AFS4Food
Agroforestry for food security

Third Interim Narrative Report

April 2013 to March 2014

Didier Snoeck, CIRAD (Tree crop based Systems)
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Content

AFS4FOOD

Third Interim Narrative Report
Period: April 2013 – March 2014

1. Description

1.2. <u>Name of beneficiary of grant contract:</u> Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

1.3. Name and title of the <u>Contact person</u>: Dr Didier SNOECK

1.4. Name of <u>partners in the Action</u>:
- Institut de Recherche Agricole pour le Développement (IRAD)
- International Centre for Research in Agroforestry (ICRAF)
- Centre Technique Horticole de Tamatave (CTHT)

1.5. <u>Title of the Action</u>: Enhancing food security and well-being of rural African households through improved synergy between Agro-Forestry Systems and Food-crops.
Project designator: **AFS 4 Food**

1.6. <u>Contract number:</u> AURG/031/2012

1.7. <u>Start date</u> and <u>end date</u> of the reporting period: 01/04/2013 – 31/03/2014.

1.8. <u>Target countries</u>:
- **Cameroon**: Centre Province: Bokito, Talba
- **Kenya**: Central region: Murang'a District
- **Madagascar**: East Fenerive and Sainte Marie Island

1.9. <u>Final beneficiaries & target groups</u>:
- Smallholders in the target regions and in similar agro-ecological, demographic and market conditions.
- Farmers and their organisations in the target cocoa, coffee, and clove dominated landscapes.
- Local research and extension institutions focusing on food-crops and AFS in the target zones.
- Stakeholders and policy makers at local, national and regional levels.

1.10. Countries in which the activities take place (if different from 1.7): -

2. Assessment of implementation of Action activities

2.1.   Executive summary of the Action

This progress report covers the second year of the project; i.e. from 1st April, 2013 to 31st March, 2014. It is the third progress report. It follows the two first reports, which covered the period of April 1st to September 30th, 2012 and October 1st, 2012 to March 31st, 2013. The first report was submitted upon request of the AU management Unit. The second progress report was done to support the first year of the project. Both reports were submitted without requesting for pre-financing payment. The second instalment payment is attached to this report.

During this period (year 2), we could continue all activities as planned in the timetables: Cameroon (p. 26), Kenya (p. 51), and Madagascar (p. 82). The activities include the following:

1. **Management and scientific coordination**: A management and financial progress meeting was organized early July. A workshop was organised in Kenya (one of the project countries) from 21st to 26th October 2013.

2. **Spatio-temporal dynamics:** Cameroon: 196 cocoa farmers were involved in the project's activities to evaluate the production systems and farm activities. Two Master-2 thesis were involved in the surveys in Talba area and for remote sensing in Bokito area. First results are available. In Kenya, the dynamics of farming systems on the long term is now better described with help of two graduate students; remote sensing was used. In Madagascar, students worked on the agrarian dynamic of clove on two contrasted sites of Fenerive. Analyses of the dynamic of clove-fields. A geographic database on spatial use of cloves. This allowed to sort out the first technico-economic results of typology and evaluation of the cultivation and production systems.

3. **Assessment of interactions between agroforestry systems and cash crops and pathways to improve synergies**: activity aims to assess farmers' knowledge use of the associated trees traits and functions and an assessment of the level of household food security. In Cameroon, the first results indicate that traditional family-based cocoa cultivation performed in Bokito is more favourable to diversification with fruit trees, which strengthens the contribution of this type of cocoa cultivation for food-security. In Kenya, Four graduate students worked to determine the species inventory and measure all trees present in 65 farms. This allowed the characterisation of the main traditional cropping coffee agroforestry systems and tree management by smallholders and how they manage to improve their soil fertility. In Madagascar, plot characterization and typology of cropping systems was done on a sample of 74 clove based plots; more detailed description was done on 27 plots. More studies were started in another type of environment.

4. **Characterization of agroforestry systems product quality, and drivers of agroforestry systems product quality**: In Cameroon, genetic origin of cultivated cacao has an impact on cocoa gustative quality; and some simple techniques can be applied to improve shelf-life and valorise Safou. In Kenya, study was done on the effects of shade, genotype and altitude on coffee quality; this included the characterization of the final product biochemical composition. In Madagascar, the Malagasy clove-oil was compared to others oils (Indonesia, Tanzania); the impact of the phenological stages on the oil composition was analysed; the optimal stage to harvest bud to optimize the oil extraction was studied.

5. **Dissemination of results and student trainings:** Several students were trained on the various activities. The visibility of the project is guaranteed through a bilingual website that has been created.

The current status of the financial report is provided in annex 5.2 for information. A separate financial report will be attached to this annual narrative report.

The next workshop will be organised in Madagascar from 20th to 25th October 2014.

2.2.   Activities and results

2.2.1. Scientific coordination of the project

The project is divided into five work packages (WP), each with activities distributed into the three countries of the project. To organize the activities and manage the project, we have organized two progress meetings and create a tool for managing the budget online.

The project has organized its annual meeting of the project partners in Kenya from 21 to 26 October 2013. A total of 21 participants from the partner institutions and CIRAD were present. Four days were devoted to the presentation of activities in each country and the organization of future project activities. A day was set aside to visit the coffee-based agroforestry systems. During the first two days, the partners of the three countries involved in the project (Cameroon, Kenya, and Madagascar) presented the progress of the activities in their countries. The third day, a visit to the surveyed areas and trials in Kenya has allowed everyone to visit coffee farms in Murang'a area and so get an idea of the situation of Arabica coffee agroforestry systems studied by the Kenyan partners. The last two days were devoted to: 1. Discussions between the partners and working group leaders (Socio-economics, agronomy, technology) with the aim of highlighting the opportunities to make transversal activities, 2. In the preparation of activities for the coming year (2014) with the objective of enabling partners to achieve the deliverables expected at the end of the project.

The program of the week and the list of participants are available on the Website at: http://afs4food.cirad.fr/en/results/meetings/kenya-workshop.

The last workshop will be organised in Madagascar from 20th to 25th October 2014.

An innovative budget management tool was developed. It uses the power of Internet to enable each partner, Work package leader, Country leader, Account manager and coordinator to follow the budget online. Thus everybody is aware of the expenses done and the remaining funds to continue the activities.

The purpose of this Web-based tool is to assist the management of the budget, which is very complex because the project activities are carried out by many management units (12) working in many countries (4), and divided into 5 work packages.

Each of these sub-divisions must contain all budget lines. Therefore, we have decided to provide the partners with a friendly tool enabling them to input their own expenses, so they can easily manage their own budget, which is accessible via the Internet. Altogether, because it is managed online, the country (or Work Package) leaders can follow the progress of the budget corresponding to the activities for which they are responsible. This tool has a twofold purpose:

- Enable a real-time monitoring of expenditure by budget lines of the project: Budget balance and direct expenditures.
- Prepare the financial reports automatically in the format required by African Union.

This tool did not exist, neither at CIRAD, nor elsewhere; thus, we had to create it.

Budget tool operation

The user accesses the tool directly on the Internet (http://afs4food-bd.cirad.fr).

To enter the budget, a user must enter his/her login and password.

The tool has four main tabs plus two tabs for managing users' accounts.

- **Budget**: displays the initial and achieved budget. It is used to monitor the budget.
  - ✓ The updated budget can be exported. We have developed an Ms Excel ™ worksheet to process the updated data. They are exported in a pivot table, which effortlessly displays the updated realised budget in the correct format; the one required by the African Union.

- **Invoice List**: displays the list of all expenses. A check mark shows the locked invoices. Details of each invoice include the receipt as attached file.
- **Invoice Input**: contains a menu to input new expenses. Available budget lines for input are filtered according to user's rights.
- **Invoice Modification:** allows viewing editable invoices. An invoice can be modified as long as it is editable. If an expense is modified, then the corresponding budget line is automatically updated in the budget database.
- **My account**: allows modifying the user's account.
- **Admin.**: *only visible by the project manager*, is used to create users accounts and manage user rights.

The different levels of management are linked to the Login.

A **regular user** can view his/her own budget and can input expenses for the budget that he/she manages. He/she has partner level rights.

A **user with Country (or WP) rights** is allowed to view the budgets and expenses of all activities of all the partners involved in the country (or WP) that he/she manages.

A **user with accountant rights** can input or modify the exchange rate(s) of one or more invoices associated with his/her partner rights, as long as they have not been locked by the chief accountant in charge of the project. The **chief accountant** can additionally manage the budgets and expenses of all partners. At the end of each accounting period, he/she will lock the invoices once they are submitted to the AU.

On top of that, the **project manager** can also create user accounts and manage their access rights.

Results of Scientific coordination
- Management meetings were done to launch the activities.
- Website www.afs4food.cirad.fr/en is improved and updated frequently.
- Online budget management is fully operational, allowing daily updating by users.
- Follow-up of technical and financial activities are done on a regular basis, so as to fulfil the targeted deliverables.

2.2.2. Cameroon

Country leader: Dr Olivier SOUNIGO

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WP1: Management
1.1. Identification of target farms and communities

Two localities were identified in Cameroon:

Bokito: locality characterized by small cocoa farms managed by families, on a forest-savannah transition area. IRAD and CIRAD have worked with cocoa farmers in this area for the last ten years in the frame of several projects. During these projects, some cocoa farmers have been encouraged to test experimental cocoa cultivation practices, based on simultaneous planting of cocoa and intercropped species trees, resulting in the absence of permanent shade during the ten years following planting. This practice differs from the traditional one, mainly based on cocoa planting cocoa under the shade of older intercropped trees. One of the activities of the current project consists in a comparative assessment of the profitability and performances of traditional cocoa plots and of cocoa plots managed under the new practices.

A total of 20 farmers were involved in a survey aiming to characterize, understand and model the economic functioning of surveyed households, including the assessment of food security and diversity levels.

In addition, 66 other farmers were involved in their cocoa plot characterization (level of tree diversity and use, spatial structure, soil fertility).

Talba: locality characterized by the presence of large cocoa farms generally managed by employees. 50 farmers were involved in a survey aiming to characterize, understand and model the economic functioning of surveyed households, including the assessment of food security and diversity levels. In addition, 60 other farmers were involved in their cocoa plot characterization (level of tree diversity and use, spatial structure, soil fertility).

1.2. Creation of multi-sector Advisory committees and External advisory panels
Done in year 1.

1.3. Scientific coordination of the funded operations and the network
Participation of four researchers of IRAD and CIRAD-Cameroon in the workshop organized in Kenya (October 2013).

1.4. Capacity building and capitalization of knowledge

Two researchers from CIRAD (O. Sounigo and S. Saj) and 2 researchers from IRAD (F. Bella Manga and H. Todem Ngogue) took part in the annual workshop organized in Kenya in November 2013.

Results of WP1

- Activities: 196 cocoa farmers were involved in the project's activities.
- Training: Two Master-2 thesis completed:
  - one French student from Lille university (France) and one Cameroonian student from Dschang University (Cameroon);
  - Two Master-2 thesis started in 2013: two Cameroonian students from University of Dschang (Cameroon).

WP2: Characterisation of farming systems and identification of long term drivers at household and landscape levels

2.1. Spatio-temporal dynamics of farming systems

2.1.1. Understand the dynamics of farming systems on the long term

This activity of the WP2 was carried out within the framework of the mission in April 2013 of P. Pedelahore (CIRAD), on the site of Talba, where, in spite of a price-cutting of the cocoa paid to the grower (of 1000-1200 FCFA/kg in 2010 with 800-850 FCFA/kg in 2012 /2013), the dynamic of cacao-based plantations remain strong.

Figure 1 shows the movement of the pioneer front.

The circuit Talba-Voundou-Nguila Babouté-Ntui-Talba represents the active part of the pioneer front in the Mbam and Kim. It has moved north during these last years (*see the red arrows on the map*) and most cocoa plots are created on forest land and rarely on savannah.

Talba area is no more a pioneer front and most of cocoa plots there are at least 10 years old.

These elements need to be validated by diachronic analysis of aerial imageries.
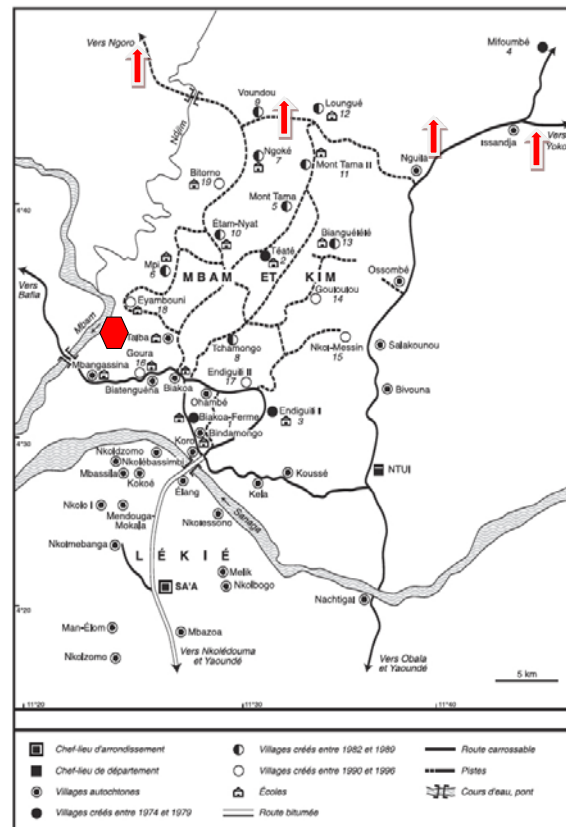
Figure 1: The main migrant villages in Lékié in Mbam-et-Kim from North to South

2.1.2. Analysis of aerial imagery and Geographic Information System
   1) <u>Surveys in Talba area</u>

The researchers involved in this action are S. Dupuy and C. Lelong of CIRAD.

The follow-up of the dynamics of the pioneer front involves the use of the oldest possible stock of images, but having a sufficient resolution.

The range of satellites Spot images (1, 2.3 and 4) made it possible to obtain a history over more than 20 years. The coverage of the images is of 3600 km² for a spatial resolution of 20 m, which does not make it possible for example to identify the trees in a grove, nor a structured raised solid plantation from another one that is more heterogeneous. The Spot 5 satellite with a resolution of 2.5 meters and same coverage (3600 km²) are those allowing the best compromise between spatial resolution and coverage. However, the satellite is in orbit since 2002 only. It will thus be necessary to use different data to carry out a precise cartography of the actual position then to measure the evolutions on data having a less detailed spatial resolution. Within the framework of this project, we presented a request for financing for the acquisition of stock-shot images (cf. table 1) and a request for programming for new images starting from the beginning of 2014.

Captor	Referen-ces	type	Spatial Resolution	Spectral Resolution	Acquisition Date	Incidence Angle
Spot 3	83 / 340	Multispectral	20 m	G, R, NIR	21 Feb. 1995	-8,6°
Spot 3	85 / 340	Multispectral	20 m	G, R, NIR	21 Feb. 1995	-4,3°
Spot 5	84 / 340	Multispectral	10 m	G, R, NIR PIR, MIR	6 Dec. 2009	0,9°
Spot 5	84 / 340	Pan-chromatique	2,5m	-	6 Dec. 2009	0,9°

Table 1: List stock-shot requested via program ISIS. G=Green, R=red, NIR= near infra-red, average MIR= Middle infra-red. Two acquired images on February 21st, 1995 were necessary to cover the influence of the acquired image on December 6th, 2009.

While waiting the image for 2014, we worked on the existing images and got the following results:
- A first cartography starting from the image spot 5 2009 was elaborated, which requires to be supplemented by precise locations on the ground and the collection of keys of interpretation on various raised textures (cf. figure 3);
- A cartography was also carried out from an image acquired in 1995 but with a less detailed typology;

However, by comparison of the 2 images on equal classification level, it was possible to highlight the zones of reforestation between 1995 and 2009, which will be given for interpretation to the field specialists (cf. figure 4).

It remains to evaluate the relevance to carry out the cartography on the former dates which are with less detailed resolution, where it is thus particularly difficult to distinguish various structures of tree canopies.

In addition, it was possible, by work of photo-interpretation which were carried out on the Spot images of 1995 and 2009, and, while waiting for the frame grabbing Spot 5 2014, by mobilizing

an image Landsat 8 2014, to locate the progression of the tracks in time, indicators of progression of the pioneer front (figure 5).

- ▨ Autres espaces boisés avec pic de vegetation SP
- ▨ Autres savanes et cultures SP
- ▨ Eau SP
- ▨ Espaces boisés avec texture SP
- ▨ Espaces boisés pic de vegetation SP
- ▨ Espaces boisés sans texture SP
- ▨ Nuages et ombres de nuages SP
- ▨ Savane avec texture SP
- ▨ Zones en végétation non boisées SP
- ▨ Zones urbaines SP
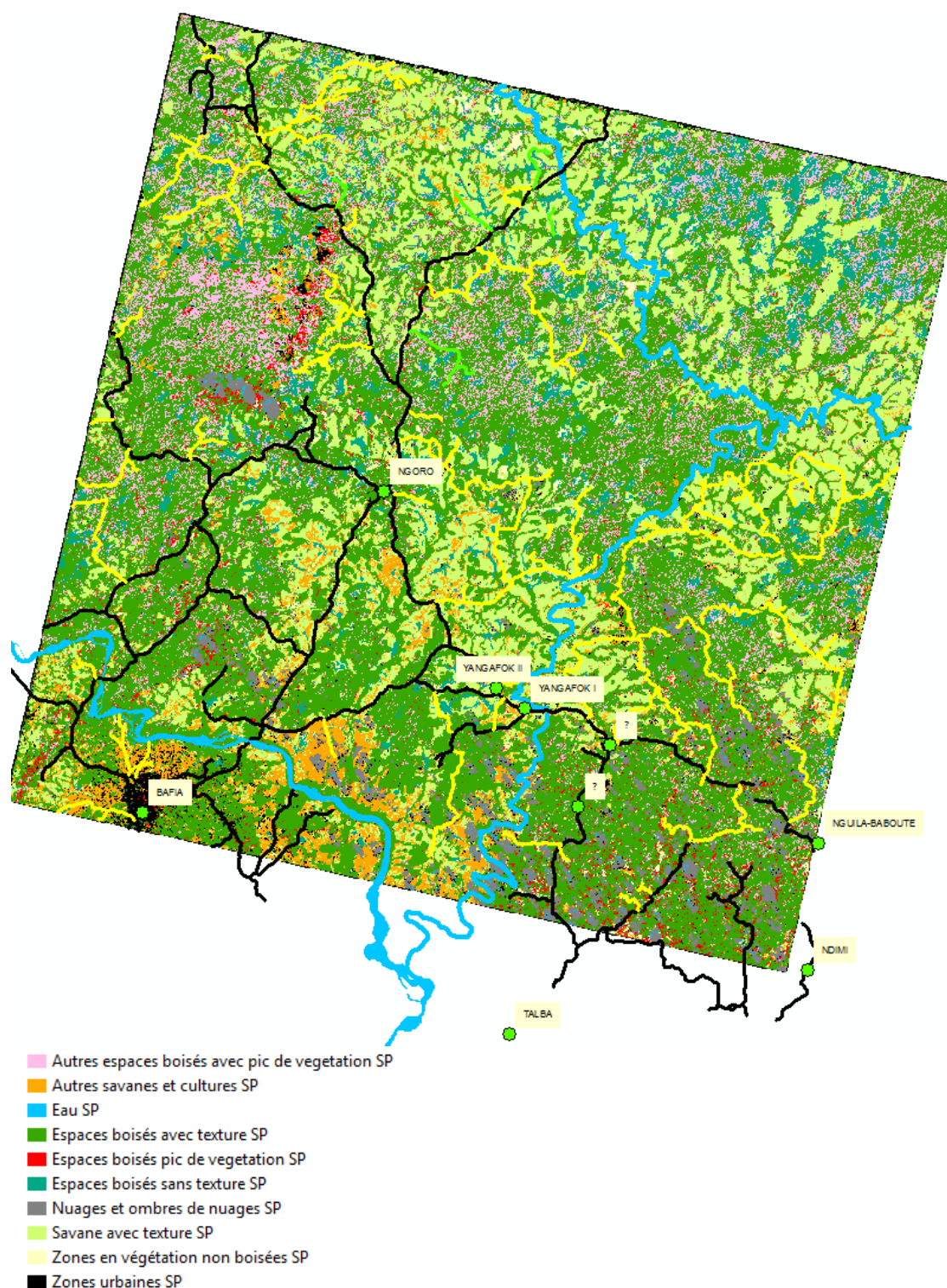
Figure 3: Cartography of the zone based on the spot 5 2009 image
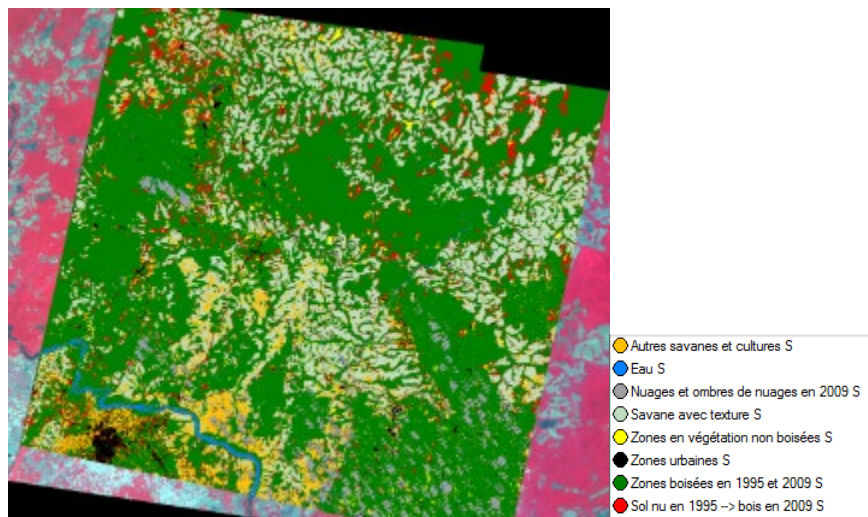
Figure 4: Compared cartography resulting from the spot 5 2009 and spot 3 1995 images.
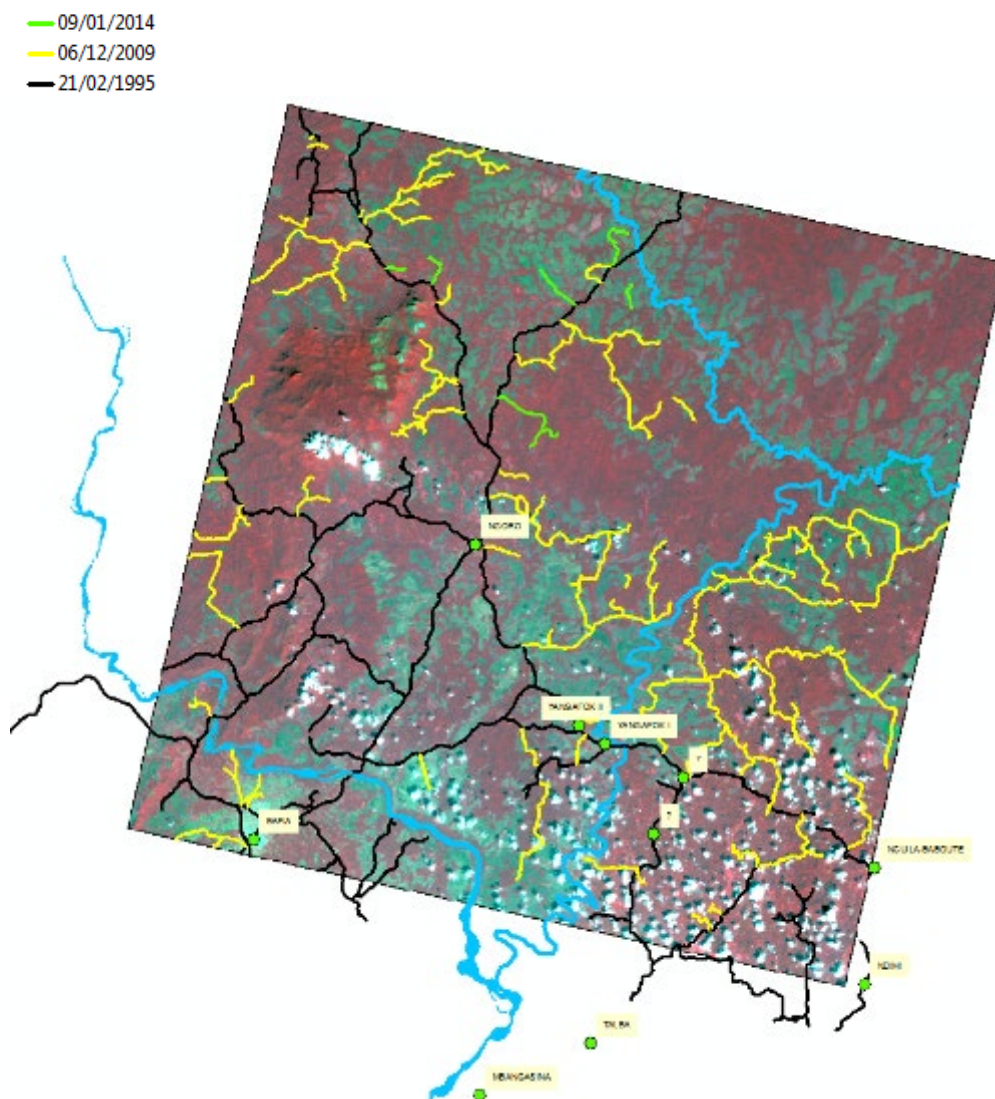
Figure 5: Progression of tracks openings

2) Remote sensing in Bokito area

The researcher involved in this action is C. Lelong of CIRAD, and C Alexandre, a master student of University Montpellier III Paul-Valéry, Mention IGT Ingénierie et Gestion Territoriales et Mention Informatique, Spécialité Géomatique (March to September 2013).

The purpose of the study is to set up a map indication land occupation by the different types of agriculture, in order to complete data from surveys. The work was realized from images with very high resolution (THRS) WorldView 2012, on a surface of approximately 110 km² (top left corner at 11°6' 44.86" E and 4°35' 51.69" N, and bottom right corner at 11°15' 40.77" E and 4°32' 8.09" N). The resolution of the panchromatic image is of 0.5 m that of multispectral made up by 8 bands is of 2 m. The analysis of these images was crossed with data ground (raised GPS decorated of photographs of the close environment) resulting from several missions of ground from various agents.

The area under study is very heterogeneous, with the existence of four types of plots: 1) food crop plots 2) AFS plots 3) mono-crop plots and savannah. The complexity of the land occupation made it necessary to combine several techniques in order to interpret the obtained images. Despite this complexity, we managed to carry out a very fine classification of the zone with 14 classes including 4 relating to the agroforestry (cf. figure 6). This classification makes it possible to understand the spatial organization of the various cultivation systems (cocoa, food) in this zone of savannah, and to put it in glance with the toposequence: localization of the cacao-plantations on the heights, food and savannah in bottom of slope and underworld. Certain statistical analyses made it possible to validate the fact that agroforestry space tends to colonize savannah from existing AFS and not from spots scattered in savannah. These AFS are mostly traditional cocoa plots.

In addition, the available information will be analysed at a lower scale to study the spatial structure of cocoa plots (spatial design of cocoa trees, baobabs and other shade trees, presence of poorly shaded spots….) and try to link it with agronomical performances of the studied plots. A very high quality WorldView2 image without clouds was acquired in December 2013 and will be used in order to complete the map of the area during 2014.
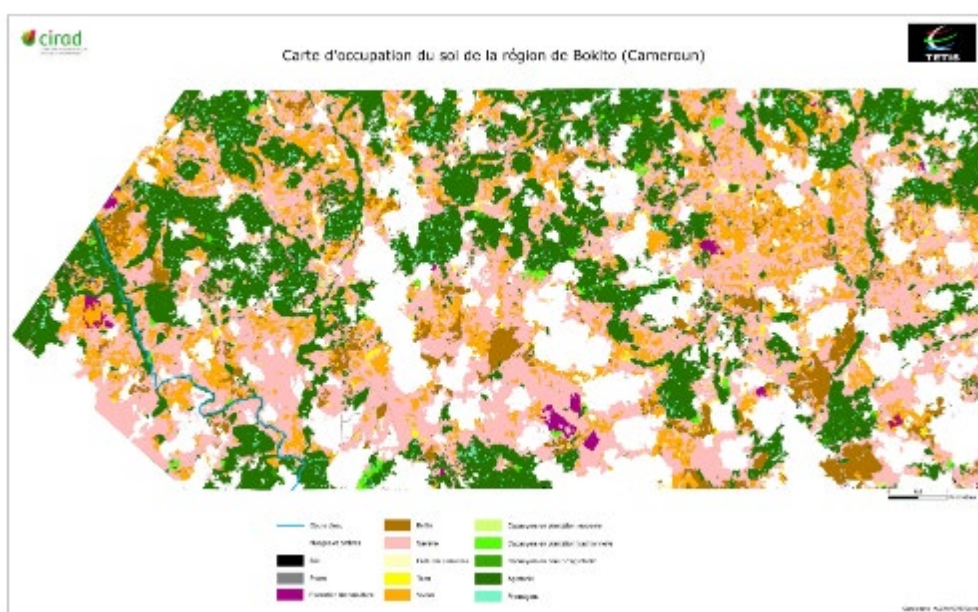
Figure 6: Occupation of soils in Bokito region

2.2. Evolution of smallholders' strategies and agricultural activities. Contribution of food crops and AFS to food security and well-being of households

2.2.1. Typology, farmers management and strategies

In 2013-2014, this activity will continue on the Talba site. On this site, it should already be noted that the WP2 is articulated with another project (project SAFSE of the AIRD), which recently started to produce results on the strategies of the farmers of the zone, their diversity, and characteristics of the systems cacao-trees implemented by the various types of actors. If not, activities WP2 of the site of Talba continued through work of surveys conducted between July and September 2013 by a researcher IRAD Yaoundé associated with the project, André Nso Ngang, supported by P. Pedelahore of the CIRAD. These data concerning 30 farms are in the course of treatment.

2.2.2. Evaluation of production systems and farm activities

This job is in continuation of the first results obtained from the investigations of A. Nso Ngang in Talba, and of those carried out by the WP3 with Talba and Bokito by H. Todem Ngnogue.

Several surveys were made in 20 farms in Bokito and 20 farms in Talba, in order to characterize the socio-economic structure of farms for which cocoa AFS is putatively the main source of income. A comparative study of the obtained information revealed major differences between Bokito and Talba:

- Cocoa farmers in Bokito are mainly from the region while the ones in Talba have different geographical origins. The diversified population in the Talba region results in a diversification of nutritional habits.
- Farms are on average much larger in Talba (16 ha, ranging between 3 and 65 ha) than in Bokito (1.5 ha) and the average cocoa yield is higher in Talba (700 kg /ha/year) than in Bokito (500 kg/ha/year).
- Cocoa plots are usually the main component (on average 85%) of farms in Talba, their relative importance being even higher (up to 100%) in large farms. They represent 50 to 75% of the cultivated area of farms in Bokito, in which staple food crops are largely cultivated. 75% of the farmers interviewed in Talba cultivate food crop, while this proportion is 100% in Bokito. In Talba, the household relative revenues from cocoa vary between 85% in small farms to 100% in large farms.
- Labour force is rarely hired in Bokito while 75% of the interviewed farmers in Talba hired between 2 to 14 workers. Women have started to get involved in cocoa cultivation in Talba while they remain mainly involved in food crop cultivation in Bokito. In both sites most of the hired labour force is dedicated to pod breakage
- 80% of the interviewed farmers in Talba own a house while this % is 100% in Talba.
- Land can be rent for cocoa cultivation in Talba, which is not the case in Bokito. Cocoa is much less currently cultivated on savannah in Talba than in Bokito.
- The low level of food crop production in Talba results from: 1) the decrease in plantain and cocoa yam, usually cultivated in the young cocoa plots, which are now less common, since the forest land has become scarce 2) the concurrence for savannah with housing 3) the concurrence for labour force with cocoa.
- On the other hand, a high level of plantain and cocoa yam is currently produced on the young cocoa plots on the pioneer front, and these products are exported to Cameroonian cities and other countries of the region (Equatorial Guinea, Gabon, Congo…)
- This situation leads farmers to purchase food, which generally costs around 20% of the household revenue (which range between 2,000 and 10, 000 U.S $ per year), for most of the interviewed farmers, this proportion being negatively correlated to revenue. Anyhow,

the interviewed farmers did not report any fear about their food security, since they have sufficient revenues to purchase food.

In partnership with the WP3, which has as objective in 2014 to assess exactly the various productions (cocoa and others) of cacao-AFS in Talba and Bokito, on a sample of already characterized plots, we launched 2 training courses of master degrees (2 Cameroonian students) who will work in collaboration with two students from WP3 (cf. below). These 2 WP2 students will work on the same sample of farms that those of the WP3 in Bokito and Talba, but will have to analyse the productions of plots other than cacao. After pooling of the data, we will be then able to evaluate the whole of the cultivation systems, and thus the systems of production which include them, that we will analyse by type. For WP2, the researchers involved in this action are I Michel (SupAgro), P. Pedelahore (CIRAD) and 2 students from the University of Dschang.

2.3. Modelling and prospecting at farms and landscape levels
To be done in year 3.

Results of WP2
- A report of student master-2 of remote sensing;
- Fine cartography of the types of plots cultivated in the area of Bokito;
- First cartographies, much more summary, of the Talba zone, with diachronic analysis;
- Follow-up of the pioneer front in Talba and knowledge of ongoing dynamic agricultural activities;
- In Talba, beginning of farms typology, and first evaluations of farmers' activities;
- Beginning of comparison analysis between both sites, Talba and Bokito.

WP3: Assessment of the productive and environmental performances of AFS and their synergies with food-crops at plot, farm, and landscape levels

3.1. Productive and environmental interactions between AFS and food crops at plot, farm and landscape levels (characterization)

3.1.1. Characterization of indigenous knowledge related to agronomic or environmental functions and uses of the cultivated species (mainly trees species) in a range of AFS and food crop combinations

This activity aims to:
- Assess farmers' knowledge about the trees within their cocoa plots,
- Assess farmers' use of the associated trees,
- Link the use of these associated trees to eco-physiological traits and functions,
- Better understand the management of associated tress within the range of AFS studied.

The researchers involved in this action are S. Saj (CIRAD), K. Mvondo and M.L. Avana (University of Dschang) and C. Durot (ISA Lille). K. Mvondo and C. Durot are two Master-2 students.

The aims of this study is (i) to link the farmers' knowledge and use of associated trees with cocoa to ecophysiological traits and functions, and (ii) to better understand the management of associated tress within a range of cocoa agroforestry systems (AFS). Since no toolbox nor survey methodology were provided as it was initially scheduled, the characterization of indigenous knowledge related to agronomic or environmental functions and uses tree species in a range of AFS had been undertaken in Bokito and Talba from March 2013 to October 2013 via "classic surveys" at the same time as assessment of plots' structure and floristic composition.

The collected data are listed in database and their statistical analysis will be performed by August 2014. Thus, in Bokito, 1505 associated trees were inventoried within 66 plots (55 AFS; 4 savannah; 7 forests). In Talba, 1017 associated trees were counted within 60 plots (55 AFS and 5 forests).

A Master 2 thesis is available for Bokito. A Master-2 thesis for Talba is currently under correction.

The main results of this study, obtained by the two Master 2 students are the following ones:
- Four major types of associated trees uses can be distinguished: wood (fire wood or construction wood); fruit production; provision of an agronomical service (shade and fertility) and cultural use (mainly medicine provision).
- Associated trees that produce fruits are more numerous in cocoa AFS of Bokito than those of Talba. Thus, in Bokito, fruit trees (especially citrus fruit) should be more significantly directly or indirectly (via selling production to the market) support food security or diversity than in Talba.
- Cocoa AFS produce staple food only when cocoa trees are young (under 5-7 years). Therefore, cocoa AFS contribute directly to food security or diversity only at that stage. Then the contribution can only be indirect via the purchase of food with the revenue form cocoa (which is to be confirmed).
- One species of associated tree can provide multiple services to the farmer;
- Species use by farmers can be associated to some intrinsic functional traits (such as leaf life span or successional position);
- Diversity of trees in cocoa AFS is significantly lower in AFS than in forests, yet associated trees are the main contributors of C storage in AFS. The C storage is highest at maturity e.g. between 40 and 65 years old. In Bokito, C storage of associated trees can be considered as equivalent to that of local forest.
- Diversity of associated trees tends to decrease with aging and AFS since farmers make trade-offs between the services they provide and cocoa production.

3.1.2. Assessment of productive and environmental performance of agroforestry and food cropping systems and of their synergy

The activity has started in April 2013. This activity is mainly undertaken on the field by the IRAD researcher H. Todem Ngnogue. The other researchers involved in this action are S. Saj, G. Chirat and R. Bourgoing from CIRAD). The characterization of the socio-economic structure of 40 farms (20 in Talba; 20 in Bokito) for which cocoa AFS is putatively the main source of income has been done from April 2013 to September 2013. The objective of these surveys is to characterize, understand and model the economic functioning of surveyed households and to help to assess the food security level in cocoa farms. In Bokito, these surveys

will complete past research on cocoa agroforestry systems with adding new data on food crops. In Talba, they will create new data where there is no data yet at plot level. Data that have been collected are currently implemented in a database and a global statistical analysis is to be performed by the end of the project.

The surveys involved a socio-economic characterization of farm structure and an assessment of the level of household food security. Farmers were subjected to a twenty pages questionnaire covering the last two years (2011 and 2012) preceding the survey) on all the farm activities (agricultural and non-agricultural), but also the income from these activities, the redistribution of the income based on the various items of expenditure and the investment priorities of farmers.

At the end of this study, the assessment of food security will allow to relate the structure of farms with the level of household food security. The assessment of food security has two components: (i) the index of household dietary diversity and (ii) the household food insecurity access scale that is the scale of determining access to household food insecurity.

- Index of household dietary diversity: data collection for the evaluation of this index began in October 2013 and will be completed in October 2014. It consists in listing what the family members have eaten and drunk from waking to sleeping, once a month and a day of the first week, with a sample of households larger than those concerned by the survey.

- Household Food Insecurity Access Scale: data collection is ongoing and will end in April-May 2014 that is to say during the period of stress (lack of resources to feed normally). The sample gathers 300 households (including farmers involved in the survey on the structure) at a rate of 150 households per site.

Some preliminary results of this study can be given:
- In Bokito, farmers do not use hired labour to work in their fields. Rather they use family labour or they use self-help groups to which they belong. Instead, at Talba, 75% of farmers use hired labour workers at a rate of 2-14 workers. Regardless of the site, 50% of the amount of hired labour is due to the pod breaking.
- In Bokito, 20% of the farmers do not own a house while all those Talba own at least one house. In Talba, the average values of non-agricultural equipment of farmers producers is 2.4 times greater than that those in Bokito.
- In Bokito, the average size of cocoa plots is 1.34 ha while it is 3.37 in Talba. The minimum size of cocoa plots is 0.25 ha in Bokito while it is and 0.5 ha in Talba. The maximum size of cocoa plots is 3 ha in Bokito while it is 12 ha to Bokito in Talba.
- In Bokito, all cocoa farmers have at least one plot of food crops a year, while only 75% of farmers have one in Talba. In Bokito, the size of these food crops plots varies from 0.03 to 1.5 ha while in Talba it ranges from 0 to 1 ha.
- The average yield of commercial cocoa is 507 kg ha^{-1} in Bokito while it is 722 kg ha^{-1} in Talba.
- The average gross income of food crops sales is 67948FCFA/ha^{-1} in Talba and 415138FCFA·ha^{-1} in Bokito.

3.2. Pathways to improve synergies between AFS and food crops at plot level

3.2.1. Assessment of the plot structure

This activity aims to link AFS plot structure and composition to different plot performances and characteristics such as: yield of the different crop trees, soil quality, pest and disease abundance and impact on the different tree species.

The researchers involved in this action are S. Saj (CIRAD), K. Mvondo and ML Avana (University of Dschang) and C. Durot (ISA Lille). K. Mvondo and C. Durot are two Master 2 students.

The objective of this study is to link plot structure and composition of cocoa AFS to cocoa yields, soil quality, pest and disease. The experimental design is based on plots of 800 m^2 (for cocoa and trees with a DBH < 30 cm) /2400 m^2 (for threes with a DBH > 30 cm) setup in the network of farmers' cocoa AFS that have been established in Bokito (66 plots) and in Talba (60 plots). From July 2013 to October 2013, more than 10 000 cocoa trees and 3704 companion trees were counted. We measured trees' DBH, height and classified the vertical structure of each plot.

The collected data are listed in database and their statistical analysis will be performed by August 2014. A Master 2 thesis is available for Bokito. A Master 2 thesis for Talba is currently under correction.

The main results that can be summarized from the two Master 2 theses are the following ones:
- Cocoa AFS size differs greatly between the two studied sites. Talba gathers plots of ca. 5 ha whilst Bokito plots are 1.5 ha on average.
- Plot vertical structures differ greatly between the two sites studied. Bokito is characterized by 3 strata (from the lowest to the highest): cocoa trees, fruits trees and shade trees. Talba plots do not or rarely contain the fruit strata.
- C storage is ensured by big associated trees that can account for more than 80% of storage.
- The two sites are characterized by an equivalent cocoa tree density (approx. 1100 ind.ha^{-1}) whilst Bokito possess a much higher associated trees density (17 ind ha^{-1}) than Talba (7 ind ha^{-1}).
- Bokito is characterized by a steady decrease of associated tree densities whilst the number of associated trees remains equivalent all along with aging in Talba.
- Bokito is characterized by a steady decrease of cocoa tree densities with age (-40%).
- Talba is characterized by a steady decrease of cocoa tree densities until 60 years (about -40%). Yet, regeneration then clearly takes place and densities increase again with the plantation of young cocoa trees.

3.2.2. Assessment of the various productions (cocoa and others), assessment of pests and disease impacts on the main products (cocoa); assessment of the microclimatic (humidity, and light) conditions and the soil conditions

Fieldwork activities have started in April 2013. Researchers involved in this action are G. M. ten Hoopen and L. Bagny Beilhe (CIRAD), L. Sob (Cameroonian student, level Ing. Agro. University of Dschang), J.P. Bidias and A. Agoume (local observers in Bokito) and farmers.

1. The assessment of black pod disease impacts on cocoa production is based on weekly observations on 20 selected cocoa trees in each of the eight study plots (8 study plots x 2 sub-plots x 20 cocoa trees = 320 cocoa trees in total) (see also first activity report) started on the 30th of May 2013 and finished on the 12th of December 2013. The collected data (e.g. number of cherelles, healthy, ripe and diseased pods, etc.) are actually being used to describe pod production dynamics in these plots (see for example Fig. 1a and 1b). Three times during the year (in May, August and November), all cacao trees were evaluated for mirid damage and presence. These data are currently being analysed.
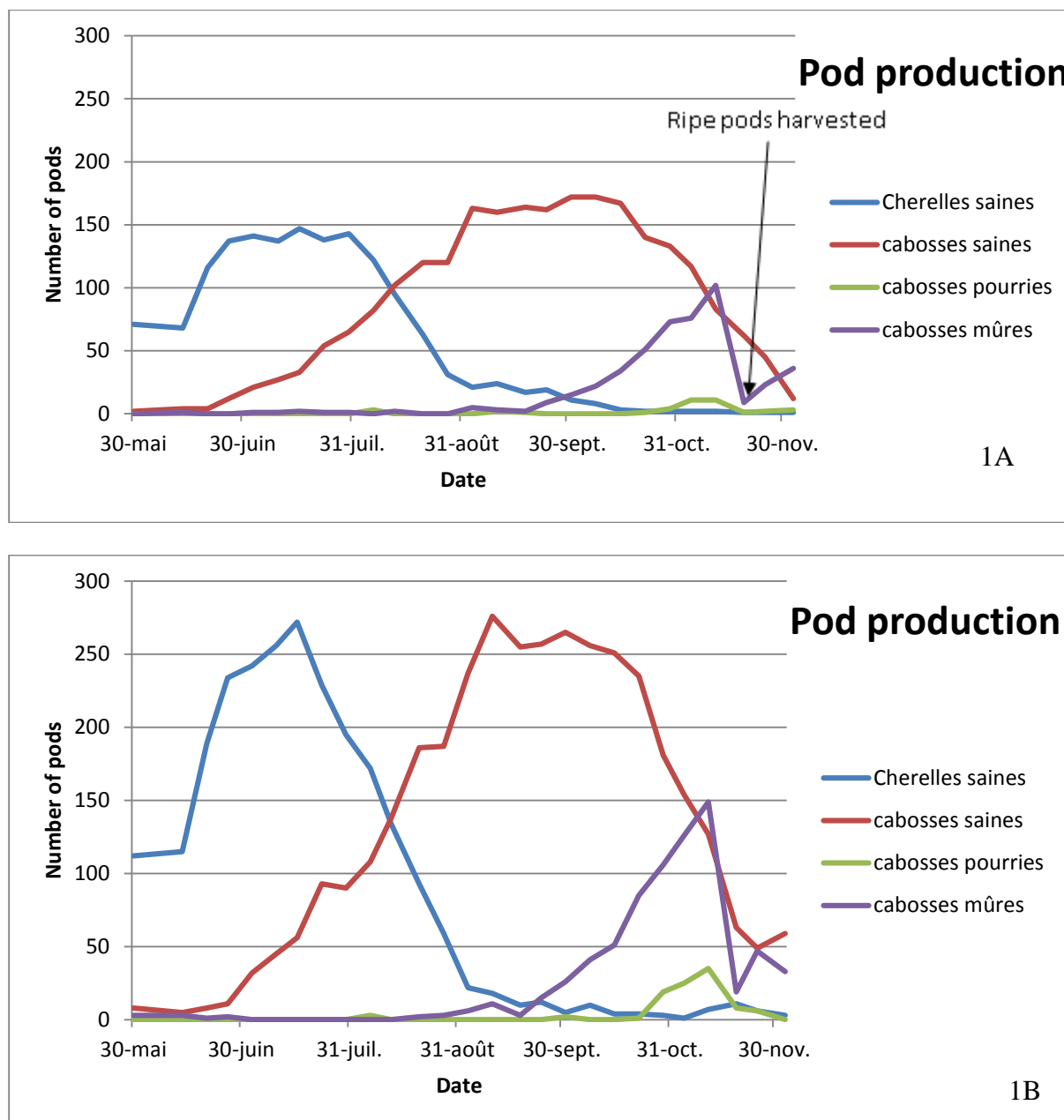
Figure 1. Pod production in plot 19 (Nouanda) under less shaded (1A) versus highly (1B) shaded conditions. NB Cherelle production has only been determined between 0 and 2 meters above ground level whereas pod production has been estimated for the whole tree.

Microclimate measurements (Temp and RH) started on the 23rd of May 2013 and are ongoing. Small yet clear differences in microclimate are observed between highly and less shaded sub-plots (Figure 2a and 2b). The amplitude between mean maximum temperature and mean minimum humidity in highly shaded versus less shaded subplots varied over the course of the year (data not shown) yet are generally between 1 and 2 °C and 3-11% RH. The fact that these differences are relatively small is probably partly due to auto-shading by cacao trees.

2a
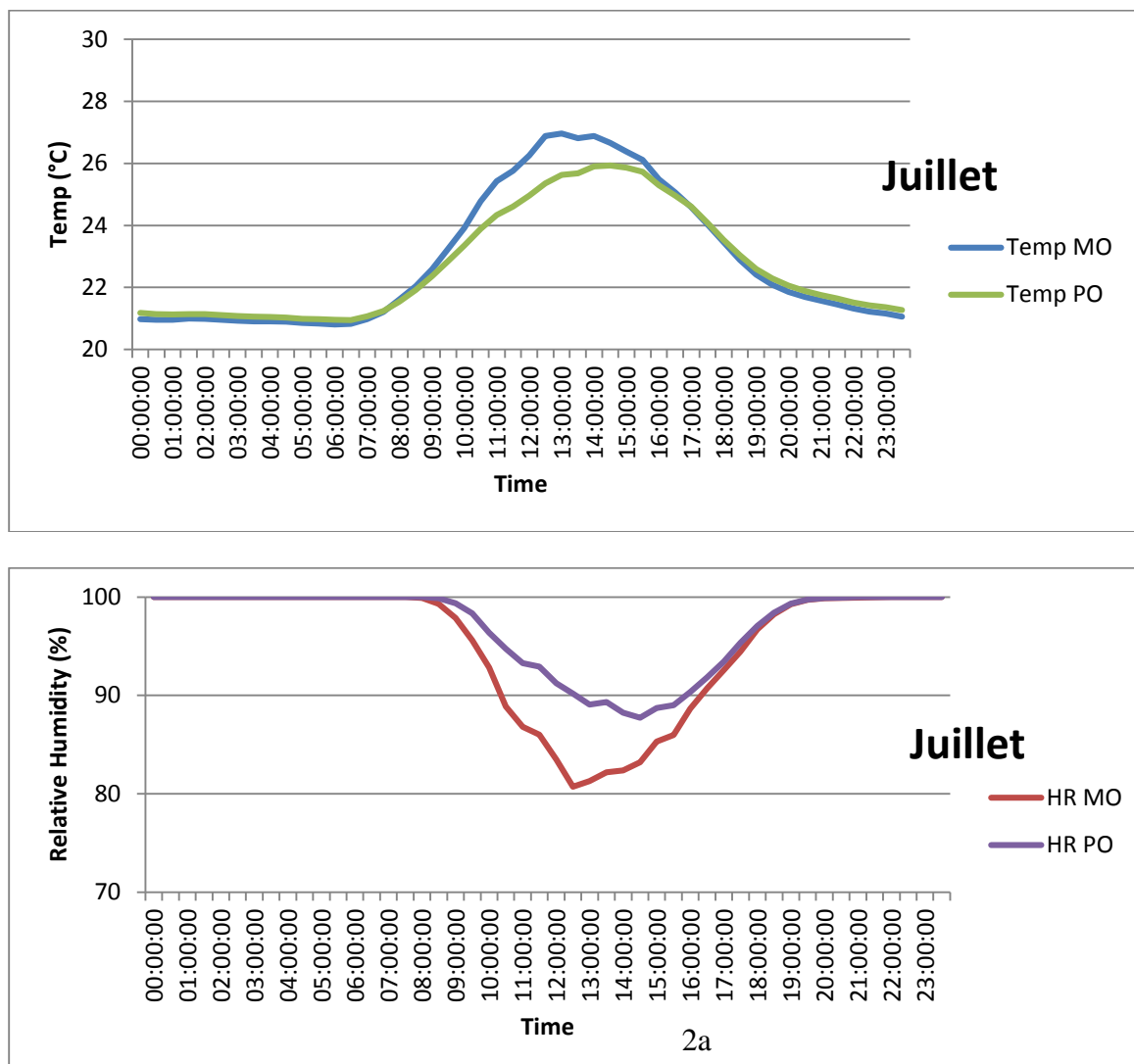
Figure 2. Mean daily temperature (2a) and relative Humidity (2b) for the month of July 2013 for the less (MO) and highly shaded (PO) subplots of plot 19 (Nouanda).

A detailed description of the horizontal and vertical distribution of cocoa and associated plant species has been made and maps of each subplot have been constructed. These data have been used in the shademotion software package (www.shademotion.com) to analyse and quantify spatial shade distribution (light conditions). In turn, these data are being used to explain the observed differences in microclimate between subplots with differential shade conditions. For 7 out of 8 cases/plots, a weak yet significant relationship was found between the amount of shade (in hours per week) and mean maximum temperature in the plots (see Fig. 3 for an example).

2b

Temp max

$y = -0,1455x + 30,495$
$R^2 = 0,1834$
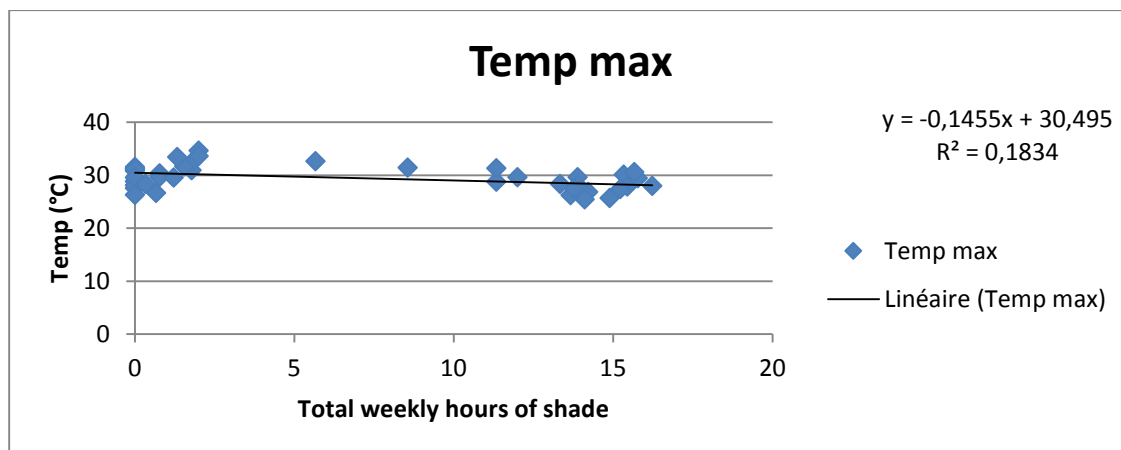
Figure 3. Relationship between weekly number of hours shade and mean maximum temperature for plot 19 (Nouando).

Difficulties encountered:
The student responsible for this project has had health problems which has delayed data-entry and data-analyses. Moreover, some irregularities on the data collection sheets as well as with the data-entry process itself have made it necessary to recheck the entered data which also has delayed data-analyses.

Plantation management varies considerably between farmers and pod losses due to diseases are better explained by the number of fungicide treatments than by microclimatic conditions. Financial constraints however, do not allow us to reimburse farmers for losses incurred due to a demand from our side to not treat the cacao study plots.

Perspectives 2014:
The student, L. Sob will continue to analyse her data regarding the impact of shade on microclimatic conditions and the link with pest and disease incidence and severity.

Current microclimate measurements will continue until the 23rd of May 2014. Afterwards, the Tiny tag Data loggers will be placed in a different configuration that will hopefully allow us to differentiate between the effects of shade by associated trees and autoshading by the cacao trees. Data loggers, instead of being placed at approximately 2 m above ground level will be placed along a vertical gradient (1, 2, 3, 4, 5 meters above ground level and above the cacao canopy).

2. The assessment of mirid impacts on cocoa production is based on field activities conducted in Bokito in four cocoa AFS where cocoa trees are associated with fruit trees (2 plots), palm trees (1 plot) and coconut trees (1 plot). In these different plots, an inventory of the entomofauna of trees was carried out (i) to highlight generalist predators of mirids and (ii) to get a census of the mirid population. The first results show that cocoa AFS with the highest indices of richness and species diversity of ants have the lowest levels of mirid infestation.

However, the results are not conclusive for new and old damages. About the myrmecofauna collected, there is a greater similarity between plots with a similar composition (association of fruit trees with cocoa trees) between two adjacent plots than different composition (cocoa/fruit *vs* cocoa/coconut for instance).

This work will be completed by inventories that will be conduct in Bokito (Bakoa) in new farmers' plots where cocoa trees are associated with fruit trees, palm trees and coconut trees, and in traditional cocoa AFS agroforestry plots. The aim of this activity conducted in a new network is to understand how different types of SAF allow contributing to the control of pests.

Two temporary were recruited in March 2014 to identify (i) insects collected in trees on tarpaulins after insecticide applications performed in 2012 and (ii) insects collected in traps in 2013 in different types of cocoa plots. The objective of these studies is to establish trophic relationships within plots to determine which organisms can be involved in the control of cocoa pests.

Two new activities were implemented in 2013. The first one concerns the mesofauna found in different cocoa AFS in Bokito and Talba. This activity is conducted in collaboration with S. Saj. Soil mesofauna was extracted following the Berlese Tullgren method. Samples are preserved in alcohol and they will be sent for identification in 2014 at the end of collection periods. The second activity is currently underway to identify the impact of mirids on potential cocoa yield. A student from the University of Dschang has been recruited for this activity and will start its work in April 2014.

3. People involved in the assessment of soil fertility (soil organic matter and main nutrients) are G.M. ten Hoopen and L. Bagny Beilhe (CIRAD, UR 106), S. Saj (CIRAD UMR System), D. Begoude (IRAD), T.F. Oben (University of Dschang), G. Meko, J. Enana Nfongo and O. Mbohou Ndam (Master 2 students from University of Yaoundé 1 and University of Dschang), J.P. Bidias and A. Agoume (local observers in Bokito) and farmers.

Thanks to a cooperative effort between the projects AFS4FOOD and SAFSÉ and with a financial aid of the Research and Training Platform in Partnership (DP PCP Agroforestry Cameroon) through CIRAD's Incitative Action), all cacao plots in Bokito (n=55) and Talba (n=55) have been sampled for the assessment of soil fertility. The plots in Ngomedzap (n=37) are currently being sampled.

The objective of this activity is to link cocoa yield, diversity and plot structure of cocoa AFS to soil quality. This action is currently undertaken by a Master 2 student from the University of Dschang (G. Meko).

Soil sampling was done from October 2013 to January 2014. Soil samples are currently in lab for physicochemical analyses. Then, statistical analyses and M2 thesis to be done by the end of 2014

The collected samples are also being used to study (i) the diversity of natural enemies (mycoparasites/antagonists) of *P. megakarya* (the causal agent of cacao black pod disease) and (ii) the diversity of mycorrhiza propagules. These activities are supervised by M.G. ten Hoopen and D. Begoude). The collected samples are also being used to study mesofauna present in the soil of the cacao study plots. This last activity is supervised by L. Bagny Beilhe). Currently, two Cameroonian students of the University of Yaoundé 1 (J. Enana Nfongo and O. Mbohou Ndam) are working on these subjects.

Moreover, yet only in the Bokito region, in each cacao study plot, roots of 10 cacao trees as well as roots of all associated trees present in the study plots are being collected. These roots will be analysed regarding their level of mycorrhizal colonization as well as the diversity of mycorrhiza. So far, 40 of the 55 plots have been sampled. Currently, soil samples are being analysed.

Difficulties encountered:
The collection of root samples of associated trees is difficult and laborious since only fine roots are to be sampled. Moreover, the arrival of the dry season has hardened the soil to such a degree that collection of the last 15 cacao studied cocoa AFS will have to take place in March/April 2014.

Perspectives 2014:
In 2014, three students under supervision of S. Saj will determine potential production in all study plots in Bokito, Talba and Ngomedzap which could be used to see whether mycorrhizal diversity and/or level of colonization of cacao trees, could also help explain (partially) differences in potential productivity. A fourth student (supervised by L. Bagny Beilhe with backstopping by M.G. ten Hoopen) will continue to look into pest and disease impact on cacao productivity.

4. The objective of the assessment of the various productions (cocoa and others) of cocoa AFS is to evaluate the performance of all on-farm products on a yearly time step. This activity will connect particularly cocoa yield to the plot's history of management (technical management, strategic choices for the installation and maintenance of plots). We will also try to link the performance levels of cocoa production and food production.

This activity will be undertaken in Bokito and Talba by two Master-2 Cameroonian students who will work in collaboration with two students from WP2. WP3 will take care of yields in cocoa-based AFS. This work shall be done at least for the plots surveyed in 2013. WP2 students will work on yields in other on-farm systems. Both WP3 and WP2 shall work with a common batch of farmers (39 farms in total).

The researchers involved in this action are S. Saj (CIRAD), K. Mvondo (IRAD), E. Fonkeng, J. Tarla and J.P. Mvondo Awono (students from the University of Dschang).

The field work will be conducted from April 2014 to November 2014. Protocols for field work are ready. Coordination with WP2 activities is also ready for Bokito while is pending for Talba.

Results of WP3
The first results from WP3 seem to indicate that traditional family-based cocoa cultivation performed in Bokito is more favourable to diversification with fruit trees, which strengthens the contribution of this type of cocoa cultivation for food-security, compared to the entrepreneurial cocoa cultivation performed in Talba.

They also indicate a low but significant impact of shade-trees on micro-climatic conditions in cocoa plots (reduction of temperature and increase of relative humidity). These shade trees are also identified as the major contributors of carbon storage, which can be as high as the one observed in forest (case of Bokito). On the other hand, the level of tree species diversity is lower in the AFS plots than in forests.

WP4: Characterization of the AFS main-crop quality for value addition to farmers' incomes

4.1. Characterization of the quality of AFS products at plot level

During the second year of the project, the 16 samples collected during the first year were submitted to sensory analysis in Cameroon and to biochemical analysis in Montpellier. These analyses failed to indicate any difference between cocoa samples issued from the same cocoa varieties grown on different types of soils. On the other hand, slight differences were observed among cocoa samples issued from different commercially released cocoa varieties.

In addition, two of these cocoa samples were shipped to France for evaluation in the frame of the "Cocoa Award" contest, organized in October 2013. These two samples were first analysed by a panel of tasters who assessed them on cocoa liquor. Both samples were considered as good enough to be submitted to chocolate assessment by a larger panel during the 2013 edition of the "Salon du Chocolat" in Paris. The samples were favourably scored by half of the panellists and unfavourably by the other half.

Two additional cocoa sample collecting and preparing sessions were conducted in October and November 2013. These two sessions aimed at:

Experiment 1: Comparing the cocoa quality from 3 types of samples issued from:
   a) Commercially released varieties, consisting in full-sib progenies, released at large scale through seed-gardens
   b) Traditional variety (German cocoa, consisting in *Amelonado* genetic origin)
   c) "Farmers' hybrids" consisting in half-sib progenies obtained from pods collected in farmers' fields
   d) Full-sib progenies newly created and still under assessment in experimental plots

Experiment 2: Assessing the influence of shade level on cocoa quality:
So far, 12 samples from the 20 collected in experiment 1 have been tested for their gustative quality. The first results obtained with these samples indicate:
   -   a higher "chocolate" flavour for the traditional variety (b) than for "hybrids" cocoa trees issued from crosses between different genetic origins (c, d, e);
   -   the existence of a slight "floral" flavour in samples issued from "local hybrids" (c) and in one recently created variety (d);
   -   a higher "fresh fruit" flavour in three newly created varieties (d) than in the currently released ones (a).

The 12 samples collected for experiment 2 have not yet been analysed for their gustative characteristics.

4.2. Identification of main drivers of the quality of AFS products at plot level and at first transformation

4.2.1. Safou shelf-life optimization

Gustative quality of Safou was assessed after different drying process/type of packaging combinations.

Large Safou slices (>400 mm^2) were dried during 15 to 24 hours at 60°C (slow process) while small ones (<100 mm^2) were dried at the same temperature during 3 to 5 hours (rapid process).

The comparison between the different types of packaging showed that:
- Safou slices packaged in glass bottles and in plastic bags under vacuum showed no rancidity after 90 days, after both drying processes
- A packaging in polyethylene and polypropylene bags resulted in strong rancidity after a rapid drying process and in a slight rancidity after a slow drying process

4.2.2. Use of Safou powder as an essential lipid and mineral fortification agent in the production of rice

IRAD has developed the confection of biscuits using broken rice, thus adding value to this product. Unfortunately, such biscuits show a rather low nutritive value, because of their low content in proteins, minerals and essential lipids.

Fortification of these biscuits using Safou, a product already in the local population diet and characterized by a short shelf-life, appears like a win-win strategy.

Sensory evaluation of rice-Safou made biscuits resulted in a level of acceptance as high as the one of rice biscuits.

Nutritive evaluation of rice-Safou made biscuits revealed a higher value than rice biscuits for minerals (magnesium, potassium, iron and zinc), fat and protein contents.

Results of WP4
The first results from WP4 seem to indicate that:
- genetic origin of cultivated cacao in Cameroon has an impact on cocoa gustative quality;
- some simple techniques can be applied to improve shelf-life and valorise safou. A generalized use of these techniques would increase revenue from cocoa-based AFS plots as well as their contribution to food-security.

Reason for modification for the planned activity

Activities could be done according to planned schedule; no modification were necessary.

What is your assessment of the results of the Action so far?

The project has allowed the collecting of a large amount of information, obtained from a large number of cocoa farms. Even if the use of powerful statistical analyses is planned in year 3, in order to get definitive and precise results, the data obtained still allow us to identify interesting trends:

The first results from WP2 were interesting because they seemed to indicate that:

- Traditional and familial cocoa cultivation based on small size cocoa plots does not concurrence food-crops, even when cocoa cultivation is partially performed on savannah plots (case of Bokito).
- Entrepreneurial cocoa cultivation based on medium to large size cocoa plots and the use of hired workers is less favourable to food crop, even when the cocoa cultivation is nearly restricted to forest area (case of Talba)
- Entrepreneurial cocoa cultivation on the pioneer front are associated to a high level of plantain production dedicated to distant markets and even export rather than to local trade.
- The shortage in food crops results in the necessity of purchasing food from markets in towns, which is not a major problem because of the reasonably high revenues obtained by farmers.

The first results from WP3 seemed to indicate that traditional family-based cacao cultivation performed in Bokito might be more favourable to diversification with fruit trees, which strengthens the contribution of this type of cocoa cultivation for food-security, compared to the entrepreneurial cocoa cultivation performed in Talba. They also indicate a low but significant impact of shade-trees on micro-climatic conditions in cocoa plots (reduction of temperature and increase of relative humidity). These shade trees are also identified as the major contributors of carbon storage, which can be as high as the one observed in forest (case of Bokito). On the other hand, the level of tree species diversity is lower in the AFS plots than in forests.

The first results from WP4 seem to indicate that:
- Genetic origin of cocoa cultivated in Cameroon has an impact on gustative quality
- Some simple techniques can be applied to improve shelf-life and valorise Safou.

A generalized use of these techniques would increase revenue from cocoa-based AFS plots as well as their contribution to food-security. These assumptions need to be tested over an extra harvesting period.

Potential risks that may have jeopardized the realisation of some activities and explain how they have been tackled

The activities were never jeopardized during the period.

Activities planned but not implemented

All planned activities were implemented.

Nevertheless, it would be of interest to increase the amount of data by adding one more harvesting period.

Updated action plan Cameroon

Activities	Year 1												Implementing bodies
	1st Semester						2nd Semester						
Months	1 Apr	2 May	3 Jun	4 Jul	5 Aug	6 Sep	7 Oct	8 Nov	9 Dec	10 Jan	11 Feb	12 Mar	
1.1. Identification of study farms and communities			x	x	x								CIRAD, IRAD
1.2. Creating Eval. committees & Ext. adv. panels				x	x								CIRAD, IRAD
1.3. Scientific Coordination	x	x	x	x	x	x	x	x	x	x	x	x	IRAD
Workshops							c						CIRAD, IRAD
1.4. Capacity Building							x	x	x	x	x	x	CIRAD, IRAD
2.1. Spatio-temporal Dynamics							x	x	x	x	x	x	CIRAD, IRAD
3.1. Assess interactions AFS and food crops											x	x	CIRAD, IRAD
3.2. Pathways to improve synergies													CIRAD, IRAD
4.1. Characterization of SAF product quality							x	x	x	x	x	x	CIRAD, IRAD
4.2. Drivers of AFS product quality							x	x	x	x	x	x	CIRAD, IRAD
5. Dissemination of results													CIRAD, IRAD

Activity	Following years					Implementing body
	Year 2		Year 3		Year 3+	
Semesters	3 Apr – Sep 13	4 Oct 13 – Mar 14	5 Apr – Sep 14	6 Oct 14 – Mar 15	7 Apr – Sep 15	
1.3. Scientific coordination	x	x	x	x	x	All partners
1.4. Capacity building	x	x	x	x	x	All partners
2.2. Evolution of farmers' strategies	x	x				All partners
2.3. Modelling and forecasting			x	x		All partners
3.1. Assess interactions AFS and cash crops	x	x				All partner
3.2. Assess pathways to improve synergies	x	x	x	x		All partners
4.1. Characterization of AFS product quality	x	x	x	x	X	All partners
4.2. Drivers of AFS product quality	x	x	x	x	x	All partners
5. Dissemination of results	x	x	x	x	x	All partners

Reasons of changes

Changes are requested to increase the amount of data collected and thus, the quality of results and outputs.

2.2.3. Kenya

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WP1: Management

1.1. Identification of target farms and communities

This activity was performed during the first year of the project by the AFS4Food team in Kenya in collaboration with local partners (i.e. ICRAF, CRF and the Union of farmers' cooperatives of Murang'a). The team is now working closely with a series of about 100 target farms in the district of Murang'a.

1.2. Creation of multi-sector Advisory committees and External advisory panels

The local steering committee is constituted, but not on a formal basis. Nonetheless, the AFS4Food team in Kenya periodically exchanges information and points of view with farmers as well as representatives of local authorities, extension services and representatives of NGO working with local communities in the region on the goals and the results of the project.

1.3. Scientific coordination of the funded operations and the network

For Kenya, a management unit has been constituted since the onset of the project between ICRAF & CIRAD to follow up financial, technical, and administrative matters and to strengthen the local research network and communication with the coordinator in Montpellier, France, as well as partners in the 2 other countries.

1.4. Capacity building and capitalization of knowledge

The team in Kenya has helped the project management unit to organize the first international workshop that took place in Yaoundé in October 2012. It has also facilitated the field work of several graduate students and local researchers (see details below).

The Kenyan team organized the second international workshop of AFS4Food from 21st to 26th October in Nyeri, Central region, in the heart of the coffee region of Kenya. This gave the opportunity to researchers from Cameroon, Madagascar and France to see the various coffee and food cropping systems and exchanged on the ground about research activities and results.

Results of WP 1

- Management unit in place;
- First annual report delivered to Coordinator;
- Organization in October 2013 of the 2nd international workshop of the project;
- Periodic consultations of the members of the steering committee and key local stakeholders.

WP2: Characterisation of farming systems and identification of long term drivers at household and landscape levels

2.1. Spatio-temporal dynamics of farming systems

2.1.1. Understand the dynamics of farming systems on the long term

The results of the bibliographical, cartographic and statistical research works, and the mission carried out in December 2012 (observations of the agrarian landscapes and interviews with people resources), made it possible to bring the first information on the dynamic space ones of the various basins coffee-trees of Kenya (figure 1) and the dynamic ones of recombining of the agroforestry systems containing coffee of the basin of the Centre the east, most important of the country. This last accounts for 79% of coffee surfaces from Kenya (86,750 ha/109,711 ha), 90% of Kenyan the coffee-plantation production (51,076 tons/56,735 tons) and 76% of the small farmers gathered in cooperatives (434,295 members/570,824 members).
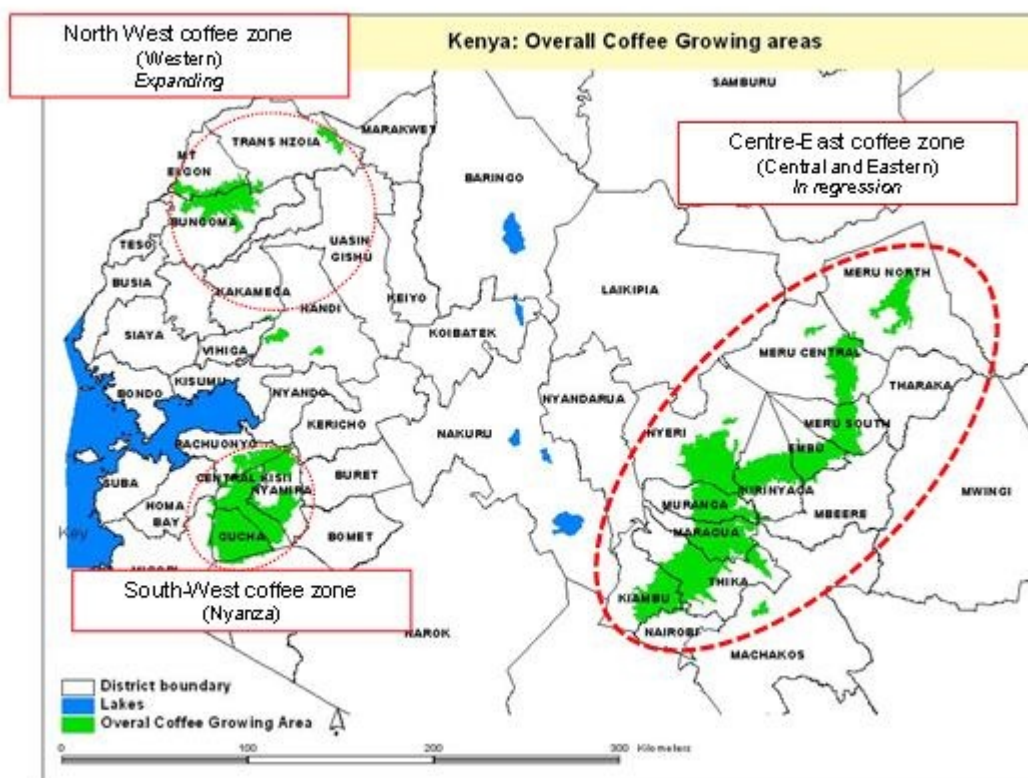
Figure 1: Localization of the main coffee basins of Kenya.

Source of chart: given by Philippe Vaast.

It appears that the surface occupied by the coffee agroforestry systems of the Centre-East basin does not know significant evolution but a strong replacement of the coffee-plantation production by other commercial speculations (milk, food, tea, khat, bananas …). In a depressed general panorama of the coffee sector in Kenya, only the North-West basin knows a strong dynamics of plantation and extension of coffee-plantations surfaces. This expansion does not succeed for the moment to stop the fall of the production of coffee in Kenya. Taking into account the distance of the basin of the North-West and duration of our mission we could not return there and observe in a more precise way the dynamic which developed and the type of

operators who carry them. It was in the same way for the South-west basin, but we could not visit it during this mission.

The first information collected on the principal recombination dynamics of the Southern Centre basin is presented on figure 2.
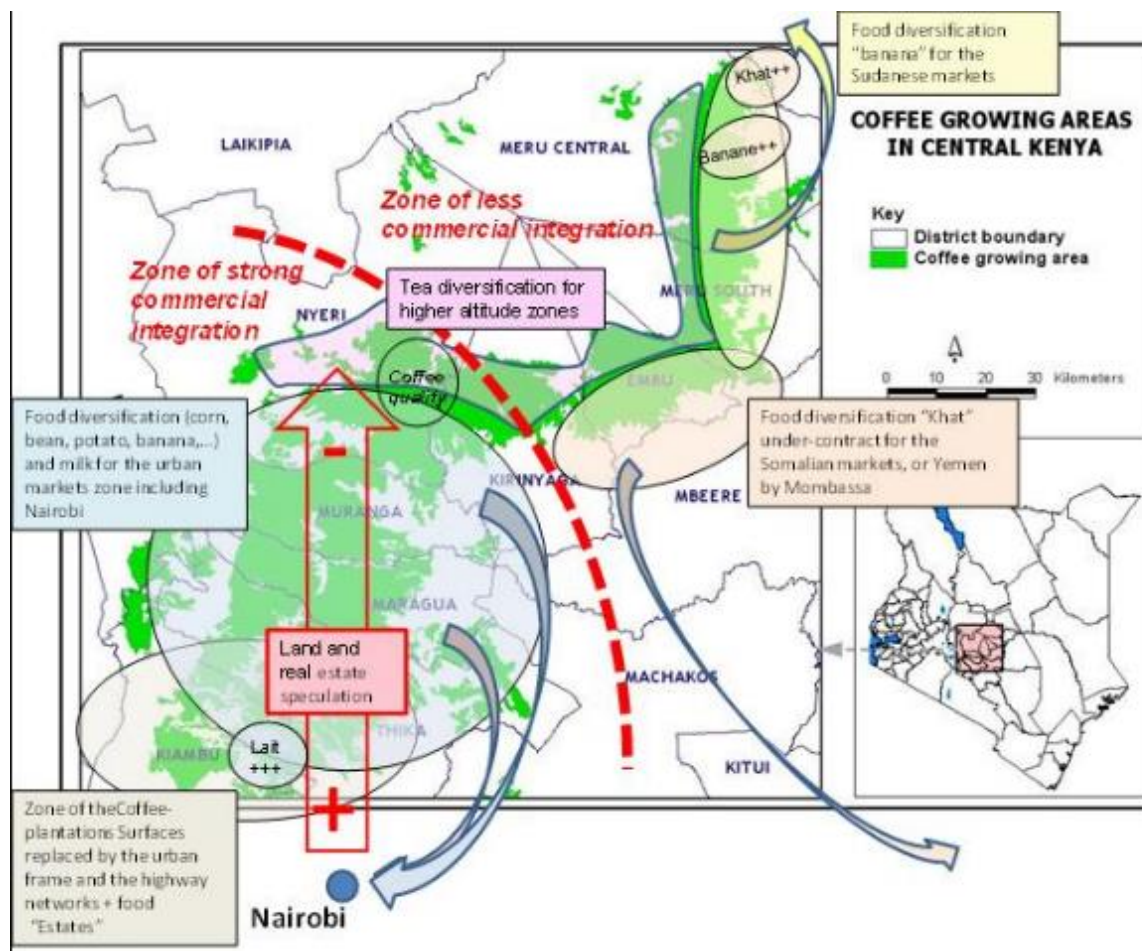
Figure n°2: First elements of zoning of the zone central coffee-plantation and strategies of diversification of the coffee growers.

This work made it possible to retain two study zones representative of the dynamic diversity of space and recombining of the coffee AFS of the Centre-East basin. The study of these two zones made it possible to analyse the incidence of the forms of production (domestic, employers', capitalistic …) on becoming and functions of the coffee systems (function patrimonial, economic, of food safety …).

The first study zone selected was that of Murang'a County, where the coffee AFS are carried in majority by small domestic producers brought together in cooperatives. In this district there are not dynamic the space particular ones taking into account the seniority of land saturation and the creation of heritage of domestic land, but one attends the dynamic ones of recombining of the systems containing coffee. These recombinations are based on a reduction in surfaces reserved for the coffee-plantation production and an increase in other productions in particular of trees, food and animal (small animal breeding and especially dairy production) which take part in the growing complexity of the AFS coffee.

The second zone of study is that of Kiambu County where dominate large farms of the capitalist type ("coffee Estates"). The library searches and the investigations of field conducted by Juliet Wainaina (in charge of research ICRAF-CRF) between May and September 2013 made it possible to specify the dynamic spatial ones and recombinations of the systems coffee-trees of this district. With regard to the dynamic spatial ones, it appears that on 22 Estates appearing on the lists proposed by the CRF for this County, 3 eliminated already the coffee plantations to replace them by real estate projects, 6 could not be solicited or did not wish to answer these questions, and on 13 Estates remaining, 54% of them had already presented at the time of the investigation a request enabling them to transform their plantation coffee-plantation into real estate project. For these 13 Estates the data of investigations show that between 1990 and 2013 31% of surfaces coffee-plantations were already replaced by real achievements or breeding of dairy cows in stalling. These data underline the strong dynamics of recession which have known for about twenty years surfaces coffee-plantations of this district close to Nairobi. With regard to the dynamic ones of recombining, the data of investigations show that between 1990 and 2013, the share of surfaces coffee-plantations cultivated under shade (in opposition to the coffee "full sun") passed from 2% to 30%. One thus attends in this zone with a double movement of reduction of surfaces coffee-plantations and a progressive growing complexity of part of surfaces remaining coffee-plantations.

These investigations also made it possible to specify the number and the characteristics of the various types of farm labourers of these Estates (statutes, functions, wages, age, sex, source…) for better knowing their diversity and allowing their sampling for activity WP2-2. It appears that 90% (in man-month/year) of these blue-collar workers are the occasional ones ("casual workers") and that 70% of them are engaged for the harvest of the coffee. 80% of the latter are women. These characteristics and the low level of the practiced wages (220 ksh/day is 63,300 Ksh/year) confirm the declarations of the people questioned who perceive this kind of employment like a displaced activity "reserved" for the least qualified and with neediest of the rural ones.

2.1.2. Analysis of aerial imagery and Geographic Information System

During the first year, C. Lelong identified with the help of the Kenyan team the study area where remote sensing images will be used. A very high spatial resolution Worldview2 satellite image was acquired in 2013. This image covers a rectangle of (157km2) is in the vicinity of Murang'a town (at the East) and Kangema town (at the North-West), comprised between -0.694° and -0.765° of latitude, and 36.92° and 37.10° of longitude (cf. Figure 11).
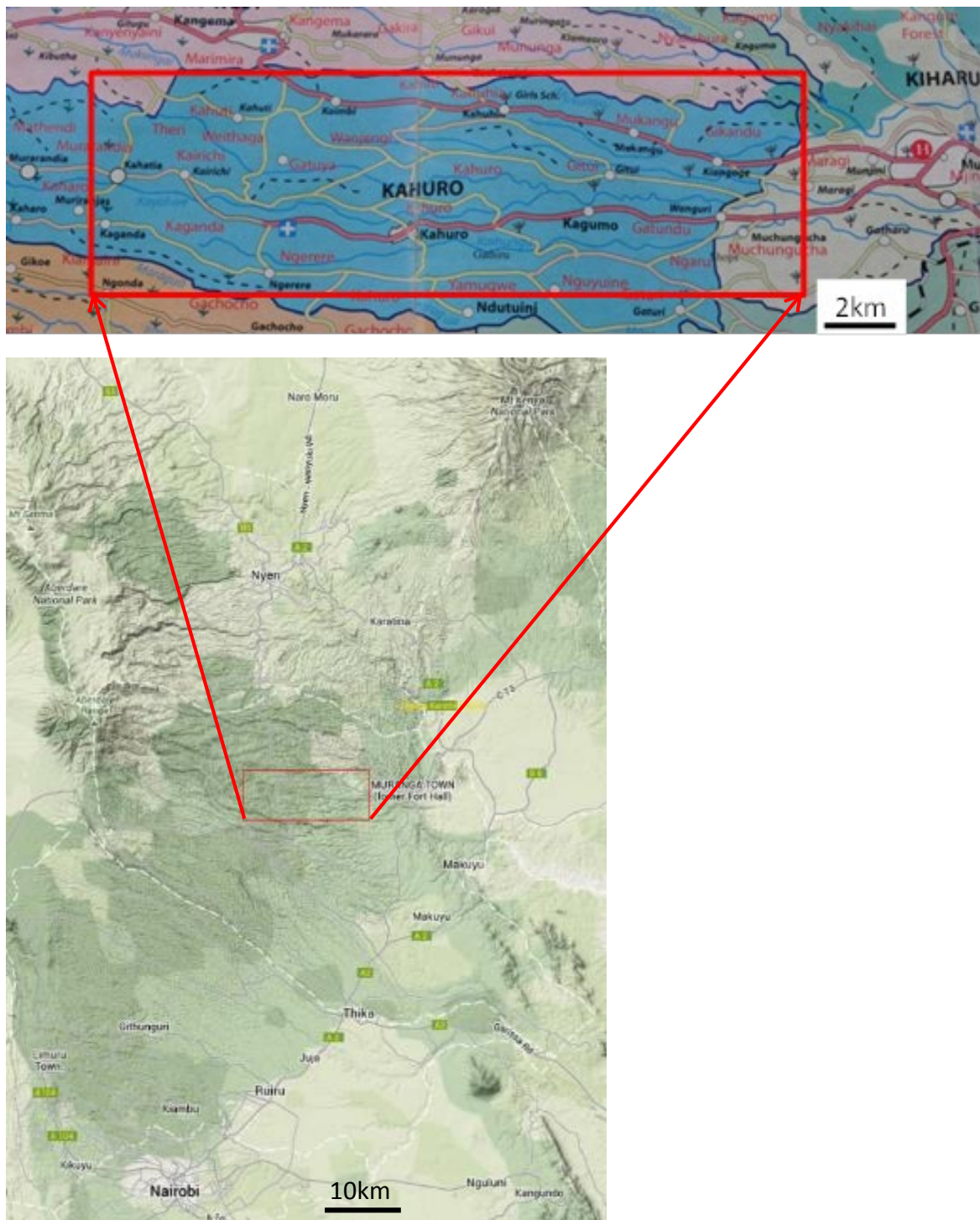
Figure 1: location of the Murang'a study site remote sensing frame

WorldView 2 satellite was programmed to acquire an image over this area, that was achieved in May 2013, the 25th. It bundles a combination of:
- a panchromatic (monochromatic) image at 50cm / Pixel resolution
- a multispectral (8 spectral bands in Visible and Infrared wavelengths)

As the area of interest was too large for the sensor swath, the image was acquired in two different shots, providing two frames with different view angles, as shown at Figure 1.

Figure 2: WorldView 2 satellite image cover, acquired in two separate frames indicated in yellow.

This data configuration allows both to reach very small details in the landscape, such as individual trees for instance, and to get the reflectance information of the studied surface. Figure 3 shows some examples of reflectance spectra as acquired by WorldView2 on different surfaces.
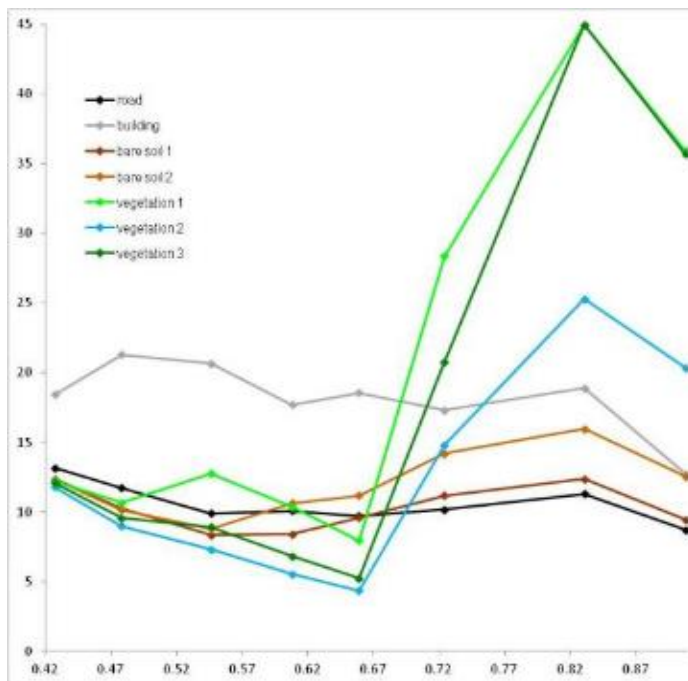
Figure 3: spectral signature of different surfaces as measured by WorldView2

The inconvenience of the two frames is the geometric distortion that the difference of view angles provokes, associated with a variation of the reflectance signal for a single surface that will be only partially corrected by the orthogonal-rectification.

Two levels of radiometric corrections were applied to the image: first a standard instrumental calibration, transforming the Digital Numbers into radiance data, followed by the conversion in top-of–atmosphere reflectance based on the sensor and sun positions at time of acquisition.

The SRTM instrument, based on board the Space Shuttle, acquires altimetric radar measurements that allow producing a digital altitude map, the so called DTM. This data is provided at 90m/pixel of resolution only, which is far from sufficient in an area with huge slopes and high variability of altitude such as Murang'a test site. But this is the only topographic data

available at the moment over the area, and it was used as the topographic reference for the WorldView2 orthogonal rectification.
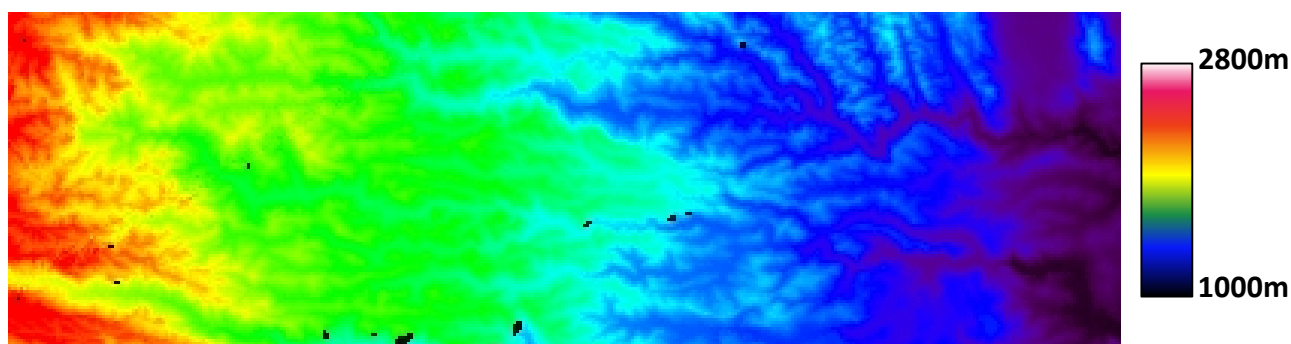
Figure 4: SRTM DTM over the WorldView2 frame of acquisition.

Another potential use of this DTM is the 3D-drapping of the image over the topography, like shown at Figure 5. This tool will be useful to understand for instance the distribution of the different cropping systems over the topo-sequence.

Figure 5: 3D-view of Murang'a landscape based on the WotldView2 image draped over the SRTM-DTM.

A field survey was achieved in May-June 2013, so quite simultaneously with the satellite data acquisition to collect information about the cropping systems and the farming practices in the Murang'a area, and to geo-reference those data to be overlaid on the satellite image. It consists in the ground observation and GPS pointing of more than 300 cropped plots, most of them being coffee crops or related to a coffee farm. A plot description was registered as paper material that still has to be digitalized now. This description includes a list of trees, other crops associations, estimation of tree and coffee density, information about the agronomical status of the crops. The use of these records is to provide with interpretation keys for the image classification, as long as validation samples to estimate the classification quality.

A second type of survey consisted in locating accurately in the image (printed in paper sheets) and by GPS a large range of individual trees, about 50 trees. The goal is to analyse the potential of WorldView2 data to discriminate each species or at least some types of trees, to evaluate the vegetal diversity inside a plot and the functionality of shading trees in coffee plots.

The product of this survey, still under digitalization processing, is a vector file (a shape file useable in any GIS, see
Figure 6) delimitating the plot or pointing the trees, associated with an attribute table giving all the recorded information.

	ID	OS	assoc	comments
1	539 plot	coffee	rare banana	port haut, manque d'azote
2	540 plot	nappier	other grasses	
3	542 plot	wattle	cyprus	
4	545 tree	avocado		4-5 trees
5	546 plot	coffee	few banana	sunlight - photo
6	546b plot	coffee	banana grevillea	
7	545c plot	grass		weeds
8	541 tree	avocado		neflier coll. NE, bananier au S, puis au
9	560 tree	croton mukindori		
10	560b tree	erythrina		
11	561 tree	erythrina		
12	562 tree	erythrina		
13	552 plot	coffee	grevillea	
14	557 plot	nappier/maize		
15	544a tree	erythrina		
16	544b tree	erythrina		
17	544c tree	erythrina		
18	545b tree	cordia africana		fleuri
19	543 tree	cyprus		3 trees in the axis N-S
20	547 tree	mango		

Figure 6: Example of digitalization of the field survey referred plots and individual trees: plots contours or tree centre are delimitated by hand on the image to create a vector; and an attribute table is created to register the vegetal species that are found into the plot, the eventual associations, and some comments

Due to the high complexity of textures, features, and landscape elements in the image, and to the amount of details provided by the very high resolution data, we have chosen to classify the different land-covers using the object-oriented approach(under EcOGnition software). It consists in several hierarchical steps of multi-resolution segmentation followed by a classification based on trained rules.

The first step is thus a segmentation of homogeneous objects, which can be afterwards discriminated on the basis of their mean value of any relevant parameter. The first deal is thus to find the adequate level of segmentation (see examples at Figure 7).

Figure 7: example of 2 levels of segmentation: the first one in the middle provides with two large object, not homogeneous enough, while the one at the right gives better definition of objects but too smell in some cases…. A compromise has to be analysed.

The hierarchical classification consists in an iterative classification process of higher level classes and child classes at different levels. These levels correspond mainly to the brain (cognitive) scheme used to discriminate every surface and are quite intuitive.

In order to enhance both the radiometric, texture and structure information contained in the data, several products were derived from the initial WorldView2 data and associated to the P and the MS data in the data stack:
-   The textural indices based on the co-occurrence matrix (Haralick), named variance, contrast, dissimilarity, and correlation. They were calculated on the panchromatic image with 3 different neighbourhood sizes: 9, 11, 21, and 31 pixels. These parameters were selected after a sensibility analysis and a principal component analysis among a wider range of textural indices and sizes of sliding window.
-   The principal components derived on the stack of data composed of the panchromatic image and all the selected textural indices: the first 8 principal components were kept.

- The 8 principal components derived on the stack of data composed of the 8 spectral bands.

It results in a whole data stack of 42 parameters.

Attributes selection to be used in each object-based process is optimized by experimental processes.

In the Murang'a area, the first level of information was established to be the areas without any vegetation: roads, buildings, bare soil. A first level of segmentation thus aimed at defining small objects homogeneous in terms of vegetation presence or not. It was found to be parameterized by a scale parameter of 20, a shape criterion fixed to 0.1 and a compactness fixed to 0.1. Then vegetated and non-vegetated areas were classified on the basis of the NDVI, with a threshold of 0.47. This first level of classification is very accurate.

After fusion of all the objects belonging to the "vegetation" class, these objects were then segmented in sub-objects with a multidimensional segmentation at 25 of scale parameter, shape criterion equal to 0.1, and compactness criterion equal to 0.5.
The herbaceous vegetation and the trees were discriminated on the basis of a threshold applied to the sixth principal component derived from the panchromatic and textural indices. At this step, that still has to be improved in the next future, most of the trees (and indeed the large trees) are correctly detected and mapped, but there are still areas were the coffee trees or plantations, for instance, are not recognized as tree crops.
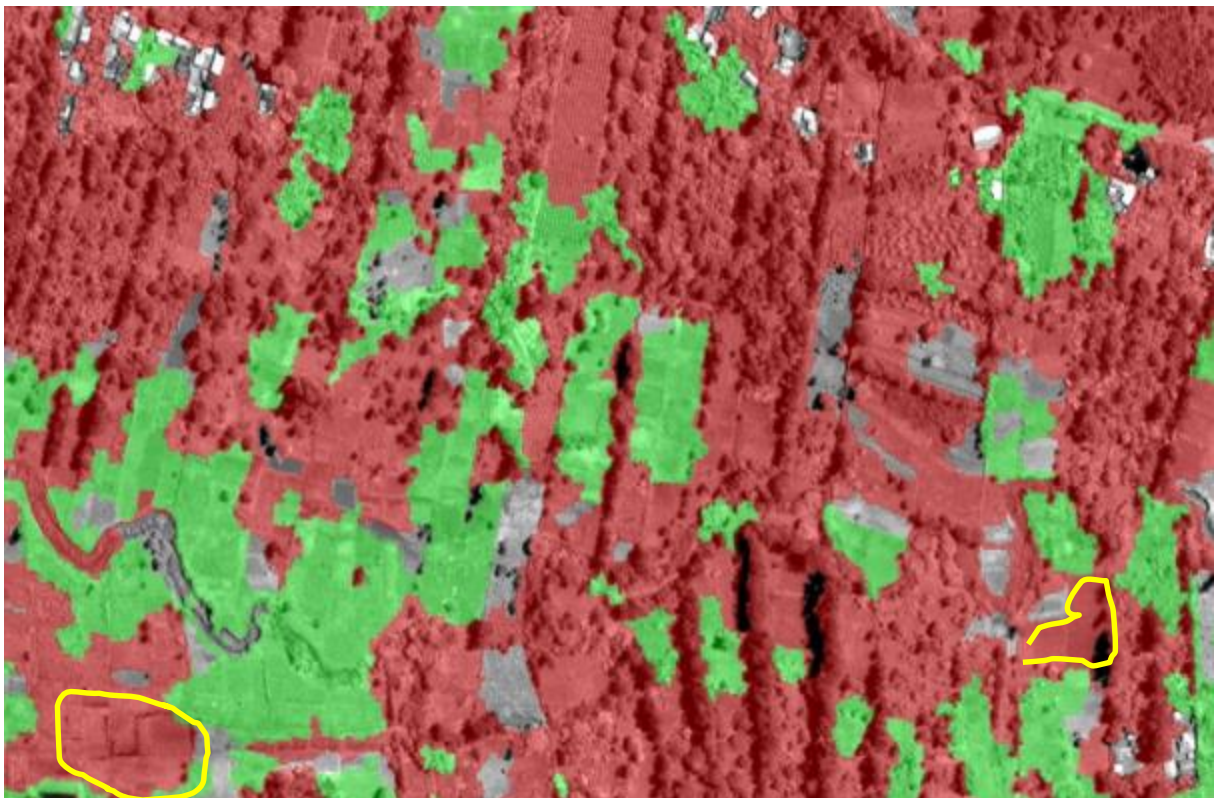
Figure 8: Example of the classification of trees (in red) and herbaceous vegetation (in green) were many annual crops are wrongly classified as trees (examples under-lined in yellow).

Figure 9: Example of the classification of trees (in red) and herbaceous vegetation (in green) were some coffee crops are wrongly classified as herbaceous vegetation (examples underlined in yellow)

Now the work to be done is to continue the hierarchical process to reclassify the wrongly assigned areas and to provide with a confident classification of trees.

Afterwards, some object-oriented methods will be applied to estimate the density and the distribution of trees in the plots. But this is still under development.

Figure 10: Example of second segmentation level objects

	Data used for segmentation	Weight of layer in the segmentation process
Level 1	NDVI	2
	Panchro	3
	PCMS1	1
	PCMS2	2
	PCMS3	2
	PCMS4	1
	PCT3	1
	PCT4	2
	PCT6	2
Level 2	MS1	1
	MS2	1
	MS3	1
	MS4	1
	MS5	1
	MS6	1
	MS7	1
	MS8	2
	Panchro	4
	PCMS1	1
	PCT1	2
	PCT2	2
	PCT3	2
	PCT4	2
	PCT5	1
	PCT6	3
	PCT7	2
	PCT8	2

Table 1: List of the data attributes that were used to perform the first two segmentations. MSx relates to the xth multispectral channel, PCMSx to the xth principal component of the multispectral data, and PCTx to the xth principal component of the textural data.

This work will be intensified in 2014, particularly with the help of a graduate student who will be taking measurements in the field for 3 months from April to June 2014.

2.2. Evolution of smallholders' strategies and agricultural activities
This activity was developed in the two study zones: Murang'a County and that of Kiambu.

2.2.1. Typology, farmers management and strategies
For Murang'a County, Claude Toko, trainee of the IRC Montpellier, carried out, between April and August 2013, the investigations of about 30 selected agricultural families according to their pedoclimatic situation and the size of their farms, and 6 families of farm labourers.

The got results show that the variations of incomes, between the four socio-economic categories of typology carried out, go today from 1 to 30 (from 40,000 to 1.2 million Ksh/year). They show that 5 families of our sample (4 small coffee producers and 1 farm labourer), on the 36 questioned, are below poverty line (equivalent with 61,000 Ksh/year). They also show that non-agricultural activities and activities except ground (dairy breeding, poultries …) represent respectively 35 to 45% and 15 to 45% of the total incomes of the various types of families. They show finally that there is no correlation between the agricultural surface had by the families and their level of income. This information shows that one assists, because of reduction of agricultural surfaces available by family and the increasing economic integration of this rural area to the national economies and under regional, with the development of the domestic of

diversification of agricultural activities and non-agricultural strategies. These strategies aim at maximizing the valorisation of the ground and the domestic task force. These observations, which go in the direction of a good capacity of adaptation and impact strength of these rural populations, must be relativized since the demographic data show that County of Murang'a has known for about twenty years an important deceleration of the growth of its population. The first statistical data, which require to be supplemented and confirmed by more deepened demographic analyses, seem to indicate that this deceleration of the growth of the population of this County represents a strong rural depopulation into the urban areas and the activities of the secondary sectors and tertiary sectors of the Kenyan economy, and that it would relate to in particular the young generations.

For Kiambu County, this work concerned the blue-collar workers of the large plantations (Estates) of type employers' or capitalist. In these agrarian spaces it is indeed this socio-economic category which is most likely to be affected by security issues food since their average incomes are right above poverty line (63,300 Ksh/year against 61,000 ksh/year). The data resulting from the investigations conducted between October and December 2013 by Juliet Wainaina near a sample of 29 blue-collar workers from Estates were already seized and partly treated; treatment which it is necessary to continue before having the first results of them.

2.2.2. Evaluation of production systems and farm activities
This part of the activity has started in the 1st semester of year 3.

Bonds between the socio-economic situations of the agricultural families and the developed systems of production, in particular the types of coffee systems implemented, remain to be made; it is the objective of a work of master degree 2 which will be held between April and October 2014 in Murang'a. We will be then able to define, in a context pedoclimatic given, which is the most powerful combination from an economic and food point of view, between food systems and separate coffee-trees and closely associated systems, combining or not the breeding; and this for a diversity of socio-economic situations.

2.3. Modelling and prospecting at farms and landscape levels
This activity is planned for the 3rd year of the AFS4Food project and will be based on the data obtained by the two other preceding activities (WP2-1 and WP2-2). However, the first macro-economic data already collected by the field studies (Wainaina J and Toko C.) and during the various missions (December 2012 and May 2013) bring interesting indications. They showed that farmers waited since the years 1990 an increase in the difference between the incomes of the coffee or the level of remuneration of the farm labourers and the prices of farm land, or the price index with consumption (figure 3).

Continued revalorization of earned incomes of the civil service since the years 2000 (figure 3: "wage official employers") did not make it possible to catch up with the increase in the cost of living, but it places these employees of the secondary and tertiary sector of the Kenyan economy were in a position less unfavourable than the agricultural credits.

These tendencies let think that the dynamic ones currently observed, namely the development of the multi-activity and of rural depopulation in Murang'a County and the replacement of surfaces coffee-plantations by real estate in Kiambu County have to continue, to even intensify, in the years to come. The relative weight of the coffee systems in the distribution of monetary incomes and the maintenance of the food safety of the Kenyan population is thus likely to

decrease as the other sectors of the economy develop. Even if technical margins of progress exist and must be explored, one can think that the future of the role of these systems coffee-trees in food safety will depend probably less on the improvements of their technico-economic performances that health of the other sectors of the Kenyan economy and their capacities to absorb the new generations. The validity of these first conclusions remains to be tested by the analyses to come.
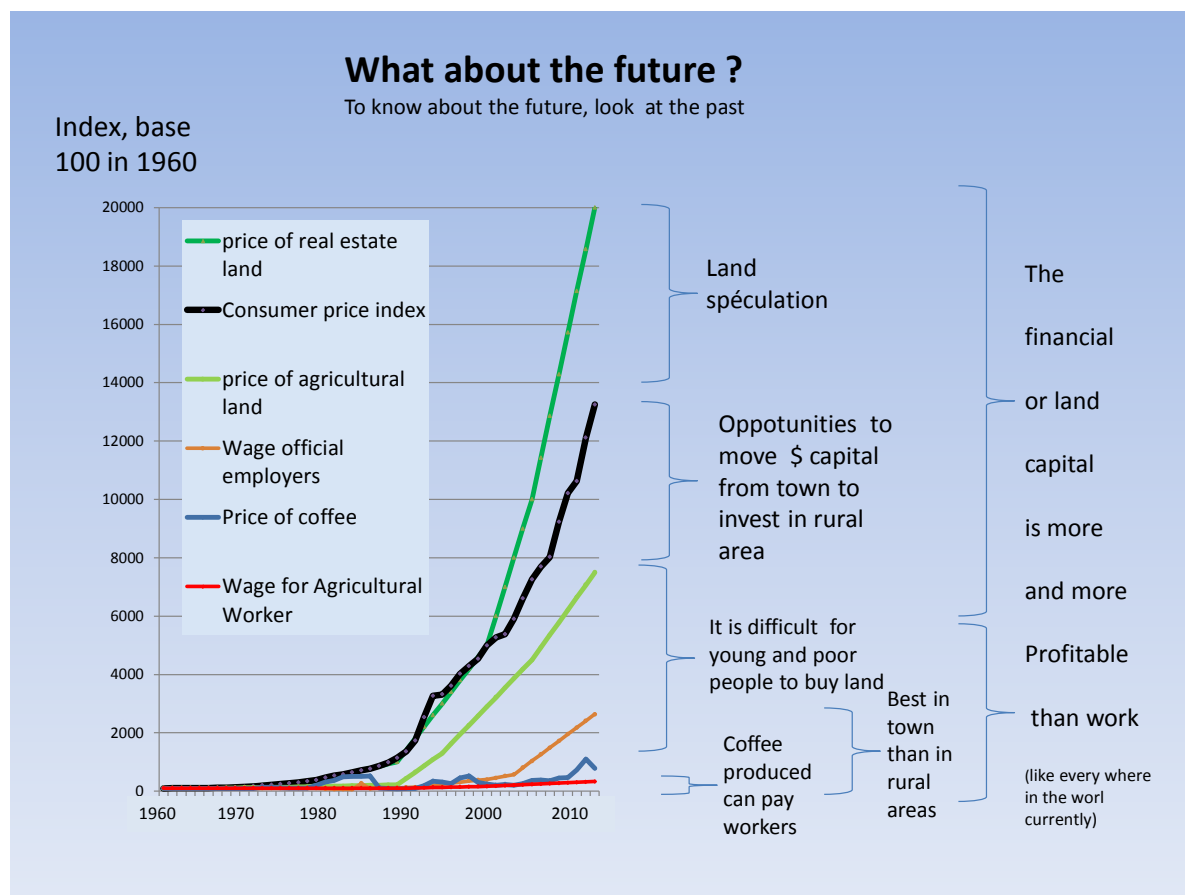
Figure n°3: First data on the evolution of various macro-economic indicators over the period 1960-2013 (index 100 in 1960).

Sources: our surveys + Kenyan statistical series.

Results of WP 2

- Sites selected for forthcoming surveys.
- Data set on main features for around 60 households in two contrasted coffee producing counties.
- Enhanced knowledge of stakeholders' strategies in rural coffee communities.
- Importance and evolution of agricultural and off-farm activities in the livelihood of farmers in the county of Murang'a.
- Typology of coffee farms is in progress.
- Two graduate students (Claude Toko of Cameroon and Juliet Wainaina of Kenya).

WP3: Assessment of the productive and environmental performances of AFS and their synergies with food-crops at plot, farm, and landscape levels

3.1. Productive and environmental interactions between AFS and food crops at plot, farm and landscape levels (characterization)

3.1.1. Characterization of indigenous knowledge related to agronomic or environmental functions and uses of the cultivated species (mainly trees species) in a range of AFS and food crop combinations

The characterization of local knowledge on agroforestry practices and key attributes of trees associated to coffee and, to a lesser extent associated food crops, has already been intensively undertaken in the target zone by a previous project. ICRAF is currently working on a publication (expected by mid-2014) to that respect. They are also refining the tool to select trees according to their desirable attributes for a beneficial association with coffee and food crops and in accordance to farmers' needs.

3.1.2. Assessment of productive and environmental performance of agroforestry and food cropping systems and of their synergy

Soil fertility and performance of pure/mix cropping systems
In 2012, a MSc student from Morocco conducted interviews of farmers and collected information on the various cropping systems (coffee and food crops) and their management in a series of 50 farms. He registered basic information on the main productions in each farm, and completed an inventory of trees species and their position with respect to cropping systems and farm boundaries. From December 2013 to March 2013, an ICRAF technician completed this work with an extra 15 farms so that a total of 65 farms is fully documented, including GPS.

Furthermore, soil sampling was undertaken in all the target farms and soil analyses were done by ICRAF laboratory. This has allowed the assessment of carbon sequestration in the various cropping systems, as well as providing baseline information on soil fertility on all the reference farms.

In 2014, two studies started assessing the effects of organic manure, the main fertilisation source of the target zone, in pure coffee systems, coffee intercropped with food crops and in pure food crop systems. These 2 studies will be ongoing until January 2015 to register production and nutritional status of coffee and the main food crops and to assess the competition or synergy effects of associating coffee and food crops on the same plot.

Coffee pathology:
The main purpose of the pathology study undertaken in the 2nd year of the project was to assess the shade influence on coffee disease epidemics in the Kenyan smallholder environment. Two students were involved in this work from April 2013 to December 2013.

Shade is frequently seen as an important production factor for coffee as it influences the coffee bush environment. It influences coffee physiology and phenology, and hence its productivity, through its direct effects on the microclimate variables such as light intensity, temperature and humidity. In doing so, it is most likely that shade also impacts the development of the coffee diseases, which are highly dependent of the climate variables.

This work package component proposed to focus on the shade impact on coffee diseases. Considered diseases include leaf rust (CLR) and anthracnosis (CBD) and the pest scolyte (CBB). Its general objective was to evaluate if the amount of measured disease could be related and further explained by the intensity of shade.

Figure 1: From left to right: Coffee berry Disease, Coffee Leaf Rust and Coffee Berry Borer

Two activities are implemented under the component: **Activity 1** focussed on 1 single coffee plot, aiming at the fine characterization of the shade – disease relation. **Activity 2** aims at the global characterization of the same relation by the comparison of several coffee plots, with various levels of shade, distributed along an altitudinal gradient from the Aberdare East slopes.

Activity 1: Assessing shade effect at tree / plot level.
In the Kenyan context, coffee plots are highly heterogeneous for canopy cover, generating various levels of shade above the coffee bushes. Under the designed protocol, one coffee plot from the Murang'a County was considered and characterized for its shade heterogeneity levels.
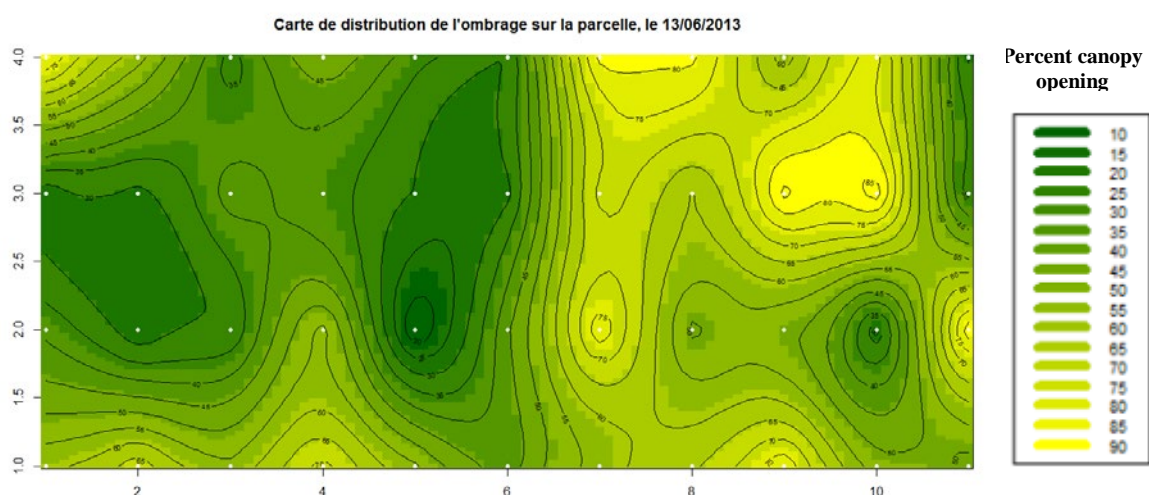
Figure 2: Canopy Cover openness over the studied coffee plot

Coffee diseases (CLR, CBD and CBB) were fortnightly monitored from December 2012 to July 2013. The spatial distribution of the diseases was recorded on 40 trees inside the plot, together with continuous recording of temperature and humidity at 10 locations in the plot. From the collected data, analysis was implemented to seek correlation between the various level of shade inside the plot, the microclimate variables and the quantity of observed disease.

The main outputs from the study indicated that the diseases development inside the plot was highly variable, tree dependent and seasonal, leading to a high level of disease heterogeneity. Attempts to explain such heterogeneity were not successful: shade effect appeared weak, with no clear relation between diseases patterns and shade levels. Furthermore, punctual, local climate parameters could not strongly be correlated to local shade level.
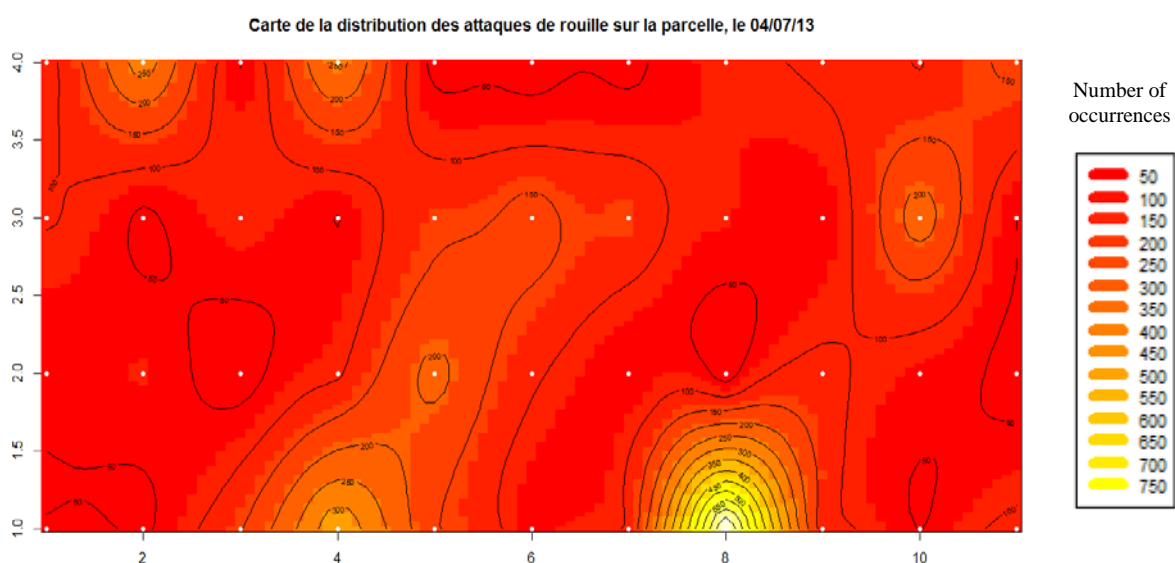
Figure 3: Coffee Leaf Rust severity distribution on the studied coffee plot (4 July 2013)

As a conclusion, it was stated that the coffee X environment interaction leading to the development of diseases was complex and difficult to capture: in this trial, shade did not appear as the main driver of the disease dynamic which may have been influenced by other factors like soil chemical composition. Detailed outputs from this work have been presented in the Master Thesis of Julie Borg, from the French school of agronomy AgroParisTech (Sept. 2013). This study was implemented with the support of a Kenyan post-graduate student (Julius Kanyari) who received specific training in disease assessment and data management.

Activity 2: Assessing shade effect through coffee plots comparison along an altitudinal gradient.

As an outcome, results from activity 1 were used to design a new approach to assess the shade effect on coffee disease in a trial where we characterized shade effect at a broader scale, assuming that the effect could be better captured at plot level, rather than at tree level.

This study was implemented in collaboration with the plant pathology department of the coffee Research Foundation (CRF) of Kenya. The protocol includes 34 shaded coffee plots randomly distributed along an altitudinal gradient on the Aberdare East slope, from Murang'a to Kangema towns. The plots were visited monthly for CBD, CLR and CBB assessment. This activity

includes the contribution of CRF scientific staff and constitutes the research project for a Master of sciences from the University of Nairobi (Master student Getrude Alwora).

The disease monitoring was initiated in January 2014. Ten rounds of field monitoring are scheduled during the 2014 coffee production year before the end of the trial by December. No result yet have been obtained has the data acquisition process is still ongoing.

3.2. Pathways to improve synergies between AFS and food crops at plot level

Surveys undertaken by 2 graduate students in 2013 (see details above) are the initial step in the assessment at plot level of the trade-offs and synergies of AFS containing food crops in terms of productivity and services. Clearly, this particular sub-activity will go on during the full duration of the project. As previously mentioned, 2 studies are ongoing in 2014 which should allow us to achieving this goal.

Results of WP 3

- Species inventory and measurement of all trees present in 65 farms.
- Characterisation of the main cropping systems (coffee monoculture, coffee associated with trees, coffee and food crops, mixed food crops) predominating in target farms.
- Description of the traditional agroforestry and tree management by smallholders.
- Description of cow manure production and timing of organic amendment in coffee and food crop plots.
- Database on soil characteristics of all target farms.
- Soil samples collected in all the cropping systems of these farms and soil analysis (carbon & nitrogen) undertaken for 188 soil samples.
- Advices given by CRF to farmers on how to improve their soil fertility management.
- Collaboration with the plant pathology unit from CRF initiated for joint implementation of field activities.
- Two studies on assessing the shade effect at tree / plot levels on coffee pests & diseases carried out.
- Four graduate students (Kenya, Morocco and France) trained and involved in research since onset of project.

WP4: Characterization of the AFS main-crop quality for value addition to farmers' incomes

4.1. Characterization of the quality of AFS products at plot level

Based on the results of WP2 and WP3, 30 sites were selected (Table 1). This selection was undertaken based on the following 3 criterions:

- Altitude (along an altitudinal gradient going from 1380 to 1970 m),
- Shade / Full sun,
- Coffee genotypes (traditional cultivars versus improved one (R11) recently released).

Ripe coffee cherries were collected by the CRF team at the peak of harvest, i.e. from mid-October 2013 to January 2014. Coffee samples were processed at the CRF research station of Ruiru. A sub-sample of "green coffee" (200 g), originating from each of the samples collected in the field, was send to Montpellier for NIRS analysis; the sensorial analysis will be done in CRF. Each sample of coffee can be described according to the specific parameters in Table 2.

Coffee samples collected by CRF received at CIRAD were registered with a specific laboratory number, and kept at -20°C until analyses. Ground samples were prepared from about 50 g of green coffee using a coffee cutting mill (Retsch, Z200). About 3 g of coffee powder were analysed by NIRS.

Table 1: Information on the area coffee selection

Name of farmer	Variety	Shade	Altitude	Code Cirad	Code CRF
Monica Wamaitha	R11	Shade	1377	154/14	M25/2014
Emma Wanjiru	R11	Shade	1386	141/14	M12/2014
Peter Mwangi (Mwalimu)	SL28	Full sun	1389	138/14	M9/2014
Phyllis Mugechi	R11	Full sun	1389	159/14	M30/2014
Mwangi Karanja	R11	Shade	1390	132/14	M3/2014
Mwangi Karanja	R11	Full sun	1390	145/14	M16/2014
Francis Gathima	SL28	Full sun	1455	150/14	M21/2014
Benson Gitao Kabiro	SL28	Full sun	1525	136/14	M7/2014
Benson Gitao Kabiro	SL28	Shade	1525	155/14	M26/2014
Harrison Kamanu	SL28	Shade	1567	158/14	M29/2014
David Maina Kanja	SL28/SL34	Shade	1593	135/14	M6/2014
James Mwangi Irungu	R11	Shade	1697	147/14	M18/2014
Edward Waiguru	SL28	Shade	1732	151/14	M22/2014
Cecilia Muritu	R11	Full sun	1793	146/14	M17/2014
Joram Muritu Kirenge	R11	Shade	1793	152/14	M23/2014
Stephen Kigondu	SL28	Full sun	1810	133/14	M4/2014
Kihara Komu	SL28	Full sun	1821	139/14	M10/2014
Peter C. Matheri	R11	Shade	1848	130/14	M1/2014
Samel K. Thairu	SL28 and K7	Shade	1848	156/14	M27/2014
Samwel Kirubi	SL28	Full sun	1864	137/14	M8/2014
Samwel Kirubi	SL28	Shade	1864	148/14	M19/2014
Grace Waruinu	SL28	Full sun	1867	153/14	M24/2014
Michael Kabugu	R11	Full sun	1876	131/14	M2/2014
Michael Kabugu	SL28	Full sun	1897	149/14	M20/2014
Francis Maina	R11	Full sun	1925	144/14	M15/2014
Mary Benard	R11	Full sun	1933	134/14	M5/2014
Charles Muchiri	R11	Shade	1933	157/14	M28/2014
Duncan Thiongo	SL28	Full sun	1943	142/14	M13/2014
John Karina	SL28/SL34	Shade	1967	140/14	M11/2014
John Karina	SL28/SL34	Full sun	1967	143/14	M14/2014

Table 2: Number of coffee samples according to variety, shade regime and altitude.

	Shade	**Altitude**								
	Full sun			**Total Full sun**	**Shade**			**Total Shade**	**Total**
Variety	**1**	**2**	**3**		**1**	**2**	**3**		
R11	2	2	2	**6**	3	3	1	**7**	13
SL28	3	4	2	**9**	2	2		**4**	13
SL28 and K7						1		**1**	1
SL28/SL34			1	**1**	1		1	**2**	3
Total	**5**	**6**	**5**	**16**	**6**	**6**	**2**	**14**	**30**

A NIRS 6500 monochromatic (Foss NIR Systems, Silver Spring, USA) was used to scan reflectance from 400 to 2500 nm at 2 nm intervals. Measurements were done with ring cups (50 mm in diameter) filled with about 3 g of ground coffee powder. Data were saved at the average of 32 scans and stored as log(1/R), where R was the reflectance at each wavelength. Spectra were acquired randomly, each sample being measured twice and the average spectrum stored. Spectra were mathematically corrected for light scattering by using the standard normal variation and detrend correction. The second derivative was calculated on five data points and smoothed using Savitzky and Golay polynomial on five points.

Statistical analysis were performed using Win-ISI II software (Intrasoft International, Port Matilda, PA, USA) and XLstat software (Addinsoft, Paris, France)

The spectral database built with the 30 samples was compared to Cirad coffee database in order to check their conformity to classical coffee powder spectra and to apply prediction models developed in Cirad. The Cirad Database is constituted of more than 3000 spectra collected for many coffee origins and post-harvest treatments over 20 years.

Comparing the set of samples to this database consists of the calculation of their H Mahalanobis distances to the base. Then, if these distances are inferior or close to the limit (H ≤ 3), the predictive models can be applied.

The projection of the 30 samples spectra on the Cirad PCA led to an average H distance equal to 0.99 with a minimum of 0.238 and a maximum of 2.629. No samples presented an H distance superior to 3 (table X.1).

Table X.1: NIRS determination of biochemical compounds content of green Kenyan coffee.

Code Cirad	Code CRF	Name of farmer	Variety	Shade	Altitude	H distance	DM	Caffeine	Fat	Trigonelline	Sucrose	CGA
130/14	M1/2014	Peter C.Matheri	R11	Shade	1848	1,22	91,01	1,38	13,00	0,72	8,68	8,75
131/14	M2/2014	Michael Kabugu	R11	Full sun	1876	1,09	90,96	1,45	11,83	0,79	8,01	8,73
132/14	M3/2014	Mwangi Karanja	R11	Shade	1390	0,92	91,29	1,33	14,37	0,87	7,70	9,50
133/14	M4/2014	Stephen Kigondu	SL28	Full sun	1810	1,29	91,17	1,22	15,90	0,73	8,26	8,27
134/14	M5/2014	Mary Benard	R11	Full sun	1933	2,63	91,73	1,40	11,96	0,76	8,48	8,61
135/14	M6/2014	David Maina Kanja	SL28/SL34	Shade	1593	1,01	91,48	1,44	15,03	0,73	7,66	9,21
136/14	M7/2014	Benson Gitao Kabiro	SL28	Full sun	1525	1,18	91,52	1,37	15,98	0,76	7,96	9,39
137/14	M8/2014	Samwel K. P. Mwangi	SL28	Full sun	1864	0,86	91,00	1,37	14,95	0,74	8,24	9,14
138/14	M9/2014	(Mwalimu)	SL28	Full sun	1389	0,57	91,38	1,40	15,52	0,80	7,99	9,99
139/14	M10/2014	Kihara Komu	SL28	Full sun	1821	1,08	91,52	1,37	14,40	0,82	8,71	9,09
140/14	M11/2014	John Karina	SL28/SL34	Shade	1967	2,39	91,22	1,43	13,79	0,75	7,97	8,89
141/14	M12/2014	Emma Wanjiru	R11	Shade	1386	1,23	91,65	1,49	14,82	0,75	7,50	10,39
142/14	M13/2014	Duncan Thiongo	SL28	Full sun	1943	0,25	91,24	1,40	13,60	0,82	7,86	9,05
143/14	M14/2014	John Karina	SL28/SL34	Full sun	1967	0,24	91,13	1,31	13,63	0,77	8,72	8,54
144/14	M15/2014	Francis Maina	R11	Full sun	1925	0,59	91,09	1,40	13,12	0,75	8,17	8,71
145/14	M16/2014	Mwangi Karanja	R11	Full sun	1390	1,50	91,53	1,23	14,70	0,75	8,34	9,57
146/14	M17/2014	Cecilia Muritu	R11	Full sun	1793	0,75	91,12	1,45	12,61	0,81	8,58	9,05
147/14	M18/2014	James Mwangi Irungu	R11	Shade	1697	1,04	90,95	1,39	13,83	0,79	7,93	9,12
148/14	M19/2014	Samwel Kirubi	SL28	Shade	1864	0,88	91,26	1,37	14,51	0,72	7,92	8,58
149/14	M20/2014	Michael Kabugu	SL28	Full sun	1897	1,85	91,24	1,28	14,16	0,77	8,80	8,33
150/14	M21/2014	Francis Gathima	SL28	Full sun	1455	0,64	91,34	1,44	14,65	0,82	7,70	8,73
151/14	M22/2014	Edward Waiguru	SL28	Shade	1732	0,83	90,85	1,42	13,39	0,79	7,76	9,50
152/14	M23/2014	Joram Muritu Kirenge	R11	Shade	1793	0,46	91,17	1,39	13,44	0,80	8,18	8,91
153/14	M24/2014	Grace Waruinu	SL28	Full sun	1867	0,73	91,11	1,21	14,45	0,71	8,82	8,53
154/14	M25/2014	Monica Wamaitha	R11	Shade	1377	0,92	91,51	1,45	15,65	0,79	7,09	9,82
155/14	M26/2014	Benson Gitao Kabiro	SL28	Shade	1525	0,47	91,42	1,27	14,87	0,73	8,70	8,56
156/14	M27/2014	Samel K. Thairu	SL28/K7	Shade	1848	0,66	91,07	1,36	14,71	0,73	7,56	8,52
157/14	M28/2014	Charles Muchiri	R11	Shade	1933	1,45	90,82	1,50	12,91	0,81	7,54	9,06
158/14	M29/2014	Harrison Kamanu	SL28	Shade	1567	0,61	91,15	1,34	14,82	0,80	8,20	8,99
159/14	M30/2014	Phyllis Mugechi	R11	Full sun	1389	0,66	91,56	1,39	15,45	0,79	7,53	9,62

The representation of projected Kenyan samples on the first three PCs (Figure 1) showed the fair repartition of these samples among the Arabica coffee database. The samples are just at the limit of the representation. This could be due to the fact that the variety is a new one and few data are present in our database.
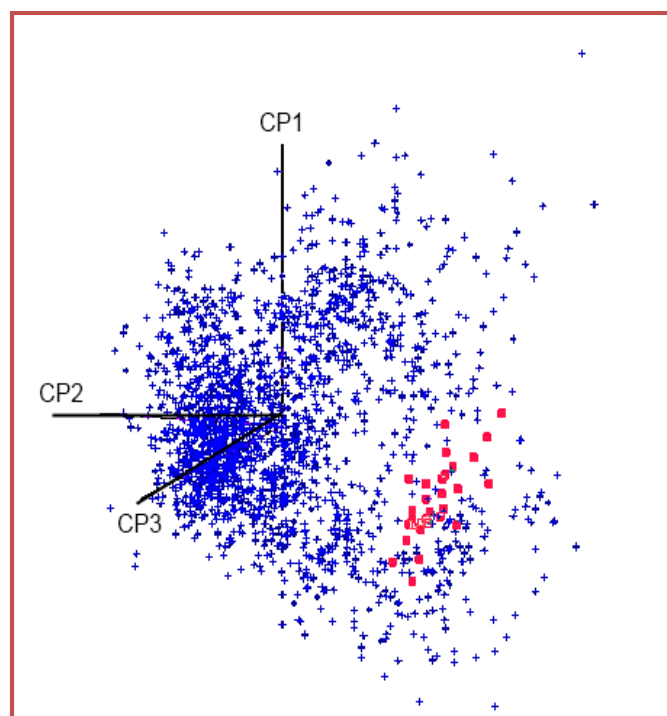
Figure 1: Repartition of the 30 Kenyan's coffee samples on Arabica coffee Cirad Base

4.2. Drivers of the quality of AFS products at plot level and at first transformation

Prediction of chemical composition of coffee

NIRS predictive models were applied to these coffee samples in order to predict: dry matter (DM), caffeine, fat, trigonelline, sucrose and chlorogenic acids (CGA). The overall (30 samples) descriptive statistics are reported in Table 3. Dry Matter content ranged between 90.82% and 91.73%, with an average content of 91.25%; these values correspond to relatively high moisture content for commercial coffees. Samples from altitude 1 presented the highest average content (91.45%).

Table 1: Descriptive statistics of predicted values for each constituents of coffee

	N	Minimum	Maximum	Mean	SD
DM	30	90,82	91,73	91,25	0,24
Caffeine	30	1,21	1,50	1,38	0,07
Fat	30	11,83	15,98	14,20	1,09
Trigonelline	30	0,71	0,87	0,77	0,04
Sucrose	30	7,09	8,82	8,09	0,46
CGA	30	8,27	10,39	9,04	0,51

N: Number of samples

Caffeine content ranged between 1.21% and 1.50% with an average value of 1.38%. The caffeine contents observed were typical of Arabica coffees. There was no statistical difference on growing zones with respect to caffeine content.

Fat content ranged between 11.83% and 15.98% with an average content of 14.20%. These values are relatively low for Arabica coffees. Samples from variety R11 presented the lowest average content (13.55%) while samples from SL28 had the highest average content (14.55%). Samples from altitude 1 presented the highest average content (15.1%), while samples from altitude 2 had the lower average content (13.2%); close to samples from altitude 2 (13.8%).

Trigonelline content ranged between 0.71% and 0.87% with a uniform distribution over growing zones.

Sucrose content ranged from 7.09% to 8.82%, samples. Samples under full sun presented the highest average content (8.24%) while samples under shade had the lowest average content (7.88%). Others parameters studied (Variety, Altitude) did not show any significant variation.

CGA content ranged from 8.27% to 10.39% with an average content of 9.04%. As for DM, samples from altitude 1 presented the highest average content (9.45%), while samples from altitude 3 had the lower average content (8.75%); close to samples from altitude 2 (8.85%).

To date, the characterization of the sensorial quality of coffee is ongoing. When all the analyses will be done, we will used all the data obtained by WP3 on the soil analyses and by the WP 4 on organoleptic and biochemical composition to determine the relationships between the sensorial quality and the specific characteristics of each samples. The results observed on the 30 samples will be confirmed and validated on "intermediate" (June 2014) and main harvest of 2014.

Results of WP 4
- Selection and description of 30 sites for study on the effects of shade, genotype and altitude on coffee quality.
- Collection and processing of 30 samples in target farms.
- Characterization of the biochemical composition (DM, caffeine, Fat, Trigonelline, sucrose and CGA) by NIRS

Reason for modification for the planned activity
None.

What is your assessment of the results of the Action so far?
Partners are collaborating fully and farmers' representatives and local authorities are also keen to participate and share their views. Clearly, this is due to contacts and activities developed with these local partners during a previous project (CAFNET: Connecting, enhancing and sustaining environmental services and market values of coffee agroforestry in Central America, East Africa and India) which has facilitated the work of the Kenyan team.

Farmers are fully collaborating and providing ample information on their management strategies and constraints during interviews while often helping to take soil samples in their various cropping systems.

Due to possible civilian unrest during the general election in Kenya in March 2013, the fieldwork was halted from January to late March 2013, but resumed fully thereafter as explained above.

Therefore, the activities were slightly delayed, and the country partners would appreciate to be able to increase the collection of data by working in the fields up to May 2015. This would mean working on the results up to July 2015.

Potential risks that may have jeopardized the realisation of some activities and explain how they have been tackled
So far, no major problem has been encountered in the target zone. There was a risk of possible civilian unrest due to the fact that Kenya went through general elections, including presidential election, in March 2013. As we anticipated, fieldworks and meetings with local stakeholders were stopped during the first months of 2013. Nonetheless, intensive field activities and meetings have resumed since April 2013 to March 2014 in terms of farm selection and characterisation (see details below) and socio-economic surveys.

Activities planned but not implemented
Field harvest of coffee samples were slightly delayed in year 1 of the project. Therefore, the analysis of samples are delayed.

The project can be fulfilled within the scheduled period, but it would be appreciated to allow a prolongation of the project period by 6 months. This would allow the researchers to improve the quality of results, and recommendations.

Updated action plan Kenya

Activities	Year 1												Implementing bodies
	1st Semester						2nd Semester						
Months	1 Apr	2 May	3 Jun	4 Jul	5 Aug	6 Sep	7 Oct	8 Nov	9 Dec	10 Jan	11 Feb	12 Mar	
1.1. Identification of study farms and communities			X	x	x								CIRAD, ICRAF
1.2. Creating Eval. committees & Ext. adv. panels				x	x			x	x				CIRAD, ICRAF
1.3. Scientific Coordination	x	x	X	x	x	x	x	x	x	x	x	x	ICRAF
1.4. Capacity Building							x	x	x	x	x	x	CIRAD, ICRAF
2.1. Spatio-temporal Dynamics							x	x	x	x	x	x	CIRAD, ICRAF
2.2. Evolution of farmers' strategies							x	x	x	x	x	x	All partners
3.1. Assess interactions AFS and food crops													All partners
3.2. Pathways to improve synergies													All partners
4.1. Characterization of SAF product quality									x	x	x	x	All partners
4.2. Drivers of AFS product quality									x	x	x	x	All partners
5. Dissemination of results							x	x	x	x	x	x	All partners

Activity	Following years					Implementing body
	Year 2		Year 3		Year 3+	
Semesters	3 Apr – Sep 13	4 Oct 13 – Mar 14	5 Apr – Sep 14	6 Oct 14 – Mar 15	7 Apr – Sep 15	
1.3. Scientific coordination	x	x	x	x	x	All partners
1.4. Capacity building	x	x	x	x	x	All partners
2.2. Evolution of farmers' strategies	x	x				All partners
2.3. Modelling and forecasting			x	x		All partners
3.1. Assess interactions AFS and cash crops	x	x				All partner
3.2. Assess pathways to improve synergies	x	x	x	x		All partners
4.1. Characterization of AFS product quality	x	x	x	x	x	All partners
4.2. Drivers of AFS product quality	x	x	x	x	x	All partners
5. Dissemination of results	x	x	x	x	x	All partners

Reasons of change

To improve the quality of data and thus, the quality of results and further recommendations to farmers.

2.2.4. Madagascar

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WP1: Management

1.1. Identification of target farms and communities

This year the activities concentrated in the area of Fenerive Is (zone of concentration of the collection of nails and petrol of clove). The works were especially undertaken in the communes of Ambodimanga II and Ambatoharana. The activities were carried out in collaboration with the persons in charge of the communes and Fonkontany (subdivision administrative of the communes) and local partners (CTHT, ESSA, University of Sciences).

1.2. Creation of multi-sector Advisory committees and External advisory panels

A local committee had been created during the first year of the program. However, it was not possible to join together it this year because the political situation did not allow it. However, the information concerning the activities of the project are regularly disseminated with the members of this committee.

The sector was however recently structured with the creation of the GEGM (Grouping of the Exporters of Clove of Madagascar) whose President now belongs to the members of the follow-up committee of the Project. This implication should allow better a diffusion of the search listings.

1.3. Scientific coordination of the funded operations and the network

For Madagascar, the activities and the budget appropriations of the project are planned at regular meetings gathering the whole of the scientific partners (CIRAD, CTHT, ESSA).

1.4. Capacity building and capitalization of knowledge

See details below.

Results of WP 1

• Regular meetings of the scientific partners to improve the realization of the activities.
• Contribution to the creation of a grouping of exporters for better targeting the research actions in support with this sector.

WP2: Characterisation of farming systems and identification of long term drivers at household and landscape levels

2-1: Spatio-temporal dynamics of farming systems

The clove was introduced in Madagascar at the onset of the 19th century, under colonial administration, initially on the Holy Island Marie, before gaining the east coast of Madagascar. On the whole of the sites, the current cultivation systems vary between the pure plantations, the agroforestry systems and in very high proportion the sparse systems containing cloves where food crops can be practised in association. The clove resource is growing old, strongly impacted by the frequent passage of cyclones in the zone. The identification of the socio-economic conditions enabled the establishment of the clove resource and the identification of the determinants of the evolution of this resource until today are necessary to analyse and understand the relative place of the current systems in the territories and the farms. After having analysed the dynamics on Holy Marie island, the works undertaken in 2013 were done in the East Fenerive area. It was realized within the framework of a training course of end of studies of engineer (Lobietti 2013), the study was done into two communes chosen according to their accessibility and so that the whole of the study zone covers a rather vast territory: Ambodimanga II and of Ambatoharanana (cf. Chart n°1). Within each commune, principal Fokontany was retained: Mahavanona for the commune of Ambodimanga II and Ambodihazinina for the commune of Ambatoharanana. The launching and the framing of this training course Lobietti 2013, which was done in parallel and on the same sites as a training course WP3 (Panco 2013, cf. below), were the occasion to carry out several missions of support, France (I. Michel), Reunion (T. Michels) and Madagascar (E. Penot), and to interact with the carriers of the WP3 (P. Jagoret). The results of this work, on which we will focus ourselves in the continuation of this report, are useful currently basic for the studies who will continue, in deepening and complement.

2.1.1. Understand the dynamics of farming systems on the long term

The study done by Lobietti in 2013 made it possible to cross the results resulting from two types of approach: (1) an analysis of dynamic agrarian and clove at the level of Fokontany, starting from observations, of interviews near people resources (representatives of various national and regional institutions, chiefs of Fokontany, Tagalamena, of the old farmers) and a bibliographical second reading; (2) a fine characterization of a reasoned sample of 29 clove plots (specific composition, density of the various raised species, age and surface of the individuals, uses of the lower layer, density of the stocks and species …), of which one recalled the trajectory of evolution to statement of farmers.

The agrarian analysis highlights the great upheavals induced by the introduction of perennial cultures into territories initially structured by the rain rice culture on the slopes of the tanety, in systems of slash and burn with long fallow allowing the forest regeneration (rice of tavy), and where the access to land was managed by the communities. The introduction of the coffee-tree by the French colonial administration into the years 1900, then clove in the years 1930, served as the individual strategies of appropriation of land, and tightened space reserved for the rice culture of tavy, taking part in the reduction of times of fallow and supporting the progressive disappearance of forest spaces; especially the clove, more plastic, which could gain the slopes of tanety, whereas the coffee-trees, established for the majority under shade of *Albizzia*, remained confined with bottoms of slopes near the places of dwelling, and/or near a water supply point (cf. figure 1). At the origin, in the 2 studied sites, the cloves were established by the village populations in two manners: in partnership with the coffee-trees and their trees of shade, near the dwellings; mainly and everywhere on the slopes of tanety, in mono-specific

plantations, with raised densities, quite higher than 200 trees/ha. In parallel, the installation of bottoms funds in the years 1950 which allowed the development of the rice culture irrigated in these spaces, supported the rise of the clove plantations to the detriment of rain rice on tanety. But gradually, vis-a-vis the strong demographic pressure which characterizes the area of Fenerive and with the parcelling out of the farms to the wire of the successions, the rice plantations came to miss: the rice culture regained the slopes of tanety, under the cloves, in rotation with the cassava, sweet potato and a few years of fallow. The bovine breeding has also to recolonize these spaces, the herds coming to graze under the cloves, either for the periods of fallow, or in reserved zones. This transformation on tanety of clove mono-specific into parks cultivated and/or grazed cloves was favoured in the years 1980 by the passage of cyclones particularly violent one, destroying part of the cloves, especially in the tops of slopes. As for the systems associated coffee-tree-cloves near the dwellings, following the decline of the coffee in the years 1970, they diversified little by little, the farmers introducing of other fruit-bearing species like the litchi, of the banana trees, the vanilla plants, and the species with wood, causing complex agroforestry systems. Some, to a lesser extent, would have become cultivated and/or grazed parks, of more diversified composition.
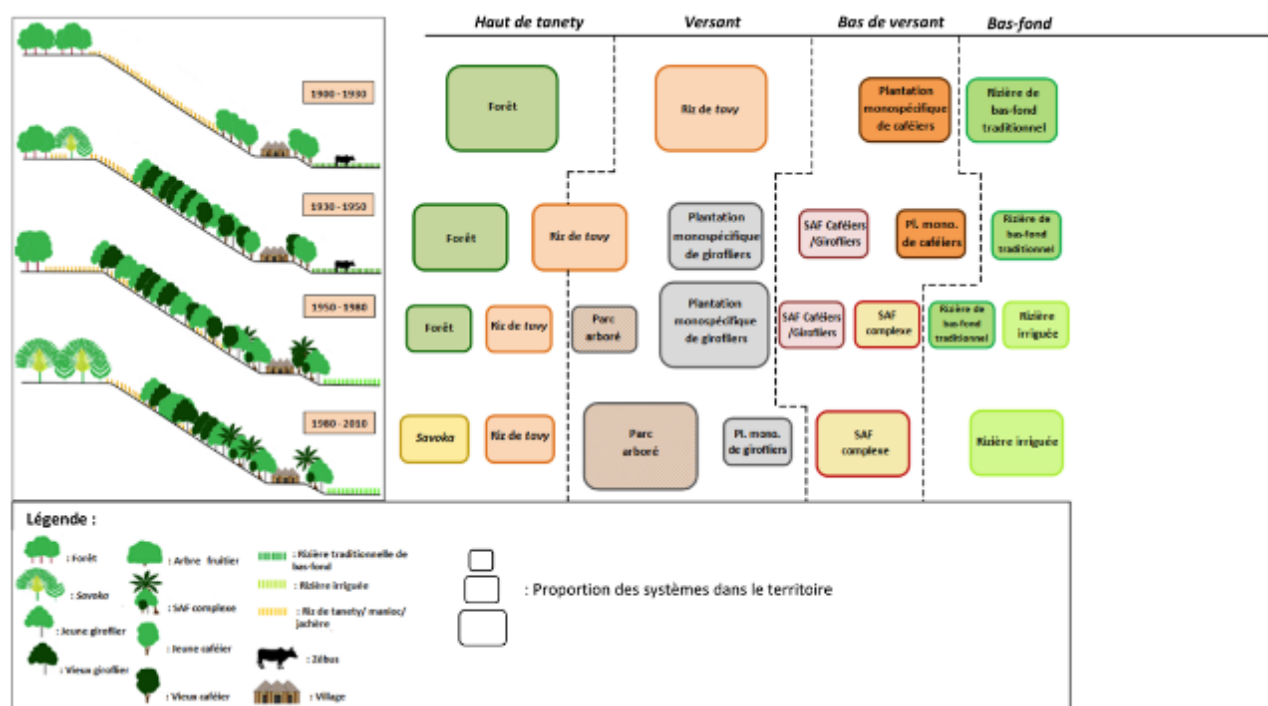
Figure 1: Evolution of distribution of the cultures in the territory in the course of time and evolution of the importance of the cultivation systems in the course of time according to topography (Lobietti, 2013)

The analysis carried out on the sample of 29 plots confirms this evolution of clove in the course of time, while characterizing their current structure and while bringing complementary elements: (1) the mono-specific plantations still observed, largely least widespread, are made up as a large majority of cloves of more than 30 years, confirming the seniority of their creation. Including a small minority of other species raised in edge, they are characterized by a high density individuals (292 trees/ha on average, including 240 cloves/ha); (2) the raised cultivated and/or grazed parks, systems the most represented, gather old plots and plots much more recent, indicator of a renewal. They understand a certain diversity of perennial species, especially at most recent, but of which more than 60% are cloves. Density average total is of 302 individuals

trees /ha (including 180 cloves/ha), which remains high, but over-estimated because of the young parks which start their trajectory with higher densities of trees; (3) the complex agroforestry systems have a great diversity of species raised with a preponderance of cloves (43%). The total average density is of 422 trees /ha (including 195 /ha cloves). Like the preceding systems, they gather and of the old plots and most recent, sign of a renewal. With majority close relations of the dwellings, one finds some henceforth in more distant situation and on slope.

A whole range of intermediate situations "of transition" were also observed, like monospecific plantations developing gradually in park. In addition, certain recent parks can start with an agroforestry initial structure once complexes, transformed then by demolition of the trees into excess the cloves become ripe.

One thus notes a larger diversity of systems cloves, with several possible points starting and various trajectories of evolution, which confirms the relevance to analyse the systems in a dynamic way. In addition, a thorough work of identification and characterization of the various systems must continue in 2014 and 2015, starting from the results of the measures made on our network of plots, currently recorded in the form of database.

With final, the results of Lobietti 2013 show well a tendency to the diversification of the clove monospecific plantations which in the past dominated, worms of the systems associating the clove with food crops, breeding, or with other perennial species. In addition, so most current systems are the result of old more or less transformed, some are resulting from more recent creations, showing a certain renewal of the resource. With final, on all 29 measured plot, any confused type, nearly 50% of the cloves have less than 10 years.

2.1.2. Analysis of aerial imagery and Geographic Information System
With the beginning of the year 2014, a new work started: a training course of end of studies of a Malagasy student (Harimandimby Hasina), from the master degree "Remote sensing and natural hazards (TRN)" of La Réunion University and Ankatso University (Madagascar), under the direction of C. Horned, a CIRAD researcher, specialist in spatial information systems. This work will take the continuation of that of Lobietti 2013 and Panco 2013 of the WP3, being pressed on its compartmental device and mobilizing various types of aerial images covering the 2 sites (cf. Figure 2).
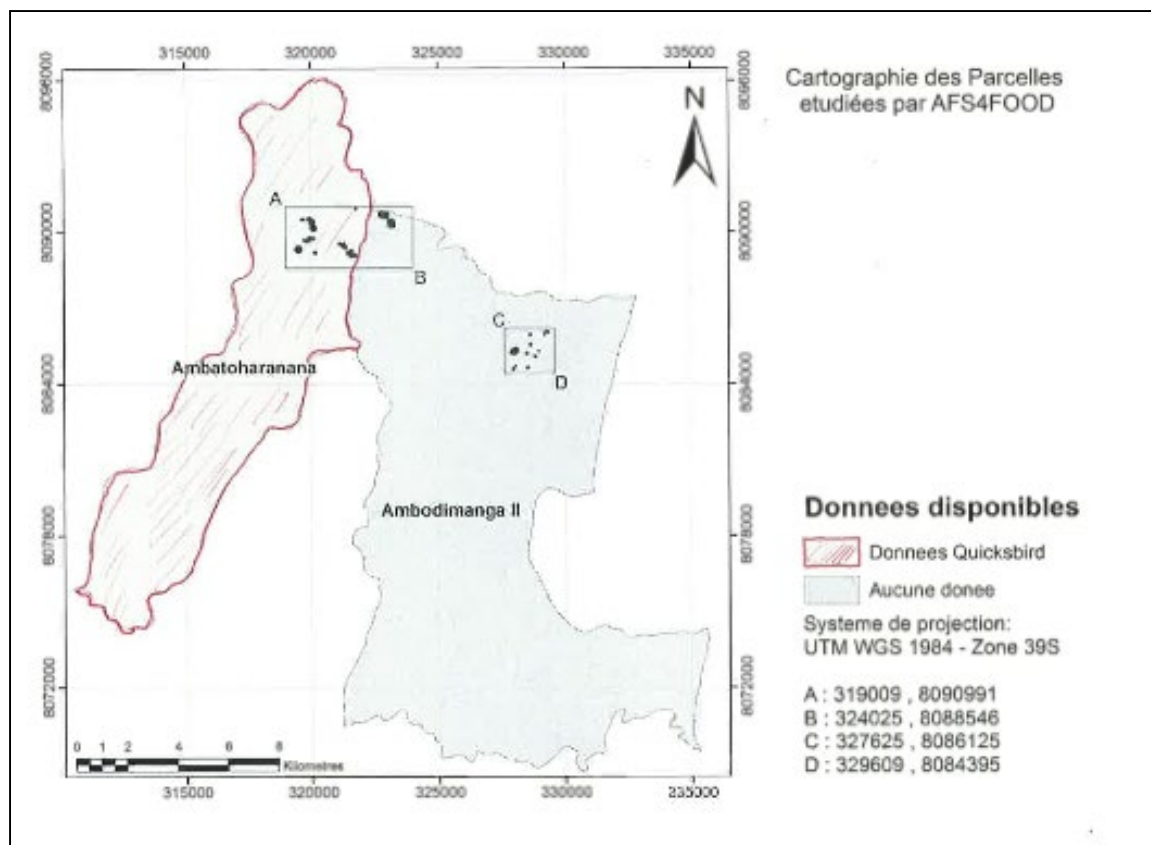
Figure 2: various types of aerial images covering the 2 sites

Cloves by its morphology and coloration of its foliage stands out quite clearly on satellite images tell a very high spatial resolution (VHSR) of inframetric resolutions. This study aimed to characterize the spatial organization of clove fields in East Coast mobilizing photointerpretation of VHRS images. More specifically, it is: clove fields identify and locate, evaluate their size, their structure and environment (forest more or less) in order to classify them according to the main types of organization observed in the project (type to determine). VHRS Quickbird satellite images of the study area and those available on the Google Earth virtual globe are mobilized to carry out this work.

The other objective of the study is to characterize the spatial evolution of clove fields over a period of 60 years. The Malagasy Mapping Institute (FTM) has aerial photographs of the study area taken in 1957. The approach developed with VHRS images will be adapted to study these aerial photographs to describe the spatial organization of clove fields 60 years before and compare this information with the current spatial organization (diachronic study).

On the basis of available satellites images covering the study area, the work is to write identification keys, which allow to identify clove fields depending on their type. This iterative work has been validated by a field mission in the region of Fenerive East. Observations and collected spatial data are being processed and will help to refine identification keys. These keys will be subsequently adapted to the analysis of monochromatic aerial photographs. Finally, these results will be compared to produce spatial data on the evolution of clove fields. The results will be presented in the form of maps and spatial analysis connected to others activities of the project on this theme.

2-2: Evolution of smallholders' strategies and agricultural activities

In parallel of the study of the agrarian systems and systems cloves, the work of Lobietti 2013 made it possible to define the first typology of farms, and to make a first evaluation as of the their agricultural activities in terms of food safety.

The farmers self-consume mainly their rain and irrigated rice, which in majority is not enough to cover the totality of their needs. During the difficult periods from February to April, then from September to November, the food intake is supplemented mainly with cassava, then of sweet potato, the breadfruit tree, potato and bean. The incomes resulting from the cultivated perennial species make it possible to buy missing rice and thus to improve food safety of the households. For the whole of the surveyed farms, the products of the clove represent more than 50% of the monetary resources. If the sale of the nails is used with the purchase of the products of first need and for the foreseeable expenses, the petrol makes it possible on the other hand to face specific events: it is a variable of adjustment.

A first evaluation shows that most surveyed exploitations do not reach food rice self-sufficiency, and live under the poverty line. The access to food safety is thus major problems in the district of To East-Fenerive, but is not posed with same acuity according to the types of farmers.

2.2.1. Typology, farmers management and strategies
On the basis of the fact that the current farmers belong to 2nd even to the 3rd generation of clove growers, resulting in majority from native populations but not only, typology was built starting from the following elements: origin of the head of the family and place in filiations, age group, cultivated total surface area and proportion of irrigated rice plantations, size of the households. Starting from a reasoned sample of 29 contrasted farms distributed on the 2 sites, 5 types are identified:

- The types A and B concern households of big size (5 to 6 people on average), of which the head of the family of middle age, resulting from chalk-linings founders, works with its sons. Type A is well provided on the surfaces, with on average more than one hectare of irrigated rice, which allows him a rice self-sufficiency. The type B has less of surfaces, with on average less than one hectare of irrigated rice, which is not enough to meet its food needs.
- The type C concerns households of small size (2 people on average), with old farmers resulting from chalk-linings founders which already partly transmitted their plots to the children. They preserved on average a hectare of irrigated rice, contributing to a sufficient production out of rice.
- The types D and E relate to young people, made recently or descendants of chalk-linings founders but (or only partially) not having still inherited. They have less than 1 hectare of irrigated rice, but according to the size of their household, the situations differ: the type D with a household on average of 4 people, is not in food situation of insecurity, whereas it is the case of the type E, whose household is composed on average of 6 people.

The analysis crossed with the great types of systems cloves implemented shows several elements: the types A and D, which do not have food difficulties, implement the 3 great systems, and this in a balanced way (overall, 1/3 their surfaces are in irrigated rice plantations, 1/3 in raised parks, 1/4 in complex agroforestry systems, and the remainder is divided between the monospecific plantations and the systems of transition). The type D which has of less total

surface area and less irrigated rice compensates by a more important proportion of complex agroforestry systems; the type C, very centred irrigated rice, does not have any more complex agroforestry systems, already transmitted to the children; the types B and E, which are in food situation of insecurity with spring cleanings on small surfaces implement a significant proportion of raised parks and/or irrigated rice plantations, to the detriment of quasi non-existent monospecific plantations. The complex agroforestry systems account for approximately 20% their surfaces.

This typology must be validated and supplemented at the end of 2014, and the bond with the types of systems refined cloves.

2.2.2. Evaluation of production systems and farm activities
Work is currently carried out, in collaboration with the WP3, via the technico-economic evaluation of the cultivation systems rice and cloves: a new training course engineer (April to October 2014) and one VI (2014-2015). The place of the activities of breeding in the economy of the households, and their contribution to the food safety of the families will be particularly studied.

2.3. Modelling and prospecting at farms and landscape levels
Idem, works in progress currently, in collaboration with the WP3.

Results of WP 2
- Bibliography is now completed.
- Knowledge of dynamic agrarian and clove in two contrasted sites of Fenerive. Analyses of dynamics of clove-fields.
- Database to geographically plot the spatial use of cloves, using analysis of aerial imagery and Geographic Information System.
- Typology of farms in two sites of Fenerive and first technico-economic results, on which to base itself to continue work of typology and evaluation of the cultivation and production systems.
- A report of student engineer (cf. appendix 5) and reports of mission.

WP3: Assessment of the productive and environmental performances of AFS and their synergies with food-crops at plot, farm, and landscape levels

3.1. Characterization of productive and environmental interactions between AFS and food crops at plot, farm and landscape levels

3.1.1. Database of knowledge of farmers regarding the use and physical characteristics of tree species in each project site

Inventories of the species composing the various clove AFS were conducted from April to August 2014 by a Master 2 student from Montpellier Supagro-IRC (M. Panco) under supervision of E. Penot (CIRAD, UMR Innovation). This study was completed on the east coast of Madagascar where farmers rely on the clove tree products to assure household food security. These farmers are changing their farming practices in the clove crop production and

diversifying species to improve their farming systems. The assessment of different types of knowledge and practices can help to acknowledge the preferences for a certain type of cropping system. The decision making process is nevertheless influenced by the internal and external factors, like cyclones and price fluctuations. The research took place in 2 villages in the East Fenerive district (Figure 1). The diversity of farming systems practiced in the villages and parklands especially denotes farmers' needs for food crops, while the agroforestry systems can assure a broader range of income.

The village sample was based on previous surveys realized by the CTHT in 2009 and 2010 in communes of Ambodimanga II, the fokontany (a sub-administrative area compound of 2-3 villages) of Mahavanona, and Ambatohorana, the fokontany Ambodihazinina. The geographical distance from the main town and markets (10 km and 25 km respectively) and proximity to the coastline (4 km and 17 km) was considered in the sample. The annual rainfall in the region varies between 180 and 300 days per year, with the monthly average precipitation from 80 to 160 mm during the wet season (October to April). In the dry season, from April to September, there is less rainfall and the average temperature is 25°C (FIDA, 2006). The landscape in the study area is predominantly characterized by lowland rice and hilly fields covered with clove trees on the slopes varying from 20-120 m in elevation. The landscape has been changing since the 1920s with the introduction of clove trees. Mixed clove farming is common and is based on upland rice-cassava intercalated amidst clove trees. Food crops are grown to meet the subsistence needs of the households, with any surplus sold on the market. The cash crops (cloves, coffee, litchi and vanilla) contribute to family income, with cloves accounting for 20-50 % of the cash income (Penot et al., 2011).
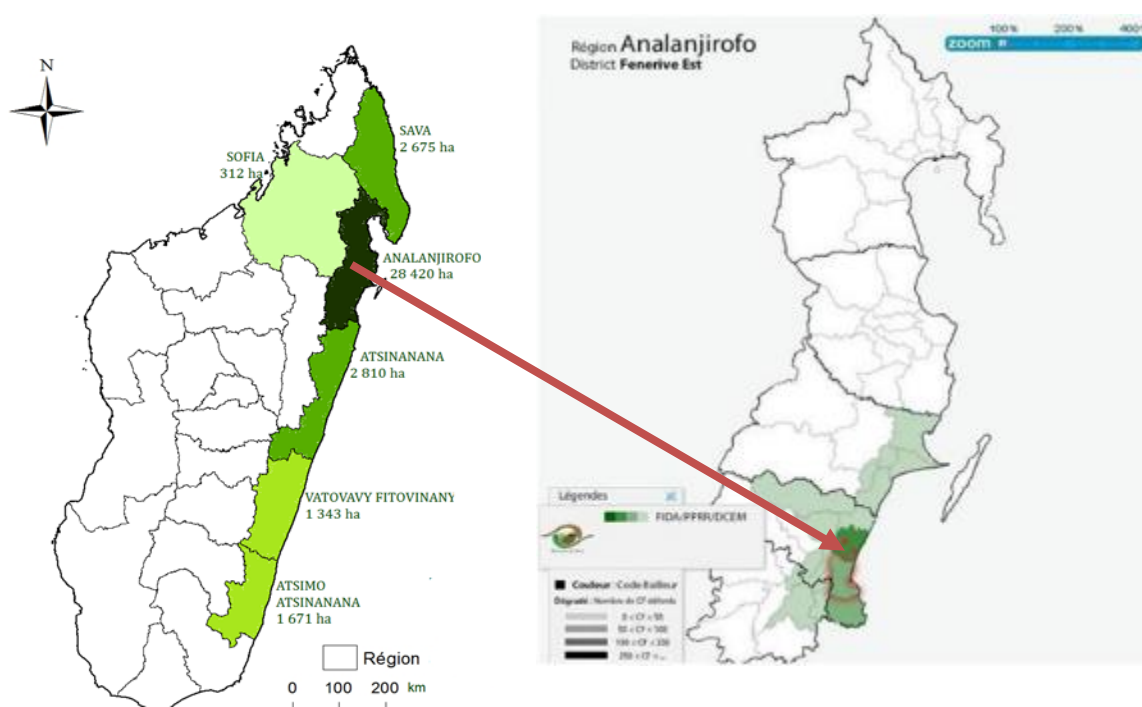

Figure 1. Clove tree growing area in Madagascar and study zones (Ministry of Agriculture, 2005; Michels, 2010)**.**

1. The study employed qualitative collection methods (33 in-depth semi-structured interviews) and focus group discussions (one in each village). Prior to the main survey, three pilot test of the interview were taken for evaluation. The interviews were translated from French to Malagasy and were held either in their homes or on the plots. Lastly, participatory rural appraisal (PRA) methods were applied to supplement data collection (preference matrix), timeline and mapping (Mikkelsen, 1995), active participatory observation and transect walks with key informants. PRA offers the advantage of learning with and from rural people, interacting daily and directly, on the site (Chambers, 1990). Living in the village for the duration of the study permitted for ongoing observation and informal discussions, which enhanced the depth of understanding of the local context and the local social situation.

2. The tree population was counted in 27 plots in the two villages. The most significant result of the study is the confirmation that local farmers adopt different types of clove tree based cropping systems depending on factors which weighed more heavily than knowledge, including land size and number of clove trees per plot. The diversification of farming systems and the tree density is influenced by many factors (land size and availability, family size and labour availability), and other farmers' needs (produce enough rice to sustain family's food needs, other expenses). These drive farmers to plant or retain other trees or non-tree crops to sustain and improve their family's livelihoods. In this section we present the results of the farmers' knowledge and management practices on the clove tree plantations; their impact on the evolution of clove tree cropping systems and the factors that determine these changes.

3. Following the description of clove tree cropping systems in the study area, two different types of knowledge and management practices of clove trees were identified. The local knowledge appears as an important source of information to understand the change of practices and landscapes. From the interviews, 79 % of the producers asserted they learned how to plant, maintain and harvest cloves and leaves from their parents, passed on through orally from generation to generation. Apart from their parents, this knowledge comes from neighbours (12%) and one had learned it from his grand-parents (3%). Some of the farmers (6%) did not know the plant requirements from the beginning (water, soil, shadow and light), nor were they aware of better and less favourable associations within the plots (annual or perennial crops); these farmers achieved their knowledge about the clove tree cropping system from personal observation.

4. This local knowledge grew together with the spread of clove trees in the villages. The traditional knowledge, received from the parents or other farmers with more authority, results in easier adaptations in term of clove tree management. All of the farmers confirmed that they rely more on the advice of family members and they do not use compost in traditional system management, which is recommended in the improved plantation (Maistre, 1964, Michels, 2011), neither the distance between the trees; for example, they do not respect the size of the hole dug to deposit the compost around the tree, nor the distance.

On the other hand, according to farmers, there is another "innovative" method of organization. The most important are: (i) Operation Pepper-Coffee-clove and Agricultural extension services (1960s), (ii) PPRR and CTHT (2000s). Producers asserted that this type of formal and technical information is concerning the practices from creation of the clove tree nursery and tree management as follows:

- For the nursery: the seeds need to be soaked in the water for 3 days in order to start the germination process
- For the transplantation of a new seedling: the new place has to be prioritized for weeding
- The creation of the hole should respect the measures: 60*60cm and 1m deep
- Compost application is recommended; and could be a mix of the inversed shallow layer from the soil surface with the dried leaves and herbs
- Distance to respect between the trees: 7-8 m
- Need for shade for the immaturity period up to 3 years
- Mulching of trees with the fallen dry leaves
- Pruning to facilitate the canopy development.

The survey showed that even if 48% of the farmers (16 out of 33) know about the improved techniques, only 68 % from those who have this knowledge actually applied it on their field due to the availability of land or time. The labour demand and the time availability for plantation is a limiting factor for the adaptation of these improved techniques. According to farmers who used this technique, one man can plant only 20 trees in one day with the improved method compared to 100 trees with the traditional method. On the other hand, this method has some visible advantages: clove trees planted grow faster and become productive after 7-8 years compared to 10 years for those planted with the traditional method. From the interviews, farmers received this type of innovative information after they had already achieved local traditional methods by their parents or neighbours. Farmers who implemented innovative methods (7 out of 33) are the ones who are younger (less than 50 years), have still some land available, and have the objective of improving their livelihoods or have been incited by the national or international development programs.

In the both villages the share of the type of knowledge differs. More than 70 % of the producers in the village of Mahavanona, which is closer to the city, have access to the agricultural training compared to only 29 % of the producers from the remote community. Also, the men are more likely to benefit from agricultural training than women (only one in the sample).

About the historical evolution of tree diversity in clove systems, from the free walks on the fields it was observed in some AFS the association of clove and coffee trees in sequential arrangements within the plots, issued from the same period as monocropping systems (colonial period). Coffee (C. *canephora*) was introduced in the region before clove trees (1900s) (Ramilison, 1985) as participants of the timeline exercise confirmed. Monocropped plantations of coffee were damaged by a fungus attack in the early 1930s by « *Hemileia vastarix* » (Ramilison, 1985). Old coffee trees were replaced with clove trees. Though, in the households' surveys the AFS (18% of our sample) appear to be more recent cropping system from the period that farmers started to diversify after 1980s.

From the tree inventories clove tree agroforests have many tree species in common with 8 predominant species. The closer the AFS to the dwelling the composition of species is more divers, with more fruits tree species. The number of cash crops is increasing with the distance from the village. Tree diversity is higher in the villages that have access to the market. This fact is indicating that socio-economic and ecological factors influence the composition of clove based AFSs. Trees with edible products are most planted in the clove agroforestry systems (Fig. 2) as the Malagasy farmers rely on them to complement family's food production. Exotic fruits trees are the most planted or retained when inherited (from the parents or grand-parents time) after clove trees. The timber trees density decreased as the clove trees are maturing.

Clove tree distribution in agroforestry systems

Legend: Banane, Ravenala, Grevilea, Arongana, Albizzia, Bread fruit, Avocado, Coconut, Corosol, Jack fruit, Mango, Ramboutan, Litchi, Canelle, Coffee, Clove
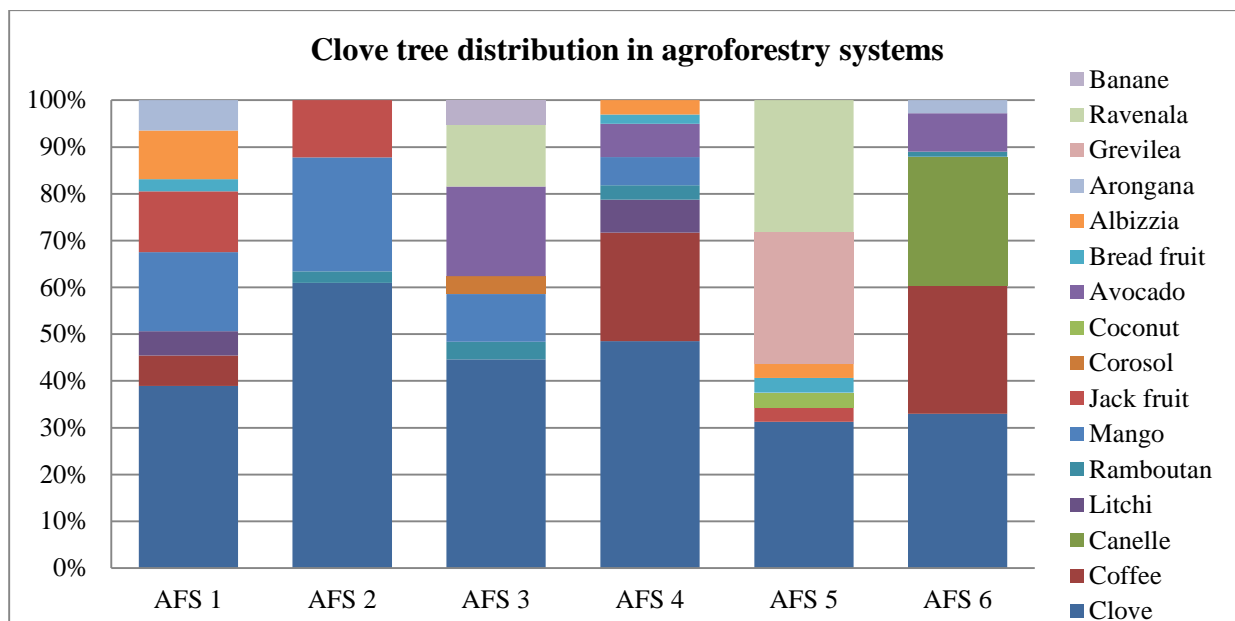
Figure 2: Species distribution and share of cloves in AFS

In agroforestry systems, the clove trees have the bigger share as the farmers give the priority to highly economically valued trees: 30-60 % cash crops (cloves, coffee), 20 % of fruits trees (mangoes, jackfruits, avocado, litchis), and 20 % of timber trees (arongana, grevilea, Albizzia).

For the study as a whole, 18 different species associated with clove trees have edible fruits other 10 different species are used in the construction or as timber or fuel wood and 8 trees are considered by farmers as enriching the soil quality. Farmers did not specify any medicinal uses for the trees, but highlighted the importance for auto consumption of fruits that allows them overcome food shortages (jackfruits, brad fruits). Among the edible trees, only one is native to the region while 17 are exotic fruits.

Beyond producing cloves, farmers rely on the agroforestry systems for the income of the household from other cash crops. Two main crops play an economic role in AFS, according to the farmers. Litchis started to gain an important role in the family's economy as it has increased in the export demand and can be sold at a higher price than cloves. Fourteen out of 33 producers have litchis, with a low density (only 1 to 6 trees per whole farm). However, it can contribute around 20 % to the households' of the income; a single litchi can provide around 200 kg of fruits. Once very important, to date the old coffee plantations yield less (2 kg per tree) and have a lower price on the market. Only 8 out of 33 producers still have coffees issued from the colonial era, where the numbers of tree per farm is varying 1-40 trees. The average density of these trees is lower, although it tended to increase with the stimulation of free tree distribution and implementation of improved techniques for crops development (pruning for litchi and farm establishment for coffee).

3.1.2. Typology of clove producers in relation to the diversity of production systems

The current plantations are issued from the first colonial implantations in the 1930s and 1960s on the eastern coast. The aging trees and their overexploitation and lack of replanting between 1960s and 2000s have led to the alteration of the plantations structure and function (Penot, 2011), as well as the fall of the production in the latter years (Michels et al, 2011). Their

structure evolved from the monocropping systems to parklands and agroforestry systems (AFS) after ecological hazards (cyclone) and socio-economic risks (price volatility, human pressure).

Three types of clove cropping systems can be described (table 1):

(i)   Monocropping systems are plantations sown with only one crop (the clove tree).

(ii)   Parklands, or "tree-shaded parks", are defined as associations involving a limited number of a perennial crop (clove tree) with annual species (rice, cassava, sweet potato) cultivated and grazed after (De Foresta & Michon, 1999). This cropping system resulting from ancient clove tree monocrops (Penot et al., 2010), where clove tree canopies are spatially scattered and permits the intercalation of food crops beneath the tree.

(iii)   Agroforestry systems are land-use systems with a complex, dense, multi-strata structure comprising many perennial species on the same land unit, as defined by Torquebiau (2000).

Table 1: Characteristics of cloves tree cropping systems

Type of cropping system / Variables	Monospecific	AFS	Parkland
Surface (ha)	0, 49	0, 25	0,31
Number of plots per farmer	3,25	4,22	3,27
Number of inherited clove trees per plot	32	20	19
Number of planted clove trees per plot	92	65	41

To conclude, the double objective of this study was to identify the local farmers' knowledge and their process that determines the livelihood strategies. The clove tree farms are following a dynamic evolution based on the farmers' practices guided by their knowledge. However, the internal factors (land access, familial labour and physical capital) push them to handle respond in different manner to the external factors (price fluctuations and climatic conditions altogether). The monocrops issued from the colonial period are maintained and preferred by the older producers because demands less labour. The parklands are responding to the farmers' needs to maximize land utility and ensure food production, the risk management strategy to cope with the clove prices volatility. Agroforestry clove trees systems are shown to be more diversified in terms of species and ecological and economic benefits, where income from associated crops can complement those of the cloves. The diversification of agricultural crops is the most spread strategies in the rural communities.

A report and a working document written in French, as well as a summarized report in English were released in December 2013.

3.2. Pathways to improve synergies between AFS and food crops at plot level

A research action is currently conducted by a student from the University of Antanarivo (L.N. Arimalala). The overall objective of this study is to characterize ecologically each type of clove

plots, according to our typology (monoculture, parks and agroforestry) and according to the results of the surveys implemented in the two target villages.

The specific objectives of this are to:
- Identify the local species that can grow temporarily and / or permanently in each type of agroforest.
- Make the dendro-chronological study to determine the age of the plantation and the potential for growth of clove individuals.
- Evaluate the aboveground woody biomass of each type of agro parks or forest.
- Determine the vegetation structure of each type of agro parks or forest.
- Identify the typical local agroforestry system according to traditional practice.
- Determine the ecological roles made by wild species associated with clove.

The total number of plots where this study is conducted is 14: 4 plots under « park » management, 5 plots under agroforestry management and 5 monoculture plots. The current data are under analysis for further release in June 2014.

A study to analyse the impact of public policies and private sectors actions is currently implement by a student from AgroParisTech (I. Maincent) in Tamatave and East-Fenerive area. The study will be also implemented in Mananara in June 2014. The objective is to effectively identify public and private sector actions that have or has any impact on the clove sector. The report will be released in September 2014.

Perspectives 2014:
The project will welcome:
- In April, two Master 2 students from Montpellier Supagro-IRC: (i) C. Fourcin who will work on clove based farming system modelling in East-Fenerive, and (ii) R. Simanjuntak for a study on leave distillation ("from leaves to the alembic").
- In April, another trainee from FIFA/CIRAD for a survey on impact assessment of replanting programs in the 2000's.

Results of WP 3
In Madagascar, 3 studies were implemented:
- **Study 1:** Plot characterization and typology of cropping systems: a sample of 74 clove based plots were selected to characterize plot structure from this 74 plots, 29 were selected and monitored by M. Lobietti in 2013 to perform a typology based on the preliminary studies done by T. Michels, E. Penot, P. Danthu and S. Levasseur in 2012.
- **Study 2:** A sample of 27 clove based plots were identified for dendrometric analysis and the study of the biological composition, in order to obtain a more detailed typology according to trees, plants and crops associated to clove in the 3 systems: monoculture, parks and agroforestry systems. The study has been implemented by Natacha Arimalala Lydi under the supervision of P. Danthu and E. Penot, in 2013. The current results need to be completed by an additional sample with 6 monoculture plots and 15 parks plots in April 2014. A publication is scheduled on that research for end of 2014.
- **Study 3:** A selection of 10 farmers with 30 plots have been selected in the East-Fenerive area for 2 years continuous monitoring on practices and outputs. The monitoring will be implemented every 1 or 2 months according to seasons and activities. It began in March 2014.

WP4: Characterization of the AFS main-crop quality for value addition to farmers' incomes

4.1. Characterization of the quality of AFS products at plot level

4.1.1. Comparison of Malagasy species with species from other major producing countries

Title:

Bud, leaf and stem oil composition of clove (*Syzygium aromaticum* L.) from Indonesia, Madagascar and Zanzibar.

Objective:

The purpose of this study is to compare the chemical composition of Madagascar, Indonesia and Zanzibar bud, leaf and stem essential oils.

Experimental trial:

S. aromaticum essential oil used in this study were commercial samples provided by either industrial exporting companies of Madagascar, of Indonesia and of Zanzibar (Table 1). The essential oil samples were dried over anhydrous sodium sulphate (Na2SO4) and stored in a cool and dark chamber until their analysis by Gas Chromatography (GC).

Table 1: *S. aromaticum* essential oil samples

	Anatomic origins		
Geographic origins	Bud	Leaf	Stem
Madagascar	39	28	27
Indonesia	6	4	2
Zanzibar	-	-	15
Total	45	32	44

The distribution of the 121 essential oils samples was analysed by principal component analysis (PCA) using the XLSTAT Version 2012 statistical software package. The data set was composed of the values taken by the variables identified by GC and the 121 S. aromaticum essential oil samples.

Results:

The 121 essential oils samples were analysed by GC and ten constituents were identified from the whole. The major constituent of Madagascar and Indonesia bud essential oils was eugenol (72.08 – 80.71% and 77.32 – 82.36% respectively). Out of this constituent which was common to Madagascar and Indonesia bud essential oils, significant difference was observed with respect to eugenyl acetate (11.68 – 21.32% vs 8.61 – 10.55% respectively) and β–caryophyllene (2.76 – 6.38% vs 5.34 - 8.64% respectively). Comparing chemical composition of leaf essential oils from Madagascar with those of Indonesia, variation in the contents of main constituent, eugenol (80.87 – 83.58% vs 75.04 – 77.54%), β-caryophyllene (11.65 – 15.02 vs 17.04 – 19.53%) and eugenyl acetate (0.29 – 1.45% vs 0 - 0.06%) was observed. The major constituents of Madagascar, Indonesia and Zanzibar stem essential oils were eugenol (91.81 - 96.65%, 88.76 - 89.28% and 87.52 - 89.47%, respectively) and β-caryophyllene (1.66 - 4.48%, 7.40 - 7.75% and 7.19 - 9.70%). For each plant material, variation in the percentage of the main constituents was observed according to the sample geographic origin.

The results will be available in an article titled: "Bud, leaf and stem oil composition of clove (*Syzygium aromaticum* L.) from Indonesia, Madagascar and Zanzibar." This article was submitted at International Journal of Basic and Applied Sciences on January 2014.

4.1.2. Determination of quality oils and nail sheet in relation to the complexity of the structure (AFS monoculture agro-forest simple and complex) and seasonality of production

The overall objective of this study is to evaluate the sources of variability determining the quality of clove nails, the chemical composition of buds, leaf and stem essential oils to understand their origins to optimize the conditions of clove oil production that meet the quality criteria sought on the international market: a highest possible content in eugenol.

To answer the question and unlike numerous works (the vast majority) addressing the issue of the variability of oils, the procedure that we developed in this study was based on two innovative principles that we believe relevant: (i) develop a traceability method from the harvest of nails and oil in plant materials collected on each identified tree until analysis, (ii) take into account both climatic factors and factors modulated by cultural practices to assess the individual variability of the main clove products.

To achieve these targets, many training courses were conducted.

Work 1:

Title:

Effects of phenological stages on yield and composition of essential oil of *Syzygium aromaticum* buds from Madagascar.

Objective:

The Objective of this work is to describe the essential oil yield and composition of *S. aromaticum* buds at different phenological stages as well as to determine the optimal accumulation period of eugenol content.

Materials and methods:

Cloves buds of *S. aromaticum* were collected at different phenological stages from three individual trees, named 1, 2 and 3, grown in the region Atsinanana of Madagascar, fokontany Analamalotra (S 18°05' / E 049°21') (Table 1).

Harvesting time was performed monthly from July 2012 (young bud) to February 2013 (full fruiting). Thus, 24 samples were used in this study.

Phenological stages	Harvesting time	Bud Colour	Length (mm/bud)	Dry weight (mg/bud)	Moisture content (%)
Young bud	July 2012	Green	5.88±1.43 a	13.23±6.15a	47.63±1.04 a
Budding 1	August 2012	Green	6.18±1.47 a	13.68±7.01 a	48.23±2.56 a
Budding 2	September 2012	Green	10.75±1.06 b	41.97±9.66 b	53.47±1.83 b
Budding 3	October 2012	Pale yellow	13.31±1.20 c	61.23±12.98 c	57.57±1.01 c
Full budding	November 2012	Yellow to pink	17.80±0.93 d	83.81±8.49 c	70.64±0.83 d
Flowering	December 2012	Red	21.45±0.91 e	334.55±20.90 d	71.48±1.06 e
Initial fruiting	January 2013	Red	24.38±1.74 f	449.95±29.85 e	74.63±0.82 f
Full fruiting	February 2013	Dark red	25.93±2.49 g	531.13±32.72 f	79.56±0.95 g

100 g of fresh clove buds from each tree were subjected to hydro distillation using a Clevenger apparatus over 4 h. The oils obtained were separated from water by decantation, dried over anhydrous sodium sulphate (Na_2SO_4) and yield percentage was calculated as volume of essential oil per 100 g of plant dry matter weight. The extracted oils were stored at 4 °C in the dark until their analysis by gas chromatography (GC).

Results:

The essential oil yield varied from 2.52% to 17.94%, reaching a maximum at the end of budding stage, after which it rapidly decreased. The essential oil was analysed by GC and four constituents were identified and quantified for whole phenological stages. Eugenol and eugenyl acetate were the main compounds in all samples. Eugenol, was lower in the young bud stage (39.66%) and increased in the subsequent phenological stages to reach maximum in the full fruiting stage (94.89%). In contrast, eugenyl acetate was higher in the young bud stage (56.07%), after which decreased to reach minimum in the full fruiting stage (2.01%).

The results will be available in an article titled: "Effects of phenological stages on yield and composition of essential oil of *Syzygium aromaticum* buds from Madagascar". This article was accepted at International Journal of Basic and Applied Sciences on July 2013 and was presented by the poster during three days of the Qualireg in Reunion from 19 to 21/11/2013.

Work 2:

Title:

Chemical Composition of Volatile Essential Oil from Intact and Fallen Leaves of *Syzygium aromaticum.*

Objective:

A study was therefore undertaken to explore the variability in the content and chemical constituents of the volatile oil of *Syzygium aromaticum* leaves at different stages, *i.e.* intact (juvenile and adult leaves) and brown leaf litter.

Materials and methods:

Five individual trees of *S. aromaticum* growing in the region Analanjirofo, east of Madagascar, fokontany Ambatombary (S 17°20'14 / E 049°21'07) were selected for collection of plant material used in the present study. Different stages (T1 to T4) of leaves were plucked from each

tree and leaf litter (T5) was collected also from the tree floor. Essential oil was obtained from all the five leaf types by hydro-distillation in a Clevenger's apparatus over 4 h. All essential oil samples were analysed by GC and GC–MS.
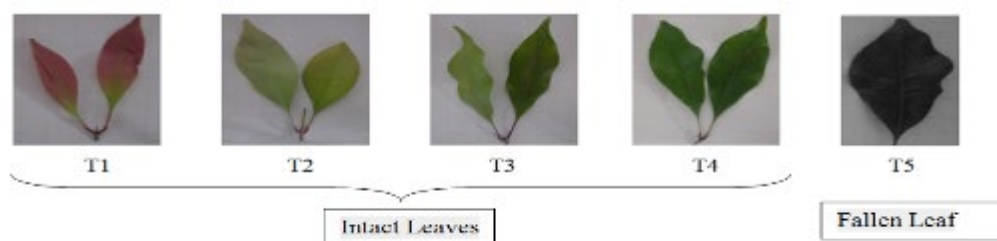
Results:

- *Essential oil yield*
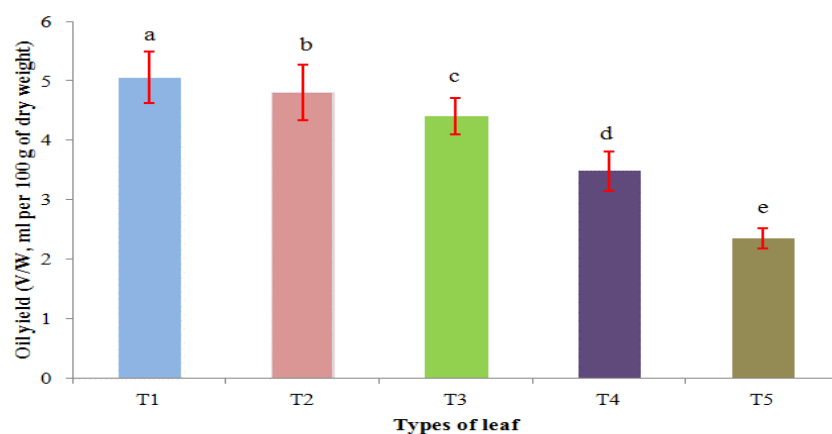
: Essential oil yield (v/w) of five types of leaf. Essential oil yields with different subscript (a - e) were significantly different at $p \leq 0.05$ (Fisher test).

- *Essential oil composition (Major constituents)*

■ eugénol ■ β-caryophyllène ■ acétate eugényle ■ oxyde de caryophyllène
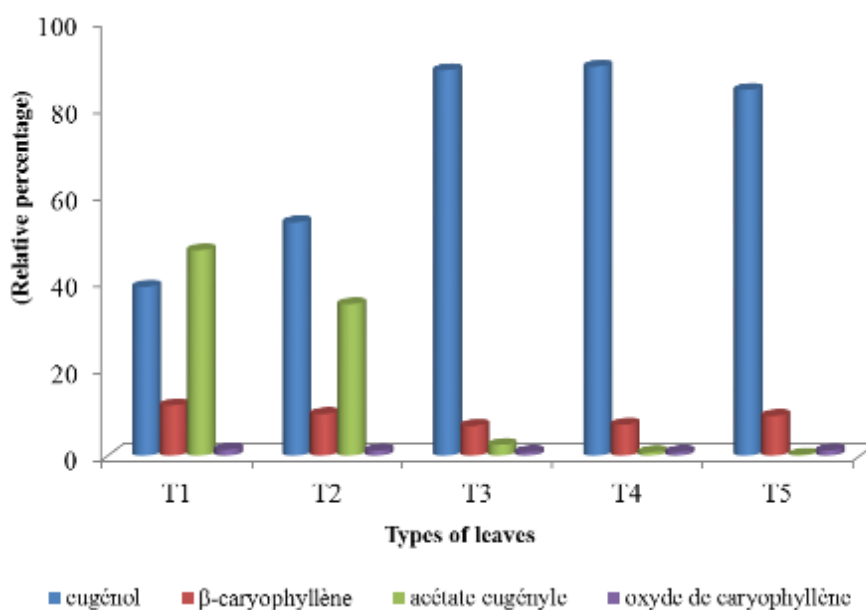
- *Conclusion*

It is thus evident from the above results that although the composition of essential oil from different leaves of *S. aromaticum* was more or less the same, yet there was a great variation in the relative amount of major constituent. The litter leaves with a relatively higher amount of eugenol (84.17%) could serve as an important source for commercial exploitation.

The results will be available in an article titled: "Chemical composition of volatile essential oil from intact and fallen leaves of *Syzygium aromaticum*". This article will be submitted at Journal of Essential Oil Research.

Work 3:

Title:

Chemical characterization of the *Syzygium aromaticum* leaves oil from Madagascar: Influence of treatments and state of leaves on the quality of oil.

Main Objective

The objective of this work is to evaluate the sources of yield variability and the oil chemical composition of *Syzygium aromaticum* leaves to understand their origins and to optimize the production conditions.

Specific Objectives

Determine the factors connected to the plant material which can influence the quality of the essential oil.

Put at the disposal of the operators (farmers, collector…) informative data allowing to optimize the quantity and the quality of essential oil.

Expected Results

The study should bring information objectified as for the methods impact and the conduct of distillation on the yield and the quality of clove leaves oil, collected in the Malagasy context so that these products correspond to the international standards.

Localization of the middle of studies

Situated on the east central coast of Madagascar, Ambatoharanana is a member of the District of East Fenerive in the region Analanjirofo. It is localized between 17° 12' and 17° 25' of latitude South and 49° 12' and 49° 20' of longitude East.

Source : FTM

Auteur : M. RAKOTOARISON, 2013

Figure 1: Localisation de la zone d'étude

: Limite District

: Limite Commune

: Zone d'étude
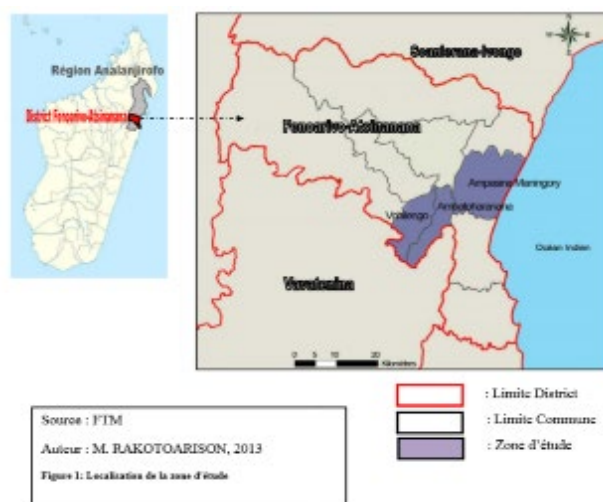
Essential oils sampling (Identical with the previous report)

Gas chromatography

Essential oils were analysed by gas chromatography (GC) using Focus GC equipped with a flame ionization detector (FID) and capillary column (polyethylene glycol: 30 m×0.25 mm i.e., 0.25 µm film thickness). The flow of the carrier gas (N_2) was 1 ml/min and the split ratio 1:10 (1µl 10:100 heptane solution). Temperature was programmed to increase from 60 to 180°C at the rate of 7C/min. Injector and detector temperatures were respectively held at 230 and 250°C.

Statistical analysis

The distribution of the 64 samples was analysed by Principal Component Analysis (PCA) by Agglomerative Hierarchical Clustering analysis (AHC) and Discriminate Factorial Analysis (AFD) using the XLSTAT Version 2013 statistical software package. The data set was composed of the values taken by four variables identified by GC and the 64 clove leaf oil samples

Results

The objective of the present study is to determine the factors connected to raw materials which can influence yield and chemical composition on the essential oil of clove. For that purpose, it is advisable to determine the various current practices made by the producers of essential oil.

- *Various treatments of leaves before the distillation*

a) Drying
- 1 day
- 2 days
- 3 days
- > 4 days

b) Storage
- 0 day
- 1 day
- 2 days
- 3 days
- > 4 days

- *Yield according to the duration of drying*
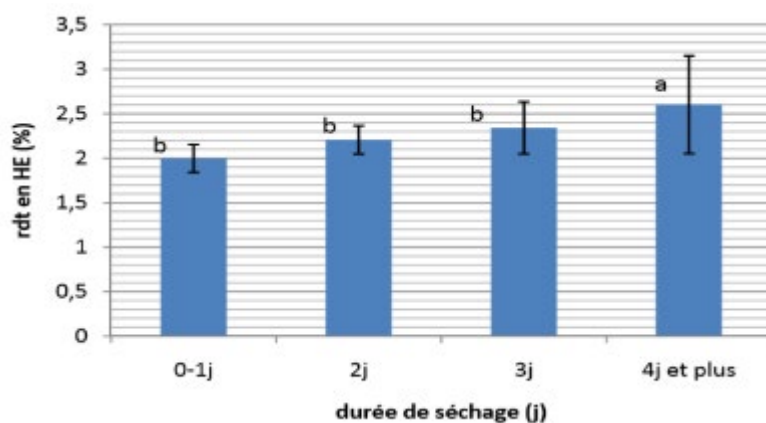
- *Yield according to the duration of storage*
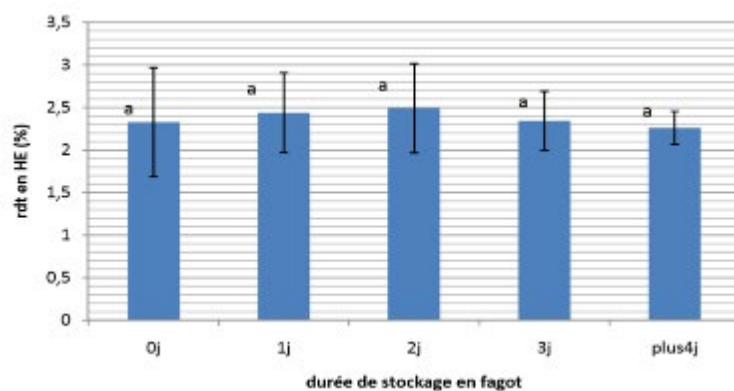
- *Chemical composition according to the duration of drying*
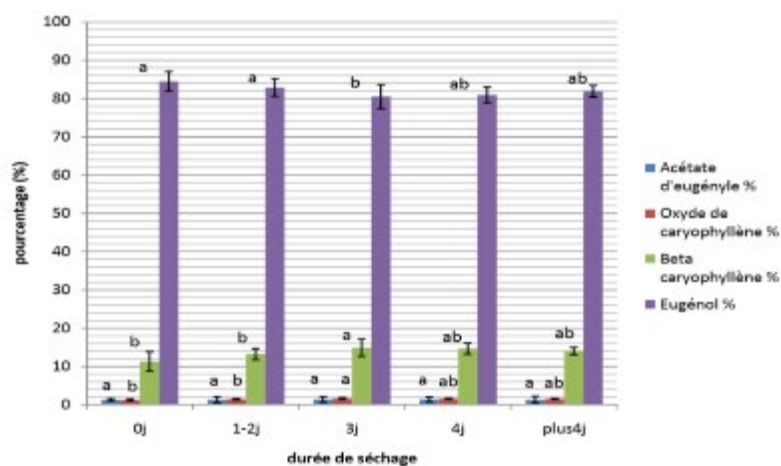
- *Chemical composition according to the duration of storage*
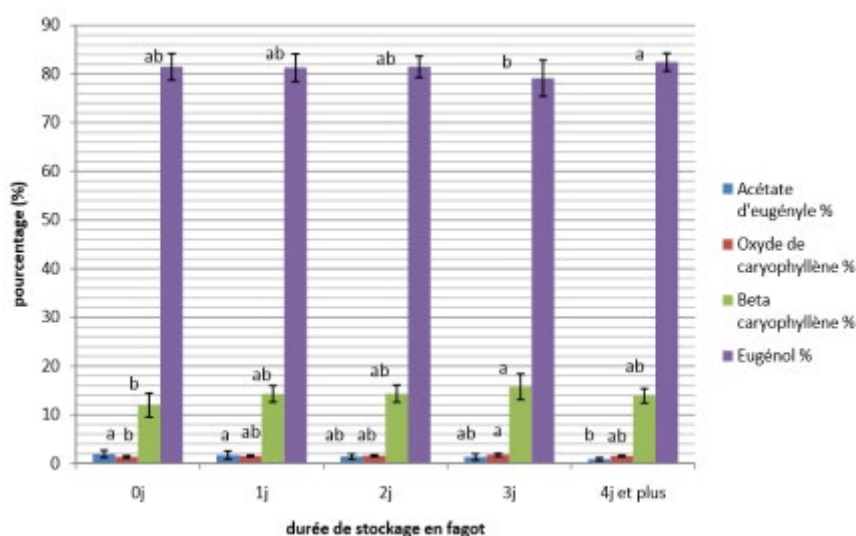
Conclusion

An increase of the yield in essential oil of leaves according to the duration of drying was observed. However, yield decrease following the storages of leaves. Drying has not impact on the chemical composition of oil extracted from fresh leaves or dried after 4 days. The content in majority components remains approximately stable.

Recommendations

- Drying leaves in the shade not exceeding one week;
- Avoid exposing leaves to the sun and in the rain (loss of yield);
- Avoid the storage in bundle of sticks (fermentation of leaves, depreciates the organoleptic quality of oil);
- Before distillation, place leaves under the covered area which protects the "alembic" by enlarging it;
- Leaves to be distilled for higher content of eugenol: fewer young leaves, many old leaves and 20 to 30 % of twigs.

Work 4:

Evolution post-harvest on the quality of clove buds essential oil and the clove buds flavour: organoleptic, physico-chemical characteristics and chemical composition. RANDRIAMIARINARIVO Manitriniaina (Master II ESPA Génie Chimique).

4.1.3. Influence of tree crop productivity on the final product quality

The study was started during last semester through a training course done in the framework of a DEA at University of Antananarivo.

Title:

Development of clove performance in Madagascar: the effect of endogenous and environmental factors

Objective:

The objective of this work is to provide the first knowledge basis about the factors influencing the flowering of clove, and therefore the development of nail performance. This work will follow several cycles of nails production to quantify the yields fluctuation. We are interested in the flowering of a point of view of yield and for its development over time (more or less synchronized within the trees and between the trees: effect on the maturity and nails quality, many harvest rounds). Given the current knowledge on clove and more generally on tree flowering, and field observations done in December 2011, three assumptions are made about the nature of these factors:
- Factors specific to the species: flowering is related to architectural development in terms of structural and temporal, of the tree;
- Environmental factors: temperature, rainfall, soil type, water supply ...;
- Farming practices: particularly severe pruning of trees for distillation can affect flowering.

This year was devoted to the implementation of monitoring the phenology and climate in the areas of Tamatave and Fenerive and periodic monitoring of the occurrence of different plant (buds, branches, leaves) and reproductive (inflorescences drafts , claws and nails) organs.

Preliminary results:

The observations related to 32 trees (20 in Tamatave area and 12 in Fenerive area) showed that cloves are distributed on tanety (hillsides) and lowland. The trees in Tamatave areas were differentiated according to whether they are pruned or not pruned. The results of the observations done since March 2012 showed a very weak flowering. On the 640 axes studied at the beginning, only about ten gave well differentiated inflorescence in June. These floriferous axes are gathered on same trees which in majority are located on lowland. From the architectural point of view, they are also characterised by a former flowering. The easier access to water and the climatic conditions can explain why only certain trees flowered on the same site. The trees located on tanety for Tamatave, having been pruned, did not flower and present branches which dried out in the course of time. The evolution of floral buttons is not synchronous with the floriferous branches. Deeper observations in time are necessary to specify the factors producing clove. These will be continued during year 2 of the project. At present, the sampling is initiated to map the oil quality in relation with the production system. Two students (University of Antananarivo, Ecole Supérieure des Sciences Agronomiques) were appointed to realize a study on the quality evaluation in the relation with the distillation system and to have information about the best conditions to obtain oil with high content of eugenol. They are working on these topics during three months (12 February to 12 May 2013).

4.2. Drivers of the quality of AFS products at plot level and at first transformation

On the clove tree, we are nothing information on the process of distillation. The first action will thus be to characterize the various existing systems and the second stage will be to realize this extraction in conditions controlled to obtain the best eugenol contents, because this parameter is the main parameter of the prize of the essential oil.

Work 1:

Title:

Effects of the distillation parameters on the quality of oil of *Syzygium aromaticum* leaves: Studies of the functioning of traditional "alembic" in the district of Ambatoharanana, region of Analanjirofo east of Madagascar.

Main Objective

The main objective is to optimize the conditions of production of yield and chemical composition of essential oil, according to the "alembic" and the parameters of distillation.

Specific Objectives

- To describe the essential oil yield and composition of S. aromaticum leaves collected in the district of Ambatoharanana, region of Analanjirofo east of Madagascar (typology of alembic).

- To analyse the relations between the chemical composition and the yield, on hand, and to analyse the parameters of distillation on the other hand.

Expected Results

- Quantification of the impacts of the parameters of distillation and the specificity of "alembic" on the quantitative and qualitative variations of leaves essential oil of clove tree.

- Finalized by a decision-making tool intended for the actors (farmers, collectors, exporters…) in this the sector.

Localization of the middle of studies

Situated on the east central coast of Madagascar, Ambatoharanana is a member of the District of East Fenerive in the region Analanjirofo. It is localized between 17°12 ' and 17°25 ' of latitude the South and 49°12' and 49°20' of longitude East.
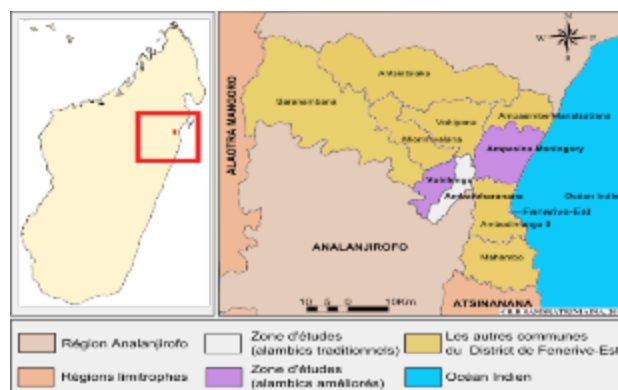
64 essential oils were used in this study (see Figure and Table below).
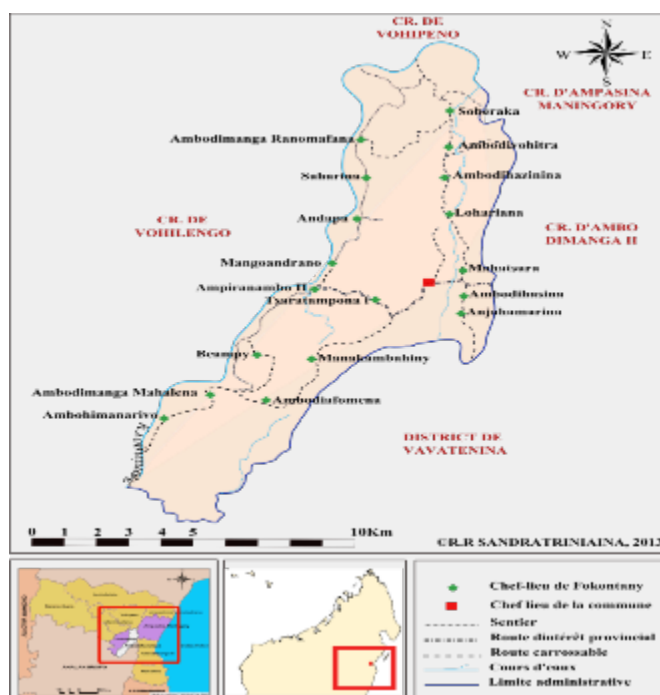
N°	FOKONTANY (commune)	Villages	Codes	Samples	Number
1	AMBATOHARANANA		AMB	AMB1, AMB5, AMB2A, AMB2B, AMB2C, AMB2D, AMB3A, AMB3B, AMB3C	9
2	LOHARIANA		LHR	LHR1, LHR2, LHR3A, LHR3B	4
3	AMBODIHAZININA		AHZ	AHZ1, AHZ3, AHZ5, AHZ6, AHZ7C, AHZ8, AHZ4A, AHZ4B, AHZ4C, AHZ7A, AHZ7B,	11
4	AMBODIVOHITRA	Ambodivohitra	ABV	ABV1, ABV2, ABV3, ABV4,	4
		Marovanihy	MRV	MRV1	1
		Tsaratampona 2	TSR	TSR1, TSR2, TSR3,	3
		Andratambe	ADR	ADR1, ADR2, ADR3,	3
5	SOBERAKA	ambolomadinika	ABL	ABL1, ABL2	2
		Sahavolo	SHV	SHV1	1
		Ambodiovitra	ABO	ABO1	1
		Antanankoro	ATK	ATK1	1
		Manaratsandry	MNR	MNR1	1
6	AMBODIHASINA		ABH	ABH5, ABH9A, ABH9B, ABH9C	4
7	TSARATAMPONA I		TST	TST1, TST2, TST3, TST4, TST6, TST7, TST8	7
8	MANAKAMBAHINY		MKB	MKB1, MKB2, MKB3	3
9	AMBODIAFOMENA		AFM	AFM1	1
10	AMBOHIMANARIVO		AMN	AMN2	1
11	AMBODIMANGA MAHALENA		ABM	ABM1	1
12	AMPIRANAMBO II		APR	APR3	1
13	MANGOANDRANO		MGD	MGD1, MGD2	2
14	BEAMPY		BAP	BAP1	1
15	Commune de VOHILENGO		VHL	VHL1	1
16	Commune d'AMPASINA MANINGORY		APM	APM2	1
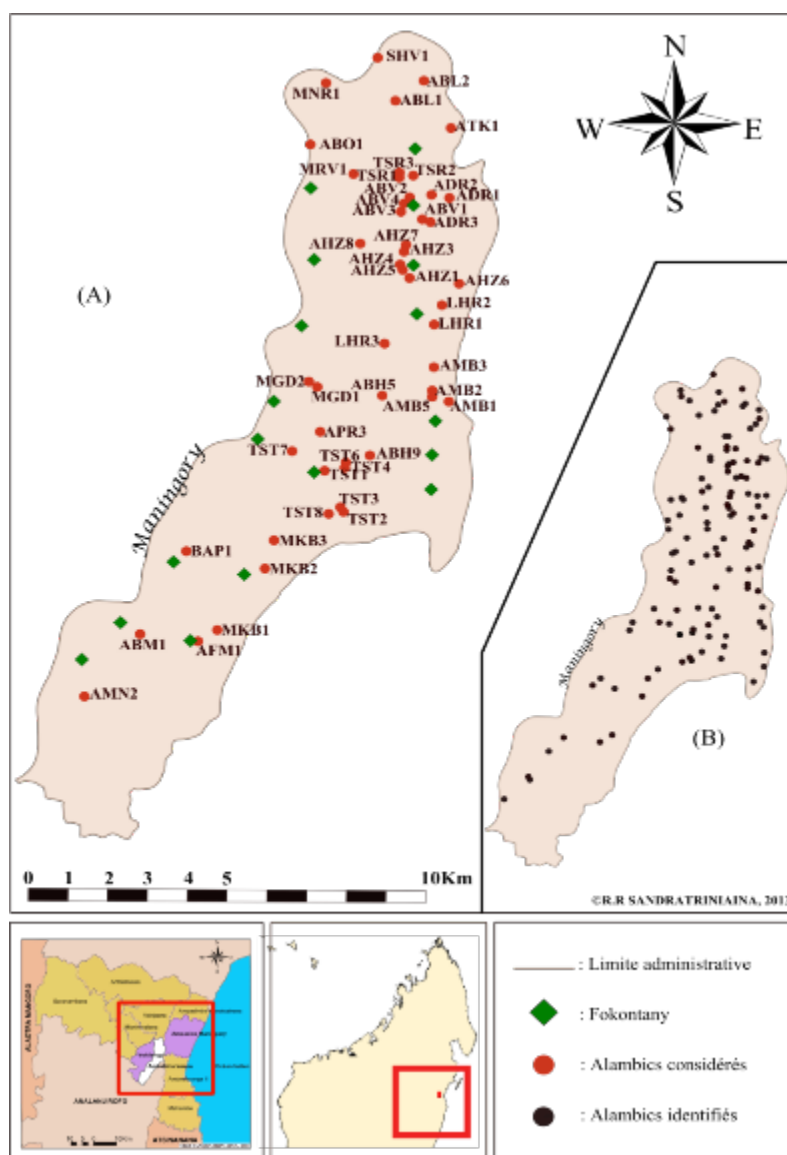
©R.R SANDRATRINIAINA, 2013

Legend:
— : Limite administrative
◆ : Fokontany
● : Alambics considérés
● : Alambics identifiés

Gas chromatography

Essential oils were analysed by gas chromatography (GC) using Focus GC equipped with a flame ionization detector (FID) and capillary column (polyethylene glycol: 30 m x 0.25 mm i.e., 0.25 µm film thickness). The flow of the carrier gas (N_2) was 1 ml/min and the split ratio 1:10 (1µl 10:100 heptane solution). Temperature was programmed to increase from 60 to 180 °C at the rate of 7 °C /min. Injector and detector temperatures were respectively held at 230 and 250 °C.

Statistical analysis

The distribution of the 64 samples was analysed by Principal Component Analysis (PCA) by Agglomerative Hierarchical Clustering analysis (AHC) and Discriminate Factorial Analysis (AFD) using the XLSTAT Version 2013 statistical software package. The data set was composed of the values taken by four variables identified by GC and the 64 clove leaf oil samples.

Results

- *Yield*

- *Chemical composition*

Répartition spatiale des groupes d'alambics étudiés

❖Bleu: alambics de type 1
❖Vert: alambics de type 2
❖Rouge: alambic de type 3

=> La variation géographique de la composition chimique n'est pas perceptible

LES ALAMBICS CONSIDERES
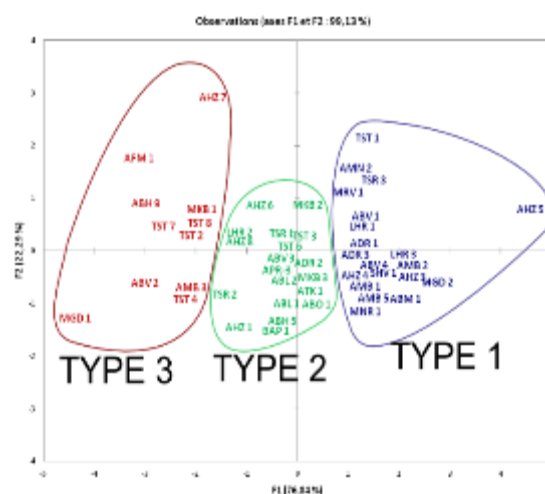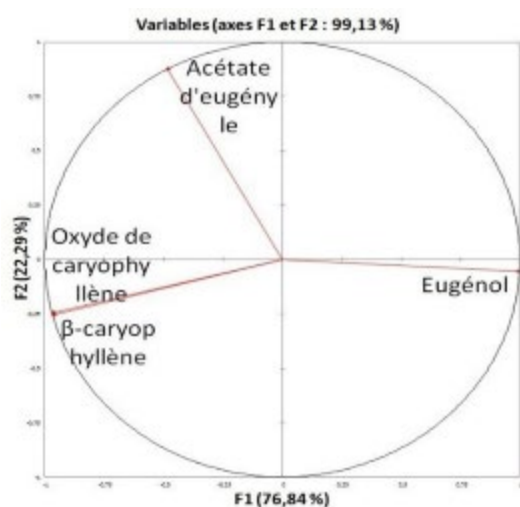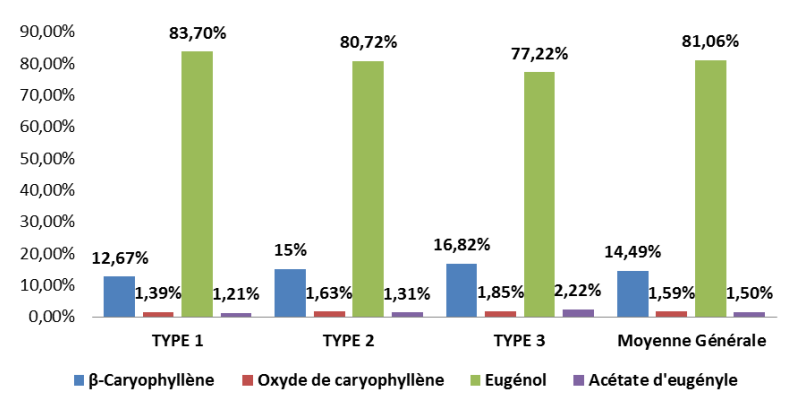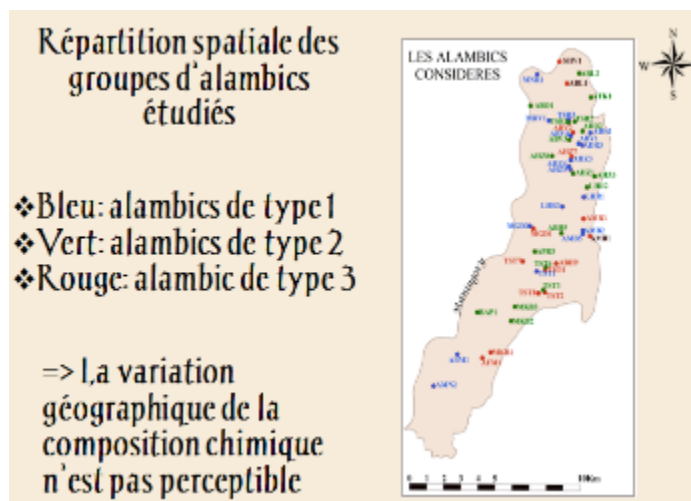
Recommendations to optimize yield and eugenol content

- *Reorganization of the fireplace (*FOYER*)*

SCHEMA FOND DE CUVE FLORALE

VUE DE FACE
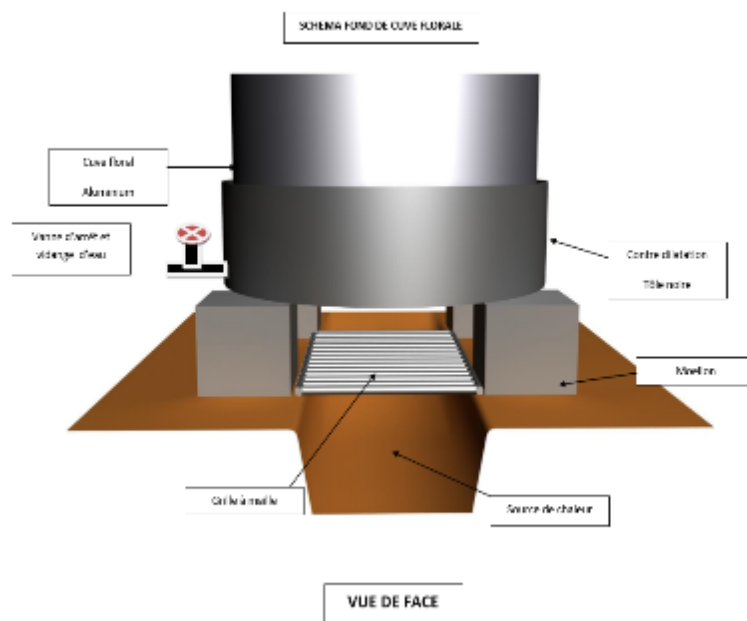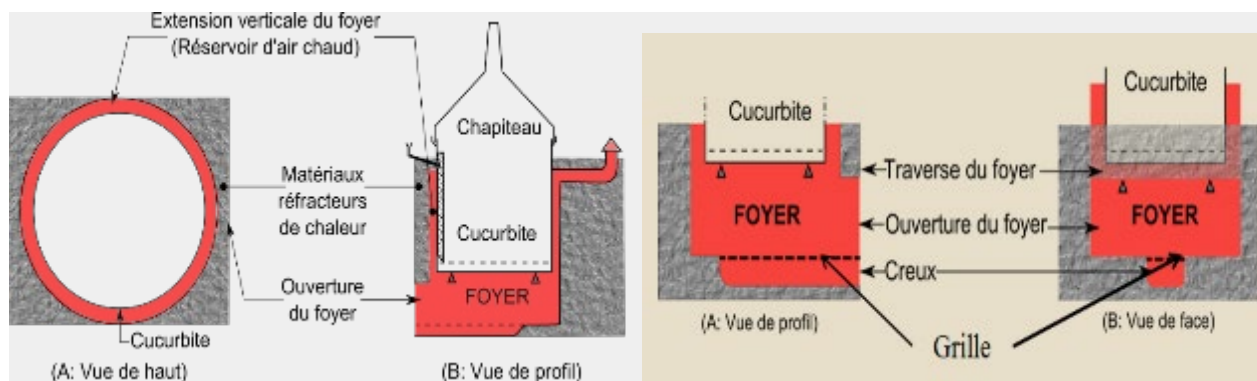
- *Conception of the lid (*chapiteau*) and the hydraulic joint*
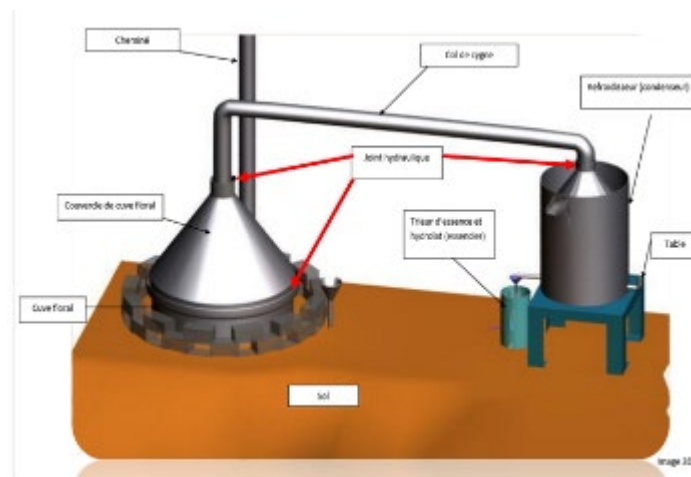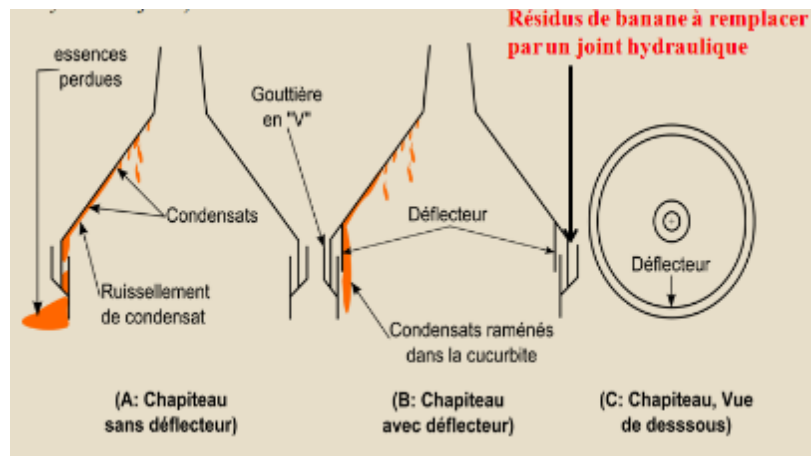
- *Conception of improved distiller (*essencier*) and condenser*
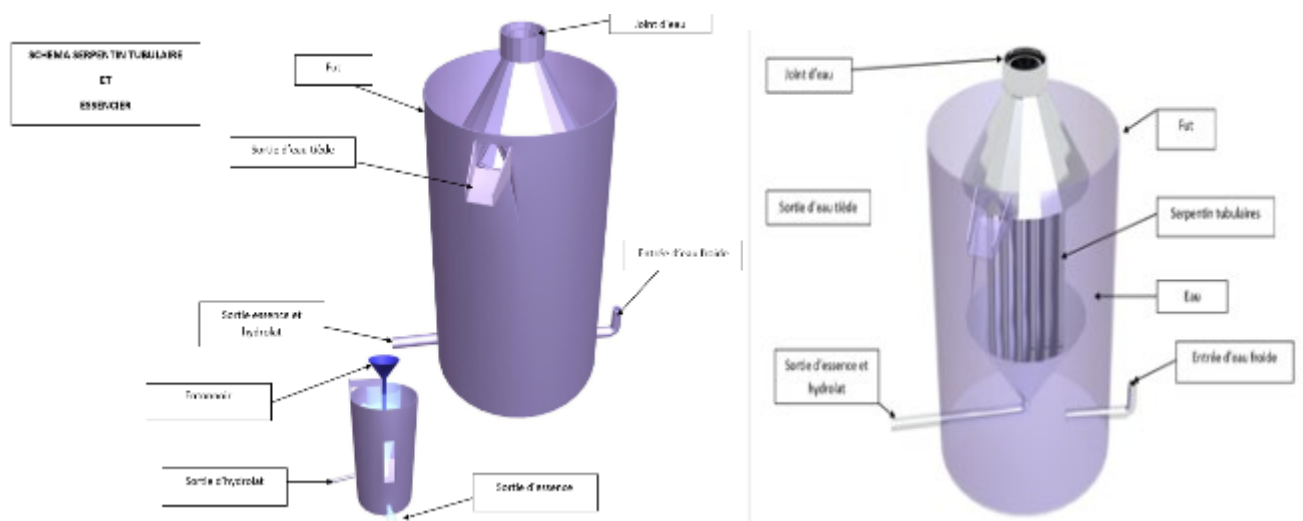
- *Conception of the cohobating system*

Tige de bambou
vidée

Essenciers

tuyauterie de
cohobation

Essenciers

(A) SYSTEME DE COHOBATION
ACTUEL

(B) SYSTEME DE COHOBATION
MODIFIE
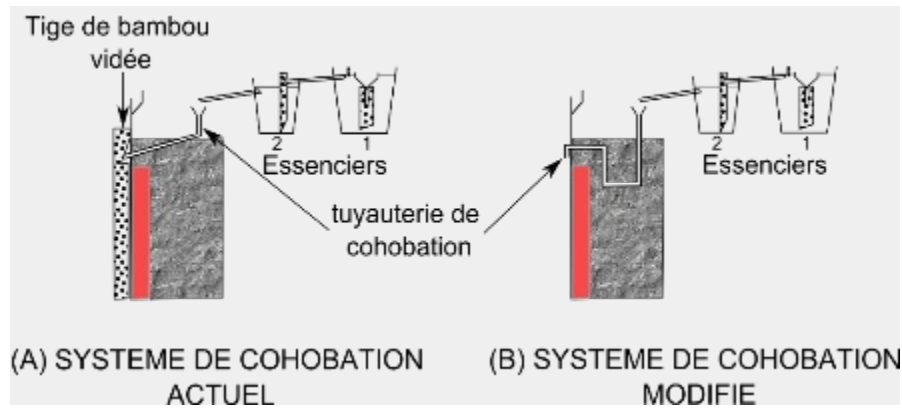
- *Fuels*

Fuels relatively dry wood and of sections averagely reduced.

Results of WP 4
- Bibliography consulted;
- Competitiveness of clove oil from Madagascar will help Malagasy farmers to complete others origins;
- Some determinants of the variability on the quality (eugenol content) and quantity (yields) of cloves buds, leaves and stems essential oils were determined;
- Some recommendations to optimize the conditions of essential oil production (yield and eugenol content) according to the treatment of raw material, the "alembic", the distillation method were supplied;
- One article, one poster and two student's reports are available.

Reason for modification for the planned activity
None.

What is your assessment of the results of the Action so far?
Partners are collaborating fully and farmers' representatives and local authorities are also participating and sharing their views. The results are satisfactory and are appropriate to expected schedule.

Potential risks that may have jeopardized the realisation of some activities and explain how they have been tackled
So far, no problem has been encountered in the target zone.

Activities planned but not implemented
None.

The project can be fulfilled within the scheduled period, but it would be appreciated to allow a prolongation of the project period by 6 months. This would allow the researchers to improve the quality of results, and further recommendations to farmers.

Updated action plan Madagascar

Activities	Year 1												Implementing bodies
	1st Semester						2nd Semester						
Months	1 Apr	2 May	3 Jun	4 Jul	5 Aug	6 Sep	7 Oct	8 Nov	9 Dec	10 Jan	11 Feb	12 Mar	
1.1. Identification of study farms and communities			x	x	x	x	x	x	x				CIRAD, CTHT
1.2. Creating Eval. committees & Ext. adv. panels				x	x				x	x			CIRAD, CTHT
1.3. Scientific Coordination	x	x	x	x	x	x	x	x	x	x	x	x	CTHT
1.4. Capacity Building							x	x	x	x	x	x	CIRAD, CTHT
2.1. Spatio-temporal Dynamics							x	x	x	x	x	x	CIRAD, CTHT
2.2. Evolution of farmers' strategies										x	x	x	All partners
3.1. Assess interactions AFS and food crops										x	x	x	All partners
3.2. Pathways to improve synergies													All partners
4.1. Characterization of SAF product quality							x	x	x	x	x	x	All partners
4.2. Drivers of AFS product quality							x	x	x	x	x	x	All partners
5. Dissemination of results									x	x	x	x	All partners

Activity	Following years					Implementing body
	Year 2		Year 3		Year 3+	
Semesters	3 Apr – Sep 13	4 Oct 13 – Mar 14	5 Apr – Sep 14	6 Oct 14 – Mar 15	7 Apr – Sep 15	
1.3. Scientific coordination	x	x	x	x	x	All partners
1.4. Capacity building	x	x	x	x	x	All partners
2.2. Evolution of farmers' strategies	x	x				All partners
2.3. Modelling and forecasting			x	x		All partners
3.1. Assess interactions AFS and cash crops	x	x				All partner
3.2. Assess pathways to improve synergies	x	x	x	x		All partners
4.1. Characterization of AFS product quality	x	x	x	x	X	All partners
4.2. Drivers of AFS product quality	x	x	x	x	x	All partners
5. Dissemination of results	x	x	x	x	x	All partners

Reasons of change

An increase of the project period of 6 months would be appreciated to allow the researchers to better test the apparatus used for essential oil extraction and also increase the amount of publications.

3. Partners and other Co-operation

3.1. Cameroon

3.1.1. How do you assess the relationship between the formal partners of this Action

Links with IRAD are very close as both CIRAD and IRAD researchers based in Cameroon are involved in the project. Moreover, they are already working together for several years on the research station near IRAD Yaoundé.

Partnership with IRAD as regarding the implementation of administrative and financial procedures and scientific programming takes place quite satisfactory.

3.1.2. How would you assess the relationship between your organisation and State authorities in the Action countries?

CIRAD has good relations with the Cameroonian authorities and a framework agreement was signed between CIRAD and the French Ministry of Research (MINRESI).

3.1.3. Describe your relationship with any other organisations involved in implementing the Action

Links with cocoa farmers in the region of Bokito existed for over ten years through various research activities conducted by IRAD and CIRAD.

3.1.4. Outline any links and synergies you have developed with other actions

A synergy has been implemented with an agroforestry based project (SAFSE) involving CIRAD and other institutes involved in agronomical research and with a research platform in Cameroon ("DP Agroforesterie"), gathering CIRAD, IRAD, universities and NGO specialized in agroforestry.

3.2. Kenya

3.2.1. How do you assess the relationship between the formal partners of this Action

• Partner
ICRAF is fully collaborating with the project, particularly in hosting African and European graduate students, as well as via technicians and researchers participating in data collection in the target zone. ICRAF also plays the role of administrative support to the project in Kenya

and has greatly contributed to the organisation of the Second International workshop of AFS4Food in Nyeri, Kenya in October 2013.

• Associate

CRF is fully collaborating in meetings, workshops and contacts with local coffee communities. CRF has led on the ground the study on coffee quality in WP4, particularly in selecting farms, taking soil and coffee samples at the peak of harvest. For all the farms sampled, CRF has done soil analyses and given written recommendations of fertilizer applications that have been greatly appreciated by farmers.

3.2.2. How would you assess the relationship between your organisation and State authorities in the Action countries?

The relationships between the project partners (CIRAD, ICRAF & CRF) and local organisations and authorities are good as the partners periodically have feedback meetings with their representatives and the project work appears very relevant to them.

3.2.3. Describe your relationship with any other organisations involved in implementing the Action

• Final Beneficiaries and Target groups

Clearly, the project relationships with target farmers and coffee societies (local farmers' unions) are excellent as the work undertaken and themes studied (coffee quality, soil fertility, assessment of constraints of coffee farmers) are very relevant for them.

• Other third parties involved (including other donors, other government agencies or local government units, NGOs, etc.)

The project work is well perceived by local third parties as results and recommendations from the project are useful to them. Clearly, these third parties, especially NGOs, would have like very much that the project would go beyond research and recommendations into implementation (for example, establishment of shade tree nurseries), but funds allocated to the project do not allow us to do so.

3.2.4. Outline any links and synergies you have developed with other actions

Due to the project and information already gathered, two agronomy students have been selected and will start working for their PhD in the target zone of AFS4Food; the first one, Ethiopian, will start his socio-economic research in mid-May 2014 and the second one, Spanish, will be start his work on gas emission and mitigation in September 2014.

Due to the AFS4Food project and existing partnership in Kenya, a proposal has been developed and submitted early March 2014 to the Swiss Research Foundation in collaboration with the University of Zurich (ETH) to study the promising adaptation potential of coffee agroforestry systems to climate change.

3.3.   Madagascar

3.3.1. How do you assess the relationship between the formal partners of this Action

Where applicable, describe your relationship with any other organisations involved in implementing the Action:

• Partner

The local partner (CTHT) provides a major function in the implementation of the operations on the identified sites of intervention because it has of a qualified supervisory staff and a good knowledge of the zone. Its logistic support is essential for the reception and the operation of the trainees and the experts.

In addition, the laboratory of the CTHT guarantees a fast treatment of the products to be analysed.

The whole of the administrative procedures related to the contract agreement of the trainees is ensured by the CTHT.

• Associate

The ESSA is the main Malagasy scientific partner contributes actively to the implementation of the research activities by the framing of national trainees and the mobilization of experts in charge of the operations of distillation. This structure co-signs all the publications.

3.3.2. How would you assess the relationship between your organisation and State authorities in the Action countries?

The relationships with the Malagasy administration (agriculture and research) remained little developed because of the current political context (absence of recognized government). Information concerning the project however is transmitted to the local services in charge of agriculture.

3.3.3. Describe your relationship with any other organisations involved in implementing the Action

• Final Beneficiaries and Target groups

Taking into account our regular presence in the zone, the relations with the producers are good and their contribution is effective.

The exporters have just gathered in professional body to defend the interests of their sector and to contribute to his structuring. In this context the works undertaken on the quality of the petrol and the improvement of the techniques of distillation interest these professionals particularly.

3.3.4. Outline any links and synergies you have developed with other actions

The PARRUR project (financed by French Embassy) which is interested more particularly in aromatic quality of the products resulting from the clove, cooperates with the agents involved in the activities of the WP4 because it constitutes a complementary information source.

4. Visibility

4.1.   Website

To ensure the visibility of the project, we have created a Web site, available at: http://afs4food.cirad.fr/en.
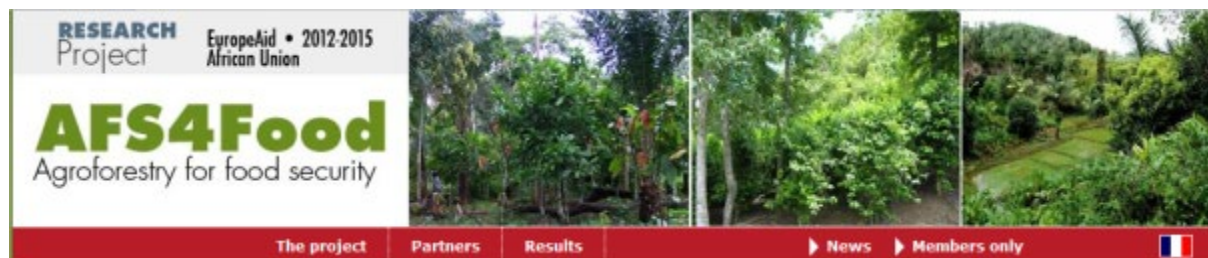
4.2.   Advertisement

The website is also advertised in other partners' websites; and particularly on the website of Cirad in East Africa.

The European Commission may wish to publicise the results of Actions. Do you have any objection to this report being published on EuropeAid Co-operation Office website? If so, please state your objections here.
I have no objections

Name of the contact person for the Action: Didier SNOECK

Signature: …………………………………………

Location: CIRAD
            TA B34 / 02
            Avenue Agropolis
            34398 Montpellier Cedex 5
            FRANCE

Date report due: 04 May 2014

Date report sent: 03 July 2014

5. Annexes

5.1. Students' reports summaries

5.1.1. Cameroon

On this topic here are the main results that can be summarized from the M2 theses written in 2013:

- Four major types of use can be distinguished: wood (fire wood or construction wood); fruit production; provision of an agronomical service (shade and fertility) and cultural use (mainly medicine provision).
- Associated trees that produce fruits are more numerous in AFS of Bokito than those of Talba. Thus, in Bokito, fruit trees (especially citrus fruit) should be more significantly directly or indirectly (via selling production to the market) support food security or diversity than in Talba.
- AFS produce staple food only when cocoa trees are young (under 5-7 years). Therefore, AFS contribute directly to food security or diversity only at that stage. Then the contribution can only be indirect via the purchase of food with the revenue form cocoa (which is to be confirmed).
- One species of associated tree can provide multiple services to the farmer;
- Species use by farmers can be associated to some intrinsic functional traits (such as leaf life span or successional position);
- Diversity of trees is AFS is significantly lower in AFS than in forests, yet associated trees are the main contributors of C storage in AFS. The C storage is highest at maturity e.g. between 40 and 65 years old. In Bokito, C storage of associated trees can be considered as equivalent to that of local forest.
- Diversity of associated trees tends to decrease with aging and AFS since farmers make trade-offs between the services they provide and cocoa production.

Memoire of Cyprien ALEXANDRE – WP2
Alexandre C., 2013 – " *Analyses use of the soil of the area of Bokito (Mbam and Inoubou, Cameroon) starting from the data of remote sensing and implications on the agroforestry cultivation systems*".
Memoire of Master 2 of University Montpellier III Paul-Valéry, Mention IGT Ingénierie et Gestion Territoriales et Mention Informatique, Spécialité Géomatique, 38 pp.

In a global food crisis context, agronomic issues are crucial. In the sub-Saharan area, the agroforestry is predominant and could be a sustainable solution. Several multi-disciplinary projects aim to assess its contribution to the household income. The study area (Bokito region in Cameroon) has the particularity of being a savannah-forest transition, where agroforestry is largely cocoa-based. The purpose of this study is to provide a land cover map and analyse the crop spatial distribution. Thus, a land-use map was produced with 85 % of global accuracy, based on WorldView2 imagery, and thanks to several remote sensing skills (e.g. spatial, textural analyses) and an object-based classification tool. Its typology is rather fine, especially for the agroforestry crops, and allows the analysis of the various cropping systems. A first spatial

analysis of this classification shows a landscape clusterization, highly related to the altitude, which will help the agronomists to infer about the cropping practices in the area.

5.1.2. Kenya

Memoire of Claude TOKO KAMENI, WP2

Toko Kameni C, 2013 – « *Les systèmes agroforestiers à base de café au Kenya: stratégies des agriculteurs du Centre Kenya pour l'amélioration de leur sécurité alimentaire et de leurs conditions de vie* ». 68 p. Mémoire présenté pour l'obtention du Diplôme d'Ingénieur en Systèmes Agricoles et Agroalimentaires Durables au Sud, Institut des régions chaudes de Montpellier SUPAGRO, Spécialisation « Ressources, Systèmes Agraires et Développement ». Mémoire dirigé par Philippe PEDELAHORE du CIRAD.

Whenever a population is facing a food crisis, it must increase its agricultural production. To do that it can either increase its acreage or change the cropping system or (and) production areas. The population of the county of Murang'a has not been spared from the coffee crisis caused by the global drop in coffee prices in the nineties. The work carried out within the framework of this report is to clarify the role of coffee in the construction of farm incomes, study the different paths followed by these ones, and refine their strategies. The results are based on survey results of 12 resource persons and 36 farms. From this study, it appears that crisis has leaded farms to transform the production system previously based solely on coffee in complex coffee-based agroforestry systems. More deeply, the fall of the price of the coffee led the farmers to diversify their monetary income sources, in particular by the development of the bovine breeding milk and the nonagricultural activities. Today, those which depend only on the cultures coffee-plantations and food live below poverty line.

5.1.3. Madagascar

Memoire of Mélanie LOBIETTI, WP2

Lobietti M., 2013 – « *Analyse des systèmes girofliers à East-Fenerive, Madagascar: dynamiques spatiales, trajectoires et stratégies paysannes* ». 95 p. Memoire presented for obtaining the Diploma of Agricultural engineer of Bordeaux Sciences Agro, Spécialisation « Ressources, Systèmes Agraires et Développement » done at the Institut des régions chaudes de Montpellier SUPAGRO. Mémoire dirigé par Isabelle Michel de SUPAGRO, et par Thierry Michels du CIRAD.

The proposed study is part of the European project Europaid ASF4Food whose main objective to strengthen food security and well-being of African rural households through the association between food crops and agroforestry systems. This study took place in Madagascar, in the district of East Fenerive and aims to understand the clove's evolution and the impact that this has resulted in two sites. The analysis is mainly based on a qualitative approach supplemented by quantitative factors across three scales: planning, farm and plot. The analysis of the evolution of farming systems in space and time has revealed changes of rice practices as well as the diversification of agricultural systems in the territory Betsimitsaraka following the introduction of clove by settlers in 1930. The characterization of these systems clove and their dynamics since their introduction highlighted the preponderance of tree parks, the recent development of complex agroforestry systems and the presence of residual monospecific clove plantations.

5.2. Updated action plan

A prolongation of the project duration is requested to increase the amount of data collected (particularly, it would add the possibility to add one harvest season) and thus the quality of results, and finally, improve the recommendations to the farmers.

The updated action plan includes 6 months, i.e. year **3+**.

Activities	Year 1												Implementing bodies
	1st Semester						2nd Semester						
Months	1 Apr	2 May	3 Jun	4 Jul	5 Aug	6 Sep	7 Oct	8 Nov	9 Dec	10 Jan	11 Feb	12 Mar	
1.1. Identification of study farms and communities			x	x	x	x	x	x	x				CIRAD, CTHT, ICRAF, IRAD
1.2. Creating Eval. committees & Ext. adv. panels				x	x				x	x			CIRAD, CTHT, ICRAF, IRAD
1.3. Scientific Coordination	x	x	x	x	x	x	x	x	x	x	x	x	CTHT, ICRAF, IRAD
1.4. Capacity Building							x	x	x	x	x	x	CIRAD, CTHT, ICRAF, IRAD
2.1. Spatio-temporal Dynamics							x	x	x	x	x	x	CIRAD, CTHT, ICRAF, IRAD
2.2. Evolution of farmers' strategies										x	x	x	All partners
3.1. Assess interactions AFS and food crops										x	x	x	All partners
3.2. Pathways to improve synergies													All partners
4.1. Characterization of SAF product quality							x	x	x	x	x	x	All partners
4.2. Drivers of AFS product quality							x	x	x	x	x	x	All partners
5. Dissemination of results										x	x	x	All partners

Activity	Following years					Implementing body
	Year 2		Year 3		Year 3+	
Semesters	3 Apr – Sep 13	4 Oct 13 – Mar 14	5 Apr – Sep 14	6 Oct 14 – Mar 15	7 Apr – Sep 15	
1.3. Scientific coordination	x	x	x	x	x	All partners
1.4. Capacity building	x	x	x	x	x	All partners
2.2. Evolution of farmers' strategies	x	x				All partners
2.3. Modelling and forecasting			x	x		All partners
3.1. Assess interactions AFS and cash crops	x	x				All partner
3.2. Assess pathways to improve synergies	x	x	x	x		All partners
4.1. Characterization of AFS product quality	x	x	x	x	X	All partners
4.2. Drivers of AFS product quality	x	x	x	x	x	All partners
5. Dissemination of results	x	x	x	x	x	All partners

Interim financial report for the period:

		Budget as per contract/rider			Reallocation	Per currency EUR Exchange rate pof the period: 1.000000			
From: 04/04/2013 To: 04/03/2014 **Expenditures**	Unit	# Units (a)	Unit cost (in EUR) (b)	Costs (in EUR) (a)*(b)	allowed reallocation	# Units (d₁)	Unit cost (in EUR) (e₁)	Total cost (in EUR) (f₁) = (d₁)*(e₁)	Total cost (in EUR) (g₁)= (f₁)*(Fx-rate₁)
1. Human Resources									
1.1 Salaries (gross salaries including social security charges and other related costs, local staff)						= f₁ / e₁	= TDCI_B / T₁	= TDCI_C	= TDCI_D
1.1.1. Technical staff Cameroon	Per month	96	115	11,040	0	0.0	115	-	-
1.1.1. Technical staff Kenya	Per month	31	695	21,750	0		695	3,168.59	3,168.59
1.1.1. Technical staff Madagascar	Per month	43	259	11,254	0	0.0	259	-	-
1.1.1. Technical staffs France	Per month	3	4,380	13,140	0	0.9	4,380	3,962.40	3,962.40
1.1.2. Administrative/ support staff Cameroon	Per month	36	200	7,200	0	9.8	200	1,967.92	1,967.92
1.1.2. Administrative/ support staff Kenya	Per month	36	200	7,200	0	0.0	490	-	-
1.1.2. Administrative/ support staff Madagascar	Per month	36	200	7,200	0	0.0	0	-	-
1.1.3. Student training Cameroon	Per month	23	46	1,062	0	24.5	46	1,128.94	1,128.94
1.1.3. Student training Kenya	Per month	43	420	16,620	1400	8.5	420	3,550.02	3,550.02
1.1.3. Student training Madagascar	Per month	73	199	14,555	0	29.6	149	4,414.02	4,414.02
1.1.4. Researcher Cameroon	Per month	75	460	34,500	0	0.0	0	-	-
1.1.4. Researcher Kenya	Per month	8	4,500	36,000	0	0.0	4,500	-	-
1.1.4. Researcher Madagascar	Per month	90	296	26,640	0	0.0	0	-	-
1.1.4. Researchers France	Per month	33	12,000	396,000	0	15.5	12,000	186,089.85	186,089.85
1.2 Salaries (gross salaries including social security charges and other related costs, expat/int. staff)					0				-
1.2.1. Administrative/ support staff Cirad France	Per month	6	5,000	30,000	0	2.6	5,000	12,763.46	12,763.46
1.2.2. Student trained in France	Per month	41	420	17,220	0	13.3	420	5,566.92	5,566.92
1.2.3. Researcher Cirad France	Per month	27	6,800	183,600	0	19.4	6,800	132,064.54	132,064.54
1.2.4. Coordinator Cirad France	Per month	5	9,700	48,500	0	2.1	9,700	20,375.88	20,375.88
1.3 Per diems for missions/travel									
1.3.1. Abroad staff assigned to the Action Cameroon	Per diem	146	132	16,941	2400	26.7	132	3,520.96	3,520.96
1.3.1. Abroad staff assigned to the Action Kenya	Per diem	154	144	22,830	-2951	102.2	123	12,610.90	12,610.90
1.3.1. Abroad staff assigned to the Action Madagascar	Per diem	206	97	20,258	1901	30.5	86	2,629.60	2,629.60
1.3.1. Abroad staff assigned to the Actions Ethiopia	Per diem	0	180	2,520	-2520	0.0	0	-	-
1.3.2. Local staff assigned to the Action Cameroon	Per diem	1,910	22	41,313	790	471.1	22	10,365.20	10,365.20
1.3.2. Local staff assigned to the Action Kenya	Per diem	461	35	7,020	9150	0.0	149	-	-
1.3.2. Local staff assigned to the Action Madagascar	Per diem	30	19	560	0	0.0	19	-	-
1.3.3. Seminar/conference participants Cameroon	Per diem	120	20	2,400	0	0.0	20	-	-
1.3.3. Seminar/conference participants Kenya	Per diem	120	20	2,400	0	17.6	20	352.64	352.64
1.3.3. Seminar/conference participants Madagascar	Per diem	120	20	2,400	0	0.0	20	-	-
Subtotal Human Resources				1,002,123	10,170			404,531.84	404,531.84
2. Travel									
2.1 International travel									
2.1.1. International travel Cameroon	Per flight	12	1,200	16,800	-2052	2.5	1,200	2,983.06	2,983.06
2.1.2. International travel Kenya	Per flight	14	1,200	16,600	-296	8.3	1,029	8,587.35	8,587.35
2.1.3. International travel Madagascar	Per flight	11	1,500	16,600	948	4.1	1,185	4,867.05	4,867.05
2.1.4. International travel Ethiopia	Per flight	0	1,500	6,000	-6000	0.0	0	-	-
2.1.5. International Travel across Africa	Per flight	18	1,500	27,000	0	3.8	1,500	5,761.19	5,761.19
2.2 Local transportation									-
2.2.1. Local transportation Cameroon	Per month	36	180	6,480	0	1.8	180	328.37	328.37
2.2.2. Local transportation Kenya	Per month	54	424	15,520	7330	16.0	424	6,789.17	6,789.17
2.2.3. Local transportation Madagascar	Per month	33	709	25,533	-2000	5.9	709	4,176.99	4,176.99
Subtotal Travel				130,263	-1,800			33,493.18	33,493.18
3. Equipment and supplies									
3.1. Purchase or rent of vehicles Cameroon	Per vehicle	1	28,000	28,000	0	0.0	28,000	-	-
3.2. Furniture, computer equipment	per unit	5	988	4,940	0	2.0	988	1,984.23	1,984.23
3.3. Machines, tools	per unit	13	918	11,930	0	0.1	918	133.22	133.22
3.4. Spare parts/equipment				0	0	0.0	0	-	-
3.5. Other (please specify)	per unit	7	1,300	9,100	1600	3.2	1,300	4,201.16	4,201.16
Subtotal Equipment and supplies				53,970	1,600			6,318.61	6,318.61
4. Local office									
4.1. Vehicle costs	Per week	272	40	8,480	2400	69.0	40	2,759.89	2,759.89
4.2. Office rent	Per month			0	0	0.0	0	-	-
4.3. Consumables - office supplies	Per month	123	374	67,280	-21210	15.5	384	5,930.21	5,930.21
4.4. Other services	Per month	180	31	5,580	0	0.0	31	-	-
Subtotal Local office				81,340	-18,810			8,690.10	8,690.10
5. Other costs, services									
5.1. Publications	per unit	27	160	4,320	0	0.0	160	-	-
5.2. Studies, research	per unit	78	154	11,575	500	0.0	123	-	-
5.3. Expenditure verification	per unit	12	1,725	20,700	0	0.0	1,725	-	-
5.4. Evaluation costs	per unit			0	0	0.0	0	-	-
5.5. Translation, interpreter	per unit			0	0	0.0	0	-	-
5.6. Financial services (bank guarantee costs etc.	per unit	108	50	5,400	0	0.0	50	-	-
5.7. Costs of conferences/seminars	per unit	3	1,820	5,460	0	1.4	1,517	2,190.84	2,190.84
5.8. Visibility actions	per unit	1	260	260	0	0.0	260	-	-
Subtotal Other costs, services				47,715	500			2,190.84	2,190.84
6. Other									
6.1. Material for laboratory trials Cameroon	per unit	46	411	20,550	-1440	12.4	411	5,102.57	5,102.57
6.1. Material for laboratory trials Kenya	per unit	3	1,000	3,000	0	0.0	1,000	-	-
6.1. Material for laboratory trials Madagascar	per unit	10	1,000	6,000	6000	0.0	0	-	-
6.2. Quality analysis Cameroon	per unit	70	125	7,500	1200	1.8	125	224.08	224.08
6.2. Quality analysis Kenya	per unit	304	68	13,500	7000	8.4	325	2,719.87	2,719.87
6.2. Quality analysis Madagascar	per unit	35	838	33,500	-6000	2.0	838	1,636.32	1,636.32
Subtotal Other				84,050	6,760			9,682.84	9,682.84
7. Subtotal direct eligible costs of the Action (1-6) (excluding taxes)				1,399,461	-1,580			464,907.41	464,907.41
8.1. Contingency reserve				0	1580			217.53	217.53
9. Total direct eligible costs of the Action (7+ 8) (excluding taxes)				1,399,461	0			465,124.94	465,124.94
A.1. Administrative Costs				97,962	0			32,558.75	32,558.75
11. Total eligible costs (9+10) (excluding taxes)				1,497,423	0			497,683.69	497,683.69
12. Taxes[11]									
13. Total eligible/accepted[12] costs of the Action (11+12)				1,497,423	0			497,683.69	497,683.69
UA FINANCE 50 %				748,711					

Expenditures incurred

# Units d_2 (USD)	Unit cost e_2 (USD)	Total cost f_2=$(d_2)(e_2)$ (USD)	Total cost g_2=$(f_2)(Fx)$ (EUR)	# Units d_3 (MGA)	Unit cost e_3 (MGA)	Total cost f_3=$(d_3)(e_3)$ (MGA)	Total cost g_3=$(f_3)(Fx)$ (EUR)	# Units d_4 (XAF)	Unit cost e_4 (XAF)	Total cost f_4=$(d_4)(e_4)$ (XAF)	Total cost g_4=$(f_4)(Fx)$ (EUR)	Total # units Sum$(d_1{\to}d_4)$	Total cost (EUR) h=Sum$(g_1{\to}g_4)$	Cumulated costs before i (EUR)	Cumulated $(h)+(i)$ (EUR)
0.0	0	-	-	0.0	0	0	-	25.2	75,435	1,900,700	2,897.60	25.2	2,897.60	1,166.23	4,063.83
8.2	928	7,645.78	5,725.39	0.0	0	0	-	0.0	0	0	-	8.2	8,893.98	-	8,893.98
0.0	0	-	-	3.8	766,387	2,913,477	984.61	0.0	0	0	-	3.8	984.61	1,352.76	2,337.37
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.9	3,962.40	-	3,962.40
0.0	0	-	-	0.0	0	0	-	2.6	131,191	340,000	518.33	12.4	2,486.25	-	2,486.25
0.0	267	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	10.9	591,805	6,480,000	2,189.91	0.0	0	0	-	10.9	2,189.91	2,092.19	4,282.10
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	24.5	1,128.94	-	1,128.94
0.0	561	-	-	0.0	0	0	-	0.0	0	0	-	8.5	3,550.02	969.04	4,519.06
0.0	0	-	-	1.6	588,846	960,000	324.43	0.0	0	0	-	31.2	4,738.45	715.58	5,454.03
0.0	0	-	-	0.0	0	0	-	41.4	301,740	12,494,688	19,048.03	41.4	19,048.03	6,153.92	25,201.94
0.0	6,009	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	14.1	875,871	12,373,970	4,181.77	0.0	0	0	-	14.1	4,181.77	8,100.22	12,281.99
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	15.5	186,089.85	113,794.84	299,884.69
			-				-				-				-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	2.6	12,763.46	10,877.18	23,640.64
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	13.3	5,566.92	3,575.63	9,142.55
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	19.4	132,064.54	36,788.52	168,853.06
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	2.1	20,375.88	19,349.65	39,725.53
															-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	26.7	3,520.96	10,687.00	14,207.96
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	102.2	12,610.90	2,130.00	14,740.90
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	30.5	2,629.60	981.63	3,611.23
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	0.0	0	0	-	14.3	14,431	206,000	314.04	485.4	10,679.24	2,390.35	13,069.59
0.0	47	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	32.7	56,221	1,839,500	621.66	0.0	0	0	-	32.7	621.66	457.89	1,079.54
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	1,819.03	1,819.03
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	17.6	352.64	-	352.64
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
		7,645.78	5,725.39			24,566,947	8,302.38			14,941,388	22,778.00		441,337.61	223,401.64	664,739.25
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	2.5	2,983.06	5,520.27	8,503.33
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	8.3	8,587.35	3,001.36	11,588.71
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	4.1	4,867.05	3,427.04	8,294.09
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	3.8	5,761.19	6,334.09	12,095.28
											-	0.0	-	-	-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	1.8	328.37	265.36	593.73
5.4	377	2,047.00	1,532.86	0.0	0	0	-	0.0	0	0	-	21.4	8,322.03	861.13	9,183.16
0.0	0	-	-	1.6	2,097,948	3,448,700	1,165.49	0.0	0	0	-	7.5	5,342.48	950.62	6,293.09
		2,047.00	1,532.86			3,448,700	1,165.49			0	-		36,191.52	20,359.87	56,551.39
0.0	0	406.58	304.46	0.0	0	0	-	0.0	0	0	-	0.0	304.46	27,898.35	28,202.81
0.0	1,333	-	-	0.0	2,923,516	0	-	0.0	648,086	0	-	2.0	1,984.23	1,189.60	3,173.83
0.0	1,226	-	-	0.0	0	0	-	1.8	602,169	1,083,848	1,652.32	1.9	1,785.54	471.07	2,256.60
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	3.2	4,201.16	-	4,201.16
		406.58	304.46			0	-			1,083,848	1,652.32		8,275.38	29,559.02	37,834.41
0.0	0	-	-	0.0	0	0	-	58.2	26,238	1,527,360	2,328.45	127.2	5,088.34	1,561.18	6,649.52
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
18.5	499	9,242.38	6,920.97	3.5	1,106,675	3,928,540	1,327.65	6.5	245,328	1,606,560	2,449.18	44.1	16,628.01	2,230.03	18,858.04
0.5	41	19.10	14.30	18.7	91,730	1,719,271	581.03	20.7	20,335	421,500	642.57	39.9	1,237.90	189.04	1,426.94
		9,261.48	6,935.27			5,647,811	1,908.67			3,555,420	5,420.20		22,954.25	3,980.25	26,934.50
															-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	2,250.00	2,250.00
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	82.32	82.32
0.0	2,304	-	-	0.0	5,104,317	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.7	67	48.94	36.65	0.0	147,951	0	-	0.0	32,798	0	-	0.7	36.65	-	36.65
0.0	0	587.13	439.66	0.0	0	0	-	0.0	0	0	-	1.4	2,630.50	573.97	3,204.47
0.0	347	-	-	0.0	769,346	0	-	0.0	0	0	-	0.0	-	316.34	316.34
		636.07	476.31			0	-			0	-		2,667.15	3,222.63	5,889.78
0.0	0	-	-	0.0	0	0	-	1.4	269,598	366,520	558.76	13.8	5,661.33	965.59	6,626.92
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	0.0	-	-	-
0.0	0	-	-	1.7	2,959,024	5,058,000	1,709.35	0.0	0	0	-	1.7	1,709.35	1,723.63	3,432.98
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	1.8	224.08	-	224.08
0.0	0	-	-	0.0	0	0	-	0.0	0	0	-	8.4	2,719.87	-	2,719.87
0.0	0	-	-	2.1	2,479,662	5,184,414	1,752.07	0.0	0	0	-	4.0	3,388.39	4,092.29	7,480.68
						10,242,414	3,461.42			366,520	558.76		13,703.01	6,781.51	20,484.52
		19,996.91	14,974.29			43,905,872	14,837.96			19,947,176	30,409.27		525,128.93	287,304.92	812,433.85
			-			0	-			0	-		217.53	361.35	578.88
		19,996.91	14,974.29			43,905,872	14,837.96			19,947,176	30,409.27		525,346.46	287,666.27	813,012.73
		1,399.78	1,048.20				1,038.66				2,128.65		36,774.25	20,136.64	56,910.89
		21,396.69	16,022.49			43,905,872	15,876.61			19,947,176	32,537.92		562,120.71	307,802.91	869,923.62
			-												-
			16,022.49				15,876.61				32,537.92		562,120.71	307,802.91	869,923.62

5.4. Forecast budget for year 3

The forecast budget in the following table includes the budget reallocations requested.

Budget year 3

AFS4FOOD

	New Budget as per contract/rider				Expenses declared	Forecast Budget for year 3			
	Unit	# Units (a)	Unit cost (in EUR) (b)	Costs (in EUR) (a)*(b)		Unit	# Units (a)	Unit cost (in EUR) (b)	Costs (in EUR) (a)*(b)
1. Human Resources									
1.1 Salaries (gross salaries including social security charges and other related costs, local staff)									
1.1.1. Technical staff Cameroon	Per month	96	115	11 040	4 063,83	Per month	61	115	6 976,17
1.1.1. Technical staff Kenya	Per month	31	695	21 750	8 893,98	Per month	19	695	12 856,02
1.1.1. Technical staff Madagascar	Per month	43	259	11 254	2 337,37	Per month	34	259	8 916,63
1.1.1. Technical staffs France	Per month	3	4 380	13 140	3 962,40	Per month	2	4 380	9 177,60
1.1.2. Administrative/ support staff Cameroon	Per month	36	200	7 200	2 486,25	Per month	24	200	4 713,75
1.1.2. Administrative/ support staff Kenya	Per month	36	200	7 200	-	Per month	36	200	7 200,00
1.1.2. Administrative/ support staff Madagascar	Per month	36	200	7 200	4 282,10	Per month	15	200	2 917,90
1.1.3. Student training Cameroon	Per month	23	46	1 062	1 128,94	Per month		46	-66,94
1.1.3. Student training Kenya	Per month	43	420	18 020	4 519,06	Per month	32	420	13 500,94
1.1.3. Student training Madagascar	Per month	73	199	14 555	5 454,03	Per month	46	199	9 100,97
1.1.4. Researcher Cameroon	Per month	75	460	34 500	25 201,94	Per month	20	460	9 298,06
1.1.4. Researcher Kenya	Per month	8	4 500	36 000	-	Per month	8	4 500	36 000,00
1.1.4. Researcher Madagascar	Per month	90	296	26 640	12 281,99	Per month	49	296	14 358,01
1.1.4. Researchers France	Per month	33	12 000	396 000	299 884,69	Per month	8	12 000	96 115,31
1.2 Salaries (gross salaries including social security charges and other related costs, expat/int. staff)				0	-				0,00
1.2.1. Administrative/ support staff Cirad France	Per month	6	5 000	30 000	23 640,64	Per month	1	5 000	6 359,36
1.2.2. Student trained in France	Per month	41	420	17 220	9 142,55	Per month	19	420	8 077,45
1.2.3. Researcher Cirad France	Per month	27	6 800	183 600	168 853,06	Per month	2	6 800	14 746,94
1.2.4. Coordinator Cirad France	Per month	5	9 700	48 500	39 725,53	Per month	1	9 700	8 774,47
1.3 Per diems for missions/travel				0	-				0,00
1.3.1. Abroad staff assigned to the Action Cameroon	Per diem	146	132	19 341	14 207,96	Per diem	39	132	5 133,04
1.3.1. Abroad staff assigned to the Action Kenya	Per diem	138	144	19 879	14 740,90	Per diem	36	144	5 138,10
1.3.1. Abroad staff assigned to the Action Madagascar	Per diem	229	97	22 159	3 611,23	Per diem	191	97	18 547,77
1.3.1. Abroad staff assigned to the Actions Ethiopia	Per diem	0	180	0	-	Per diem	0	180	0,00
1.3.2. Local staff assigned to the Action Cameroon	Per diem	1 910	22	42 103	13 069,59	Per diem	1 317	22	29 033,41
1.3.2. Local staff assigned to the Action Kenya	Per diem	461	35	16 170	-	Per diem	461	35	16 170,00
1.3.2. Local staff assigned to the Action Madagascar	Per diem	30	19	560	1 079,54	Per diem		19	-519,54
1.3.3. Seminar/conference participants Cameroon	Per diem	120	20	2 400	1 819,03	Per diem	29	20	580,97
1.3.3. Seminar/conference participants Kenya	Per diem	120	20	2 400	352,64	Per diem	102	20	2 047,36
1.3.3. Seminar/conference participants Madagascar	Per diem	120	20	2 400	-	Per diem	120	20	2 400,00
Subtotal Human Resources				**1 012 293**	**664 739,25**				**347 553,75**
2. Travel									
2.1 International travel									
2.1.1. International travel Cameroon	Per flight	12	1 200	14 748	8 503,33	Per flight	5	1 200	6 244,67
2.1.2. International travel Kenya	Per flight	14	1 200	16 304	11 588,71	Per flight	4	1 200	4 715,29
2.1.3. International travel Madagascar	Per flight	12	1 500	17 548	8 294,09	Per flight	6	1 500	9 253,91
2.1.4. International travel Ethiopia	Per flight	0	1 500	0	-	Per flight	0	1 500	0,00
2.1.5. International Travel across Africa	Per flight	18	1 500	27 000	12 095,28	Per flight	10	1 500	14 904,72
2.2 Local transportation					-				0,00
2.2.1. Local transportation Cameroon	Per month	36	180	6 480	593,73	Per month	33	180	5 886,27
2.2.2. Local transportation Kenya	Per month	54	424	22 850	9 183,16	Per month	32	424	13 666,84
2.2.3. Local transportation Madagascar	Per month	33	709	23 533	6 293,09	Per month	24	709	17 239,91
Subtotal Travel				**128 463**	**56 551,39**				**71 911,61**
3. Equipment and supplies									
3.1. Purchase or rent of vehicles Cameroon	Per vehicle	1	28 000	28 000	28 202,81	Per vehicle	0	28 000	-202,81
3.2. Furniture, computer equipment	per unit	5	988	4 940	3 173,83	per unit	2	988	1 766,17
3.3. Machines, tools	per unit	13	918	11 930	2 256,60	per unit	11	918	9 673,40
3.4. Spare parts/equipment				0	-				0,00
3.5. Other (please specify)	per unit	8	1 300	10 700	4 201,16	per unit	5	1 300	6 498,84
Subtotal Equipment and supplies				**55 570**	**37 834,41**				**17 735,59**
4. Local office									
4.1. Vehicle costs	Per week	272	40	10 880	6 649,52	Per week	106	40	4 230,48
4.2. Office rent	Per month			0	-	Per month			0,00
4.3. Consumables - office supplies	Per month	123	374	46 070	18 858,04	Per month	73	374	27 211,96
4.4. Other services	Per month	180	31	5 580	1 426,94	Per month	134	31	4 153,06
Subtotal Local office				**62 530**	**26 934,50**				**35 595,50**
5. Other costs, services									
5.1. Publications	per unit	27	160	4 320	2 250,00	per unit	13	160	2 070,00
5.2. Studies, research	per unit	78	154	12 075	82,32	per unit	78	154	11 992,68
5.3. Expenditure verification	per unit	12	1 725	20 700	-	per unit	12	1 725	20 700,00
5.4. Evaluation costs	per unit			0	-	per unit			0,00
5.5. Translation, interpreter	per unit				-	per unit			0,00
5.6. Financial services (bank guarantee costs etc.)	per unit	108	50	5 400	36,65	per unit	107	50	5 363,35
5.7. Costs of conferences/seminars	per unit	3	1 820	5 460	3 204,47	per unit	1	1 820	2 255,53
5.8. Visibility actions	per unit	1	260	260	316,34	per unit	0	260	-56,34
Subtotal Other costs, services				**48 215**	**5 889,78**				**42 325,22**
6. Other									
6.1. Material for laboratory trials Cameroon	per unit	46	411	19 110	6 626,92	per unit	30	411	12 483,08
6.1. Material for laboratory trials Kenya	per unit	3	1 000	3 000	-	per unit	3	1 000	3 000,00
6.1. Material for laboratory trials Madagascar	per unit	12	1 000	12 000	3 432,98	per unit	9	1 000	8 567,02
6.2. Quality analysis Cameroon	per unit	70	125	8 700	224,08	per unit	68	125	8 475,92
6.2. Quality analysis Kenya	per unit	304	68	20 500	2 719,87	per unit	263	68	17 780,13
6.2. Quality analysis Madagascar	per unit	33	838	27 500	7 480,68	per unit	24	838	20 019,32
Subtotal Other				**90 810**	**20 484,53**				**70 325,47**
7. Subtotal direct eligible costs of the Action (1-6) (excluding taxes)				**1 397 881**	**812 433,85**				**585 447,15**
8.1. Contingency reserve				1 580	578,88				1 001,12
9. Total direct eligible costs of the Action (7+ 8) (excluding taxes)				**1 399 461**	**813 012,73**				**586 448,27**
A.1. Administrative Costs				97 962	56 910,89				41 051,11
11. Total eligible costs (9+10) (excluding taxes)				**1 497 423**	**869 923,62**				**627 499,38**
12. Taxes11									
13. Total eligible/accepted12 costs of the Action (11+12)				**1 497 423**	**869 923,62**				**627 499,38**
UA FINANCE 50 %				**748 711,50**	**434 961,81**				**313 749,69**