Deutsche Gesellschaft für
Technische Zusammenarbeit
(GTZ) GmbH

HEDGES FOR RESOURCE-POOR LAND USERS IN DEVELOPING COUNTRIES

GUIDO KUCHELMEISTER

Code definition for Table 49

Col (2): Climate
Koeppen Codes see table 48
a = (semi)arid
m = mountain
s = subtropical

Col (5): Drought hardiness
M = medium hardy
H = hardy
V = very hardy

Col (6): Frost hardiness
F = frost hardy
M = moderate hardy
(occasional)

Col (7): Texture
H= heavy (clay)
M = medium (loam)
L = light (sand)

Col (8): Reaction
AC = acid (pH < 6.5)
Al = alkaline (pH > 7.5)
NE = neutral (pH 6.5-7.5)

Col (9): Drainage
W = well drained
S = season.water logg.
P = permanent water logg.

Col (10): Other soil character.
AD = adaptable
FI = fire sensivity
SA = salinity
SH = shallowness

Col (11): Remarks
IN = invasiveness
IS = insect susceptability
LD = light demander
ST = shade tolerant

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SUMMARY

The hedgebook is a collection of material with a view biased towards the specific role of hedges for resource-poor rural people in developing countries. The objectives, target groups, scope and limitations of the book have been outlined. Hedgerow growing has many advantages for resource-poor people, but also problems. Both have been discussed.

Hedges as distinct from related land uses have been defined. A typology based on functions and structure of hedges, management and genesis of hedges has been given. The occurrence of hedgerow growing practices (agro-ecological zones and brief references to countries and regions) and the experience of local people and research and development projects with regard to hedges in various land-use systems have been noted.

A hedge is not a substitute for a fence: it can offer much more. The diverse productive and protective roles of hedges have been discussed in detail. The direct and indirect roles of hedges in food security strategies for the rural poor including the specific role of leafy vegetables have been stressed.

The various functions of hedges in providing animal feed, including how to optimise and maximise biomass for animal feed, based on the feeding strategy of the land manager have been shown. Harvest recommendations for Leucaena, the best research hedge plant, have been described. How hedges can attract wildlife and semi-domesticated insects like shellac producing insects, butterflies and bees has also been shown.

Hedges provide wood. Hedge trees can also be a source of timber (high-value commercial and non-industrial wood). Techniques for obtaining high-quality timber from hedge trees have been described. The role of hedges in bringing about a significant improvement in the energy situation has been stressed, including a quantitative assessment of the contribution made by hedges to household energy requirements.

The importance of low-cost fencing for the poor has been noted, and types of living hedges including stockproof security hedges and life fence posts have been outlined.

With regard to mulch/green manure the book has analysed the potential role for small farmers, impacts from hedges in terms of micro-climate change, weed control, and plant protection, soil fertility, and result in crop yield was discussed. Determinants which affect biomass production for mulch, like planting material and density, inter-row spacing, cutting height and frequency, and type of application, with special reference to alley croppping.

Erosion is a serious problem in the tropics. Erosion by water and principal tools for control have been mentioned and the potential role and present state of knowlege regarding the efficiency of hedges, including examples, have been discussed. Hedges are used in water erosion control. Attention has been drawn to the possibility of using hedges to form living terraces and stable slopes.

Under the heading of micro-climate modification, the great relevance for small-scale farmers of manipulating microclimate has been stressed, and an outline given of how hedges can influence the microclimate (solar radiation, temperature, precipitation, dew, evaporation). A special part has been devoted to problems of frost in hill-farming, as in the Andean valleys, and the significant role hedges can play in frost protection when properly designed.

The role of windbreaks/shelterbelts in general and the specific role of hedges has been discussed, including tangible and less tangible benefits like impact on crop yield and livestock productivity; sand-dune stabilisation, support in pollution control. Principles and design guidelines for windbreaks have been explained as well.

Hedges are ecosystems. Their role in nature conservation as an important ecological reservoir, refuge for flora and fauna from the effects of intensive agriculture, their role in pest and disease control and wildlife management has been outlined.

The social and economic determinants of hedgerows have been discussed. The role of hedges for resource-poor land users has been stressed. An account has been given of the impetus of hedgerow growing and land users' perspectives (attitudes, priorities, preference, knowledge), tenure, labour, and other socio-economic issues which have to be resolved in the process of hedgerow growing.

With regard to the economics of hedgerow growing a note on economic evaluation of hedges and economic data has been given, including comparison of the cost of different types of fences, methods of establishing hedges, economic impact of hedges on mechanisation, and cost-benefit analysis with special reference to alley cropping. A specific note on the state of research and development of appropriate hedgerow technologies was given. Mention has been made of how research extension can be linked with the land users within a farming systems approach.

An in-depth evaluation of hedge-plant candidates including a note on the methodology of selection and evaluation of trees and shrubs has been made within a participatory action research approach. General criteria for species selection and hedge-specific criteria for choosing suitable trees and shrubs for hedges have been suggested. Choice of life-form of hedge plants (trees, shrubs, and climbers) and arguments for and against the integration of trees into hedges have been discussed.

Finally, general technical management aspects of hedgerow growing have been summarised. Factors to consider in the selection of applied propagation, and the state of knowledge of reproduction and application by development projects have been noted.With regard to planting out hedges, the questions of planting seasons, site preparation (staking out, bed preparation), water conservation, and irrigation, improving of soils (fertiliser, innoculation) have been discussed.

Factors which have to be considered in the design of hedgerows like life-form of trees and shrubs, inter- and intra-row spacing of plants have been summarised. Site specific planting techniques for flat sites, on top of a bank, on the side of a bank, or on a ledge at the foot of a bank, and when and how to plant hedge trees in and beside the hedge have been demonstrated. How to plant up gaps, and the protection and managing of new hedges have been mentioned as well.

With specific reference to mono-specific alley cropping, examples of how to intensify and diversify hedgerow intercropping to address the multiple problems/potentials of resource-poor land users have been shown.

Hedges and hedge trees are often shaped. The general purpose of pruning hedges, types of pruning (heading back, thinning) and the effect of trimming have been discussed. The need for early pruning, its effect on profile and height, and basic silvicultural techniques with regard to shaping hedge trees have been summarised. Special management techniques like laying and pollarding have been mentioned as well.

The final part has dealt with harvest and rejuvenation of hedges. A note on harvesting techniques, tools, and style of harvest including harvest timing and frequency, initial and subsequent harvesting, and seasons has been given. Wildlife and harvesting, multipurpose management versus maximising one output, and a note on renovation of old hedges closes the technical and field-oriented part of the book.

Summary of key issues of hedgerow growing and recommendations with regard to future action with regard to hedgerow promotions have been put forward as well.

PREFACE

People in developing countries depend on vegetation. Trees and shrubs are particularly important for resource-poor land users. These resources are consumed faster than they regrow. Hedges are a land use facet without a constituency in the past. Too tall for agronomists, too short for foresters, they fall between the disciplines. Their potential as a resource has been overlooked.

Today rural land use planners are increasingly pleading for increased planting of hedges for difficult sites and/or low external input land uses; a typical context of resource-poor land users. From the standpoint of these people hedges are not a substitute for a dead fence, but can produce significantly diverse tangible and less tangible outputs. The growing interest in promotion of hedgerows is handicapped by the lack of collection of material of research and development activities with regard to hedgerow growing. This publication responds to this need. It is a continuation of my previous 'state of knowledge report on tropical and subtropical hedgerows'(218a); it aims to show the up-to-date state of my achievements and offers practical guidelines.

Basically this book is for people working in rural development projects. It is an attempt to speak to both field staff with some experience in hedgerow promotion and team leaders to include hedgrow in land use evaluation and project implementation. It will address to both social scientists and natural scientists, regardless of professional qualifications. The focus is deliberately limited to rural areas and the resource-poor land users in the "Third World". The book will provide numerous arguments why hedges can be very important for resource-poor landmanagers. Problems and challenges of hedgerow growing will be discussed as well.

Increasing the number of hedges in an area may have little effect unless it is clearly related to the needs and priorities of the people living there. Thus promotion of hedges should arise from the objective not of growing hedges, but of improving the people's quality of life. This may involve, among other activities, the introduction of some form of vegetation like hedges. In other words, hedges should never be regarded as a panacea for pressing land management problems or an end in themselves.

People who are interested in learning more about why people in developing countries plant, do not plant, and abandon hedges, etc. are encouraged to get together (networks, workshops, etc.). I would be pleased to hear about such initiatives. Being aware of the challenge of addressing a book to various target groups, I also intend to write a practical manual on hedges (not a monograph for scientists). Critical contributions on design and contents for this project would be very much appreciated.

Many people have directly or indirectly contributed to this book with valuable information and comments. To list them all would be impossible. I ask them to accept my thanks offered generally. My greatest debt is to Waltraud my wife. She has supported the project at all stages, particularly in typing and organising the layout with a standard word processing. I would like to express my particular gratitude and thanks to Dr. D. Burger, Wulf Raubold and Cornelia Sepp, GTZ, and to Francis J. Sullivan, Bioresources/WWF, U.K. for their most valuable comments and assistance. Thanks also go to Mr. Terence Oliver for his efforts to improve my English manuscript. Responsibility for errors of facts and judgement is mine alone (I apologize in advance for any incorrect statement or impression given and not perfect layout).

Last but not least, the compilation of the present book has been greatly facilitated by a special contract with GTZ.

March 1989

Guido Kuchelmeister

Feed back from the user:

The user of this book is requested to comment critically on the book. New information and suggestions will be incorporated into a manual on hedges. Please send all communication to:

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), FB 424, P.O.Box 5180, D-65726 Eschborn, Federal Republic of Germany

1 INTRODUCTION

1.1 Background and justification

Natural woody vegetation has provided fuel, fodder, building material and many other forest products. Forest fallow has been essential to maintain soil fertility in low external input agriculture in the tropics. Natural resource planners and scientists have drawn attention to the serious and mounting ecological problems related to deforestation. Disappearing woody vegetation affects mainly the rural poor.

Over the past decade farm and community forestry have emerged as one principal response to the problems caused by the widespread loss of trees and forest cover in developing countries. Its aim is to help people to solve their wood supply problems in forest products, to meet their own needs and to preserve the environment in which they live by planting trees on their farms and around their villages. Ecological agriculture, i.e. site-specific and appropriate agriculture and agroforestry, an old land use practice, is increasingly appreciated in research and development. In this context the potential role of hedges is frequently perceived as one important component.

In the past, due to the abundance of natural vegetation and an ignorance of the potential of hedges, particularly for the resource-poor people in developing countries, there has been a lack of efforts to develop these natural resources further. The depletion of woody vegetation combined with pressure from an increasing rural population has resulted in an interest in this group of plants.

Today there is a greater awareness of the potential role of hedges in rural development. Increasingly hedges have been discovered as one tool in land use planning and more attention has been paid to their socio-economic importance for the rural population. Nevertheless hedges and resource-poor people more often than not have one thing in common, namely that they do not have a strong lobby.

The scientifically organised body of knowledge on tropical hedges is limited. There are various organisations with a mandate for research and development of hedgerow technologies. Scattered information on various aspects of hedges exists. To complicate matters, much valuable information is not easily accesible for field staff. Hardly any global attempts exist to coordinate, compile and synthesise existing knowledge. No practical manual for development workers exists.

1.2 Scope and limitations of the book

The book is primarily a collection of material relating to hedges in a development context. It is also a preliminary effort to develop a manual on hedges.

Objective: The main goal of the book will be to supply information about:

- the potential role of hedges in solving/mitigating some of the problems of resource-poor land users in developing countries;
- the ecological, technical and social, economic and cultural determinants in hedgerow promotion;
- the state of knowledge on the role of hedges and the techniques and problems associated with hedgerow planting.

The discussion on hedge plants is restricted mainly to trees and shrubs, but it is acknowledged that other groups of plants, like grasses, are important as well (see e.g. 3.8.5).

The book will provide a systematic appreciation of experience gained to date from hedgerow growing in developing countries. The focus will be on tropical and subtropical environments with special emphasis of the role of hedges for resource-poor land users, i.e. land users whose human (e.g. labour, management skills) and natural resources (e.g. land, water) do not currently permit a secure livelihood.

The book also intends to provide a stimulating and up-to-date account of these environments and problems associated with hedgerow growing.

Target groups: The book has been written basically for the following target groups:

- Field staff in development programs and projects who already have a basic understanding of hedges and/or some idea of the potential of hedges for resource-poor land users;
- Project team leaders who are not aware of the potential of hedges in the context of rural development.

Scope and limitations: Our present knowledge on hedges and their significance for resource-poor land users is limited. Hedges mean different things to different people. There is no universally accepted definition of the term. A sharp distinction from other land use components is difficult and to some degree arbitrary. From the point of view of the resource-poor land user this is insignificant. For the land user hedges and similar items are a means (not a panacea) to achieve land management goals.

In the light of the underdeveloped state of knowledge with regard to hedgerows in developing countries it was found more appropriate to include certain systems and species than to exclude them.

With regard to eco-zones the discussion will focus on humid tropical lowlands, semi-arid areas and tropical mountains. The great potential of hedges for arid areas, in combination with irrigation is only touched on briefly. The same is true of hedges in an urban environment.

1.3 How to use the book

Chapter 2 will provide information on the definition, typology and occurrence of hedges (agro-ecological zones and regions/countries), an overview of uses and functions of hedges and social and economic issues, and conclusions and main recommendations of the book for future actions. Chapter 3 will discuss the productive and protective functions and uses of hedgerow systems in depth. It forms the core of the book. Historical, cultural, social and economic determinants in hedgerow growing will be described in chapter 4. The next chapter will summarise information on trees and shrubs which can be used as hedgeplants. Chapter 6 will provide additional technical information with regard to hedgerow planting and management.

Background information including case studies on hedgerow systems, resource persons, biomass production from hedge plants, datasheets of hedgeplants, and research and development of hedgerows (experimental hedgerow research) is appended.

To satisfy both the information need of project leaders and technical field staff the content of the book had to be organised in a specific style. Project leaders are advised to read Chapter 2, which will give an overview of all important issues dealt in this book. It also includes key aspects of Chapters 3 and 4. Chapters 5 and 6 are basically written for technical staff.

2 HEDGEROW GROWING IN DEVELOPING COUNTRIES - AN OVERVIEW

There are great variations in hedgerow systems and perceptions of what a hedge is. The purpose of the following discussion is to provide an introduction to hedgerow growing: The term hedges will be defined by distinguishing it from related terms and concepts. Some thoughts on how to distinguish hedges are put forward.

A brief overview of hedges in developing countries begins with a note on why hedgerow growing may be attractive for resource-poor land users. A brief mention is made of where hedgerow growing (agroecological, regional) is practised, and who has experience of it (vernacular and research and development projects). Finally key issues of Chapters three and four are summarised and conclusions and recommendations for future action are represented. The summary consists of highlights and technical instructions and lessons learned. Particularly for teamleaders the highlights will give a quick overview of the essentials of this book. In addition more technical oriented field personal will find key technical issues.

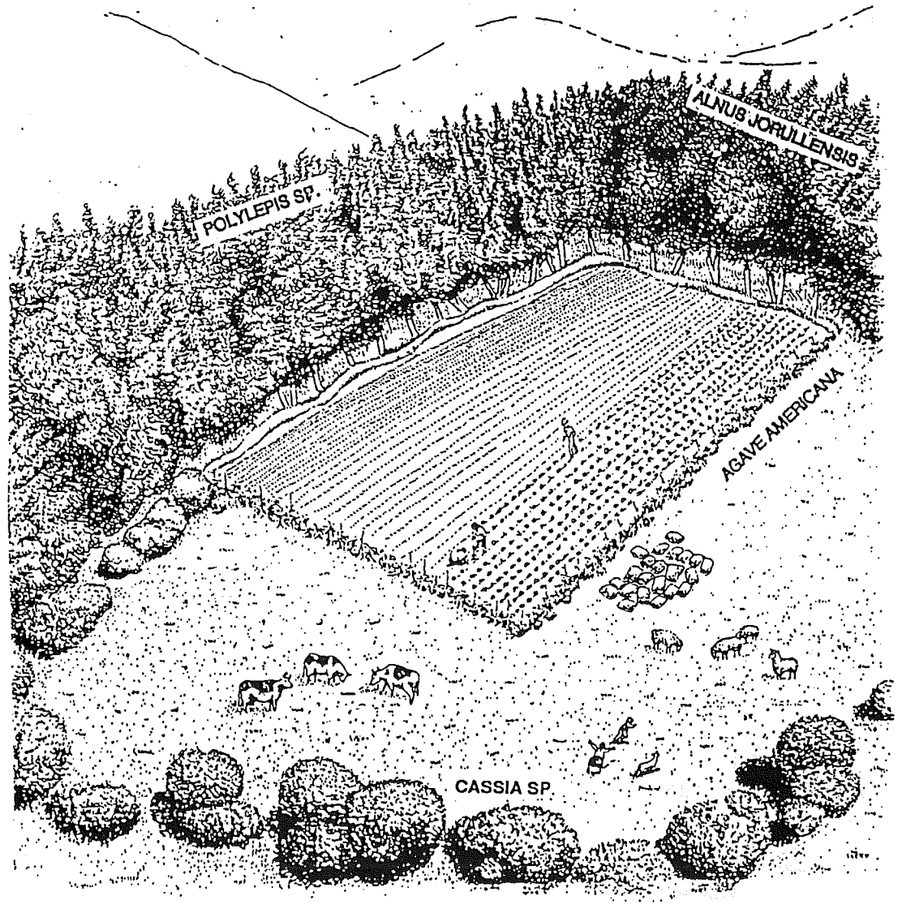

Figure 1: Hedges in the Andes (34)

2.1 Definition and typology

2.1.1 What is a hedge: Definition, synonyms, and related terms

Definition by contrast with other terms

Both dead and living hedges exist. The discussion in this book is restricted to living hedges. For convenience the term hedge (and not living hedge) is used.

The appreciable differences in the appearance of hedges show that a general definition is of only limited value (93). The term cannot be divorced from the historical context and the perception of the land users.[1] Hence no generally accepted definition exists. Common descriptions of hedges are biased towards western hedge history; they underline the stockproof (249), or ornamental (65, 94), and recently the nature conservation aspect of hedges (52). For the resource-poor land user in developing countries hedges have to fulfil primarily productive functions.

Hedges are one kind of border/boundary planting (others: boundary trees). They form one style of windbreaks, or are part of it; others are windbelts consisting of various rows. Fence posts without wire or cross piece are not a fence. Alley- and boundary trees are not a hedge or a fence. However, with wire they become live fence posts, when set closely to live fences and as a part of a hedge to hedge trees. When hedges are grown in the interspace of arable crops (= avenue/alley) this is called alley cropping. The most significant feature of hedges is that they are closed at or near the ground, unlike tree rows which may be closed at the canopy level.

Hedges are generally dominated by low and tall growing shrubs and occasional trees (93). Unmanaged and left to their own devices, hedges become overgrown in a short period. This can sometimes lead to a rather fine distinction between a broad hedge and a long, narrow wood. However the question is rather academic (346).

Nevertheless it is welcome that ICRAF has opened the discussion on hedge related terms. It is also right that it is still a moot point how to refer to systems in which the woody perennials consist of separate trees, rather than a continuous hedge (188b). This academic discussion assists in clarifying perspectives (for one good example see the term alley cropping versus hedgerow intercropping in Chapter 3).

In this book the term hedge is restricted to all relatively narrow lines/bands of vegetation which form a continuum and are closed at or near the base. Generally hedges are dominated by woody plants. They are one or two rows wide in most cases. Living fences supporting wire are relatively wider spaced and when frequently pollarded are only relatively dense. The main feature of most woody hedgeplants is that they can be heavily pruned.[2]

Obviously there is a transition between hedges and other forms of land use. The present state of knowledge with regard to developing countries does not allow a rigid distinction. From the standpoint of resource-poor land users this is immaterial or hardly significant. For them hedges are not a fence, but a multiple purpose item. Whatever these types of vegetation may be called, they should help resource-poor land users to solve or mitigate some of their specific problems.

Synonyms

Since there is no universal accepted definition of a hedge, various terms are used synonymously. For further literature searches on hedges consider also the following terms. Details will be discussed in the relevant chapters.

1. From its etymological origin the word hedge (haeg) indicates territorial boundary (93, 211).
2. In science or law sophisticated definitions may be required. In some Eurpopean countries, for example, hedges are distinguished in height from closed tree rows. This is important for law regulation of a distance between neighbouring land. The main feature of hedges to be dense at the base or relatively close to it is only limited applicable to living fences supporting wire. Hence it was suggested to define hedges as "barriers of relatively closed-spaced plants and living fences as lines of relatively wider-spaced woody-stemmed plants used to create a barrier together with other materials (e.g. fencing wire) attached to them (181a).

The terms hedge and hedgerow have become synonymous in common use, although hedgerow is frequently reserved to denote tall hedges and those containing a large number of trees; or alternatively, to describe a line of hedges or a boundary, irrespective of its conditions (93). In this book hedge and hedgerow are used interchangeably.

Sometimes the term "living fences" is used synonymously with "living hedges" (e.g. compare English and French version of 382). Hedge plants are also categorized as "enclosure plants" (304) or "barrier plants" (6). In the Spanish-speaking literature often "setos vivos" (living hedges) and "cercas vivas" (living fences) are used interchangeably. Living fences are also called "security hedges" (165). Living fence posts are included in this category as well. Quickset is another name for a thorny hedge. Quickset or quick originally means any living hedge, not necessarily of thorn as understood today (44).

2.1.2 How to distinguish hedges

There are various ways to distinguish hedges, e.g. according to their structure and functions. There is a great variation depending on their main purpose(s), history, and management practices. Also agro-ecological zones restrict species adaptability, e.g. in coastal areas salt-tolerant windbreak hedges have to be chosen.

Functions of hedges

Hedges are designed for their primary uses and are called for example fruit bearing hedges or windbreak hedges. A cattle-proof hedge has to look different from one managed for ornamental or organic manuring purposes. Hedges are often classified according to adjacent land use (pasture, field, garden, road hedges); thus they are called e.g. field or garden hedge. A hedge can be intended either as a permanent feature of the landscape or as a temporary device. This book deals with the latter.

Structure of a hedge

Also hedges can be distinguished according to their structure in space, i.e. what kind of plants are dominant (trees, shrubs, herbs, climbers, etc.) and their position in the hedges (middle part, outer rim, upper storey, undergrowth, etc.) (more detailed description and analysis see e.g. 219). Although hedges are usually dominated by shrubs or low growing trees, tall trees may sometimes be part of a hedge. A tree is not a hedge tree in itself, but in the hedge or very close to it becomes a hedge tree. Hedges can also consist of a herbaceous layer; the first stage of the sucession. Hedges also differ with regard to the number and regularity of rows (one row, multi rows) and whether they consist of mixed or single species. Biophysical features of plants used in hedges (summary see Table 33) may result in a typical structure: This may be independent of the sociological composition of the species in the vegetation (219). A practical distinction can be made between a dwarf hedge (<1m), a medium one (1-2m) and a tall hedge (>2m) (124). Generally hedges are associated with a vegetation of limited size. However, height is not a restricting criterion. The degree of plant density is another factor, ranging from very closely planted hedges (up to 10 plants per meter) to widely planted live fences, windbreaks, etc. Density can be created not only by close set plants and heavy trimming of a one row hedge; it is also achieved by the structure of a natural hedge.

Management of hedges

The intensity of management influences the appearance of a hedge (main form see following figure). If a garden hedge is neglected the fact is immediately apparent. In a situation where little care is essential, the most sensible plan is to plant shrubs and trees that largely look after themselves. Hedges can be managed either mechanically, manually, or by a combination of both methods. Few affordable mechanised tools exist for small-scale farmers.

According to their management, hedges may be laid, clipped, trimmed, pollarded, thinned, or naturally grown. Plants can be chosen to allow them to grow naturally or to be only slightly shaped. A useful distinction can be drawn between informal (natural-like) hedges and formal (heavily trimmed) hedges.

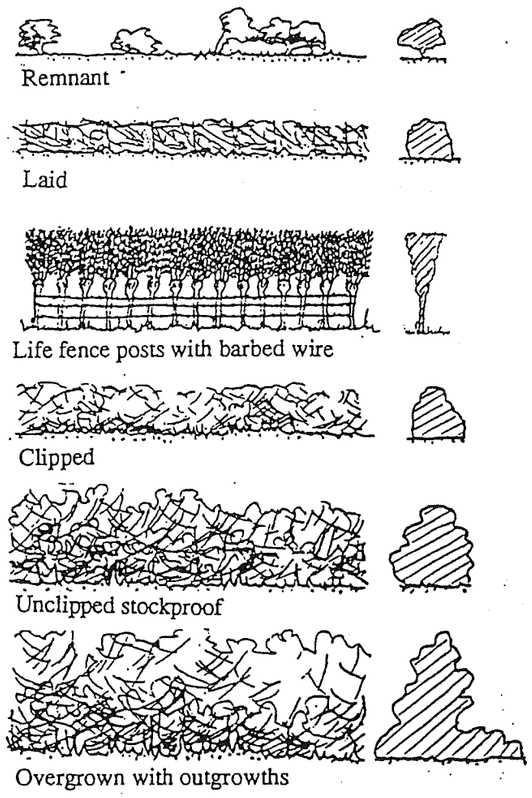

Figure 2: Hedge types according to management

modified from 44

Informal hedges are lines of shrubs or trees in which some or all of the natural outline of the plant is preserved (168). Natural hedges and free-growing hedges with little manipulation belong to this group. The width is not a very rigid criterion; the transition to band (belt) planting is obvious.

Natural hedges are like the two edges of a natural sound forest. The multistorey structure of the free growing hedge provides a dense structure (representation of structure see Figure 3). Informal hedges are regularly cut back to form a dense interwoven mass of stems, branches and foliage. Formal hedges form an unbroken line (one or two rows) of close-set woody species in which the individuality of each plant is lost (65).

History of hedges

Hedgerow systems are evolved by local population (vernacular) or have been designed or redefined by modern research and development (R&D). A special autochthon system exists in some parts of Africa where hedges have functioned as strategic barriers (272) (e.g. see Figure 12).

Hedges have different origins: Hedges may be found around forest clearings made for agricultural purpose. They can either be planted or taken from the woods or may be relicts of woodland plants managed to form a hedge. They may be formed by managing shrub growth which has colonised previously unhedged field boundaries or open field strips. They may be planted as mixed or single species hedge. They may originate through a combination of factors

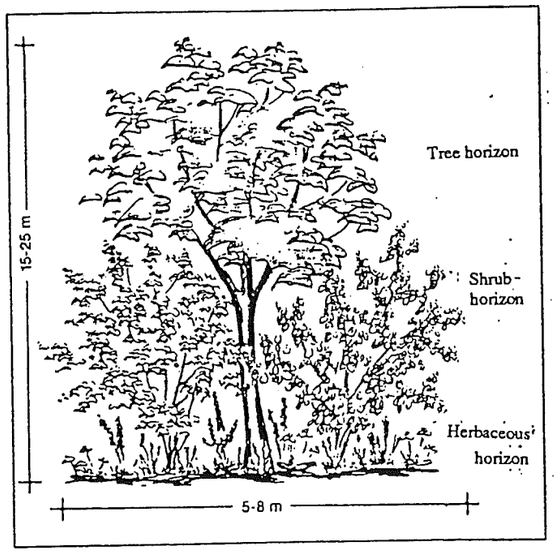

Figure 3: Naturally oriented (free-growing) hedge (211)

The structure of a multi-storey hedge consists of herbaceous plants, trees and shrubs. They are similar to the natural healthy edge of a forest. Two forest edges together form such a "hedgeforest".

2.2 Hedgerow growing in developing countries

The following account indicates examples of reported hedgerow systems; it is by no means exhaustive (details may be found in the case studies - Appendix 1 - and under specific uses).

2.2.1 Why hedgerow growing may be appropriate for resource-poor people

Poor people have been depending on natural woody vegetation to satisfy their needs like food, wood, shelter, fencing, to name only a few. Traditionally small-scale farmers attempt to obtain a sustainable level of production through yield diversification and risk avoidance. The natural vegetation (forest fallow, mulch, green manure, fodder, etc.) has been utilised in management systems characterised by low external inputs. The disappearance of natural vegetation affects resource-poor land users, in particular.

With increased privatisation of land and fewer trees on common property the incentives and opportunities for using trees, hedges, and hedge trees to satisfy needs, and to use them as assetts have become increasingly important for poor people. Degradation often occurs under "production pressure", i.e. the need to produce more with equal/less land and labour.

How hedges can be an important component for counteracting problems facing small-scale farmers as well as other resource-poor land users will be shown in detail in Chapter 3. There is evidence that hedges are also grown in situations of abundant land and natural forests, e.g. growing of vegetable hedges near the house.

Hedgerow growing can have enormous advantages for small-scale farmers (for a summary see in particular Table 1) and other resource-poor land users. Hedgerow growing also has problems (summary of pros and cons of hedges see Table 2). Mature tree integration into hedges has its particular merits, such as increasing the overall productivity of the hedge, but also its problems (see Table 3).

Despite the great potential of hedges this tiny land use component has been taken for granted or ignored by official land use planning in developing countries. Although hedges are no panacea they can be a very important item for resource-poor land users in developing countries (for a summary of arguments why hedges can be important for the resource-poor people see especially Chapter 4.1).

2.2.2 Where hedge growing is practised

Hedgerow growing can be observed in all homoclimes in developing countries including tropical and subtropical temperate, arid and semi-arid, humid and subtropical zones. Hedgerow growing has been practised from the high mountains (e.g. Andes) to the humid lowlands (e.g. Bangladesh). Recorded experience is widely scattered. The present knowledge does not allow the establishment of a correlation between homoclimes and hedge growing. For references in the book to agro-ecological zones consult Tables 49, 56, 57.

Hedges are grown in all continents. There is increasing evidence that in many countries hedgerow growing is practised much more than is realised by official planning. A list of potential hedge plants with examples according to major geographical zones is given in Table 46. With regard to regions/countries the sources are indicative and by no means exhaustive.

Table 1: Some principal differences between commercial and small farms and the role of hedges for improving small farming systems

Issues	Commercial farmers	Small-scale farmers	Role of hedges for small-scale farmers
General feature	maximizes profit from cash crops and/or animals by relying mainly on wage labor on fertile soils; removal of production limits;	sustains relatively low level of production and yield diversification and security on fragile land; depends mainly on family labor: tries to optimise labor and other limiting production factors;	fits in well with small-scale farmer's strategy;
Level of external input	high level;	low level;	reduces dependence on external inputs;
Vulnerability towards wind, drought, etc.	attempts to make production independent of irrigation, greenhouse, etc.;	attempts to avoid extremities by microclimate management, cropping pattern, etc.	reduces risks of calmities through microclimate management;
Vulnerability towards crop failure	is less vulnerable through crop insurance, savings and/or other source of income;	attempts to diversify and avoid risks, etc.;	compensates partially for crop failure even pledged, mortgaged;
Harvesting intervals	can afford long unproductive periods of investment due to credits and savings;	cultivates short-cycle crops and invests in long-term tree crops by agroforestry techniques;	can produce in a very short time often for a long period;
Flow of income, food, etc.	needs no regular flow of income and products;	requires a regular flow of income, employment, and outputs for subsistence needs like food, fuel, etc.;	produces multiple outputs regularly;
Storage	can invest in modern storage technology;	depends on low cost storage technology or living storage;	can serve as living storage, e.g. for fodder and food at the end of the dry season;
Soil erosion control	reduces erosion more by physical than biological means;	reduces erosion mainly by biological means, and some affordable physical techniques;	planted along contours reduces erosion;
Fertilising	applies mineral fertiliser;	depends on organic fertiliser, forest fallow, etc,;	provides mulch and green manure;
Weeding	depends on herbicides and/or weeding by wage labour;	applies manual (selective) weeding, mixed cropping, fire, fallow, etc.;	can reduce weeding needs by application of mulch from hedges and reduced size of parcels in hedgerow intercropping ;
Plant protection	relies on pesticides;	reduces danger of pests and diseases by appropriate cropping patterns, local varieties; uses local pesticides, etc.;	can contribute to ecological balance, thereby reducing pest and disease problems; can produce natural pesticides;
Fencing	relies on artificial fencing with low maintenance costs and/or flexible application;	needs cheap multipurpose fencing material;	livefences producing various important products may be essential for small farmers.

Table 2: Some advantages and problems of hedgerow growing by resource-poor people

Advantages of hedges can be:
- they contribute to income and quality of life;
- they produce a sustained yield of many tangible products e.g. food, forage, timber, fuelwood;
- they yield less tangible outputs like security, manure/mulch, erosion control, microclimate modification, nature conservation;
- they produce medium yields with low external input;
- they stabilise soil and ameliorate microclimate;
- they enhance soil fertility
- they contribute to ecological stability (like pest and disease control);
- they enhance income and quality of life of resource-poor rural people significantly.
Disadvantages of hedges can be:
- they occupy badly needed space;
- they are unproductive for a period longer than economic horizon of land users;
- they are difficult to protect during early growth;
- they harbour pests and diseases;
- they compete with agricultural crops for biological resources (water, light, nutrients), e.g. roots can spread into the fields, where they can compete with crops for nutrients and moisture;
- they conflict with labour and other cultural practices in existing land use patterns;
- they adversely affect the social system like tenure arrangements.

Table 3: Some advantages and disadvantages of integration of large hedgerow trees into a hedge

Advantages of hedge trees can be:
- they provide shade for stock and people;
- they produce industrial and non-industrial wood;
- they are extremely important for fodder, fruit, etc.;
- they provide valuable habitat for wildlife especially for birds;
- they enhance and diversify the landscape;
- they increase the height of a windbreak.
Disadvantages of hedge trees can be:
- they compete with crops with regard to biological resources;
- they ruin the hedge below or retard its growth;
- they make a hedge non-stock-proof;
- they form gaps in the hedge when cut back, unless left at hedge height;
- they harbour pests;
- they cause the air to stagnate, and they provoke turbulences.

2.2.3 Who has experience in hedgerow growing

Vernacular hedgers

Hedges are one approach to natural sound shaping of vegetation and landscape. In a situation of high population density and marginal soils hedges are one component in land use, as can be observed among the Ukara on an island at Lake Victory (229) or in Papua New Guinea (247), e.g. Tari, densely-populated southern Highland Province. One of the most sophisticated hedgerow network systems has been evolved by the Bamileke in Cameroon (179). The Kikuyus in Kenya are also skilled hedgerow cultivators (212). Hedges are popular among the Chagga in Tanzania (124), the Mayas in Central America (9), and peoples in Sri Lanka (12).

Research and development projects

Research: Hedges, particularly tailored to the needs of resource-poor people, are not a research priority for most national and international organisations.

ICRAF, ILCA, IITA have hedge-related research activities of one kind or another. CATIE is the only institute which has a specific program for living fences. In recent years most research has probably been dedicated probably in recent years to hedgerow intercropping (alley cropping) (more on experimental hedgerow research and development see Appendix V).

Development: Many projects promote or are aware of hedges. Today ecofarming, agroforestry, soil conservation, community forestry, and animal production projects promote hedges. In some integrated rural development programs and food-for-work programs the value of hedges is appreciated as well.

Non-governmental organisations when grass-root-based, are very keen on hedgerow promotion. E.g. OXFAM regards live fences as very important because of their good land utilisation and multipurpose uses (279). Very few organisations have pointed out the high potential of hedges for the rural poor (e.g. 144) (for more details of research and development activities see Chapter 3-6).

2.2.4 Hedges in land uses - where to plant hedges

Hedges are grown in urban (357) and rural areas. Hedges can be important for urban and rural people. The former is not the subject of this book. Also there is evidence of great importance for urban areas (357). Hedges have been integrated in many land use systems. They are common in homegardens, commercial field crops (commercial vegetable gardening), annual plantations, cashcrops in perennial agro-ecosystems like smallholdings and large scale plantations.

There is evidence of many interesting systems. Some outstanding examples (see Appendix 1) include:

- Arid watershed management to fertilise, maintain and extend flood plain farming - the case of Sonora/Mexico;
- Frost protection and fuel production hedgerow system in the Sierra of Peru;
- Fuel/green manuring production of border planting in the humid lowlands;
- The case of the combretum-rice system in South East Asia;
- The control of livestock by means of the well planned hedge network of the Bamileke in Africa.

There are many others to be discovered and documented. Most hedgerow systems have evolved among local populations, others have been designed by modern research and development (R&D). Alley cropping is a prominent example. Hardly any historical research exists on hedge history in the tropics, often it is impossible to draw a strict dividing line between vernacular (autochthonous) and modern hedges.

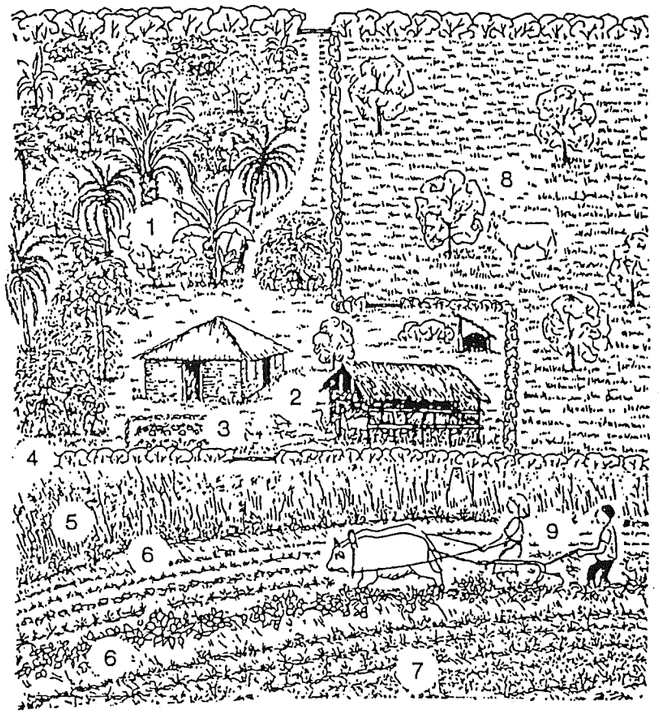

Figure 4: Hedges in a Bamenda model farm in Cameroon (296)

(1) = agroforestry sector;(2) = homestead with cattle shed and roofed-over manure deposit;(3) = housegarden;(4) = the leguminous hedges;(5) = planted fallow plot;(6) = the contour bunds;(7) = the field strips between the bunds planted in mixed cropping;(8) = improved pasture;(9) = weed control with oxen tradition.

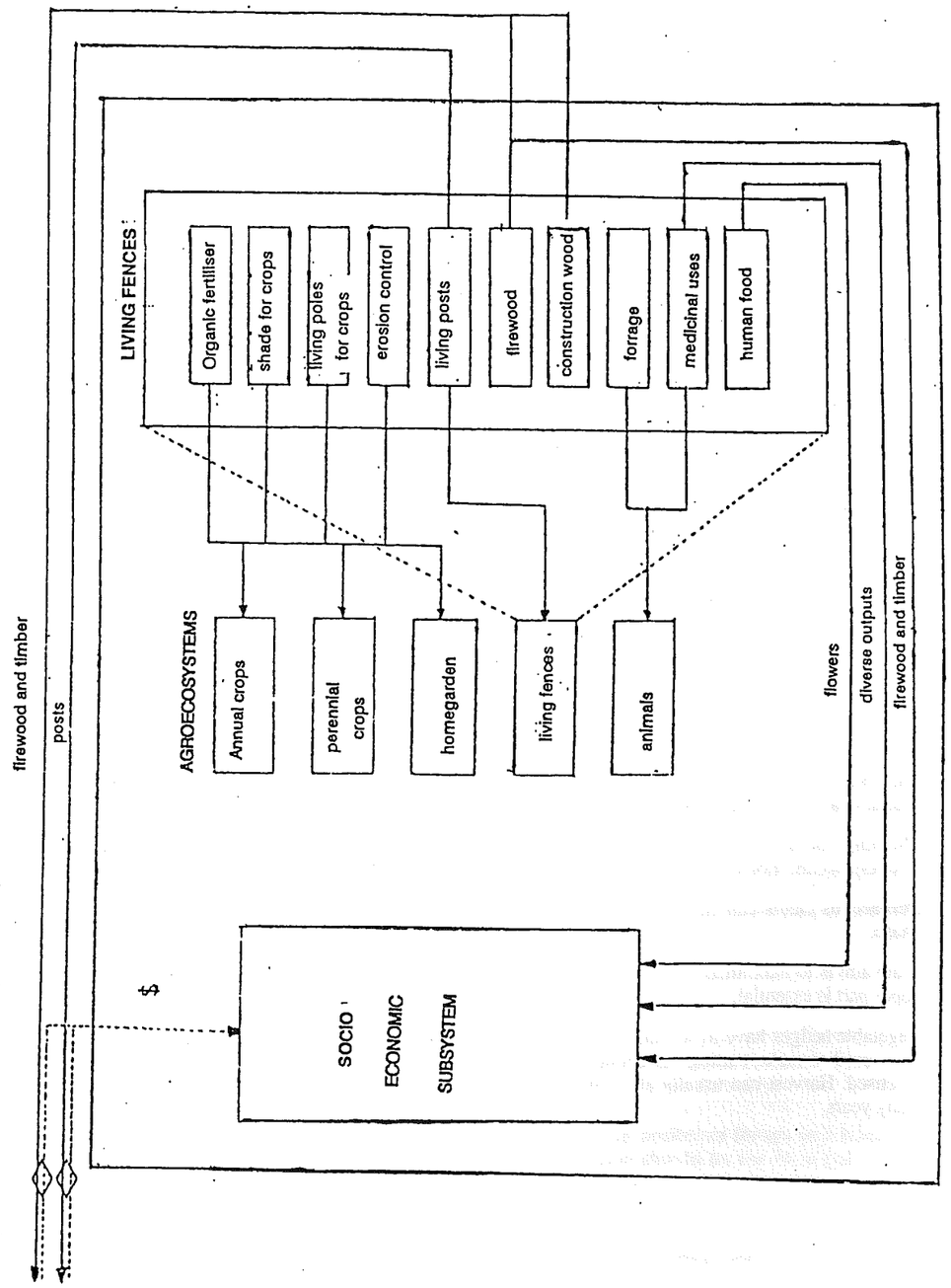

Figure 5: Simplified diagram of a farming system with emphasis of some possible uses of a living fence agro-ecosystem (Gliricidia sepium) in Costa Rica

2.3 Hedges for resource-poor land users - summary, conclusions and recommendations

The following discussion will highkight key issues of chapter three and four including conclusions and recommendations for future action . The purpose of to give for both teamleaders and technical project staff a quick overview of the essentials of this book. The overview of uses and function of hedges follows a summary of important social and economic issues of growing hedges for resource-poor land users.

2.3.1 Uses and functions of hedges

1. Food and hedges

Highlights

- Food is an intimate part of culture. Food plants that might be recommended from a nutritional point of view may not be accepted culturally or socially.
- When space and food are restricted, but an urgent need for carly harvest or food availability in critical periods (like end of the dry season) exists, hedges can be a significant component for a balanced diet for poor men and women.
- Also as a matter of convenience people plant hedges near the house, because they are readily available and a secure source of food.
- Some fruit/nuts and seeds obtained from hedge trees can enrich the diet of the family.
- Research and development organisations have begun to realise the potential of trees for food; to a lesser extent the role of hedges.
- There are many species that could be candidates. Most of them are among the lesser known species.
- The great potential of leafy vegetables grown in hedges is still not widely appreciated by planners.
- Before the promotion of new food plants, biochemical analysis should be made to prove that the food has no toxic or noxious component or side effects.

Key technical instructions

- Fruit-bearing hedges can be grown as natural hedges, or in a one-row unpruned hedge. If very little space is available a trimmed hedge may be the only viable option.
- Thinning out and regeneration pruning will improve the yield of various fruit-bearing species. Plants with inferior regeneration capability should only be slightly manipulated in the natural development.
- Herbaceous plants can be grown in the lower layer. Shade-tolerant plants have to be considered in a later phase.
- If the aim is to maximize fruits/nuts/seeds a wider spacing and special care to allow the trees to grow in the upper part is essential.
- Vegetable hedges have to withstand frequent trimming to obtain young shoots and tops. Thick branches are often used to make cuttings of about 20 cm in length. Narrow intra-row spacing up to 20 plants/meter is practised. Harvest can usually start after 2 months, with very high frequency of harvests, sometimes over many years.

Lessons learned

Most nutritional and tree related research and development activities have ignored or underestimated the potential role of hedges improving the nutritional situation of poor land users. There is a great need in all food security strategies to assess the role hedges do play and can play.

2. Forage from hedges

Highlights

- Commercial farmers attempt to maximize yield from hedges grown in plantations.
- Increased, diverse, and secure supply of animal feed can make hedges and hedge trees attractive for resource-poor land users.
- Early start of and flexibility in harvest make hedges an excellent contingency asset for small-scale farmers.
- Hedges can provide secure and valuable forage in critical periods (such as at the end of the dry season), thus small scale farmers try to optimize this resource. Whether this is done for the whole herd or the most productive animals depends on specific strategy of the poor land user.
- Combinations of hedges and hedge-fodder trees have the advantage that hedge shrubs and small trees yield a quick harvest, supplemented by fodder trees later.
- Hedges can attract wildlife. Some species are an important source of feed for butterflies, bees, lac lice, birds and many other animals.
- The potential role of hedges for sound wildlife conservation, i.e. active and sustainable management, is hardly understood and studied.
- Management know-how is limited to a few species among research and development organisations.

Key technical instructions

- Spacing for forage production varies according to main use and woody perennial; e.g for live fences around 1.5 - 3 m; closer spacing can be more beneficial.
- Fodder trees can be integrated in loose or dense stands in a hedge according to the needs of the farm.
- Hedges and hedge trees have to be protected at the initial stage. This can be done by temporary barriers and obstacles (ditches, stones, prickles, plants), or keeping animals away from the young hedge.
- Harvesting methods for fodder trees are lopping and/or pollarding and for low growing hedges coppicing and trimming; even controlled grazing of hedges is possible.
- To maximize forage from a hedge, high cutting height and frequent pruning is necessary for many species.
- To encourage wildlife management natural-oriented hedges can be manipulated to provide an attractive habitat or an important component (e.g. role in food, web) of it.

Lessons learned

Instead of countless feeding trials and study to maximize yield from Leucaena and a few other species it is important to take a comprehensive view, starting with the context of small-scale farmers.

Support in a flexible forage production strategy, which reduces risk and optimises forage and labour for the whole herd, or the most productive animals in the most needy season should be the focal point of any research and development program attempting to reach small-scale farmers.

Hedges are advocated by environmental groups as one ecological refuge. Sound conservation implies active management. Wildlife in hedge-like vegetation deserves attention in development.

3. Timber from hedges

Highlights

- Sustainable timber production is possible from hedgerow trees. Poles and posts can be also obtained from hedges in a sustainable fashion.
- Free standing trees like hedge trees can grow faster than in plantations.
- The production of a few commercial timber species can be an attractive source of income, e.g. to meet contingency needs for poorer land users.
- When space is limited, growing of large timber trees is inappropriate; but poles and posts can be produced.
- It seems that hardly any extension service has helped small land users to obtain high quality timber.
- Restricted cashability of hedge trees can jeopardize technical advice on how to produce commercial timber.
- Non industrial use of wood may be an even more important function of hedges.

Key technical instructions

- Planting site has to be suitable for felling and transportation of timber trees; this is less important for poles.
- Hedgerow trees can develop spontaneously or from nursery stock.
- The basic silvicultural techniques for producing high class hedgerow timber (minimum length of unblemished stems) are coppicing, high pruning and thinning.
- Trees which split into planks or form "Y-shaped" posts need different treatment.
- The use of fence wire and nails should be minimised if the aim is to obtain top quality timber.
- . Hedgerow trees need wide spacing and access to light; this allows them to grow really quickly and attain the size required for veneer timber.

Lessons learned

A few high-quality timber species or even one sold in a crisis or to meet contingency needs and other trees used for construction replacement, farm tools and utensils, can make a great difference to a poor household. A social forestry concept has to investigate and allocate funds to this totally neglected area.

4. Fuel from hedges

Highlights

- There are many energy "crop" species suitable for producing fuel from hedges.
- Hedges can contribute to improving the energy supply significantly: vernacular experience and some research trials have demonstrated that hedges for fuel can make families self-sufficient even in harsh climates and at high altitudes.
- Fuel may be a welcome by-product in hedgerow intercropping for home consumption or even for sale.
- Government-funded village woodlots and windbreak projects (justified by fuel for the poor) are often used to sell timber and poles. Quicker, often less costly, and more secure support for the poor may be possible by hedgerow promotion.

Key technical instructions

- The basic harvesting methods for fuel production from hedges are coppicing and pollarding.
- Generally fuelwood production can be maximized by a low cutting height, close but not too close spacing (< 1.5 m), and longer rotation (2-4 years)

Lessons learned

Promotion of hedge planting for fuel production on public land, e.g. along roads may be important for the poor.The freedom to harvest any time should not be restricted by guidelines for maximizing fuelwood. Agricultural departments can contribute to the energy situation by including energy-biased hedgerow promotion in their programs.

5. Security hedges (live fences)

Highlights

- Hedges can act as either enclosures or exclosures, or both.
- From the point of view of the poor they are not a substitute for dead fences; they are more, because they can provide diverse outputs.
- Many farmers have already made traditional living fences. In some areas living fences, such as thorny hedges, have been introduced inside traditional networks for additional protection.
- Projects and commercial farmers can afford to invest in expensive artificial fencing; poor land users need low cost fencing with quick, diverse and secure outputs.
- Living fence posts are not very suitable for commercial farmers (labour-intensive but very suitable for small ranchers: cheaper, multiple products).
- For the very poor only local fencing without barbed wire is viable (security against thefts and animals).
- Few interesting local living fence designs and patterns have been discovered.
- With a few exceptions low-cost fencing has hardly been a research topic.
- Protection of a young living fence may be a greater challenge than planting out for a resource-poor land user.

Key technical instructions

- Traditionally, cuttings are preferred to seeds, due to their easy establishment and quick closing. This is particularly true of liveposts supporting wire.
- Fast growing, easy rooting and rapid production of sprouts are important criteria for choosing plants. Thorny plants are important for stockproof hedges.
- Fences can be planted in one or two rows (e.g., second row planted 50 cm to 1 m behind the first one) Agave may be planted in bulbils or double zigzag rows 20 cm apart. Livefence posts supporting wire are usually spaced at intervals of between 1.5 and 2 m.
- To get a dense hedge, plants have to be planted very close, trimmed and strengthened, e.g. with a stick of bamboo.
- To achieve early closing, sunflowers or climbing vegetables (Passion Flower, Ceylon Spinach, Chayote, etc.) are useful entanglers and fillers (list see Table 13).
- Livestock has to be controlled during the establishment phase.

- If a real stockproof hedge is required the only limitation in choice and profile height is that the hedge be high enough and that long-term growth be enhanced as much as possible (around 1 m for some sheep; 1.2 - 1.4 m for cattle). The A-shape, because it tapers to the top must be left taller than the other forms to keep it cattleproof. Some animals, like goats, are difficult to control even when fences are 1.5 m high.
- Mature tall hedgerow trees have to be excluded from stockproof hedges.
- In any hedge gaps will appear from time to time. If these are neglected they will gradually widen and weaken the fence. Gaps under trees should be closed up with posts and cuttings obtained from the hedge and other gaps should be planted up.

Lessons learned

Local farmers and a few projects have developed low cost fencing with quick, diverse and secure outputs. There is an urgent need for research and development organisations to learn more about these existing fencing techniques and test or modify them to suit specific situations.

6. Green manure/mulch production from hedges

Highlights

- Hedges (particularly hedgerow intercropping) can be an efficient substitute and/or precondition for costly mineral fertiliser to maintain and enhance soil fertility.
- The substitution of mulch for capital (mineral fertiliser, weeding cost, etc.) can have various benefits for small-scale farmers.
- The value of mulching in weed control is limited to the control of weed species which multiply by seeds. Regrowth originating from roots or stumps of vegetation is unlikely to be checked by a mulch layer.
- For user-friendly alley cropping, efficient management especially with regard to pruning is important.
- Pest and disease problems are also site specific. There are no reported specific problems of plant protection in mulch obtained from hedges in comparison with other permanent land use components.
- Overall biomass contribution is more important than focusing exclusively on nitrogen-fixing trees. Slow decomposition rate of biomass and/or not too quick resprouts (shade) can reduce weeding costs.
- Multiple harvest is essential for poor land users; harvesting total biomass can result in a nutrient drain.

Key technical instructions

- Hedge intra- and inter-row distance methods, timing of pruning, and cutting height are management variables that can be used to optimise limiting factors or to maximize biomass.
- Narrow alley width gives more herbage per hectare.
- Closer intra-row spacing produces more biomass and reduces the process of woodiness in some plants.
- Generally the lower the hedgerow and the taller the crop, the less frequently pruning is needed.
- Generally the amount of harvestable leaves decreases as harvesting intervals increase.
- Incorporation of prunings in the soil may be more efficient than surface application. This also avoids mulch being carried away.
- Close intra-row spacing (less woodiness), girdling, and low cutting height are strategies for reducing labour input for pruning hedges.
- The best mulch material is one that combines a notable durability with a favourable ratio of volume to weight.

Lessons learned

Farmers may prefer to grow cash crops rather than to plant green manure plants. Chosing multipurpose hedges, or gradually increasing the number of hedges is one strategy. Food for work may be justified in specific situations as well.

Labour economy and natural resource (water, nutrients) interferences (sharing, competition, etc.) must not be seen in a compartmentalised fashion style (component research). The overall farm management strategy of small-scale farmers has to be the framework. This is gradually being understood by leading research and development organisations.

7. Hedges for water erosion control

Highlights

- For small-scale farmers with little external input hedges are a cost-effective means of reducing erosion, increasing, and diversifying productivity in hill farming.
- Even on steep slopes contour hedges can significantly reduce erosion; hedges can be the only realistic approach for poor land users.
- Grass hedge-based soil moisture conservation cum erosion control in-situ should not be underestimated and deserves special attention.
- The prime consideration should not be maximising protection, but how much the farmer can afford or is willing to invest. Finally the number of rows and distances is determined by the extent to which the farmer is willing and able to establish contour hedgerows and invest in complementary physical methods.
- Conservation should start at the farm level; all conservation methods which are affordable by smallholders should be promoted.
- Tasks beyond the capability of individual farmer families should be supplemented by local coordination and cooperation in order to avoid jeopardizing individual effects or increase the overall impacts..
- The integration of conservationists' ideas in the farmers' priorities (e.g. increasing corn yields, green manuring, etc.) is the challenge in designing agroforestry hedgerow technologies.
- The general principles of erosion control must be studied.
- Grass-hedge-based soil moisture conservation cum erosion control in-situ should not be underestimated and deserves special attention.

Key technical instructions

- For effective soil erosion control the dense and closed structured hedges have to be planted along contour lines
- A dense structure near the ground can be obtained or strengthened by climbing plants, successive litter, grasses, brushwood, stones or rocks piled at the base of the hedge
- Simple instruments which can be easily used by farmers with a high degree of acuracy include the A-Frame (see Figure 29) and the hose level.
- Planting distances between strips/rows vary according to soil, rainfall, etc. (For layout and spacing of permanent living induced terraces see Figure 24).
- Narrow intra-row spacing with a density of up to 10 plants per meter is recommended. Two dense hedgerows are more reliable than one.
- Direct seeding and cuttings are the main methods recommended for reproduction; retaining and enriching natural vegetation (leaving strips) must be considered as well.

- Pruned branches can be used to establish trash ridges anchored by trees. Planting on mounds, which prevents seeds from being washed out, is important on steep slopes (133).
- To allow the root system to develop, first harvesting should not be done in the first year in most cases.
- Combination with other methods (groundcover) and interactive physical structure may be essential for more effective soil conservation on steep and shallow slopes and high rainfalls.

Lessons learned

The scale of degradation of the natural resource base in hillfarming can only be reduced if there are sufficient incentives for affordable erosion control technologies. Food-for-work and similar aid programs should depart from promoting perfect but costly physical infrastructure wherever possible. The farm and not a remote watershed has to be the focal point. In this context hedges can be one appropriate conservation technology.

8. Hedges for microclimate modification

Highlights

- In specific situations hedges can be very effective for microclimatic manipulation, e.g. to secure yield or extend rain fed farming to areas prone to frost and sometimes dry farming to areas otherwise not suitable.
- The microclimate intervention can only be done on a small-scale. It can be done at the field level and does not require a local microclimate management strategy.
- Otherwise to avoid the shifting, of cold air to neighbouring fields and/or to increase the overall local impact of the shelter a design at community level is warranted.
- The role of hedges for microclimate manipulation has not been systematically approached in development and research programs.

Key technical instructions

For a technical summary on microclimatic manipulation by wind and by mulch see Chapters 3.7 and 3.10. The following recommendations are made with regard to frost protection.

- Zones mostly affected by frosts and altitude to which the phenomenon of thermalc inversion exists have to be assessed.
- The barrier against frost protection should not be confused with windbreaks.
- The main purpose of these barriers is protection against frost. Therefore they have to be very dense (impermeable) and free from interruptions. A gap of as little as five meters is too much.
- Density can be achieved by multi-storey structure (natural hedges) and pruning and increasing spacing by planting on ridges (trimmed hedges.
- In order to prevent the cold air from entering the field, "off-contour line" barriers, i.e. diagonal hedges, have to be established which force the cold air to descend to the waterway.

Lessons learned

Poor farmers have little flexibility to react to global weather changes. Results of global surveys and trend studies on climate are meaningless to them. Weather advice on how to improve the manipulation of the microclimate is of great relevance for small land users. Extension services should consider this in their programs. Hedges can be an important component in such programs.

9. Hedges for controlling wind erosion

Highlights

- There is ample evidence that farmers are more often than not aware of the role of vegetation in decreasing wind velocity.
- Whether windbreaks are necessary and advantageous can only be answered on a site-specific basis (including socio-cultural context).
- Experience has also shown that the idea of windbreaks is more readily accepted by many small-scale farmers than most soil conservation techniques.
- It seems that farmers prefer one-row hedges because when properly designed the greatest effect in terms of protected areas can be obtained with the minimum space sacrified.
- Hedges are particularly suitable at farm level or for small gardens and poor people.
- Soils which are quickly degrading, but are still intensively farmed, need immediately protection. Hedges can be successful where conventional windbreaks are doomed to fail.
- The decision on how wide a windbreak should be mainly depends upon the amount of land which can economically be devoted to its planting and the minimum number of rows required to maintain the desirable permeability;
- In a situation where complex land tenure arrangements and social situations exist the overall windbreak design at local level has to be flexible. Hedges on individual farms fit well into this flexibility.
- Local planning and the ability to enforce set goals at local level will finally determine the layout and scale of windbreak networks.
- Support in achieving clearly defined tree and land tenure arrangements, particularly user rights to windbreaks on communal land, is as important as developing technical packages.
- At the field level, the freedom to cut down a windbreak (contingency rights) should only be limited by local consensus and group sanctions (not by law enforcement).

Key technical instructions

- Optimum wind protection by hedges can be achieved when the hedge is homogeneous, has sufficient height and permeability
- Hedges provide a homogeneous (vertical) structure in the base of a windbreak.
- Individual hedge trees are important to achieve the desired height, but can cause wind eddies.
- There is a direct relationship between the height of a hedge and the area sheltered. A-shape and/or capped A-shape is preferable if there is a need for a low hedge.
- Compact (dense) hedges are the most effective in reducing wind velocity, but only over a limited distance. Permeable hedges provide less absolute reduction in wind speed, but affect a greater distance downwind.
- As a rule of thumb the appropriate permeability exists when movements, but not objects, can be seen clearly.
- A network of many hedges can be superior to a small number of wider shelterbelts with regard to their productive and protective roles.
- The width of the windbreak is of little importance; in theory a single row is often sufficient. However, the risk of one row is that it may develop and funnel winds. Several rows also allow a more convenient alternative harvesting of the stem by coppicing.
- A hardy lower woody perennial at the windward side, and a taller faster-growing tree may be combined. The species combination is more restricted in order to achieve optimum structure of the windbreak. In general, species are planted close together to obtain early closing.

- Orientation of the windbreak depends on wind direction, topography, shading, land tenure, etc.
- Windbreaks have to be protected against animals, which have to be kept out in the initial stage. Compaction of the soil by animals may result in the destruction of trees and shrubs. Obstacles (ditch, prickly plants) have to be considered.
- The hedge design for dust, pollution control has to be similar to windbreaks (dense stands act as solid barriers, particularly in high winds, causing the pollutants to be lifted and then deposited in the turbulent lee of the trees). The width of the hedge may have to be larger so that the dust etc. can be deposited in the hedge.
- Living fences can also be used in sand dune stabilisation. Even to establish a living fence, more often than not a protective dead structure (palisade) may be required. Several species can be established from freshly cut branches.

Lessons learned

Today large areas are ecologically threatened by wind erosion. Classical shelterbelt concepts (multi-rows, long gestation periods, several kilometers long/high protection costs) have, with a few exceptions, had no significant impact on the magnitude of the problem. They have the greatest ecological impact on fertile soils. Poor farmers are often forced to cultivate less fertile soils.

There are sound arguments that many small windbreak hedges particularly in a network based on family/local initiatives should be the starting point for promotion schemes: Coordination and cooperation at local level, whenever possible is desirable to increase the overall wind protection and avoid jeopardising individual efforts (e.g. though animal encroachment).

The international community can continue to allocate funds to a few development and research pilot projects with the aim of maximising wind protection. The better option is to test other planning methodologies and cost-efficient wind protection with immediate results. Hedges will have a prominent place in these endeavours.

10. Hedges as an ecosystem

Highlights

- The role of hedges in nature conservation frequently requires the reconciliation of conflicting viewpoints. "Modern" farmers tend to regard them as a liability, while conservationists are anxious to promote their survival as sanctuaries for wildlife.
- The best way of nature conservation (not to be confused with preservation) is active management.
- The amount of shelter for wildlife does not depend primarily on the length of the hedge but on the quality and quantity of ecological niches and the way it is maintained.
- Hedges managed in a sound way can contribute to ecosystem stability and increase the productivity of rural areas and poor people.
- There is no such thing as an ideal hedge from an ecological point of view. Conditions that are favourable to one animal species may be less favourable to another and actually prohibitive to a third.
- From the perspective of the poor farmer sound nature conservation is most likely if tangible benefits can be secured for him in a short time.
- For many animal species, particularly birds, trees form the most important component of the hedgerow flora.
- The role of hedges in pest management is not sufficiently understood; but it has a high potential (biological control and natural pesticides).
- Hedge can be a trap plant for pests, but also a host crop; this is not only plant-specific but also site-specific. It is possible that increased diversity of plant species in hedges could actually be an advantage in diverting harmful pests and promoting other creatures more beneficial to the farmer in particular circumstances.

- A variety of plants exist which are relatively resistance to pollutants; some hedge plants can also serve as bioindicators.

Key technical instructions

- A great diversity of native plant species have to be considered to provide habitat and ecological niches.
- Hedges should be wide so that the inner part can develop into an undisturbed habitat for many animals.
- Hedges should be allowed to grow more or less naturally and be coppiced infrequently instead of being trimmed regularly.
- To allow birds and other animals to escape, only a small part should be coppiced at a time. This should fit in with the breeding periods.
- Hedge trees should be part of a natural hedge; a desirable selection should be preserved in the process of hedge management (trimming and cutting back for rejuvenation, etc.).
- To encourage wildlife the habitat of desired animals can be improved (e.g. year-round flowering plants for bees).
- Networks of hedges and combination with small woodlands can increase the overall ecological impact of hedges.

Lessons learned

Increasingly higher awareness of the potential of hedges for nature conservation can result in the allocation of more funds for basic research. Accumulation of scientific knowledge on understanding the hedge as an ecosystem is of limited development value if results are not capable of application by poor land users.

From the point of view of poor people any intervention in hedgerow growing should serve several purposes at the same time, not merely preservation.

2.3.2 Social and economic issues

1. Social dimension of hedgerow growing

Highlights

- Local people have mastered the techniques of land management by planting hedges.
- Hedges are one option (not a panacea) for mitigating the problems of small-scale farmers and the very poor. There seems to be a close relationship between the potential of hedges and poor people.
- The perspectives of target groups (priorities, attitudes, experiences) can favour or inhibit hedgerow growing.
- Research organisations have hardly made any comprehensive assessment of the role of hedges and have yet to design a special top-priority program for the rural poor.
- Development organisations have more often than not neglected the socio-cultural and the socio-economic dimension of hedgerow growing as well.
- The nutritional impact of hedges has not yet been studied.
- Whatever the specific history of hedges or hedge-related vegetation, it is important to investigate their genesis, to see if it is possible to build on existing traditions. This is a wiser policy than introducing something alien to a target group.

Social issues

Some relevant social factors which have to be understood and studied (interactively with the target groups) in the process of designing a specific hedgerow program include: equality and inequality, land (availability, security), social priorities, need, aspirations, decision-making processes, individual and/or communal strategies of promotion, local participation, enforcement of plans, government policy, definition of project success, dissemination and documentation (for more details, see Table 25).

Lessons learned

Hedges are not a panacea, but with the appropriate political context, they can help to reduce deprivation. Hedges and a few other trees can make a big difference to a poor family. Seen from the point of view of the poor themselves they are like bank deposits with low initial deposits and high rates of appreciation.

It is of little value to investigate how to maximize biomass from hedges when under real farm conditions other considerations, particularly labour issues, determine the management strategy. Given the low resource base of resource-poor land users, their priority interests have to be the criterion on which research and development must be based.

Also institutional incentives have to be sought prior to giving technical recommendations, particularly secure user rights including freedom for cashability whenever there is a contingency or other needs. This freedom should not be restricted by law enforcement but only by local consensus and sanctions.

2. Economics of hedgerow growing

Highlights

- Most hard economic data exist on alley cropping and classical windbreaks.
- Economic analysis has demonstrated (within their limits) that the ecological effects of hedges compared with other tree growing can be attractive in economic terms.
- Hedge planting, e.g. for soil conservation requires initially more work and loss of land.
- Research with a mandate for serving small-scale farmers has to take the overall management strategy of the poor land users (not necessarily maximising yield, income, etc.) as its framework.
- From a microeconomic point of view it can be a rational choice, even for small-scale farmers, to rely on subsidised inputs like mineral fertiliser, herbicides and not to utilize the biomass, e.g. from hedges.

Lessons learned

More economic analyses are needed to demonstrate that the ecological effects of hedges, compared with other tree growing and treeless land uses, can be very attractive in economic terms. Strict economic analysis divorced from the total context of poor land users can be meaningless as a tool for planning.

2.3.3. Conclusions and recommendations for future actions with regard to hedges

1. General findings

In this book hedges are defined as narrow strips of unbroken or nearly continuous vegetation, generally dominated by woody plants. Hedges are closed at or near the base and have some degree of density. Living fences supporting wire are relatively wider spaced and when frequently pollarded are only relatively dense. The main feature of most woody hedgeplants is that they can be heavily pruned.

In the past insufficient attention has been paid to hedgerow research and development. Hedges are one option (not a panacea) for mitigating problems of small-scale farmers and the very poor. There seems to be a close relationship between the potential of hedges and poor people. This is not sufficiently documented. In research and development, hedgerow growing there is hardly any specific focus on specific target groups.

From the point of view of the poor, hedges are not a substitute for dead fences; they are more, because they can provide diverse outputs. There is no universal definition of a hedge; a transition to and overlapping with other land use systems is obvious. The present state of knowledge often makes a rigid distinction impossible. From the viewpoint of resource-poor people this is of minor importance. The greatest potential of hedges is for poor people and agriculture on marginal and difficult soils. Knowledge exists among local people.

Recently research and development organisations have begun to design and promote hedges. There are at least two reasons for active involvement of local people in hedgerow design: a valuable source of know-how and a greater chance of acceptance. Hedgerow research and development will become more attractive when they respond to the multiple problems of resource-poor land users.

2. Recommendations

Major recommendations

There are many gaps in knowledge, but sufficient evidence and knowledge for more action than inaction.

- There is a need to research and develop hedgerow systems further, building on the current knowledge base (combine knowledge of existing practices with experimental hedgerow research).
- Land-users who are forced to cultivate marginal land and/or have a very limited resource base (land, labour, capital) should be the prime target groups of hedgerow promotion.
- Not only small farmers but even landless people can be involved in management and benefitting from hedges by giving them secure access and usufructuary rights on public land, e.g. along roads.
- The role hedges can play for the resource poor and in particular for women needs more in-depth studies and documentations.
- Instead of paying too much attention to sophisticated classification and definitions there is a need to focus on hedgerow and related growing of trees and shrubs with acceptable tangible and less tangible benefits for resource-poor people.
- There is a need to make an in-depth inventory of various hedgerow systems in various zones, with the main aim of assessing the possibility of transfer to similar socio-economic and ecological contexts.

Specific recommendations

Tangible and less tangible benefits from hedges:

Food:

- There is a great need in all food security strategies to assess the role hedges play and can play. Hedges as a source of leafy vegetables deserve special attention.
- Prior to the introduction of new hedge species and varieties, it is absolutely necessary to pre-test whether they are culturally accepted.

Fodder:

- There is a need for further development of management systems for high fodder production during dry periods taking into consideration genotype variations, cutting regimes, and land management strategy.

Wood:

- How to manipulate hedges (like thinning and high pruning) to grow commercial timber and non-industrial wood from a sustainable base needs more investigation from promising species.
- There is a need to assess further and develop the potential of hedges for fuelwood, based on a large amount of information on energy crops and existing systems.

Living fences:

- There is an urgent need for research and development organisations to learn more about existing living fencing techniques and test or modify them to suit specific situations.
- Special emphasis has to be given to developing more affordable and living fences without barbed wire which very quickly provide a stockproof hedge and/or yield diverse outputs.

Soil and water conservation:

- The overall biomass contribution to soil fertility can be more important than focussing on nitrogen-fixing trees only.
- Negative impacts of mulch (like pest and disease) have to be assessed in an ecosystem perspective and not plant-specifically.
- If not only soil fertility but also weeding costs are a major land management problem, plants have to be considered which combine a notable durability with a favourable ratio of volume to weight. More research is needed for hedge plants which have a slow decomposition rate of biomass and/or do not resprout (shade) too quickly.
- Conservation should start at the farm level. The farm and not a remote watershed has to be the focal point in hedgerow promotion.
- The impacts of hedgerow growing on soil and water, particularly the optimum intra/inter-row spacing for adequate soil erosion control, especially in areas with unreliable but erosive rainfall, and the water requirements for hedges where water is scarce deserve further research.
- When using hedges in erosion control the aim should not be perfect protection but how much the land user can afford or is willing to invest in soil conservation. Finally the number of rows and distances of hedges for erosion control have to be determined by the farmer.
- The decision on how wide a windbreak should be mainly depends upon the balance between the amount of land which can be economically devoted to its planting and the minimum number of rows required to maintain desirable permeability.

Microclimate:

- There is a need to investigate microclimate variables such as light interception, moisture regime, and wind reduction.
- Extension services should include advice on how to improve the microclimate by including hedges.

Nature conservation and ecosystem:

- From the point of view of poor people any intervention in hedgerow growing should serve several purposes at the same time; not only preservation.
- A great diversity of native plant species have to be considered to provide habitat and ecological niches.
- There is a need for further research into the role of hedgemade ecosystems (e.g. impact of partial substitution for natural forests in a network with woodlands).
- More research is required on the function of hedges in pest and disease issues (biological control).

Socio-economics:

- Socio-economic determinants have to be understood and studied (interactively with the target groups) in the process of designing a specific hedgerow program.
- More detailed economic analysis is required to determine which land use systems (with and without hedgerows) are favourable. The analysis has to be made on different scales.

Research, extension, and training:

- It is not optimising one of the outputs of hedges (e.g. maximum windprotection or perfect water erosion control) that should be the rationale for development and resource conservation but hedgerow systems which are most acceptable, affordable and hence promise the greatest overall impact on the landscape and quality of the life of resource-poor land users.
- Given the low resource base of resource-poor land users, it is their priority interests that have to be the reference framework of research and development.
- In countries where a unified extension service exists and which have a strong link to research, the core for hedgerow research and demonstration can be the field research stations. Starting at farm level to identify technological packages and research priorites are warranted as well.
- In order to create a greater awareness of the potential of hedgerows for rural development, all communication channels and media have to be utilised. Policy decision makers require a different level of information from fieldworkers.
- It is strongly recommended that research and training should build on the experience of ICRAF, CATIE, and IITA.
- However the production of extension aids should be decentralised in order to be site and target-group specific.
- The development of a hedge manual, for which multi-language co-publication would be essential, may prove an important guide for developing decentralised extension material.

Species:

- Testing of a greater variety of hedgerow candidates is highly recommended. A panel of experts should screen the most important hedge plants (consult the perspective of resource-poor land users) and develop further a master list of the most relevant hedge plants for different agro-ecological zones, land uses and resource-poor people.
- There is a need to focus on species with quick and diverse output and which can be grown on adverse sites and are easy to establish and manage.
- There is also a need to clarify the taxonomy with regard to species and related genera.

- More horticulturists, anthropologists, and ethnobotanists, and above all, local people should be consulted in species selection and testing.
- There is a need to expand the evaluation of germplasms through networking, concentrating on edaphic and management variables, etc., and to develop genetic improvement strategies and selection objectives for the poor. International exchange of information and seeds is important. Local networking and banks of local planting material deserve even greater support.

Establishment and management:

- The further development of cost-efficient and affordable planting and management techniques on difficult sites should be one top priority of research and development.
- Multi-purpose hedges on marginal sites deserve special attention in monitoring nutrient cycling including N-fixation, total nutrient budget, mineralization rates, and root interaction.
- More research is needed into the establishment of hedgerows by cutting and direct seeding. In particular, a comparison of seeds and stake establishment is required.
- The management/hedgecrop interaction needs to be further studied in specific agroforestry land uses.
- In extension and land-use planning more emphasis has to be given to how to protect young hedges.
- More research is required into harvesting techniques like pollarding, lopping, and multi-purpose management.
- More research is required into optimum timing, frequency and cutting height of pruning in representative agro-ecological zones for specific uses. More often than not there may be a need to depart from the general tendency to maximise biomass and other outputs.

International cooperation and future action program:

- The organisation of an international workshop on hedges for rural development, bringing together all persons concerned (scientists, planners, field workers), is an important next step.
- Feedback from the field of this publication and the pragmatic workshop and updating hedgerow activities (beginning in 1989) should be used as major inputs for the development of a manual on hedges.
- Technical cooperation between developing countries (TCDC) is recommended. Regional cooperation with regard to hedgerows should focus on information exchange, training, research, and demonstration.
- Networking should be fostered. Instead of creating a specific network for hedges, an alternative suggestion is that an informal lobby should develop a strategy for integrating hedgerow messages in relevant networks.

3 USES AND FUNCTIONS OF HEDGES

A hedge is not a substitute for a fence, it can offer much more. Hedges can serve all social groups. The potential role of hedges differs from one group to another: rich and poor, urban and rural. Chapter 3 is the core of the hedge book. Uses of hedges and specific targets to achieve are the theme of this chapter. The discussion of specific uses of hedges will show the whole range and complexity of the multidimensional aspects of utilisation. For more general technical aspects see Chapters 5 and 6. The perspective of the resource-poor land users is the main reference base (for more details consult Chapter 4). The bias is towards rural areas. The fact that in the near future half the human race will live in urban areas indicates future tasks for hedgerow research and development.

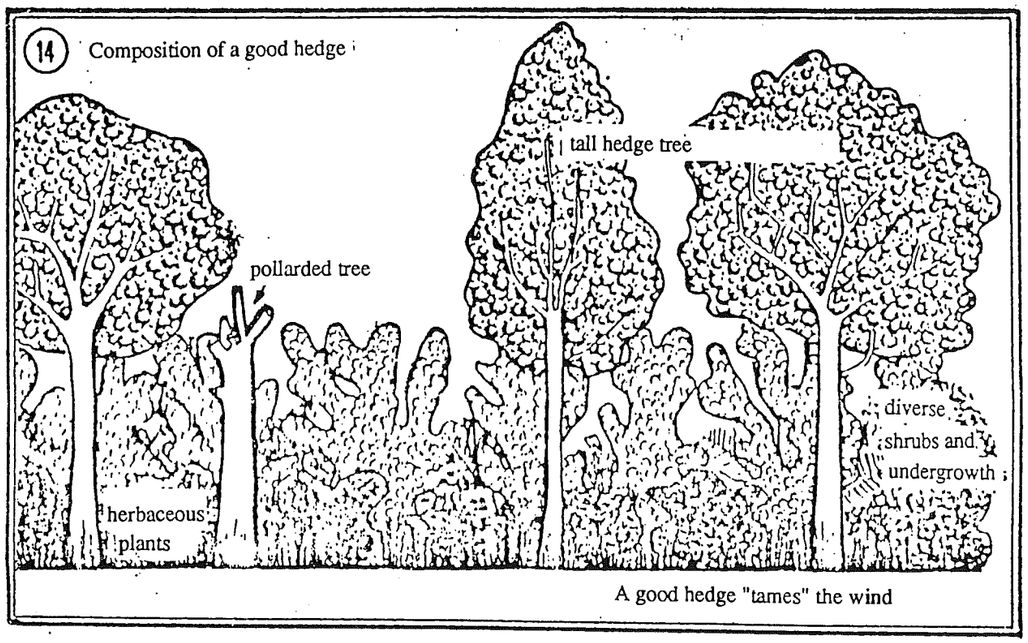

Figure 6: Example of a multipurpose hedge for resource-poor land users (98)