Topic 1: Forests as safety nets

Traditional forest gardens as "safety net" for rural households in Central Sulawesi, Indonesia

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SUMMARY

Forest gardens have a long tradition in Central Sulawesi, making them an example for an especially successful agroforestry system. Apart from yielding a multitude of timber- and non-timber forest products for use in the household and generating cash income, forest gardens have an important function as a "safety net" for times of hardship, thus contributing to improve rural livelihoods. In this paper, three forest gardens in different villages of Central Sulawesi are compared in a case study, using methods from natural sciences as well as from social sciences. First, the structure, composition and biodiversity of these forest gardens are analysed and compared with those of nearby natural forests. Tall cultivated trees like sugar palm (*Arenga pinnata*), coconut palm (*Cocos nucifera*) and candle nut tree (*Aleurites moluccana*) form the canopy of forest gardens, under which shrubs and herbaceous plants are grown. This structure gives forest gardens a forest-like appearance, and with up to 120 species of useful plants per ha, the biodiversity in forest gardens is much higher than in most other land use systems. Even though the three forest gardens described in this paper differ in many respects, they all have 19 species in common, including important cash crops like coffee (*Coffea canephora*) and cocoa (*Theobroma cacao*) as well as staple crops like cassava (*Manihot esculenta*). In the next chapter, the different development cycles of forest gardens are described, showing that forest gardens that look similar today may well have a very different history. Then, yields and prices of forest garden products are presented and the cash income from forest gardens is calculated. The investigated forest gardens generate between 57 and 77% of their owner's total cash income. Finally, different mechanisms of forest gardens acting as a safety net are described and discussed.

Acknowledgements

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INTRODUCTION

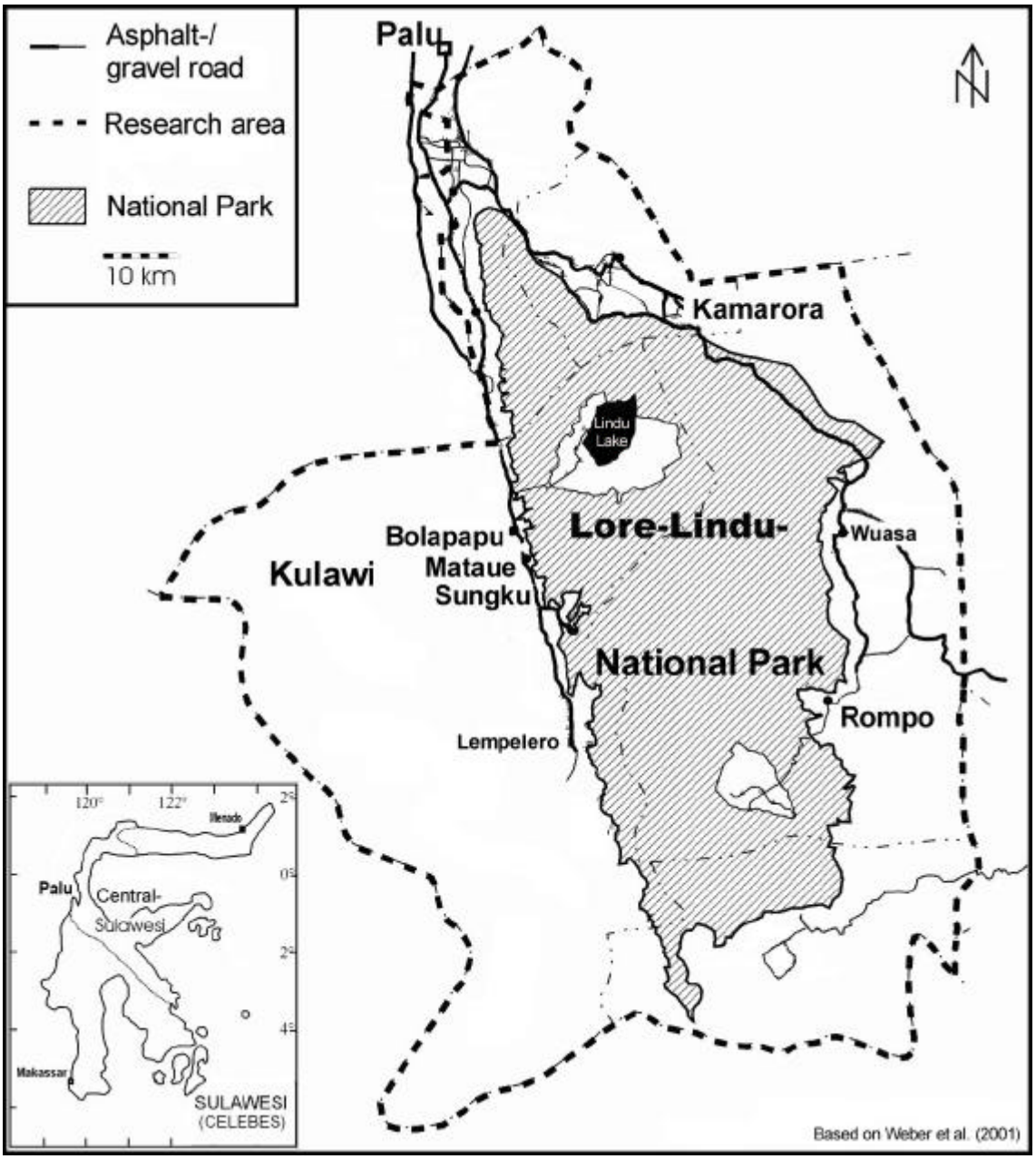
In Indonesia, forests play an important role for the livelihood of rural people. While agriculture is the most important activity, forests provide a wide variety of additional products for cash generation as well as for subsistence use. Timber and rattan are sold for cash income, while firewood, fruits and medicinal plants are used in the household. This source of income becomes especially important when the main crops have failed or additional cash income is needed. In those situations, forests act as a "safety net". The wish to maximise the output of forest products has led people to manage the forests, which in turn has resulted in the establishment of forest gardens in some places. Many different types of forest gardens are known in Indonesia, like the "Dusuns" of Central Maluku (Kaya et al. 2002), the "Tembawangs" of West Kalimantan (Sundawati 1993) or the rattan gardens of Central Kalimantan (Arifin 2003). While the above-mentioned forest gardens are already well researched, little is known about this land use system in Sulawesi. With the aim to close this gap, the authors carried out research in three forest gardens in Central Sulawesi, an old traditional, yet very flexible and apparently sustainable, land use system. The following objectives were formulated for this study:

- Describe the composition and structure of forest gardens
- Identify and compare different types of forest gardens
- Describe the establishment and management of forest gardens
- Record the products from forest gardens and describe their use
- Assess the role and importance of forest gardens for rural livelihoods

MATERIAL AND METHODS

The study was conducted on Sulawesi Island (2° N – 4° S, 119°–125° E), Indonesia, in the province of Central Sulawesi, within the framework of the STORMA project (Stability of Rainforest Margins). The climate in the research area varies considerably from the semi-arid Palu Valley with an average annual rainfall of 747 mm (Whitten et al. 2002) to the humid mountains of Lore Lindu National Park with a precipitation of 2,237 mm in Kulawi (Metzner 1981), only 70 km away from Palu. The mean annual temperature is 27.6° C in Palu and 26.0° C in Kulawi (Gunawan 2003). The research sites are situated in or near the Lore Lindu National Park (218,000 ha). A major part of the National Park lies at an altitude of more than 1,000 m with Gunung Nokilalaki (2,280 m) being the highest mountain. Fig. 1 shows a map of the research area.

Figure 1. Location and overall view of the research area in Central Sulawesi



One objective of the study was to compare different types of forest gardens. After first investigations, three main factors influencing the composition and management of forest gardens could be identified: cultural preferences for certain crops, climate (correlating with altitude) and market access. Considering these parameters, typical forest gardens were selected in three villages around Lore Lindu National Park. For an evaluation of the biodiversity and sustainability of forest gardens, nearby natural forests were selected to serve as a reference. The geographical and socio-economic characteristics of the research villages and research plots are compiled in Table 1.

Table 1. Geographical and socio-economic characteristics of the research villages and research plots

Village	Kulawi	Rompo	Kamarora
Ethnic group	Kulawi Moma	Besoa	Mixed
Geographic position	S 01°27' E 119°59'	S 01°24' E 120°20'	S 01°12' E 120°08'
Altitude of forest garden plot	Approx. 600 m asl	Approx. 1,000 m asl	Approx. 700 m asl
Forest garden established in	1962	1940	1981
Altitude of natural forest plot	Approx. 1,100–1,200 m asl	Approx. 1,000–1,100 m asl	Approx. 1,000 m asl
Market access	Intermediate	Far, difficult access	Close, easy access

The aim of the study was not to give a representative overview of all types of forest gardens in the region, which often include modern variants concentrating on few species of cash crops. The investigations were rather designed as case studies of the few remaining *traditional* forest gardens. To that end, traditionally managed forest gardens were ascertained through interviews with key informants and surveys in the field. In each village, one forest garden with a size of one hectare and a natural forest plot of the same size were selected. In Rompo, the forest garden of the "kepala desa" (village head), who is also the "ketua lembaga adat" (elder of the council for traditional law) was chosen. His forest garden was established in 1940. In Kulawi, the forest garden of the former kepala desa, who is still a member of the "lembaga adat" (council for traditional law) was selected. This forest garden was established in 1962. With the owners of FG Rompo and FG Kulawi being indigenous and holding important functions in the social and cultural life of the village, they have a profound knowledge of forest garden plants and their uses, the site conditions and the appropriate management. Kamarora, however, is a relatively new village. It emerged from a resettlement in 1978-79 and is ethnically diverse. The forest garden in Kamarora which was selected for this study belongs to an ethnic Kulawinese, who moved here in 1979 and established his forest garden in 1981. Thus, one of the oldest forest gardens in Kamarora was chosen, but it is still much younger than the forest gardens in Rompo and Kulawi.

In the next step, the research plots were permanently marked and then inventorised. In these inventories, the following silvicultural parameters (i.a.) were recorded for all big trees (diameter at breast height = 10 cm):

- tree species (local name and scientific name)
- potential and actual uses of the species
- tree diameter at breast height (1.30 m above the ground) (dbh)
- tree height (h)

Data on smaller trees and seedlings were collected in systematic samples. In the forest garden plots, however, *all* the cultivated and useful plants were counted, measured and identified, regardless of their size. A detailed description of the methodology is given in Brodbeck et al. (2003).

To complete the inventory data from these case studies, socio-economic data on forest gardens were collected on a broader basis during several field stays between 2000 and 2002. The number and duration of field stays is detailed below: Kulawi: 13 stays with a total duration of 79 days; Rompo: 11 stays (98 days); Kamarora: 12 stays (38 days). First of all during these stays, the inventories were carried out, soil samples were taken and herbarium specimen were collected together with the respective forest garden owners and 2 to 3 assistants from the village. These assistants were forest garden owners themselves and could also provide valuable information. First observations of management practices were made during that time and many questions on the history of forest gardens, forest garden products and their use, yields and prices could be discussed in the natural environment on site. Furthermore, the author participated in many activities of forest garden management as well as harvest and processing of forest garden products, which gave additional insights through participatory observation. Only after that phase of socialization in the village and improving skills in Bahasa Indonesia, the author carried out semi-structured interviews with several forest garden owners and other key informants in each village. Much information was also gathered through personal observations and many informal conversations and discussions with memory protocol during the extended field stays. Basic socio-economic data on household and village level were collected by other sub-projects within the STORMA project but are mostly unpublished yet.

RESULTS FROM INVESTIGATIONS WITH METHODS FROM NATURAL SCIENCES

Silvicultural parameters of natural forests and forest gardens

The focus in this paper is on socio-economic aspects, so silvicultural aspects will only be discussed inasmuch as relevant in that context. For a detailed silvicultural analysis of forest gardens in Central Sulawesi, see Brodbeck et al. (2003).

Table 2 shows a comparison of silvicultural parameters of natural forests and forest gardens. The stand basal area (sum of the cross sections of all the trees at 1.3 m height), which takes into account the number *and* the diameter of the trees, is a good measure for the density of a stand. In the natural forest plots, the stand basal area varies only slightly, between 31.6 and 33.1 m²/ha. In forest garden Kulawi, the basal area (29.4 m²/ha) is almost as high as in the natural forest, which gives that forest garden a forest-like appearance. The high basal area in FG Kulawi is achieved with a relatively small number of trees (only 265 in FG Kulawi compared to 471 to 819 in the NF plots), meaning that the average diameter of the trees in FG Kulawi must be much higher than in the natural forest. The respective values in Rompo (21.6 m²/ha) and Kamarora (17.8 m²/ha) are much lower, indicating a less dense tree cover. The low basal area in FG Kamarora, together with the small number of trees (N=110), show that this agroforestry system does not have the forest-like structure which is typical for traditional forest gardens. Actually, the stand in Kamarora is a temporary

forest garden, being converted into a coffee- and cocoa plantation. This conversion process is impressively illustrated by the high basal area of dead trees in Kamarora (3.0 m²/ha): to satisfy the light demand of the cash crops, the canopy has to be gradually opened, trees are ring-barked and slowly die. The other extreme, a very low basal area of dead trees, can be observed in FG Rompo (0.2 m²/ha). Here, virtually all the dead trees are used as firewood; hardly any woody litter is left behind in the stand.

Table 2. Silvicultural parameters of natural forests and forest gardens in Central Sulawesi

Parameter	Natural Forest Kulawi	Natural Forest Rompo	Natural Forest Kamarora	Forest Garden Kulawi	Forest Garden Rompo	Forest Garden Kamarora
Stand basal area (G) [m²/ha]	33.1	31.6	32.1	29.4	21.6	17.8
Basal area dead trees [m²/ha]	2.6	1.2	1.6	1.6	0.2	3.0
Number of trees/ha (dbh µ 10 cm)	819	471	535	265	297	110
Tree species/ha (dbh µ 10 cm)	81	89	92	40	32	38
Useful plants/ha[a] (number of species)	-	-	-	120	58	82

[a] Cultivated and wild plants (including tree species) which are use

The number of tree species (dbh µ 10 cm) varies from 81 to 92 species per ha in the natural forest plots, compared to only 32 to 40 species per ha in the forest gardens. The higher tree species diversity in the natural forest plots is due to the fact that aside from useful trees, the natural forest contains many tree species that have no direct use for the local people. In the course of establishing a forest garden, those "inferior" trees are removed and replaced with useful species like fruit or timber trees. This practice results in a high diversity of useful plants in forest gardens, which can reach up to 120 species per ha. The most common tree species in forest gardens, ranked according to their Importance Value after Curtis and McIntosh (1951) are shown in Table 3.

Table 3. The most common tree species in three forest gardens (FG) of Central Sulawesi by their Importance Value (IV)

Rank	Species	Dominance [m²/ha]	Abundance [N/ha]	Frequency [%]	IV
I. FG Kulawi					
1	*Ficus* sp.	14.74	5	5	55.0
2	*Theobroma cacao*	0.89	78	23	45.8
3	*Arenga pinnata*	3.39	27	20	33.3
4	*Cocos nucifera*	1.47	19	15	20.8
5	*Aleurites moluccana*	1.42	13	11	16.1
6-40	Other species	7.46	123	99	129.0
1-40	Total	29.37	265	173	300.0

II. FG Rompo					
1	*Erythrina subumbrans*	11.29	50	36	89.2
2	*Coffea canephora*	1.56	84	25	49.5
3	*Eucalyptus deglupta*	1.20	12	10	15.2
4	*Acalypha caturus*	0.54	15	12	14.3
5	*Erythrina fusca*	0.38	18	9	12.9
6-32	Other species	6.64	118	87	118.9
1-32	Total	21.61	297	179	300.0
III. FG Kamarora					
1	*Erythrina subumbrans*	1.35	15	12	33.1
2	*Magnolia* sp.	2.26	4	4	20.3
3	*Phoebe tenuifolia*	1.33	5	5	17.0
4	*Ficus* sp.	2.13	2	2	15.7
5	*Palaquium obovatum*	1.31	3	3	13.1
6-38	Other species	9.45	81	75	200.8
1-38	Total	17.83	110	101	300.0

Source : Brodbeck et al. 2003

In FG Kulawi, the five most common tree species are cultivated or useful trees: *Ficus* sp. is important in traditional beliefs and for the production of bark-cloth; cocoa (*Theobroma cacao*), sugar palm (*Arenga pinnata*), coconut palm (*Cocos nucifera*) and candlenut tree (*Aleurites moluccana*) yield valuable crops for sale as well as for use in the household. In FG Rompo, the most common trees include two species of *Erythrina*, an important multi-purpose tree in agroforestry; coffee (*Coffea canephora*) as a cash crop; an indigenous species of *Eucalyptus* which is highly appreciated for its valuable timber and *Acalypha caturus*, a tree from the natural vegetation of which the young leaves are consumed as a vegetable and often serve as an "emergency food". The most common trees in FG Kamarora are, with the exception of *Erythrina*, left over from the natural forest. Apart from temporarily providing shade and cover for the cash crops, these trees have no particular use themselves.

Similarity of forest gardens

Table 3 shows that all forest gardens have some tree species in common (*Erythrina subumbrans* in FG Rompo and Kamarora; *Ficus* sp. in FG Kulawi and Kamarora) even though only the five most common tree species of each forest garden are considered in this overview. A detailed comparison of the species composition in forest gardens, considering all the useful species (including shrubs and herbaceous plants) as shown in Table 4, can be regarded as an indicator for the similarity of forest gardens.

Table 4. Similarity of species composition in forest gardens of Central Sulawesi

	FG Kulawi	FG Rompo	FG Kamarora
	[N]	[N]	[N]
Useful species (total)	120	58	82
Species in common with FG Kulawi	-	9	23
Species in common with FG Rompo	9	-	7
Species in common with FG Kamarora	23	7	-
Species occurring in all 3 forest gardens	19	19	19
Unique species	69	23	33

A total of 19 species occur commonly in all three forest gardens. These species include cash crops like coffee (*Coffea canephora*) and cocoa (*Theobroma cacao*); staple crops like cassava (*Manihot esculenta*), taro (*Colocasia esculenta*) and sweet potato (*Ipomoea batatas*) as well as tall trees like sugar palm (*Arenga pinnata*), candle nut tree (*Aleurites moluccana*) or coconut palm (*Cocos nucifera*). FG Rompo and FG Kamarora both have approximately 60% of their species in common with one or both of the other forest gardens, while approximately 40% of the species in each of these two FGs are only found there. In FG Kulawi, where the total number of useful species is very high (N = 120), the proportion of plant species unique to this forest garden is also higher (58%), as could be expected. The plants occurring in only one of the forest gardens include cinnamon (*Cinnamomum verum*) and ginger (*Zingiber officinale*) in FG Kulawi; jackfruit (*Artocarpus heterophyllus*) and *Solanum violaceum* (a vegetable) in FG Rompo; as well as avocado (*Persea americana*) and two *Brassica* species in FG Kamarora. From this analysis, it can be concluded that the main plants producing cash crops and staple food are the same in all three forest gardens, while the difference in the species composition is mainly due to individual preferences of the forest garden owners for certain vegetables or spices. Other dissimilarities can be explained by different climatic conditions in the forest gardens: while plants like durian (*Durio zibethinus*) and langsat (*Lansium domesticum*) grow well in the hot lowland climate of FG Kulawi and Kamarora (altitudes 600-700 m asl.), these species can not be found in the montane climate of FG Rompo (1,000 m asl.), where typical highland species like *Coffea liberica* and *Coffea arabica* are more dominant.

Annual and perennial plants in forest gardens

Another typical feature of forest gardens is the high proportion of perennial plants like fruit trees that yield regularly over a long period without needing much care. This is particularly important, because in normal times, farmers concentrate their labour on the cash crops from forest gardens and the cultivation of rice, while the by-products from forest gardens don't receive much attention. In times of hardship, however, forest gardens are used as an alternative source of food. Perennials like *Manihot esculenta*, which can be found in all three forest gardens, taro (*Colocasia esculenta*) and sweet potato (*Ipomoea batatas*) are especially well suited for that task. The total number of perennial plant species in forest gardens is shown in Table 5.

Table 5. Useful plant species [N] in forest gardens (FG) and home gardens (HG) of Central Sulawesi according to their durability

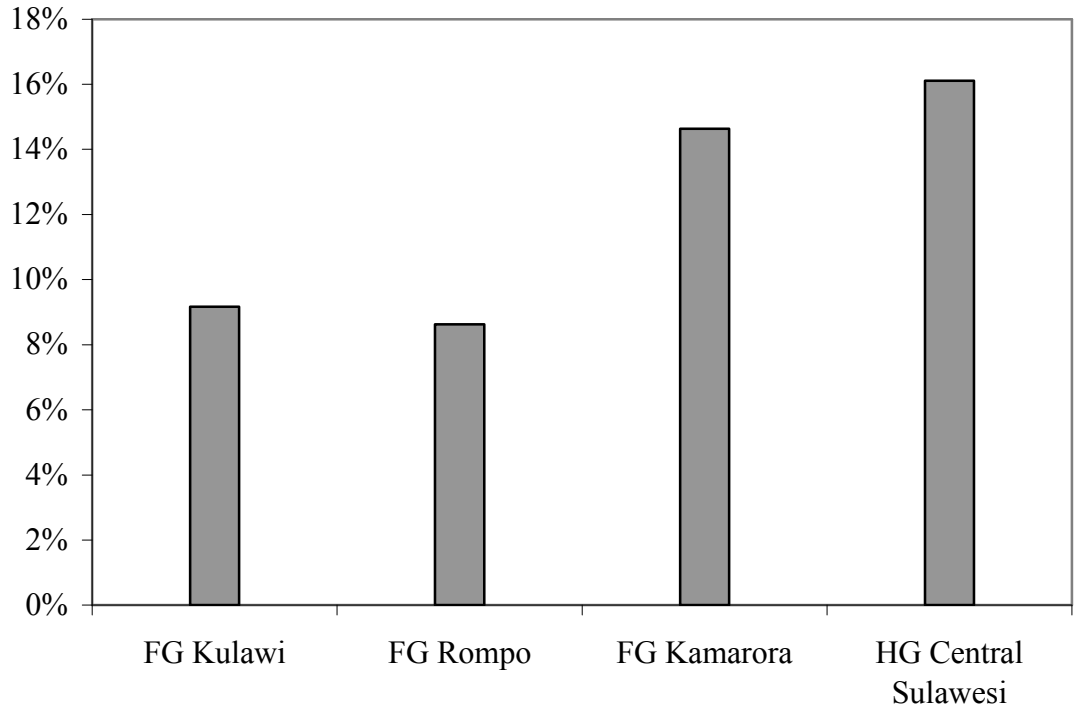
	FG Kulawi [a]	FG Rompo [a]	FG Kamarora [a]	HG Central Sulawesi [b]
Annuals and biennials	11	5	12	24
Perennials	109	53	70	125
Total	120	58	82	149

[a] Number of useful plant species in one forest garden of 1 ha

[b] Number of useful plant species in 30 home gardens of 3 villages in the Lore Utara subdistrict with a total area of 2.47 ha (according to KEHLENBECK 2002)

In all three forest gardens, perennial plant species by far outnumber annual and biennial plants. While the latter provide less than 10% of all species in FGs Kulawi and Rompo, this proportion is considerably higher in FG Kamarora with 14.6%, a value similar to the 16.1% found by Kehlenbeck (2002) in home gardens of Central Sulawesi (cf. Fig. 2). The relatively high proportion of annual and biennial plant species in FG Kamarora, together with the low basal area and the small number of trees per ha (cf. Table 2) indicate the garden-like character of this particular forest garden, compared to the forest-like character of FGs Rompo and Kulawi with higher basal areas, higher numbers of trees and higher proportions of perennial plants.

Figure 2. Annual and biennial plants as a percent of all useful plant species in forest gardens (FG) and home gardens (HG) of Central Sulawesi (data from home gardens according to KEHLENBECK 2002)



RESULTS FROM INVESTIGATIONS WITH METHODS FROM SOCIAL SCIENCES

Use of forest garden plants

After having discussed the species composition of forest gardens under ecological and silvicultural aspects, the focus will now be on the socio-economic importance of this land use system. The wide variety of uses of forest garden plants is impressively shown in Table 6, classifying the cultivated and used plant species after their primary use.

Table 6. Useful plants in forest gardens of Central Sulawesi and their primary uses

	Useful plant species [N]		
Primary Use	**FG Kulawi**	**FG Rompo**	**FG Kamarora**
Shade and cover plants	20	18	31
Edible fruits and nuts	24	5	8
Vegetables	12	10	13
Medicinal and poisonous plants	19	1	2
Stimulants	8	5	6
Spices	10	4	3
Staple food	5	2	2
Soil improvement	3	3	2
Household items	3	2	2
Vegetable oils and fats	2	3	2
Construction timber	0	3	2
Ornamental plants	3	0	1
Construction material (non-timber)	2	0	2
Forage	2	1	1
Crafts, handicrafts	1	1	1
Ritual use	2	0	0
Fibres	2	0	0
Sugar	1	0	1
Essential oils	1	0	1
Furniture and interior decoration	0	0	2
Total	**120**	**58**	**82**

A total of 20 classes have been defined for primary uses of forest garden plants. However, only the uses known and actually practised in the respective village were considered for this classification. A medicinal plant growing in a forest garden was not counted when the owner did not know about its use. On the other hand, all the plants which were named as used for medicinal purposes were taken into account in this study, regardless of whether their pharmaceutical effects are proven or not. Besides the above-mentioned primary uses, most species have one or several

secondary uses, further increasing the wide variety of functions served by forest gardens.

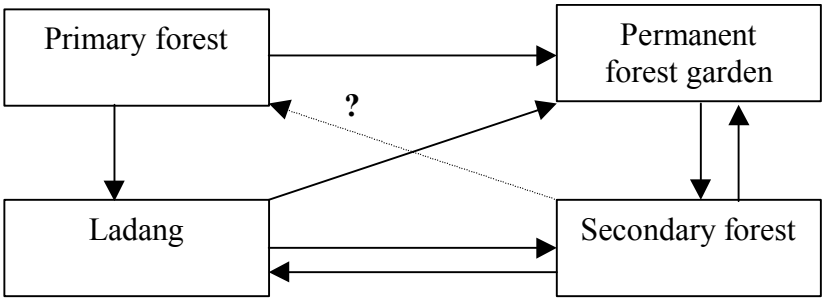
Most numerous are shade and cover plant species, followed by plants bearing edible fruits and nuts. With 10-13 species, all forest gardens harbour a similarly high number of vegetables. The cultivation of medicinal plants in forest gardens is most developed in the traditional society of Kulawi (19 species). In the relatively young resettlement of Kamarora, farmers lack the knowledge on indigenous medicinal plants. Only two species from that group were recorded in FG Kamarora. On the other hand, people in Kamarora have good access to industrially manufactured medicaments. Rompo takes an intermediate position. With Rompo being the most remote of the three villages in this study, and having very difficult access to medical care, it seems surprising that only one species of medicinal plants is cultivated in forest gardens. However, many vegetables, spices or fruit were named to be also used for medicinal purposes. Other medicinal plants in Rompo are collected in the natural forest.

The high number of species which only act as shade and cover plants in FG Kamarora (31 species) is somewhat untypical for forest gardens, where cover trees mostly have other primary uses. In FG Kamarora, however, the few cover trees are mostly maintained from the natural forest, while in the other two forest gardens, many of the cover trees are planted useful species.

Development cycle of forest gardens

Even though most forest gardens in the research area look similar at first glance, their origin and history differ considerably. The development cycle of forest gardens in the three research villages is schematically shown in Figs. 3-5.

Figure 3. Development cycle of forest gardens in Rompo



The most common and most simple model is shown in Fig. 3, the development cycle of forest gardens in Rompo. It comprises various possibilities:

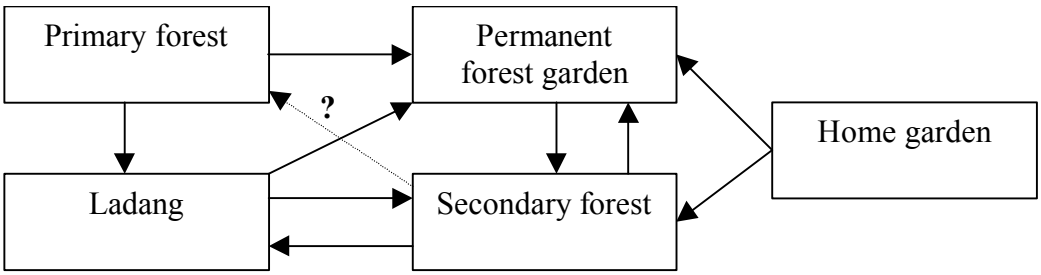
a. Primary forest is directly converted into a permanent forest garden.
b. Primary forest is first converted into agricultural land ("Ladang"). When the yields start to decrease, these Ladangs are left fallow and a secondary forest establishes itself. This secondary forest can either be used as a cover during the fallow period, before being turned into agricultural land again, or it can be

converted into a permanent forest garden after some years. If further left undisturbed, these secondary forests could theoretically recover to become primary forests again.

c. In some cases, perennial cultivated plants like coffee (*Coffea canephora, C. arabica*) cocoa (*Theobroma cacao*) or fruit trees are planted directly after clearing the forest. For some years, annual crops like rice (*Oryza sativa*) or maize (*Zea mays)* are intercropped. By the time yields of rice or maize decrease, the above-mentioned perennial crops are established and return their first yields. These enriched fallows can be easily further developed into permanent forest gardens.

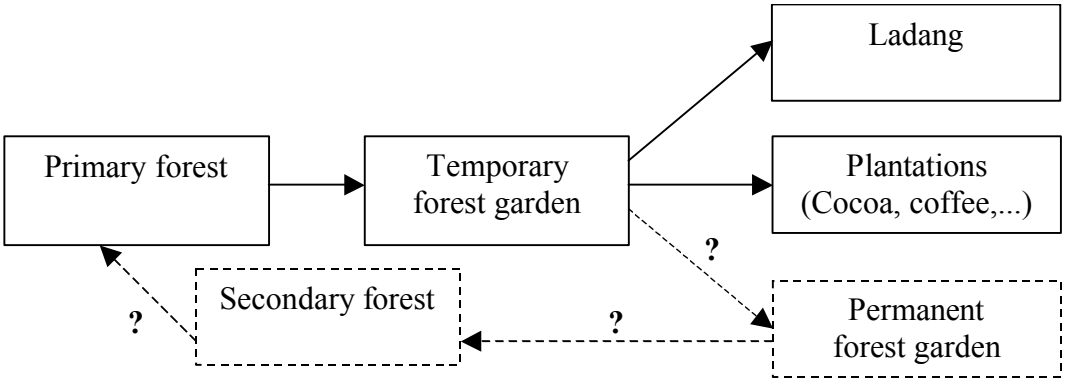
d. If forest gardens are left untended for several years, cultivated plants gradually disappear and are replaced by forest tree species in the course of natural succession. The resulting secondary forest can be converted into a forest garden again, temporarily be cleared for Ladang, or, when natural succession is further allowed, develop into primary forest.

Figure 4. Development cycle of forest gardens in Kulawi



The development of forest gardens in Kulawi (Fig. 4) follows basically the same scheme as described for Rompo, with one additional variant: when families or whole villages move to other places, old home gardens are abandoned. These home gardens, which usually contain a wide variety of cultivated plants, including trees, can develop into secondary forests if they are completely abandoned. In some cases, former home gardens are still tended, though to a lesser extent. Through natural succession and active planting of perennial cultivated plants, these extensively managed former home gardens can develop into permanent forest gardens.

Figure 5. Development cycle of forest gardens in Kamarora



In Kamarora, forest gardens have a more temporary character (Fig. 5). In one variant, cash crops like cocoa (*Theobroma cacao*) and/or coffee (*Coffea canephora, C. arabica*) are planted under the cover of the primary forest. The canopy, however, is increasingly opened to satisfy the growing light demand of the crops. For a limited time, annual plants can be intercropped. In the high canopy layer, trees from the natural vegetation are gradually replaced by nitrogen fixing leguminous tree species like *Erythrina* spp.. The final result of this process is a cash crop plantation. The transition phase, the stage of temporary forest garden, can be as long as 20 years. If however, the forest is to be converted into Ladang for rice or maize cultivation, the process is much faster. With that variant, the stage of temporary forest gardens with the cultivation of annual crops under a tree cover may only last one or two years. With Kamarora being a relatively young resettlement, most farmers here don't have a tradition of managing permanent forest gardens. The settlers from other parts of Sulawesi often also lack the knowledge of the local flora and indigenous useful plants. This fact, together with the proximity to the provincial capital Palu and the good market access, leads to the widespread transformation of temporary forest gardens into cash crop plantations.

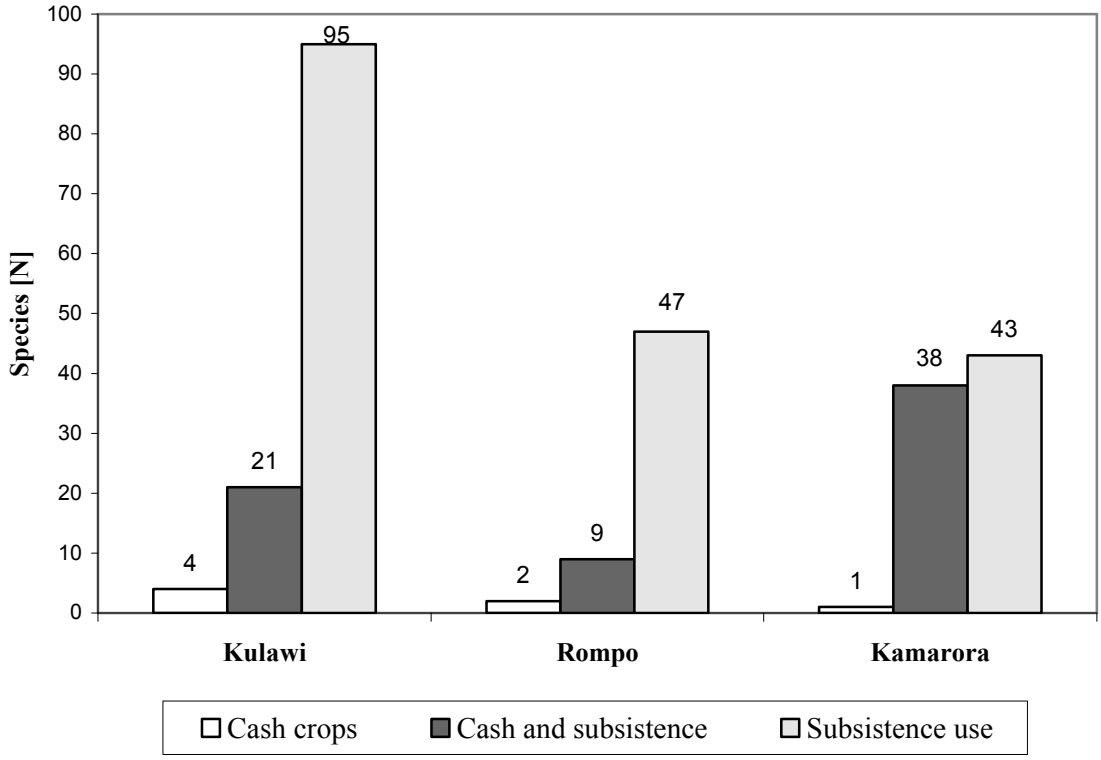
Socio-economic importance of forest gardens

Cash crop production and subsistence farming

Products from forest gardens with their manifold uses are partly sold for cash income and partly consumed in the household. The importance of these two functions, however, varies greatly between the three forest gardens described in this study. The numbers of species which are exclusively used for sale, solely used in the household or fulfil both functions at the same time are shown in Fig. 6. In all three forest gardens, most species are solely used in the household, and the number of *pure* cash crops is very low. These are cocoa (*Theobroma cacao*) in FG Kamarora; cocoa and vanilla (*Vanilla planifolia*) in FG Rompo, and additionally clove (*Syzygium aromaticum*) and candle nut (*Aleurites moluccana*) in FG Kulawi. These *pure* cash crops produce two thirds of cash income in FG Kulawi (cf. Table 7). In FG Rompo and Kamarora however, coffee (*Coffea canephora, C. arabica*), a product from the category "cash *and* subsistence", has the highest share of cash income. With a long tradition of coffee-cultivation, coffee is a very popular drink in the research villages, and part of the coffee yield is used in the household with the rest being sold.

The low number of species in the category "cash *and* subsistence" in Rompo (N = 9) can be explained by socio-economic and cultural factors: the access to external markets is difficult due to the weak traffic infrastructure. An internal market for agricultural products is virtually non-existent in Rompo because the purchasing power of the inhabitants is low and most of the villagers are self-sufficient farmers anyway. Due to strong social and family ties in Rompo, harvest surpluses are usually given away to relatives or neighbours rather than being sold, a fact also observed by Kehlenbeck (2002) for products from home gardens in the same village. With this mechanism, however, the forest gardens of Rompo have an important socio-economic function not only for their owners, but for the whole village.

Figure 6. Useful plant species in forest gardens according to their function for income generation



Role of forest gardens for income generation

In the course of the investigation, yields and prices of forest garden products were assessed. From these data, the annual cash income of the three forest garden owners in this case study was calculated. The results are presented in Tables 7-9.

Table 7. Cash income of the owner of FG Kulawi in 2001

	sold production per year[1]	price per unit [IDR][2]	cash income [IDR][2]
I. Regular cash income from the investigated forest garden(1 ha)			
Cocoa	310 kg	10,000 per kg	3,100,000
Candle nut	820 kg	1,500 per kg	1,230,000
Clove	32 kg	35,000 per kg	1,120,000
Palm wine (“Saguer”)	1,440 liter	750 per liter	1,080,000
Durian	300 pieces	2,500 per piece	750,000
Langsat	630 liter	1,000 per liter	630,000
Pineapple	200 pieces	1,250 per piece	250,000
Coconut	120 pieces	1,000 per piece	120,000
Vanilla	1.5 kg	70,000 per kg	105,000
Subtotal (forest garden)			8,385,000

II. Cash income from other sources			
Coffee (1 ha of old FG, extensively managed)	500 kg	4,000 per kg	2,000,000
Handicraft (brooms)	100 pieces	5,000 per piece	500,000
Subtotal (other sources)			2,500,000
Total (FG and other sources)			10,885,000
Cash income from investigated FG in % of total cash income			77%

[1] For some products, the total yield is higher, but part of the yield is consumed in the household

[2] IDR = Indonesian Rupiah

With nine different products generating regular cash income, the investigated forest garden in Kulawi shows the highest degree of diversification. The total cash income generated from this forest garden is much higher than in FG Rompo and FG Kamarora. Altogether, FG Kulawi provides 77% of the total cash income of its owner, a proportion which is much higher than in FGs Rompo (57%) and Kamarora (61%).

The wide variety of regularly sold products in FG Kulawi gives its owner a high stability of income, equally distributed over the year and less influenced by the fluctuation of prices for individual crops.

Table 8. Cash income of the owner of FG Rompo in 2001

	sold production per year[1]	price per unit [IDR][2]	cash income [IDR][2]
I. Regular cash income from the investigated forest garden(1 ha)			
Coffee	1,000 kg	4,000 per kg	4,000,000
Cocoa	88 kg	9,500 per kg	836,000
Vanilla	12 kg	60,000 per kg	720,000
Candle nut	480 kg	1,000 per kg	480,000
Chilli pepper	20 kg	3,000 per kg	60,000
Subtotal (forest garden)			6,096,000
II. Cash income from other sources			
Coffee (2 ha of old FG, extensively managed)	1,000 kg	4,000 per kg	4,000,000
Maize (plot of 0.5 ha)	1,000 kg	700 per kg	700,000
Subtotal (other sources)			4,700,000
Total (FG and other sources)			10,796,000
Cash income from investigated FG in % of total cash income			57%

[1] For some products, the total yield is higher, but part of the yield is consumed in the household

[2] IDR = Indonesian Rupiah

In FG Rompo, a total of five different products which are regularly sold generate 57% of its owner's total cash income. The lower degree of diversification of income sources in FG Rompo compared to FG Kulawi (9 products) is partly due to climatic conditions: durian (*Durio zibethinus*) and langsat (*Lansium domesticum*) are

successfully cultivated in FG Kulawi (altitude 600 m asl.), but are not found in the montane climate of FG Rompo (1,000 m asl.). Compared with FG Kulawi, the regular cash income from FG Rompo is lower, forcing the owner of FG Rompo to cultivate additional plots. With these other sources, however, the total annual income of the owner of FG Rompo reaches the same level as that of his counterpart in Kulawi.

Table 9. Cash income of the owner of FG Kamarora **in 2001**

	Sold production per year[1]	Price per unit [IDR][2]	Cash income [IDR][2]
I. Regular cash income from the investigated forest garden (1 ha)			
Coffee	1,000 kg	4,250 per kg	4,250,000
Palm wine ("Saguer")	480 liter	750 per liter	360,000
Cocoa	20 kg	10,250 per kg	205,000
Subtotal (forest garden)			4,815,000
II. Cash income from other sources			
Cocoa (0.8 ha of young plantation)	200 kg	10,250 per kg	2,050,000
Labour	100 days	10,000 per day	1,000,000
Subtotal (other sources)			3,050,000
Total (FG and other sources)			7,865,000
Cash income from investigated FG in % of total cash income			61%

[1] For some products, the total yield is higher, but part of the yield is consumed in the household

[2] IDR = Indonesian Rupiah

In FG Kamarora, the good market access led to a loss of diversification. Only three products from the investigated forest garden are regularly sold to provide cash income. Altitude and climatic conditions in Kamarora are similar to those in Kulawi and can not explain the absence of certain crop species, as was the case in FG Rompo. Some products secure higher prices in Kamarora than in the other two research villages (cocoa 10,250 IDR/kg in Kamarora vs. 10,000 IDR/kg in Kulawi and 9,500 IDR/kg in Rompo; coffee 4,250 IDR/kg in Kamarora vs. 4,000 IDR/kg in Kulawi and Rompo). Nevertheless, the total cash income generated in FG Kamarora is the lowest of the three investigated forest gardens. Fruit trees, which generate additional income in FG Kulawi (durian, langsat) and FG Rompo (candle nut) are lacking in FG Kamarora, a fact that is also reflected in the low basal area of that forest garden (cf. Table 2). Thus, the potential of FG Kamarora is not fully exploited. The owner of FG Kamarora, who is currently depending on labour for additional income, tries to improve his situation by planting additional cocoa trees in his forest garden. In the inventory, a total of 452 recently planted cocoa trees were counted, meaning that this forest garden will develop into a cocoa plantation in the near future.

Role of forest gardens as a safety net

The management of forest gardens is closely linked to certain stages of life: in Rompo, young men are given a piece of land to establish a forest garden after their marriage. In all of the surveyed villages, banana is commonly planted in forest

gardens after marriage of the FG owners: the fruits of the banana plants are considered to be an ideal food for the expected babies. The owner of FG Kamarora reported to have planted his coffee trees in two waves: after he married for the first and second time. The coffee trees were supposed to provide him with income to support the expected children from his marriages.

The different mechanisms of forest gardens acting as a safety net are detailed below:

Emergency food

As for most people in Indonesia, rice is the main staple in the research villages. It is mostly cultivated as wet rice (*padi sawah*), only few households have plots with upland rice (*padi ladang*). Other staple crops like cassava (*Manihot esculenta*), taro (*Colocasia esculenta*) and sweet potato (*Ipomoea batatas*) are grown in forest gardens but rarely used for human consumption. These crops, which are considered to be a "poor man's food", are usually used as fodder for domestic pigs. In times of hardship, however, for example when rice harvest fails or when stocks of rice are used up shortly before the next harvest, people use cassava, taro, sweet potato and other crops from their forest gardens as an emergency food. The fact that cassava can stay in the ground for several years without deteriorating makes it an ideal source of emergency sustenance which can be found abundantly in all forest gardens. Throughout this study, it could be observed that part of the yield, especially fruits, is not picked and left to rot in the forest gardens when their owners are busy with their rice fields or cocoa plantations. All forest garden owners, however, stated that they thoroughly collect all fruits in times of hardship.

Source of emergency income

Cash crops from managed forest gardens such as cocoa, vanilla, coffee and clove are a more or less regular source of income. However, many farmers in Rompo and Kulawi have several forest garden plots. Those which are close to the village are well tended and regularly used. The forest garden plots which are further away from the village are less intensively managed and tended, and sometimes only consist of some old coffee trees under a dense forest canopy. Due to the old age of the coffee trees, the dense cover and the poor attention they are given, yields in these forest gardens are quite low. When the workload on the rice fields is high and income is sufficient, many forest garden owners don't bother to go to their remote plots and collect the small yield of coffee. If however other sources of income break away, coffee and timber trees, as detailed below, from these remote forest gardens are used as an emergency source of income.

Source of extra income

The data shown in Tables 7-9 only consider cash income from products that are *regularly* sold. Many other crops in forest gardens, like fruit or vegetables, are mainly produced for subsistence use. If, however, a surplus is produced, the owners occasionally sell these products and have some extra cash income. Another source of extra income is timber trees, like *Magnolia* sp. and *Palaquium obovatum* in FG Kamarora or *Eucalyptus deglupta* and *Duabanga moluccana* in FG Rompo, which are only felled on rare occasions, especially when construction material is needed to build or repair the house of a family member. But these timber trees also have an important

function as a savings bank: their value increases from year to year with increasing diameter and quality, and they can easily be turned into cash when exceptional expenses have to be covered or when "emergency income" is needed, e.g. to buy rice after crop failure. Seedlings from such valuable species are collected in the natural forest to be planted and tended in forest gardens.

Forest gardens are only rarely and irregularly used as sources of emergency- or extra income, making it difficult to estimate the size of these types of income. It was, however, named by all the interviewed forest garden owners as an important function of their forest gardens.

Pharmacy for the poor

Medicinal plants cultivated in forest gardens are particularly important for the poor who can't afford to buy medicaments. While some plants in forest gardens are exclusively grown for medicinal uses, many forest garden plants with other primary uses also play an important role in traditional medicine, ensuring basic medical care in the villages (cf. chapter 5.1 "Use of forest garden plants" and Table 6).

Old age "pension"

All of the interviewed farmers stated that they regard their forest gardens as a provision for their old age. The establishment of a forest garden, with the opening of the forest, felling of big trees, planting of cocoa- and coffee trees is hard work that is preferably done in early stages of life. Once the forest garden is established and the cash crops start to yield, there is relatively little work to be done except for the harvest. Thus, coffee- and cocoa trees in forest gardens can provide a good income over many years, making forest gardens a popular provision for old age in a country where a general governmental pension scheme does not exist.

CONCLUSIONS

While forests play an important role in sustaining and improving rural livelihoods, forest gardens can perform this task even better than an unmanaged natural forest. The natural forest in the research area is regarded as common property and the use of the forest and its products is hardly regulated at village level. Because of the remoteness of the area, state regulations are scarcely translated into action. Due to the lack of land titles, people have no incentive to manage these "public" forests in a sustainable manner. Managed forest gardens, however, are regarded as private property, and the usufruct is guaranteed to the owner by traditional regulations. In forest gardens, customary rights (*adat*) give farmers a high degree of certainty which is necessary for a sustainable management which includes planting, tending and the control of natural processes as an investment in the future. To avoid conflicts between customary right and national law, however, it is necessary to give the farmers legal titles to their plots. One such conflict is about old forest gardens which, after the declaration of the Lore Lindu National Park in 1993, are now inside the National Park. An informal compromise was found in tolerating the existing forest gardens in their present form and size, but not allowing the establishment of new forest gardens in the National Park. Many farmers, however, have difficulties to prove that their forest garden existed before 1993.

With a wide variety of cultivated plants and useful plants from the natural vegetation, forest gardens do not only satisfy many needs of the rural population, they also harbour a rich biodiversity. 32 to 40 tree species were found in one hectare of forest gardens in Central Sulawesi; similar to the 19 to 46 tree species in rattan gardens of Central Kalimantan (Arifin, 2003).

Even though forest gardens are, compared to cocoa plantations or the cultivation of annual crops, a less intensive land use system, they play an important economic role in rural areas. One hectare of a well managed forest garden can yield more than 10 million IDR of cash income per year, which corresponds to up to 77% of the total cash income of it's owner. The value of the numerous other forest garden products which are consumed in the household is difficult to estimate, but surely adds to the socio-economic importance of this land use system.

In *traditionally* managed forest gardens, a high degree of diversification of products leads to a maximization of cash income, which in modern forms of "forest gardens" is achieved by intensification. While income from intensive cultures of a single cash crop, like cocoa, is subject to price fluctuations, traditional forest gardens provide a more stable income.

By generating stable cash income, supplying many products for subsistence use, acting as a source of extra- and emergency income and as an old age pension, traditional forest gardens help to improve rural livelihoods and prevent poverty.

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