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Autor: Ackermann, Klaus

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Utilisation of wild growing yams as supplementary nutrition and its impact on the dry forest ecosystem in north-western Madagascar

KLAUS ACKERMANN

Keywords: *Dioscorea antaly*; *Dioscorea maciba*; dry forest; forest fire; rice production; wild growing yams; Madagascar. FDK 181.43 : 26 : 43 : 913 : (691)

Abstract: Wild growing yams (*Dioscorea* spp.) are an important supplementary food in Madagascar, especially during periods of rice shortage in the rainy season. Yams grow in dry forests and there is a particularly high occurrence of yam tubers in recently burned, open secondary forest formations. The study found that the uncontrolled harvest of yams can contribute to the degradation of dry forests due to the high quantity of wild yams harvested by the local population and the widespread practice of intentionally burning forests to increase yams production.

Abstract: Wilder Yams (*Dioscorea* spp.) wird in Madagascar, insbesondere während den Perioden des Reismangels in der Regenzeit, zur Ergänzung der Grundnahrung genutzt. Yams wächst in Trockenwäldern und der Bestand an Yamsknollen ist besonders hoch in lückigen Sekundärwäldern, die vor kurzem abgebrannt sind. Die Studie hat gezeigt, dass die unkontrollierte Ernte von Yams zur zunehmenden Schädigung der Trockenwälder beiträgt: einerseits durch das Ernten grosser Mengen von wildem Yams und andererseits durch den weit verbreiteten Brauch, die Wälder niederzubrennen, um die Produktion von Yams erhöhen zu können.

1. Introduction

In the livelihood system of the rural population living in the vicinity of dry forests in north-western Madagascar, wild-growing yams (*Dioscorea* spp.) are traditionally used to supplement food requirements during periods of food shortage. Originally, the tradition of yam-collection was only practised by the Sakalava tribe, who settled mainly along the northwest coast of Madagascar. Due to insufficient rice production, other tribes also practise yam extraction nowadays. Consequently, much more *Dioscorea* is now harvested.

The two study areas of Mariarano and Tsilakanina are characterised by high rates of forest destruction, 3% and 7% per year, respectively (ACKERMANN 2003). The loss of forest cover is attributed to various reasons such as: timber exploitation, charcoal production, uncontrolled grazing and forest conversion for maize and manioc cultivation. Unintentional, as well as intentional fires considerably contribute to forest degradation. Owing to the accumulation of dry biomass, most of the previously exploited forests are severely threatened by forest fires. Local institutions and natural resource management regulations are weak and cannot prevent fires spreading to the forests when open land is burned for pasture or hunting. In addition, intentional burning of forestland takes place to facilitate cattle grazing and the extraction of *Dioscorea*. Without adapting the traditional livelihood strategy of yam collection, the high demand for yams will, therefore, contribute to the depletion of dry forests in north-western Madagascar.

2. Conceptual framework

In this study, livelihood strategies are analysed and examined with particular reference to their natural capital. The socio-economic and ecological systems are regarded as interdependent sub-units of a superior socio-ecological system (DE GRAAF *et al.* 1999). The continual, mutual influence of sub-systems leads to a process of co-evolution, during which the system components themselves change (NORGAARD 1981) or adapt to each other (co-adaptation¹).

Changes in ecosystems are either intentionally induced by human beings to suit their needs (e.g. slash and burn cultivation), or the result of unintended processes of ecosystem re-organisation after man-made or natural disturbances (e.g.

transformation of dry forests to savannah) (MARTEN 2001). Co-evolution can thus have positive and/or negative effects on the ecosystem. The sustainability of a socio-ecologic system can be measured by the degree of co-adaptation of its 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)

Ecosystems are quite resilient in their capacity to continue functioning over a range of human interventions. If an ecosystem is modified too intensely by man, it can shift to another stability domain and its benefits to human beings may be irretrievably lost. The overexploitation of *Dioscorea* spp. can lead, for example, to a transformation of the dry forest ecosystem into savannah. In order to devise methods to counteract such undesirable changes, a thorough investigation into the impact of human resource utilisation on the ecosystem is required.

3. Methodology

3.1 Study sites

The study region is situated in north-western Madagascar in the Mahajanga province. Two study sites were selected. The Fokontany² Mariarano is located 60 km northeast and the Fokontany Tsilakanina approximately 60 km east of Mahajanga town (figure 1). The study sites were selected for three reasons. First, the presence of dry forests in the vicinity of the settlements and their intensive utilisation by the local population; second, the ethnic composition of the population, which is representative of northwest Madagascar; and third, the willingness of the local communities to participate in the study.

¹ 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).

² The lowest level of territorial administration in Madagascar, formed by one village community or several settlements.

	Mariarano		Tsilakanina	
	Interviewed households	Households covered by key persons	Interviewed households	Households covered by key persons
Σ of households	24	133*	31	78*
Ø number of persons / household	5.9	4.7	5.1	5.3
Represented population	143	639	165	439
Per cent of total population	17%	76%	35%	95%

* household information was obtained from key persons

Type of forest	Area	Size of sample plots [m*m]	Number of plots	Total sample area [m ²]
	Secondary forest (very young)	Mariarano	20 x 20	6
Tsilakanina		10 x 100 10 x 200	2	3000
Primary forest	Mariarano	6 x 20	7	840

Table 1: Number of households considered in the study.

Table 1: Anzahl der in der Studie berücksichtigten Haushalte.

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

Table 2: Anzahl der Probeflächen der Dioscorea-Inventur in verschiedenen Waldtypen.

The region is characterised by a distinct dry season that lasts for 6 to 7 months. Annual precipitation is approx. 1600 mm. According to the climatic conditions, dense dry forest is the naturally occurring forest type (KOECHLIN *et al.* 1997). A pattern of savannah and forest patches is typical for the region. The location of forest patches is determined by soil properties and the regime of vegetation fires. The traditional balance between forest and savannah ecosystems is shifted by human intervention in favour of the savannah ecosystem, particularly through forest utilisation and fire-based land use practices.

3.2 Social research methods

3.2.1 Participatory Rural Appraisal (PRA)

Since the participation of the local population was an essential precondition for the success of the research process, the PRA approach was chosen for primary data collection (see also POFFENBERGER *et al.* 1992; SCHÖNHUTH & KIEVELITZ 1993; SDC 1997). By direct communication with the villagers during the PRA it was possible to explain the aim and purpose of the investigation and to reduce any mistrust towards outsiders. For triangulation, a multidisciplinary research team was set up, composed of a social scientist, two agronomists and two forest experts. Various research instruments were employed which included household interviews, group discussions, interviews with key informants, transects of the villages and participatory mapping.

According to the research problem, the PRA centred on the following, previously determined core issues: agricultural activities in the region, the utilisation of primary and secondary forest formations and the history of forest degradation. As a final step in the PRA process, the collected information was presented to the local population for verification.

3.2.2 Surveys

Based on the results of the PRA, household surveys were conducted over a 10-month period. Since most Sakalava people are distrustful of strangers, interviews with key informants supplemented the surveys. Data obtained from key informants comprised, among other things, the type of agricultural and non-agricultural activities, the number of household members and particularly sensitive issues, such as the amount of charcoal production. In total, 12 key informants were interviewed in both study areas. Household interviews were

conducted in all villages and hamlets where inhabitants utilise the forest areas under study. Some households that had already been investigated during the interviews with key informants were also included. *Table 1* presents the number of households considered in the present study. Household baseline data was obtained from the household interviews, as well as information on the household economy, such as type and extent of agricultural and non-agricultural activities, and their relationship to forest resources.

Based on the findings from the household interviews, group discussions were conducted to estimate the proportion of villagers involved in particular agricultural and non-agricultural activities. In-depth studies of selected households were conducted to analyse aspects of intra-household decision-making.

3.3 Inventory of *Dioscorea spp.* in dry forests

Due to the physiology of *Dioscorea spp.*, the lianas only occur during the rainy season from January to March. Since this period coincides with the major harvesting season of yam tubers, the inventory took both lianas and holes dug in the ground to harvest yams into account. The inventory was carried out in the traditional harvest zones of wild yams. These areas were identified during the interviews with the local people and cross-checked among different hamlets. Furthermore, several villagers were accompanied to the harvesting grounds.

Sample plots were selected systematically within the harvesting zones and the number of holes and number of still harvestable plants was determined. Planting holes were classified according to their estimated age³. The size and shape of sample plots differed according to the density of ground vegetation. In dense forest formations sample strips along a pre-determined line were employed, whereas in open forests sample squares were used (*table 2*). The findings from the major harvesting zones in secondary forest formations were contrasted with results from sample plots established in harvesting zones of primary forests (see also WONG *et al.* 2001).

The stock of yams was calculated from the number of holes and the average yield per hole. To obtain the latter, the amount of tubers extracted by the villagers who had been accompanied to the yams harvest was weighed. The remaining tubers that had not been harvested were also counted.

³ Local guides estimated the age of the harvesting holes. Holes older than two years were summarised in one age class.

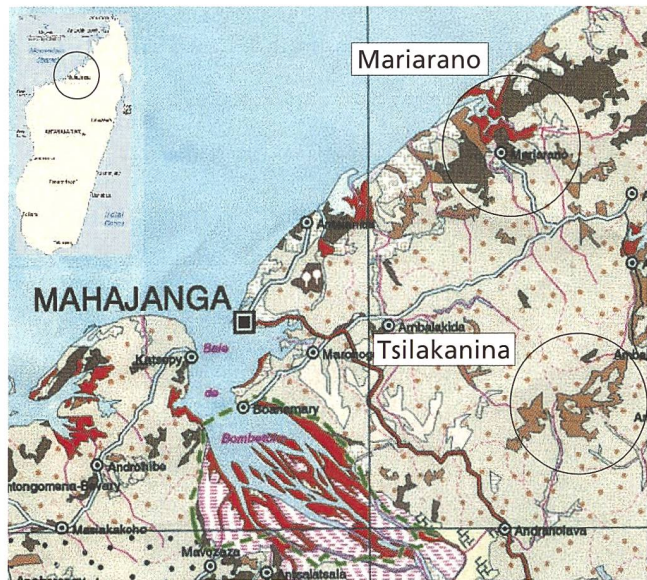


Figure 1: Location and major vegetation types of the study sites (Ministère de l'Environnement 1996: Inventaire Ecologique Forestier National. Carte de la végétation de Madagascar, Feuille SC38P, Antananarivo).

Abbildung 1: Lage und bedeutendste Vegetationstypen der Untersuchungsgebiete.

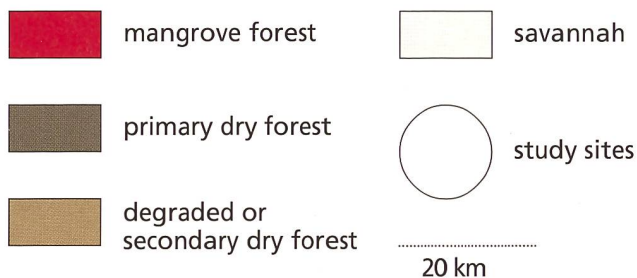


Figure 4: Harvest of *Dioscorea* in dry forest (photo: K. Ackermann).

Abbildung 4: *Dioscorea*-Ernte im Trockenwald (Foto: K. Ackermann).

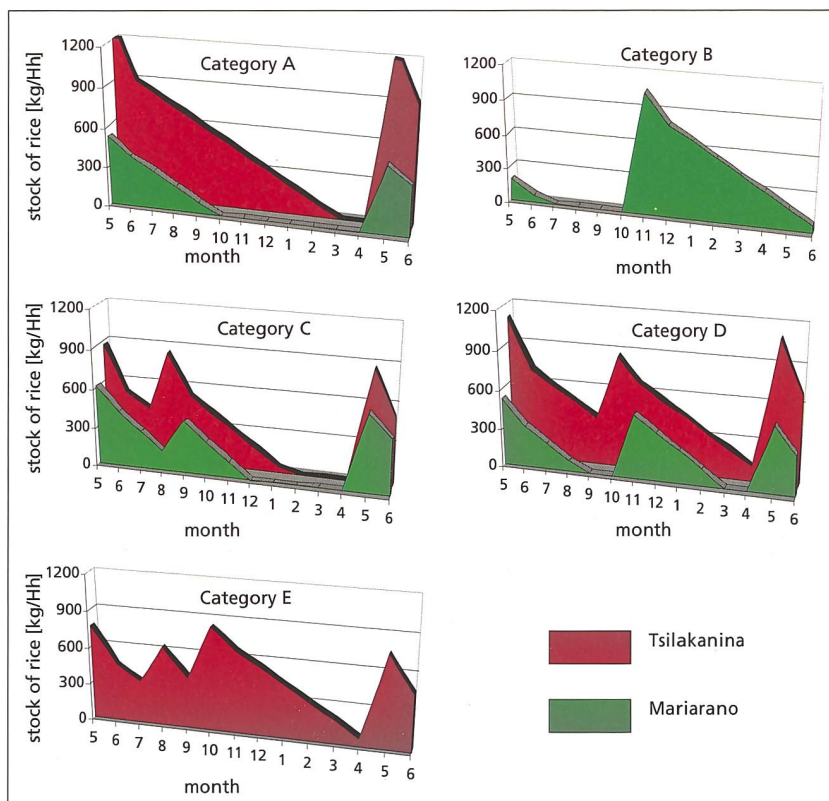


Figure 2: Household types and their periods of rice shortage.

The calculation is based on a monthly consumption of unpolished rice of 120 kg/household⁸.

Abbildung 2: Haushaltstypen und ihre Perioden an Reismangel.

Die Rechnung geht von einem monatlichen Verbrauch von 120 kg ungeschältem Reis pro Haushalt aus.

⁸ The consumption of polished (white) rice amounts to 470 g per day and person during the periods of rice sufficiency. The annual average (including the period of rice shortage) is 384 g (BASLER 1992). By polishing rice a loss of weight of about 30% was calculated. In an average household six persons are living.

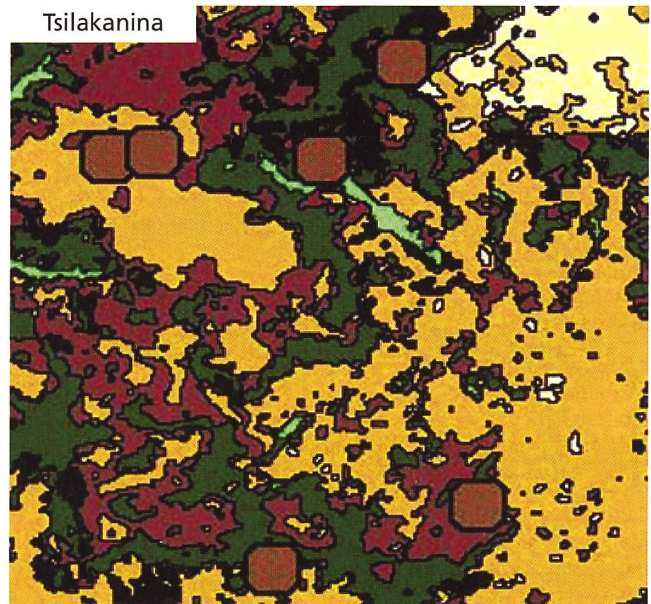
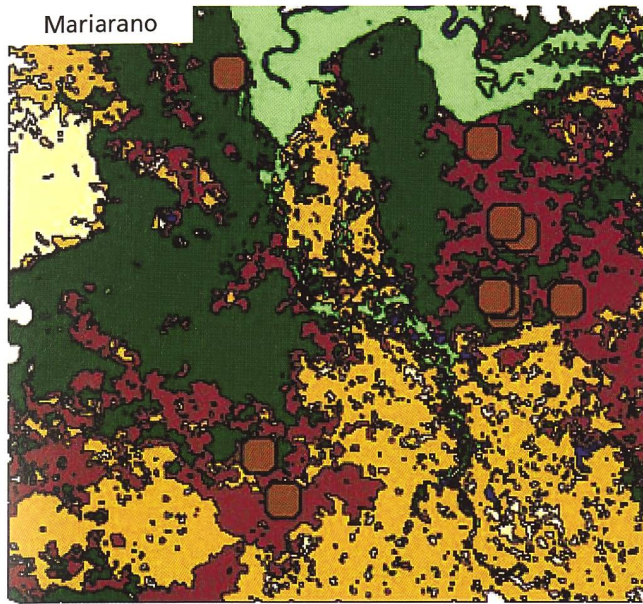


Figure 3: Major areas of *Dioscorea* harvest in Mariarano and Tsilakanina.

The maps are based on satellite photos of the year 1999. The harvest zones were marked by the use of GPS (Geographical Positioning System).

Abbildung 3: Die bedeutendsten *Dioscorea*-Ernteregionen in Mariarano und Tsilakanina.

Die Karten basieren auf Satellitenfotos aus dem Jahr 1999. Die Erntezonen wurden mit Hilfe von GPS (Geographical Positioning System) gekennzeichnet.

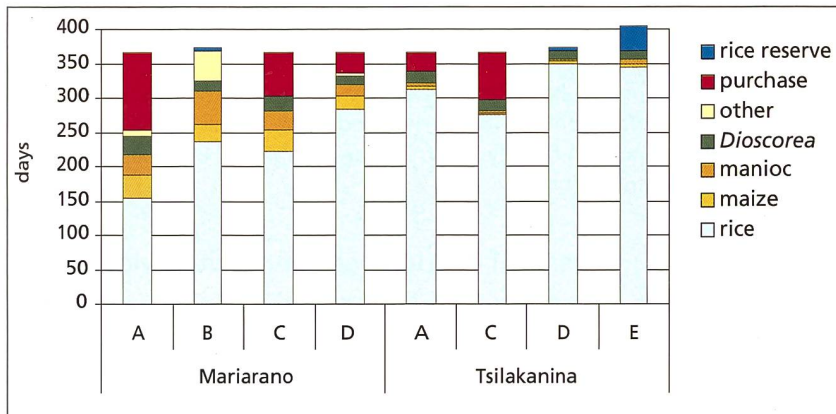
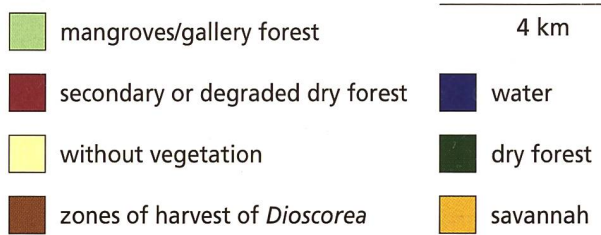


Figure 5: Provision of food from different sources (average number of days).

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

Abbildung 5: Nahrungsmittelversorgung aus verschiedenen Quellen (durchschnittliche Anzahl Tage).

Der tägliche Verbrauch auf der Basis von Reis/Mais beträgt etwa 476 g pro Person und auf der Basis von Maniok und wildem Yams rund 2 kg pro Person. Zur Definition der Haushaltskategorien A bis E vergleiche Tabelle 4.

Figure 6: Number and age of harvesting holes per ha in Mariarano.

Even harvesting holes which were older than 5 years could be identified by local guides. Therefore the number of holes before 1999 is quite high in the primary forest.

Abbildung 6: Anzahl und Alter der Erntelöcher pro ha in Mariarano.

Sogar Erntelöcher, die älter als fünf Jahre waren, konnten durch lokale Führer identifiziert werden. Deshalb ist die Anzahl der Löcher vor 1999 relativ hoch im Primärwald.

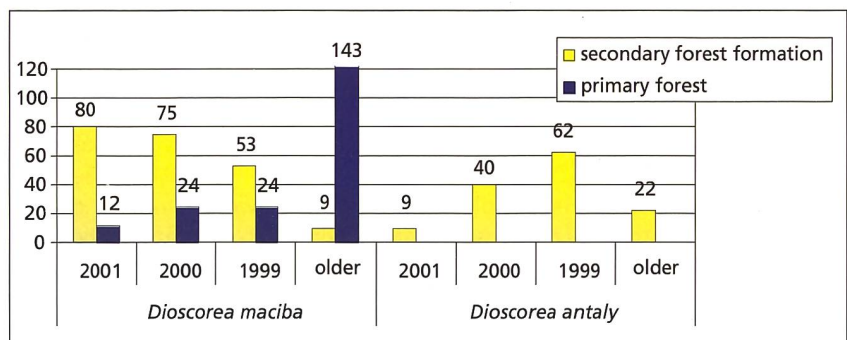
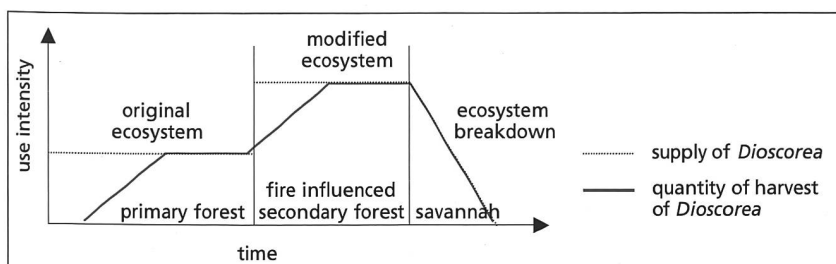


Figure 7: Model of the modification within the ecosystem to increase the supply of *Dioscorea* (SEPP et al. 1997, modified).

Abbildung 7: Modell der Veränderung des Ökosystems zur Erhöhung des Angebots von *Dioscorea* (SEPP et al. 1997, abgeändert).



	Mariarano	Tsilakanina
Main vegetation types (Base for household activities)	dry forests savannah riverside forests mangrove forests	dry forests savannah riverside forests
Ethnic composition of the population	73% Sakalava 24% Tsimihety 3% Betsileo	55% Merina 16% Sakalava 12% Betsileo 17% other ethnic groups
Distance of villages to the forest	adjacent to the dry forest	approx. 2 km
Agricultural activities of households		
Rice cultivation	almost every household (Ø 1.0 ha)	almost every household (Ø 1.6 ha)
Manioc cultivation	62% of Hh; in the forest, outside the forest	70% of Hh; only outside the forest
Maize cultivation	38% of Hh; in the forest, outside the forest	55% of Hh; only outside the forest
Other household activities		
Mat weaving	75% of Hh	35% of Hh
Harvest of <i>Raphia sp.</i>	10% of Hh	40% of Hh
Charcoal production	60% of Hh	–
Timber extraction ⁴	10% of Hh	–
Mangrove collection	20% of Hh	–

Hh = household

4. Results

4.1 Basic socio-economic findings

The socio-economic activities of the study households vary greatly with their ethnic composition and their access to natural resources (table 3). Rice is the major staple food in the study region. The average area of rice paddies per household is 1 ha in Mariarano and 1.6 ha in Tsilakanina. This reflects the strong tradition of rice cultivation among the Merina ethnic group. Since the cultivation of maize and manioc in Mariarano is also practised in the dry forest by slash and burn, the average size of the cultivated area per household is much higher than in Tsilakanina.

4.2 Rice production

4.2.1 Types and performance of rice production

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

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

In both study areas, all households cultivate rain-fed wetland rice, whereas irrigated paddy is cultivated by only 60% of the households in Mariarano and 45% of the households in Tsilakanina. Prolonged rain-fed wetland rice is the least important type of rice production.

The average rice yield is far below the national average⁵ and varies between 0.6 and 1.2 t/ha in both areas. The low productivity is mainly due to increasing irrigation problems. The average rice production per household is roughly 1 t in Mariarano and 1.7 t – or 70% higher – in Tsilakanina. The sale of surplus rice production contributes between 250 000 and 350 000 FMG⁶ per household to the household income in Tsilakanina, and only 90 000 FMG or less in Mariarano. In the latter village, rice is grown almost exclusively for subsistence and hardly for cash income generation.

4.2.2 Household typification according to the prevailing rice cultivation system

According to the prevailing types of rice production, households can be grouped into the following categories (table 4). The proportion of these household types among the village population is derived from the interviews with key persons. Most households cultivate rice during two periods, allowing them to harvest twice per year. However, more than a third of the households use only one production cycle per year. Households without rice production (type F) amount to a proportion of only 4% in Mariarano and will be neglected in the following.

4.3 Seasonal fluctuations in household rice stocks

Depending on the periods of rice harvest and yield, different household types face different periods of rice shortage. The duration of rice shortages are closely linked to the system of rice cultivation. Households that depend on only one system of cultivation are usually most threatened by rice scarcity (figure 2). The severity of rice shortage influences the importance of alternative sources of food and/or sources of income to purchase food. Decreasing rice yields or crop failures increase the importance and utilisation of alternative resources.

In Tsilakanina there is a rice shortage during the rainy season, while in the dry season rice stocks are sufficient in all households. This is mainly owing to the larger average field size per household compared to Mariarano, where the households of types A, B and D also face shortage during the dry season. A period of rice shortage lasting more than one month was reported in both study areas for household types A, C and D during the rainy season and concerns 80% of the households interviewed.

⁴ Timber exploitation by external agents, e.g. users from Mahajanga town, is not included although widespread in Tsilakanina.

⁵ In the highlands of Madagascar, rice yields of 2–3 t/ha can be attained with improved irrigation and fertilisation practices (SICK 1979), compared to the Madagascan average of ca. 2.1 t/ha (ROUBAUD 1997).

⁶ Franc Malgache: 1 US\$ is roughly equal to 6000 FMG (2001). 50 kg of unpolished «paddy» rice cost around 50 000 FMG.

Table 3: Selected socio-economic findings.

Table 3: Ausgewählte sozioökonomische Daten.

Table 4: Household types according to their prevailing rice cultivation system.

Tabelle 4: Haushaltstypen entsprechend dem vorherrschenden Reisanbau-System.

Household type	Types of cultivation	Prevailing rice cultivation systems			Number of households			
		Total average field size [ha]		Month of harvest	Mariarano		Tsilakanina	
		Mariarano	Tsilakanina		I*	KP**	I*	KP**
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	no rice cultivation	–	–	–	1	8	0	4
Σ					24	133	31	78

* interviewed households

** households covered by key persons

RR: rain-fed wetland rice; pRR: prolonged rain-fed wetland rice; IR: irrigated wetland rice

Shaded boxes indicate household types that are less frequent and therefore not included in the following.

4.4 Extraction of *Dioscorea* from the dry forests

4.4.1 Season, method of harvesting and yield

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

<i>Dioscorea maciba</i> Jumelle et Perrier	(Maciba; Malliti)
<i>Dioscorea antaly</i> Jumelle et Perrier	(Antaly)
<i>Dioscorea bemandry</i> Jumelle et Perrier	(Bemandry)
<i>Dioscorea sp.</i>	(Angaroky)

Dioscorea maciba and *Dioscorea antaly* are of exceptional value owing to their quality and abundance. *Dioscorea antaly* can be stored over a long period of time after being processed. *Dioscorea maciba* is harvested until March and April, while *Dioscorea antaly* can be harvested until May. This period of harvest coincides with the period of rice shortage during the rainy season. Because the tubers are easily transported, even long 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 5.

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 closed forests. Harvesting zones are therefore concentrated in open forest formations, where between 60% and 70% of the yams are harvested (figure 3). For most people, the collection in primary forests is only an alternative where open secondary forests are not available. Traditionally, people try to harvest the tubers carefully to guarantee the survival of the plant. Different harvesting methods are applied (COMMUNE RURALE

DE MARIARANO & DIREF MAHAJANGA 2001a,b; KAMM 2000; LUZI 1999):

- harvesting the tubers without damaging the lianas and their connection to last year's tuber;
- leaving tubers of the previous year or newly emerging tubers;
- leaving a part of the tuber (usually the upper part) and covering it with soil⁷; and
- harvesting 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 lianas of *Dioscorea antaly* grow in clusters. On average, the tubers of 4 plants are harvested by digging one hole (figure 4). The yields of *Dioscorea maciba* and *D. antaly* are shown in table 6.

Table 5: Criteria for the choice of harvesting area of yams.

Tabelle 5: Kriterien für die Auswahl der Yams-Erntegebiete.

	Primary forest	Open secondary forest (0–2 years after fire)	Secondary forest (medium age)
Quality of the tubers	++	+	+
Quantity	–	++	++
Ease to detect lianas	–	++	+
Penetrability of the stand	+	++	–

++ = very good, + = good, – = bad

Estimation based upon information drawn from 5 key informants.

Table 6: Average daily harvest of *Dioscorea*.

Tabelle 6: Durchschnittliche *Dioscorea*-Ernte pro Tag.

	Ø weight of tubers / liana	Number of tubers / harvesting hole	Number of harvesting holes dug per day	Amount harvested per day
<i>Dioscorea maciba</i>	1.2 kg	1	4–6	5–7 kg
<i>Dioscorea antaly</i>	1 kg	5–10	1–5	12.5 kg

⁷ According to REHM (1989), yam plants are more likely to regenerate from only parts of the tuber if the upper part of the tuber from which the liana grows is left in the soil.

Table 7: Number of *Dioscorea* harvesting households and average amounts harvested.Tabelle 7: Anzahl der *Dioscorea* erntenden Haushalte und durchschnittlich geerntete Menge.

Household types	Marianano					Tsilakanina					
	A	B	C	D	Σ	A	C	D	E	Σ	
Interviewed households	Total number of households	5	3	2	13	23	13	4	10	4	31
	Number of harvesting households	4	2	2	9	17	8	4	8	4	24
Households covered by key persons	Total number of households	45	14	9	55	123	28	7	23	11	69
	Number of harvesting households	31	8	8	41	88	23	5	16	10	54
	Quantity of harvest [kg]	331	271	325	214	–	282	180	177	133	–
	Total amount of <i>Dioscorea</i> harvested	23 800 kg/year (123 households)					11 500 kg/year (69 households)				

4.4.2 Harvest quantity of *Dioscorea* in the study areas

For many households whose rice stocks are exhausted, yams and maize will be the main diet during the rainy season, whereas during the period of rice shortage of the dry season manioc is an important staple food. Table 7 shows the number of households harvesting yams, and the respective amounts harvested. In both study areas, households of all categories practise wild yams harvesting. In case of a diet solely based on *Dioscorea*, a daily consumption of 2 kg/person is estimated. For an average household of six persons, the yams collected from the forest thus provide sustenance for a period of 11 to 28 days, depending on the household category. The contribution of yams to the people's diet in Marianano can, therefore, be compared to that of agriculturally produced food, such as maize and manioc (cf. figure 5). 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.

4.4.3 Stock of *Dioscorea* in dry forests

The stock was estimated by counting the harvesting holes and the yam plants left. Harvesting zones in open secondary and primary forests were compared (figure 6). The number of annually dug harvesting holes in primary forests is much lower than in open secondary forests because of the higher abundance of *Dioscorea* in the latter. In primary forests, yams grow mainly on non-shaded spots, such as along paths. A maximum of 24 holes per ha of *Dioscorea maciba* from one year were found, corresponding to a yield of 29 kg of tubers (cf. table 8). For *Dioscorea maciba*, all ripe tubers were harvested at the end of the harvesting season 2001, whereas 44 *Dioscorea antaly* plants per hectare still remained to be harvested. Table 8 summarises the stock of yam tubers in the inventoried areas. The total stock of harvestable wild yams is 176 kg/ha in secondary forests and about 29 kg/ha in primary dry forests.

4.4.4 Effects of yams harvest on dry forest

The total annual amount of wild yams harvested is estimated to be 24 t in Marianano and 11.5 t in Tsilakanina. Assuming a value of average stock per ha and a proportion of yams harvest from open forest formation of 65%, approximately 90 ha and 290 ha in Marianano, and 43 ha and 138 ha in Tsilakanina of secondary and primary forest, respectively have to be harvested annually. We can distinguish the direct and indirect effects of yams extraction on the forest. First, yams harvesting impacts massively on the soil structure, since most harvesting holes are not filled up after tubers are extracted. However, the indirect impact resulting from the common practice of burning the forests to create open forest formations with a higher harvest potential of *Dioscorea* are far more serious. In addition, harvesting is easier after burning disturbing ground vegetation and lianas.

Although changing ecological conditions such as light, radiation and humidity increase the supply of *Dioscorea* in the short term, in the long term this practice leads to irreversible forest degradation. Burning the forest during the late dry season constantly shifts the species composition towards pyromorph savannah vegetation, since in this period the nutrients are already transported from the roots of the plants to the parts above-ground (TROLLOPE 1982) and a loss of these parts extremely weakens or even kills the plants that are not adapted. Furthermore, regeneration of the secondary forests in the study area is mainly vegetative (coppicing). Due to the frequent occurrence of man-made fires, the young sprouts cannot reach maturity and produce seeds, and the vitality of the coppice declines (FAO 2000). Consequently, species with short reproduction cycles are promoted. We estimate that 3 to 4 forest fires over a period of 15 years can transform an intact dry forest into a savannah (BLOESCH 1999). An intense use of *Dioscorea* including the burning of dry forest may therefore contribute to a «savannisation» of the forest ecosystem,

Table 8: Comparison of stock and the amount harvested.

Tabelle 8: Vergleich zwischen Vorrat und geernteter Menge.

	Average yield/hole	Harvesting holes/ha	Harvestable lianas/ha	Total stock/ha	Amount harvest/ha
<i>Dioscorea maciba</i> (open secondary forest)	1.2 kg	80	0	96 kg	96 kg
<i>Dioscorea maciba</i> (primary forest)	1.2 kg	24	0	29 kg	29 kg
<i>Dioscorea antaly</i> (open secondary forest)	4 kg (1 kg/liana)	9	44	80 kg	36 kg
<i>Dioscorea antaly</i> (primary forest)	4 kg (1 kg/liana)	0	0	0	0

thus leading to the destruction of the habitat of wild yams (figure 7). Furthermore, the induced forest degradation contributes to a fragmentation of the remaining dry forests. In the long run, this will lead to a loss of biodiversity, which would limit the future potential use values of the forests.

4.5 Conclusion and steps towards a sustainable utilisation of *Dioscorea*

The high demand for yams has resulted in a management practice that benefits from forest fires or even motivates burning of forestland and promotes the transformation of dry forests into savannah. However, to maintain the traditional function of dry forests in north-western Madagascar as a major provider of food during periods of rice shortage, tubers must be harvested in such a way so as not to lead to forest degradation. Sustainable use of *Dioscorea* requires the control of human-induced fires. Another precondition for sustainable *Dioscorea* management is to ensure that wild yams are not utilised beyond their natural regeneration capacity. It is thus vital to balance the extraction with the reproductive capacity of primary dry forests. Burning of forests to stimulate yam regeneration should be banned.

From the results it is evident that in the long term the dry forest ecosystem cannot buffer insufficient agricultural production, but rather temporarily function as a safety net. It is absolutely vital for sustainable forest management that rice production and agricultural productivity will be increased. Sound irrigation management harbours considerable potential to improve the low and unstable rice yields. The cultivation of *Dioscorea maciba* and *D. antaly*, for example along the borders of fields or on fallow land, could further relieve the pressure on dry forest. We strongly recommend trials on appropriate cultivation technologies in co-operation with interested households.

Land use planning has to become a central element in resource utilisation. In line with the current forestry policy of decentralising resource management, integrated forms of local land use planning have to be developed. To ensure a direct participation of resource users in the planning process, easy and understandable approaches are needed. With regard to the utilisation of *Dioscorea*, it is of paramount importance to find ways to organise the extraction so as to exclude benefits arising from both man-made burning practices and natural fires. We recommend the establishment of protection zones in areas where fires occurred recently and that the harvesting of *Dioscorea* in such zones be restricted.

In view of the pace of forest destruction in the study areas, urgent action is required if the functioning of the dry forests and the traditional livelihood system they support is to be sustained. The local population needs help, above all, with the implementation of management systems and the creation of local institutions that actively guide and facilitate a sustainable utilisation of the resource.

Summary

In the dry forests of north-western Madagascar, wild yams (*Dioscorea antaly*; *Dioscorea maciba*) are appreciated by the local inhabitants as a supplementary diet. The harvest period of yams coincides with the period of rice shortage. Although rice stocks in the households of Mariarano are much lower than in Tsilakanina, more than 70% of the population of both study areas harvest yams in the forests. The harvested yams provide households with staple food for periods of 11 to 28 days.

Dioscorea spp. is a light-demanding species. A high frequency of these plants can be found in recently burned forests that usually are well penetrated by light. About 65% of the yams collected by the local people stems from such open forest formations. The corollary of this is an incentive to burn the forests intentionally.

However, stimulating the growth of yams by means of forest fires is only viable in the short term. In the long run, the ecosystem will be degraded and finally transformed into savannah formations. In turn, this naturally leads to the destruction of the habitat of the preferred species of yams. Steps to a sustainable utilisation of wild growing yams are land-use planning, cultivation of yam species and fire management. A precondition for the sustainable management of dry forests in north-western Madagascar is the improvement of low and unstable rice yields.

Zusammenfassung

Die Nutzung von wildem Yams zur Nahrungsergänzung und ihr Einfluss auf das Ökosystem der Trockenwälder in Nordwestmadagaskar

Die Bevölkerung der Trockenwaldregion Nordwestmadagaskars nutzt gewisse Arten von wildem Yams (*Dioscorea antaly*, *Dioscorea maciba*) zur Nahrungsergänzung. Die Erntezeit von Yams fällt mit der Periode, in der Reismangel herrscht, zusammen. Obwohl die Reisreserven der Haushalte von Mariarano viel kleiner sind als in Tsilakanina, ernten mehr als 70% der Bevölkerung beider Untersuchungsgebiete Yams in den Wäldern. Die geernteten Mengen bilden für elf bis 28 Tage die Nahrungsgrundlage der Haushalte.

Als lichtliebende Arten sind *Dioscorea spp.* weit verbreitet in Wäldern, die vor kurzem abgebrannt sind. Etwa 65% der von der lokalen Bevölkerung geernteten Menge stammt aus derartigen Waldbeständen. Folge davon ist, dass Wälder niedergebrannt werden, um sie offen zu halten und das Wachstum des Yams zu fördern. Allerdings bringt dieses Vorgehen nur kurzfristig einen Gewinn. Langfristig wird das Ökosystem geschädigt und die Wälder degradieren, was wiederum die Zerstörung des Lebensraums der bevorzugten Arten von Yams zur Folge hat.

Schritte zu einer nachhaltigen Nutzung von wildem Yams sind Landnutzungsplanung, Kultivierung von Yams und Feuerbewirtschaftung. Voraussetzung für eine nachhaltige Bewirtschaftung der Trockenwälder in Nordwestmadagaskar ist die Verbesserung der tiefen und instabilen Reiserträge.

Résumé

L'utilisation d'ignames sauvages comme complément alimentaire et son impact sur les écosystèmes de forêt sèche du nord-ouest de Madagascar

La population de la zone des forêts sèches apprécie certaines espèces sauvages d'ignames (*Dioscorea antaly*, *D. maciba*) en guise de complément d'alimentation. La saison de récolte des ignames coïncide avec la période de soudure (pénurie de riz). Bien que les réserves de riz des ménages du village de Mariarano sont moins importantes que celles des ménages de Tsilakanina, plus de 70% de la population des deux sites étudiés pratique la récolte d'ignames en forêt. Les quantités récoltées constituent l'alimentation de base des ménages durant une période de 11 à 28 jours.

Espèces héliophiles, les *Dioscorea* sont très fréquentes dans les forêts récemment parcourues par le feu. Environ 65% de la quantité récoltée par la population locale provient de ces formations forestières. Ce fait peut expliquer les incendies intentionnels qui visent à maintenir les forêts ouvertes pour faciliter la croissance des ignames.

Cette pratique, cependant, n'est profitable qu'à court terme. A plus longue échéance, les écosystèmes se dégradent, ce qui entraîne la destruction du milieu de vie des espèces préférees d'ignames. Pour assurer l'utilisation durable des ignames sauvages, il convient de promouvoir l'aménagement du territoire, la culture d'ignames et la gestion du feu. L'amélioration du rendement de la culture du riz, faible et irrégulière, constitue une précondition de la gestion durable des forêts sèches du nord-ouest de Madagascar.

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Author

DR. KLAUS ACKERMANN, Lerchenrain 53, DE-04277 Leipzig.
E-mail: klausackermann@web.de.

⁹ Direction Inter-Régionale des Eaux et Forêts.

¹⁰ «Appui à la mise en œuvre de la nouvelle politique forestière».