Agroforestry pathways towards sustainable land-use

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ABSTRACT

The main objective of this report was to evaluate the suitability of a series of proposed agroforestry technologies, and recommend the most promising ones for further research and implementation in the selected research area. It is the completion of all phases up to the implementation phase of the Diagnosis and Design Methodology (ICRAF, 1987).

The research which consists of two parts was carried out in the uplands of the municipality of Baybay, Leyte, Philippines. The first part by Dekker and Parma, 1992 consisted of the identification of the research areas, an inventory of socio-economic problems faced by farmers in the area, current farming systems used, and environmental problems related to land use. The objective of this exercise was to design a set of agroforestry technologies which can halt environmental degradation, and yield and income reduction. The selection of suitable practices was done with the help of the pathways theory for shifting cultivation as developed by Raintree and Warner (1986). In total, nine alternatives were formulated.

Luijt and Rippen conducted the second part of the research in 1993. The objective was to take the proposed agroforestry technologies, test their suitability in the field and to recommend the most promising ones. After further refinement of technologies, informal talks with key farmers were used to assess the adoptability of the proposed technologies as well as to obtain feedback on possible improvements to the designs. The productivity and sustainability proposals were the evaluated. A qualitative analysis was used for this exercise due to insufficient data. Lastly, using the results from this ex-ante evaluation as well as data on the physical aspects of the area, a suitability classification was developed based on the FAO methodology of land evaluation for forestry (1984) and adapted to agroforestry according to Young (1990). This resulted in the selection of the technologies deemed most suitable for the research area.

The diagnosis and design methodology should be seen as an iterative process during the remaining stages, i.e. further research and implementation phases. It was necessary to take steps back in the methodology so as to constantly refine the proposals according to the demands of the users and the environment they are working in. The participatory approach was used so that the most favorable result can be reached to benefit both farmers and their environment.

Keywords: Agroforestry; sustainable land use; upland farming; farmer participation; adoptability

INTRODUCTION

In the uplands of the province of Leyte, Philippines, the area under cultivation is increasing. The causes behind this development are population growth, declining income generating opportunities in the lowlands and migration to unstable peace and order situation. As a result, farming practices are becoming more and more unsustainable and the level of deforestation is increasing. Upland farmers are faced with problems of low income (majority live below the poverty threshold), lack of land security, and declining yields due to loss of soil fertility, erosion and leaching.

A possible solution to this problem is the alternative land-use practice which is integration of a tree component into farming systems, i.e. turning them into agroforestry systems.

Although there are many interesting agroforestry systems, the question remains fully open as to whether the farmers are willing or can adopt such practices.

To develop a sustainable form of land-use, which can also increase the standard of living of small-scale farmers, the authors set themselves the following aims:

- to design sustainable agroforestry systems for the uplands of Leyte, Philippines, and thereby improve the standard of living of the farmers;
- to evaluate the suitability of the proposed agroforestry technologies and recommend the most promising ones for further research and implementation in the selected research area.

The Diagnosis and Design (D&D) methodology developed by ICRAF (1987) was used in the selection, evaluation and suitability classification of eight agroforestry technologies deemed suitable for the research area. The selection of the possible alternatives was based on the pathway-theory for shifting cultivation, developed by Raintree and Warner (1986). The alternatives were next evaluated in terms of productivity, sustainability and adoptability. With these results, a suitability classification was developed using the methods from FAO's Land Classification for Forestry (1984). The entire research, except for the initial interviews was carried out in a qualitative manner, using aspects of rapid rural appraisal.

BACKGROUND

The research area was selected within the boundaries of the municipality of Baybay, on the west coast of Leyte. The area is approximately 5800 ha lying between 100 and 500 meters above sea level. It consists of three major soil types which were used as land units, namely orthic Lixisols, dystric Nitisols and orthic Acrisols. Unfortunately, specific information on soil characteristics was lacking. However, some of the most important characteristics of the area relevant to the research, slope classes, rates of erosion and vegetation type (as a rough indicator of soil degradation) were easily measurable. The most dominant slope class is between 25 and 35% with relatively many slopes between 35 and 50% in the area. The average erosion in the area is 1-2 gullies per 100 meters land surface. Those areas with cogon (*Imperata cylindrica*) infestitation have the poorest soil quality, those with more or less natural forest vegetation having the highest soil qualities.

The area climatically lies in the humid tropics (Af, Köppen classification) with precipitation throughout the year. The average minimum and maximum temperatures are at 22.0 and 32.8 °C, respectively. The highest humidity rate has an average of 96% and a lowest of 59% (ViSCA-PAGASA-PCARRD, 1992). Due to the islands location along the eastern typhoon belt of the country, tropical cyclones occur frequently. This is a major crop development constraint in the area. Furthermore, four main vegetation mozaics are distinguishable, namely forest, regeneration forest, denuded areas and coconut areas. The complete research site is a public domain owned by the government such that all farmers in the area are "officially illegal". However, many coconut-based farmers own their land while the shifting cultivators or *kaingineros* are illegal. The issue of land ownership in the uplands of the Philippines as a whole is still quite controversial.

METHODS

The D&D methodology served as the guideline throughout the combined researches. This methodology consists of six stages which are more or less adjusted to the local circumstances. Dekker and Parma (1992) completed the first three stages of the research, namely the prediagnostic, the diagnostic and the technology design stages.

The prediagnostic stage consisted of a regional reconnaissance survey, identification and description of current land-use and selection of a research site. This was largely carried out through a literature study combined with information obtained from ViSCA staff-members, local farmers and other sources. Secondly, a diagnostic survey of the selected site was undertaken. An initial identification of potential agroforestry pathways was made for the major forms of land-use based on the pathways theory (Raintree and Warner, 1986). This is a model which shows the different stages in the evolutionary sequence of land-use systems (Figs. 1 and 2). The model has been adapted to make it suitable for the classification of agroforestry systems according to Nair (1986). Furthermore in this phase, a sample of 49 coconut-based farmers (10% of the total) was interviewed with questions concentrated on social, demographic and farming characteristics. The technology design stage consisted of identification of candidate technologies based on the pathways theory. A basic technical design was made for each, concentrating mainly on structure and species composition.

In the follow-up research by Luijt and Rippen (1993), the next two stages were undertaken. These are the evaluation and redesign, and the planning stage with the latter only partially completed.

The first part of the two stages consisted of an ex-ante evaluation of the proposed technologies based on:

- farmers' response - a series of intensive talks with a small group of 14 farmers in order to discuss the proposed technologies in an informal manner and note their suggestions. Here, the rapid rural appraisal was used.
- expected performance of the technologies in terms of productivity, sustainability and adoptability. A series of tables which evaluated these three criteria was constructed. Due to lack of hard data, this was done qualitatively through literature review and results from similar agroforestry projects.

At the end of this stage modifications suggested by the farmers were made to the proposed technologies.

The second part determined the suitability of the proposals based on the framework of Land Evaluation for Forestry (FAO, 1984). Some adaptions were made to suit the authors' needs using Young's guidelines for Land Evaluation for Agroforestry (1984).

RESULTS

Results of the preliminary research

Social, demographic and farming characteristics

Coconut-based farmers

The interviews with the coconut-based farmers gave the following results: the farmers had an average age of ca. 60; two-thirds were male, 9 of 10 were married. The average household size was 4.1 and the majority of the respondents finished primary school. The average coconut-based farm size was 1.1 ha while the mean total farm size was 2.6 ha. All respondents had additional sources of income, but coconut farming was the main income for 50% of them.

More than 75% of the respondents already use intercropping with (non-) fruit trees and/or annual crops in their coconut fields. Thirteen percent of the respondents were not interested in planting trees other than coconut trees, because the fruits of the former are earlier to harvest. However, 25% indicated their interest to convert their coconut parcels into lumber tree farming. Most of them were younger with usually shorter farming experience and an above average total farm size. The most preferred tree species were jackfruit (*Artocarpus heterophyllus*), avocado (*Persea americana*), and ipil-ipil (*Leucaena leucocephala*) where were already growing between the coconut trees in many cases. Seventy-four percent of the respondents used both firewood and coconut products for fuel but 44% of them mentioned increasing difficulties in fuelwood gathering.

Kaingineros or shifting cultivators

Two types of *kaingin* or shifting cultivation are distinguishable, i.e. the long fallow *kaingin* in the forest and the short fallow *kaingin* in denuded areas which compare 40 and 48% respectively (BSWM, 1986). Most *kaingineros* are relatively new settlers with additional sources of income apart from their *kaingin* income.

The forest-*kaingineros* cultivate land (plots of 2-4 ha) for an average of 4 years, followed by a forest fallow period of 10 - 15 years. On the average they have one *kaingin* under cultivation, one economically enriched, and two under forest fallow. Farming methods are slash-and-burn although burning is not as rampant nowadays due to efforts of extension workers and environmentalists. Their system was an ecologically sound before but increased migration and population pressure has decreased the fallow period. The main problems the farmers face are:

- lack of security on their land since they are not the legal owner;
- the government and ViSCA are forcing them to stop their shifting practices;
- unstable and low income.

Crops consist of corn, rice, abaca, banana, pineapple, papaya, and rootcrops, and are all for home-consumption although surplus is sold. Distances from the house to the *kaingin* range from 2 to 15 km.

The *kaingineros* in the denuded areas are in a more precarious position. Their land is already heavily denuded and eroded. Cultivation lasts for 2 - 5 years, followed by a 3.5 years average fallow which is too short for any significant soil regeneration. Population increase, tenure status, and peace and order situation are causing extra pressure on the land. The cogon (*Imperata cylindrica*) infestation further aggravated the problem, made farming extremely labor intensive, and offered very strong competition to crops. Due to shortage of land, farmers are forced to reopen these cogonal lands for cropping only after a short fallow. Therefore the main problems faced by these farmers are:

- declining fertility of the land
- erosion
- cogon (*Imperata cylindrica*) proliferation

However, some farmers already practice a form of fallow improvement using ipil-ipil and kudzu (*Pueraria phaseoloides*). The predominant crops grown are corn, rice, cassava, sweetpotato and vegetables.

Selection of possible agroforestry pathways

After analysis of the problems and possibilities, nine possible agroforestry solutions were found through the pathways theory. A short description of the choices is found below.

For the coconut-based farming, the following pathways were distinguished:

- Plantation crop combinations; coconut parcels intercropped with trees, perennials and annuals in a mixed arrangement.
- Plantation crop combinations to multilayer tree garden; the coconut is no longer the main produce. The parcel takes on a more natural forest-like appearance with a layered structure.
- Plantation crop with pasture and animals; high quality pastures are sown between the coconut trees in order to provide grazing for cattle and/or other farm animals.

In the forest, these are:

- Improved fallow to plantation crop combinations or multilayer tree garden; fallow lands are already enriched with perennial crops. This can be intensified by planting tree species to create one of the options.
- Improved fallow to alley cropping; a biologically improved fallow which is later opened leaving rows of leguminous trees for fertility enhancement and erosion control.
- Taungya; tree crops intercropped with annuals for 1-2 years.

For the kaingin in denuded areas, the choices are:

- Improved fallow; fallow periods are biologically enriched for soil restoration in a sustainable manner.
- Improved fallow to alley cropping; as above to enhance fertility and to control erosion.
- Taungya; as above.

Taungya turned out to be a short term solution because it takes agricultural land out of production. It is therefore not recommended as an agroforestry pathway.

Results of the ex-ante evaluation

Productivity

The overall results obtained on this aspect of the ex-ante evaluation showed a trend in which the more diversified and complex technologies have the highest production potentials.

As a measure of the expected biomass production compared to that of natural vegetation, the biological potential of the systems increases with the number of vertical layers, number of species and their densities. Accordingly, multilayer tree gardens and plantation crop combinations with multiple layers have the highest potential. At the bottom of the list are plantation crops intercropped with agricultural crops and combinations with pastures and animals. The structure, species density and diversity of species are the lowest in these cases. This means these technologies will not utilize the full potential of the area. Thus, biological production will be lower than with the more diverse technologies.

In contrast, economic efficiency of the proposals shows a much more even distribution. The relations between the different inputs and outputs show that all the technologies have their advantage or disadvantage over another. For example, alley cropping requires high inputs (in the form of labor) but produces relatively high outputs in terms of increased yields, mulch, firewood or even forage. A multilayer tree garden has lower (labor) inputs, high overall outputs but these outputs are spread over a large number of products, each with relatively low quantities. Only improved fallows especially biological ones can be expected to have low levels of inputs and outputs. Their economic efficiency lies not so much in the fallow itself but in the result of the fallow, i.e. soil amelioration. Diversity of production closely connected with economic efficiency. This entails the number of different products a technology can supply. The more diversified the production, the higher can be the self sufficiency of the farmer and his/her family. The overall expected performance of the proposed technologies is shown in Table 1.

Sustainability

Many factors influence sustainability of the proposed technologies. They can be roughly split into factors which are biotic (e.g. soil fauna, maintenance of organic matter) and those which are abiotic (e.g. erosion control, maintenance of nutrients) in nature.

When looking at the technologies offered, the combined effects of diversity, complexity and management requirements influence its sustainability. Tree gardens with their multiple layers and high species composition, ensure good root stratification and high litter fall which in turn allows maintenance of organic matter, nutrients, physical structure and drainage. Also, microclimatic changes in a tree garden are much smaller than in an open field: temperature and moisture remain steady, while effects of wind are reduced. Preservation of species diversity, habitat for pollinators and other animals responsible for the reproduction and fruiting of valuable plant and tree species are also important to sustainability.

The situation described above decreases with the complexity of a system. However, management of a system has also positive effects. This can be seen with alley cropping in which pruning and mulch application combined with a rotational crop production system greatly reduce erosion and keep nutrient levels relatively constant.

Table 1. Overall expected performance of the proposed technologies.

Proposed technology	Productivity	Sustainability	Adaptability
1) Plantation crop combination			
a) Integrated multistorey combination	++	++	0
b) Mixture of plantation crops	+	+	+
c) Intercropping with agricultural crops	+	0	+
2) Multilayer tree garden (MLTG)	++	++	-
3) Plantations with pastures and animals	0	-	+
4) Improved fallow --> MLTG	++	++	0
5) Alley cropping with MLTG	+	+	0
6) Biologically improved fallow (BIF)	0	+	+
7) BIF ---> alley cropping	+	0	0

Definitions: ++ = very high; + = high; 0 = medium; - = low

Adoptability

As stated earlier, one of the most important features of new technologies is the measure in which they are adopted by the intended users. The previous two headings have shown that the more complex and diverse technologies are the ones with the best expected performance for the research area. However, when the human factor is considered, this situation changes.

The results obtained from the discussions with the *kaingineros* were very interesting. The main adoptability problem arises in the integration of tree components to the farming-systems on a large scale. Due to the long gestation time of woody elements, farmers are reluctant to spend valuable time, land and money on these components because of lack of security on future yields. This was emphasized by all farmers. If and when the problem of land/crop security will be solved, the farmers stated willingness to adopt new ecologically more sound land-use alternatives.

The coconut-based farmers in the research area mostly own or lease their plots. Earlier research by Dekker and Parma (1992) revealed that a substantial number (30%) of coconut farmers is willing to incorporate tree elements into their farming systems.

Land ownership is not only important in determining the most suitable proposed management, cultural attitudes, fulfillment of basic needs (e.g. ready supply of fuelwood) and labor allocation. Also, knowledge of agroforestry practices among farmers obtained through existing demonstration plots and extension activities has influenced adoption especially by coconut-based farmers (Dekker and Parma, 1992).

An inherent characteristic of agroforestry systems is that, its adoption often requires increased labor (especially during the first 2-4 years) and a change in overall management (Young, 1989). The success of a newly introduced technology depends on whether the farmer is able or willing to invest the required amount of labor for the management of the system. This will often compete with other activities.

Dekker and Parma found that 50% of the coconut-based farmers have only supplementary income out of coconut products. For them increase of labor is a limiting factor.

The situation for the *Kaingin* farmers is different. This group has little off-farm economic activities (fishing being the most important; ViSCA/GTZ Ecology Program, unpbl.). The limiting factor is the distance that must be crossed to reach the plots. Only 6 out of 14 farmers noted that labor could be a problem mainly due to the distance problem. However, most of this group stated that once the peace and order situation is stabilized, they would most likely return to live on their farms.

Overall, the least complex systems received were the most favorable response (Table 1). This has to do with the amount of components present, the amount of perceived labor intensification and cultural attitudes towards the technology.

The coconut-based farmers interviewed believed that the opinion that the plantation crop combinations with coconut as the main plantation species could incorporate lumber species as long as the latter can be harvested before the crowns surpassed the coconut in height. Also, the crowns should be small and the branches easily pruned. Preference towards local species rather than exotics was shown. Bamboo (*Bambusa* sp.) was also desirable due to scarcity of this important building material in the area. Overall, the less complex plantation crop combinations were acceptable because they just elaborate already existing practices. Integrating pastures and animals into the coconut plantations was positively received although labor could be a constraint if the system is to be well managed.

The *kaingineros* were positive about the improved fallows. But intensive work will be needed in order to change these fallows into well managed alley cropping systems. The most negatively received technology is the mixture of alley cropping with a tree garden, due to cultural reasons - the tree garden is seen as 'forest like'.

Land suitability classification

As expected, the multilayer tree garden obtained the highest suitability rating because it provides best protection on the steeper slopes. This same suitability rating was given to the biologically improved fallow for the heavily degraded areas. Medium suitability was awarded to the more complex plantation crop combinations with limiting factors being slope and erosion hazard. Alley cropping is also awarded medium suitability. Here, the limiting factors are management requirements and erosion hazard. Lastly, plantation crops intercropped with agricultural crops is awarded low suitability with slope erosion hazard and management requirements as the combined limiting factors. However, when these physical suitabilities are matched with social (i.e. adoptability) factors, the results changed dramatically.

This has resulted in the multilayer tree garden becoming unsuitable due to its low adoptability. Table 2 shows the overall final suitabilities according to land unit.

Suitability of the proposals varies from land unit to land unit. This variation is caused mainly by the dominant slope angle and its consequent erosion hazard. Thus for example, plantation crops intercropped with agricultural crops (no. 3) obtained S2 for slopes between 25-35% but was awarded S1 where slopes are between 18-25%. The assumption is that management will be sufficient. For the land unit orthic Acrisol, only alley cropping in combination with tree gardens is suitable but here, more or less natural forest growth is the deciding factor.

CONCLUSIONS

The first most important conclusion is that, for *Kaingin* farmers to adopt new ecologically sound land-use alternatives, they need to be guaranteed in form of land ownership or stewardship. Without this, they will not be willing to make the required long term investments (especially labor) and consequently the innovations will most likely fail. If and when the problem of land/crop security will be solved, the farmers stated willingness to adopt new, ecologically more sound land-use alternatives. However, intensive extension work will be needed for the technologies to be established successfully especially in the first few years.

For the coconut-based farmers, the proposals will only be attractive if the financial re-

Table 2. Suitability classification according to land unit.

Land Unit	Proposed Technology								
	1	2	3	4	5	6	7	8	9
orthic lixisol	S3	S1	S2	NS	NS	NS	S1	S1	S1
dystric Nitisol	S2	S1	S1	NS	S2	NS	S1	NS	NS
orthic Acrisol	NS	NS	NS	NS	NS	NS	S2	NS	NS

Definitions: S1 = highly suitable S2 = suitable; S3 = moderately suitable; NS = not suitable turns can justify the allocation of extra labor to the new technologies. If competition with other farming and economic activities is too great, then the new technologies will not be readily accepted. Thus, for the proposals to be interesting for this group of farmers, the labor to return ratio must exceed that of the off-farm activities. For these farmers, the less complex plantation crop combinations seem the better choice since they are just elaboration of already existing practices, and will thus not require much extra labor input.

Adoption of the technologies can be said to be the overall limiting factor in their suitability for the research area.

The main conclusion here is that, regardless of how ecologically or environmentally sound the design, and what are the expected economic benefits, the final success stands or falls with the intended users perception of the design. Thus, as has been seen, the multilayer treegarden is deemed unsuitable in social terms even though its ecological and economic benefits are the highest in the long run. Finally, it is the less complex, more understandable technologies which are most acceptable: improved fallows, alley cropping, the plantation crops intercropped with agricultural crops and the mixture of plantation crops.

DISCUSSION

At first, the use of formal interviews, using a large number of individuals was thought so as to obtain a statistically relevant view of farmers attitudes towards the proposed technologies. However, it quickly became apparent that this quantitative approach would not reveal 'real' attitudes towards adoption of new technologies. As can be expected, the results of this evaluation are fairly general in nature. However, this is justifiable by the limitless number of possibilities in arranging an agroforestry system. Trying to analyze this immense number of variables would be an impossible task (Clarke, 1991). Furthermore, due to the overall lack of technical information on agroforestry, it proved difficult to analyze the technologies using hard data. The initial choice

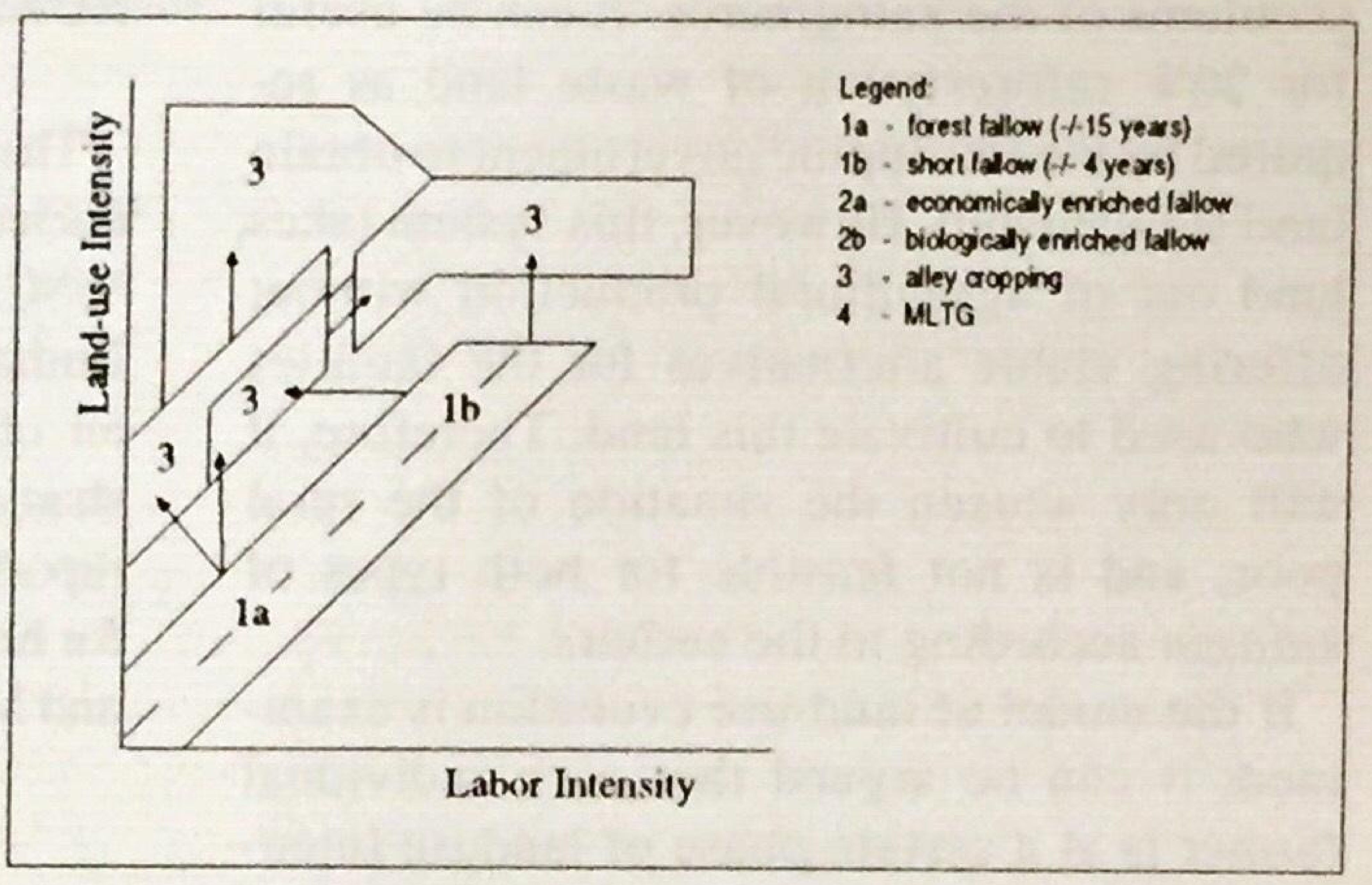

Figure 1. Possible pathways open for *Kaingin* farmers (based on Raintree and Warner, 1986)

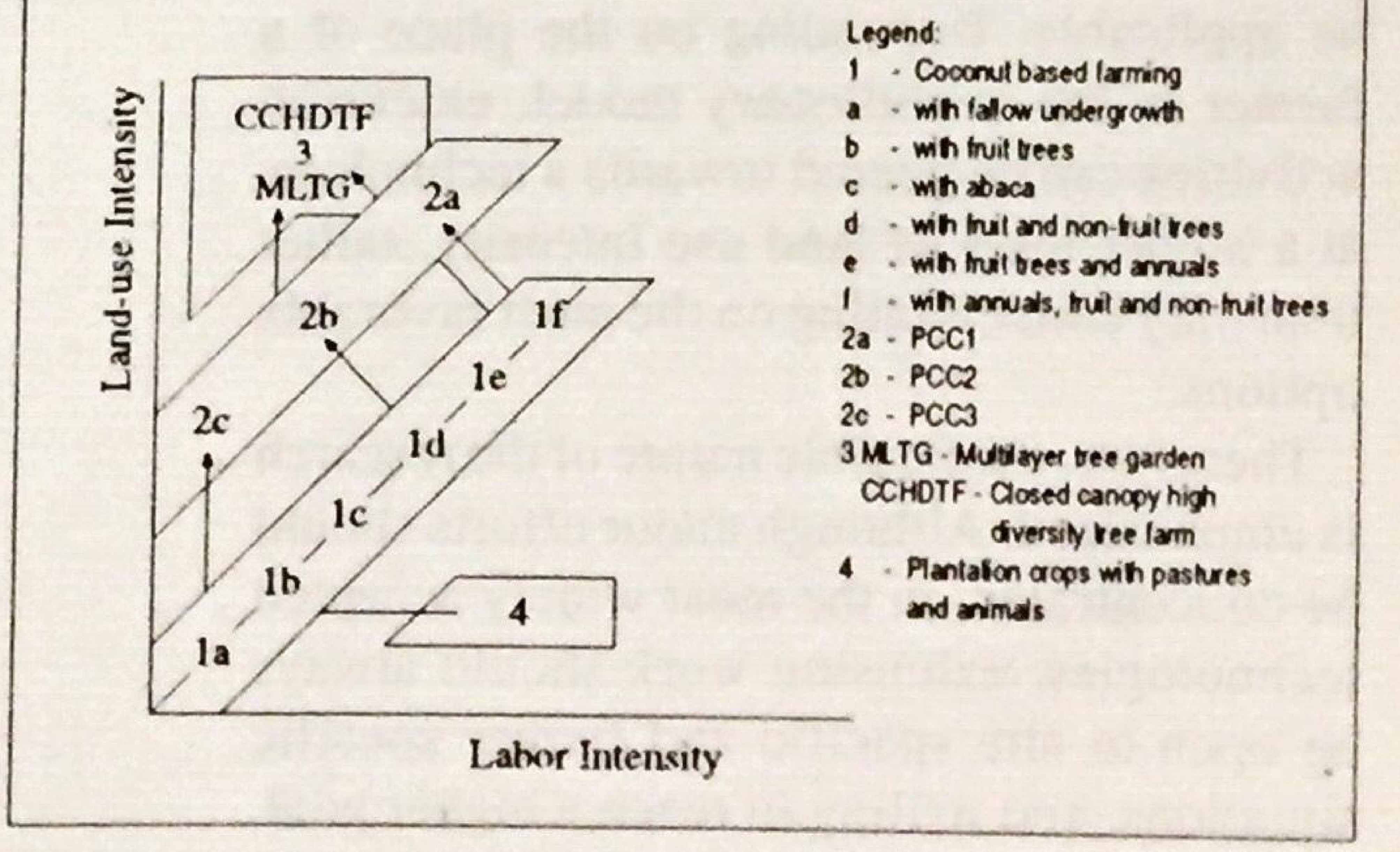

Figure 2. Possible pathways open for coconut-based farmers (based on Raintree and Warner, 1986).

for agroforestry technologies was based on Raintree and Warner's (1986) theory of the evolution of land use due to population pressure adapted to Nair's (1985) classification of agroforestry. The choices were further based on the present land utilization types as found by Dekker and Parma, (1992) (Figs. 1 and 2). For the coconut-based farmers, six major forms of intercropping with coconut were identified. This inventory is lacking for the *kaingin* but forms of relay cropping and intercropping were seen as well as the use of trees on crop land. Taungya is a short term solution to the problems of the kaingineros. It can be useful for 20% reforestation of waste land as required by the Philippine government to obtain land stewardship. However, this system takes land out of agricultural production without offering viable alternatives for the families who used to cultivate this land. Therefore, it will only worsen the situation of the rural poor, and is not feasible for both types of *kaingin* according to the authors.

If the model of land-use evolution is examined, it can be argued that each individual farmer is at a certain phase of landuse intensity. With the increasing population pressure in the area, the next obvious step would be for the farmer to increase this intensity. The proposed agroforestry practices can therefore all be applicable. Depending on the place of a farmer in the evolutionary model, extension activities can be geared towards a technology at a higher level of land use intensity, rather than only concentrating on the most favorable options.

Therefore, the flexible nature of the research is emphasized. Although major efforts should be concentrated on the most widely accepted technologies, extension work should always be open to site specific and farmer specific situations, and willing to reach a higher goal.

It is important to note that much more in depth, multidisciplinary research is necessary before implementation should be attempted. This is especially important for aspects concerning economic impacts, legislation (land issues) and ecological aspects (component interaction; effects on soil properties ; etc.). Lastly, it would be very advisable to do continued research and refinement of the technologies in close cooperation with the farmers directly involved. This way, a more farmer participatory oriented approach to development can be achieved, with a higher degree of involvement and success.

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