises from a massive social forestry program in India, though the quality and stocking of much new 'plantation' is questionable; a clearer picture of afforestation in tropical China; and programs of steady expansion in many countries. The bulk of the increase in the neotropics has occurred in Brazil, owing to the fiscal incentives program which ran from 1967 to 1986 and averaged some 300,000 ha per year from the early 1970s, but has since diminished to about one-tenth of this level.
An examination of tree planting schemes in the last 10 years shows a shift from one of replacement of natural forest formations, e.g. Jari, Brazil, to afforestation of already badly degraded land or natural savanna, cerrado, or grassland. This change is both laudable from a conservation point of view and reflects the fact that huge areas of land, since long deforested, are suitable for tree planting but not a lot else. The 40 million ha of Imperata grassland in Indonesia are a striking example.
Correct choice of species for a given site is fundamental to sustainable plantation forestry. Poor species choice will not only give poor yields about may increase risk of pest and disease damage. The ingredients of successful matching of species to site

include first climate matching followed by attention to soil factors.
Industrial plantation forestry has been dominated by planting of a very few species in the lowland tropics. Indeed *Pinus caribaea*, *Gmelina arborea*, teak, and *Eucalyptus grandis*, *E. camaldulensis* and E. *urophylla* probably account for 90%.
The last 10 years has seen a significant broadening. Increased use of little tested species, promotion of nitrogen fixing trees, and advances in vegetation propagation technology have contributed to this.
In addition to variation due to provenance, and to all sources of variability, there is evidence of an interaction between the selected genotype and the site. The highest ranked provenances, varieties, families or clones will not necessarily be the same on all sites. This is known as genotype x environment interaction (GEI) and breeding strategies must recognize this feature.
Plantation forestry is a feasible silviculture in the lowland tropics provided attention is paid to sound practice to ensure properly matched species and sites and regular management inputs. It is not a cheap form of forestry, but with commitment over time to a project, including tree breeding programs, the large investment can repay in highly productive forest which appears to be sustainable on most sites.

1163 92 - 7/77

Agroforestry
Latin America, Peru, study, project, forest management, Indians, land tenure, forestry cooperative

STOCKS, A.

THE PALCAZU PROJECT: FOREST MANAGEMENT AND NATIVE YANESHA COMMUNITIES.

Journal of Sustainable Forestry, 1, (1), 1992, pp. 97-123

This paper presents some of the background and the current operations of a novel management system incorporating landholders in tropical forestry.
The Palcazu Valley ist mostly in the Cerro de Pasco department in the central selva region of Peru.
The Palcazu project began in 1981 as a part of the larger scheme of regional development in the central selva of Peru. The regional plan was part of an even larger national plan for development of the tropical Andean foothills.
The Palcazu forest project is socially as well as ecologically oriented. The pilot program is taking place among native Amazonian Indians, the Yenesha of eastern Peru.
The two features of the forestry component of the Palcazu project that make it unusual are its involvement with Amazon Indians and the uniqueness of the strip-shelterbelt natural forest management system.
As this paper emphasizes, the social ties, knowledge of the forest, values placed on forest preservation, communal land tenure patterns, and willingness to work toward a common goal all militate for involvement of the project with the Yanesha in forest management.
For the forest management system to spread as a general model, people other than Indians will need to be included.
As this article attempts to make explicit, there are a number of ecological reasons why this kind of forest management should be promulgated. A balanced perspective would probably be that the social model proposed by the Palcazu project requires investment in quite different sectors than the usual forest exploitation with attendant high training costs, but that the extra effort may well be worth it if the outcome is rational forest management and stable social systems.
Technically, some problems have surfaced with the extraction system, especially the use of oxen with a population that has no tradition with them as draft animals. Oxen also require superior forage which involves an entire other subsystem of pasture maintenance just for the draft animals. There may be relatively low-cost and low-ecological-impact mechanical means of removing logs from the strips that can be developed.
Economically, the project still requires some subsidies both in supports to cooperative workers and in technical assistance. This support is currently being provided by World Wildlife Fund.

On the positive side, the market for preserved posts, initially very weak, has improved recently.
Failure of the forestry cooperative would have severe socioeconomic and political consequences for the Yanesha people, perhaps calling into question their very survival as an indigenous culture.
The Palcazu project points the way for future natural forest management projects, both in its unusual approach to forest management and in its social assumptions. Its survival during more than five years of national and regional political turmoil is largely due to the strong sense of ownership and commitment by the Yanesha cooperative members.

1164 92 - 7/78

Agroforestry
Latin America, Mexico, study, tropical forestry, mahagony forest tenure, silviculture, tree yield, research, DESFIL, USAID

SNOOK, L.C.

OPPORTUNITIES AND CONSTRAINTS FOR SUSTAINABLE TROPICAL FORESTRY: LESSONS FROM THE PLAN PILOTO FORESTAL, QUINTANA ROO, MEXICO.

In: Proceedings of the Humid Tropical Lowlands Conference, Panama, 1991, pp. 65-83

The Plan Piloto Forestal (PPF) of Quintana Roo, an 8-year-old community forestry project on the Yucatan peninsula of Mexico, has been heralded as a model for sustainable tropical forestry. In order to extract useful lessons from this experience, it is important both to evaluate its current and future potential as a sustainable system, and to understand the opportunities and constraints that have defined its development. Such an analysis should yield insights applicable not only to the continuing evolution of the PPF, but to the design of sustainable forestry projects elsewhere.
The first premise of this article is that the achievements of the PPF in community forestry are a product of both circumstances and the approach followed by the development team. The ecological characteristics of the forestand, the history of land and forest tenure and use in Quintana Roo created a favorable setting for community forestry based on timber harvesting. Nonetheless much of the success of the project can be attributed to the development philosophy, political connections, and long-term-commitment of the international team which initiated and has fostered the Plan Piloto Forestal (PPF).
The second premise is that while favorable ecological and institutional circumstances are necessary predictions for the establishment of successful tropical forestry projects, the long-term sustainability of forest activities depends on the design and application of appropriate silvicultural practices. This in turn, requires the capacity to define and acquire the necessary information on forest and species ecology and the impacts of forestry, and to develop and modify forestry practices accordingly.
During its first eight years the PPF has capitalized on existing opportunities and overcome a series of obstacles to accomplish its primary objectives of reorganizing forestry in Quintana Roo and contributing to socioeconomic development.
The benefits obtained from forestry activities by local people with secure tenure to their forest lands and decisionmaking power provide an incentive for managing forests with a long-term perspective.

1165 92 - 7/79

Agroforestry
Africa, Ghana, study, taungya system, forest types, timber production, farmer attitudes, commercialisation

BROOKMAN-AMISSAH, J.

THE TAUNGYA SYSTEM IN SOUTH-WEST GHANA.

In: FAO Soils Bulletin No. 53, 1984, pp. 183-185

This study uses a rather narrow definition of intercropping agricultural and forestry crops without regard to who owns the agricultural crop, so as to bring out variations. It also sees the Tropical High Forest Zone in the country as covering South-West Ghana.
The taungya system, as it was developed in Burma, involves peasant farmers in afforestation or reforestation. This system interplants trees with agricultural crops, particularly the local population's staple foods, and so serves to satisfy the farmer's quest for arable land.
This type of forest reaches the coastline for approximately a quarter of its length and thereafter is separated from it by a belt of mangrove, scrub and coastal savanna formations, which fan out from west to east.
The zone is characterized by uniformly high temperatures, a rainfall regime with two peaks, mean annual precipitation ranging from 2135-3000 mm in the southwest to 1250-1375 mm in the northeast, and a high relative humidity. The humid environment maintained by the forest cover enables the cultivation of such cash crops as cocoa, oil palm, rubber and kola nuts. Cocoa and timber are the two major export commodities.
The taungya system was introduced with two objectives: to establish plantations of fast-growing, useful timber species and, second, to meet the peasant farmer's demands for arable land, using forest reserves where land was genuinely needed.
The size of the forest land allocated annually depended on the demand and the ability of the Forestry Department to cope with it. The latter was largely determined by the stock available. On a few occasions, farmers were asked to raise seedlings themselves.
In exchange for this privilege, farmers were asked to assist in establishing the plantation by preparing the site. They provided pegs, tended the planted tree crop alongside other food crops and also were governed by restrictions as to choice of species and spacing imposed by the Forestry Department. Farmers continued to receive allocations only if they adhered to these conditions.
Peasant farmers were generally pleased. These allocations gave them the opportunity to raise crops on relatively fertile forest land, increasing crop yields and improving the standard of living. Preparing sites in the Tropical High Forest is the most expensive operation in plantation establishment. The farmer did not reap the full benefit of this investment, but this did not concern him unduly. He had no opportunity cost for his labour and in so far as

he could handle the work, involving his family, all his produce was profit. He expressed his gratitude to the forester by adhering to the rules, and generally becoming increasingly cooperative.
The large-scale reforestation scheme gave rise to yet another type of farmer, the big time city dweller, who used hired labour to cultivate food crops on the plantation sites.
The Forestry Department felled big trees and allocated plots to these "entrepreneur farmers" for a fee. The system resulted in a number of powerful farmers too difficult to control and consequently it failed. The poor peasant farmer was excluded from these areas.
The advantages of the taungya system is that the forester may be able to raise a tree crop at a lower cost, and at the same time increase food production. The farmer always has the advantage of being able to use land which has been kept fertile under a forest cover.

1166 92 - 7/80

Agroforestry
Latin America, Africa, review, book, field experience, agroforestry approaches, agroforestry planning methods

BUDD, W.D. et al.

PLANNING FOR AGROFORESTRY.

Elsevier Science Publishers, Amsterdam, The Netherlands; ISBN 0-444-88634-6, 1990, price USD 89.75, Dfl. 175.00

This book incorporates selected contributions from an international symposium held in 1989 at Washington State University in the USA. It provides an overview of planting methods for agroforestry research and development projects, based on experience from the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), CARE International, ICRAF, Washington State University, and the University of Wageningen (The Netherlands), among others. Discussions cover methods already in use and others currently under consideration.
Four chapters present various approaches to agroforestry planning, among these the diagnosis and design methodology developed at ICRAF. The rest of the book is devoted to accounts of field experience in Costa Rica, India, Indonesia, Kenya, Malawi, Sudan, and the islands of the Pacific.
Some of the key questions are:
- Planning for whom: Who are the farmers? What are their objectives and priorities? Or is the focus on the needs of the research, extension or government institution?
- Planning for what and in what context: Is the aim to design a project for research, for development, or both? Is the scale of planning at the macro (national, regional), meso (community, watershed, land-use system) or micro (household, farmer) level?
- What criteria should be used: How relevant are considerations such as biophysical and socio-economic indicators, adaptability/transferability, sustainability, institutional complementarity or scientific value?
- What method should be used: Techniques are available from fields such as land evaluation/landscape analysis, farming systems research and development, diagnosis and design, and agroecosystems analysis. Each has strengths and they could be combined depending on objectives and resources.

As the editors state, "all these questions cannot be addressed with one planning method". However, there are a few important factors that must be considered in any planning exercise for agroforestry. These are integration, iteration, participation and sustainability. This book presents a range of both proven and new, innovative options.
It will be a valuable reference for anyone with a serious interest in agroforestry. It addresses the complexity of the planning process, focuses on critical issues and priorities, and provides much food for thought.

1167 92 - 7/81

Agroforestry
Review, book, tropics, temperate climate, forests, sowing methods, aerial seeding

BOSTID

SOWING FORESTS FROM THE AIR.

National Academy Press, Washington, D.C., ISBN 80-83796, Third Ed., 1986, 57 p. + annex

This report discusses reforestation in which the seed is broadcast from a plane or helicopter. It relies mainly on experiences in Australia, New Zealand, Canada, and the United States.
Sowing forest seed directly on the site to be forested is known to foresters as direct seeding, broadcast seeding, or broadcast sowing. The availability of chemicals for coating seeds to repel birds, rodents, and insects has made this a practical and more reliable method of reforestation.
In many parts of the world, deforestation has reached critical proportions. Africa, Asia, and Latin America have vast areas of once-forested land that is now denuded. Many have been left largely unplanted.
These enormous areas of virtually unproductive land are increasing. Traditional revegetation methods should be applied more extensively, but the time also seems right for examining alternative methods.
Dropping seed from planes or helicopters is a well-known and well-established technique for sowing pastures as well as agricultural crops such as soybeans, wheat, and rice. Forests have also been established in this way. However, aerial seeding of forests is largely unappreciated, even by most foresters.
When conditions and species are right, and seed supplies sufficient, aerial seeding could be an important technique for reforesting large areas. It is easy to organize and seems well suited for reforesting sites that have rough terrain, debris, or difficult access. If it can be developed for sites and objectives in developing countries, aerial seeding could offer opportunities for vastly accelerating their reforestation programs.
Aerial reforestation is not a replacement for planting seedlings by traditional methods. It is best considered as a potential complement to conventional planting and to natural seeding, an additional tool for foresters to use when the needs, sites, and species are appropriate.
Sowing tree seed directly in the field is an old technique, but it was little used until the development of repellents to protect seed from insects, rodents, and birds.
It was learned that an additional coating of commercial insecticide would guard the seed against insects and rodents. These findings signalled the beginning of large-scale aerial seeding of forests in USA.

New Zealand demonstrates its success. Some of these forests have been established despite seemingly adverse conditions - for example, on steep slopes and on overburden from strip mines.
Aerial seeding is unproven in the tropics. The panel's purpose is not to recommend it over conventional reforestation techniques but to suggest trials of aerial seeding as a possible supplementary tool.
This book is not a textbook nor a practical guide to aerial seeding: details of the operations and techniques can be found in the selected readings. The purpose is to show administrators and foresters that this fast and often economical technique can be successful on appropriate sites, at least in temperate climates. The authors hope that the report will stimulate trials with, and research into, direct seeding (with or without the use of aircraft). In particular, trials are needed in the tropics where deforestation is most severe.
Aerial seeding presents many challenges for researchers, especially those in developing countries. While technology and techniques are developed and available, they are yet to be tested and adapted for use in those Third World areas now suffering devastating deforestation. Because experience with aerial seeding of forests in the humid tropics is limited, little is known about predators and the best species to sow.
Aerial seeding could be an expensive failure unless small-scale trials show that direct seeding can be successful for the given species and sites.
Initially, these trials do not require use of aircraft. It is necessary only to broadcast a small amount of seed (pretreated, if necessary) on a small patch of the area being tested with conventional tree-planting methods.
The existing knowledge on seed coating and pelleting should be reviewed. Successes and failures are reported in different situations.
Seeds can be targeted accurately (often within a meter or two). Thus direct seeding might prove feasible for filling in the widely scattered breaks in the forest left by slash-and burn farmers with useful species that best protect the vulnerabale soil.

1168 92 - 7/82

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, 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 development 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.

1169 92 - 7/83

Agroforestry
Pacific, Papua New Guinea, highlands, coffee, casuarina, food, ICRAF

BOURKE, R.M.

FOOD, COFFEE AND CASUARINA: AN AGROFORESTRY SYSTEM FROM THE PAPUA NEW GUINEA HIGHLANDS.

In: Agroforestry Systems in the Tropics; Kluwer Academic Publ., Dordrecht, The Netherlands; 1989, pp. 269-275

The paper describes an agroforestry farming system from the Papua New Guinea highlands (1,400-2,100 m) that has been developed by village farmers since about 1960 and has expanded rapidly since about 1970.
The majority of new coffee plantings made by smallholders in recent years have been in agroforestry systems that incorporate annual and perennial food crops, coffee and shade species. One such system is described here.
Major components of the system are numerous species of annual and perennial food crops (especially bananas), Arabica coffee and *Casuarina oligodon*. This system provides food, a cash crop and timber for construction and fuel.
C. oligodon is a fast-growing woody species that provides shade and timber for fencing, house construction and firewood. Its timber is easy to split and it burns well. The food crops include bananas (*Musa* cvs) (mostly triploid cultivars at these altitudes), taro (*Colocasia esculenta* and *Xanthosoma sagittifolium*), sugarcane (*Saccharum officinarum*), maize (*Zea mays*), highland "pitpit" (*Setaria palmifolia*), Amaranthus spp., *Oenanthe javanica*, *Rungia klossii* and others. Other components which may be present are nut pandanus (*Pandanus jiulianettii*) at altitudes above 1,800 m and oil pandanus (*Pandanus conoideus*) below 1,700 m. Pigs commonly graze under established coffee/casuarina/banana stands, but they are not a critical component of the system. Cassava (*Manihot esculenta*) is an important component of a similar system used on better drained soils, but not in this system on the wetter soils.
The basic structure of the system is that mixed vegetable gardens are gradually converted into coffee/banana gardens and eventually into coffee/casuarina stands.
The system described here is an extension of the traditional mixed vegetable garden system and it is the most widely practised of the recently developed integrated food/coffee/timber systems.
The overall performance of the system has not been quantified and hence not evaluated. Judging by the system's rapid expansion and widespread adoption, it is much more efficient than the officially promoted method of establishing coffee.
Because the canopy is maintained continuously by a sequence of faster and slower growing species, the need for weeding is minimized.

It is a conservation system in that the soil is protected from the direct action of the elements by continuous vegetative cover.
A reasonable level of managerial ability is needed to manage the system, but this is within the capability of most village growers. The level of management may be more difficult to attain when larger plantings are being established in a limited time, for example areas larger than 3 ha.
The research needs for this system are numerous and urgent, given that this farming system and similar ones are the most important ones that are used to establish new plantings.
Once farmer practices have been documented, innovations and potentially superior techniques need to be evaluated in controlled experiments. The growth pattern, nitrogen-fixing ability and ecological requirements of Casuarina also require immediate study.

1170 92 - 7/84

Agroforestry
Africa, Benin, Nigeria, Zaire, humid tropics, ICRAF, case studies, traditional farming systems

KANG, B.T. et al.

AGROFORESTRY IN AFRICA'S HUMID TROPICS - THREE SUCCESS STORIES.

Agroforestry Today, April-June 1991, pp. 4-6

This article describes three traditional agroforestry systems that combine multipurpose woody species with food-crop production on low-fertility soils in humid tropical Africa.
Efforts to increase food-crop production in the humid tropics by importing high-input 'modern' technologies have repeatedly led to disappointing results. For this reason, there has been a resurgence of interest in the traditional farming systems that have proven successful over the years.
The traditional slash-and-burn cultivation system of tropical Africa appears to be biologically stable as long as there is enough land to allow sufficient periods of natural fallow. The productivity of the traditional system declines rapidly with intensification of land use. In response to increasing pressure on land, farmers in some parts of the region have developed innovative production systems combining trees and crops. These systems are well adapted to prevailing soil and climatic conditions and help meet local needs for food and other products.
In Benin's Mono Province bordering Togo, the Adja people practice an improved-fallow system involving the replacement of the traditional bush fallow by densely planted oil palms (*Elaeis guineensis*). They grow these trees primarily to produce palm wine, which is often further distilled to make a popular local drink. Fruits from the trees also provide palm oil and the leaves are used for fodder, fencing, roofing, and baskets. When the trees are felled, the trunks, roots, and other biomass left in the fields help renew soil fertility.
Acioa barteri is one of the three most important woody species in the bush-fallow system of southeastern Nigeria.
This shrub is planted or retained by farmers for nutrient cycling, weed suppression, staking, browse, and domestic uses.
Farmers plant acioa in hedgerows at intervals of 2 to 3 metres. At the beginning of the cropping cycle, the shrubs are burned and the stems cut to a height of 10 to 20 centimeters above ground. Some stems are collected for yam staking or for sale. Plots are then interplanted with yam, cassava, and sometimes maize. During the second cropping year, only the cassava remains, growing between the acioa hedgerows. In the third year, the hedgerows cover the entire field.
Farmers have practiced this rotational hedgerow-intercropping (alley-cropping) system for generations.
In the Bas-Zaire region of southwestern Zaire, pigeonpea (*Cajanus cajan*) is the third most important grain legume after groundnut

and phaseolus beans. Pigeonpea is grown most intensively along with cassava in the Songololo area. It fills a crucial protein gap in the local diet between September and December before the harvest that follows a long dry season. After the pods are harvested, farmers apply the leaves as green manure on intercropped cassava.
This pigeonpea/cassava system of Bas-Zaire, which produces food and a little cash, may be a candidate for wider adoption. Experiments are in progress at M'Vuazi and Kimpese, Zaire, to test different spatial arrangements and timing of operations that might improve the traditional system.
These three examples show that farmers are fully capable of developing agroforestry systems that are well suited to their environmental and economic conditions - and without chemical inputs. Although the practices described here may not be as productive as more intensive, high-input systems, they achieve effective nutrient cycling and a degree of sustainability by combining deep-rooted woody species with food crops.
It might be possible to make these traditional systems more productive without losing their advantages, for example by adding low levels of fertilizer or other inputs, or by incorporating more nitrogen-fixing trees. There is a danger that these systems will be replaced by unstable 'modern' approaches, emphasizing short-term gains at the expense of long-term sustainability.
Research on these well-adapted traditional systems might lead to ideas for making them even better. Insights gained in these areas might also provide a basis for developing more sustainable and productive food-production systems in other parts of the region.

1171 92 - 7/85

Agroforestry
Review, developing countries, fuelwood production, biomass energy, forestry, firewood species, farm forestry, community forestry, woodlots, land-use systems

NAIR, P.K.R.

AGROFORESTRY AND BIOMASS ENERGY/FUELWOOD PRODUCTION.

In: Agroforestry Systems in the Tropics; Edt. P.K.R. Nair, Kluwer Academic Publishers, Dordrecht, The Netherlands; 1989, pp. 591-597

The fuelwood situation in many developing countries has become alarming in recent times.
Recent studies have indicated that fuelwood cutting is second only to clearing land for agriculture as a major cause of deforestation.
Although fuel for cooking is the most important use of firewood, there are also other uses such as heating and lighting. Wood remains the main fuel source even in areas where forests are rapidly disappearing.
Trees and shrubs constitute the main source of firewood and other forms of biomass energy.
The problem of fuelwood shortage cannot be tackled in isolation from other aspects of rural development. The rather unimpressive performance of large-scale forestry and reafforestation programmes in the developing countries offers a good lesson.
The chances of a programme for fuelwood production being successful are greatly enhanced if it can be tackled the production not only of fuelwood but also of food crops.
Agroforestry can be of value in this context by:
- Incorporating and integrating appropriate species of woody perennials on farmlands along with other components of the farming system not in a competitive but in a complementary way;
- Integrating herbaceous crops and livestock on forest land according to the agroforestry management schemes so as to facilitate simultaneous production of wood and food crops; and
- Employing agroforestry techniques for reclamation of degraded lands and proper utilization of "wastelands".

Integration of appropriate fuelwood species on crop- and livestock-production units thus seems to be one of the best strategies for fuelwood production in the rural areas of the developing countries.
The greatest scope for improving their efficiency and obtaining tangible results in such a programme lies with initiatives in smallholdings.