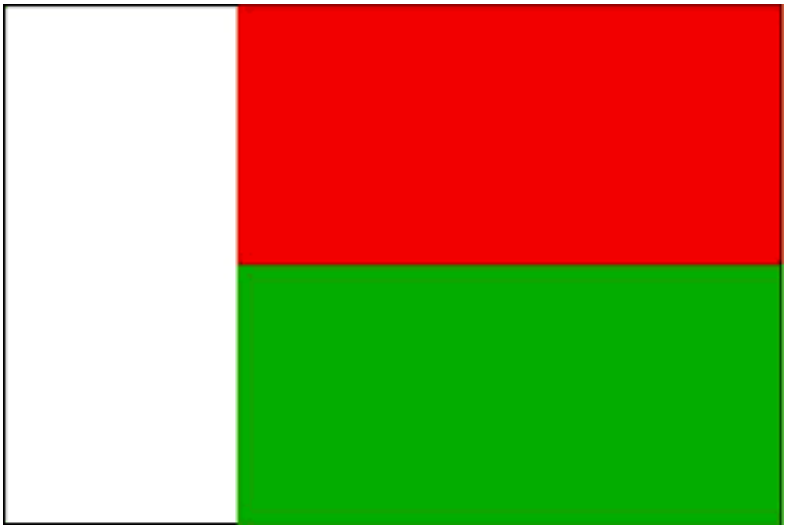
Country Pasture/Forage Resource Profiles

MADAGASCAR



by

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1. INTRODUCTION

Geographical situation and relief

The island of Madagascar is to the southeast of Africa, from which it is separated by the Mozambique Channel. Originally Madagascar was part of the supercontinent Gondwanaland. The island began to break away from the continent about 165 000 000 years ago and arrived in its present position 121 000 000 years ago (Rabinowitz *et al.,* 1983). It lies between 11^0 57 and 25^0 29 S and 43^0 14 and 50^0 27 E (see Figure 1). Its length from north to south is 1,580 km and its greatest width east-west is 560 km. Madagascar has a coastline of 5 000 km and is at the southern limit of the tropics. Its area is 587 041 km^2.

The relief is very broken with the Highlands (above 888 m) which occupy the whole north–south axis with peaks such as Maromokotra (2 876 m) in the north, the Ankaratra (2 643 m) in the centre and in the south the Andringitra (2 658 m). The eastern slopes of these heights fall abruptly to the Indian Ocean. The western versant on the other hand has gentler slopes occupied by great plains that extend to the Mozambique Channel. In these plains flow the longest rivers, which enter the sea by large deltas such as the Betsiboka, the Tsiribihina and the Mangoky.

Figure 1. Map of Madagascar

Population (EPM, 2000) and administration

On an area of 587 041 km^2 the island has about 14 600 000 inhabitants (1999 estimate), which represents a population density of 24.9/km^2. The population is relatively young with 45% below the age of 15. The annual population growth is 2.8%. [According to the World Factbook the July 2006 population estimate was 18 595 469 with a growth rate of 3.03%]. The rural population comprises 77.8%. At national level the population is unevenly distributed with a high density in the highlands, leaving great unpopulated tracts in the occidental part of the country, notably the west and south.

Data collected in 1999 show that 71.3% of the population is classified as poor, with incomes that do not assure a daily ration equal to or in excess of 2 133 calories daily. Among the rural population 76.7% are below the poverty level and 61% are illiterate.

Table 1. Some characteristics of the Independent Provinces

Province	Areas (km^2)	% of national population
Antananarivo	58 283	27.9
Fianarantsoa	102 373	18.7
Toamasina	71 911	15.5
Mahajanga	150 023	13.7
Toliary	161 405	15.6
Antsiranana	43 042	8.6
Total	**587 037**	**100.0**

The main activity is agriculture but it is constituted by a multitude of small exploitations mainly aimed at subsistence. Agriculture is the main income source of the population and that population expends 70% of its income on food. The staple food is rice (consumption estimated at 113.5 kg annually per inhabitant, one of the highest in the world). That foodstuff also absorbs 40% of all food expenditure. Protein of animal origin is consumed at the level of 22.4 kg per inhabitant annually.

Administratively Madagascar comprises six Independent Provinces, the areas and population percentages of which are given in Table 1.

The economy

Madagascar is classified among the world's poorest countries. Nevertheless, during recent years, the macro-economic situation has improved, the growth rate being 6.7%.

The economy is based on a number of classic export products (coffee, vanilla, cloves, seafood etc.) and the income from "booster sectors" (tourism, mines, manufacturing industries oriented to

export). Several factors limit the rapid expansion of the economy, particularly the poor performance of agriculture, difficult access for producers to various markets: the state of the roads is such that farmers prefer to consume their production.

Agriculture

In 2000 agriculture (agriculture *sensu stricto* + forestry +stock rearing) represented about 35% of GDP (Ministère des Finances 1999 – policy letter on Rural Development).

Malagasy agriculture is typified by a multitude of small units (average cultivated area 1.2 ha) that involve several activities (crops and livestock), the products of which are mainly aimed at domestic subsistence (EPM, 2000). Studies made in 1999 show that 91.6 of the stock-owning families practised agriculture (EPM, 2000). Rice is the staple food of the Malagasy population, but yields are stationary at about two tonnes/hectare.

2. SOILS AND TOPOGRAPHY

The geology of Madagascar is in two great groups (Besairie, 1973): the sedimentary rocks which occupy all the coastal zones and comprise one-third of the island; the basement complex on which the highlands rest, or two-thirds of the island.

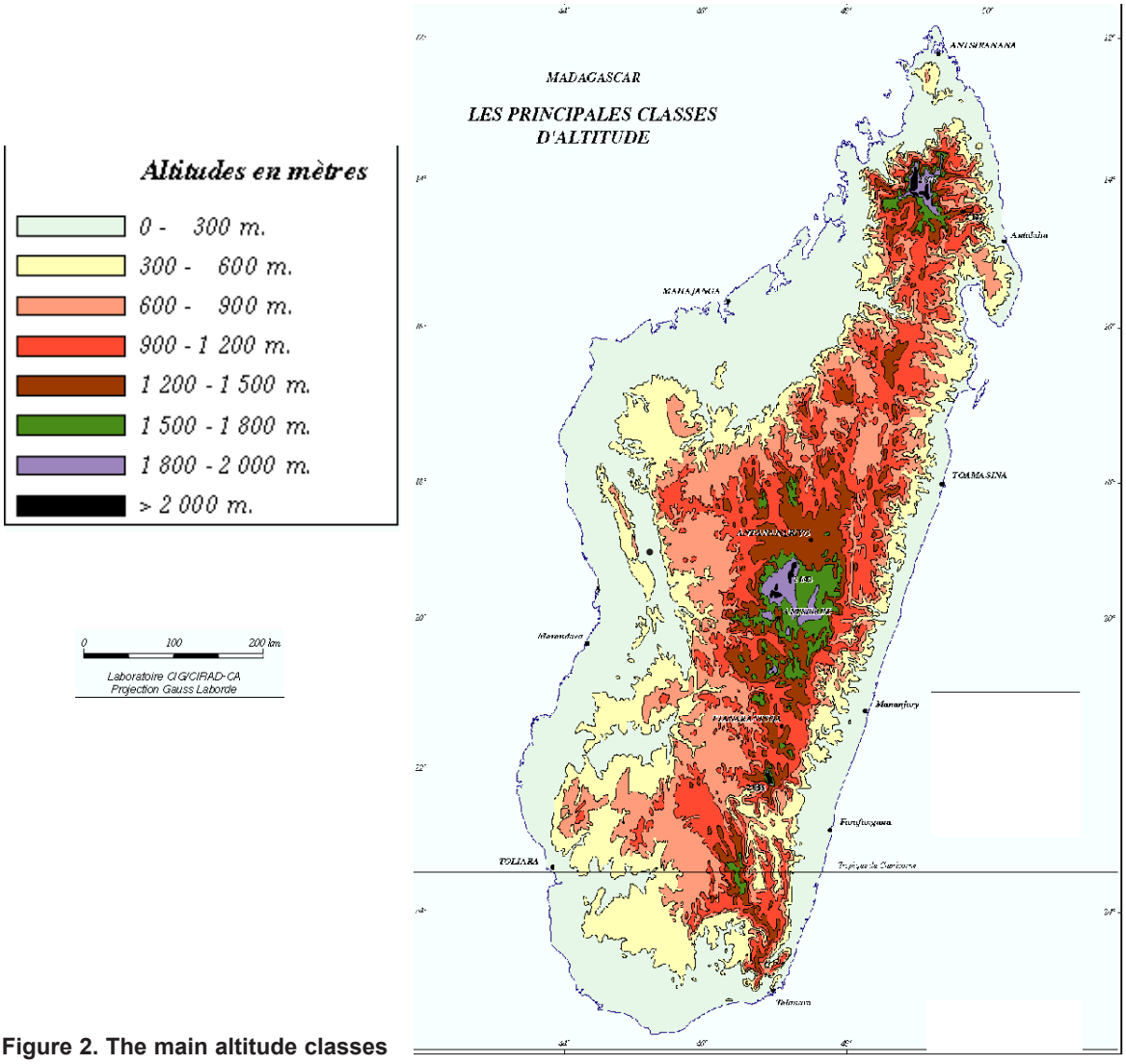


Figure 2. The main altitude classes

The work of Roederer (1971) separates the Malagasy soils into four different types:

(i) The ferralitic soils with several variants according to their parent rock. These are the most widespread soils of the highlands and the east coast. They occupy about 40% of the island.

(ii) Ferruginous tropical soils which cover large areas of the west and the south represent 27.5% of the island.

These two types of soil continue to undergo an erosive process, to different degrees, partly because of their topographic position and also through human activities such as bush fires and clearing of the woody cover.

(iii) Hydromorphic soils, more or less peaty, occupy the bottom lands and are of priority use for rice cultivation (6.5% of the area of the island).

(iv) Alluvial soils, juvenile but very fertile, are found mainly close to the great rivers in the western region (26% of the island).

The importance of erosion

The latest estimates propose figures of 200–400 tonnes of soil per ha annually that are removed by runoff, whereas the world average is about 11 tonnes (EPM, 2000). The majority of the erosive phenomena take place on the topographic areas of the plateaux and slopes that are used for crops or as pastures. This erosion obviously brings about a reduction of soil fertility. The topography of Madagascar is shown in Figure 2.

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

Climate

Madagascar has a unimodal tropical climate characterized by alternating rainy (November–March) and dry seasons (April–October), the lengths of which vary from one region to another. Altitude accentuates temperature differences. The dry season can thus be particularly cool in the highlands where, sporadically, there can be frost (regions of Antsirabe and Ambatolampy).

The East Coast is particularly well watered (over 2 000 mm annually over 11 months). On the other hand the South is notable for its low rainfall (275 mm at Toliary) and a very long dry season The main climatic regions are shown in Figure 3.

During the rainy season, and particularly between January and March, Madagascar suffers the ill effects of several cyclones that are formed either in the Indian Ocean or in the Mozambique Channel.

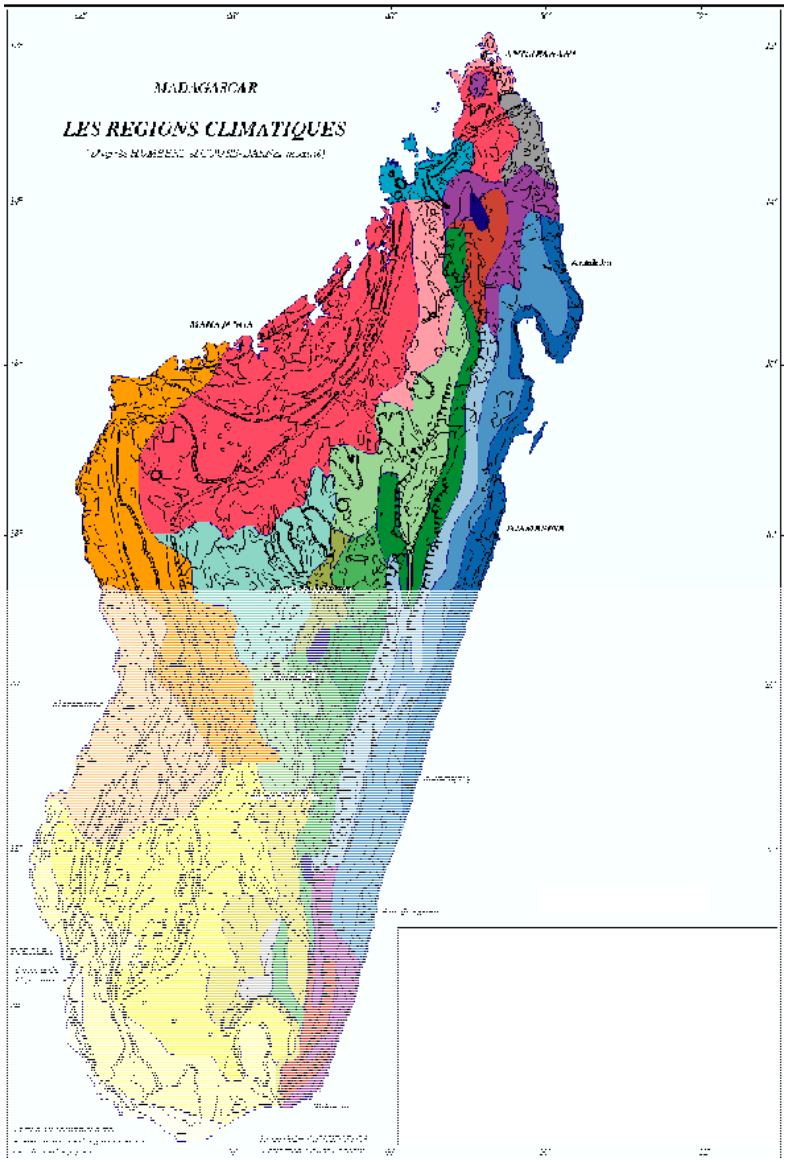
In his study of the characteristics of the island for rice production, Oldeman (1988) has defined five great agro-ecological zones which are shown in Table 2.

Table 2. The main agro-ecological zones of Madagascar

Regions	Number of rainy days annually	Area as% of the whole Island	Notes
East Coast	More than 255	9	East coast excluding the southern Tolagnaro region
High, humid areas	165–255	1	The highest parts of the Ankaratra
Highlands	110–165	36	The central highlands and their western versants above 500 metres
North-West lowlands	75–110	24	The North-West Region including the zone of Lac Alaotra
South-West and South ; low altitude areas	Less than 75	30	The South and South west below a line joining Maintirano to Ambovombe

(Oldeman , 1988)

Figure 3. The climatic regions



PLUVIOMETRIE ANNUELLE (mm)		TEMPERATURE MOYENNE DU MOIS LE PLUS FRAIS				NOMBRE DE MOIS SECS (P < 50 mm)
		t > 20°	15° < t < 20°	10° < t < 15°	0° < t < 10°	
PER-HUMIDE	P > 2 000					3 - 4 1 - 2 0
HUMIDE	1 500 < P < 2 000					5 - 6 3 - 4 1 - 2 0
SUB-HUMIDE	1 000 < P < 1 500					7 - 6 5 - 6 3 - 4 1 - 2
SUB-ARIDE	600 < P < 1 000					7 - 6 5 - 6 3 - 4
ARIDE	400 < P < 600					7 - 6
TRES ARIDE	P < 600					9 - 11

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

The most recent livestock censuses were carried out in 1984 and 1987 (SEDES, 1988. The estimates of Madagascar's livestock numbers in 1999 have been published by the Ministry of Livestock Production and are shown in Table 3.

The trends that this table shows are a serious reduction in the number of cattle, due to several causes. It should be understood that the last real census was carried out in 1997; thereafter figures are based on estimates which have had little field verification. The second cause is the general insecurity in the countryside, which has caused a large number of stock owners to reduce the number of livestock presented for vaccination, and leaving their cattle in a semi-feral state "malia" and thus not figuring in the statistics.

The overall trend that comes out of this table is the reduction in the number of cattle. But this hides a constant increase in the number of cattle kept for milk production, especially in the Highlands as well as zebus kept for draught. In fact farmers, most of whom keep cattle, seem to get a better return from using them for agricultural work (traction and puddling rice fields) than from meat production. Small ruminants have always had a limited role insofar as they are concentrated in the south of the island. (Ranaivoarivelo, 2002).

It can therefore be estimated that each Malagasy, at present, has 0.54 livestock units of domestic stock. If only ruminants are taken into account this becomes 0.51 livestock units per inhabitant.

Livestock data from the FAO databases are given in Table 4. While the downward trend in cattle numbers is evident the numbers are higher in 2004/5, and the sheep and goat numbers appear to have levelled off. Allthough not included in Table 4 numbers for pig stocks are much higher (1.5 M in 1999 and 1.6 M in 2004) while poultry stocks are similar (19 M in 1999, 21.5 M in 2000 up to 24 M in 2004). Beef and veal exports fell away from the mid 1990s.

There are two systems of livestock production: the first is the extensive system which is important in the rural areas; the second, more intensive, predominates in peri-urban regions.

The extensive system dominates the keeping of zebus and small ruminants. It is not exclusively oriented towards a logic of production and marketing, although in some regions a tendency towards commercial exploitation (strategies of buying and selling) and use for agricultural work have been noticed (Ranaivoarivelo, 2002). In fact for the great majority of the rural population in the West and South, having a large herd of zebus is an external sign of riches often allied to a great decision-making capacity. Zebus are also used for agricultural work for puddling rice fields as well as for ploughing and pulling carts to carry goods and passengers.

Table 3. Estimates of livestock numbers

	Census of Ministère de la Production Animale et des Eaux et Forets - SEDES - (1988)	Estimate Ministry of Animal Husbandry 2000
Zebus	9 042 300	5 776 008
Dairy cattle	289 000	500 000
Draught oxen	889 200	1 000 000
Goats	961 571	997 704
Sheep	484 064	541 276
Swine	744 849	432 365
Poultry	18 000 000	21 935 250
Equines		288

Milk production is mainly carried out in peri-urban areas in intensive dual-purpose, milk and dung, systems. During the past decades milk

Table 4. Madagascar statistics for livestock numbers, meat and milk production and milk imports for the period 1996–2005

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cattle nos (,000,000)	10.3	10.3	10.3	10.4	10.4	8.8	7.9	8.0	10.5	10.5
Sheep nos (,000)	756	700	640	590	584	633	655	843	650	650
Goats nos (,000,000)	1.3	1.3	1.3	1.2	1.0	1.2	1.2	1.3	1.2	1.2
Beef and veal prod. (,000 mt.)	146.6	147.3	147.9	147.9	147.9	118.6	111.6	114.8	146.6	146.6
Sheep meat prod. (,000 mt)	2.7	2.6	2.4	2.2	2.2	2.4	2.5	3.2	2.5	2.5
Goat meat prod. (,000 mt.)	6.8	6.6	6.4	6.1	5.3	6.0	6.1	6.1	6.1	6.1
Cow milk prod. (,000 mt.)	515	520	525	530	535	535	535	535	535	535
Milk equiv. imports (,000 mt)	16.1	17.7	11.6	13.7	22.2	11.2	21.0	11.4	20.7	n.r.
Beef and veal exports mt	1 840	609	40	8	8	9	9	0	0	n.r.

Source: FAOSTAT 2006; n.r. no record

production in the highlands has developed to a certain extent because of the conjunction of favourable factors such as the successful genetic improvement of dairy cattle, the availability of veterinary services and supplies, the development of a market in the big , expanding, towns such as Antananarivo and Antsirabe.

For monogastrics (pigs and poultry) the production systems are also very diverse, ranging from extensive ones where the stock are left to find their own food to intensive ones copying those of developed countries. The pig population suffered a dig decrease in 1997–1998 because of an epidemic of African swine fever.

5. THE PASTURE RESOURCE

A large part of Madagascar used to be covered by forest. Now, under the pressure of many, mainly human, factors the forest cover is decreasing rapidly and is now only about 22% of the land area. (Rakotovao, 1998).

The origin of the savannahs has been the subject of numerous studies (Gauthier, 1902 ; Perrier de la Bathie, 1921; Granier, 1967; Morat, 1973 and Koechlin *et al*. 1974). According to some these savannahs have a natural origin, but other authors support an anthropic origin. In the light of more recent work there is a tendency to agree that, before the arrival of humans on the island, there were already some natural savannahs within a mainly forest vegetation. Afterwards, humans arrived and accelerated the extension of the savannahs thanks to their manipulation with the axe and fire.

Measurements made by Faramala (1988) show that the present area of savannah is 387 404 km^2, or 68% of the Island. Most of the savannahs (62%) are in the west and the south. In addition 76% of these grassy areas are below 800 m (Rakotoarimanana, 2002). The main vegetation types are shown in Figure 4.

The grasses of Madagascar's pastures were the subject of an in-depth study by Bosser (1969) that describes 291 species out of the 450 listed in the flora of Madagascar.

Bush fires occur all over the pastoral areas, every year. They have become a common event in savannah regions. It is estimated that on the average 450 000 ha of savannah are burnt yearly. These fires, usually intentional, destroy forests and contribute to an extension of the cleared areas estimated at 300 000 ha annually (Langrand and Wilme, 1995).

Fire control through legislation has been the subject of numerous texts and directives (Bertrand, 1994; Sourdat, 1996). These have not, unfortunately, been able to reduce or stop the practice of pasture burning. Land tenure in the pastoral land is essentially traditional; its management depends, gro*sso modo* on whosoever (or the community) that uses it to graze their livestock. That insecurity of tenure is a factor favouring the continues extensive use of the savannahs.

The fires are most often lit towards the end of the dry season (August to October). Stock-owners are generally blamed for starting these fires since they get some advantage by grazing their zebus on the regrowth after fire. It should, however, be noted that the quantity of regrowth is small and it dries up rapidly because of the general aridity of the environment.

It is late fires which produce a quantitatively interesting amount of fodder for livestock, because they take place just before the rains. Early fires, during the cool season, cannot provide forage for the rest of the dry season except when they are in places with good retention of soil moisture (humid areas) (Ranaivoarivelo and Milleville, 2001).

Intentional fires are also among the strategies used in stock theft to distract the attention of the owners and to hide the tracks of the stolen animals. During the period 1987–1993 the greatest areas burnt were in the provinces of Antananarivo and Mahajanga.

Natural pastures

From the pastoral point of view Madagascar can be divided into six large regions. They do not correspond to the administrative divisions of the autonomous provinces, but are tied to ecological aspects and livestock production systems. The main pastoral regions are shown in Figure 5.

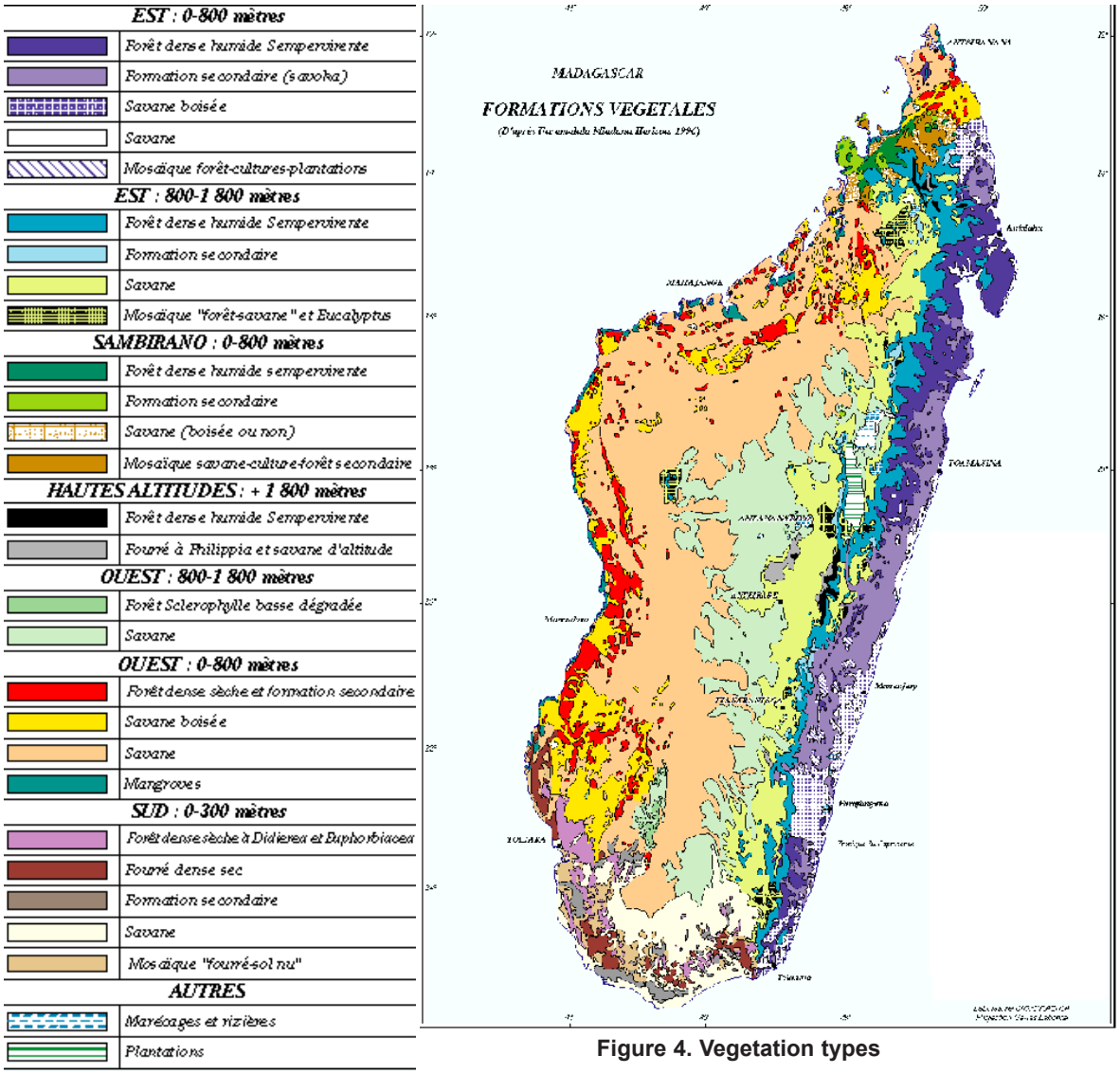


Figure 4. Vegetation types

The North

The region of northern savannahs comprises those found north of a line between Port- Berger (13°34 S; 37°41 E) and Mananara Nord (16°10 S; 19°46 E), always excluding that part beside the Indian Ocean as far as Vohemar which belongs to the Eastern pastoral region. The relief of the region is dominated by the Massif de Tsaratanana which reaches 2 875 m, the highest point in the Island. Cattle rearing is relatively important in this region insofar as Vohemar is one of the ports which exports cattle to the neighbouring islands of Mauritius and Reunion.

Globally the natural pasture exhibits the following characteristics: on the plateaux*Heteropogon contortus* is the dominant species. It can be replaced by *Aristida* in areas subject to severe erosion. At the foot of slopes and on colluvions the two commonest grasses are *Hyparrhenia rufa* and *Hyperthelia dissoluta*. The bottom lands are mainly covered by *Echinochloa* spp. and a retinue of secondary grasses. (IEMVT, 1970; Suttie 1976b).

The North-West

The North-West is essentially occupied by the Autonomous Province of Mahajanga and its southern limit is a line connecting the towns of Maintirano and Ihosy. The general relief of the region is dominated by vast plains at altitudes below 300 m with rounded hills and great rivers the mouths of which often form deltas. The climate is sub-humid tropical. Overall the mean annual rainfall is 1 000 mm and the dry season lasts between 205 and 235 days from mid March to the end of November.

Cattle production is important in this region. This explains why, in 1911, a firm was set up in Mahajanga to handle zebu meat. More recently a slaughterhouse of European standards has been built. The town of Mahajanga is also a port which exports live cattle to the Comoros. Furthermore several projects for development of cattle production have been executed in that region. Dairy production is developing in the immediate vicinity of Mahajanga.

The grass cover of the region is tied to the various topographic sites. Hills with little erosion are covered by the two most widespread grasses in Madagascar: *Hyparrhenia rufa* and *Heteropogon contortus*. In the Maintirano region there are communities of *Urochloa mosambiciensis*.

The eroded hills are covered by grassy vegetation of *Aristida rufescens* or the association *Aristida rufescens* + *Chrysopogon serralatus.* These hilly zones have characteristic formations of the palms *Hyphaene schatan* and *Medemia nobilis*. The base of the lower slopes are covered by three grasses: *Cynodon dactylon, Sporobolus* and *Panicum maximum*.

The zones of seasonal flooding "baiboho" along the rivers have grass cover of *Hyparrhenia variabilis* and *Ischaemum.*

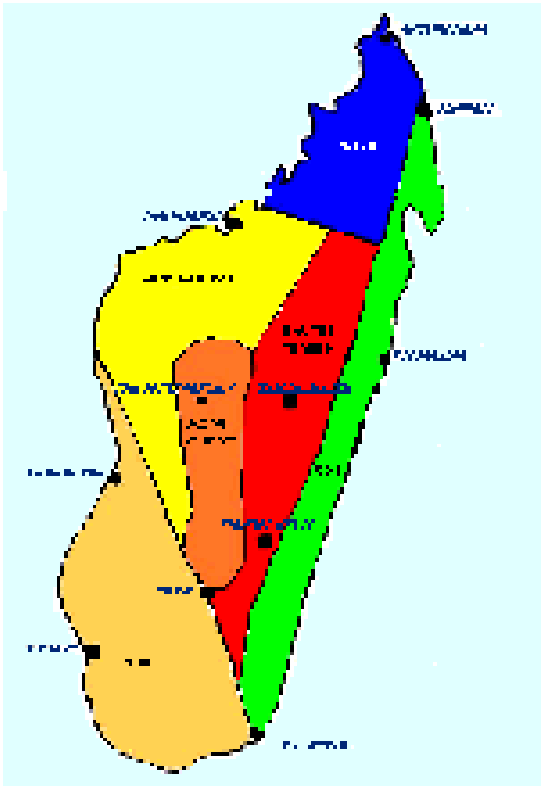


Figure 5. Map of pastoral regions

Productivity of natural pasture in the North West

Two trials have been carried out on North-West pastures to measure liveweight gain of zebus in relation to stocking rate. The first trial was at the State Farm "Sainte-Marie" where the pasture consisted of *Heteropogon contortus* and *Aristida* spp. growing on a red ferralitic soil. The other trial was on the experimental station of Miadana (FO.FIFA) where the pasture is mainly of *Chrysopogon serrulatus* and *Heteropogon contortus* on a grey sandy-clay soil. The trial at Sainte Marie was in 1982 and lasted one season (Rasambainarivo *et al*., 1983). That at Miadana began in 1987 and ended in 1989 (Rasambainarivo and Schmidt, 1990).

The zebus used in the trials were assigned to lots in paddocks according to a set stocking system and remained in the paddocks during the whole season of experimentation. At Miadana the animals were changed each year, at the beginning of the rains. The Saint Marie trial preceded the Miadana one by several years. It served to define the range of stocking rates to be tested at Miadana. This explains the disparity of rates used in the two trials which go from 0.07 to 3 animals per hectare.

These trials showed that, in terms of liveweight gain, stocking rates above 0.75 animals per hectare brought about weight loss of zebus at Sainte Marie, even during the rainy season and the lighter stocking rates used at Miadana allowed weight gains of 3 to 12 kg/ha, although the gains varied greatly with years. At Miadana the best results came from a stocking rate of 0.25 animals/ha although gains varied widely with years. Results recorded during the dry season showed a constant weight loss.

In the light of these results some conclusions can be drawn about the management and productivity of zebus raised on natural pastures in the West:

1. The general productivity of natural pastures, expressed in terms of liveweight gain, is very low. In fact these gains did not exceed 15 kg/ha during the rainy season.
2. The optimum stocking rate may be about 0.23 beasts/ha. Heavier stocking brings about a reduction in weight gain.

The South

This region, by definition, occupies the southern part of the Island. It is between the line Ihosy - Maintirano and Fort-Dauphin. It is the largest of the regions which have been defined. The general

topography is defined by vast plains. From the climatic point of view the region is characterized by low rainfall which is spread over a small number of rainy days. The town of Toliary is the driest with 275 mm of rain over 27 days. There is very great inter-year variability depending on whether or not cyclones pass by. In any case the rainiest months are from December to February. Watering their livestock is a problem for stock-owners between April and November. Water availability is a prerequisite for using the forage resources of the different regions (Toutain and Rasambainarivo, 1997). The sole exception in all that dry area is the town of Fort-Dauphin and its immediate surroundings where the rainfall exceeds 1,500 mm because of its being on the Indian Ocean.

The South is renowned for its big herds of zebus and small ruminants. In fact the majority of the Malagasy sheep and goats are concentrated there. The town of Ampanihy is known for its artisanal weaving of wool. Fort-Dauphin sometimes exports live ruminants. From the socio-cultural standpoint, the zebu occupies a very important place in traditions. The population of the south live in what is called "a cattle civilisation". The zebu takes a place in all the important moments of the life of man from birth to death.

Several authors have made local descriptions. Morat has presented the savannah vegetation of the Horombe Plateau (Morat, 1969) and a very detailed study of the savannahs around Ankazobe (Morat, 1973). An FAO team (Suttie and Hablützel, 1974) have described the dominant pastoral vegetation of the extreme south, from Ankazoabo to Amboasary. Several missions of the IEMVT composed of Granier and Razafindratsita (1970) and Cabanis and Razafindratsita (1971) have described the pastoral vegetation of southern Madagascar. The authors agree that *Heteropogon contortus* is the commonest grass on soils not subject to waterlogging. According to the topographic site and the degree of erosion, some species can dominate, this is the case for *Loudetia simplex* and *Aristida* spp. which occupy degraded slopes. As for *Hyparrhenia rufa, Hyperthelia dissoluta* and *Cynodon dactylon* they occupy low-lying areas which may receive runoff.

Cactus, *Opuntia* spp., are characteristic fodder plants of the south. The original local cactus was destroyed by the intentional introduction of mealy bugs. The cactus which grow there now are resistant (Berte and Suttie 1974, 1975).

The Mid-West

The herbaceous vegetation of this region has been the subject of numerous studies and particularly in the six zones of Belobaka, Ambatomainty, Ambaravaranala and Fenoarivo-Centre with the object of creating the ranches for fattening off grass "Fermes d'Etat Omby".

The plateaux and the gentle slopes are mainly covered by two grasses *Heteropogon contortus* and *Hyparrhenia rufa.* In many places *Hyparrhenia rufa* and *Hyperthelia dissoluta* have fallen prey to more or less serious erosion which has allowed *Aristida* and *Loudetia* to establish themselves. In any case the soil cover of these perennials is quite low and does not exceed 20–40%.

The steep slopes have fewer of the species found on the plateaux and are mainly covered by *Aristida rufescens* and *Loudetia simplex*. The%age of bare soil is high (90%) which indicates serious erosion. The colluvions are covered by *Panicum maximum* and *Hyparrhenia variabilis*.

The wet bottom lands are characterized by their floristic homogeneity. Three grasses dominate: *Leersia hexandra, Cynodon dactylon* and *Brachiaria arrecta* to which are added Cyperaceae, especially in the most peaty areas. (Granier, 1965; Granier and Lahore, 1967).

Granier (1967) distinguished two possible types of evolution of the pastures of the Mid-West. On one hand a regressive evolution under the influence of repeated burning. It favours the disappearance of *Hyparrhenia* spp. and *Heteropogon* to the benefit of *Aristida* spp. and *Imperata.* The inverse evolution, called progressive, is the consequence of protection (no fire and minimum access of livestock) and results in the development of woody vegetation and the plateaux being overgrown by bush. The yield of biomass on the plateaux is less than that on the bottom land and colluvions. In addition six cuts can be made on colluvions against two or three on the plateaux.

In a system of pasture exploitation for the plateaux without inputs of fertilizer, Gaulier *et al*. (1967) recommended on one hand mowing in late March or April to make hay and on the other hand rotational burning in the dry season with a period between the fire and the entry of livestock which should only take place when the regrowth is 35 cm high.

The stock owners of the Mid-West practise a traditional fattening of zebus on pasture which is commonly called "dabokandro" which lasts between six months and three years.

Many trials have shown that, in the dry season, the natural pasture of the plateaux cannot meet the maintenance needs of cattle. This means for some a loss of body weight which can go to 25%. For others, more vulnerable, it can be so serious as to lead to death (de Reviers 1970). Large seasonal weight fluctuations (about 60 kilos liveweight for males and 40 for females) have also been recorded in the Sakhara region. And that despite feeding conditions which were considered satisfactory taking into account the supplementation of dried savannah grazing with forage taken from low-lying areas or in the forest (Ranaivoarivelo, 2002).

During the rains liveweight gains can vary between 30 and 120 kg per animal. It has been shown (Rasambainarivo *et al*., 1984) that the extensive system allows weight gains of 41 to 98 kilos of liveweight per head.

The Highlands

The natural pasture in the highlands is mainly the herbaceous cover of the hills of which the most constant genera are *Aristida*, *Loudetia*, *Ctenium*, *Elionorus* and *Trachypogon*. They are characteristic of eroded and degraded soils (Granier and Bigot, 1971; Bigot, 1977). The bottom land and the colluvions are generally more fertile; they carry a herbaceous vegetation of grasses such as *Cynodon, Leersia* and *Axonopus* and some Cyperaceae. These bottom lands play an essential role for the survival of cattle because, in the dry season, they are the only place where the vegetation is palatable. On the other hand they provide conditions which favour the development of the giant liver fluke (*Fasciola gigantica*) and for the infection of cattle therewith. This parasite is one of the most serious scourges of cattle raising in Madagascar.

The sub-region of Lake Alaotra

The pastures of Alaotra have been the subject of numerous studies (Gaston, 1988). Savannah vegetation covers the various catchments which surround the lake. It is usually a grass savannah which shows serious soil degradation. Thus *Aristida multicaulis* dominates the plateaux and the slopes. It can in many places form a monospecific formation. In other, less degraded areas *Hyparrhenia rufa* and *Heteropogon contortus* share the space with *Aristida multicaulis* . As everywhere else on the Malagasy pastures two main factors favour the degradation of the environment: bush fires repeated annually and the topography which accelerates erosion.

In certain places on the "*tanety"* (uncultivated hillsides) *Pteridium aquilinum* forms well- delimited patches in pure stands. All the studies agree on the rapid and regressive evolution of this natural pasture. The areas under *Aristida multicaulis* get larger and the clumps of grass become rarer leaving bare soil which can be up to 60–80% of the total (Gaston, 1988).

On those colluvions and bottom lands which have not been transformed into paddy fields the dominant grasses are *Cynodon dactylon*, *Digitaria humbertii* and *Leersia hexandra*.

Sub-region of the Central Imerina and the Vakininkaratra

The Central Imerina comprises the area around Antananarivo, the capital, whereas, further south the Vakininkaratra is centred on the town of Antsirabe. That region has a high altitude tropical climate with the wet and dry seasons having about equal length. The dry, cool season begins in April and ends in October; then rain is rare but there are drizzles and precipitation in the form of dew and mist.

In addition temperatures are low. Frost occurs between July and August in areas above 1 200 m and can last from 2 to 40 days. The low temperatures is an additional limiting factor for the growth of tropical forages which explains the use of forages from temperate countries (oats, ryegrass) grown in the off season after the rice harvest in April–May.

Cattle husbandry in the Central Imerina and Vakininkaratra shows more signs of intensification and integration with crop production. Milk production there is more important than in the rest of the island. Milk sales are an important source of income for smallholders. There are numerous milk-related industries and artisanal dairies. The dung produced is mainly used to fertilise paddy fields and rice straw is fed to the cattle. Intensive fattening of zebus is practiced for various family festivals. However, for reasons of security and expense this fattening is done less and less.

The East

The dominant vegetation is evergreen forest with quite large areas of savannah. The natural pastures of that region have been described by Kuehn (1957) and Solaja (1969). The natural pasture of the hills is composed mainly of two grasses *Hyparrhenia rufa* and *Aristida rufescens*. After repeated fire the *Hyparrhenia* tends to disappear in favour of *Aristida rufescens*. Because of this *Aristida* pastures occupy ever increasing areas. That floristic succession is also a sign of advanced degradation of the pasture land. Thus the quality of the natural pasture is determined by the reduction of the soil fertility which can only support grasses of low feeding value.

Alluviums and colluvions occupy very limited areas and the grasses which grow there have a minor fodder role. The pastures are composed of *Hyparrhenia rufa*, *Cynodon, Stenotaphrum dimidiatum, Axonopus compressus, Paspalum conjugatum*; the last three are known in the vernacular as "ahipisaka" (flat grass).

Artificial pastures and fodder crops

The first importations of cultivated forages took place in the nineteen-forties. These introductions were in the highlands around Antananarivo in private dairy farms. Since 1964 many observations and trials have been carried out by various research institutions such as FOFIFA, FIFAMANOR, l'IEMVT, l'IRAM, l'ORSTOM, and L'université de Madagascar. Initially the work was concentrated in the highlands, but later the various institutions introduced fodder species to all the ecological zones of Madagascar (Borget 1962, Borget 1971, Delhaye and Granier, 1966).

It is difficult to have an exact number of the fodders which have been imported and tested under different ecological conditions. It is however possible to give a rough figure of 200 different plants combining grasses, legumes and forage trees and shrubs. Tables 5 and 6 list the grasses which have been tested and show their adaptation to the various zones. These trials have been carried out on plots of very different sizes and

Table 5. Forages/grasses introduced to Madagascar and their adaptation

	Regions where tested					
Grasses	**North**	**North-west**	**South**	**Mid-west**	**High-lands**	**East**
Andropogon gayanus		+++		+		
Arrhenatherum elatius					++	
Avena sativa				++	+++	
Brachiaria brizantha	+++	+++	+++	+++	+++	+++
Brachiaria mutica	+++	+++		+++	+++	+++
Brachiaria ruziziensis	+++			+++	+++	+++
Cenchrus ciliaris	+++	+++	+++	+	++	
Cenchrus setigerus (2)		+++		+		
Chloris gayana	+++	+++	+++	+++	+++	
Chrysopogon serrulatus		+++				
Coix lac rima jobine		++				+++
Dactylis glome rata					+	
Digitaria decumbens			-	++		
Digitaria smutsii					++	
Eragrostis curvula	+++	+		+	++	
Eragrostis tef					+++	
Eragrostis chloromelas	+++					
Eragrostis superba	+++					
Euchlaena mexicana	+++					
Festuca arundinacea					+	
Lolium multiflorum					++	
Lolium perenne					+++	
Melinis minutiflora	+++	++	+++	+++	+++	+++
Panicum antidotale	+++					
Panicum maximum		++	-	++	+++	
Panicum purpurescens	+++					
Panicum trichocladum	+++					
Paspalum conjugatum				+		
Paspalum dilatatum					++	
Paspalum plicatulum				+++		
Paspalum virgatum	+++	+		+++		
Pennisetum cland estinum				+	+++	
Pennisetum purpureum	+++	+++	+++	+++	+++	+++
Phalaris aquatica					++	
Phalaris arundinacea					++	
Phalaris tuberosa					++	
Phleum					+	
Saccharum procenum					++	
Setaria anceps =sphacelata)	+++	+	+	+++	+++	+++
Setaria splendida				+++		
Sorghum spp			+++		+++	
Sorghum almum		+++				
Sorghum bicolor (5)		+++				
Sorghum sudax		+++				
Tripsacum laxum		+++		+++	+++	+++
Triticum (fourrage)6/16					+++	
Urochloa mosambicensis		++		+		
Zea mays			+++	+++	+++	+++

Legend: + poorly adapted; ++ moderately adapted, +++ very well adapted

over longer or shorter periods according to the authors. In fact only about a dozen plants have shown themselves to be truly adapted under different conditions and have been taken up by dairy farmers.

Grasses for the rainy season

Most of the cultivated fodders are those which are installed, and exploited, during the rainy season; this is the case for perennial tropical grasses like *Pennisetum purpureum, Tripsacum laxum (andersonii?), Chloris gayana, Setaria anceps* and *Brachiaria brizantha*. These are grown on non-flooded land. In the Highlands where arable land is scarce the big grasses *(Pennisetum purpureum* and *Tripsacum laxum)* are the best known.

Pennisetum purpureum is the most widely grown plant. Two clones are well known and the oldest is "Collet Rouge" which has by definition a red collar at the insertion on the leaf sheath as well as urticaceous hairs on its leaves. That variety has been dropped in favour of "Kizozi" (Granier 1971) which is noticeably less urticaceous. In fact *P. purpurem* is used for other purposes than fodder; it is known for its capacity as protection against erosion - it is grown on field margins and terrace banks on crop land to reduce soil loss.

Establishment of the big grasses is usually by cuttings and a placed dose of manure at the base of each cutting. Later a dose of manure is given annually. Yields vary according to climate, and soil moisture.

Tripsacum laxum is more demanding in moisture supply. It is mainly grown on bottom land for optimal production. The big grasses are rarely grazed directly but cut and fed to the stock.

Chloris gayana is well suited to the conditions of the highlands (Huynh-Van-Nhan, 1971) and is usually grown for haymaking because of its rapid early growth.

Table 6. Fodder legumes tested in the different regions

	Regions where tested				
Legumes	**North**	**North-ouest**	**South**	**Mid-west**	**High-lands**
Aeschynomene americana	+++				
Calopogonium muconoïdes	+++	+			
Canavalia ensiformis	+++				
Canavalia gladiata				++	++
Centrosema brasilianum				+	
Centrosema plumieri	+++			+++	+++
Centrosema pubescens	+++	+++			+++
Clitoria ternatea	+++				
Desmodium intortum			+	+++	+++
Desmodium lasiocarpum	+				
Desmodium s et wicense				+	
Desmodium uncinatum				++	+++
Dolichos lablab	++	++		+++	
Glycine soja			++		++
Lablab niger			+++		
Leucaena leucocephala (5)		++			
Lotononis bainesii				+	+
Lotus corniculatus					+++
Macroptilium atropurpureum		+++		+++	+++
Macrotyloma axillare				+++	++
Macrotyloma uniflorus		+		+++	
Medicago sativa					+
Mucuna utilis	+++	+++	+	+++	+++
Neonotonia wightii (2)			+	+++	+++
Phaseolus ricciardianus				+++	
Phaseolus aureus			+		+++
Phaseolus lathyroïdes				+++	
Phaseolus lunatus				+++	
Pisum arvense				+	
Pisum sativum					++
Psophocarpus palustris				+++	
Pueraria phaseoloïdes	+++	+++		+++	+++
Pueraria thumbergiana				+++	
Soja hispida				+++	
Stylosanthes bojeri		++			
Stylosanthes guyanensis	+++	+++	+	+++	+++
Stylosanthes hamata		+++		+++	
Stylosanthes humilis		+++	+++	+++	
Stylosanthes scabra				+++	
Stylosanthes subsericea				+++	
Trifolium hybridum					++
Trifolium incarnatum					+
Trifolium pratense					++
Trifolium repens				+	+++
Trifolium semipilosum					+
Vicia faba				+	
Vicia sativa				++	++
Vigna unguiculata	+++	+++	+++	+++	+++

Legend: + poorly adapted; ++ moderately adapted, +++ very well adapted

Setaria anceps , Brachiaria brizantha (Granier and Lahore, 1966) and *B. ruziziensis* (BDPA, 1963) have been used in several ways. Because *B. brizantha* is very difficult to eliminate if it precedes rainfed crops like rainfed rice, stock owners who do such cropping avoid growing it.

Melinis minutiflora has been grown and distributed in some parts of the highlands (Albengue, 1971) and Lac Alaotra (Birie - Habas, 1961; Razakaboana 1967, 1969, 1970), but it is little used nowadays.

The only annual grasses grown in the rainy season are maize (*Zea mays*) and sorghum (*Sorghum* spp.)

(Rasambainarivo *et al*. 1980), they are mostly used for making silage for dairy farms of a certain size. Trials of feeding silage to zebus have been successful (Rasambainarivo *et al*. 1980) but the economic conditions were not favourable for its use in the farms of the Mid-West.

Off-season grass production

This technique is at present only used for milk production in the highlands. The forages most widely grown are oats and ryegrass. Granier and Razafindratsita (1970) showed that it was possible to grow green fodder in the middle of the dry season through off-season cropping of rice fields in the Antananarivo region. Since these trials it has become clear that oats is a fodder crop of prime importance for dairy producers (FIFAMANOR, 2000).

The technique consists of preparing the fields rapidly, immediately after rice harvest to profit from residual moisture while using some supplementary irrigation. Oats are well adapted to the dry season, which is also the cool season. Oat fodder is only used green; it is very rarely grazed in view of the small size of the plots grown. Three to five cuts can be made on the same plot through the season and yields vary with the fertilizer supplied. The commonest fertilizer is urea which also has a residual effect on the following rice crop. It has been observed that too high fertilizer use can lead to excessive vegetative growth of the following rice, which is undesirable.

Sorghum (*Sorghum bicolor*) has been grown experimentally on receding flood water on the "baiboho" of the western region (Granier and Bigot, 1970). The results obtained have given liveweight gains of 602 kg/ha. for the four months of exploitation of this kind of pasture (Rasambainarivo *et al*., 1980).

Fodder legumes

Fodder legumes are of relatively recent utilization compared to the grasses. The most detailed studies and extension activities have been in the Mid-West with *Stylosanthes guianensis*, between the nineteen sixties and 1980. The work of Granier and Lahore (1966), Granier (1970, 1971, 1973) and Granier *et al*. (1972) tried to determine the most favourable factors for establishing *Stylosanthes guianensis* to improve natural pasture. The authors recommended reduction of competition from the natural vegetation by burning and light cultivation of the soil before sowing the legume. *S. guianensis*, particularly the cultivars 'Endeavour' and 'Schofield', were very successful in the Mid-West during the years 1970 - 1980. State farms and private individuals grew *Stylosanthes,* either in pure stand, (Rasambainarivo and Rakotozandrindrainy, 1980), or for improving natural pasture. Towards the mid nineteen-eighties anthracnose appeared and destroyed the artificial pastures and natural pastures improved by that plant. At present some cultivars more or less resistant to the disease have been established.

In the drier areas of the south *Stylosanthes humilis* and *S. hamata* were tested and used in extension work (Suttie and Hablutzel, 1974; Suttie, 1976, 1977).

Under several ecological conditions in the western regions *Macroptilium purpureum* 'Siratro' and *Pueraria phaseoloides* 'Kudzu' (Capitaine *et al*., undated) showed themselves to be well adapted.

Generally legumes are very useful plants for feeding livestock during the first part of the dry season. It is for this that they are now recommended following livestock production trials (Rasambainarivo 1979 and 1980).

The means needed to install and maintain a pasture of legumes are much greater than those necessary for grasses. This is a major limiting factor for their large-scale adoption. The other constraint is connected to area: a legume pasture requires an area relatively greater than the big grasses. Now, farmers only have limited land to devote to fodder production. Lastly the plots of improved pasture are not usually fenced and for that reason farmers are reluctant to invest for a communal use.

Grass-legume mixtures have been tried and have shown promise (Rasambainarivo, 1980). Nevertheless the management of this kind of pasture has shown itself to be complicated.

Multipurpose shrubs

The use of shrubs as fodder began in the dry regions of the south (the Androy zone) with several cultivars of *Atriplex nummularia* and *A. canescens* which showed themselves to be well adapted (Suttie and Berte, 1974).

More recently in the Mid-West and the Highlands (Rasambainarivo and Razafindratsita, 1991), several trials have shown the utility of shrubs as supplements for cattle during the dry season. Under various

conditions the most interesting plants are *Leucaena leucocephala, L. diversifolia, Calliandra calothyrsus, Acacia mangium,*and *Albizia falcataria.* The recommended establishment method is transplanting young nursery raised plants aged 3–4 months. After 18–24 months the bushes can be harvested and yield 600–650 grams of dry matter per bush and per year in two or three cuts (Rasambainarivo *et al*. 1993).

Sundry fodders

Several unconventional plants have been introduced for use as fodder, especially roots and tubers. They are intended for dairy cattle at the end of the rainy season and the first half of the dry season. The plants best adapted are radish, turnips *(Brassica rapa*) and beet *(Beta vulgaris*). The areas under these plants are still small compared to grasses and legumes. The farmers who grow them are in the zones where FIFAMANOR is active. A recent evaluation estimated that 32.5% of stock owners in these zones grow fodder roots. The total of 41 farms studies were growing a total of 81 ares of roots (FIFAMOR 2000).

In the south of the island, the driest region, cactus *(Opuntia ficus indica)* has been grown for various purposes. The work of Berte and Suttie, 1974 ; Hablützel and Suttie, 1975 and Suttie 1976, 1977) showed that the crop is very interesting, but its adoption on a large scale clashes with the still very extensive production systems of the region and the different priorities of the herders who are often confronted with problems of drought.

Crop residues

Rice straw is the most readily available crop residue and the most used as ruminant feed. Urea treatment of straw was the subject of research work financed by FAO and other development activities. The technical and economic advantages of the technique have been demonstrated in station (VERO) and on farm (PSE) several of which took it up. Nevertheless the practice has come up against several constraints of which the main are the extra work involved in transporting the straw from the field to the cowshed, the high price of urea, the small increases in milk production which the treatment brings compared to alternatives such as growing oats or ryegrass in the off season.

The question has been asked on several occasions about the technical and economic effectiveness of urea either for straw treatment or for fertilizing fields of oats or ryegrass on out-of-season rice fields. The responses show an advantage for its use as fertilizer which has a residual effect on rice grown after oats.

Fodder conservation

Fodder conservation is limited to a few dairy farms. A survey in the highlands in 1993 showed that 11% of small dairy farms make hay and 4% make silage. The most commonly made hay is from natural herbage (Gaulier *et al*., 1967) from *Chloris gayana* or oats.

Silage has been the subject of trials on finishing zebus during the dry season. Technically the Madagascar zebu responds well to intensive fattening with silage (Rasambainarivo *et al*., 1980).

Fodder seed production

FIFAMANOR is now the only organization which produces and supplies pasture seed on a permanent basis. It is based in Antsirabe (Rakotondramanana *et al*., 1988). The production of recent years is shown in Table 7.

It should be noted that oats is very much in demand by farmers but their needs cannot always be met because of disease problems. Seed is sold at relatively high prices and some farmers try to produce cheap seed but often its quality is doubtful.

Table 7. Recent evolution of fodder seed production in kg at FIFAMANOR

Forage	1997	1998	1999
Oats	82 000	2 000	Black rust
Chloris	385	700	1 400
Bracharia	620	0	200
Setaria	52	100	655
Ryegrass	617	700	878

(Source FIFAMANOR report 1999)

6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

The areas of savannah and natural grazing in the Island are relatively large in relation to its ruminant livestock. Thus extensive rearing is the commonest management system. In this context stock rearers adopt a traditional method of rearing and profit to the maximum from the phenomenon of compensatory growth of livestock at pasture. The great majority of attempts to improve natural pasture have been technical successes, but have not lasted because of mainly socio-economic factors. In fact rearing zebus remains a traditional system which is not oriented towards commercialisation of its products and the grazing areas are still under communal use and nobody has any interest to improve them. The technology which seems the most suitable in some cases would be the installation of "protein banks" of fodder shrubs for some classes of stock during the dry season. But, in any case, the legal status of the land requires a suitable solution.

Within the general framework of environmental protection "protected areas" have been installed. The management of grazing lands within these areas requires studies combining technical and socio-economic aspects.

Fodder production, on the other hand, is developing well in dairy farms in peri-urban zones but on small areas in proportion to the small farm size. Technical improvements and assuring adequate production of dry season fodder require solutions which would favour milk production.

7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

Pasture and fodder research is undertaken by several institutions of which the most important are FOFIFA, FIFAMANOR, le CNRE and l'Université d'Antananarivo.

FOFIFA (National Centre for Applied Research in Rural Development) has a mandate for all agricultural research at national level. The Department of Veterinary and Zootechnical Research (DRZV) of FOFIFA is, among other activities, in charge of matters concerning natural and artificial pasture as well as animal nutrition in general. Fodder collections are maintained at the Regional Research Centre of Lake Alaotra and seeds can be produced.

FIFAMANOR is an institution with joint Norwegian and Malagasy funding; it is mainly concerned with developing milk production in the Vakininkaratra and the Highlands.

The Université d'Antananarivo and the National Centre for Research on the Environment (CNRE), among other activities, are mainly concerned with university teaching and studies on natural pastures.

Although the biological information does not yet cover the whole pastoral area entirely, it can be affirmed that there is a lot of biological and social information about the pastures. However, we have less information on their economics. If the totality of information recounts work based on trials and studies, very little information is available which would allow modelling to forecast the bio-economic impacts of a management system on the general environment of men and on nature.

The future of Malagasy agriculture and its escape from its present poverty are conditional on activities to increase productivity and rationalise use of natural resources. In the field of pastures and ruminant production, more intensive and systematic activity should be undertaken by multidisciplinary teams.

It must be kept in mind that a real development of fodder production and grazing livestock can only be realised if the stock owners and all partners feel a real willingness to increase their income, in a favourable economic environment.

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