Topic 1: Forests as safety nets

The role of dry forests in Madagascar as a safety net in the rural livelihood system

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The role of dry forests in Madagascar as a safety net in the rural livelihood system

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INTRODUCTION

In the livelihood system of the human population living in the vicinity of dry forests in northwest Madagascar, wild-growing forest species of yams (*Dioscorea spp.*) are traditionally used as a supplement and substitute during periods of food shortage. The tradition of food collection is mainly typical for the Sakalava tribe, who originally settled along the Northwestern coast of Madagascar. Nowadays, due to insufficient rice production much more *Dioscorea* is harvested than in former times. Also other tribes have adopted this tradition as well, in order to supplement their diet.

In the two focus areas of the study high rates of forest destruction (3% per year in Mariarano and 7% per year in Tsilakanina) were found. The loss of forest cover is attributed to a multitude of reasons such as timber exploitation, charcoal production, the harvest of *Dioscorea*, animal grazing in the forests and the forest clearance in order to gain arable land for maize and manioc cultivation. Fire as a secondary factor of forest destruction plays a major role here. The occurrence of uncontrolled vegetation fires in the region is very high due to the widespread use of fire-based land use practices (like stimulation of grass growth in pasturelands or for hunting) as well as the inefficiency of local institutions and weak natural resource management regulations. Previously used dry forests are severely threatened by forest fires due to the accumulated dry biomass.

By intentional burning of dry forests the structure of vegetation is changed in order to facilitate certain uses such as cattle grazing or the harvest of *Dioscorea*[2]. However, with the current land use, it is usually hard to determine whether the use of resources is the result of an intended fire or if people simply benefit from changed conditions after non-intended fires. Important is the fact that short-term benefits motivate prescribed burning of dry forests. Therefore, an increased demand for yams may carry the danger that the traditional livelihood strategy of yams collection will contribute to the destruction of dry forests.

CONCEPTUAL FRAMEWORK

In order to structure and analyse the complexity of livelihoods, a special framework was developed (DFID[3], 1999). Within this framework the holistic approach of livelihoods is subdivided into five subsystems: *vulnerability context* (for example seasonality in food production); *livelihood assets* (social, natural, physical, financial and human capital); *transforming structures and processes*; *livelihood strategies* (combination of activities to achieve goals) and *livelihood outcomes*.

In this study, livelihood strategies are examined and analysed with regard to their natural capital. Furthermore, the socio-economic and ecological systems are regarded as subsystems of a socio-ecological system because of their interdependency (DE GRAAF, 1999). The mutual influence of subsystems over a long period leads to a

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[2] *Dioscorea* is a light demanding species, and thus sprouts more frequently when the forest canopy is opened or removed.
[3] Department for International Development

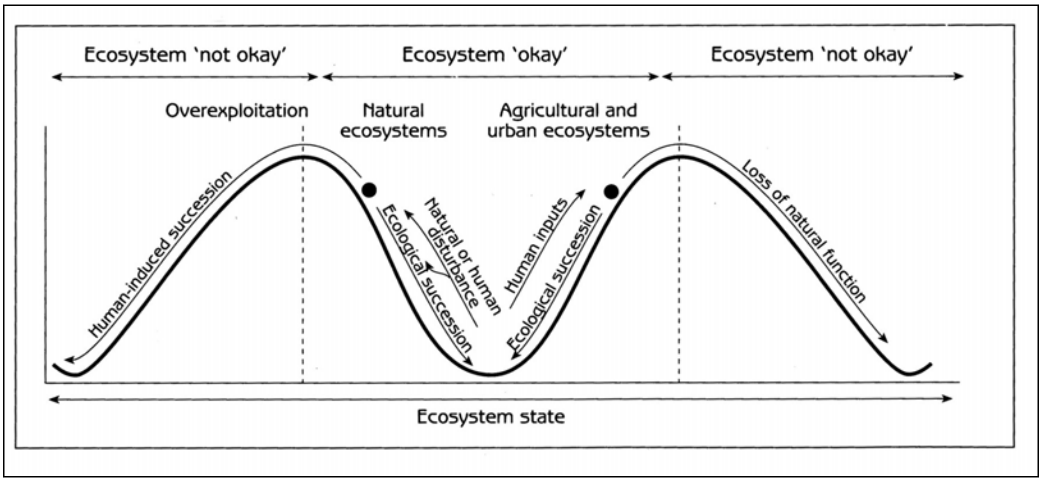
process of co-evolution, during which the system components themselves change (NORGAARD, 1981) or adapt to each other (co-adaptation[4]).

The change of ecosystems is either induced intentionally in order to adapt the ecosystem to the needs of humans (e.g. slash and burn), or unintended processes of re-organisation within the ecosystem will take place as a reaction to human influence (e.g. dry forests' transformation into savannah) MARTEN (2001). Co-evolution can therefore have positive and/or negative (degradation) effects on the ecosystem. The sustainability of a socio-ecologic system can be measured by the degree of co-adaptation of system components:

"As a rule, human-ecosystem interaction is sustainable when social system and ecosystem are co-adapted. Conversely, interaction is less sustainable when co-adaptation is weak. Sudden changes in the social system or ecosystem can disrupt co-adaptation, setting in motion a chain of effects that reduces an ecosystem's ability to provide essential services." MARTEN (2001): 136.

The possible reactions of an ecosystem to human influence are depicted in figure 1.

Figure 1. Human influence on ecosystem state



Source: MARTEN (2001: 88).

Figure 1 indicates that ecosystems are quite resilient in their capacity to continue functioning over a range of different uses. But if an ecosystem is modified too intensely by human activities, the state of the ecosystem can shift irreversibly to another stability domain accompanied with the loss of its previous functions for humans. In this sense, an overexploitation of *Dioscorea* spp. from the forest can lead to a transformation of the ecosystem from dry forest into savannah.

To avoid this undesired transformation of ecosystems, a know-how basis regarding the influence of use to the ecosystem is crucial. A basis for decision-making, for example, could be a previously determined yield.

[4] Co-adaptation is the process of mutual co-evolution of two or more systems (e.g. ecological, social) to suit each other's existence. The impulse may come from changes in landscape, land use, use of resources etc. (MARTEN, 2001).

METHODOLOGY

Socio-scientific methods

Participatory Rural Appraisal (PRA)

The PRA approach was chosen because the participation of the local population was an essential condition for the success of the research process (see also POFFENBERGER et al., 1992; SCHÖNHUTH et al., 1993; SDC, 1997). The direct contact with the people during the PRA enabled the researcher to explain the aim of the research and the expected results. In this way the PRA process helped to reduce the mistrust of the local population towards outsiders.

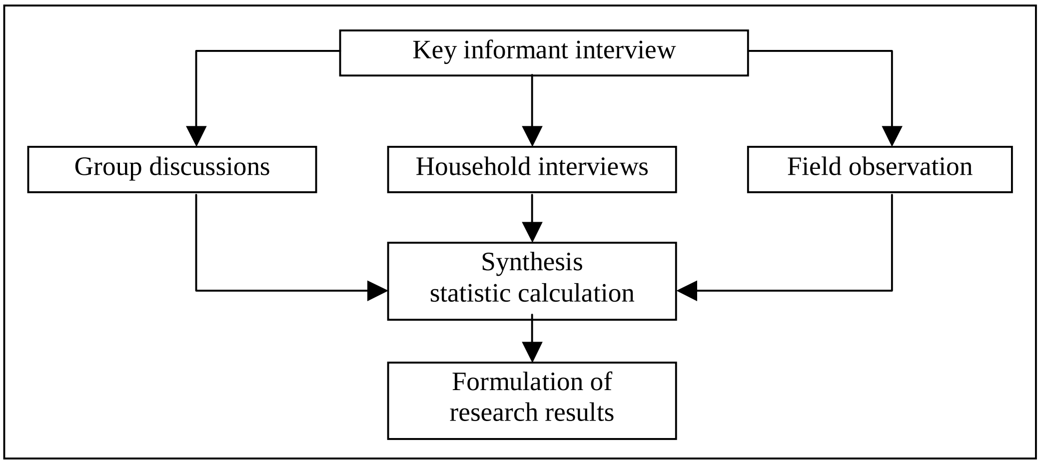
A major principle of PRA is triangulation, which is based on the diverse perspectives of the members of the multidisciplinary research team and on the use of a multitude of tools. The research team consisted of 5 people: one social scientist, two agronomists and two forest experts.

The instruments used were household interviews, group discussions, key informant interviews, transects of the villages, and mapping. To be consistent with the aim of research, the PRA centered around previously determined core issues, e.g. agricultural activities of the region, the use of different forest formations (primary forest, secondary forest) and the history of forest degradation. At the end of the PRA process, the collected information was analysed and the results were validated.

Surveys

Over a period of 10 months, surveys were conducted in the focus areas, taking into account the results of the PRA. A combination of the instruments used included group discussions, individual interviews, and field observations (compare figure 2):

Figure 2. Pattern of surveys, after WERNER, 1996: 87 (modified)



According to their reputation most of the Sakalava are distrustful against strangers. Therefore key informant interviews were used to supplement the information collected. Furthermore, especially sensitive issues were analysed through key informant interviews in order to validate the research results. In total, 12 key informants were involved in both focus areas.

Household interviews were conducted in all villages that used the relevant forest areas. Table 1 presents an overview of the interviews.

Table 1. Number of interviewed households

	Mariarano		Tsilakanina	
	Interview of households	Interview of key persons	Interview of households	Interview of key persons
∑ interviewed households	24	136*	31	82*
Ø number of persons / household	5,9	4,7	5,1	5,3
Represented population by selected households	143	639	165	439
Portion of the total population of the area	17%	76%	35%	95%

* Number of household of which information were obtained by key persons

The household interviews concentrated on household statistics and household economy (agricultural and non agricultural activities), as well as their relation to forest resources.

The results from household interviews were later used for group discussions with villagers. This allowed for an estimation of the proportion of people involved in certain economic activities. In some households, in-depth interviews were conducted to analyse the way in which decisions about household economy are made.

Inventory of *Dioscorea* spp. in dry forests

Due to the specific physiology of *Dioscorea spp.* their lianas are visible only during a few months of the rainy reason. Therefore, an inventory had to be conducted in the period from January to March. The coincidence of this period with the time of tuber harvesting necessitated the inventory to be a combination of counting the lianas and the holes dug for harvesting.

In order to determine the inventory areas, the zones occupied by the yam species (harvest zones) were identified through interviews with local people. By triangulation of the results of different villages the most important zones for yam harvesting could be identified. Furthermore, several people were accompanied during the harvesting process.

Within the harvesting zones, sample plots were systematically selected and the number of holes (differentiated according to their estimated age) plus the number of unharvested tubers were determined (Table 2).

Table 2. Number of sample plots of the *Dioscorea*-Inventory in different types of forest

Type of Forest	Area	Size of sample plots [m²]	Number of plots	Total sample area [m²]
Secondary forest (very young)	Mariarano	20 x 20	6	2.400
	Tsilakanina	10 x 100 10 x 200	1	3.000
Primary forest	Mariarano	6 x 20	7	840

The main harvesting zones were located in secondary forest formations. For the purpose of comparison sample plots were also selected in indicated harvesting zones of primary forest (see also WONG et al., 2001).

The stock of yams was calculated by multiplying the number of holes and the calculated average yield per hole (determined by weighting). Additionally the unharvested tubers were considered.

RESULTS

Basic socio-economic features

The socio-economic activities of the study population greatly vary with the ethnic composition and the levels of natural resource endowments of the households (Table 3).

Table 3. Selected socio-economic features of the study areas

	Mariarano	Tsilakanina
Main vegetation types (Basis for important socio-economic activities)	Dry forests Savannah Riverside forests Mangrove forests	Dry forests Savannah Riverside forests
Ethnic composition of the households	73% Sakalava 24% Tsimihety 3% Betsileo	55% Merina 16% Sakalava 12% Betsileo 17% other ethnic groups
Distance of villages from the forest	Adjacent to the dry forest	About 2 km
Mean household size	5-6 members	5-6 members
Agricultural activities by households		
Rice cultivation	Almost every household (Ø 1,0 ha)	Almost every household (Ø 1,6 ha)
Manioc cultivation	62% of HH; inside, outside of the forest	70% of HH; only outside of the forest
Maize cultivation	38% of HH; inside, outside of the forest	55% of HH; only outside of the forest

Other activities by households		
Mat weaving	75% of HH	35% of HH
Harvest of *Raphia* sp.	10% of HH	40% of HH
Charcoal production	60% of HH	-
Timber extraction[5]	10% of HH	-
Mangrove collection	20% of HH	-

HH = household

Rice is the most important source of diet for the people living in the study areas. Whereas an average household in Mariarano cultivates 1 ha of rice field, the mean size of rice field in Tsilakanina is 1,6 ha. This reflects the strong tradition of rice culture among the Merina ethnic group. Since the cultivation of maize and manioc in Mariarano is also practiced inside the dry forest, the average size of the cultivated area per household is much higher than in Tsilakanina.

Rice production

Types and data of rice production

Depending on the system of water supply, three different types of rice production can be distinguished:

- Type RR: rain-based wetland rice (use of backwater during rainy season)
- Type pRR: prolonged rain-based wetland rice (use of backwater after rainy season)
- Type IR: irrigated wetland rice

In Mariarano as well as in Tsilakanina, rain-based wetland rice is produced by all households, whereas the use of irrigation is practiced by only 60% of the households in Mariarano and only 45% of the households in Tsilakanina. Prolonged rain-based wetland rice is the least important type of production in both areas. Table 4 shows the average data of rice production for both areas.

Table 4. Average data of rice production

	Mariarano			Tsilakanina		
	RR	*pRR*	*IR*	*RR*	*pRR*	*IR*
Number of HH	20	2	15	31	8	14
Portion of HH [%]	83	8	62	100	26	45
Average cultivated area [ha]	0,6	0,6	0,7	1,0	0,8	0,8
Average Yield [kg/ha]	867	1128	1165	1094	618	856

HH = household

[5] Timber exploitation by outside users, which is widespread in Tsilakanina, is not included.

The average size of the rice production area per household in all three systems of rice production is larger in Tsilakanina. The yield of rice varies greatly in both areas, from 0,6 to 1,2t/ha, which is far below the average production of Madagascar[6]. The reasons for these low yields are mainly increasing irrigation problems.

The mean rice production per household is about 1t in Mariarano and 1,7t in Tsilakanina, i.e. Mariarano has only about 60% of the rice stock per person, compared to Tsilakanina. Therefore, the possibility to earn income from selling a proportion of the harvested rice differs greatly. In Tsilakanina, 250.000 – 350.000 FMG[7] per household can be earned by selling rice, whereas only a maximum of 90.000FMG[8] can be made in Mariarano. It can therefore be noted that in Mariarano rice is almost exclusively used for subsistence and not as a source of income.

Definition of household categories according to the rice cultivation system

According to the types of rice production different household categories can be distinguished (table 5):

Table 5. Definition of household categories according to the rice cultivation system

Cultivation systems in categories of households					Number of households			
					Mariarano		Tsilakanina	
Category	Types of cultivation	Total average field size [ha]		Month of harvest	H*	KP*	H*	KP*
		Mariarano	Tsilakanina					
A	RR	0,6	1,2	05	5	45	13	28
B	IR	0,9	-	11	3	14	0	5
C	RR + pRR	1,3	1,6	05+08	2	9	4	7
D	RR + IR	1,2	1,7	05 + 11	13	55	10	23
E	RR + pRR + IR	-	2,3	05 + 08 + 11	0	2	4	11
F	-	-	-	-	1	8	0	4
Σ					24	133	31	78

*Source of data: H=interview of households; KP=interview of key persons (for triangulation)

RR: rain based wetland rice; pRR: prolonged rain based wetland rice; IR: irrigated wetland rice

The categories A-F contain 98% of the households in Mariarano and 95% of the households of Tsilakanina. In most cases rice production is done in two periods, allowing two harvests per year. However, more than a third of the households use only one production cycle per year. Category F (no rice production) is found in Mariarano with only 4% of all households and is therefore neglected.

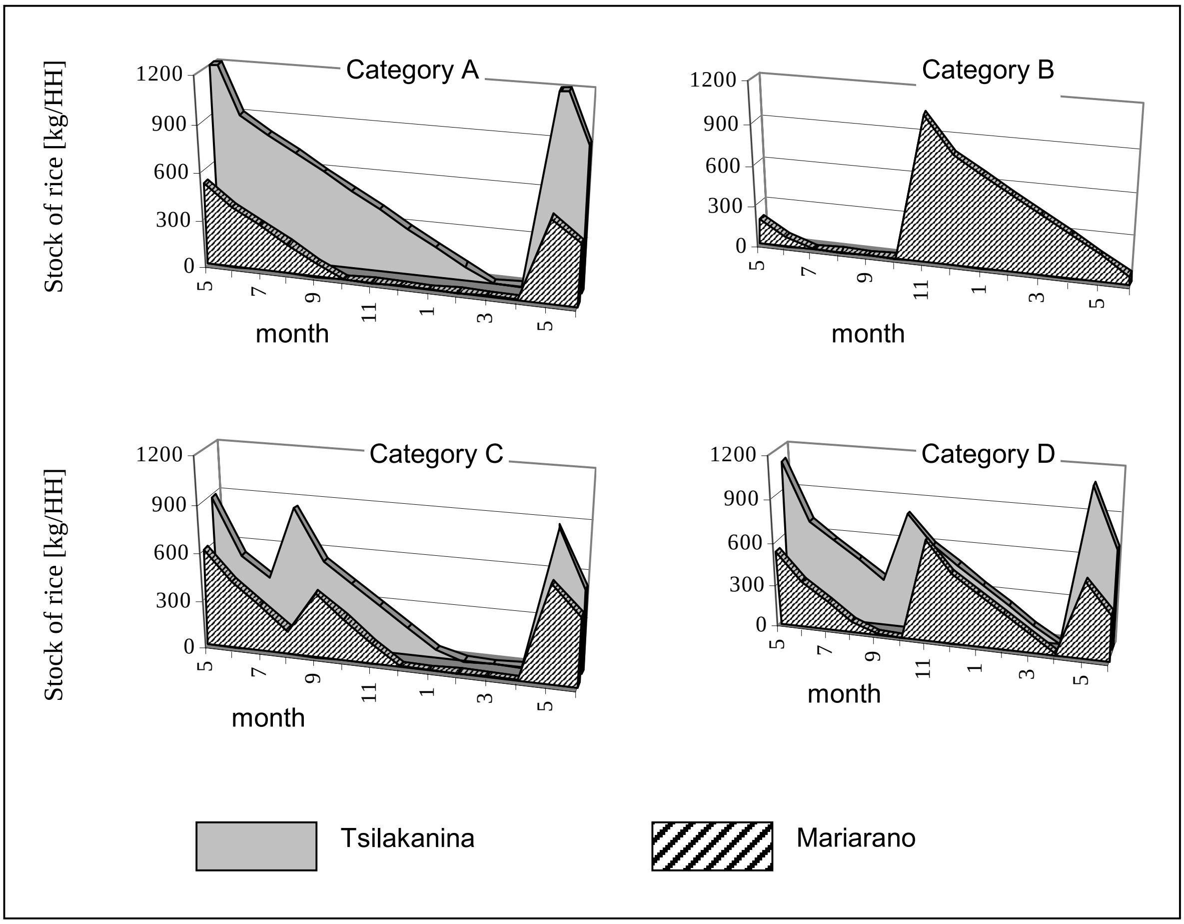
[6] In the highlands of Madagascar rice yields of 2-3t/ha can be reached due to improved irrigation and fertilisation (SICK, 1984), whereas the Madagascan average is about 2,1t/ha (ROUBAUD, 1997).
[7] Franc Malgache: 1 US$ are about 6.000FMG (year 2001)
[8] The price of 50kg of unpolished rice (“paddy”) is about 50.000FMG.

Seasonal fluctuations in household rice stocks

Depending on the harvesting periods and the yields, there are different periods of rice shortage during the year. These periods vary widely according to the household categories. The duration of rice shortage is influenced by the system used for rice production. Households that use only one system of production are usually most severely threatened by shortages in supply (figure 3).

Figure 3: Periods of rice shortage

The calculation is based on a monthly consumption of unpolished rice of 120kg/household [9]



The severity of rice shortage influences the importance of alternative sources of food and/or sources of income for the purchase of food. In this sense, decreasing rice yields or even crop failures lead directly to the increased use of other resources.

It becomes clear that in Tsilakanina there is a rice shortage only during the rainy season, whereas in the dry season rice stocks are sufficient in all households. This is mainly due to the larger average of field size per household as compared to Mariarano

[9]The consumption of polished (white) rice amounts to 470g per day and person during the periods of rice sufficiency. The annual average (including the period of rice shortage) is 384g (BASLER, 1992). By polishing rice a loss of weight of about 30% was calculated. In an average household six persons are living.

where the households of categories A, B and D experience shortages also in the dry season.

During the rainy season, a rice shortage lasting several months was noted in both areas for the household categories A, C and D. In total 80% of interviewed households are concerned.

The harvest of *Dioscorea* in the dry forests

Season, method of harvesting and yield

There are 32 *Dioscorea* species in Madagascar (KOECHLIN, 1997), of which 26 are endemic. The following forest species of yams are collected by the people interviewed in the study:

Dioscorea maciba Jumelle et Perrier	(Maciba; Malliti)
Dioscorea antaly Jumelle et Perrier	(Antaly)
Dioscorea bemandry Jumelle et Perrier	(Bemandry)
Dioscorea sp.	(Angarok)

Dioscorea maciba and *Dioscorea antaly* are of exceptional value due to their quality and abundance. Furthermore, *Dioscorea antaly* can be stored over a long period of time after being processed.

Dioscorea maciba is harvested in March and April, while the harvest of *Dioscorea antaly* can proceed until May. This period of harvest coincides with the period of rice shortage during the rainy season.

Because the tubers are easily transported, even larger distances are covered to collect them. In Tsilakanina the harvesting zones are up to 8 km away from the village. The condition of the soil is the most important factor in deciding where to harvest. According to the villagers' experience, the largest tubers grow in soft deep soils. Other criteria for the choice of harvesting areas are shown in table 6:

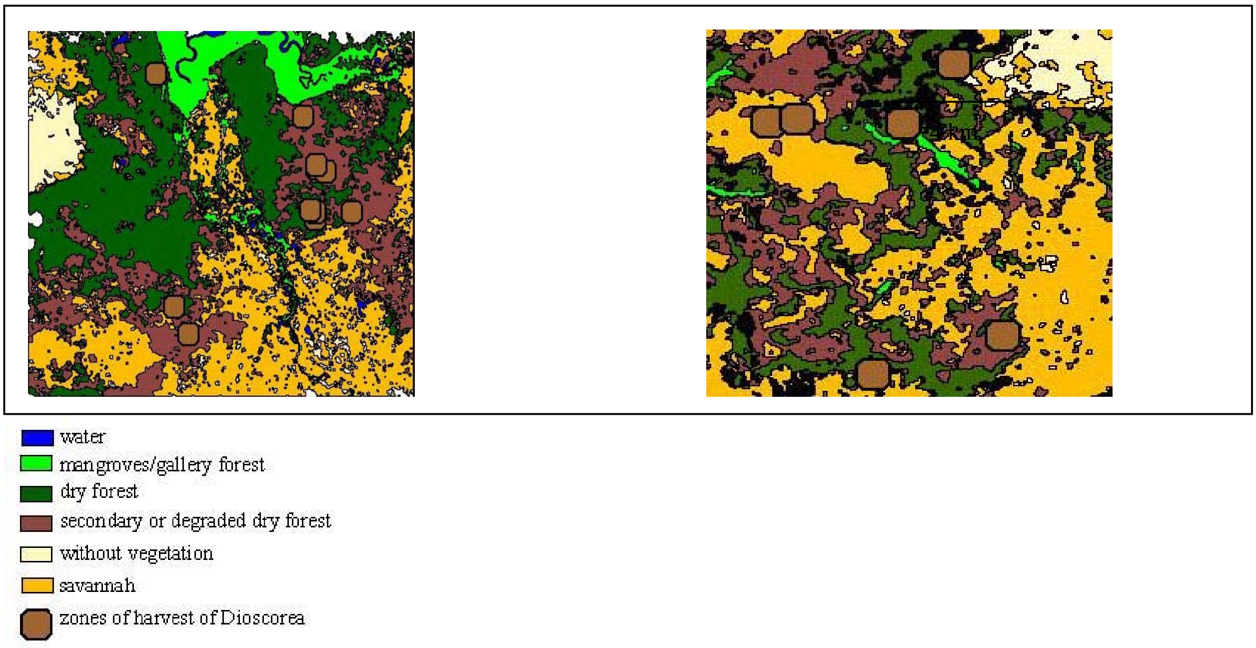
Table 6. Criteria for the choice of harvesting area of yams

	Primary Forest	Open Secondary Forest (Age 0-2 years)	Secondary Forest (middle aged)
Quality of the tubers	++	+	+
Quantity	-	++	++
Easiness to detect lianas	-	++	+
Penetrability of the stand	+	++	-

++ = very good + = good - = bad

Since *Dioscorea* is a light demanding species it grows best in open secondary forests. Additionally in these forests the lianas are easier to detect than in a closed forest. Consequently the harvesting zones are concentrated in open forests formations. In total, 60 to 70% of the yam harvest is done in such forests (figure 4).

Figure 4. Important harvesting zones of *Dioscorea* in Mariarano und Tsilakanina



Traditionally, the tubes are tried to be harvested carefully in a way that guarantees the survival of the plant. Different methods are used in this regard (COMMUNE RURALE DE MARIARANO, 2001a,b; KAMM, 2000; LUZI, 1999):

- Harvesting of the tubers without damaging the lianas and their connection to last year's tuber
- Leaving tubers of previous year or the tubers that are just growing
- Leaving a part of the tuber (usually the upper part) and covering it with soil[10]
- Harvest of the tubers only after the plant has produced seeds

Dioscorea maciba produces one tuber per plant. The lianas grow in a rather scattered pattern across an area, and a hole has to be dug for each tuber. The weight of a tuber varies between 0,5 and 2 kg (at a length of 1m) being 1,2 kg on average. One person harvests 4 to 6 tubers per day, achieving an average daily harvest of 5-7 kg.

The lianas of *Dioscorea antaly* grow in clusters. In average the tubers of 4 plants are harvested by digging one hole. The yields are higher than from *Dioscorea maciba*, reaching up to 12,5 kg/day.

[10] According to REHM (1989) the possibility of regeneration of the yam plant from only parts of the tuber is higher, if the upper part of the tuber from which the liana grows stays in the soil.

Figure 5: Harvest of *Dioscorea* in dry forest

Realized harvest in the research zones

For many households whose rice stocks are exhausted, yams will be the main food source during periods of shortage. Table 7 shows the number of households harvesting yams, and their respective amount of harvest:

Table 7. Number of *Dioscorea* harvesting households and average harvest amounts

Research zone	Mariarano					Tsilakanina				
Category of HH	A	B	C	D	Σ [%]	A	C	D	E	Σ [%]
Number of harvesting HH [n]*	4	2	2	9	75	8	4	8	4	77
Quantity of harvest** [kg/HH]	331	271	325	214		282	180	177	133	
Weighted quant. of harvest*** [kg/HH]	265	182	325	148		175	180	141	133	
Total amount of *Dioscorea* harvested in the focus area	Σ for 164 HH: 34.000kg/year					Σ for 88 HH: 14.000kg/year				

*total number of interviewed HH: Mariarano: 24; Tsilakanina: 31

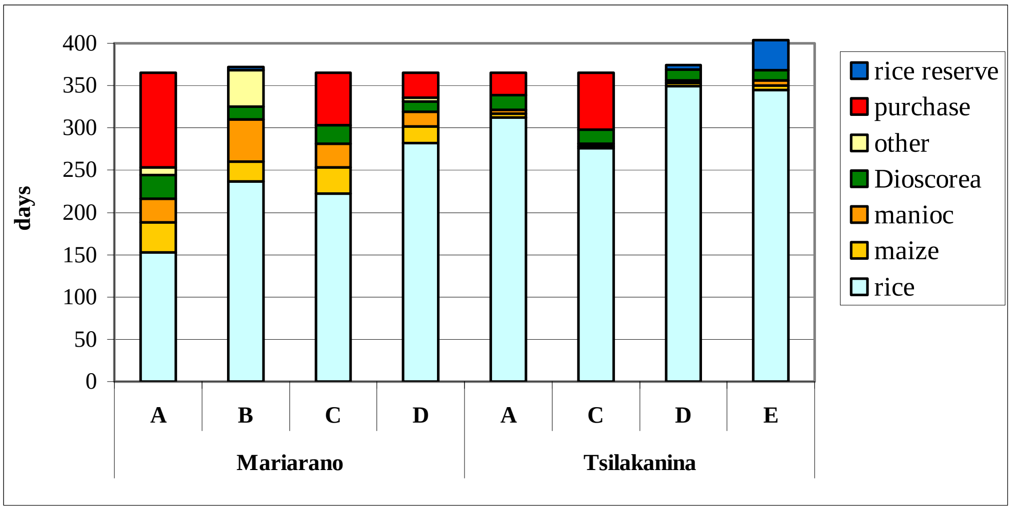
** real harvested amount/HH

*** with the whole number of HH in the category weighted amount of harvest/HH

The harvest of wild yams is practiced by all household categories in both focus areas. In case of a diet solely based on *Dioscorea*, a daily consumption of 2 kg/person could be estimated. Thus for an average household of six persons the amount of harvested yams can provide the diet for 11 to 28 days according to the household category. The contribution of yams to the people's diet in Mariarano can therefore be compared to that of agriculturally produced food, such as maize and manioc (comp. figure 6). Since the cultivation of manioc and maize is not very popular in Tsilakanina, *Dioscorea* and some additionally purchased food are the most important supplements of diet.

Figure 6. Average number of days of food provision by different sources

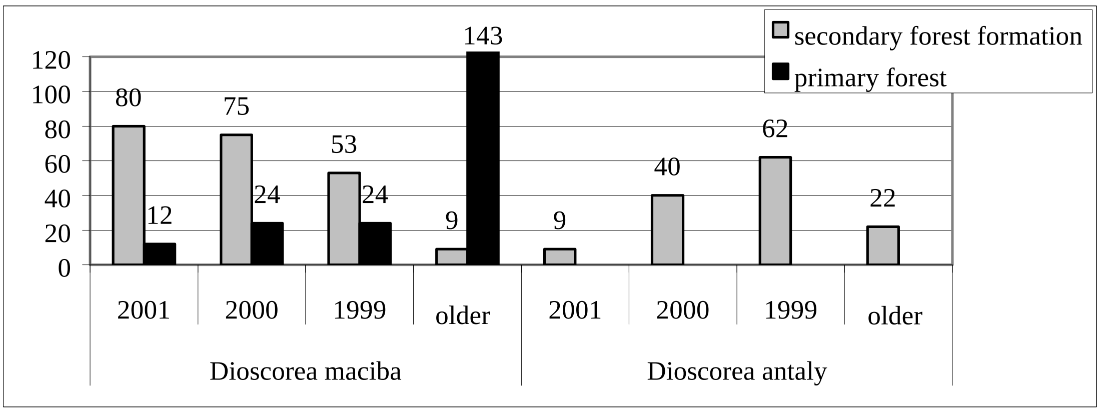
The daily consumption on the base of rice/maize is about 476g/person and on the base of manioc and wild yams about 2kg/person.
For the definition of the household categories A to E compare table 4.



Stock of Dioscorea in dry forests

The stock was estimated by counting the harvesting holes and the yams plants left. Harvesting zones in open secondary and primary forests were compared. The number of counted holes amounts up to 350 per ha in secondary forests (total number of holes from several years). About 80 holes/ha of *D. maciba* and 9 holes/ha of *D. antaly* were dug recently (figure 7).

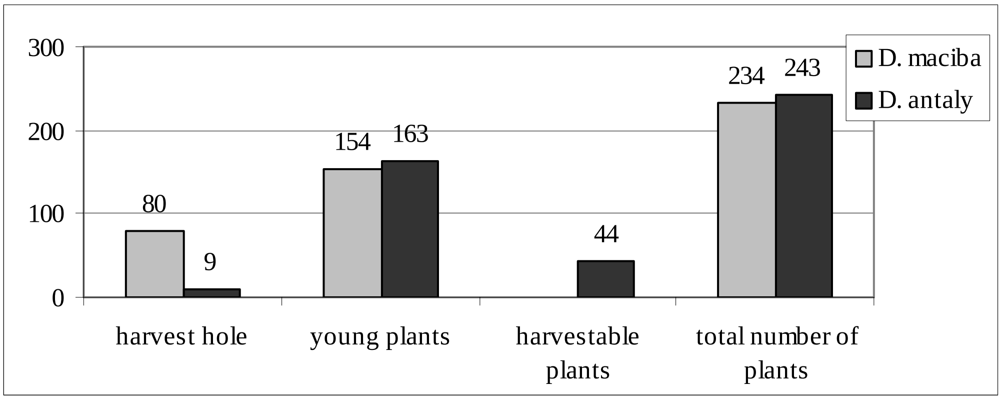
Figure 7. Number of harvesting holes per ha from different years



The number of annually dug harvesting holes in primary forest is significantly lower than in open secondary forests. In primary forests yams grew mainly on unshaded spots such as along paths. A maximum of 24 holes per ha from one year were found, corresponding to a yield of tubers of 29 kg (*D. maciba*).

For *Dioscorea maciba,* all ripe tubers were harvested at the end of the harvesting season, whereas for *Dioscorea antaly* 44 plants per hectare were still unharvested at that time. About 150 plants of *D. maciba* and 160 of *D. antaly* per ha cannot be harvested yet. Taking into account all harvested and unharvested plants, the total occurrence of *D. maciba* und *D. antaly* is approximately 240 plants per ha (figure 8).

Figure 8. Harvesting holes and yam plants per ha in secondary forests of Mariarano. One hole of *Dioscorea antaly* corresponds to 4 plants



A third of all available *Dioscorea maciba* (100% of plants possible to harvest) were harvested during the harvesting season. The resource use of this species, therefore, has reached the limit of its bio-ecological availability. The utilisation intensity of *Dioscorea antaly* is significantly lower. The following table summarises the stock of yams tubers in the areas of inventory:

Table 8. Comparison of stock and the amount harvested

	Average [yield/hole]	Harvesting [holes/ha]	Harvestable [lianas/ha]	Total [stock/ha]	Realised [harvest/ha]
Dioscorea maciba (second. forest formation)	1,2kg	80	0	96kg	96kg
Dioscorea maciba (primary forest)	1,2kg	24	0	29kg	29kg
Dioscorea antaly (second. forest formation)	4kg (1kg/liana)	9	44	80kg	36kg
Dioscorea antaly (primary forest)	4kg (1kg/liana)	0	0	0	0

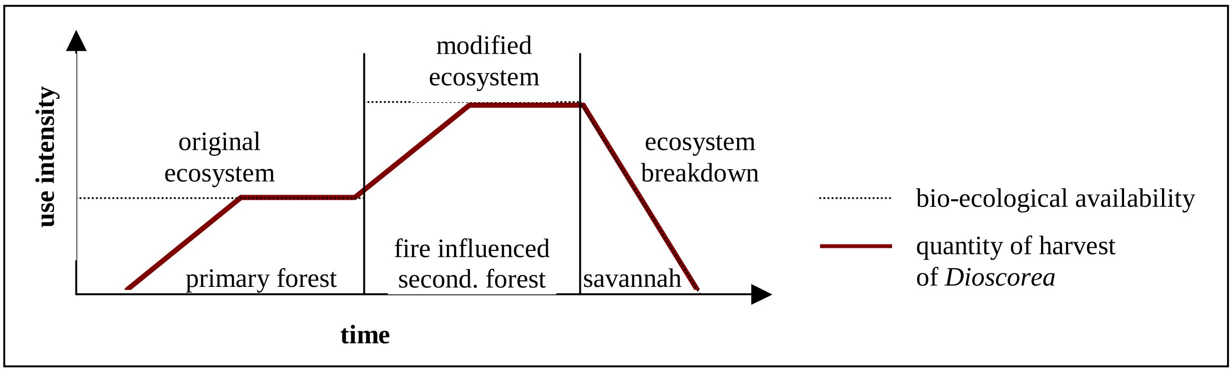
The total stock of harvestable wild yams is **176kg/ha** in secondary forests and about **29kg/ha** in primary dry forests, at maximum. This shows that, through human influence and fire-induced changes in vegetation, the yield can be increased six fold over a short period of time.

Effects of harvesting Yams in the dry forest

The total annual demand of wild yams is estimated to be 34t in Mariarano and 14t in Tsilakanina. 65% of the harvesting takes place in secondary forests, which people prefer. For most people, the collection in primary forests is only an alternative where open secondary forests are not available. To meet the people's demand of yams, approx. 130ha of secondary forest and 400ha primary forest in Mariarano (resp. 50ha and 170ha in Tsilakanina) have to be harvested annually. A direct effect of the yams harvest is a massive impact on the soil structure, especially if harvesting holes are not closed after harvest of tubers. Even more severe in their impact are indirect effects resulting from the people's motivation to burn the forests at the end of the dry season, creating those open forest formations in which the harvest potential of *Dioscorea* is very high. Besides, harvesting is getting easier when other disturbing lianas are destroyed.

By changing ecological conditions such as light, radiation and humidity, the bio-ecological supply of *Dioscorea* is increased on a short-term basis. This practice is at the cost of long-term and irreversible forest degradation through the use of fire: fire during the late dry season causes a reduction of the range of forest species. In this phase, the nutrients stored in the plant are already transported into the upper parts (above surface) of the plant (TROLLOPE, 1982). If these nutrients are lost, the plant is extremely weakened or even dies. Consequently pyromorph savanna species are encouraged. Furthermore, the reproduction in secondary forests in the focus area is almost exclusively dependent on coppicing. Due to the high human-induced frequency of fires, these plants cannot reach maturity in order to produce seeds. The vitality of the coppice declines (FAO, 2000). Species with shorter reproduction cycles are promoted. It can be assumed that 3 to 4 forest fires within 15 years can transform an intact dry forest into a savannah formation BLOESCH (1999). An intense use of *Dioscorea* in dry forests may therefore contribute to a savannisation of the forest ecosystem, involving the destruction of the habitat of wild yams (figure 9).

Figure 9. Model of the modification within the ecosystem to increase bio-ecological supply of *Dioscorea* (SEPP et al. (1997), modified)



Furthermore, the induced forest degradation contributes to the fragmentation of the remaining dry forests. This leads, in the long run, to a loss of biodiversity, which limits the future potential use values of the forests.

CONCLUSION AND STEPS TOWARD A SUSTAINABLE UTILISATION OF *DIOSCOREA*

The increased demand of yams has introduced a practice that benefits from forest fires and motivates the burning of forest. The transformation process of dry forests into savannah is therefore enforced. To maintain the traditional function of dry forests in Northwestern Madagascar as a safety net for providing tubers of wild yams during periods of rice shortage, the harvest of tubers must not contribute to the degradation of the forests.

Sustainable use of *Dioscorea* is only viable if the use of human-induced fires is controlled.

A vital precondition is to ensure that wild yams are not over-utilised beyond the natural capacity of the forests. It is thus vital to balance the sustainable harvest with the natural productive capacity of the primary dry forests. Burning of forests to stimulate more yam regeneration should be discouraged to guarantee long-term sustainable production. The presently over-harvested quantity must therefore be substituted with alternative food crop production.

This clearly shows that a dry forest ecosystem cannot act as a long-term buffer for insufficient agricultural production, but that dry forests can only temporarily function as a safety net. Important framework conditions for long-term forest management are therefore an increase in rice production. There lies great potential especially in irrigation management to improve currently low and unstable rice yields.

The cultivation of *Dioscorea maciba* and *D. antaly* for instance, along the borders of fields or on agricultural fallow land, could further release pressure on the dry forest. Trials on appropriate production methods are recommended. Cooperation with households who are already experienced should be considered.

Land use planning must become a central element in resource utilisation. According to the current forestry policy of decentralisation of resource management, integrated forms of local land use planning must be developed. To ensure a direct participation of resource users in the planning process, easy and understandable approaches are needed. Most important in land use planning with regard to the utilisation of *Dioscorea* is to find ways to organize the harvest without applying fire or without profiting from fire. Zones have to be determined where the harvest of *Dioscorea* is restricted after recently occurred fires.

Considering the pace of forest destruction in the focus areas, urgent action is required to sustain the functioning of the dry forests and the traditional livelihood system based on these. Support for the local population is mostly necessary with regard to the implementation of management systems and the creation of local institutions that actively guide and facilitate a sustainable utilisation of the resource.

REFERENCES

BASLER, A. (1992): Landwirtschaft, Nahrungsversorgung und Ressourcenschutz. In BITTNER (1992).

BITTNER, A. (Hrsg.) (1992): Madagaskar. Mensch und Natur im Konflikt. Birkhäuser Verlag. Basel, Boston, Berlin.

BLOESCH, U. (1999) : Fire as a management tool for conservation and development of the Ankarafantsika Reserve complex and its buffer zones, Madagascar. Geobotanical Institute, Swiss Federal Institute of Technology (ETH).

CIMMYT (1988) : From agronomic data to farmer recommendations. An economics training manual. Completely revised edition. Mexico D.F., Mexico.

COMMUNE RURALE DE MARIARANO ; DIREF MAHAJANGA (2001a) : Cahier de charges relatif à la gestion de la forêt d'Ankatsabe gérée par la Communauté de Base « Tanteraka » dans le Fokontany et Commune Rurale de Mariarano.

COMMUNE RURALE DE MARIARANO ; DIREF MAHAJANGA (2001b) : DINA de la Communauté de Base « Tanteraka » relatif à la gestion de la forêt d'Ankatsabe de Mariarano.

DE GRAAF, H.J.; MUSTERS, C.J.M.; TER KEURS, W.J. (1999): Regional opportunities for sustainable development. Theory, methods and applications. Kluwer Academic Publishers, Dordrecht; Boston; London.

DFID (1999): Shaping forest management: how coalitions manage forests. Department for International Development, London.

FAO (2000): Management of natural forests of dry tropical zones. FAO Conservation Guide 32. Rom.

FRIEDRICHS, J. (1990): Methoden empirischer Sozialforschung. Westdeutscher Verlag, Opladen.

GTZ; INSTITUT FÜR INTERNATIONALE FORST-UND HOLZWIRTSCHAFT, TU-DRESDEN (Hrsg.) (1999): Rahmenbedingungen von Waldschutz- und Waldbewirtschaftung in den Tropen: Einflüsse und Rückkoppelungen anderer Politikfelder.

HUNTLEY, B.J. ; WALKER, B.H. (1982) : Ecology of tropical savannas. Ecological Studies 42. Springer Verlag.

KAMM, U. (2000): Gestion des produits forestiers dans les formations secondaires au Menabe Central. Rapport de Stage. Interccoperation, Bern.

KOECHLIN, J.; GUILLAUMET, J.-L.; MORAT, P. (1997) : Flore et Végétation de Madagascar. Gantner Verlag.

LAMBIEL, P. ; SHRESTA, G. ; BEEK, R. (?): Guideline for the inventory and sustainable management of four non timber forest products. Nepal Swiss Community Forestry Project. Swiss Agency for Development and Cooperation (SDC) and Intercooperation (IC).

LUZI, S. (1999): La gestion durable des produits forestiers dans la région du Menabe. Rapport de Stage. Intercooperation ; Programme Menabe, CFPF Morondava.

MARTEN, G.G. (2001) : Human ecology. Basic concepts for sustainable development. Earthscan Publications, London.

NORGAARD, R.B. (1981) : Sociosystem and Ecosystem Coevolution in the Amazon. Journal of Environmental Economics and Management, 8: 238-254.

POFFENBERGER, M.; McGEAN, B. ; KHARE, A.; CAMPELL, J. (1992): Field methods manual. Volume 2: Community forest economy and use patterns: Participatory Rural Appraisal (PRA) methods in South Gujarat, India. Society for Promotion of Wastelands Development, New Dehli.

REHM, S. (Hrsg.) (1991): The cultivated plants of the tropics and subtropics. Verlag Josef Markraf; Weikersheim.

ROUBAUD, F. (1997) : La question rizicole à Madagascar : les résultats d'une décennie de libéralisation. In RAJAOBELINA (1997) : 37-61.

SCHÖNHUTH, M.; KIEVELITZ, U. (1993): Partizipative Erhebungs- und Planungsmethoden in der Entwicklungszusammenarbeit: rapid rural appraisal; participatory appraisal; eine kommentierte Einführung. Gesellschaft für Technische Zusammenarbeit (GTZ).

SDC (1997): Participatory Rural Appraisal, PRA. A working instrument in the series Working Instruments for Planning, Evaluation, Monitoring and Transference into Action (PEMT), Bern.

SICK, W.-D. (1979): Madagaskar. Tropisches Entwicklungsland zwischen den Kontinenten. Wissenschaftliche Buchgesellschaft Darmstadt.

TROLLOPE, W.S.W. (1982): Ecological effects of fire in south African savannas. In HUNTLEY et al. (1982).

WERNER, J. (1996) : Développement participatif d'innovations agricoles. Procédures et méthodes de la recherche en milieu paysan. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Centre Technique de Coopération Agricole et Rurale (CTA), Schweiz.

WONG, J.L.G.; THORNBER, K.; BAKER, N. (2001): Resource assessment of non-wood forest products. Experience and biometric principles. FAO: Non-Wood Forest Products 13. FAO,