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Caractérisation de la diversité de peuplements arborés dans les agroforêts à café d'Haro (Mana Woreda de Jimma Zone) Ethiopia

(Characterisation of the Trees Diversity in the Agro-forests of Coffee of Haro(Manna Woreda of Jimma Zone, Ethiopia)
(Under program "Biodivalloc" of IRD in Ethiopia)

For obtaining Diploma of Masters GEEFT with speciality FRT

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TABLE OF CONTENTS

List of Figures and Tables

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Integrated land use systems such as agroforestry are believed to enhance agricultural sustainability due to the intimate association between a multitude of crops, trees and livestock which provide various ecological and economic benefits. The traditional agroforestry home gardens of South Western Ethiopia are one such stable agro-ecosystem which supports a very dense population of up to 400 persons per km2. These systems have contributed to improvements in food security, regional and national economies and environmental resilience. However, they have generally been less studied. An in-depth analysis on the components of the systems and how they function is important in order to propose options for their improvement. The present study, which aims at analyzing the diversity and composition of trees species in the systems, is believed to contribute towards the filling of this gap.

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ABSTRACT

Ethiopia located in Horn of Africa is a country with greatly varying landscapes ranging from high mountains to deep gorges and incised rivers to rolling plains and it is one of 25 top biodiversity rich countries but there were not many studies on the agroforests of coffee of Ethiopia. This study was conducted in agroforests of Haro, in Mana Woreda of Jima Zone. In this study we have found that coffee agroforests in this area are two major types of agroforests (1) Mature coffee Agroforests which have been developed either from natural forests or from agriculture or grazing land which was natural forest a long ago and has changed to agriculture or grazing land and (2) Young Agroforests i.e. being developed from agriculture or grazing land. Among Mature coffee agroforests there are two types of agroforest on basis of shade tree canopy (1) Mix canopy type and (2) *Acacia+Albizia* type. The analysis of these types have shown a great difference between tree diversity and structure of the tree stand, as in A+A type only 6 tree species were found while in Mix canopy number of species found was 29 with significant difference in density/ha. Furthermore we saw a variation in occupation of coffee forests with changing altitude and found that more coffee agroforests are found in range of 1600-1800m and it starts decreasing with the changes in these limits.

The livelihood of the farmers of Haro area highly depends on coffee and management of coffee agroforests is resulting in conservation of tree diversity but change towards specific canopy type threatens diversity and according to this study a sustainable method of management should be evolved and adopted for betterment of diversity and farmers as well.

RÉSUMÉ

LÉthiopie située dans la Corne de l'Afrique est un pays avec beaucoup de paysages variés allant des hautes montagnes avec des gorges profondes et des rivières à des plaines ondulantes et est l'un des 25 principaux pays riches en biodiversité, mais il n'y avait pas beaucoup d'études sur les agroforêts à café d'Ethiopie. Cette étude a été réalisée dans les agroforêts de Haro, Woreda de Mana de la zone de Jima. Dans cette étude, nous avons trouvé que les agroforêts à café dans cette région ont évolué de deux façons (1) agroforêts mature évolué de forêt naturelle ou des champs et patûrage qu’il était forêt naturelle il y a long temps, et (2) agroforêts en construction c'est-à-dire développant à partir de les champs ou des pâturages. Parmi les agroforêts mature à café il y a deux types de agroforêts sur la base des arbres de l'ombrage (1) la canopée Mélangé et (2) *Acacia + Albizia* Type de agroforêts. L'analyze de ces deux types ont montré une grande différence entre de la diversité de l'arbre et la structure de la forêt, comme dans A + A type seulement 6 espèces d'arbres ont été trouvés par contre dans la canopée mélangée 29 d'espèces a été trouvé et aussi la différence sur densité/ha des arbres. En outre, nous avons vu une variation de l'occupation du café à l'évolution des forêts d'altitude et a constaté que plus les agroforêts du café se trouvent dans l’altitude de 1600-1800m et il commence à la baisse avec l'évolution de ces limites.

Les conditions d'existence des agriculteurs de la région d’Haro dépendent fortement sur le café et la gestion des agroforêts café se traduit par la conservation de la diversité des arbres, mais le changement vers des canopée type menace la diversité et en fonction de cette étude une méthode durable de gestion devrait être développé et adopté pour l'amélioration de la diversité et les agriculteurs aussi.

1. GENERAL INTRODUCTION

1.1 Background

This research project is a part of the main project named BIODIVALLOC (**Biodiversité et instruments de valorisation des productions localisées**) which refers to promotion of traditional ecological knowledge (TEK). TEK is being considered with increased interest at the international level, as a way to involve local populations in biodiversity management and conservation. When associated to local productions and recognized by national and/or international authorities through labels, it is seen as an asset to support local communities' development and to protect the landscapes and ecosystems on which they rely. Among the more promising institutional tools are geographical indications (GI), eco-certification, fair trade labels and park trademarks (IFP 2006). BIODIVALLOC has to analyse the local perceptions and management regimes of biodiversity, and evaluate how those tools can adapt to them and integrate local concerns while satisfying the global objective of conserving the cultural and biological diversity. The project has also to identify the relevant elements for managing biodiversity that need to be accounted for to implement those schemes properly, propose indicators for decision making processes at the local and national levels, support their adaptation to local objectives and contexts, and enable their monitoring. The BIODIVALLOC (Biodiversity and Valuation Tools for Localised Productions) project spans over 6 countries (Brazil, Ethiopia, India, Niger, Senegal and South Africa). It will compare the findings with other 6 field studies, where the development of such schemes ranges from emerging strategies and early identification process to actual implementation of labels. (IFP 2006)

1.2 Biodiversity & Biodiversity Conservation:

The term biodiversity is used to convey the total number, variety and variability of living organisms and the ecological complexes in which they occur (Rosenzweig, 1995) while floristic biodiversity is referred to the number, variety and variability of the flora. Biodiversity is valued and has been studied largely because it is used, and could be used better, to sustain and improve human well-being (WCMC 1994). However, there has been a rapid decline in the biodiversity of the world during the past two to three decades (Whitmore and Sayer 1992; Whitmore, 1997). Recently, conserving biodiversity in a wide variety of ecosystems has become a major environmental and natural resources management issue of national and international importance (Salwasser 1991; Angermeier and Karr 1994; Lovett *et al*., 2000). It is consequently essential to study not only diversity in perfect environments but also the impact of alternative uses and management practices on biodiversity to conserve as much as possible where disturbance and deforestation cannot be prevented and, where possible, to improve the conservation value of areas already overexploited. So for the purpose of conservation of the biodiversity for the welfare of human being it is firstly required to know and characterise it and this research is being conducted to fulfil this purpose.

In view of the growing threat to biodiversity, the now it is time to regard the Earth's biological resources as assets to be conserved and managed for all humanity. Conservation and sustainable use of these resources can prolong the services and functions they provide to human beings. According to Kumar (1999), there are three global objectives of biodiversity conservation. These are: (1) to maintain essential ecological processes and life-support systems, (2) to preserve genetic diversity, and (3) to ensure the sustainable utilization of species and ecosystems. In addition, biodiversity needs to be conserved as a matter of principle, as a matter of survival and as a matter of economic benefit.

Ethiopia, located in the Horn of Africa, is a country with greatly varying landscapes ranging from high and rugged mountains, flat-topped plateaus, deep gorges, and incised rivers to valleys and rolling plains. These diverse physiographic features have contributed to the formation of diverse ecosystems characterized by great species diversity. According to WCMC (1994), Ethiopia is one of the top 25 biodiversity rich countries of the World. The flora of Ethiopia, for instance, is estimated to comprise between 6,000 and 7,000 higher plant species (Cufodontis' 1953-1972 in Senbeta 2006; Gebre- Egziabher 1991) and about 10 –12% of these are estimated to be endemic to Ethiopia (Brenan 1978; Thulin 1983; Gebre-Egziabher 1991 in Senbeta 2006). In general, the forest areas of Ethiopia have a high biodiversity and are of considerable economic and ecological importance to the nation.

Ecological and historical studies have demonstrated the dramatic human influences on the forest vegetation of Ethiopia. The main driving forces behind deforestation are the expansion of agricultural land, unrestrained exploitation of forest resources, overgrazing and establishment of new settlements into forested land coupled with increasing population pressure. As a result, forest biodiversity is disappearing rapidly in the forest landscapes of Ethiopia (Sanbeta and Denich 2006).

1.3 Agroforestry & Diversity in Agro-forests:

Agro-forestry is a dynamic, ecologically based, natural resources management system that, through integration of trees on farms and agricultural landscapes, diversifies and sustains production for increased social, economic, and environmental benefits for all land users at all levels (World Agro-forestry Center 2003). Agro-forestry can also be viewed as a strategy to overcome the lack of success in past tree planting by providing opportunities for both food and tree production on the same unit of land, thus reducing competition for this scarce resource (Bishaw and Abdelkadir 2003).

Agro biodiversity could be considered a delineated part of biodiversity referring to the functional use of biological resources for agricultural purpose. In this context, biological resources comprise crops and animal species that are directly related to productivity but also life supporting species such as worms maintaining proper soil characteristics and bees for pollination (LNV 2002).

It is believed that most of the agro-forests in Ethiopia have evolved from forests and situated on high altitudes ranging from 1500-2300 m. Farmers built them by keeping upper storey trees and clearing the undergrowth to open up space for planting, coffee and other crops. Partial harvesting of the upper storey trees may also takes place to obtain wood and to create favourable growing condition for the other crops. Most of the forests are used up and there is increasing shortage of land. In situation of shortage of forest land as most of the forests have already been converted, some farmers are observed to convert their plot of grazing land into multi-species complex systems (Abebe 2005).

Coffea arabica L. is found natively in afromontane rainforests of Ethiopia. In the forest wild *C. arabica* is found as under storey plants, local farmers, traditionally manage the forest for coffee production, which focuses on the reduction of the density of trees and shrubs in order to improve the productivity of the wild coffee plants. The level of management ranges from little or none in the undisturbed forest coffee to significant in the agroforest coffee systems. Although these coffee management systems have been in existence for many years, there is limited information concerning their relative influence on forest biodiversity (Fayera, 2006).

The problem of coffee forest management, from a biodiversity point of view, has been its tendency to reduce the variation in natural forests, leading to homogenization of the age, size and species composition of the forests, consequently reducing species diversity. In view of the above, understanding coffee management and its effects on the forest biodiversity are necessary for the sustainable management of the forest. Therefore, a comprehensive analysis of the ongoing coffee forest management is helpful in elucidating the extent of its influence on the coffee. Keeping this situation in view we have formulated this study with the basic objective of characterisation of the tree stand diversity in agro-forests of Haro zone and for attaining this objective some specific objectives are set which are given as follows:

- To verify the typology set by Hubert De Forest and Adou Yao in program of project BIODIVALLOC in 2006 and 2007 at Bonga and Jimma and establish new typology (if needed) in the agro-forests of the area of Haro (Manna Woreda of Jima zone).

- To characterise tree structure and diversity associated to these coffee agro-forests of Haro.

- To compare this diversity structure of coffee agro-forests with the diversity structure of the natural forests of the same region (if possible).

2. Material & Methods:

2.1 Study Site:

This study was conducted in the Regional State of Oromiya of Ethiopia which is the largest region of the country in Haro Administrative zone (Kabélé) in District (*Woreda)* of Mana situated in Jima Zone (as shown in Fig. 1). According to Statistical Abstract (2002) of Jimma zone, it has an area of approximately 19,300 Km². The zonal capital, Jimma town is 335 Km southwest of Addis Ababa. Altitude in the zone varies from 880 to 3,340 m above sea level; the topography includes mountains, dissected plateaux, hills, plains, valleys and gorges. There are several perennial rivers and intermittent streams. The Zone is classified into three agro-climatic zones: Kolla (14.9% - lowlands); Woinadega (64.4% -mid Highlands); Dega (20.5% - highland). High forest, woodland, riverine, shrubs and bush, and man made forests are all found in the zone. Rainfall variation across the whole zone is between 1200 and 2400 mm per year, with a long rainy season from February/March to October/November. Of the 13 Woredas of Jimma Zone: Goma, Mana, Limmu Seka and Limmu Chekrosa woredas are known as predominantly coffee growing areas. Mana Woreda (district) is the smallest district in the zone and is situated approximately 30-40 Km from Jimma town. Mana woreda is found in central parts of the zone. It has an area of 480Km² and one urban centre, Yebu town, the district capital. It lies between 1,470 and 2,610m altitude. It is classified in to Dega(12%), Woinadega (63%) and Kolla (25%) agro-climatic zones. It is most densely populated district in the zone, at 308 persons per Km². Actual population is estimated at 132,358. Average rainfall is 1,467 mm per year. According to data collected from Haro administration office (2007) it is situated between 7°46.5 and 7°51.5 in North while 36°40 and 36°42 in East and has a population of about 7324 habitants in 2005. It is situated about 35 Km from Jima town and about 6 km from Yebu town which is woreda capital. It has annual rainfall of 1467 mm/annum with a minimum and maximum temperature of 13°C and 24.8°C respectively. It occupies loamy soils with production of coffee, cereals and vegetables. Coffee accounts for 80% of the production. It has a total area of 1342.52 ha out of which 801 ha of area is occupied with coffee. Haro kabélé is administratively divided into 15 “Eders” which are Gijaab, Al Katama, M/ Saffar, D/Saffar, Kullo Saffar, Mantina, Inkullu, Kharioo, Gobuu, Kobi, Machara, Manyoo, Qawahii, etc. which has their own committees for administration.

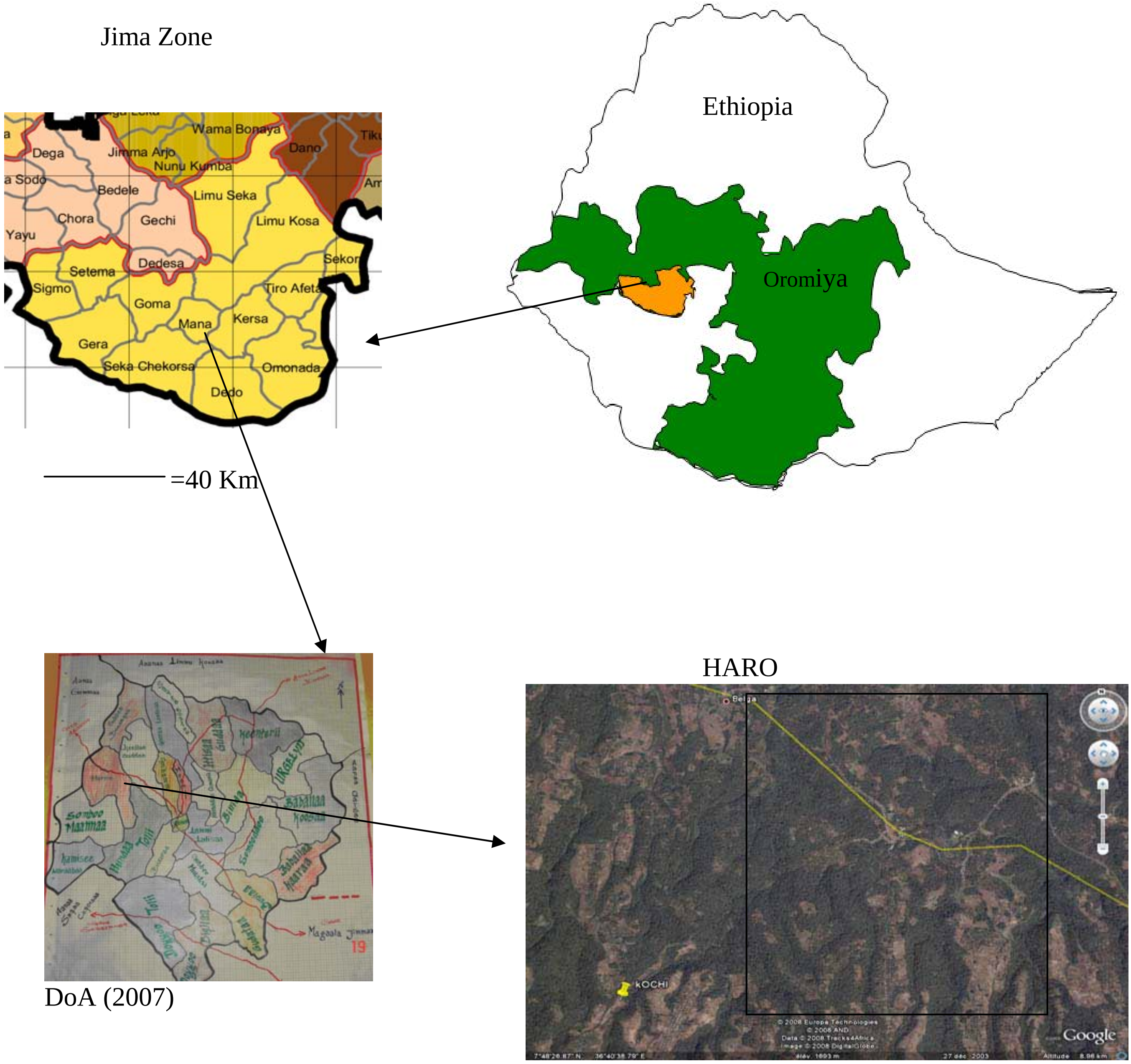


Figure 1: Description of Study Site

2.2 Methodology:

The study was carried out between May and August 2008 in the agroforests of Haro. This research was conducted in three phases. First phase was about to verify the typology established by Hubert De Foresta and Adou Yao in 2006 and 2007 near Jimma and as well as to establish new typology if neede. Prior to vegetation sampling, a reconnaissance survey accompanied by interviews to know about the questions like “since how long these forests are present”, “how these forests have evolved in the area”, “are they increasing or decreasing with time now” etc. was carried out in the area to identify the major forest types harboring coffee for one and half month accompanied with Antonin Cancino a French student working on diagnostic of agricultural systems in the same area. For this purpose we have visited almost 100 km² area centred at Haro with about 5Km in each direction to understand the different types of agroforests as well as study zone and finally due to difficulty in access routes and weather after discussing with Hubert De Foresta it was decided to concentrate on a zone of about 60Km² between *Urgessa* and *Wanja* rivers, where *Urgessa* forms the frontier between Mana Woreda and Gomma Woreda.

In month of June vegetation sampling from these agroforests was started for characterization of these agroforests and for this purpose 15 agro-forests were selected randomly to make inventories for characterization of these mature agroforests after establishing and verifying typology of Hubert and Adou. For this selection tree stand diversity and management practices were taken into account as well as origin of the agro-forest. On the basis of our typology we have selected randomly 5 parcells of Acacia+Albizia type canopy cover as it is very specific type with no other trees in the agro-forest making tree stand very homogenous. On the other hand we have chosen 10 mix canopy agro-forests on random choice method.

In third phase to find the change in presence of coffee agroforest with altitude we made 5 transects as our zone of study lies between almost 1500-1900m altitude a.s.l. These transects were made in descending order i.e. from higher altitude to lower altitude. And in these transects we made inventories in the all mature agro-forests which we found in these transects.

2.3 Data Collection:

For this research we had used the "variable space" sampling method (Sheil et al, 2003). This method allows characterizing the structure and composition of flora in the parcels rapidly. Briefly this method uses multiple applications of small and easy to apply variable –area subunits in which area is defined by simple and objective rules. Compared with any fixed area approach the sample unit is quick and easy to apply even in difficult terrain, and the amount of information collected varies little with stem densities. Further, it can not be extended to arbitrary size, but remains compact, allowing data to be linked to local site variables. This method is a modification of variable-area transects method. In this method we use short variable transect cells directed sideways from a central baseline and in each cell of width 'w', a maximum and minimum length 'L_{max}' & 'L_{min}' and number of maximum trees to be sampled 'r_{max}'will be fixed and further sampling will be done as follows:

- If horizontal distance L_{min} is travelled without having any tree the cell will be scored as empty.
- If at least one tree is encountered before reaching L_{min}, and some maximum number of trees 'r_{max}' is counted before reaching a maximum horizontal distance 'L_{max}', the cell will be recorded as containing 'r_{max}' trees, and its length is recorded as the distance from the centre-line to tree r_{max}.

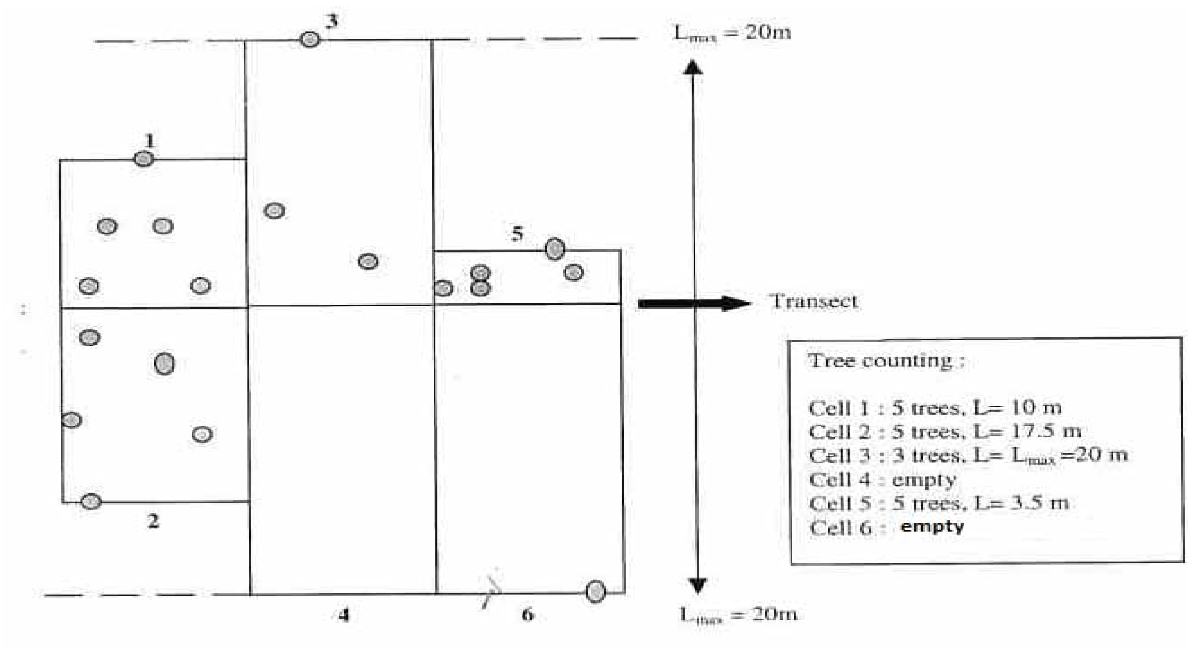


Figure 2: Variable space sampling method (From Sheil et al, 2003)

- If L_{max} is reached before r_{max} trees have been counted, then sampling will be stopped and the cell will be recorded as containing the number of trees counted so far, and its length is recorded as L_{max}.

For qualitative data and determine the history of the area and the dynamics of agro-forestry interviews of the farmers and coffee growers were done which enabled us to establish the typology of the agro-forests in the region.

2.4 Data Analysis:

After data collection we had established a typology of the agro-forests of coffee on the basis of interviews, personal observations and also reviewing literature.

The quantitative data is subjected to analysis for structural parameters such as densities of trees and also coffee, basal area, distribution on basis of diameter class.

While for diversity parameters data is analysed for species richness, evenness, Shannon diversity index and Importance Value of species were calculated.

Species richness is a biologically appropriate measure of alpha (α) diversity and is usually expressed as number of species per sample unit (Whittaker 1972). The Shannon diversity (H') and evenness (E') indices are calculated as a measure to incorporate both species richness and species evenness (Magurran 1988). The Shannon diversity index (H') is calculated from the equation:

$$H= - \sum P_i \log P_i$$

Where pi, is the proportion of individuals found in the i^{th} species. The values of Shannon diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Magurran 1988). Evenness (E') was calculated from the ratio of H to $\log N_0$, where $\log N_0$ indicates the inverse of total number of species found.

$$E = H/ \log N_0$$

Where Importance Value is the Sum of Relative Dominance (Rdom), Relative Density(R dens) and Relative Frequency(R freq).

3. Results & Discussion:

3.1 Forest Typology:

After having a deep observations and making interviews with the farmers in Haro Kabélé we came to develop following two major types of agro-forests:

- Mature Agro-forests: In this type of agroforests the farmers have either cultivated coffee by clearing the small shrubs and herbs on ground to provide place and facilitate growth of but keeping old big trees intact as the shade trees for coffee or a long ago it was cultivated or grazing lands which were formed by cutting forests. In this type of forests we have found species like *Albizia, Acacia, Milletia, Sapium, Vernonia* etc
- Agro-forests on Building (Young Agro-forests): These are the agro-forests which are being established in the agricultural or grazing land with passage of time. The methodology for agro-forests on building is that farmers plant trees of *Sesbania sesban* before planting coffee whose main use is mainly to provide shade to coffee as it is very fast growing. But there are a lot of farmers who use *Croton macrosatychus* as well as a tree for shade because *Sesbania* is a very fast growing tree but with a very short life period of 7-10 years, comparing *Croton* is a little slow growing than *Sesbania* but it has a long life. But with passage of time farmers change these shade trees with others. We can find *Albizia, Acacia, Croton, Cordia* type of species in this kind of Agro-forests.

In addition to these two major types established on the basis of age of the agroforest there were found two different sub-types of agroforests on basis of management and canopy tree basis in mature agroforests as our study is only related to the mature agroforests, which we define as following

- Acacia + Albizia canopy type: In this type of agroforests we have found almost only presence of *Acacia abyssinica* and *Albizia sp.*, or sometimes only *Acacia abyssinica* or only *Albizia sp.* with some *Croton macrosatychus.* In this type of forests there is no diversity of shade trees have been found as they have mostly 2 species with mostly only two layers of canopy, the upper layer comprising of Acacia or Albizia while the Second layer comprising of Coffee with herbaceous cover on ground.

- Mix Trees canopy type: In this type of agroforests we have found a canopy cover comprised of different big and medium trees sometimes with a little number of shrubs also forming 2-3 canopy layers in agroforest. First layer having big and old trees like *Prunus africana*, *Trichilia emetica*, and also *Croton macrosatychus*. While second layer is made of young planted or regenerated *Croton macrosatychus*, *Cordia africana*, and sometimes *Albizia sp.* also, with third layer of coffee having herbaceous cover on ground. In this type of agroforests we can find *Croton macrostychus*, *Cordia africana*, *Prunus africana*, *Milletia ferruginea* and also sometimes *Acacia abyssinica* and *Albizia sp*.

Mix Canopy Agroforest

A+A Type Agroforests

On having these two distinct types of agroforests on basis of canopy trees, we had developed a hypothesis that either there is any difference of production between coffee agroforests under Acacia + Albizia canopy type or Mix trees canopy type. For this purpose we have made interviews focusing on the hypothesis and we found a clear difference of production between Acacia + Albizia and Mix tree canopy type of agroforests.

3.2 Vegetation Structure of Agroforests:

Most plant communities consist of a large number of species and hence it is not possible to include all species in a survey. Only trees of >5cm diameter were used for the present structural analysis. The objectives of the study are to evaluate the community structure of the tree stand.

3.2.1 Density and basal area:

(a) Big Trees >10cm DBH

The total basal area per hectare and densities of big trees for these two types of agroforests are compared in Table 1. The highest density of trees was recorded in mix canopy type agroforest which was 212.0 individuals/ha while for A+A type maximum density calculated was 81.3 individuals/ha with a median of 93.75 and 62.5 individuals/ha respectively. The lowest density of big trees for mix canopy type and A+A type agroforests was calculated 43.8 and 31.3 individuals/ha. The average basal area per ha for mix canopy and A+A type agroforests is 18.9 and 17.2 m²/ha respectively, with minimum and maximum of 8.9 and 30.2 for mix canopy and for A+A is 13.5 and 22.5 respectively (Table 1).

Table 1: Density and Basal area of Trees DBH> 10cm

Characteristics	A+A Type	Mix Canopy
Total Plots	6	19
Min. Tree Density/ha	31.3	43.8
Max. Tree Density/ha	81.3	212.0
Median of Density/ha	62.5	93.75
Min. Basal area/ha	13.5	8.9
Max. Basal area/ha	22.5	30.2
Average Basal area/ha	17.2	18.9
Average Density of coffee	4354	3595

(b) Small Trees 5cm<DBH<10cm

The total basal area per hectare and densities of small trees for these two types of agroforests are compared in Table 2. The highest density of trees/ha was recorded in mix canopy type agroforest which was 118.8 individuals/ha while for A+A type maximum density/ha calculated was 25 individuals/ha with a median of 37.5 and 6.3 individuals/ha respectively. The lowest density of small trees for mix canopy type and A+A type agroforests was calculated zero ndividuals/ha. The average basal area per ha of small trees for mix canopy and A+A type agroforests is 0.19 and 0.02 m²/ha respectively, with minimum of 0 for both types and a maximum of 0.6 and 0.06 m²/ha for mix canopy and A+A type respectively (Table 2).

Table 2: Density and Basal Area of Small Trees

Characteristics	A+A Type	Mix Canopy
Total Plots	6	19
Min. Tree Density/ha	0.0	0.0
Max. Tree Density/ha	25.0	118.8
Median of Density/ha	6.3	37.5
Min. Basal area/ha (m²)	0.0	0.0
Max. Basal area/ha (m²)	0.06	0.6
Average Basal area/ha (m²)	0.02	0.19

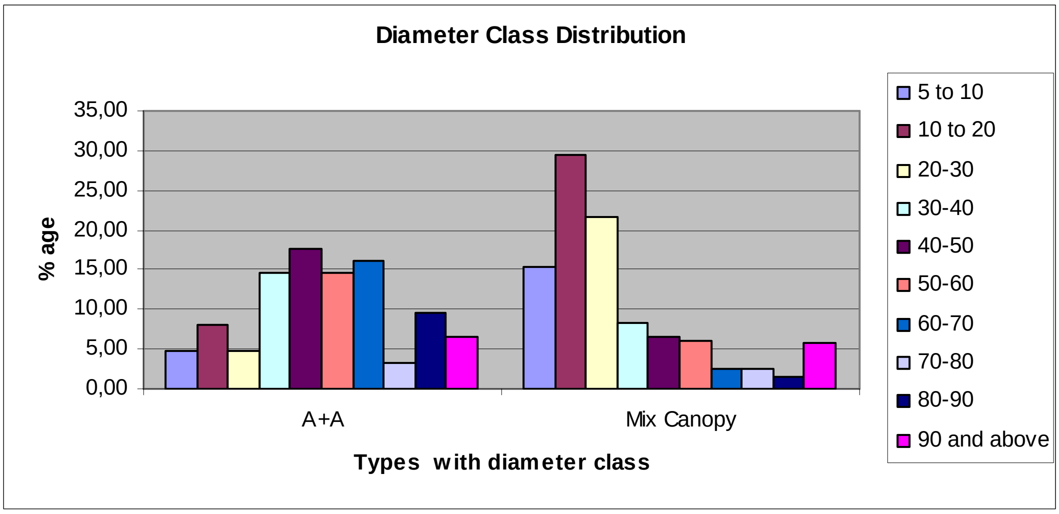
The results shown above indicates on basis of density and basal area analysis that mix canopy type agroforests have significant difference for tree density/ha but on the same time density /ha of coffee is small for mix canopy while it is high for A+A type, which may indicate that in A+A type coffee has taken place of the trees resulting small density/ha for trees. For small trees we can see there is a significant difference between densities in both types which we can refer to abundance of coffee as well as in A+A type coffee is more abundant resulting less regeneration of trees and resulting in small densities.

3.2.2 Distribution on Diameter Basis:

(a) Mix Canopy:

In this type of agroforests a considerable amount of trees was found in the small diameter classes as upto 30cm there is 66% individuals, while 22% in average class diameter while a few were found in the large diameter class (Fig. 3) with maximum diameter of 160.7 of *Prunus africana* followed by *Albizia schimperiana* of 156.9. The patterns of diameter class indicate the general trends of population dynamics and recruitment process. This type of pattern is called as inverted J type diameter class pattern in which most of the individuals are found in the lower diameter class.

Fig 3: Diameter class Distribution



(b) A+A Type:

While for A+A type of agroforests diameter class distribution shows that most of the individuals were found in the middle diameter class i.e. 63% between 30-70 cm diameter, while only 18% in small class and 19% in big diameter. The maximum diameter in this class recorded was 125 for *Albizia schimperiana*, followed by *Acacia abyssinica* of 102 cm. This type of distribution of diameter is called as Bell shape distribution in which most of the individuals are found in middle diameter class with a little number of individuals in small or large class diameter.

The patterns of diameter class distribution indicate the general trend of population dynamics and recruitment processes of species in an agroforest. For diameter class distribution we can see that mix canopy type agroforests have an inverted J-type distribution which clearly indicates that most of the individuals are found in small diameter class with some in average and very few in large diameter class, while for A+A type agroforesrs diameter class distribution was of Bell-type, which indicates that most of trees are found in middle class diameter while having almost no regeneration and also a few in large diameter class.

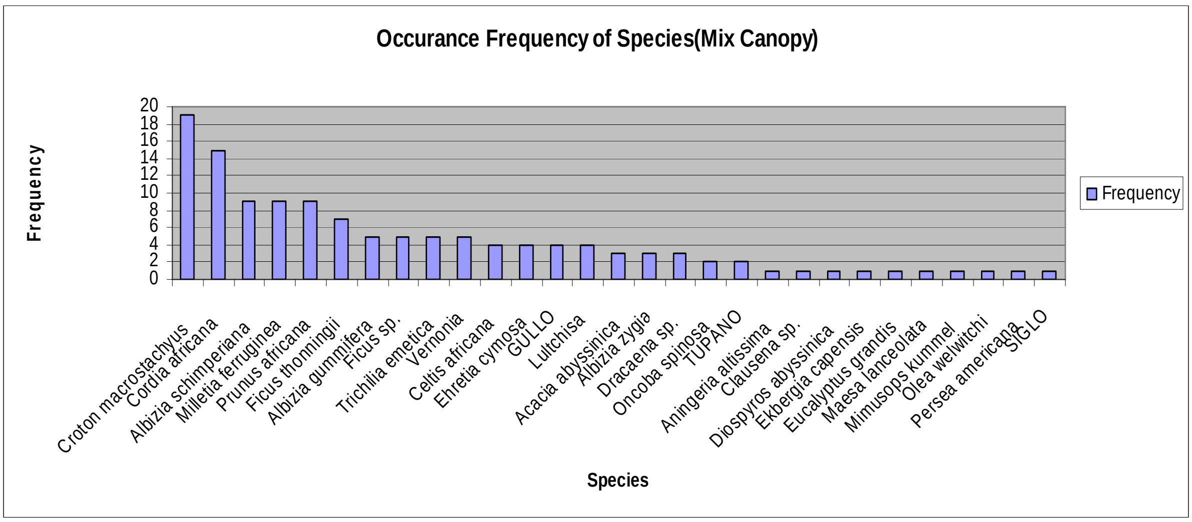
3.3 Floristic Composition of Agroforests:

3.3.1 Occurance Frequency of Species

(a) Mix Canopy

In total 29 tree species were recorded in the coffee agroforestry systems of Haro. Frequency of occurrence of the species across these agroforests was rather variable (Figure 4) but considering mix canopy agroforests we can find that only one species was found in all the agroforests i.e. *Croton macrostychus* while five species were found in nine agroforests out of 19 sampled. *Croton macrostychus* was the most frequent species occurring in 100% of the mix canopy farms. It is followed by *Cordia africana* (79%), *Milletia feruginea* (47%), *Albizia schimperiana* (47%). On the other hand, 10 tree species were rare each occurring only in one of the farms. Out of the total number of species, only 10% were exotic while the remaining 90% were indigenous.

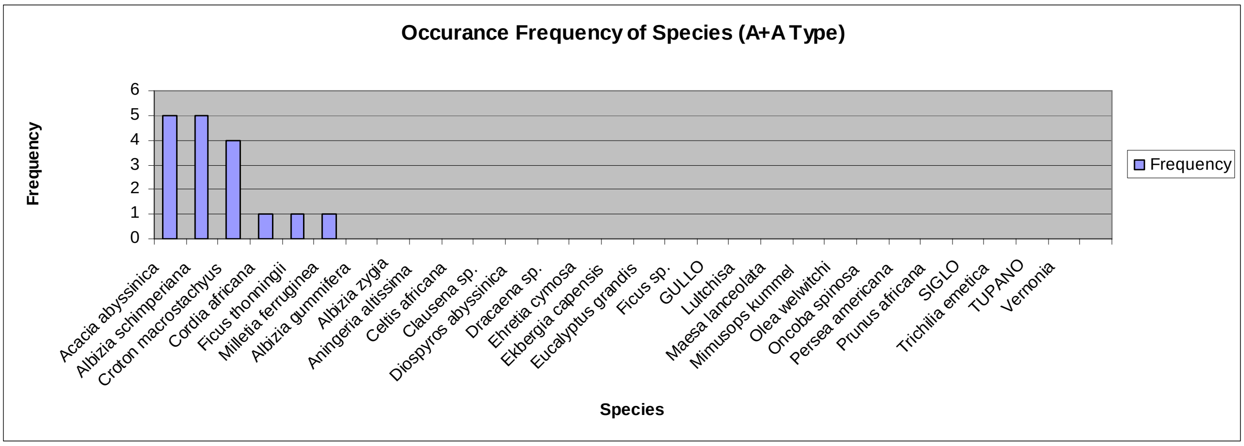
Fig 4: occurance frequency (%) of species (Mix Canopy)



(b) Acacia +Albizia Type:

In case of Acacia+Albizia type of agroforests no much number of species were found as it is especially managed agroforests with *Acacia sp., Albizia sp.,* or both species at the same time as shown in the figure below. In this type of agroforests *Acacia abyssinica* and *Albizia schimperiana* were found in 5 samples each out of 6 Agroforests measured, followed by *Croton macrostychus*, which was present in 4 agroforests out of 6 measured. With this there are some traces of *Cordia Africana*, *Ficus sp.* and *Milletia ferruginea* also found.

Fig 5: Occurance Frequency (%) of Species (A+A Type)



These results indicate a significant difference of species present in both types of agroforests, which may be referred to deliberate selection of species by cutting non-desirable trees which results in homogenous structure of agroforest.

3.3.2 Importance Value of Species:

Importance value of a species is referred to the sum of relative dominance (R dom), relative density (R dens) and relative frequency (R freq) of the species, where R dom is calculated by dividing basal area of species / total basal area of all species * 100. R dens is calculated by dividing number of individuals of that species / all individuals * 100. R freq is calculated by frequency of species / sum of all frequencies * 100.

(a) Mix Canopy:

In mix canopy agroforests the maximum importance value of 61.8 was calculated for *Croton Macrosatychus* followed by *Albizia schimperiana* with a value of 35.13 and *Cordia africana* with a value of 28.69.

Table 3: Importance Value of species (Mix Canopy)

Species	R dom	R Dens	R freq	I.V
Acacia abyssinica	15,42	3,88	2,362205	21,66
Albizia gummifera	4,21	8,01	3,937008	16,16
Albizia schimperiana	20,81	7,24	7,086614	35,13
Albizia zygia	0,00	0,52	2,362205	2,88
Aningeria altissima	1,09	0,26	0,787402	2,14
Celtis africana	0,56	1,03	3,149606	4,74
Clausena sp.	0,00	0,26	0,787402	1,05
Cordia africana	6,03	10,85	11,81102	28,69
Croton macrostychus	15,83	31,01	14,96063	61,80
Diospyrous abyssinica	0,16	0,26	0,787402	1,21
Draceana sp.	0,37	1,03	2,362205	3,76
Ehretia cymosa	1,33	6,46	3,149606	10,94
Ekebergia capensis	1,41	0,26	0,787402	2,45
Eucalyptus grandis	1,02	0,26	0,787402	2,07
Ficus sp.	0,66	1,29	3,937008	5,89
Ficus thoningii	7,10	1,81	5,511811	14,42
*GULLO**	0,16	1,29	3,149606	4,60
*LULTCHISA**	0,15	2,07	3,149606	5,36
Maesa lanceolata	0,02	0,26	0,787402	1,06
Milletia ferruginea	2,89	10,59	7,086614	20,58
Mimusops kummel	0,06	0,26	0,787402	1,11
Olea welwitchi	1,68	0,26	0,787402	2,73
Oncoba spinosa	0,79	0,52	1,574803	2,88
Persea americana	0,03	1,29	0,787402	2,11
Prunus africana	14,38	4,39	7,086614	25,86
*SIGLO**	0,08	0,52	0,787402	1,38
Trichilia emetica	3,71	1,81	3,937008	9,45
*TUPANO**	0,04	0,52	1,574803	2,14
Vernonia	0,00	1,81	3,937008	5,75

***** Species non identified

(b) A+A Type:

In A+A type of agroforests only 6 species were found in which *Acacia abyssinica* has the highest importance value of 153.97 followed by *Albizia schimperiana* with a value of 82.3 (Table 4). These values clearly shows the dominance of these two species in this type of agroforests

Table 4: Importance Value of Species (A+A Type)

Species	R dom	R dens	R freq	I.V.
Acacia abyssinica	60,62	63,93	29,41	153,97
Albizia schimperiana	31,58	21,31	29,41	82,30
Cordia africana	4,56	1,64	5,88	12,08
Croton macrostachyus	2,78	9,84	23,53	36,14
Ficus thonningii	0,00	1,64	5,88	7,52
Vernonia sp.	0,00	1,64	5,88	7,52

3.3.3 Shanon Diversity Index and Evenness:

For mix canopy trees we had a total species of 29 while in A+A type we found a value of 6 because it was a very specific homogeneous type of agroforests. While for Shanon Index maximum diversity index of 1.07 was found for mix canopy type of agroforests while for A+A it was very low as 0.54 which indicates that mix canopy agroforests have more diverse nature as compared to the A+A type of agroforests. Regarding evenness factor in mix canopy and A+A types agroforests have 0.732 and 0.583 which indicates that species distribution is also more in mix canopy agroforests as compared to A+A type but still probability of having all species found in respective agroforests is high (Table 5).

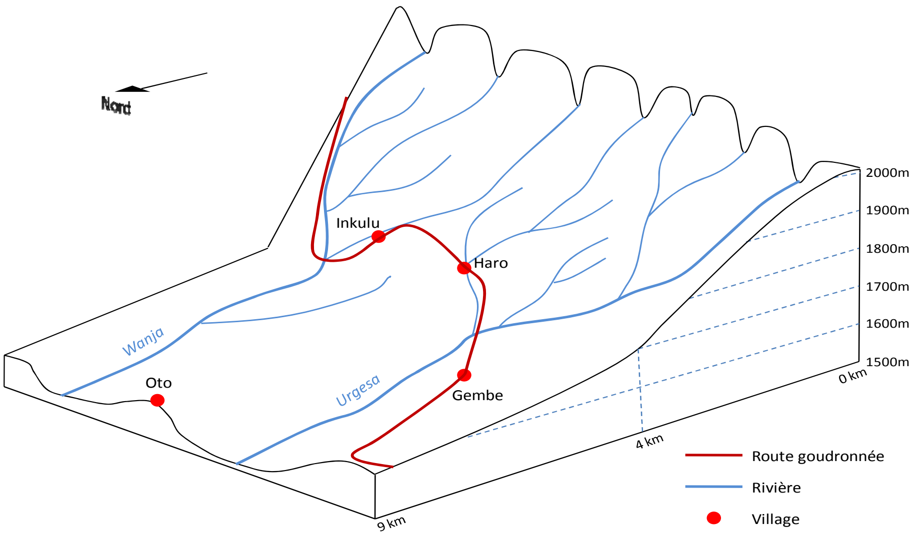
Table 5: Shanon Index and Evenness

Characteristics	**Mix Canopy**	**A+A Type**
Species Richness	**29**	**6**
Shanon Index	**1.07**	**0.545**
Evenness	**0.732**	**0.583**

These results indicate that mix canopy agroforests are more species rich than A+A type while A+A agroforests are going to be more homogenous with a very little diversity. But for distribution of species in these agroforests the value indicates that species which are found in have more probability to be found in mix canopy agroforests as compared to A+A type.

3.4 Land Occupation & Presence of Agroforests

As the area of study had an altitude ranging from 1500m in North to about 1900m in South as shown in the Figure 6 below, having steep slopes especially near rivers on southern side making almost V shaped

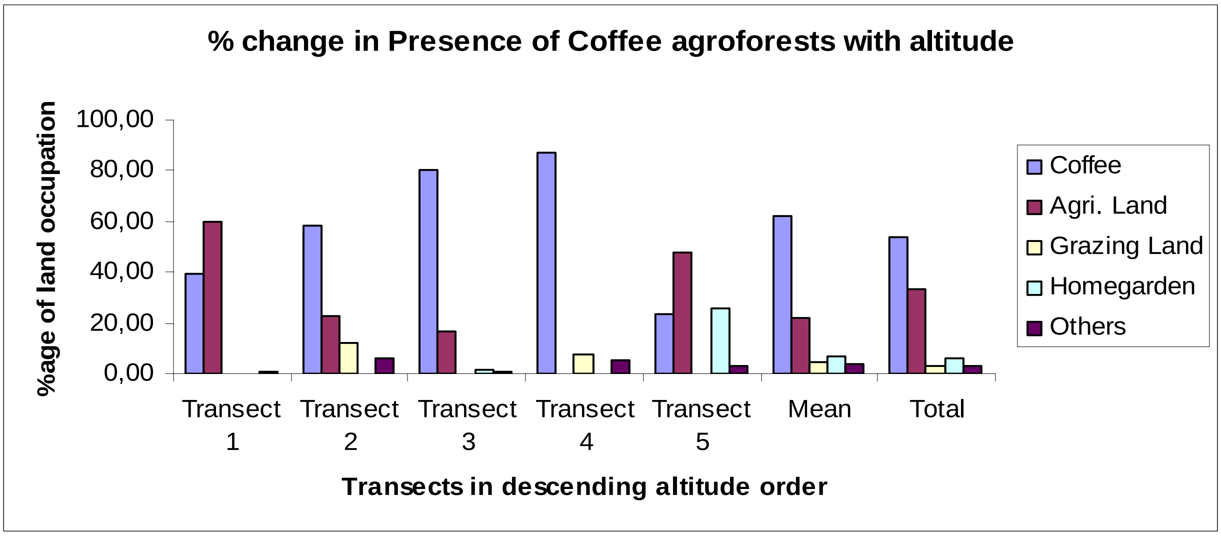


(From Cancino 2008)

Fig 6: Block Diagram of zone of study

valleys changing towards less slope and making broad valleys making broad U shape on North, so 5 transects starting from South to North were made to determine that what are the changes of occupation of soil and presence of coffee agroforests with the change in altitude. First transect was made on the South of Haro with at an altitude of about 1880 m with last transect in North having an minimum altitude of 1540 m a.s.l. As shown below in the figure 7 in first transect made on maximum altitude, there are 39% coffee agroforests present with 23% in the last transect at minimum altitude while in central zone having values of 58, 80 and 87% respectively in 2nd, 3rd and 4th transects in a range of altitude of 1640 to 1790 m a.s.l.

Fig 7: %age different occupation of soil



For agricultural land in first transect we have about 60% with 47% in last transect in North, with values of 23, 16 and zero % in 2nd, 3rd and 4th transect respectively. For grazing land it was found from 0 to 12% with an average of 4% with minimum and maximum in transect 4 and 2 respectively. While for homegardens we have found ranging between 0 to 25% with an average of 6% with maximum in transect 5. Others include paths, areas without coffee, timber production area etc which ranged from 1 to 6% with an average of 3%.

The data shows a clear change in area occupied by agroforests with the change in altitude as On basis of results shown above zone of study was divided into 3 zones named as South High Zone, Central Zone and North low Zone and descriptive diagrams were drawn for each Zone given as below.

South High Zone:

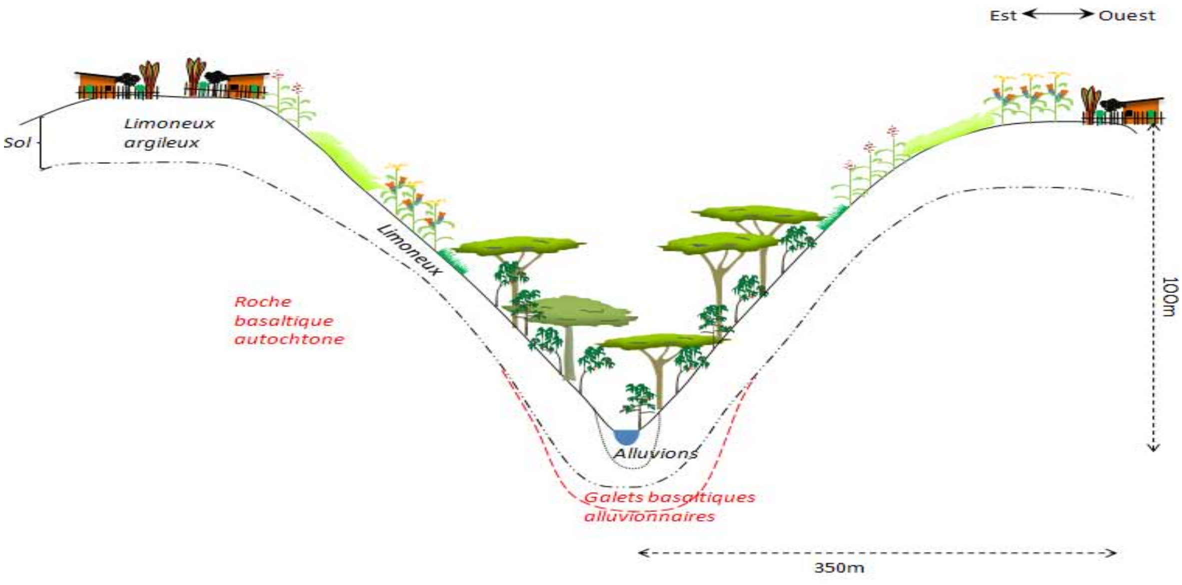


Fig 8 An example description of High part

From Cancino 2008

Central Zone:

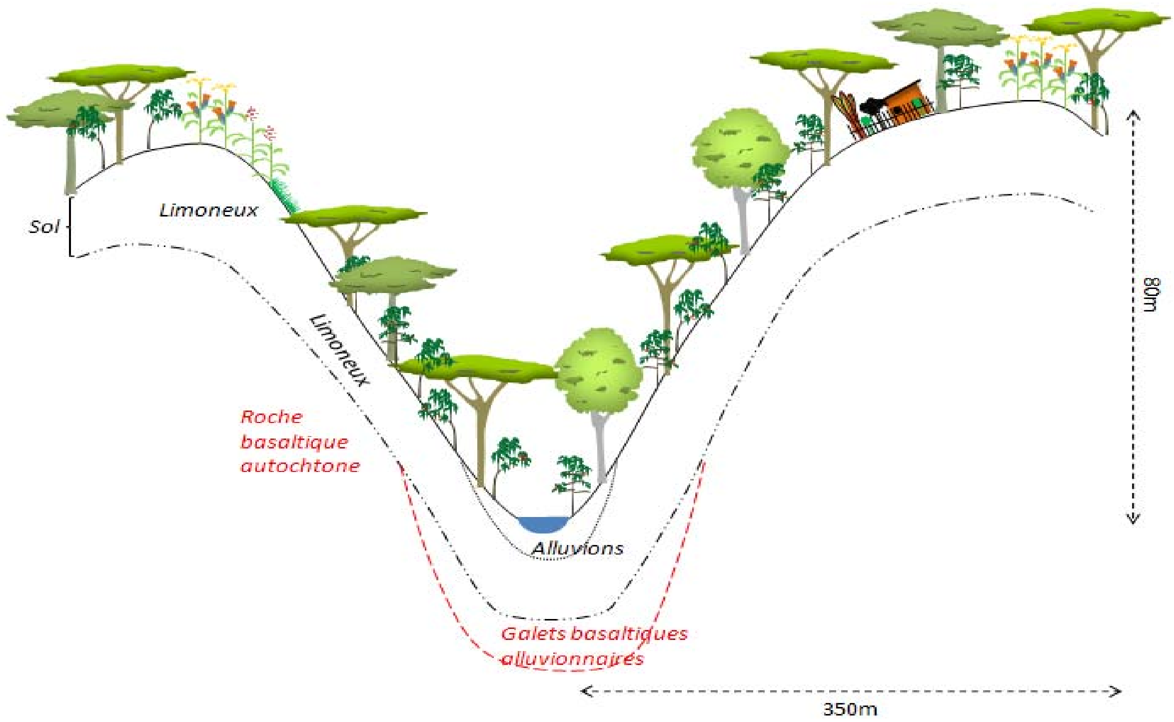


Fig 9 An example description of Central part

From Cancino 2008

North Low Zone:

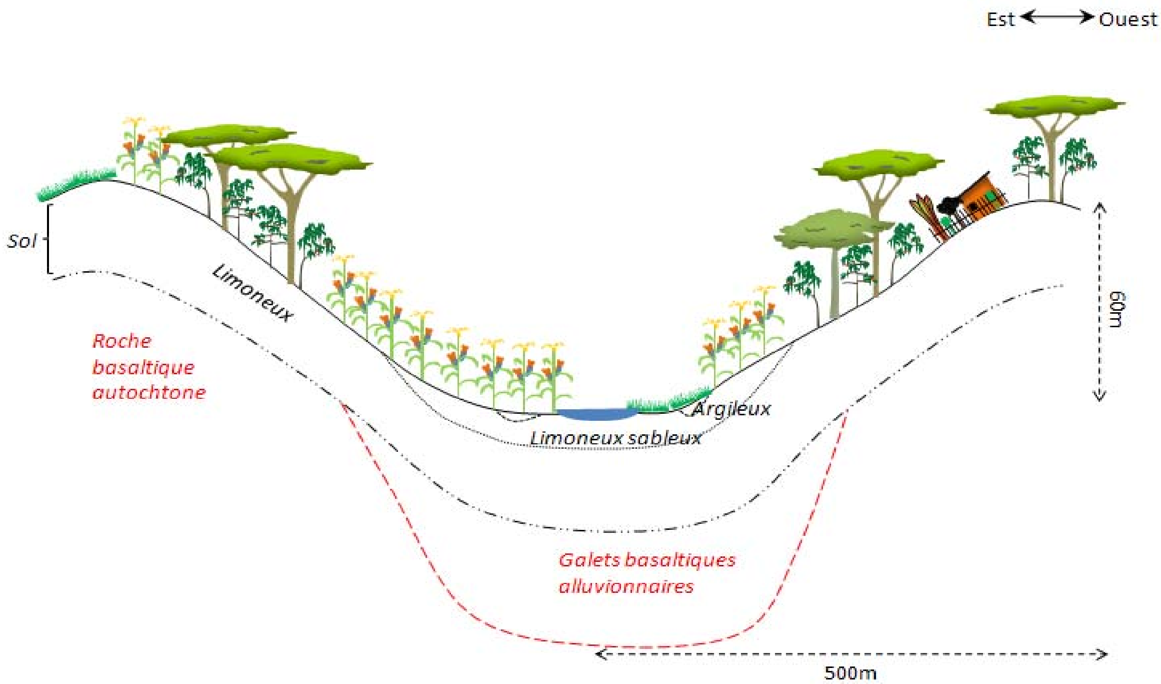


Fig 10 An example description of Low part

From Cancino 2008

4. Discussion:

Coffee agroforests are found in two major types as Mature agroforests and Young agroforests or agroforests on construction. In mature agroforests we have two types according to their origin (1) agroforests made from forests, which means that these agroforests were natural forests and coffee was planted and managed by cutting understorey plants and shrubs while keeping upperstorey trees as shade trees and (2) agroforests made from agricultural or grazing land which was natural forest a long ago. The similar findings were reported by De Foresta and Yao (2006; 2007) in their study at Bonga and Jimma as they have found two types of agroforests as Agroforests under forests and Agroforests on construction.

The pattern of diameter class distribution has often been used to represent the population structure of a forest (Khan et al., 1987). The overall distribution pattern of diameter classes in the Mix Canopy agroforests suggests that the stands consist of species with relatively wider age classes. However, in the A+A Type of agroforests the high density of trees were found in the medium or higher size classes, which suggests the removal of young trees of other species during coffee management also resulting in low density/ha as compared to mix canopy agroforests which have most of the trees in low diameter class but have high densities. We have an average density of 151 individual/ha for mix canopy while for A+A the value is 70 individuals/ha. De Foresta and Yao (2007) has reported an average density of 156 individuals in for farmers managed agroforests while 121 individuals for Red Cross Society managed forest while for our study we have found only farmers managed agroforests. Woldemariam (2003) reported similar findings in Yayu forest, Ethiopia that structural modification of the forest led to the formation of tall tree canopy and coffee canopy layers without any intermediate canopy layer. Now if this management practice continues like this, in the long-term most forest species and even coffee production will be affected.

The conversion of a forest coffee system into managed coffee agroforest affects the floristic composition and diversity of coffee forests. The floristic variation between the Mix Canopy coffee agroforests and A+A type agroforests are high according to species richness, extent of management practices. Generally, diversity value (e.g., Shannon diversity) was very low in the A+A type coffee agroforests, which is indicative of the high abundance of one or a few species. The Shannon diversity index is sensitive to numerical dominance by few species (Bone et al., 1997), hence, the low diversity of the A+A type coffee agroforests can be attributed to a large number of *C. arabica* individuals. Species richness and diversity will increase if structural and floristic diversity of the habitat is increased (Gallina et al., 1996; Roberts et al., 2000; Donald, 2004), and contrarily increased habitat disturbance changes the structure of the communities. The change of forest coffee to the cultivated and managed coffee production system has led to the loss of floristic diversity due to the clearance of understorey trees and shrubs (Woldemariam, 2003; Donald, 2004). A vegetation study conducted by Gole (2003) in the Yayu forest finds that the diversity of higher plants in the semi-forest coffee areas is only half as high as in the natural forest. The loss of species diversity especially in A+A system is likely to have negative effects on forest biodiversity and even on future long-term coffee production.

The difference in presence of species between Mix canopy and A+A depicts an ecological dynamics of selection of species suitable for the production which will result in formation of homogenous type of agroforests with very few species only favourable to the production as (Declerck et al, 2006) has found that 28% coffee forests have mono-specific canopy cover, 25% have 5 or more while 47% have 2 to 4 tree species with an average species richness of 4.6 in a study in central American states while in our study we have found an average species richness per agroforest is 6.6 species per plot. De Foresta and Yao (2007) have found an average of 6.5 species per plot in a study on characterization of agroforests near Jimma. While Sanbeta and Denich (2006) has found a mean of 30 species/plot of $400m^2$ including all vascular plants. While data for A+A type shows that in this type of agroforests there is a lot of selection of species for betterment of coffee production and dynamics of agroforests is going to be more homogenous as productivity increases in one species shade agroforest while quickly decrease as tree species are increased (Declerck et al, 2006). This difference in species found in agroforests clearly depicts the difference of management and species selection trends of local people for productivity of agroforests.

For land occupation we have clearly found a difference in presence of agroforests in relation to altitude and have found that with increasing altitude from 1800m a.s.l. the proportion of coffee agroforests is decreasing while agriculture increases. De Foresta and Yao (2007) has found coffee agroforests in valleys while at the top it was mostly agriculture or grazing lands while in this study we have found that in central zone there is no difference of valleys or hill top. We can found coffee agroforests any where but when we go to an altitude of above 1800 we only find coffee forests in valleys with steep slopes while rest of the area is mostly covered by agriculture land. In low altitude zone we have broader valleys which allow cultivation and agriculture near the rivers as valleys are open so we can find agriculture land or grazing land starting from river may be ending up with coffee agroforests.

5: Conclusions and Perspectives:

From this study it is clear that coffee agroforests of Haro are of two major types as mature agroforests and young agroforests. Mature agroforests are on production from long time either they were evolved from forests or agriculture or grazing land with two sub types according to shade trees used for coffee which are A+A type and Mix Canopy agroforests. This study shows that Mix Canopy coffee forests are more diversified as compared to A+A type of coffee agroforests on basis of species richness, diversity indexes, evenness and also density/ha. But we have not found significant difference for average basal area. On basis of our study we can see that coffee agroforests are now going to change towards A+A type which is thought to be good for production of coffee which is changing ecological dynaics of these agroforests from multispecies canopy to homogenous monospecies or dispecies canopy cover, which will result in loss in trees diversity as well as overall biodiversity. Modification of forest species diversity might affect the functional role of the forest (e.g., pollination) and disrupt the economic position and the livelihood of the people who are dependent on the forest. Also low diversity index values indicate the abundance and dominance of one or two species making forests mono-species dominant. On the other hand presence of coffee agroforests is variable according to variations in altitude as we have found that in central zone of our studies with an altitude ranging 1640 to 1790 m a.s.l. we have about 87% coffee agroforests which decreases accordingly when we go up or down from these ranges in our zone of study as in high zone of our study we have found only 39% agroforests while in low altitude zone we had a value of 24 % it clearly indicates the effect of altitude on presence of coffee agroforests.

On the basis of our findings we can say that the conversion of forests to coffee agroforests has influenced and will continue to influence the diversity if alternate management measures are not put in place. The conservation and sustainable use of species, plant communities and their supporting ecological processes in these coffee agroforests are urgently requires. The first important consideration for sustainable management of coffee agroforests is the preservation of the natural regeneration of shade trees, which will result in the preservation of the species diversification.

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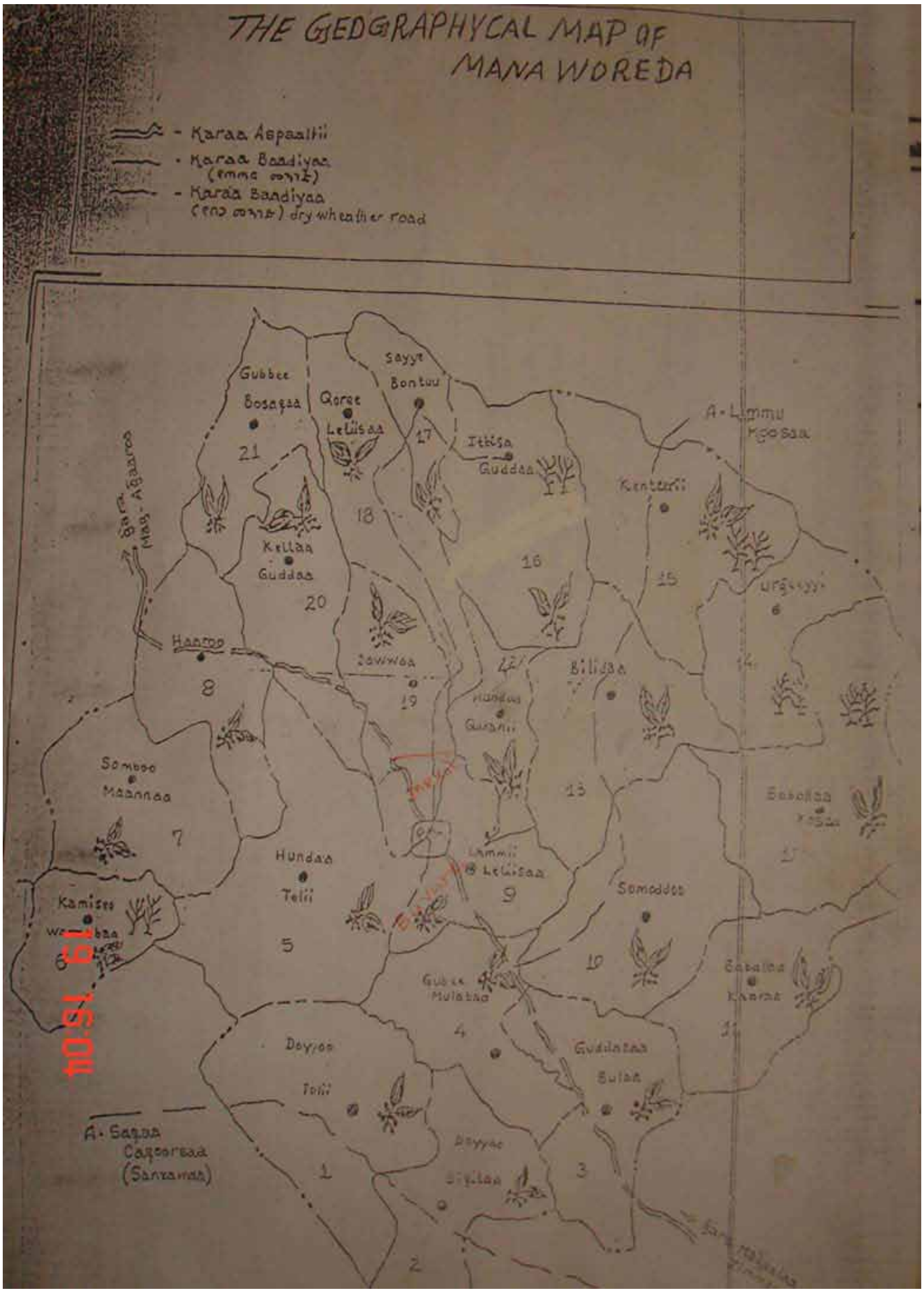
7. APPENDICES:

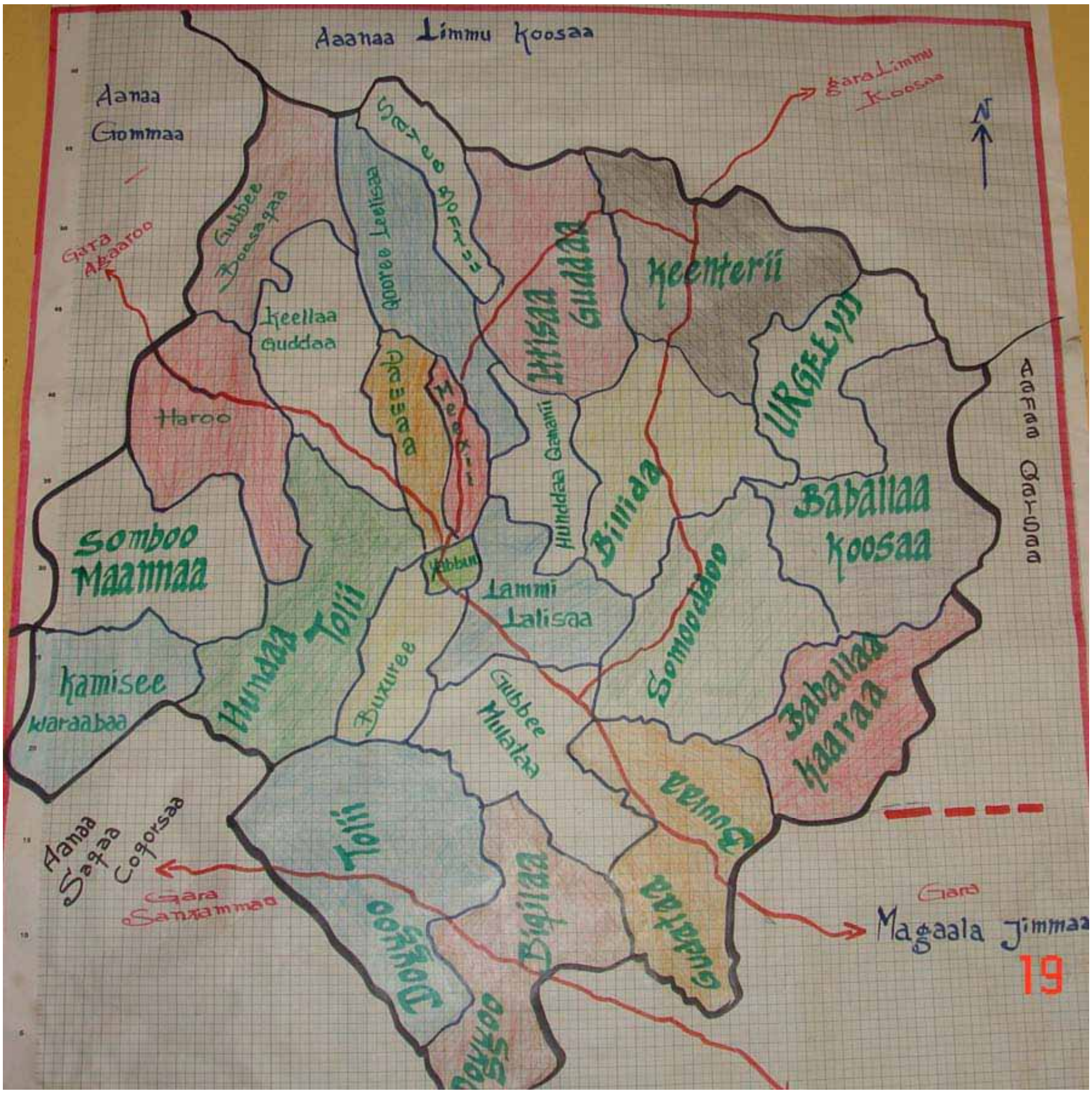
Appendix 1:

Geographical map of Mana Woreda:



Appendix 2

Map of Mana Woreda:



Appendix 3

Proposition de Stage 2008

La diversité floristique dans les agroforêts à café d'Ethiopie

Proposant et tuteur du stage : H. de Foresta (IRD)

Contact : foresta@mpl.ird.fr

<u>Contexte général de l'étude</u>

Dans le cadre d'un projet ANR-Biodiversité (BIODIVALLOC), l'IRD est engagée dans une étude des forêts et agroforêts à café du sud-ouest de l'Ethiopie.

Au cours de 2 missions (2006 et 2007), les écologues du projet ont identifié de véritables agroforêts dans la région de Jima, notamment le long de l'axe routier qui va de Jima à Agaro. Ces agroforêts se sont pour la plupart construites à partir de restes de forêt « naturelle » dans lesquels le sous-bois était coupé et le café (*Coffea arabica*) planté. La mission de décembre 2007 a permis aux écologues du projet (Adou Yao et H. de Foresta) d'établir une typologie de ces agroforêts et d'en caractériser la structure, la composition floristique et la diversité dans la région proche de la ville de Jima. Au cours de cette dernière mission, les mêmes personnes, accompagnées de Samir El Ouaamari, doctorant en géographie encadré conjointement par Hubert Cochet (Agronome, AgroParisTech-Paris) et par François Verdeaux (anthropologue, IRD, responsable de la partie Ethiopie du projet Biodivalloc), ont observé des changements physionomique importants en terme d'occupation du paysage par les agroforêts à café, à mesure que l'on se rapproche de la ville d'Agaro, à environ 50 km de Jima. Une étude comparative des agroforêts de la région de Jima et de celles de la région d'Agaro est proposée, afin de caractériser et de comprendre les différences entre ces deux zones d'agroforêts, en termes tant d'origine, de maintien, de gestion, et d'appropriation, que de pratiques et de conséquences de ces pratiques sur la structure et la diversité.

Deux études sont alors proposées, qui seront menées en parallèle, par deux stagiaires qui auront à interagir fréquemment sur le terrain, chacune des études s'appuyant sur l'autre et les deux études étant menées sur le même terrain. La première étude consistera en un « diagnostic agraire » de la région d'Agaro, comprenant une étude particulière de la place des agroforêts à café dans le paysage et dans l'économie des ménages. Cette étude sera réalisée par Antonin Cancino, étudiant en ESAT 1 à l'IRC (Supagro-Montpellier). La deuxième étude, celle qui est proposée ici, consistera en une typologie des agroforêts de la région d'Agaro, et en une caractérisation de la structure, de la composition floristique et de la diversité arborée des types d'agroforêts de la même région.

Le stage proposé s'inscrit dans le prolongement direct de l'étude menée en décembre 2007 par Adou Yao et H. de Foresta dans la région de Jima. Cette étude a permis d'établir une première typologie des agroforêts ; elle a permis également de mettre au point et de tester largement un protocole d'étude pour la caractérisation écologique de la composante arborée des agroforêts. Ce protocole est de plus uilisé parallèlement par un autre stagiaire (M. Correia) travaillant également sur des agroforêts à café, mais dans un autre pays (Guinée).

La partie « terrain » du stage s'effectuera donc en binôme avec Antonin Cancino, entre les mois d'avril et juillet 2008 pour un rendu final attendu fin septembre. Le stagiaire sera introduit au terrain par François Verdeaux en Avril (mission commune prévue avec Samir El Ouamari et les 2 stagiaires) ; le maître de stage planifiera le travail, restera en contact par courriel depuis Montpellier et visitera le stagiaire fin mai-début juin.

Objectifs et méthodologie du stage

Le stage a pour objectif d'établir une typologie des agroforêts de la région d'Agaro (Jima zone, Ethiopie) sur la même base que la typologie réalisée auparavant dans la région voisine de Jima par Adou Yao et H. de Foresta. Le stage a également pour objectif de caractériser la structure et la diversité arborée associées à ces agroforêts à café, et si possible, de comparer cette structure et diversité à celles associée aux forêts « naturelles » dans la même région.

Pour ce stage, la méthode d'échantillonnage qu'il est prévu d'utiliser a été mise au point par Doug Sheil, chercheur au CIFOR (Sheil et al, 2003). Cette méthode de transect « à aire variable » a déjà été employée par notre équipe en forêt naturelle comme en agroforêt (Indonésie, Costa Rica, Ethiopie), et permet de caractériser rapidement la structure et la composition floristique des parcelles (2 à 3 parcelles/jour). Cette méthode a été employée en décembre 2007 pour caractériser une vingtaine de parcelles d'agroforêt à café de la région de Jimma en Ethiopie, et peut être considérée comme bien au point, fiable et très pratique à mettre en œuvre.

Conditions pratiques du stage

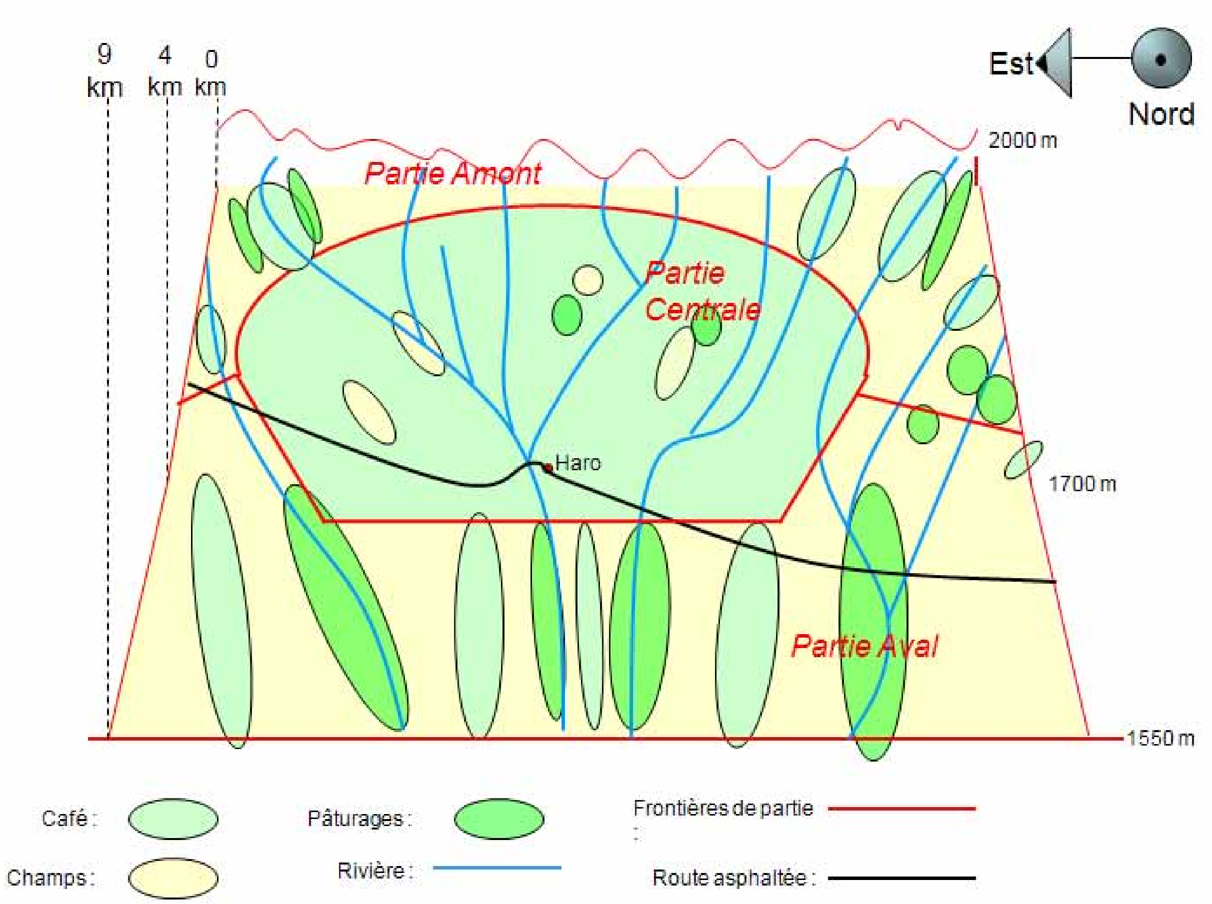
- Transport Montpellier – Agaro (Fin avril 2008) et retour (Mi-aôut 2008) pris en charge par le projet
- Frais de fonctionnement sur place (Ethiopie) pris en charge par le projet
- Indemnité de stage : 4 mois @ 384 euros/mois
- Assurance rapatriement à la charge du stagiaire, obligatoire
- Convention de stage à établir avant le départ (IRD-Bondy)

Références bibliographiques, en plus des références données pendant le cours sur les agroforêts…

- Sheil, D., Ducey, M.J., Sidiyasa, K.D. and I. Samsoedin (2003). A new type of sample unit for the efficient assessment of diverse tree communities in complex forest landscapes. *Journal of Tropical Forest Science* 15(1): 117-135.
- De Foresta et Adou Yao 2006. Rapport de mission Ethiopie (région de Bonga et Jimma).
- De Foresta et Adou Yao 2007. Rapport de mission Ethiopie (région de Jimma).
- Adou Yao C. 2007. Rapport de mission Ethiopie (région de Jimma).
- El Ouaamari 2008. Rapport de mission Ethiopie 2007 (région de Bonga et Jimma).

Appendix 4 :

Land Occupation description of Stydy Zone



Appendix 5

Table of Information

Owner Name	Code	TYPE	Site	precedent	Age	Density(big)	BA/Tree (big)	BA/ha (big)	Density(small)
						Tree/ha	cm²	m²	Tree/ha
Abba Hassan	AF 11	A+A	Slope	forest	>60	56,3	3998,5	22,5	12,5
Chambel	AF 13	A+A	Plaine	?	>60	31,3	5999,7	18,7	12,5
Muhammad Damme	AF 12	A+A	Top(plain)	forest	>50	68,8	2517,0	17,3	25,0
Abba Biya Lulesa	AF 23	A+A	Slope	forest	>40	81,3	1845,8	15,0	0,0
Abba Raya	AF 15	A+A	gental slope	forest	>40	75,0	1798,9	13,5	0,0
Michael Gissa	AF 14	A+A	Top(plain)	forest	>50	56,3	2886,0	13,0	0,0
MEAN						61,5		16,7	8,3
STD DEVIATION						17,9		3,6	10,2
Median						62,5		16,2	6,3
Minimum						31,3			0,0
Maximum						81,3			25,0
Hassan Abba Naga	AF 2	MIX	Gental Slope	cropland	>50	107,6	2788,4	30,0	37,5
Abba Zanab 1	AF 7	MIX	Av. Slope	forest	17	56,3	5328,6	30,0	25,0
Tamam Abba Fita	AF 1	MIX	Plaine	?	>40	87,5	3066,0	26,8	50,0
Abba Machha	AF 5	MIX	Slope	?	>50	68,8	3899,8	26,8	12,5
Hassan Abba Wari	AF 3	MIX	Plaine	grazing land	>70	100,0	2598,2	26,0	0,0
Abba Biya	AF 8	MIX	average slope	cropland	>50	68,8	3690,2	25,4	12,5
Abba Zanab 2	AF 6	MIX	Slope	forest	17	100,0	2100,6	21,0	50,0
Najib Yasin	AF 10	MIX	plaine	?	?	93,8	2134,2	20,0	87,5
Awal Abba Gumbal	AF 22	MIX	Riveraine/plaine		>30	212,0	907,3	19,2	25,0
Abba Diga	AF 9	MIX	Slope	cropl/grazing	>40	100,0	1624,9	16,2	37,5
Aifa Abba Diga	AF 20	MIX	Gental Slope	riverine forest	19	203,1	764,0	15,5	118,8
Khairuddin	AF 4	MIX	Plaine/Slope	?	?	160,7	936,8	15,1	87,5
Gahli She Ibrahim	AF 25	MIX	riverine/slope	?	?	87,5	1643,4	14,4	12,5
Abba Garo	AF 18	MIX	Top	?	>30	43,8	3195,4	14,0	0,0
Abba Nagga Gothama	AF 24	MIX	Slope	?	?	93,8	1399,9	13,1	60,0
Abba Zanab Abba Gibé	AF 26	MIX	riverine/slope	cropland	>70	131,8	935,8	12,3	0,0
Ahmed Shekhi	AF 19	MIX	Gental Slope	?		200,4	592,5	11,9	12,5
Abba Bulgo	AF 16	MIX	riverine/slope		>20	75,0	1235,5	9,3	50,0
Sabsib	AF 17	MIX	slope	?	18	87,8	733,9	8,3	112,5
Mean						109,39		18,70	41,65
STD DEV						49,73		6,98	37,21
Median						93,75		16,20	37,50
Minimum						43,8		8,3	0,0
Maximum						212,0		30,0	118,8

CONTINUED……………….

Owner Name	Code	TYPE	Site	precedent	Age	BA/Tree (small)	BA/ha (Small)	BA/ha (Total)	Total Tree Density	coffee density
						cm²	m²	m²	Trees/ha	Tree/ha
Abba Hassan	AF 11	A+A	Slope	forest	>60	20,4	0,03	22,5	68,8	3625
Chambel	AF 13	A+A	Plaine	?	>60	23,0	0,03	18,7	43,8	4750
Muhammad Damme	AF 12	A+A	Top(plain)	forest	>50	23,9	0,06	17,4	93,8	4062
Abba Biya Lulesa	AF 23	A+A	Slope	forest	>40	0,0	0,00	15,0	81,3	5750
Abba Raya	AF 15	A+A	gental slope	forest	>40	0,0	0,00	13,5	75,0	4875
Michael Gissa	AF 14	A+A	Top(plain)	forest	>50	0,0	0,00	16,2	56,3	3063
MEAN							0,02	17,2	69,8	4354
STD DEVIATION								3,2	17,9	966
Median								16,8	71,9	4406,0
Minimum								13,5	43,8	
Maximum								22,5	93,8	
Hassan Abba Naga	AF 2	MIX	Gental Slope	cropland	>50	47,3	0,18	30,2	145,1	2688
Abba Zanab 1	AF 7	MIX	Av. Slope	forest	17	40,8	0,10	30,1	81,3	3125
Tamam Abba Fita	AF 1	MIX	Plaine	?	>40	50,7	0,25	27,1	137,5	3500
Abba Machha	AF 5	MIX	Slope	?	>50	25,8	0,03	26,8	81,3	3000
Hassan Abba Wari	AF 3	MIX	Plaine	grazing land	>70	0,0	0,00	26,0	100,0	2500
Abba Biya	AF 8	MIX	average slope	cropland	>50	42,1	0,05	25,5	81,3	2188
Abba Zanab 2	AF 6	MIX	Slope	forest	17	29,6	0,15	21,1	150,0	2688
Najib Yasin	AF 10	MIX	plaine	?	?	37,1	0,32	20,3	181,3	4750
Awal Abba Gumbal	AF 22	MIX	Riveraine/plaine		>30	67,0	0,17	19,4	237,0	4375
Abba Diga	AF 9	MIX	Slope	cropl/grazing	>40	50,1	0,19	16,4	137,5	5875
Aifa Abba Diga	AF 20	MIX	Gental Slope	riverine forest	19	34,0	0,40	15,9	321,9	6312
Khairuddin	AF 4	MIX	Plaine/Slope	?	?	55,6	0,49	15,6	248,2	3813
Gahli She Ibrahim	AF 25	MIX	riverine/slope	?	?	54,0	0,07	14,5	100,0	3375
Abba Garo	AF 18	MIX	Top	?	>30	0,0	0,00	14,0	43,8	5312
Abba Nagga Gothama	AF 24	MIX	Slope	?	?	49,1	0,29	13,4	153,8	2500
Abba Zanab Abba Gibé	AF 26	MIX	riverine/slope	cropland	>70	0,0	0,00	12,3	131,8	2125
Ahmed Shekhi	AF 19	MIX	Gental Slope	?		72,0	0,09	12,0	212,9	2687
Abba Bulgo	AF 16	MIX	riverine/slope		>20	47,0	0,24	9,5	125,0	3250
Sabsib	AF 17	MIX	slope	?	18	56,0	0,63	8,9	200,3	4250
Mean							0,19	18,9	151,04	3595,32
STD DEV								6,9	69,12	1240,75
Median								16,4	137,50	3250,00
Minimum								8,9	43,8	2125
Maximum								30,2	321,9	6312