Project no. 510790

FOREAIM

Bridging restoration and multi-functionality in degraded forest landscape of Eastern Africa and Indian Ocean Islands

Instrument: Specific Targeted Research Project

Thematic Priority : Integrating and Strengthening the European Research Area

FINAL REPORT

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Start date of project: 1st of June 2005 **Duration: 4 and half years**

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Project coordinator organisation name: CIRAD

Foreaim Kick-off meeting
Antananarivo Madagascar
November 2005

Foreaim second meeting
Nakuru Kenya
January 2007

FOREAIM

Bridging restoration and multi-functionality in degraded forest landscape of Eastern Africa and Indian Ocean Islands

Foreaim third meeting
Kampala Uganda
April 2008

Foreaim fourth meeting
Nairobi Kenya
November 2009

1. Project execution

1.1 summary descriptions of project objectives and global methodology

Uganda, Kenya and Madagascar are strongly affected by deforestation and degradation of forest ecosystem especially in humid and sub-humid zones. Itinerant agriculture, human pressure and erosion are among the main factors driving degradation. In those countries, to secure rural livelihoods, enhance environmental benefits and enable development, forest restoration and rehabilitation are urgently required. Despite the expanding degradation, little hard information is available on restoration options for tropical humid and sub-humid regions. Thus, at national and regional scales, strategies for rehabilitation to achieve sustainable management of forest are extremely limited.

The general objectives of FOREAIM were 3 fold: with a broad based multidisciplinary approach instead of the mono disciplinary methods which currently predominate local forest restoration research, we 1) advanced scientific understanding of the restoration processes and through this we shall 2) produced knowledge, practical tools, models and management guidelines for restoration implementation and 3) with full involvement of all stakeholders, we synthesized information on economic, societal, policy and marketing issues to enhance employment opportunities and incomes, thus improving livelihoods for all sectors of the community.

In developing sustainable regeneration techniques for these natural ecosystems, we utilized ecologically and economically important species of international and export interest which are thus capable of enhancing development opportunities. Through top down and bottom up approaches with all stakeholders (dwellers, local farmers, producers, policy and decision makers) we also improved methods of knowledge and technology transfer, as well as uptake of practical forest restoration.

Scientific and technical objectives of the project:

Specifically, the goals of the FOREAIM project were :

1) **To assess stakeholders forest and tree management practices and uses**, and investigate the socio-economic and potential ecological roles of designed tree-based technologies which integrate stakeholder requirements with the object of guaranteeing their viability and thus improving sustainable rural livelihoods at landscape scale.

2) **To define bioindicators of natural forest degradation and forest rehabilitation** using chronosequences on naturally or artificially rehabilitated sites or at sites subject to varying degrees of disturbance through study of successional vegetation dynamics

3) **To promote and enable planting of native species** to restore the ecological and economical functioning of degraded forest by developing knowledge on phenology, germination and propagation. For target species, information on quality attributes, especially for “non wood forest products” and on gene flow, will be important components of studies.

4) **To produce accurate indicators of soil fertility and soil functioning in relation to the state of forest degradation/restoration**, by identifying the major soil factors limiting forest restoration and assessing the usefulness of major components of the soil biota for predicting status and changes, both positive and negative in soil functioning,

5) **To define best practise for limiting soil erosion** and encouraging ecosystem restoration in degraded tropical sub-humid ecosystems by quantifying runoff and erosion losses from, and rainfall infiltration into, differing degraded and rehabilitated systems and quantifying erosion driven losses of soil, organic matter and plant nutrients in those landscapes.

6) **To provide information on the use of economically important native species** by studying the chains of custody and markets, at local and international levels and simulating various strategies of potential uses in restoration processes.

7) **To promote methods to facilitate the transfer and effective uptake by forest restoration stakeholders** of negotiation and decision-help tools based on operational integration of scientific biological and socio-economic data.

8) **To synthesize, consolidate, share and disseminate information** on innovative restoration technologies for sustainable management of natural forests, agro-ecosystems and allied natural resources so as to catalyse restoration uptake.

Based on 7 work packages, the FOREAIM project used an integrated multidisciplinary approach involving methods in restoration ecology, biophysical techniques and social and economic approaches.

The workplan was elaborated so that each work package achieves one of the specific objectives of the project listed above. A schedule of the components of the work packages and a graphical presentation showing their interdependency are given below.

Two Work packages (1 and 6) concerned sociological and economics research, two other WPs (2 and 3) considered biological studies related to vegetation and dynamics, WPs 4 and 5 address biophysical topics such as soil and erosion and biological indicators,. WP7 integrated all results to produce tools to transfer restoration and rehabilitation technologies and practices to stakeholders, i.e, local populations, economic stakeholders, extension services and governments, both local and national.

According to the conclusions of the most recent conferences and workshops on forest landscape restoration, a single watershed, or several connected watersheds, is the most relevant landscapes in which to undertake trials in restoration. The strategy of the project consisted of implementing research activities at one main study site in each developing country (Madagascar, Kenya and Uganda). Potential sites, representative of the forest restoration issues have already been identified. (see Table below for site descriptions). The concentration of the vast majority of the field work on single sites in each country (size of a watershed or several small watersheds) facilitates the ready implementation of the different WPs, copes with their multidisciplinarity and WP to WP interconnections and dependencies. The single site approach also facilitated testing and monitoring of the effectiveness of transfer and uptake of the results by end users, because the sites are located in areas around which local populations are already operating.

Researchers in WP1 studied agro-ecological knowledge, tree management practices and the economic dependency of local populations on forests and tree based systems in the context of degradation.

Researchers in WP 2 assessed the effects of degradation of forest ecosystems on vegetation structure and composition and examine on-going rehabilitation situations (old natural and planted fallows, existing plantations and secondary forests) and their impacts on vegetation structure and composition.

In WP 3, the project addressed restoration through planting. Evaluation of native and naturalized species growing in old and more recent plantations that have been established in the same eco-climatic zone as the main study site (mean annual rainfall higher than 1200 mm) will take place. For species with good economical potential (defined in relation to WPs 1 and 6), specific studies on wood and non wood forest products were conducted. Population

dynamics of the most economical important species was undertaken through gene flow in concert with task 2.3 of WP2.

In WP 4, using the same plots as WP2, we studied the impacts of degradation and in parallel, the impacts of restoration and rehabilitation on soil chemical and physical characteristics as well as on soil functioning.

In WP5 the effects of differing vegetative covers, enrichment planting, agroforestry and other remedial treatments on runoff and losses of soil, plant nutrients and organic matter from degraded agricultural, agroforestry, fallow and forested landscapes were quantified.. Activities took place on the same sites as are used in WPs 2,3 and 4 and were thus integrated with the project as a whole.

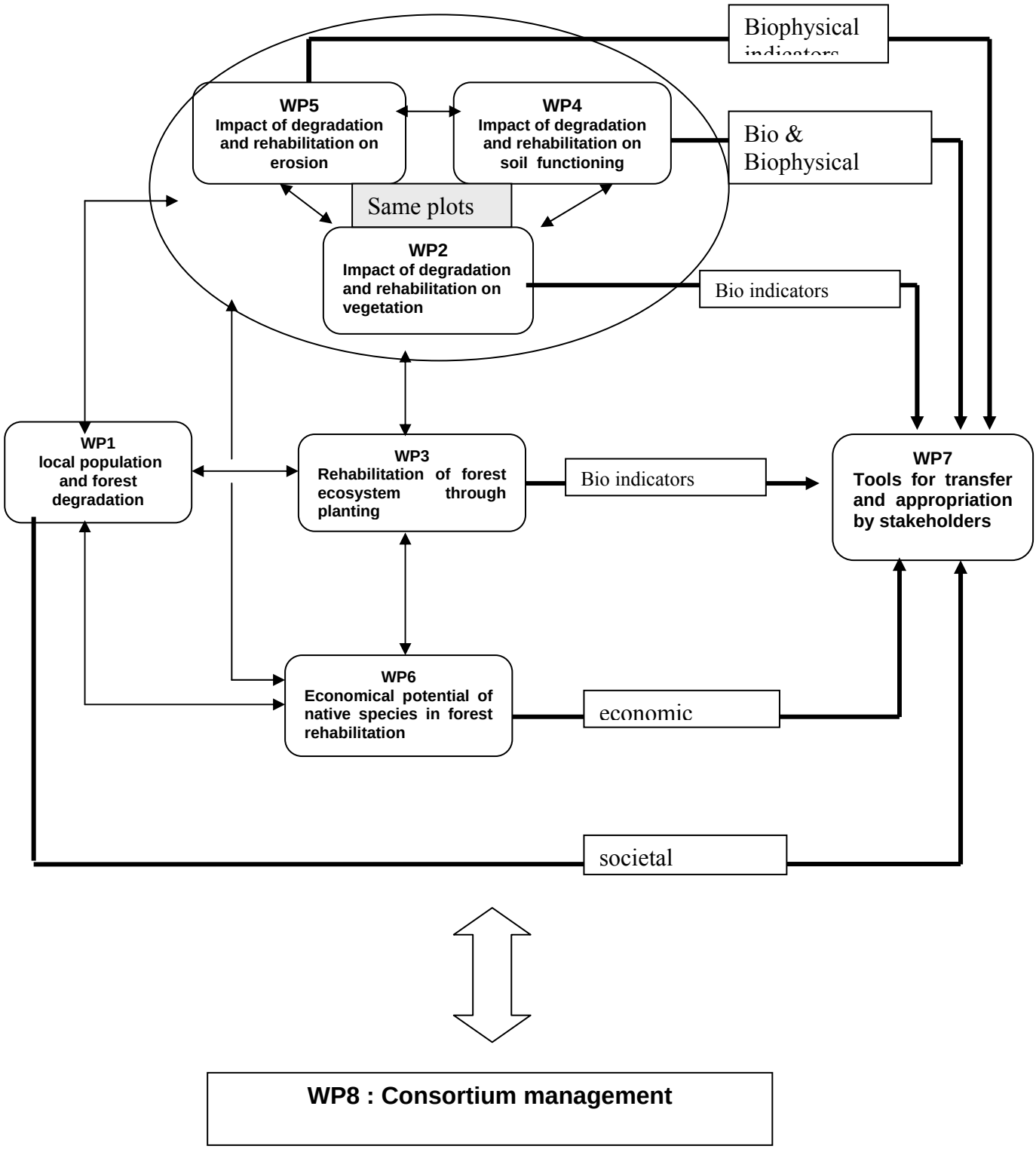
Work packages 2, 4 and 5 were closely related because their joint objectives were to quantify the degree of disturbance of the degraded forest ecosystem and to evaluate the impact of restoration and rehabilitation on ecosystem development and dynamics. The conceptual approach used in these WPs 2, 4 and 5 were that of restoration based on Vital Ecosystem Attributes. Within the 3 WPs, ecological, soil functioning and erosion studies used the same plot design. In this way these three WPs were closely integrated with WP1 which provided information concerning the main sites, historical records of vegetation degradation and of ongoing natural restoration and rehabilitation. Overall, this integration enabled establishment of a powerful and robust experimental design.

Work package 6 sought to make available to stakeholders, relevant information related to the economic revenues that can be generated by selling products from restored forests into local, national and international markets. WP6 was related to WPs 1 and 3 by cross referencing results from ecological and silvicultural studies with results of socio-economic studies to enable definition of a range of species with economic benefits that were relevant to, and offer realistic solutions to problems facing local populations.

The objective of WP7 was to ensure technology transfer and effective uptake of techniques by forest restoration stakeholders. Researchers, utilizing results from WPs 1 and 6 as well as complementary studies, first undertook elaboration of decision making processes among stakeholders by studying formal and informal relations and links between them at differing levels of scale. They then merged biophysical and socio-economic data from the two WPs to define functional and operational links and relations between outputs from the two disciplines.

The specific dissemination materials and their routes were briefly:- guidelines and recommendations to policy makers, restoration handbooks, technical papers and decision making software for extension services, guides written in local languages for local stakeholders, oral presentations and scientific papers for the research community, interactive discussions with marketing companies and SMEs.

Graphical representation of the FOREAIM project's components



1.2 - Contractors involved

The consortium consisted of eight partners, four from European countries :

- Partner 1 : CIRAD (International Cooperation Centre in Agronomic Research for Development) France. CIRAD is a French scientific organisation specialising in development-oriented research. The centre employs 1800 persons, including 900 senior engineers and researchers, who regularly work in more than 50 countries.

- Partner 2 ; IRD (Institute of Research in Development) France. IRD is a French public science and technology research institute. It conducts scientific programs contributing to the sustainable development of the countries of the South with an emphasis on the relationships between man and environment. The Institute employs 2187 persons, including 831 researchers. About 40% of permanent staff are posted overseas, mainly in Africa, the DOM-TOMs and Latin American research institutes. IRD is established in 23 tropical countries where it develops joint project with local Institutes.

- Partner 3 : CEH (Centre for Ecology and Hydrology) United Kingdom, CEH Edinburgh, annually manages research programs valued at about ,2.5 million and has been involved in Tropical forestry research for about 25 years. CEH has considerable experience of land and forest degradation/restoration following clear and selective felling in tropical rainforests in Africa and S.E. Asia. Techniques varied from enrichment planting to re-afforestation.

- Partner 4 : INA-UMB (Norvegian University of Life Science) Norway. INA-UMB Department of ecology and natural resource management of the Norwegian University of Life sciences INA-UMB has about 50 full-time researchers working in ecology, forestry, and applied and basic biological sciences. Many researchers have a focus on resource management in natural and agro-forestry ecosystems.

And four partners from East African countries and the Indian Ocean :

- Partner 5 : KEFRI (Kenya Forestry Research Institute) Kenya, KEFRI's mandate is to conduct research in forestry, co-operate with other research bodies within and outside Kenya carrying out similar research, liase with other organisations and institutions of higher learning in training and on matters of forestry research, and disseminate research findings. Its mission is to enhance the social and economic welfare of Kenyans through user-oriented research for sustainable development of forests and allied natural resources.

- Partner 6 : University of Antananarivo Madagascar, University of Antananarivo has existed for more than 40 years. The University presents two departments which will house the FOREAIM project. The department of plant Biology and Ecology (D BEV) at the Science Faculty, and the high school of Agricultural science. The department of plant Biology and Ecology teaches and trains undergraduate and graduate students in Botany and also undertakes multidisciplinary research in plant systematics, ethno botany, physiology, ecology, agroforestry, *Rhizobium* biotechnology and in-vitro plant micro propagation and genetic improvement. The team of the Water and Forestry Department of ESSA is composed of 14 researchers engaged in environmental concerns, and is acknowledged for its expertises: agroforestry linked with soil and vegetation; sustainable renewable resources management (by considering the three

essential aspects: ecological, social, and economical); silviculture (in natural and artificial forest); inventories using conventional and modern technologies (field work, remote sensing, geographical information systems); environmental impact studies; politics of forestry including commercial aspects. Most researches are conducted in a systematic and integrated manner.

- Partner 7: FOFIFA (Centre for Agronomic Research for Rural Development) Madagascar. FOFIFA is the main institution of Agriculture research of the National System of Agriculture Research in Madagascar. It includes six scientific departments. Its domains of competence are mainly farm production and fish breeding, forestry and forest resources management, the technology of preservation and after-harvest transformation, socio-economics and agro-economy.

- Partner 8: Makerere University Uganda. Makerere University is Uganda's major institution of higher learning and is one of the largest in East and Central Africa. It has twenty faculties/institutes/schools that offer study programmes to 22,000 undergraduate and 3,000 postgraduate students. The Faculty of Forestry and Nature Conservation (FFNC) housed the Foreaim project in the department of Forest Biology and Ecosystems Management (FBEM).

1.3 - Work performed and end results, elaborating on the degree to which the objectives were reached for each workpackage

Assessment of Scientific and technical objectives of the project:

1) **To assess stakeholder forest and tree management practices and uses**, and investigate the socio-economic and potential ecological roles of designed tree-based technologies which integrate stakeholder requirements with the object of guaranteeing their viability and thus improving sustainable rural livelihoods at landscape scale.

During the project the WP1 has analyzed the behavior of many actors with respect to the restoration and forest degradation in the three countries. Research teams have invested heavily in the three countries to meet people and try to understand their vision of degradation and restoration through investigations. Important efforts in training have been done through training sessions organized in some countries such as Madagascar and the supervision of students (master).
However the implementation of the WP1 logic could be implemented only partially. Indeed it was expected that the knowledge acquired in WP1 (during the first year) is used by the remaining WP, such as the establishment of experimental field or the choice of target tree species.
This logic could not be followed due to the delay in starting the project and as a result in starting the WP1.

2) **To define bioindicators of natural forest degradation and forest rehabilitation** using chronosequences on naturally or artificially rehabilitated sites or at sites subject to varying degrees of disturbance through study of successional vegetation dynamics

An important experimental field design was set up in the three countries to achieve the objectives of WP2. Despite the difficulties to implement this type of trial in the wild, the teams were able to find solutions for a correct experimental system.
Studies have quantified plant biodiversity in areas targeted by the project and established relationship between biodiversity and degradation or restoration state.
The results were fully analyzed in Kenya and Madagascar, but could be provided only partially by the end of the project for Uganda.
These results significantly contribute to current knowledge about Potential restoration species in the different zones.
Publications have been done in Madagascar and Kenya but meta analysis data could not be done due to the delay in providing information in some countries.
A significant training activity was conducted in this WP2, with master students involved in the research. A phD student belonging to the partner KEFRI (Kenya) did his PhD in the frame of this project supervised by the team of Norway.
Globally most of the tasks of this WP were covered during the project and this WP was very well leaded by INA-UMB Norway.

3) **To promote and enable planting of native species** to restore the ecological and economical functioning of degraded forest by developing knowledge on phenology, germination and propagation. For target species, information on quality attributes, especially for “non wood forest products” and on gene flow, will be important components of studies.
This WP has produced very rich and diversified results in the project. The WP3 used older sylvicultural trials to improve the knowledge on the performance of some native species on adaptation, growth or production of non wood forest product in the frame of restoration. New species have been detected through enquiries with local populations especially in Madagascar. The basic research to grow them during the juvenile stage and to understand their phenology was implemented during the project. For some new species especially in Madagascar, some researchs have been conducted to define vegetative propagation techniques. The economic role of these native species in the context of degradation and restoration has been addressed through the study of some species growing in fallows and used by local populations: case of species producing essential oil in Madagascar. The WP3 has also addressed the issue of the impact of forest fragmentation on gene flow and genetic diversity with some very emblematic species in Kenya and Madagascar.
Globally most the tasks of this WP3 have been addressed and numerous publication were produced. This WP was also very active in training student (master) and some scientists were involved in supervision of PhD student (Madagascar).
One ca regret the lack of studies bases on species common to the three countries. Only one study on the genetic diversity of *Albizzia gummifera* was undertaken involving the partners of Keny, Uganda and Madagascar.

4) **To produce accurate indicators of soil fertility and soil functioning in relation to the state of forest degradation/restoration**, by identifying the major soil factors limiting forest restoration and assessing the usefulness of major components of the soil biota for predicting status and changes, both positive and negative in soil functioning,

The WP4 addressed all the main tasks that were originally planned in the project: assessment of the change in soil characteristics according to stand degradation status, assessment of soil bio-indicator **(**Microbial biomass and activities)were done , as well as the nematode communities. The local adaptation and soil symbioses were also assessed for some specific sites in Kedowa in Kenya.
Globally a good characterisation of the different sites soil conditions, in connection with the experimental design established in the WP2 is to be noticed in this WP. It would have been very interesting, in the frame of the project, to link the soil characteristics to the vegetation composition and dynamics analysed in the WP2. This connection was difficult due to the delay in collecting and sending samples to the laboratory. A good dynamic of publication is to be mentioned in this WP4. In addition, training session, to assess bio-indicators and symbiosis activity, were organized during the project for scientists involved in Foreaim.

5) **To define best practise for limiting soil erosion** and encouraging ecosystem restoration in degraded tropical sub-humid ecosystems by quantifying runoff and erosion losses from, and rainfall infiltration into, differing degraded and rehabilitated systems and quantifying erosion driven losses of soil, organic matter and plant nutrients in those landscapes.
The project was based on one experimental site in each country. One of the objectives of this WP dedicated to erosion was to characterise erosion in each site and to assess the impact of forest degradation on soil erosion. These activities were properly conducted in Uganda during throughout the project. The experiment was running very well in Kenya during the first two years but the political troubles led to give up the experimental process because the experimental devices was damaged. In Madagascar, unfortunately, the experiment was established a little bit late in the project due to cash flow issues and the result were obtained only during the last two years, on a very short period.
The WP5 has brought new examples of relationship between soil erosion and soil cover. In conclusion in Uganda site, runoff, soil and nutrient losses were highest in the first 3 years after disturbance, when ground cover was least, however, in all the blocks, they were low compared to agricultural land elsewhere.
A significant number of publications were in prep at the end of the project taking into account the small number of scientist involved in this WP but few student were trained. The results provided by this WP should have been taken into account by WP2 (sub-objectve 2), but the difficulties to conducted WP2 and WP4 at the same time prevent from combining these data to analyse results.
This WP has shown that the pipe sampler is a low tech state of the art method and was used successfully.

6) **To provide information on the use of economically important native species** by studying the chains of custody and markets, at local and international levels and simulating various strategies of potential uses in restoration processes.

At the beginning of the project each country was able to identify a set of economically important species. The idea of the project was to improve the knowledge with these species

In Uganda important work was done to better understand the economically issue related to the species that are harvested in the Mabira forest for wood but also for non wood forest products.

For example, the project has recommended some species for Clean Development Mechanism in case it relaxes the regulations and for voluntary markets as well

In Madagascar important studies have been made on the charcoal production from eucalyptus plantations that are more and more used to replace the degraded natural forest on the Eastern part of Madagascar. The project showed that the eucalyptus plantation can be a good alternative to restore forest ecosystem in markedly degraded zone and at the same time a very good species to generate incomes through charcoal. A very interesting study showed how illegal logging impacted the natural forest.

Unfortunately it was not possible to investigate the economical potential of new species detected by the project.

7) **To promote methods to facilitate the transfer and effective uptake by forest restoration stakeholders** of negotiation and decision-help tools based on operational integration of scientific biological and socio-economic data.

The WP corresponding to this objective was very ambitious because it aimed at synthesizing the information provided by the project and at defining the tools and process to improve uptake by different stakeholders. However due to the movement of scientists involved in the WP it very was difficult to implement all the tasks that were initially planned. Finally this WP concentrated its research activity on the modelling. One of the most significant results was the implementation of a socio-ecological model for assessing sustainability of community-based regulations in the frame of the Malagasy context. Although this WP reached partially the objectives decided at the origin of the project, the research on modelling demonstrated how the global information delivered by a complex project can be used to provide decision tools to policy makers and others stakeholders.

8) **To synthesize, consolidate, share and disseminate information** on innovative restoration technologies for sustainable management of natural forests, agro-ecosystems and allied natural resources so as to catalyze restoration uptake.

Important efforts have been made in this project to communicate the results to the different stakeholders. A website was implemented at the beginning of the project and frequent visits were noticed throughout the project.

Scientists were involved with different media, press, TV, especially in Uganda where people were very active, to present the project.

One of the most significant operations to reach this objective was the elaboration of the Foreaim Forest Restoration Handbook at the end of the project in each of the country. The objective of this book has been to synthesize the new knowledge provided by the project to be used by decision policy makers and others stakeholders such as forest en environmental services to guide their policy in forest management.

1.3.1 – WP1 - Traditional ecological knowledge, tree management practices, uses and economic dependency of local population on forests and tree based systems in the context of their degradation

1.3.1.1 – WP1 -Work performed during the project, main end results

The general objective of the WP1 was to assess stakeholder forest and tree management practices, uses and system relationship in the context of their degradation and investigate the socio-economic and ecological potential roles of designed rehabilitation technologies to guarantee their viability and effectively improve rural livelihoods within a landscape framework.

The specific objectives of the WP1 were :
1. To characterize the determining factors of the forest and allied tree-based system degradation and related management practices within the existing legislation, policy framework and market driven forces;
2. To assess stakeholders agro-ecological knowledge on the forests and tree based systems they depend on and the tree management practices, notably through the dedicated roles of existing social groups and use patterns of natural resources, as well as their perceptions, needs, constraints and strategies in this regard, as a basis for designing viable rehabilitation technologies using native species of economic and ecological importance;
3. To evaluate the expected benefits of the proposed technologies and identify the conditions of participation and empowerment (training, incentives, capacity building) of the local populations and guideline adaptive management processes allowing bridging and monitoring of restoration of degraded forests and tree based systems with sustainable production systems at landscape level.

The main conclusions of the WP1 are given through some of the most significant results :

- Technologies and conditions for participation and empowerment of rural people in restoring degraded sites: a case of Mabira Forest Reserve, Central Uganda

The research aim was to assess benefits of locally proposed technologies, conditions for participation and empowerment of the forest communities in restoration of degraded forest sites. The objectives were to i) identify technologies that can be locally accepted and promote restoration of degraded forest sites and ii) determine the conditions for local people's participation in restoration practices of degraded sites.
The study was conducted in MCFR between 2007 and 2008. Data were collected using 156 individual semi-structured interviews and 12 focus group discussions.
Results show that eight technologies are possible. The most recommended ones include; promoting on farm tree planting, large scale nursery establishment, and enrichment planting in the forest, mycorhizal inoculation of soils for tree planting, soil erosion and invasive species control. The major conditions for local participation include more access rights, strengthening institutional capacity for collaborative forest management (CFM), awareness creation and capacity building among the local people, continuous monitoring of new technologies and collaboration between research and management institutions.

- Traditional Ecological Knowledge on Tree Management and Forest Restoration.

Mabira Forest Reserve, Central Uganda.
The research aims to establish traditional ecological forest restoration and management practices in order to design appropriate forest restoration measures. The objectives were to (i) assess levels of local economic and subsistence dependence on the forest and (ii) investigate traditional ecological knowledge on forest/tree management and restoration practices.
This study was conducted in Mabira Forest Reserve, from 2007 to 2008. Data were collected trhough 83 household interviews, and 73 key informants, focus group discussions and participatory field visits. Fifty percent of the respondents were highly dependent ($\geq$ 75% dependence) on the forest for subsistence products such as firewood, water, medicine, poles, craft materials while 31% of the respondents were highly dependent ($\geq$ 75% dependence) on the forest for economic needs. Local subsistence forest dependence was associated with age, ethnicity, access to forest and presence of products in the forest. Local economic forest dependence was associated with time to get to the forest, access to forest and presence of products in the forest. Fifty seven percent of the respondents planted/retained trees on-farm,

women being more involved than men. The target age group of people involved in restoration was 35-50 years. On-farm tree management practices comprised thinning, controlling parasitic plants, pruning, selective killing of undesired trees, weeding, pollarding and slashing. Subsistence dependence is of more importance to the local people than economic dependence. Traditional ecological knowledge is indirectly used to foster forest restoration through on farm tree planting/retaining and management practices.

- Policies, forests and allied tree-based system degradation:

A case of Mabira Forest Reserve, Central Uganda

The research aim was to assess the factors determining forests and allied tree-based system degradation and management practices. The objective was to characterise determinants of forests and allied tree based system degradation, and management practices within the existing legislation, policy frame work and market driven forces.

The study focussed on MCFR located in central Uganda. The history of MCFR and existing natural resource policies and legal frame works in Uganda were reviewed. Local markets, where forestry/tree based products are traded, and degraded forest sites were visited.

The results show the Presidential Decree of 1975 gave government power over ownership of all categories of land tenure in Uganda and this was a key factor to the current status of MCFR. Being centrally located and endowed with fertile soils, MCFR experienced degradation, because of immigrations in and around the reserve to cultivate in the forest. Since then, the forest has under gone several vegetation changes either due to delays in review or inadequate policy guidelines. The factors that led to degradation of forest and allied tree based resources include the fact that the forest provides the main source of income to livelihoods in and around the reserve, and the persistent escalation of conflicts between neibouring villages and management.

- Forest and on farm tree use by farmers and implications for forest restoration, Mau forest, Kenya

This study assessed stakeholders' forest and tree management uses with the aim of supporting peoples, ability to restore forests and manage trees outside forests.

Between 2005 and 2009, a research was conducted in 17 villages bordering Mau forest, Kenya. Socioeconomic data were collected using structured and semi-structured questionnaires.

Results showed that the farmers' main source of tree products is public forests (52%) and from own farms (40%). Harvested products included firewood, timber, poles, herbal medicine, thatching grass, honey, charcoal and graze their animals in the forest. Farmers in the eastern part are more dependent on the forest for cash income and there is a growing commercialization of some wood products like charcoal and firewood. The extent of forest use differs depending on the type of use (subsistence, commercial or a combination of both) and on availability of alternative income opportunities.

Charcoal making was identified as the main destructive use of the forest because the indigenous species used take long to mature and that alternative tree species on farms are limited or not available at all. The use of the forest for grazing is intensive and the presence of animals is a constraint in forest rehabilitation.

The promotion of agroforestry and multiple purpose trees is a priority to most households. The only way to cultivate a positive working relationship with the local people is to allow controlled grazing or harvest of fodder in areas where tree planting is taking place. Because

most households have small land holdings, it is desirable that trees incorporated into farming system should be compatible with current land use.

- Farmers' forest perceptions and tree management practices: the case of the Betsimisaraka on the eastern coast of Madagascar

The research aims to understand farmers' social perceptions of forests and trees and understand their tree management practices with the aim of forest restoration.
From 2006 to 2008, semi-structured, individual (1061) and group (12) interviews were conducted among farmers to understand the relationships that farmers establish between their social perceptions and their tree resources management. Ecological surveys also were undertaken to evaluate the overall status of forest species and trees cited by farmers.
The work demonstrates that the expression, "degradation of natural resources" only makes sense in relation to the functions attributed to the given resources. While farmers' social perceptions of trees are homogeneous among the Betsimisaraka, their perceptions of the forest are diverse. Furthermore, farmers choose species, both for their tree plantations and their annual crops, according to the fields' fallow period and the proximity to the forest.
Nine management systems exist, each representing an agroforestry model for individual and local development that innovatively links production and soil preservation objectives, and implicitly conservation goals.

1.3.1.2 – WP1 methodologies and approaches employed

They were based on the three following tasks
Task 1.1 : State of art on forest and allied tree-based system degradation, related management practices and livelihoods with reference to restoration
Task 1.2 : Diagnosis of local agro-ecological knowledge, stakeholders perceptions and dependency on forest and tree resources
Task 1.3 : Assessing the socio-economic benefits of the proposed technologies and identifying favourable conditions for empowerment of local communities in restoration actions and related capacity building processes.
To implement these tasks the proposed work will be successively carried out, from a field diagnosis starting point to the delivery of socio-economically viable restoration techniques and guidelines, through participative assessments with target stakeholders and the promotion of favourable conditions for sustainable management of forest and tree resources in the dedicated study sites.

1.3.1.3 – WP1 Achievements of the project to the state-of-the-art.

The WP1 brings new knowledge in understanding the behaviour of population involved in forest degradation and restoration. The project offers several case which should strengthen the body of knowledge in social sciences

1.3.1.4 – WP1 impact of the project on its industry or research sector.

The WP1 in Foreaim has provided results that increased awareness of interdisciplinary approaches and information on forest and tree based degradation and restoration, promoted local ecological knowledge, enhanced local community capacity in participative actions for restoration of forest and allied resources

The WP1 has participated to the dissemination of operational results and innovative methodologies at stakeholder level.

1.3.2 – WP2 - Assessment of forest ecosystem degradation, and community structure and species biology for the development of restoration options

1.3.2.1 – WP2 -Work performed during the project and main end results

The general objective for WP2 was to characterize the vegetation of degraded and restored sites and define methods for rehabilitation of forests. This objective was reached for all the countries by fulfilling the specific objectives as follows: 1) The degree of disturbance or degradation of natural forest by human activities have been measured in both Mau (Kenya), Vohimana (Madagascar), and Mabira (Uganda), as well as the the successional dynamics of these sites subjected to abandonment (fallows) or other uses (plantations) have been measured and analysed. 2) Data on the population structure of selected species of economic value and ecological importance along with community structure have been collected and analysed on each of the study sites. 3) The development of response variables and indicators of selected techniques of rehabilitation have been done by analysing the relationship between selected species and the performance of other species, planting of selected species, and measurements and analyses of the performance of selected species of ecological and economical value. 4) Common methods are developed to detect potential species suitable for active restoration across sites and, site specific methods for restoration have been developed. In Kenya and Madagascar, specific species are also suggested as particularly suitable for restoration, and in Madagscar some of these species are tested by planting into the fallows.

Mau forest, Kenya

Species richness, abundance and composition of tree seedlings, saplings, mature trees, shrubs and herbs were recorded in zones of different degree of disturbance, from a heavily degraded zone in the centre of a previous settlement in Itarre, through less disturbed transition zones, and in the surrounding secondary forest. In addition, we investigated if other environmental variables, such as season, grazing and human disturbances explained the species composition in the degraded forest area. Species richness and abundance of tree seedlings, saplings, mature trees, ferns and climbers increased gradually from the heavily degraded zone to the secondary forest, whereas shrub and herb richness and abundance and total species richness was highest in the transition zones. A group of tree species were not particularly associated with any of the four zones, suggesting that these species might be good candidates as restoration species of degraded forest areas. The results from Itarre contribute to the knowledge on natural regeneration of degraded forest areas in general, and on individual species characterizing the different stages of recovery of abandoned forest settlements in particular. Such information is urgently needed in designing ecologically sound management strategies for restoring abandoned forest settlements in tropical areas.

The indigenous tree species *Albizia gummifera* and *Neoboutonia macrocalyx* were present in all life stages in both the disturbed transition zones and in the secondary forest. We suggest them as potential species for restoration because they have the ability to establish as seedlings and survive as saplings and adults in both disturbed areas and in the secondary forest. We examined the relationship between these two species and the abundance and richness of the rest of the plant community to examine if they may have positive effects on other species.

Albizia was positively related with other tree seedlings and saplings in both the transition zones and in the secondary forest. *Neoboutonia* had a positive relationship with tree saplings in the transition zones and in the secondary forest. These results show that the two species have positive influence on the performance of other tree species, and that both have high potential as species for active restoration. The two species can enhance recruitment and growth of other tree species on abandoned farmlands and degraded forest sites in the mountain forest systems. These results contribute significantly to current knowledge about potential restoration species, and we suggest experimental studies to identify how these tree species interact with other plant species across ecosystems and disturbance types.

Vohimana forest, Madagascar

Slash-and-burn agriculture is an important driver of deforestation and ecosystem degradation, with large effects on biodiversity and carbon sequestration. Vohimana forest consists of fragments of slash-and-burn patches, intermingled in between secondary and primary forest.

By recording species richness, abundance, and composition of trees, shrubs, and herbs in fallows of various age and slash-and-burn history, and in the secondary and primary forest, we have shown how slash-and-burn intensity (number of cycles, duration of abandonment), years since last abandonment, and environmental factors (distance to primary forest and topography) affect the natural succession and recovery of the forest ecosystem (Table 1).

Our results showed shrub dominance, of particularly *Psiadia altissima* and *Lantana camarra*, the first years after abandonment. Thereafter, a subsequent increase in species richness and abundance of tree seedlings and saplings suggests a succession towards the diversity and composition of the secondary and primary forest, although a big gap between the oldest fallows and the secondary forest shows that this will take much more than 30 years (Fig. 1).

We used ordination analyses to examine how the species composition varied between the different successions stages, and to examine tree recruitment. Six species were abundant as seedlings and saplings independent of fallow age and level of disturbance, suggesting that these may be suitable in an active restoration programme for Vohimana forest. Based on their early colonization of the fallows and their survival through vegetation succession, we recommend further testing of the following tree species for restoration purposes: *Albizia chinensis, Croton mongue, Ficus baronii, Harungana madagascarensis*, *Tambourissa lastelliana, Trema orientalis.*

A high number and frequency of slash-and-burn cycles decreased tree seedling and sapling richness and abundance, suggesting that reducing slash-and-burn intensity will increase the speed of tree recruitment and fallow recovery. Trees can be planted into fallows to speed up vegetation and soil recovery, such that fallows can be usable within needed time and thus the extension of cultivated areas reduced.

Dynamics of forest succession after degradation in the Vohimana forest

Two scenarios are suggested for forest succession after fire and/or slash-and burn activities (see the figure below):

1st case: Depending on the number of reclaim undergo by the formation, the forest turns progressively into more and more damaged fallow where the pioneer species disappear little by little. The herbaceous species become more and more dominant. Several stages of such a succession have been observed in the region. The ultimate stage is the fallow with *Neyraudia madagascariensis* , *Scalaria abortiva* and *Paspalum* sp. However, from the fallow to *Psiadia*

altissima, associated with *Clidemia hirta* and *Lantana camara*, the forest can reconstitute itself after a prolonged rest.

2nd case: Fire transforms the secondary formation in fallow presenting pioneer species and herbaceous species. This formation turns into fallow to *Ravenala madagascariensis* where the herbaceous species dominate if it underwent an important number of reclaims. The presence of *Sticherus flagellaris*, invading species in the formation prevents all development of the woody species.

If the disruption stops, and if the fallow is abandoned during prolonged periods, the forest can reconstitute itself provided that the fallows have pioneer species and forest soil. So, in Vohimana, restoration is possible from fallows dominated by *Psiadia altissima*, *Clidemia hirta* and *Lantana camara,* although it is likely more efficient from stages with *Harungana madagascariensis, Psiadia altissima, Psidium cattleyanum,* and *Clidemai hirta* (Fig. 2)

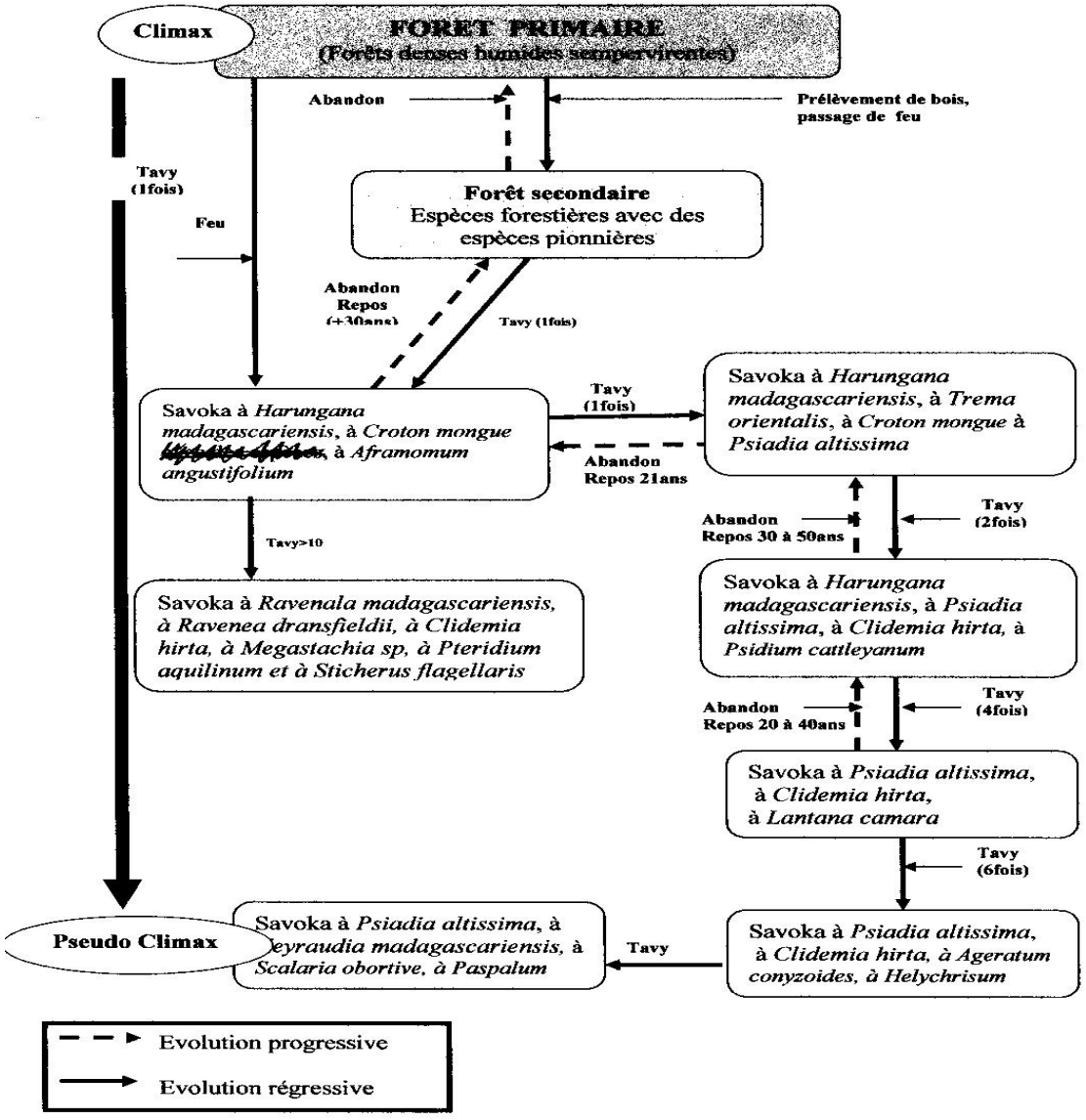


Fig. 2 . **Schéma hypothétique de la dynamique des formations végétales de VOHIMANA**

Table 1 Generalized Linear Model multiple regressions with a log link function of the relationships between fallow parameters (predictors) and the species richness and abundances of tree seedlings, saplings, adults, shrubs, herbs, and all species recorded in the fallows in Vohimana forest, Madagascar.

Predictors	Tree seedlings		Tree saplings		Tree adults		Shrubs		Herbs		All species	
	Est.	*P*	Est.	*P*	Est.	*P*	Est.	*P*	Est.	*P*	Est.	*P*
Species richness												
Distance to forest	-0.00	0.145	-0.00	0.916	0.00	0.185	**-0.00**	**0.035**	-0.00	0.446	-0.00	0.969
Years since abandonment	0.00	0.846	**0.04**	**0.013**	**0.10**	**< 0.001**	**0.02**	**0.015**	-0.02	0.213	**0.02**	**0.010**
Slash and burn cycles (n)	**-0.10**	**0.007**	**-0.06**	**0.047**	- 0.04	0.445	-0.02	0.228	-0.01	0.213	-0.02	0.203
Fallow duration	0.00	0.925	-0.07	0.063	-0.19	0.098	0.01	0.548	0.02	0.285	-0.00	0.810
Slope	0.00	0.943	0.00	0.748	-0.01	0.361	-0.01	0.229	-0.00	0.836	0.00	0.818
Species abundances												
Distance to forest	-0.00	0.288	-0.00	0.230	0.00	0.752	**-0.00**	**0.019**	0.00	0.270		
Years since abandonment	-0.12	0.130	**0.06**	**0.038**	**0.13**	**< 0.001**	**-0.93**	**0.046**	-0.01	0.465		
Slash and burn cycles (n)	**-0.39**	**0.010**	-0.04	0.389	**0.06**	**0.040**	**-1.35**	**0.036**	**0.02**	**0.051**		
Fallow duration	-0.06	0.524	-0.03	0.628	-0.20	0.152	**3.04**	**< 0.001**	0.00	0.773		
Slope	-0.03	0.055	0.01	0.662	0.00	0.844	**0.53**	**0.001**	**-0.01**	**0.018**		

Predictor variables, parameter estimates (Est.) and *P*-values are shown for each modell, significant values ($P < 0.05$) are in bold. Goodness of fit (statistics /d.f.) ≈ 1 in all cases.

1.3.2.2 – WP2 methodologies and approaches employed (used the project to describe this paragraph)

To assess the effects of degradation of forest ecosystems on vegetation structure and composition and examine on-going natural rehabilitation, synchronic approaches have been used. At each study site, a network of plots was established comprising different stages of degradation and vegetation recovery, and in the secondary and primary forest. Vegetation analyses recording the abundance and richness of tree seedlings, saplings, and adults, and shrubs, lianas, and herbs were done in all plots. Environmental variables, such as grazing, human disturbance (paths), altitude, and slope was recorded in order to explain the variation in species composition and richness together with the degree of degradation. In each site, local botanists guaranteed precise determination of the plant species. Multivariate statistical analyses were used to determine species potentially suitable for restoration based on their natural performance in the zones of different degree of degradation. Functional attributes of selected tree species were recorded to examine which functional traits that might be important for species suitable for active restoration.

1.3.2.3 – WP2 Achievements of the project to the state-of-the-art.

The results from WP2 highly contribute to the general knowledge on the effect of forest degradation on plant species richness and composition, and on the natural regeneration of degraded forest areas. Moreover, we have achieved important knowledge on individual species characterizing the different stages of recovery of abandoned forest settlements and fallows in particular. Such information is urgently needed in designing ecologically sound management strategies for restoring degraded forest areas and fallows after slash-and-burn farmland in tropical areas. We have developed a method to detect species suitable for restoration by examining the natural occurrences of species in zones of different degree of degradation. Based on this, we have suggested potentially suitable species for active restoration for each of the sites. These species can enhance recruitment and growth of other tree species on abandoned farmlands and degraded forest sites. Trees can be planted into fallows to speed up vegetation and soil recovery, such that fallows can be usable within needed time and thus the extension of cultivated areas into secondary or primary forest reduced.

1.3.2.4 – WP2 impact of the project on its industry or research sector.

This project has documented the dramatic decrease in species richness and changes in species composition as a result of forest degradation across geographical regions and degree of disturbance and land use history. Such knowledge has partly been lacking for east Africa and Madagascar. Active restoration by tree planting have been performed in degraded tropical forests, but the knowledge of species suitable for restoration have been poor, resulting in variable success. This project has also shown how species suitable for restoration can be detected by analysing the natural regeneration of species in zones or fallows of different degree of degradation and recovery. Based on the ability of the species to establish as seedlings and survive as saplings and adults in such disturbed sites, species suitable for restoration can be detected for each particular site. Such knowledge is urgent for successful restoration, and as far as we know, this approach is novel within forest management and restoration research.

1.3.3 – WP3 - restoration/rehabilitation through planting: characterisation and silviculture of native and naturalised species to restore environmental and economical function

1.3.3.1 – WP3 -Work performed during the project and main end results

The General objective of the WP3 was to promote the planting of native species to restore the ecological and economical function of degraded forest landscape.

The Specific objectives were :
1 – To define silvicultral rules to improve the production of timber or non wood products of economically important species and to accelerate the adaptation of environmentally important species
2 – To identify the economic potential of the species through study of the variation of wood or non wood forest products within the natural range in each country
3 – to define through gene flow studies, strategies to maintain the genetic diversity of economically important species in restored forest areas

The WP3 assessed the potential of species in plantations for accelerating restoration of degraded forest and producing wood and NWFP

*The Identification of species in the forest of Mabira Uganda***.** The overall objective is to provide farmers a range of socio-economically useful tree species that can diversify farm production and generate income
Identification was carried on economically important species through reviews of literature on timber and non wood forest product species production date from various experimental sites in Mabira from as far back as 1959. All the available raw data were collected, analysed for those years and growth curves plotted for the following species : *Albizia zygia, Maesopsis eminii, Canarium schwenfuthii, Fagara macrophylla and Khaya anthotheca*
The introduction and improved management of high value trees on farm is a promising avenue for diversifying farm production and developing income opportunities. The range of species made available to farmers is often restricted and does not always consider farmers' priorities. This trial offers farmers a number of promising tree species to experiment with, and will provide a test of farmer priorities, practices and problems.
Farmers from five sub-counties surrounding the Mabira forest were selected and trained. The farmers were selected from the sub-counties of: Nagojje, Najjembe, Kimenyedde, Kyampisi and Nyenga. Twenty farmers were selected to undertake this trial on their farms. An assessment to ascertain growth performance and survival of the tree species was to be done very after six months.
The farmers were left to choose their niche of planting for the tree species given and niche is an important factor in the survival, management and tells much about the growth characteristics of the tree and the value attached to it. The farmers' common planting niches are shown below:
The farmers' major niche was the home garden; fruit trees were especially planted in the home garden to ensure adequate management. However, known long rotation trees such as *Milicia excelsa* were mainly planted at the boundaries or scattered on the farm. The main reason for scattering was for trees to benefit from the general farm management such as weeding. The desired niche of planting has implications on the type of tree species planted. Trees with big and superficial roots are not recommended for planting in homesteads because they can easily lead to cracking of houses.

The diameter crown ratio has implications for intercropping trees and crops. Trees species with large crowns discourage farmers from planting them because such trees compete with their crops (see table above)

*Growth curves of native species***.** Selected Kenyan indigenous tree species of economic and ecological importance are: *Prunus africana, Juniperus procera, Polyscias fulva and Xanthoxylum gilletti* were chosen according to their economical interest in forest restoration. Measurements (tree height, girth, and quality traits) were taken in temporary sample plots of the species growing in both plantation and natural forest situations. The growth curves of the species were completed and the modelling of the growth improved with these new data. A similar research was undertaken in Madagascar and Uganda on specific tree species.

Phenology of Trees with Domestication Potential To understand the flowering, fruiting and seeding regimes of selected tree species.Several tree species both within forest and on-farm were marked using paint.
The demand for forest products is increasing and this is putting pressure on our natural forests. As a result, the Agroforestry programme has embarked on domesticating useful & multipurpose tree species. This is done to enhance availability of tree products such as firewood, timber, fruits and medicine are near the users/farmers as possible. In this activity several tree species were marked in Mabira Forest inUganda and in Vohimanana Forest in madagascar for phenology and some had data has been collected.
New data were collected to complete previous observation on the phenology of relevant tree species for restoration in Uganda and Madagascar.

The WP3 has implemented research to Develop propagation techniques for valuable tree species : fruit tree species, essential oil species, timber species and environmentally important species.
The main results obtained so far can be illustrated by these two research activities

Seasonal dependence of rooting success in cuttings from natural forest trees in Madagascar.
Four ligneous species from the tropical forest in the east of Madagascar, with a proven or potentially high economic value, were subject to 'low-tech' vegetative propagation tests from stem cuttings. The species concerned were *Aphloia theiformis*, *Ilex mitis*, *Prunus africana* and *Ravensara aromatica*. The cuttings were three-node segments of stems on which one leaf was retained. All the species proved amenable to rooting. The maximum percentage of rooting ranged from 33% for *P. africana* to 60% for *I. mitis*. Rooting success was dependant on the season of cutting (high in the hot season, from October to May, and null in cold season). This study is the first successful attempt at propagating cuttings from Malagasy forest species. This result is of particular importance to *P. africana*, threatened by destructive exploitation in Madagascar. It goes a step further in the domestication of this species by demonstrating the ability of cutting from ten year old ortets collected in natural forest to root as it offers the possibility of a reliable and effective method of reintroduction for the species in overexploited zones.

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Albizia gummifera experiment to test the impacts of the use of non-local seed in reforestation on growth performance

To test the impacts of the use of non-local seed in reforestation on growth performance, two provenances of Kenyan *Albizia gummifera* were grown in a randomised block experiment in soils obtained from Kenya, Madagascar and Uganda. Soils were characterised for mycorrhizal community and measurements of seedling growth (height) were maintained for 6 months. At the end of the experiment, seedlings were destructively harvested and dry root and shoot weights were taken and rhizobial nodule numbers and weights were obtained for each plant. Rhizobial nodules are currently being characterised using DGGE. Preliminary analysis indicates that Kenyan provenances perform best over the whole period of the trial, when grown in Kenyan soils.

The WP3 has studied the genetic variability of the most important economic species for their economical traits: growth, wood quality, essential oil, etc., to improve their performance and productivity

Essential oil production increases value of Psiadia altissima fallows in Madagascar's eastern forests. Fallow with *Psiadia altissima* is one of the most common post-'slash and burn' vegetation successions described in the evergreen forests of eastern Madagascar. Some fallows consist of almost pure stands of this species, of which the leaves produce an essential oil offering international commercial interest. The present research aims to evaluate the production potential of essential oil derived from different fallows rich in *P. altissima.* The study has revealed that fallows aged four and six years since the last crop abandonment produce the most essential oil (around 20 $L.ha^{-1}$), but relative to fallow duration, the youngest fallows (one or two year-old) are the most productive, respectively producing 12 and 6 $L.ha^{-1}.year^{-1}$. Additionally, the trees from the youngest fallows have a substantial capacity for regeneration from coppice shoots, on condition that the cut is performed well above the root collar. Although farmers earn five times less from harvesting leaves than from cultivating rice from *tavy*, the possibility is there for them to complement their income and diversify their production. The overall results show that sustainable exploitation of fallows of *P. altissima* is a conceivable option. However, this can only be achieved through an integrated approach that takes into account the environmental and social constraints associated with the development of this new activity.

Genetic structure of Albizia gummifera and its local adaptation to the associated arbuscular mycorrhiza

The aim of this study was to assess genetic structure and local adaptation of *Albizia gummifera* to associated mycorrhiza using three populations from Uganda, Kenya and Madagascar. Using variation in chloroplast DNA sequences, estimates of genetic diversity and differentiation were obtained. Local adaptation of *A. gummifera* to the associated

mycorrhiza was investigated by planting seed from different *A. gummifera* provenances into soils inoculated with soil microbial samples from respective local sites. In addition, the stability of inoculum was tested by comparing the performance of fresh and stored soils as inoculum. Four weeks after seedling emergence, height measurements were initiated and continued for six weeks. Mycorrhizas in the soil inoculum were identified using direct microscopic observation. Genetic data were analysed using GENALEX while greenhouse data were analysed using GENSTAT. The results showed that the species is genetically diverse with 14 cpDNA haplotypes identified (h_{TOT} = 0.803), with Uganda showing most diversity (h =0813) and Kenya the least (h =0.398). Although the majority of variation was distributed within populations (75%), significant population differentiation was observed (Φ_{PT} = 0.249, p > 0.01) and each population contained private haplotypes: Uganda (5), Madagascar (3) and Kenya (1). Greatest genetic distance was observed between Kenya and Madagascar (2.711). The lowest distance was observed between Uganda and Kenya (0.298). The diversity of the mycorrhizal community varied between sites with Ugandan fresh soils being more diverse than Kenyan fresh soils. For the old soils, fungal diversity was highest in Kenya, followed by Madagascar and then Uganda. Based on the growth performance measurements, there was no evidence of adaptation of *A. gummifera* provenances to local mycorrhizas though plant performance for inoculated plants was higher than that of the control. From the study, it appears that the specific kind of fungi the *A. gummifera* plants are exposed to is not important, although they benefit from the exposure. The tree populations seem to have genetically differentiated and transferring them to sites outside their own may pose a genetic threat. More research is however needed to ascertain adaptive differences of *A. gummifera* to abiotic and other biotic factors, the suitable founding genetic diversity and other factors that may affect introductions. The exact mycorrhizas that colonise the plants also need to be identified

Concerning the impact of forest degradation on the genetic diversity and the gene flow of the most important economical species, the main results can be presented as follows

Chloroplast DNA diversity in Albizia gummifera

To assess levels of population differentiation for a species common to all FOREAIM study sites, as part of an assessment of the impacts of seed transfer on performance, cpDNA markers were used to type a collection of approx. 30 individuals of Albizia gummifera from Kenya, Uganda and Madagascar. Considerable genetic diversity was identified (14 haplotypes) and population structure was evident, both between populations (most significant differentiation was between Uganda and Madagascar) and within site (Ugandan trees were mapped). Some doubt persists as to whether or not A. gummifera was recently introduced to Madagascar, although it has naturalised, but the cpDNA data show private haplotypes in Madagascar, suggesting either that the dispersal to Madagascar is ancient or that hybridisation and chloroplast capture has occurred with native Madagascan Albizia sp.. Local haplotype structuring within the Ugandan population most likely reflects predominantly local seed dispersal.

Impact of fragmentation and selective logging on the genetic diversity of Dalbergia monticola Jacq. in the oriental forest of Madagascar: an analysis at different scales.

Forest ecosystems in Madagascar have been seriously impacted by a combination of fragmentation and selective logging. Our study analysed the impact of these two factors on *Dalbergia monticola*, a tree species that plays an important economic role in Madagascar and is representative of many taxa in the oriental forest.

Leaves from 546 individuals belonging to 18 populations scattered over most of the natural range and affected by different levels of fragmentation and logging were collected and genotyped using eight microsatellite markers. The impact of fragmentation on allelic richness (R=7.36-9.55) and gene diversity (He=0.64-0.80) among the provenances was not significant. No recent bottleneck effect was observed. Overall differentiation was low (F_{ST}=0.07) and a clear relationship was observed between genetic and geographic distance, suggesting a pattern of isolation by distance. Analysis of population structure separated southern populations from central and northern populations. Analysis of the effect of logging showed that the fixation index F_{IS} was significantly higher, gene flow Nm increased between patches, and the spatial genetic structure Sp was more pronounced in logged (F_{IS}=0.283, Nm=5-8, $Sp30$=0.013-0.019.) than in unlogged provenances (F_{IS}=0.059, Nm=2, $Sp30$=0.010-0.011).
At the scale of the natural range, recent fragmentation has not reduced genetic diversity within, or increased differentiation among, populations of *D. monticola* in Madagascar, most probably because the phenomenon is too recent. However at the local scale, the combined effects of logging and fragmentation have changed genetic features.

1.3.3.2 – WP3 methodologies and approaches employed (used the project to describe this paragraph)

They were based of the following tasks :
Task 3.1 :Assessing the potential of species in plantations for accelerating restoration of degraded forest and producing wood and NWFP
Task 3.2 :Developing propagation techniques for valuable tree species : fruit tree species, essential oil species, timber species and environmentally important species
Task 3.3 Studying the genetic variability of the most important economic species for their economical traits: growth, wood quality, essential oil, etc., to improve their performance and productivity
Task 3.4 : Studying gene flow of the most important economical species

To conduct theses tasks classical methodology in silviculture were used to follow the growth of targeted species and to develop propagation techniques. The molecular tools and the theory of the population genetics were used to assess the impact of fragmentation of genetic diversity and gene flow of the most important tree species.

1.3.3.3. – WP3 Achievements of the project to the state-of-the-art.
The WP3 activities have improved the knowledge regarding the potential of some native species for forest restoration which was very limited when the project started. The project provided new elements regarding their propagation and their growth for being used in plantation to restore forest landscape.
The project has improved the understanding of forest disturbance of the genetic diversity of native tree species and particularly the effect of fragmentation and the effect of logging. This research was conducted in Madagascar one of the hotspot of biodiversity.

1.3.3.4 – WP3 impact of the project on its industry or research sector.
The WP3 activities have provided new knowledge in different domains.
For the most important species used in the Forest of Mabira in Uganda, of Vohimanana in Madagascar and Mau in Kenya, the knowledge of the silviculture and of the potential to provide wood and non wood forest products in plantation has been improved.

The techniques of germination and propagation of the most promising species for planting in restoration were improved and adapted to rural nursery conditions. The reproduction biology of the most important species was better understood.
The impact of forest degradation (fragmentation and selective logging) on the genetic diversity of species in region presenting a high potential of biodiversity was better understood.

1.3.4 – WP4 – Characterization of edaphic conditions in degraded forest landscape to predict forest restoration suitability

1.3.4.1 – WP4 -Work performed and main end results

When forest degradation occurs ecosystem function (biomass, nutrient content and cycling,…) and ecosystem structure (species and complexity) are usually reduced. The greater the degradation, the slower the forest restoration, and sometimes, critical levels of degradation are reached, preventing forest reconstitution. Quantifying the degree of ecosystem degradation is the first step to predict the change in forest dynamics. This WP, in relation with WP2 and WP5, focussed on providing indicators of soil fertility and soil functioning by assessing 1) the change in soil characteristics according to stand degradation status, and 2) bio-indicators related to the cycling of N, one of the main nutrient limiting factors for plant growth in tropical ecosystems.

The overall aim of this work package is to provide accurate indicators of soil fertility and soil functioning, in relation with state of forest restoration/degradation
The specific objectives were to identify the major soil limiting factors for forest restoration, to assess the relevance of the major soil biota compartments in predicting the state of change in soil functioning and to match relevant soil characteristics and/or bio-indicators with forest restoration dynamics.

The first task was to assess the change in soil characteristics according to stand degradation status. For a given site, the results and the conclusion from comparisons between the different situations are given in the following Table

Properties	**SITES**		
	Kenya, Kedowa	***Madagascar, Vohimana***	***Uganda, Mabira Forest***
pH KCl			
Values from…	4.91 to 5.94	3.28 to 4.58	4.8 to 7.1
Comparison	No significant difference, except for Pinus plantation being the lowest pH	Significantly lowest in Forest (primary and secondary)	Significantly lowest pH measured in forest older than 20 Yrs
C%			
Values from…	3.23 to 10.30	1.68 to 5.96	3.1 to 8.8
Comparison	Significant highest values for Natural forest, no other differences	No significant difference	Highest concentration measured in 10-20 Yrs forest, lowest in forest older than 40Yrs

N%			
Values from…	0.26 to 0.77	0.12 to 0.34	0.28 to 0.93
Comparison	See C%	See C%	See C%
C / N ratio			
Values from…	10.6 to 14.0	13.7 to 22.2	8.5 to 12.3
Comparison	See C%	No significant difference	See C%
Total P mg kg^{-1} soil			
Values from…	211 to 711	75 to 275	366 to 1946
Comparison	Lowest values in Natural forest and Pinus Plantation	No significant difference	Highest concentration in 10-20 yr old forest; the lowest value in 40-50 yr old forest
Available P mg kg^{-1} soil			
Values from…	9.2 to 92.3	7.8 to 22.2	13 to 246
Comparison	Lowest values in Natural forest and Pinus plantations	No significant difference	Highest concentration in 10-20 yr old forest, no other difference
Cation exchange capacity méq %			
Values from…	32 to 75	6.6 to 38.9	30 to 68
Comparison	No significant difference	No significant difference	Lowest values in the two oldest forest, Highest in the 140-20 and 20-30 yr old forest

A second aspect of research activities concerns the Assessment of soil bio-indicators. Concerning the Microbial biomass and activities, for a given site, the results and the conclusion from comparisons between the different situations are given in the following Table

Properties	**SITES**		
	Kenya, Kedowa	***Madagascar, Vohimana***	***Uganda, Mabira Forest***
Microbial biomass µC g^{-1} soil			
Values from…	134 to 924	6 to 130	48 to 299
Comparison	Significantly highest microbial biomass in Natural Forest, no other difference	No significant difference	Significantly highest microbial biomass in the 30-40 Yr-old forest
NH4 + NO3 mineralisation µg N g^{-1} soil			
Values from…	19 to 331	9.4 to 78.1	54 to 186
Comparison	Significantly highest N mineralisation in Natural Forest, no other difference	No significant difference	No clear pattern
Potential denitrification µg ~g^{-1} soil			
Values from…	0 to 4.7	0 to 22.1	2.2 to 142.3

Comparison	No clear pattern	No significant difference	No clear pattern

The soil changed also in term of diversity structure of the soil bacterial community. Hierarchical cluster analysis (Ward method) of the DGGE patterns from the different land uses soils indicated that bacteria community from the different situations could be differentiated. For Kenyan site, the bacterial community of the Natural forest soils clustered together apart from the other situations. The pattern was not so clear for the Situation of the Vohimana forest (Madagascar), profiles from secondary forest being closed to that of the Fallow (Savoka).
For the Mabira Forest (Uganda), the profiles obtained form the different situations were clearly apart form each other (data not shown)

For each sites, the nematode communities were efficient in discriminating the different situations. For the Vohimana site (Madagascar) where the other parameters (soil chemical and biological) were not different, nematode community can be used to discriminate the different situation (Primary Forest – FP, Secondary forest-FS,and Fallow-FW)
Nematodes were more abundant in FW (degraded forest or fallow) than in FP (primary forest) mainly because of a significant higher abundance of root-hair feeders and fungal-feeders. Carnivores were also more numerous in FW than in FP. Plant-parasitic nematodes, bacterial-feeders as well as omnivores present equivalent density in the different kind of forest
The maturity index (MI) was low in the FP (2.21) and high in fallow (2.87).These results are rather different than those obtained in temperate forests

The local adaptation and soil symbioses were assessed for some specific sites
In Kedowa in Kenya, plants grew slowly for the first 6 weeks, growing much more rapidly thereafter. From an early stage, the growth of the two species diverged, with *A. zimmermannii* becoming much taller than *A. gummifera*. These effects were significant by the third week of measurement, and continued to be so throughout the study. Overall, *A. zimmermannii* grew much faster than *A. gummifera*. Inoculum origin affected height growth of *A zimmermannii*, but not *A gummifera*, so that for *A zimmermannii*, plants with control inoculum grew the worst, and those with Kenyan inoculum the best. By contrast, for *A. gummifera*, there was no significant difference in height growth between the inoculation treatments.
Other measurements showed no nodulation in the control plants and very poor nodulation with *A. gummifera*.
Correlation coefficients between different parameters of plant growth show that for both plant species, growth was significantly and positively correlated with nodule number and weight. *A. zimmermannii* also showed significant correlations of shoot weight and nodulation (number and weight) with AMF spore number, which were not present for *A. gummifera*.

The soil inoculum, which only comprised 8% by weight of the available rooting medium, had a major effect on the growth and nodulation of *Albizia zimmermannii*, but not *Albizia gummifera*. *A. zimmermannii* was responsive to live inoculum, and plants were 30% taller in Kenyan soil than when grown with the control (autoclaved) inoculum. By contrast, for *A. gummifera*, the presence or absence of live inoculum, or its origin, had no effect on height growth. Root weight followed a similar pattern. Nodulation of *A. zimmermannii* in Kenyan soil was considerable, whereas it was slight with *A. gummifera* and was also slight with both species in the other treatments with live inoculum.

1.3.4.2 - the methodologies and approaches employed (used the project to describe this paragraph)

The studied field sites, and soil sampling design are presented in this paragraph.
The same field situations as those studied for WP2 activities were chosen for soil characterisations. For each of these situations different plots had been selected for WP4 activities. This selection was meant to take into account local specificity (i.e. slope):

Kenya, Kedowa forest, two experimental sites had been selected according to the different land uses present at Kedowa. Those different land uses are distributed within a slope composed of: An old Natural Forest (for Site 1 and Site 2): S1NatF and S2NatF, a 41 year-old Pinus (*Pinus canariensis*) plantation established after the clearance of the forest in Site 1 (S1PinPlant),a rotation: Natural forest – Cypress (Cupressus lusitanica) plantation (during 34 years) – Crops (during 3 years) – Natural revegetation since 2002 in Site 1 (S1NatCy), a rotation: Natural forest – Pinus plantation (during 34 years) – Crops (during 3 years) – Natural revegetation since 2002 in Site 2 (S2NatPi), a 15 year-old Cypress (regeneration) established after the clearance of the forest in Site 2 (S2NatCyp)
The slopes are visually assigned low, medium or high and comprised: The natural forest is on the top,The rotations (crop-forest) in the middle of the slope
The plantations (Cypress, Pinus) are down the slope
There were 6 replicate samples from the natural forest, cypress plantation and pine plantation sites and 18 replicate samples from the pine-crop and cypress-crop regeneration sites (6 from each upper/middle/lower slopes). Each sample is a composite soil sample from a replicate collected the 0-10 cm horizon. The soil samples were kept air-dried for chemical analyses or in cold room at 4 °C for molecular analyses. Parallel samples were also used for mycorrhizal analysis.

Madagascar, Vohimana
Sites corresponded to primary forest, secondary forest and degraded forest or fallow

N°	Plot reference	Vegetation type	N°	Plot reference	Vegetation type
1	FP-1	Primary forest	10	FS-15	secondary forest
2	FP-2	Primary forest	11	FS-17	secondary forest
3	FP-3	Primary forest	12	FS-18	secondary forest
4	FP-6	Primary forest	13	FW-32	fallow ou Savoka
5	FS-10	secondary forest	14	FW-33	fallow ou Savoka
6	FS-11	secondary forest	15	FW-34	fallow ou Savoka
7	FS-12	secondary forest	16	FW-35	fallow ou Savoka
8	FS-13	secondary forest	17	FW-36	fallow ou Savoka
9	FS-14	secondary forest	18	FW-37	fallow ou Savoka

Different plots were sampled at 0-10 cm within each type of forest. Each sample is a composite sample constituted by 14 sub-samples collected within 4 placettes of 5x5 m. The soil samples were kept air-dried for chemical analyses or in cold room at 4 °C for molecular analyses.

Uganda, Mabira Forest

Six forest regimes were selected in Mabira forest reserve (Table). Three plots of 150 x 50 m were randomly demarcated per forest block. Every plot was sub divided into 2 sub-plots of 50 x 50 m. Four composite soil samples weighing a kg /per forest regime at two different depths were collected. Exposure of the composite soil sample to extreme temperatures during transport or storage was minimized by placing them in a cooler when being transferred from Mabira Forest Reserve to The Soil Department, Makerere University.

Forest blocks	Degradation history in the forest blocks	Restoration age	Type of degradation-logging/agriculture	Predominant vegetation
1	Recently abandoned	0-3 years	Encroached	Plot in the size less than 3 years after the last encroachment
2	Secondary young forest	10-20 years	Encroached	Vegetation types in plots abandoned between 20 and 30 years ago
3	Old secondary forest	20-30 years	Encroached	Plots in selectively harvested areas in between these years
4	Very old secondary forest	30-40 years	Encroached	Plots mechanically harvested posts 1950
5	Almost intact secondary forest	40-50 years	Mechanically	Plots harvested pre 1950
6	Old growth and presumably undisturbed forest	>55 years	Mechanically	Plots that lie in areas that were never harvested encroached nature reserve

The detailed methodologies for soil analyses is presented as follows :

METHODES	SITES		
	Kenya, Kedowa	Madagascar, Vohimana	Uganda, Mabira Forest
Physical and chemical status of soils	IRD-ISO9001 certified laboratory LAMA, Dakar Sénégal (Resp. Patricia MOULIN).		
Biological Status of soils	IRD-LEMSAT laboratory Dakar, Sénégal (Resp; K. ASSIGBETSE)		
* Microbial biomass			
* N mineralisation			
* N denitrification			
* Nematofauna community			
* Bacterial diversity			
* Effects of landuse on	CEH laboratory	University	University Makere

mycorrhizal spore populations	(Resp J. WILSON)	Antanarivo, Dep Biology, (Resp. I. Ratsimiala Ramonta)	(Resp. G. Eilu)

1.3.4.2 - Achievements of the project to the state-of-the-art.

Among the different properties addressed in this study, our results indicated that cation exchange capacity and Potential denitrification could not be used to discriminate forest status. Soil pH and phosphorus content were lowest in natural forest or the oldest forest compared to that measured in the others situations. Contrastingly, carbon concentration (and N), microbial biomass, nitrogen mineralization were highest in soils under Forest.

This study stressed out the pertinence of the nematofauna in discriminating the impact of the different vegetation. As matter of fact, nematofauna composition (maturity index, structure of the population) revealed clear difference on soil occupation in the Vohimana Forest, where other properties failed to reveal these differences. For all situations, the investigations of the structure o the bacterial community was also helpful to differenciate the situations.

Laboratories investigation indicated that while Arbuscular Mycorrhizal Fungi have long been thought to have wide host specificity, there is increasing evidence that this is not necessarily the case. This needs to be taken into account when selecting tree species to be used in restoration.

1.3.4.3 - impact of the project on its industry or research sector.

The main impact of this work package was the assessment of the state of forest ecosystem degradation or restoration according to soil characteristics or soil functioning. An important results that could be used by environmental experts is the use of soil bio-indicators to assist forest ecosystem restoration assessment. The use of legumes to assist forest ecosystem restoration according to the efficiency of these species in N2 fixing was stressed as weel as the widescale use of inoculated plants to assist forest ecosystem restoration

1.3.5- WP5 - Examining the effects of differing vegetative covers, enrichment planting, agroforestry and other remedial treatments on losses of soil, plant nutrients and organic matter from degraded agricultural, agroforestry, fallow and forested landscapes.

1.3.5.1 – WP5 -Work performed and main end results

The objectives of the workpackage were:

1. To quantify, in differing farming, fallows, forest and agroforestry systems,(runoff and erosion losses, and rainfall infiltration, plant nutrients and organic matter levels and. erosion-driven losses of soil, organic matter and plant nutrients),
2. To arrange on-site workshops to demonstrate the effects of anti-erosion measures on ecosystem degradation, restoration and plant productivity to local communities, forest departments, GOs, NGOs and other stakeholders.
3. To define the best agricultural/forestry anti-erosion practice for sustainable economies on terrain varying in slope and landuses.

By the end of the first year, focussing on first objectives, all partners except FOFIFA had attended a training workshop in the installation and use of erosion monitoring equipment and

rain gauges, protocols for making measurements had been developed, field sites had been selected in Kenya and Uganda, experimental designs agreed, and rain gauge and erosion monitoring systems were in process of being set up in Kenya and Uganda.

By the end of the second year, still focussing on first objective, Makerere University (MU) in Uganda had collected data which showed that soil losses and run off were very low, but tend to be higher on the older plots (>40 years since last disturbance). Measurements of infiltration on the same plots indicated that the oldest and least disturbed sites had the lowest infiltration characteristics and soils generally had high saturated hydraulic conductivities, which declined with increasing time since disturbance. Soil bulk densities are low and the soils are generally porous. Soil profile pits had been dug and soil analyses and descriptions were in preparation. Soil chemical properties had been assessed, indicating generally good nutrient status and analyses of aggregated sediments are in progress. A Master's student had been involved in the project. In Kenya, KEFRI had collected rainfall and run off data, conducted some analyses of runoff water and soil profile pits had been dug and soil analysis was planned. Some preliminary data analyses had been done. A sensitization meeting with local stakeholders at Kedowa was held. In Madagascar, FOFIFA have made preliminary descriptions of the erosion plots and soil analysis was in progress. They expected to commence erosion measurements in the next reporting year.

Sub contractor ICRAF had offered technical support to all partners and provided 3 erosion gauges to FOFIFA and organised their shipment to Madagascar. Training in their installation and use was offered to FOFIFA, either in Madagascar or in Kenya, but this was not taken up by FOFIFA. Continued support, advice and site visits were made to the KEFRI site at Londiani and 12 additional tipping bucket sensors have been provided to KEFRI. Training for FOFIFA was still available.

By the end of the third year work by MU continued with the involvement of Master's students. Conclusions from the erosion plots were that runoff, soil and nutrient losses from all the blocks were highest in recently disturbed sites (0 – 3 years) but were low compared to agricultural land elsewhere. The Mabira Forest Reserve has good hydrological properties favouring vertical water flow, and the Philips model was the best predictor of infiltration.

In addition to continuing to collect data from forest plots, work in Uganda was extended to install runoff plots in agricultural land, which will contribute to task 5.2, and further engagement with farmers was planned by some demonstrations in plots aimed at enhancing agricultural production for the farmers around the forest, practices to be tested included mulch and bunds, agro-forestry. Catchment studies, (water quality measurement in the Mabira micro-catchment) were in progress.

In Kenya, water and soil nutrient analysis continued. In addition, tree planting was conducted on the experimental sites. However, political instability in Kenya affected the project and there was damage and disruption to site installations. A subsequent assessment by the KEFRI team determined that it was not possible to continue with the erosion studies at Kedowa.

At the annual meeting in April 2008, it was agreed that Dr Gilbert Majaliwa would take over from Professor Ong (ICRAF) as the co-leader of the project.

In Madagascar, cash flow problems had delayed implementation of the erosion work, and erosion monitoring did not commence in year 3 as previously planned. However, the FOFIFA

team had conducted a literature survey of previous relevant studies in Madagascar, and had estimated soil losses, applying parameters to the USLE model. In May 2008, three erosion sensors were installed, two in natural forest and one in 4 – 7 year fallow. Measurements were planned for the next rainy season.

Field-based work has been led by partners in each country. Discussions on progress and problems have been held by email and at the 2 project meetings held during this period. Inputs have been provided to scientific papers in preparation by partners at MU.

During the final 18 months of the project

- CEH has attended project meetings and assisted with the drafting of publications by MU.
- Makerere University has
  - Set up run off and soil measurement erosion plots
  - Measured rainfall daily
  - Collected runoff samples daily for assessment of run off, soil loss and nutrient loss
  - Analysed soil samples from different depths in the soil profile
  - Conducted focus group discussions with farmers around the Forest reserve
  - Set up three on-farm demonstration gardens and used erosion plots for demonstration and dissemination
  - Worked to finalise preparation of various manuscripts for submission e.g. on soil characteristics including infiltration rate, hydraulic conductivity, bulk density in relation to rainfall measurements. Others on soil chemical properties, soil profiles and soil water retention curves
  - MSc Charles K. Luswata submitted MSc dissertation and graduated with an MSc
  - Sensitised the local communities on the soil related studies
  - Worked with staff of the National Forestry Authority (NFA) to use some of the findings in the Management Plan of Mabira Forest Reserve
  - Presented papers at various for a e.g. World Congress of Agroforestry in Nairobi, Kenya

- FOFIFA has
  - Set up run off and soil measurement erosion plots
  - Measured rainfall daily
  - Collected runoff samples daily for assessment of run off, soil loss and nutrient loss
  - Analysed soil samples from different depths in the soil profile
  - From these data obtained evidence of the significant effect of slash and burn and land cultivation on soil and nutrient loss from the forest.

- KEFRI : Due to damage at the field site and political instability, KEFRI abandoned their research activities in this work package.

The most significant results were obtained in Uganda and Kenya for the understanding of soil and nutrient losses.

End results in Mabira forest

Mabira forest reserve (MFR) underwent degradation from the early 1970s as a result of encroachment and conversion of the forest cover to agriculture and settlement. However, in the mid eighties, the government banned further encroachment to allow forest regeneration. The process has been gradual, with several forest blocks at different stages (time since last

disturbance) of regeneration. There is no data on soil and nutrient losses in the restoring forest blocks. This study was therefore carried out to investigate the effect of forest ecosystem restoration on soil properties; soil and nutrient losses.
The study was carried out in Mabira forest reserve (MFR) located between 32° 52' - 33° 07' E and 0° 24'-0° 35' N. The reserve is characterized by ferralitic sandy clay loam soils on undulating hills. There were six treatments representing the different forest block ages of restoration namely, most recently abandoned (1-3 yrs), secondary young forest (10-20 yrs), old secondary forest (20-30 yrs), very old secondary forest (30-40 yrs), almost intact secondary forest (40-50 yrs) and intact forest (> 55 yrs). In each treatment, three plots, measuring 150 x 50 m were selected, based on the slope (10%).
The most important results were that runoff and soil loss exhibited similar trends, being highest in the 0-3 yrs forest block. Excluding the 0-3 yr forest block, run off and soil loss increased exponentially with forest restoration stage. Annual soil loss for the different restoration blocks never exceeded 600 kg/ha/yr. The high loss in 0-3 yrs was due to clearing of vegetation cover, preventing control of runoff and exposing soil to detachment and transportation.
Strong relationships were observed between runoff, steady state infiltration(IR) and forest restoration stage. Bulk density in all the blocks was very low ranging between 0.74 and 0.95 g/m3 for the topsoil and between 0.79 and 1.05 g/m3. Bulk density increased with soil depth whereas porosity decreased with soil depth.
In conclusion, runoff, soil and nutrient losses were highest in the first 3 years after disturbance, when ground cover was least, however, in all the blocks, they were low compared to agricultural land elsewhere. The MFR had good hydrological properties favoring vertical water flow. Philip model was the best predictor of infiltration. These studies are relatively short term and further studies over a longer time period would be preferable. Studies are also recommended to determine the hydrological importance of MFR as a watershed.

Most significant results in Kedowa forest in Kenya
Kedowa is situated in the Mau forest block located at 35º.50E and 0º.69N. This forest ranges from intact inner core to degraded adjacent sites bordering human settlement.
The site is in compartment 3Q of Kedowa block in Londiani forest station of Kericho District. It is sandwiched between a natural forest and Cupressus lusitanica regeneration. It is about fifteen kilometres from the Londiani KEFRI centre. The general slope is between 5% and 7% oriented in a north - west direction. The site was under pine plantation which was clear felled in 1995. Later, farmers were allowed to cultivate the land until 2003 when the shamba system was discontinued.
The dominant species on the site is vernonia with grasses but the adjacent natural forest is rich with the following species.
The layout of the wp5 plots which span natural forest and regeneration sites of different slopes is decribed below
Up1 - slope 11% with 10% undergrowth and100% canopy cover comprising of big trees
Up2 - slope 13% with 50% under growth and canopy comprising of big trees
Up3 - slope 21% with 30% samplings & grass as the under growth and 90% tree canopy cover
Lp1 - slope 16% with 100% grass cover
Lp2 -slope 7% with 100% grass cover
Lp3 - slope 9% with 90% grass cover upper canopy 4% of shrubs (vernonia)
Lp4 - slope 6% with 100% grass cover

Lp5 -slope 2.5%, with 60% grass and 40% canopy of vernonia species
Lp6 - slope 10% with 90% grass cover 2% of croton spp
Lp7 - slope 7.5% with 80% grass cover with scatted castor oil plants
Lp8 - slope 3% with 100% grass cover
Lp9 - slope 2% with 100% grass cover
The results showed that the animals were causing a lot of degradation especially on the cover crops such as the herbaceous plants. There is a decrease in the discharge as grass has been established. The results indicate that the plots located in the forest discharge more water than the grassland plots. The results from the soil and water analyses indicate that there is a nutrient drain from the sites. The elements mostly affected are calcium, sodium and potassium and total dissolved solids. Analysis of variance of the run off water data indicates that conductivity, potassium and total dissolved solids (TDS) varied between the plot types: conductivity and TDS were significantly higher in the natural forest and upper slope than the lower plots, and potassium in the run off water also tended to be higher although the results were less clear cut. Soil chemical analysis was also conducted on soil from soil pits.

1.3.5.2 - the methodologies and approaches employed (used the project to describe this paragraph)
The methodology of the WP5 was based on the following task :
Task 5.1 Quantifying rainfall, soil fertility, rainfall infiltration and erosion losses in sub-humid and humid landscapes differing in extent of degradation/restoration in the presence and absence of anti-erosion measures.
Task 5.2 Creation of catchment pits for verification of outputs from erosion micro-sensors and to provide a focal point during formal Workshops to demonstrate the differing extent of soil losses from “control” areas and those receiving remedial treatments.
Task 5.3 Definition of best agricultural/forestry anti-erosion practice for ecosystem restoration and sustainable economies on terrain varying in slope and landuse.

These tasks were achieved through an important field activities especially to set up the erosion measurement instruments and then to monitor the outputs.

1.3.5.3 - Achievements of the project to the state-of-the-art.
The WP5 has brought new examples of relationship between soil erosion and soil cover.
This work package 5 has shown that the pipe sampler is a low tech state of the art method and was used successfully.

1.3.5.4 - impact of the project on its industry or research sector.

The results obtained by Foreaim project, even if a longer period of observation should have been necessary to finalize all the studies, confirmed previous results obtained in other research project involving soil erosion :

- The forest plays a great role in the improvement of the of water balance by the importance of the infiltration compared to the runoff and progressive restitution of this water during the year. This process favors the forest area and their peripherals as regards availability of water. The water being the principal element of the agricultural production.
- The forest plays a dominating role as regards soil protection, which is the substrate of all agricultural activities.

- The soil losses are relatively tiny and insignificant as long as the vegetable cover remains dense.
- The slash and burn cultivation cause a strong quantity of soil loss during the cultural period. But the recovery of the soil by the vegetable decreases these soil losses quickly.

1.3.6 – WP 6: Improving human well being by developing market access and economic benefits for local populations

1.3.6.1 – WP6 -Work performed and main end results

The general objective of this WP was to improve stakeholders' information on the economic revenues that can be generated via local, national and international markets by plant products produced from restoration areas so as to benefit their livelihoods.

The specific objectives were:
- to Supply specific and current bibliographical information on marketing and processing for both local and international markets for the main plant products (either wood and non wood forest products) derived from the on going and potential forest restoration areas ;
- to provide relevant information in relation with data coming from WP1 and WP3 on the effective socio-economic benefit and share of revenues between stakeholders that could be derived from forest and agroforest restoration. Proposals related to possible improvement in product collection, processing methods and market organisation and penetration will be given, so that revenues can be shared more equitably between stakeholders to preferentially prioritise benefits to the rural poor.
- Make a draft preliminary assessment of the potential economic interest for countries and rural populations of the emerging forest plantation "carbon sequestration market".

- Significant result of the market access and benefit share from plant product deriving from restored areas were obtained in Uganda in Mabira forest.

Proper record keeping: The first report of WP6 pointed out that at the time of the study, there were no records of trends in use of wood and NWFP from Mabira Forest Reserve in terms of number of licenses issued or the volume harvested at the NFA head offices in Kampala. There is need to have proper record of accounts for products harvested from Mabira.
More data needed on timber harvested: Data on the volume of timber harvested, and revenue generated are still lacking because most of the timber harvesters are illegal. Currently there is no organized and authorized harvesting of timber from Mabira forest by NFA. Most of the timber taken out is illegally harvested.

More information on local trade patterns: The economic data provided on volumes harvested and the unit prices obtained from local harvesters of wood and NTFPs in Mabira forest is still scanty. This needs to be beefed up in order to estimate the returns from the forest relatively well.
Data especially from the local timber harvesters, herbalists, carpenters, crafts groups, rattan canes, meat sticks, and forest managers from Nagojje have been documented. Specifically, questions have addressed aspects on estimates of revenue generated, unit price and unit volumes harvested over the peak and off-peak seasons. The unit prices and total consumption at the national level was determined from the NFA and other stakeholders.

Estimates economic benefit to the community: Data on market chain analysis i.e. costs and sales at every level of production, i.e. local harvesters, processors, retailers, middlemen (buying price, transport costs, taxes, licenses, selling price), wholesale prices have been captured. The forest products are assumed to gain value at each level of production, and shift in markets from local to national and then international fetches different prices. We focused on local end user species (fuel wood, food products, and natural medicines) and high value export species (essential oils, valuable timber, etc) at the national level.

- Concerning the potential eligibility to CDM and voluntary markets of tree planting in relation to restoration activities some significant results were obtain in Uganda.

In Uganda, we have noticed that there is no plant species in Mabira forest that have potential to be planted and access benefits from CDM given the current CDM regulations. At a global level concerning clean development and mitigation of climate change, farmers around can only access money through voluntary carbon markets. We have recommended the following species for CDM in case it relaxes the regulations and for voluntary markets as well: Cordia millenii, Prunus Africana, Warburgia ugandensis, Measopsis eminii, Milicia excelsa, Albizia coriaria, Aningeria altisima, Lovoa trichilioides, Entandrophragma utile. We have recommended the nine species because of:
They have high economic potential locally, nationally and internationally;
Some of species are already being tried by farmers for plantation and woodlot development;
They accumulate high biomass and therefore can produce high carbon tonnage per hectare through sequestration;
Some farmers in other parts of Uganda have already benefited from selling carbon credits to voluntary markets of similar species (e.g. Measopsis eminii);
Given the land size requirements to CDM and other regulations, the CDM regulations are too stringent for farmers around Mabira to benefit. Though farmers around Mabira can access carbon credits through voluntary markets if organised, the voluntary markets are so fragile and with much speculation. In voluntary markets farmers get very little returns because much of the credits are taken by middlemen and other dealers.

Recommendation
We recommend that farmers around Mabira be organised in a cooperative society so that they can able to access funds from carbon trade. More household land around Mabira be planted with trees so that farmers may have enough tonnage of carbon to sell and later produce more timber and other frost demand from woodlots. This will reduce pressure from Mabira Forest Reserve.

In Madagascar two main studies were conducted
The charcoal industry does not benefit the players in the upstream and especially small primary producers. For them, this activity is a source of income that allows them to survive if food crops are not sufficiently specific. The people involved in charcoal production try well, by increasing production, improving their income. They do this by shortening the rotation length increasing the pressure on the formations that planted benefit from any development plan previously. Their methods of carbonization allow only low yields of around 8 to 10% far from average yields from 17 to 20% as can be expected using improved techniques.
This pressure on the plantations is an element that can, even if these plantations of Eucalyptus robusta existed for decades, affect their survival. The efforts of local

populations who depend on no outside support, replace the dead trees or increase the area, demonstrates their awareness of the importance of the restoration artificial forest. If the access to land continues and facilitated by the state, these rural populations are able to continue the development of these plantations that eventually replace natural formations. In the region of Moramanga, the dynamics of phenomenon of natural forest conversion natural forest into eucalyptus plantation is real and deserves to be supported. The perspective of having the forests of eucalyptus replacing the natural forest that can assume the functions of production, regulation, conservation and protection is the only solution to this degradation.

There is a trivialization of illegal logging in natural Forest. With a product demand that remains very important, all the actors, for different reasons, but understandable agree to maintain the parallel market. Rosewood chain (but this can be generalized to the timber chain) is structurally unsound. This demonstrates that it would be futile to believe in the possibility of impose a prohibition of illegal exploitation. All means are good to use these resources and if it is rather easy for loggers to go in the forest and to participate in this skimming best species, the main challenge will be to market the products. The Conditions of this operation do not allow loggers to demand good prices in view of their situation poverty. In addition, the clandestine nature of the industry puts them in a situation dominated by operators and carriers that impose prices.

1.3.6.1 - the methodologies and approaches employed

The methodology of the WP6 was based on the following task
To establish a detailed bibliography analysis
To study the market access and benefit share from plant product deriving from restored areas
To analyse the potential interest of the Carbon sequestration market

Studies on wood and NWFP presently and potentially produced in restored areas, will be carried out both at field level and along the market chain through surveys and inquiries.
For carbon sequestration market analysis simple simulation on Excel (combining biological data and economic information will be undertaken in order to test the potentiality of rewarding such activities.

1.3.6.2 - Achievements of the project to the state-of-the-art.

The project offers several cases which should strengthen the body of knowledge in economic sciences

1.3.6.3 - impact of the project on its industry or research sector.

The WP6 activities have brought relevant information on forest products market for the forest restoration stakeholders in the three countries of the project.
Some operational proposals for improving the processing and marketing of products from restoration areas have been done.
African social scientists have been trained in modern socio-economic and market analysis methodologies.
The main scientific results have been disseminated using scientific publications and support.

1.3.7 - WP 7: Effective tools for uptake by stakeholders of sustainable forest restoration strategies

The general objective of the Workpackage 7 was to ensure the transfer and effective uptake by forest restoration stakeholders of negotiation and decision-help tools based on operational integration of biological and socio-economica scientific data derived from the other WPs.

Such an objective needs a comprehensive approach of the links between stakeholders, good understanding of biological and socio-economic interactions and efficient tools for negotiation and decision making.
Activities to be developed in this work package include both more research oriented activities related to the decision process elaboration methodologies and more development oriented actions, related to the operational dissemination tools and results.

The Specific objectives were :
- Analysis of relations and decision process elaboration between stakeholders involved in forest restoration;
- Integration of biophysical, biological and socio-economic data into user-friendly data banks and into "forest restoration handbooks" giving access to the main results ;
- Development of coupled geographical information systems and spatial multi-agent systems in order to help stakeholders for negotiations on forest landscape restoration and establishment of "decision flow diagrams" for restoration planning and decision process making based on effective and relevant criteria and indicators.
- Study site case strategic prospective workshops, based on use of negotiation and decision tools during role play actions, for disseminating the sustainability of proposed restoration processes through prospective scenarios.

- One of the most significant results of the WP7 was the implementation of a socio-ecological model for assessing sustainability of community-based regulations in the frame of the Malagasy context.

The Malagasy local communities managing forest resources have difficulties in assessing the impacts of the management plans they decide upon. To help them, we have designed an integrated model with the ecological processes, the various norms (zoning, quota, etc...) and the resulting inhabitants behavior in order to explore the impacts of scenarios. The model MIRANA has been designed using the MIMOSA framework in which we must design a conceptual model using ontologies, annotate the conceptual model with the necessary processes, and design a concrete model from which to generate the simulation model. In MIRANA, the conceptual model is made of the set of ontologies describing the actors of the system (households, community, etc...), the objects they are acting on (lands, animal and vegetal species, etc.)), the actions carried out by the actors on the objects (hunting, cultivating, etc.) and the norms regulating the actions. The actors are provided with needs (food, money, etc.), objectives (conservation, production, etc.) and planning mechanisms. The objects are provided with spontaneous processes (fertility dynamics, growth of biomass, etc.). The configuration on a particular site with a given set of activities, ecological dynamics, objectives and regulations is made using GIS and excel files loaded into a data base for generating the simulation model. On-going work includes sensitivity analysis and adaptation to coastal integrated management for testing the genericity.

Based on the finding of the other workpackages some preliminary results were obtained given that only rice growing was implemented in order to fulfil the need in cereals. However, it was possible to assess the impact of the population on the degradation of land for livelihood only. The figure below illustrates the impact on the shallows of 26 households (70 people) of which the half are complying to zoning constraints.

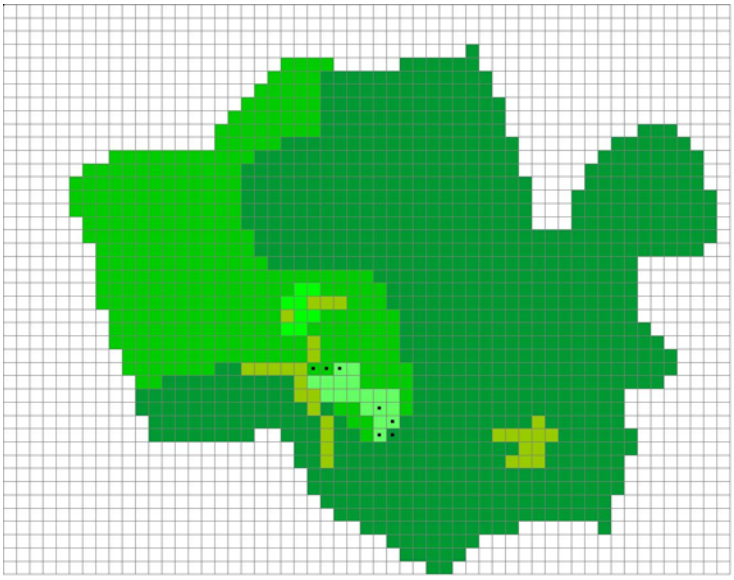

Figure 1 The map of habitats with cultivated lands in yellow.

The following figure illustrates the variation of shallow exploitation with the number of households. After 20 households, the site potential is completely exploited and the households have to turn towards swidden farming (slash and burn). This phenomenon is largely confirmed in reality.

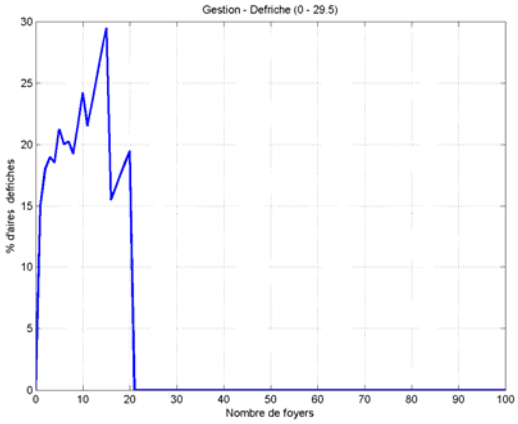

Figure 2. The variation of shallow exploitation with increase of households.

We already built the indicator for need satisfaction rate but we do not have the results yet. Further steps include taking into account the loss of fertility (already computed) and the resulting disuse of plots, the side effect of the grid size (to be corrected later), and, of course, the addition of other activities (and competition among these on available labour force).

In the frame of Foreaim the MIRANA model was presented with a first attempt, as long as we know, to incorporate norms into a socio-ecosystem simulations. The norms were represented as relations attributing roles to subjects and objects together with rights and forbidding. From

an analysis of the various norm structures from customary to administrative ones, we obtained a set of roles for the actors and the objects. These roles were used to describe the biophysical and social dynamics relevant to the question asked: what is the impact of the community level regulations on the actual ecological, economical and social sustainability of the local community and its territory? For expressing these dynamics, we proposed a simple underlying structure of operations on spaces made of entities possibly situated in other spaces and endowed with stocks. We argue that the all the dynamics we are describing shall result in the execution of the proposed operations. Finally, we showed some preliminary simulation results.

Beyond the Foreaim project, much work remains to be done. First of all, we shall extend the set of roles currently implemented to assess the complex interactions among a multiplicity of needs. The dynamics at the level of the local community with its objectives in terms of conservation and production and the related financing mechanism, is not yet implemented. Of course, further sensitivity analysis shall follow. Finally, we still have to use this model to discuss with the local communities themselves.

In a more distant future, we shall try to use this model with different maps and species to apply it to completely different situations, assessing this way, its possible genericity as a model of renewable resource management.

- A second important achievement of this work package was the elaboration of a forest restoration handbook for each country

The objectives of this book were :
- to make a synthesis of operational results issued from the Foreaim project;
- to transcribe project results from scientific language to users language;
- to allow decision makers to base their decision on scientifically recognized results;
- to give a “how to do” handbook for end users;
- to give a chance for research results to be implemented at local level.

The main target were the forest administration, national and local decision makers, the heads of communities, development societies, NGOs, …, the universities, engineering and technician schools and the Private investors.
The concerned zone was the region concerned by the Foreaim project, and by extension, equivalent ecological zones for technical aspects and all the country for methodological approaches.

The FFRH should be organised under three chapters, each of them could be distributed separately as a specific booklet:
- The first one will give the general context of forest situation and general objectives for forest restoration in the country and the concerned region ;
- The second one will present the main operational results issued from Foreaim studies under the different work packages;
- The third one will propose effective strategies and operational tools for practical restoration development, based on both Foreaim finding and expert knowledge.

it was proposed that the FFRH should be printed in each country (+/- 500 samples, to be defined in relation with national teams), and that specific presentation should be organised with key stakeholders at country level

1.3.7.1 - the methodologies and approaches employed
The methodology of this workpackage was based on the following tasks:
Task 7.1: Analysis of decision process elaboration between stakeholders for equitable partnerships. The work will be based on WP1 and WP6 results and on complementary enquiries and discussions in each country with identified decision makers.
Task 7.2: Merging biophysical and socio-economic data to direct restoration actions: Data banks on ecological results related to forest species and to restoration practice methods and on socio-economic data related to these species and methods will be crossed in order to enable identification of relations and synergies/antagonisms and other links between these various components.
Task 7.3: Negotiation and Decision help tools including two sub-tasks based on spatial based negotiation process elaboration. Tools used were spatial multi-agent systems (SMA : Cormas (software) combined with geographical information systems (GIS : Map-info (software).
Entry data were geographical information (land use, etc), biological data socio-economical data.

1.3.7.2 - Achievements of the project to the state-of-the-art.
In developing the modeling activity, the WP7 has led to progress in the use of these tools to understand the behavior of actors involved in forest sector and agriculture in forest zones.

1.3.7.3 - impact of the project on its industry or research sector.
The main results of the WP7 were:
to develop and interdisciplinary approach and operational results for sustainable forest restoration promotion at countries' level,
to produce a documented Forest Restoration handbooks for country and field forest restoration dissemination,
to implement an innovative negotiation and decision making tools for improving sustainability in forest restoration processes and equity between stakeholders,
and to favour the uptake by scientists and experts of methodologies and tools for strategy elaboration in sustainable forest restoration applications.

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2. Dissemination and use

Section 1 - Exploitable knowledge and its Use

The FOREAIM project has focused on species of economic importance and the main exploitable results are related to the research o those species.

Although the project has partly conducted research in the domains of essential oils and naturally occurring chemical compounds, it has not been planned to elaborate patent. The objective of the research activities in the fields of essential oils and chemicals (especially in Madagascar) was to produce results for the public domain..

The most significant exploitable knowledge is given in the following table.

Overview table

Exploitable Knowledge (description)	**Exploitable product(s) or measure(s)**	**Sector(s)** of application	Timetable for commercial use	Patents or other IPR protection	**Owner** & Other Partner(s) involved
Principles in restoration of forest in humid tropics	Forest restoration handbook	Forestry Environment	2010	No patents or IPR protections	Foreaim consortium
Performance of tree species for restoration	Technical notes explaining nursery and silvicultural practises for each tree species	forestry	2010	No patents or IPR protections	Foreaim consortium Public knowledge
Production of Mycorrhiza inoculants for use in forest restoration and agriculture	Mycorrhiza inoculants	1. Forestry 2. Environment 3. Agriculture	2010-2011	N/A	Partic. 8 (owner) And other FOREAIM partners

Production of bio fertilizers

Mycorrhiza perform several functions due to their formation of an extensive hyphal network which augments water and nutrient uptake, pathogen attack resistance and disease resistance plus coping with stressful environments. This translates into better or faster plant growth and improved plant productivity as well as faster restoration of the degraded patches in forests. In this study, *Glomus* greatly increased plant growth for Mabira forest while a mixture of *Glomus*, *Gigaspora*, *Acaulospora* and *Scutelllospora* increased plant growth on agricultural soils in Soroti. Nonetheless, further studies are needed to test mycorrhiza inoculant performance in different environments for better recommendations. However, the innoculant is not readily available for utilization, and therefore its production on large scale is significantly needed for commercial use.

Performance of tree species for restoration

The exploitable result consisted in techniques to propagate and grow forest tree species that can play a role in forest restoration in the different African countries. The African partners from Uganda, Kenya and Madagascar were particularly involved in the dissemination of these results that can be exploited by private companies involved in forestry, forest service, NGOs. The techniques were obtained in experimental conditions in the nursery as well as in the field and some adjustment will maybe be required to use these techniques on a wider scale. In addition further additional research and development work are needed to improve the propagation techniques and follow the growth of species on a longer period.

Foreaim Forest restoration handbook
In each African country a book on the forest restoration practises based on previous results and on new results provided by Foreaim was elaborated. This book should be exploited by all the stakeholders interested by forest restoration: representative of forest en environment services, policy makers, students, and teachers. This book is in the public domain and can be obtained through the publication services of the three partners.

Section 2 – Dissemination of knowledge

Dissemination plans in Foreaim has targeted different audiences: (i) Ministries of Kenya, Uganda and Madagascar governments and their policy makers, (ii) decision makers and extension services such as forestry services and agricultural services, (iii) national and international agencies involved in sustainable development (iv) national and international NGOs involved in sustainable use of natural resources and (v) the scientific community involved in forestry, agroforestry and restoration ecology.

- Policy makers and Extension services, decision makers etc have been provided with a restoration handbook and technical papers. Technical guides written in local languages for farmers utilising degraded forests will help develop awareness of the wide-ranging positive impacts of forest restoration, especially with the use of commercially important species with local marketing and export potential.
- Scientific papers have been written for the national and international scientific communities.

The project encompasses the interests of various regional institutions such as CORAF and networks such as SAFORGEN, as well as integrating organisations like COMESCA, EAC, IGAD and IOC. Presentation of the project and of the main results will be made to such groups during their meetings and our results will be made available through their and other international dissemination networks.
At the end of the project, a a book forest restoration methods for humid and sub-humid zones have been released to research institutes and libraries in DCs. During the project a Website has been created describing the project and containing the accumulated outputs from the participants (description of the project, photographs of fields experiments, outcomes of meetings, main results etc).
During international, regional or national workshops and other fora, papers, oral communications and posters on the various components of project have been presented (see the publishable results in annex).

Foreaim have tried to solve a recurrent problem with research : this is the effective adoption of technical results by end users. To address this issue, the project has developed dissemination in the final work package (WP7) whose objective is to try to ensure the transfer and implementation of the research results by end users. The planned development of decision making tools and methodologies based on studies developed in parallel with end users, will produce operational restoration methods that are practical and which consider social and biological constraints.

Overview table
This table present one of the most representative dissemination activities of the Foreaim project

Planned/actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
October 2005	Web-site	General public Concerned by forest restoration	international	1000-10000	CIRAD (1)
27-02-02/03-2006	Molecular Ecology Training course	Research	Kenya	small	2, 1
2007 2008 2009	Press release(press/radio/ TV)	General public	All the countries	50.000	All the partners
June2006 - May 2007	Press release(press/radio/ TV)	General public	All the countries	50.000	All the partners
June2006 - May 2007	Scientific publications	Research	international	1000-10.000	All the partners
June2006 - May 2007	Technical papers	Extension services	Uganda, Kenya, Madagascar	100 per country	Partners 5, 6, 7 and 8
14-03-21/03-2007	Mycorrhizal training	Research	Kenya, Uganda, Madagascar	small	1, 3 & 5
June2006 - May 2007	Press release(press/radio/ TV)	General public	All the countries	50.000	All the partners
Nov 2009 April 2010	Conferences -2nd World Congress of Agroforestry -AETFAT	Research	Global Global	1200 300	All partners All partners
2009 2010-2011	Publications Journal Articles	-Scientific community -Academicians -Research organisations	Global	Over 1 million	All partners
2008 2009	Posters	Scientific community	Global	Over 1200	All partners
2009	Field Sensitisation/ Demonstration activities	Local farmers	Uganda	100	Partner 8

The important point to stress in the frame of dissemination of knowledge is the web-site, which has worked for more than 48 months. In annex 1 are presented the statistics for the two last years because the use of "google analytics web site" for monitoring web sites was used in Cirad mid-2007.

The URL of the web-site is: http://foreaim.cirad.fr/

The statistics, given in the annex 1 illustrated by the different figures and tables showed the interest of people for this kind of project. We observed a stable trend in the number of visits over these two last years and the diversified origin of people accessing to the Foreaim web site.
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Section 3 - Publishable results

The publishable results are listed in annex. The table below illustrates the number of publishable results by workpackage according to the type of material.

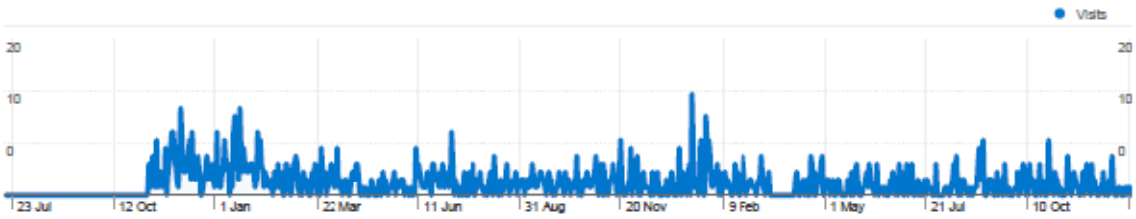
Work package	scientific papers	Congress communications and posters	Technical notes	Student master reports	Foreaim Notes and reports
WP1	1	5		10	13
WP2	15	4	1	7	
WP3	11	2	5	5	
WP4	4	6		4	
WP5	4	2	3	1	
WP6		3		5	9
WP7		1	3	1	

The Foreaim project has produced a significant number of scientific papers especially in the domain of the ecology.
The participation to congress and workshops was also noticeable for all the work packages.
Foreaim project has shown some important involvement in training through the supervision of numerous European and African students.

ANNEX 1

inco-foreaim.cirad.fr
Dashboard

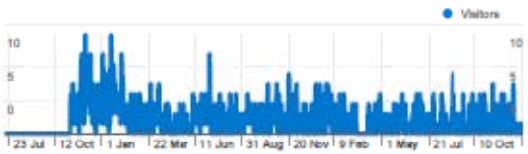
18 Jul 2007 - 31 Dec 2009
Comparing to: Site



Site Usage

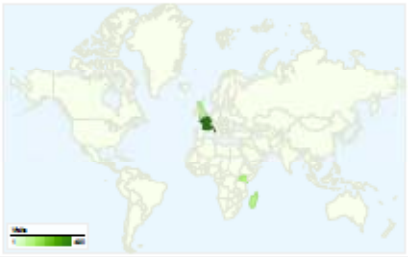
1,353 Visits	56.84% Bounce Rate
4,875 Pageviews	00:02:55 Avg. Time on Site
3.60 Pages/Visit	78.27% % New Visits

Visitors Overview



Visitors
1,059

Map Overlay



Traffic Sources Overview

Search Engines
837.00 (61.86%)
Referring Sites
291.00 (21.51%)
Direct Traffic
225.00 (16.63%)

Content Overview

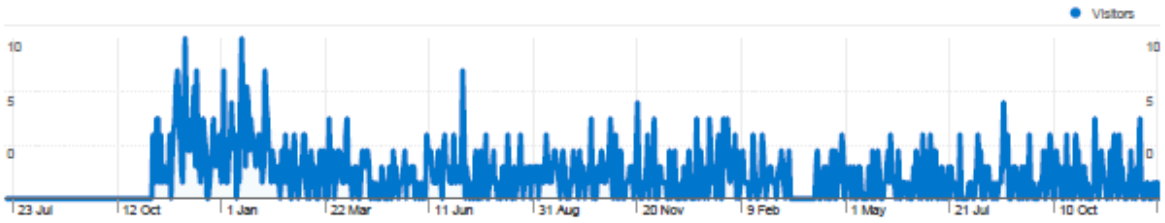
Pages	Pageviews	% Pageviews
/	693	14.22%
/project	389	7.98%
/activities	256	5.25%
/partners/kefri	194	3.98%
/home	194	3.98%

inco-foreaim.cirad.fr

Visitors Overview

18 Jul 2007 - 31 Dec 2009

Comparing to: Site



1,059 people visited this site

1,353 Visits

1,059 Absolute Unique Visitors

4,875 Pageviews

3.60 Average Pageviews

00:02:55 Time on Site

56.84% Bounce Rate

78.27% New Visits

Technical Profile

Browser	Visits	% visits
Internet Explorer	841	62.16%
Firefox	440	32.52%
Safari	27	2.00%
Chrome	12	0.89%
Mozilla	11	0.81%

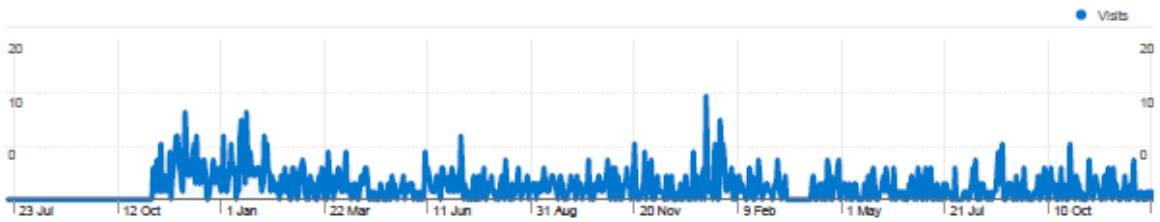
Connection Speed	Visits	% visits
Unknown	730	53.99%
DSL	316	23.37%
T1	193	14.28%
Cable	57	4.22%
Dialup	52	3.85%

inco-foreaim.cirad.fr

Traffic Sources Overview

18 Jul 2007 - 31 Dec 2009

Comparing to: Site



All traffic sources sent a total of 1,353 visits

16.63% Direct Traffic

21.51% Referring Sites

61.86% Search Engines

Search Engines
837.00 (61.86%)

Referring Sites
291.00 (21.51%)

Direct Traffic
225.00 (16.63%)

Top Traffic Sources

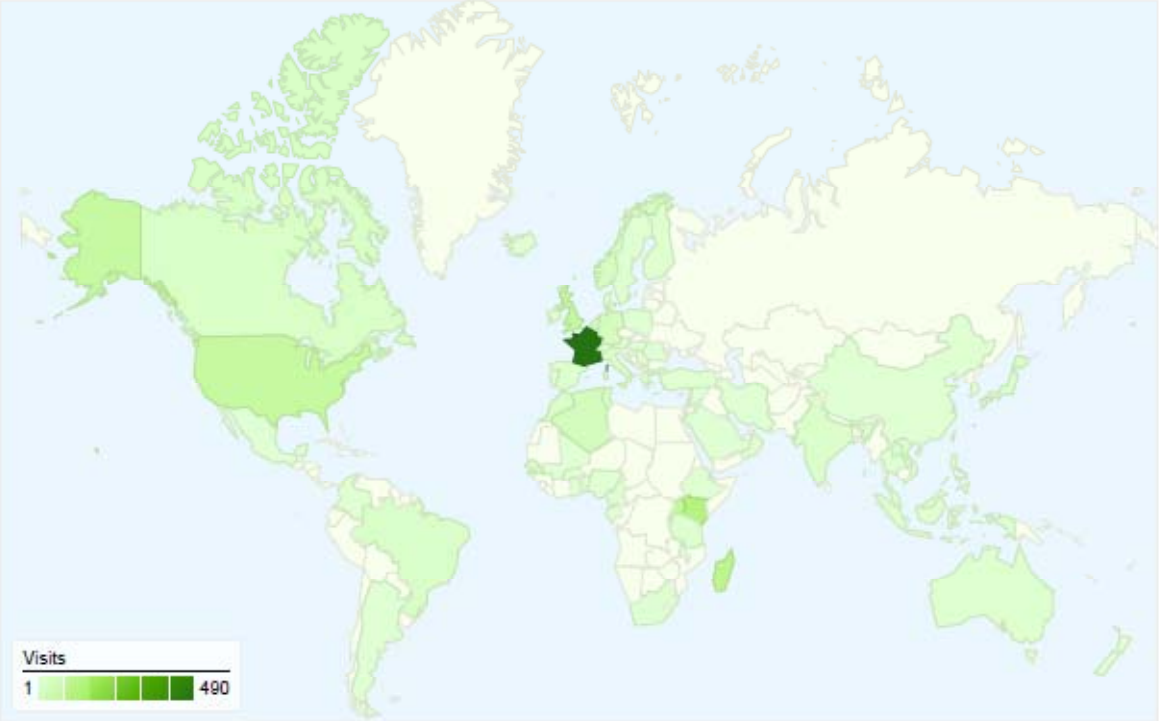
Sources	Visits	% visits
google (organic)	735	54.32%
(direct) ((none))	225	16.63%
cirad.fr (referral)	208	15.37%
yahoo (organic)	41	3.03%
live (organic)	35	2.59%

Keywords	Visits	% visits
foreaim	223	26.64%
kefri	89	10.63%
fofifa	41	4.90%
clavelée	11	1.31%
foreaim project	9	1.08%

inco-foreaim.cirad.fr

Map Overlay

18 Jul 2007 - 31 Dec 2009
Comparing to: Site



1,353 visits came from 77 countries/territories

Site Usage

Visits	Pages/Visit	Avg. Time on Site	% New Visits	Bounce Rate
1,353 % of Site Total: 100.00%	3.60 Site Avg: 3.60 (0.00%)	00:02:55 Site Avg: 00:02:55 (0.00%)	78.34% Site Avg: 78.27% (0.09%)	56.84% Site Avg: 56.84% (0.00%)

Country/Territory	Visits	Pages/Visit	Avg. Time on Site	% New Visits	Bounce Rate
France	490	4.38	00:03:25	72.04%	53.67%
Kenya	121	2.14	00:01:39	88.43%	64.46%
Madagascar	97	4.93	00:06:23	57.73%	43.30%
Uganda	82	3.23	00:04:29	71.95%	60.98%
United Kingdom	73	4.27	00:01:56	73.97%	43.84%
United States	72	1.96	00:00:21	90.28%	70.83%
Algeria	34	6.71	00:05:47	88.24%	41.18%
Germany	29	4.55	00:01:46	75.86%	37.93%
Norway	28	5.25	00:03:28	71.43%	46.43%
(not set)	26	2.04	00:02:09	73.08%	69.23%

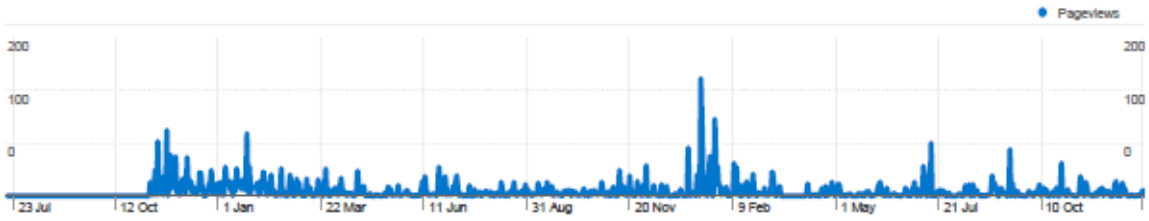
1 - 10 of 77

inco-foreaim.cirad.fr

Content Overview

18 Jul 2007 - 31 Dec 2009

Comparing to: Site



Pages on this site were viewed a total of 4,875 times

4,875 Pageviews

3,717 Unique Views

56.84% Bounce Rate

Top Content

Pages	Pageviews	% Pageviews
/	693	14.22%
/project	389	7.98%
/acivities	256	5.25%
/partners/kefri	194	3.98%
/home	194	3.98%

ANNEX2

FOREAIM

LIST OF THE MAIN PUBLISHABLE RESULTS

PUBLISHABLE RESULTS Work package 1 – Traditional ecological knowledge, tree management practices, uses and economic dependency of local population on forests and tree based systems in the context of their degradation

Publishable result title and reference (authors journal)	**Type of publication (article, student report, booklet,**	**Deliverable concerned**	**Deliverables concerned** Country/file name
Galabuzi C, Tabuti JRS, Kakudidi EK, Eilu G, Sibelet N. 2008. Traditional ecological knowledge, Management practices, use and economic dependence of local populations on forests and tree based resources: A state of art report for Mabira forest reserve, central Uganda, Makerere University, Kampala, 71 p.	Report	All the publishable results concerned most of the Deliverables	Uganda/D 1.2 WP1 UNIVMA.doc Uganda/Galabuzi Presentation.ppt 27 slides
Hervo C. 2007. Study practices, uses and representations of stakeholders in the forest to develop strategies for restoration of Mabira Forest Reserve, Central Uganda. AgroParis Tech, Montpellier. 88 p.	Master Thesis		NSstudents(Uganda)/ Présentation-Hervo-makerere.ppt NSstudents(Uganda)/ Rapport-HERVO-Ugandan FOREAIM WP1-2007.pdf NSstudents(Uganda)/ Rapport stage - foreaim uganda-1.pdf
Kübler D. 2007. Comment optimiser la participation des acteurs de la forêt de Mau dans la lutte contre la dégradation forestière? Tome 2 Comprendre les processus de décision pour construire des stratégies de restauration. AgroParis Tech, Montpellier. 67 p.	Master Thesis		NSstudents(Kenya)/ Rapport_Daniel_Kubler_Kenya.pdf
Lang'at D, Cheboiwo J, Sibelet N. 2008. Traditional ecological knowledge, tree management practices, uses and economic dependence of local population on forests and tree based systems in the context of their degradation, Nairobi, 30 p.	Report		Kenya/WP1 Kenya Report 2008.doc

Langat D, Cheboiwo J, Sibelet N, Garcia C. 2006. WP1 State of the Art Kenya, KEFRI, Nairobi, 22 p.	Report		Kenya/WP1_Kenya_state-art-draft3.doc
Mulugo L. 2008. Traditional Ecological Knowledge on tree management and restoration for Mabira forest, Uganda. Makerere, Kampala	Master Thesis		Uganda/FOREAIM- Lucy.ppt
Oddi A. 2007. How to optimise the operation of Mau forest's stakeholders participation in the struggle against forest degradation, Montpellier. 75 p.	Master Thesis		NSstudents(Kenya)/ Raport Oddi Kenya.pdf
Randriamiarinjato Charles J. 2008. Utilisation des ressources forestières dans la région de Anosibe an'ala. Antananarivo, Antananarivo. 94 p.	Master Thesis		Madagascar/Mémoire Jean Charles DRAFT.rtf
Randrianasolo R. 2006. Madagascar. Comparative study of Vohimana and Raboana, University of Antananarivo, Antananarivo, 104 p.	Master Thesis		Madagascar/2008_Mada_Randrianasolo_Rado.doc
Raveloarison RN. 2007. La conversion forestière: la régression de la forêt naturelle et la dynamique des plantations d'Eucalyptus autour de Moramanga. Antananarivo, Antananarivo. 49 p.	Master Thesis		Madagascar/Mémoire Rindra Madagascar.pdf
Razafindrabe R. 2006. WP1 state of the art Madagascar, FOFIFA, Antananarivo, 9 p.	Report		Madagascar/FOFIFA State of Art Draft2.doc
Razafindrabe R. 2006. Caractérisation de la degradation et etude des possibilités de restauraration du milieu forestier. FOFIFA, Antananarivo, 9 p.	Report		Madagascar/Rapport_FOFIFA_WP1_2008.rtf
Riche M. 2007. Etude de l'amont de filières de produits forestiers en vue de la réhabilitation des terroirs agroforestiers du triangle Moramanga-Beforona-Didy, est de Madagascar. Paris XII Val de Marne, Paris. 62 p.	Master Thesis		NSstudents(Madagascar)/ MémoireMaïwennRiche2007_10_05.pdf
Rives F. 2006. Faire le deuil de la forêt primaire pour sauver les forêts? Etude des pratiques, des usages et des représentations de	Master Thesis		NSstudents(Madagascar)/ Rapport Mastère FNS Fanny RIVES.pdf

la forêt pour élaborer des stratégies de restauration dans le corridor forestier de Ankeniheny Zahamena, est de Madagascar. ENGREF, Montpellier. 102 p.			
Rives F., Sibelet N, Montagne, P., A Mosaic of Worlds and Forests, Study of social perceptions to reconcile international concerns and local needs, *CIRAD, Montpellier, 2 p + poster*	Scientific poster		NSstudents(Madagascar)/ Rives-Sibelet-Montagne_2008_poster_Mosaic.pdf NSstudents(Madagascar)/ Rives-Sibelet-Montagne_2008_poster-texte_Mosaic.pdf.doc
Sibelet N. 2005. Start up meeting 24-28/10/2005 in Antananarivo, Madagascar, CIRAD, Montpellier, 13 p.	Mission report		NS missions reports/ Rapport_Mission_WP1_Mada_NS_2005_oct.pdf
Sibelet N. 2006. Lier restauration et multifonctionnalité pour les régions forestières dégradées en Afrique de l'est et à Madagascar. Rapport de Mission du 15 au 23 mai 2006 à Madagascar, CIRAD/FOFIFA/CENRADERU/UNIA, Montpellier, 6 p.	Mission report		NS missions reports/ Rapport_Mission_WP1_Mada_NS_2006_mai.pdf
Sibelet N. 2006. Mission Report: 2006, June 09-17, Workshop on State of The Art, CIRAD/MAK/KEFRI/FOFIFA/UNIA, Montpellier, 3 p.	Mission report		NS missions reports/ Mission_report_WP1_Uganda_NS_2006_june.pdf
Sibelet N. 2007. Listening to the stakeholders in a Research and Development project: Mission Report: 2007 May 28th June 23rd, CIRAD/UNIMAK/KEFRI, Montpellier, 30 p.	Mission report		NS missions reports/ Mission Report WP1 Uganda Kenya June-2007.doc
Sibelet N. 2007. Rapport de mission à Madagascar du 16 au 26 avril 2007, CIRAD, Montpellier, 36 p.	Mission report		NS missions reports/ Rapport mission WP1Mada NS avril 2007.doc
Sibelet N, Garcia C. 2006. Mission Report: Kenya-Uganda, CIRAD/KEFRI/MAK, Montpellier, 10 p.	Mission report		NS missions reports/ Mission_report_WP1_Kenya_Uganda_NS&CG_2006_feb.pdf
Tabuti JRS, Eilu G, Kakudidi EK, Sibelet N, Garcia C. 2006. WP1 State of the Art Uganda, University of Makerere, Kampala, 19 p.	Report		Uganda/UNIVMA WP1 State of Art Draft 2.doc

Tumuramye AM, Tabuti JRS, Muwanika V. 2008. Bridging the gap between utilization and conservation of plant resources in degraded forest landscapes of Uganda: a case study of Mabira Forest Reserve. Makerere, Kampala	Master thesis		Uganda/Presentation to FOREAIM.doc
University A. 2006. WP1 State of the Art Madagascar, University of Antananarivo, Antananarivo, 15 p.	Report		Madagascar/ WP1_state_of_art-WP1 univTana.doc
22 – 23 May 2008: Presented Paper on *Albizziz gummifera* at the Ecological Society for Eastern Africa ESEA in Sokoine University of Agriculture, Morogoro, Tanzania	Communication		Uganda/ see Ugandan team to get it
Eilu, G., Galabuzi C., Kakudidi, E., Tabuti, J.R.S, Sibelet, N. (2009). Technologies and conditions for participation and empowerment of rural communities in restoring degraded sites in Mabira forest reserve, Central Uganda : [Poster]. In : 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya. - s.l. : s.n., 2009**:** 1 p.	Poster		Eilu_Sibelet_2009_technologies&empowerment_Mabira_FOREAIM_WP1.pdf
Mulugo, L., G. N., Nabanoga K., Nabanoga, Gorettie Nsubuga K. Turyahabwe, N., Eilu, G., Galabuzi, C., Tabuti, J.R.S., Kakudidi, E. Sibelet, N.. (2009). Traditional knowledge on tree management and forest restoration of Mabira central reserve, Uganda : [Poster]. In : 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya. - s.l. : s.n., 2009**:** 1 p.	Poster		Mulugo_Sibelet_2009_traditional-knowledge_Mabira_FOREAIM_ WP1_WCA.pdf
David Langat, J.Cheboiwo, et Sibelet N. (2009) Forest use and dependency in west and south western mau forests,kenya [Poster]. In : 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya. - s.l. : s.n., 2009**:** 1 p.	Communication		
Ravelona, M., Montagne, P., et Sibelet N. (2009). The timber	Poster		

exploitation in Madagascar : from legal to clandestine passing through illegal. The case of the classified forest of Ambohilero, rural commune of Didy : [Poster]. In : Briding Restoration and Multi-functionality in Degraded Forest Landscape of Eastern African and Indian Ocean Islands Workshop, 17-20 November 2009, Nairobi, Kenya. - s.l. : s.n., 2009**:** 1 p.			

PUBLISHABLE RESULTS WP2 - Assessment of forest ecosystem degradation, and community structure and species biology for the development of restoration option

Publishable result title and reference (authors journal)	Type of publication (article, student report, booklet,	Deliverables concerned	Date of publication	Project Partners involved	Corresponding scientist
Approche sur la dynamique des formations vegetales de la reserve experimentale de Vohimana. H.Z. Hasiniaina M., C. Rajeriarison, M.A. Radimbison, E. Roger. *Tohiravina 2: receuil of document for the ecological follow-up of the program envoronnemental. Department of Vegetable Biology and Ecology. Faculty of Science, University of Antananarivo.* pp 75-83	Article	D2.2 D2.3 D2.4 D2.5 D2.7 D2.8	2007	University of Antananarivo	M.A. Radimbson, E. Roger, C. Rajeriarison
Typologie des formations vegetales de Vohimana. H.Z. Hasiniaina M., C. Rajeriarison, M.A. Radimbison, E. Roger. *Tohiravina 2: receuil of document for the ecological follow-up of the program envoronnemental. Department of Vegetable Biology and Ecology. Faculty of Science, University of Antananarivo.* pp 360-368	Article	D2.2 D2.3 D2.4 D2.7 D2.8	2007	University of Antananarivo	M.A. Radimbson, E. Roger, C. Rajeriarison
Caractérisations écologiques des formations végétales de la réserve expérimentale de Vohimana en vue d'une restauration écologique : inventaire floristique , Typologie , Profil écologique et étude diachronique . N.V. Manjato. Université d' Antananarivo . 110 p.	Master thesis	D2.2 D2.3 D2.4 D2.5 D2.7 D2.8	2008	University of Antananarivo	M.A. Radimbison, E. Roger, N. Manjato
Inventaire et typologie des formations vegetales de Vohimana en vue d'une restauration ecologique, H.Z. Hasiniaina M. 92 p.	Master thesis	D2.2 D2.3 D2.4 D2.5 D2.7 D2.8	2007	University of Antananarivo	M.A. Radimbson, E. Roger, H.Z. Hasiniaina M.

Recovery of plant species richness and composition after slash-and-burn agriculture in a tropical rainforest in Madagascar. Kari Klanderud, Hery Zo Hasiniaina Mbolatiana, Manjato Nadiah Vololomboahangy, Charlotte Rajeriarison, Marie Agnes Radimbson, Edmond Roger, Ørjan Totland. *Biodiversity and Conservation*	Article in scientific journal	D2.2 D2.3 D2.7 D2.8	2009	University of Antananarivo, UMB	Kari Klanderud
Effects of *Psiadia altissima* and *Lantana camarra* on the establishment of primary forest species in Vohimana forest, Madagaskar, K. Klanderud, Ø. Totland, H.Z. Hasiniaina M., N. Manjato V., C. Rajeriarison, M.A. Radimbson, E. Roger	Article in scientific journal	D2.4 D2.5 D2.7 D2.8	2010	University of Antananarivo UMB	Kari Klanderud
Recovery of species richness and composition of an abandoned settlement area in a tropical forest in Kenya. Jared Amwatta Mullah, Kari Klanderud, Orjan Totland. Submitted *Restoration Ecology*	Article in scientific journal	D2.2 D2.3 D2.8	2009	KEFRI UMB	Jared Amwatta Mullah
Recovery of species richness and composition of an abandoned settlement area in a tropical forest in Kenya. Jared Amwatta Mullah, Kari Klanderud, Orjan Totland.	Conference presentation	D3.7	2008	KEFRI UMB	Jared Amwatta Mullah
Selection of restoration species for degraded tropical forests. Jared Amwatta Mullah, Kari Klanderud, Orjan Totland.	Poster on scientific conference	D3.7	2009	KEFRI UMB	Jared Amwatta Mullah
Restoration of fallows using pioneer species in Vohuimana. Hery Zo Hasiniaina Mbolatiana, Manjato Nadiah Vololomboahangy, Charlotte Rajeriarison, Marie Agnes Radimbson, Edmond Roger	Poster on scientific conference	D3.7	2009	University of Antananarivo	M.A. Radimbson, E. Roger
Effects of the invasive species *Fraxinus pennsylvanica* on the population density of indigenous tree species in degraded Sub-humid Forests, Jared Amwatta Mullah, Kari Klanderud, Orjan Totland, David Odee	Article in scientific journal	D2.4 D2.5 D2.7 D2.8	2010	KEFRI UMB	Jared Amwatta Mullah
Regenerational potential of selected species of ecological and economic importance in Mau forest, Jared Amwatta Mullah, Kari Klanderud, Orjan Totland, David Odee	Article in scientific journal	D2.4 D2.5 D2.8	2010	KEFRI UMB	Jared Amwatta Mullah

Relationship between two tree species and the establishment of other species in a degraded tropical montane forests in Kenya: implications for restoration, Jared Amwatta Mullah, Kari Klanderud, Orjan Totland, Bernard Kigomi, David Odee	Article in scientific journal	D2.4 D2.5 D2.7 D2.8	2010	KEFRI UMB	Jared Amwatta Mullah
Forest restoration handbook for moist forests in Kenya	Handbook	D3.6	2010	KEFRI, UMB	Jared Amwatta Mullah
Recovery of plant species diversity and composition of degraded tropical mountain forest, Kenya. Jared Amwatta Mullah	PhD thesis	D2.2 D2.3 D2.4 D2.5 D2.6 D2.7 D2.8	2011	KEFRI UMB	Jared Amwatta Mullah
Population structure of selected timber species in Mabira FR, Balimunsi Moses	MSc Thesis	D2.5 D2.8	2008	Makerere Univ	Gerald Eilu, Joseph Obua
Tree species functional classification and its use in restoration of degraded forest: Case of Mabira Forest Reserve, Uganda. Muthalib Katumba	MSc Thesis	D2.7	2008	Makerere University	Gerald Eilu, Jan Dick
Patterns of specific leaf area of trees in Mabira forest, Uganda. M. Katumba, G. Eilu, J. Dick, M. Tweheyo, P. Ssegawa	Scientific article	D2.8	2010	Makerere University	Gerald Eilu
Describing functional groups for Mabira forest tree species and their potential role in restoration. M. Katumba, G. Eilu, J. Dick, M. Tweheyo, P. Ssegawa	Scientific article	D2.8	2010	Makerere University	Gerald Eilu
Describing functional roles of forest tree species in restoring degraded forests: the case of Mabira forest Uganda. M. Katumba, G. Eilu, J. Dick, M. Tweheyo, P. Ssegawa, R. Smith, K. Klanderud, Ø. Totland.	Poster on scientific conference	D3.7	2009	Makerere University	Gerald Eilu
Effect of harvesting techniques on the regeneration of *Acalypha neptunica* in Mabira FR, Mukono District, Kawooya Yasin	BSc.Special Project Report	D.2.5 D2.8	2007	Makerere Univ	Joseph Obua

Survival and growth of selected tree species. Muthalib Katumba, JBL Okullo	Scientific article	D2.5 D2.6 D2.8	2010	Makerere Univ	JBL Okullo, Gerald Eilu
The present and future value of floras for functional ecologists. Jan Dick, Ron Smith, Richard Wadsworth. *Descriptive Taxonomy Serving Biodiversity,* CRC Press - Systematics Association Special Volume series.	Scientific article	D2.8	2008	CEH	Jan Dick
Plant community succession after human disturbance in the Mabira forest. Paul Ssegawa, Gerald Eilu, Kari Klanderud, Ørjan Totland, et al.	Scientific article	D2.2 D2.3 D2.8	2010	Makerere Univ, UMB	Gerald Eilu
Effects of the invasive *Broussonetia papifera* on the plant species composition and diversity of degraded sites in the Mabira forest, Uganda. Mnason Tweheyo, Gerald Eilu, Paul Ssegawa, Kari Klanderud, and Ørjan Totland	Scientific article	D2.2 D2.3 D2.8	2010	Makerere Univ, UMB	Gerald Eilu
Biomass recovery after forest degradation in Mabira forest. Mnason Tweheyo, Gerald Eilu, Paul Ssegawa, Kari Klanderud, and Ørjan Totland	Scientific article	D2.2 D2.3 D2.7 D2.8	2010	Makerere Univ, UMB	Gerald Eilu
Soil properties and plant species composition following succession regimes in Mabira Forest Reserve. Gerald Eilu, Paul Ssegawa, Gilbert Majaliwa, Mnason Tweheyo, Bob Nakileza, Kari Klanderud, and Ørjan Totland	Scientific article	D2.2 D2.3 D2.7 D2.8	2010	Makerere Univ, UMB	Gerald Eilu
Potential of *Maesopsis eminii* for the restoration of degraded sites around Mabira Forest Reserve, Central Uganda: Godwin Ndemeere. Gerald Eilu	BSc.Special Project Report	D2.6 D2.8	2007	Makerere Univ	Gerald Eilu
Foreaim forest restoration handbook for Uganda	Handbook	D3.6	2010	Makerere Univ	Gerald Eilu
AVSKOGING I ØST AFRIKA OG PÅ MADAGASKAR: SUKSESJON, SAMFUNNSSTRUKTUR, OG ARTSKOMPOSISJON I ET RESTAURERINGSPERSPEKTIV	Popular science article	D2.2 D2.3 D2.8	2008	UMB	Kari Klanderud

Kari Klanderud, Ørjan Totland, Jared Amwatta Mullah. *Årsmelding INA,* 20-23.					

PUBLISHABLE RESULTS WP3 - restoration/rehabilitation through planting: characterisation and silviculture of native and naturalised species to restore environmental and economical function

Publishable result title and reference (authors journal)	Type of publication (article, student report, booklet,	Deliverables concerned	Date of publication	Project Partners involved	Corresponding scientist
Intraspecific chemical variability and highlighting of chemotypes of leaf essential oils from Ravensara aromatica Sonnerat, a tree endemic to Madagascar Hanitriniaina Sahondra Andrianoelisoa, Chantal Menut, Philippe Collas de Chatelperron, JérômeSaracco,4 Panja Ramanoelina and Pascal Danthu3* FLAVOUR AND FRAGRANCE JOURNAL Flavour Fragr. J. (In press)	Article in scientific journal	D3.5 D3.7	2008	CIRAD FOFIFA	P Danthu
Essential oil production increases value of Psiadia altissima fallows in Madagascar's eastern forests. Pascal Danthu, Miarantsoa Rakotobe, Pascale Maucle`re Æ Hanitra Andrianoelisoa, Olivier Behra Æ Voninavoko Rahajanirina Æ Barbara Mathevon Æ Eliane Ralambofetra Æ Philippe Collas de Chatelperron Agroforest Syst (2008) 72:127–135	Article in scientific journal	D3.5 D3.7	2008	CIRAD FOFIFA	P Danthu
Seasonal dependence of rooting success in cuttings from natural forest trees in Madagascar P. Danthu N. Ramaroson G. Rambeloarisoa Agroforest Syst DOI 10.1007/s10457-008-9116-7	Article in scientific journal	D3.3 D3.7	2008	CIRAD UNIVMATANA	P Danthu
Characterization of microsatellite markers in the rosewood (Dalbergia monticola Bosser & R. Rabev.) BENEDICTE FAVREAU, OLIVARIMBOLA ANDRIANOELINA,† PHILIPPE NUNEZ, ALEXANDRE VAILLANT, LOLONA RAMAMONJISOA, PASCAL	Article in scientific journal	D3.4 D3.7	2007	CIRAD FOFIFA/SNGF	JM Bouvet

DANTHU and JEAN-MARC BOUVET Molecular Ecology Notes (2007) 7, 774–776 doi: 10.1111/j.1471-8286.2007.01692.x					
Genetic diversity of Dalbergia monticola (Fabaceae) an endangered tree species in the fragmented oriental forest of Madagascar OLIVARIMBOLA ANDRIANOELINA1, HERY RAKOTONDRAOELINA2, LOLONA RAMAMONJISOA1, JEAN MALEY3, PASCAL DANTHU4 and JEAN-MARC BOUVET, Biodiversity and Conservation (2006) Springer 2006 DOI 10.1007/s10531-004-2178-6	Article in scientific journal	D3.4 D3.7	2006	CIRAD FOFIFA/SNGF	JM Bouvet
Analyse de la diversité des populations naturelles d'une espèce forestière menacée : *Dalbergia monticola* à Madagascar. Approche par marqueurs microsatellites nucléaires et chloroplastiques. NUNEZ Philippe	Thesis of master of science University of Monpellier II	D3.4 D3.7	2006	CIRAD FOFIFA/SNGF	JM Bouvet
DIVERSITE GENETIQUE D'UNE ESPECE FORESTIERE EN MILIEU FRAGMENTE : APPROCHE A PLUSIEURS ECHELLES CAS DE DALBERGIA MONTICOLA A MADAGASCAR	Thesis of master of science University Pierre et Marie-Curie Paris	D3.4 D3.7	2007	CIRAD FOFIFA/SNGF	JM Bouvet
Propagation and utilisation and conservation of African Satinwood species (Zanthoxylum Gillettii) in Kenya Michael OKEYO	Thesis for a master of science	D3.3 D3.7	Sept. 2008	KEFRI	J Mbinga
Transfer of microsatellite loci for the tropical tree Prunus africana (Hook. F.) Kalkman. S Cavers et al Silvae Genetica	Article in scientific journal	D3.4 D3.7	Dec. 2008	CEH KEFRI	S Cavers
Microsatellite markers in Prunus S. Cavers et al Conservation genetics	Article in scientific journal	DE3.7	Dec 2008	CEH, KEFRI	S. Cavers D. Odee J. Mbinga

Genetic structure of Albizzia gummifera and local adaptation to associated Natongo et al (this line is repeated below ?)	Master thesis University of Makarere	D3.4 D3.6 D3.7	Sept. 2008	CEH UNIVTA KEFRI UNIVMA	JB Okullo S cavers
Structuring of genetic diversity in Albizzia gummifera C.A.Sm. among some East African and Madagascan populations. Nantongo et al African Journal of Ecology	Article in scientific journal	D3.4 D3.6 D3.7	Oct. 2009	CEH UNIVTA KEFRI UNIVMA	JB Okullo S Cavers
Adaptation of Albizzia gummifera Nantongo et al In preparation	Article in scientific journal	D3.4 D3.6 D3.7	Dec 2010	CEH UNIVTA KEFRI UNIVMA	JB Okullo S Cavers
Handbook on silviculture of some native Malagasy species used in restoration	handbook	D3.6	May 2009	FOFIFA	Z Rakotovao N Razafindrianilana
Forest Restoration Handbook of Uganda	handbook	D3.6	May 2009	UNIVMA	G. Eilu et al.
Potential of *Maesopsis eminii* engl. for the restoration of degraded sites around Mabira forest reserve, central Uganda	Special Project Report	D3.6	Jun. 2007	UNIVMA	G Ndemere GE ilu
Propagating Indigenous Anti-Malarial Medicinal Trees A manual for *Warburgia ugandensis*, *Syzygium guineense* & *Hallea rubrostipulata*	Technical Report	D3.4 D3.6	Dec. 2008	UNIVMA	Charles Galabuzi, Gerald Eilu, Joseph Obua & Paul Ssegaw
Technical report on the planting of Malagasy species in degraded forest	Technical report	D3.6	Dec. 2008	FOFIFA	Z Rakotovao
Booklet on the silviculture of four Malagasy species	booklet	D3.6	May 2008	FOFIFA	H Randrianjafy
Technical report on propagation techniques for valuable Malagasy tree species : germination and vegetative propagation	Technical report		May 2008	FOFIFA	Z Rakotovao
ESSAI DE RESTAURATION ECOLOGIQUE ET REHABILITATION DE LA FORET DE VOHIMANA PAR PLANTATION D'ARBRES	Master thesis University of Antananarivo	D3.6	Sept. 2008	UNIVTA	Yari Jeannoda

Christophe MANJARIBE					
Movie on the exploitation of Ravensara aromatica	movie			FOFIFA CIRAD	P Danthu
Cavers, Munro, Mbinga, Degen, Odee (2009) Conservation of *P africana* in agroforestry systems: effects on genetic resources. Environmental Management.	Article in scientific journal	D3.4 D3.7	Nov. 2008	CEH, KEFRI	S Cavers
Cavers, Munro, Mbinga, Degen, Odee (2009) Conservation of *Prunus africana* in agroforestry systems: effects on genetic resources. Environmental Management.	Paper at conference	D3.7	Aug. 2009	CEH, KEFRI	S Cavers
Nantongo, Okullo, Eilu, Cavers, Ingleby, Wilson Genetic structuring of Albizia gummifera and local adaptation to associated mycorrhiza	Poster at conference	D3.7	Aug. 2009	CEH, UNIVMA	JB Okullo
Andrianoelina Andrianaivo O., Favreau B., Ramamonjisoa L., Bouvet J.M. 2009. Small effect of fragmentation on the genetic diversity of *Dalbergia rnonticola*, an endangered tree species of the eastern forest of Madagascar, detected by chloroplast and nuclear microsatellites . *Annals of botany*, 104 (6) : 1231-1242.	Article in scientific journal	D3.4 D3.7	Nov 2009	CIRAD FOFIFA	JM Bouvet

PUBLISHABLE RESULTS WP4 – Characterization of edaphic conditions in degraded forest landscape to predict forest restoration suitability

Publishable result title and reference (authors journal)	Type of publication (article, student report, booklet,	Deliverables concerned	Date of publication	Project Partners involved	Corresponding scientist
Mycorrhiza assemblages in relation to restoration stages and selected soil properties in Mabira Forest reserve, Uganda (presented at 3rd FOREAIM Steering Committee meeting, 2008) Sebuliba, E, Eilu, G., Nyeko, P. Majaliwa J.G.M, and Obua, J.	Poster and oral presentation (Student project)	4.3	2008	MU	Sebuliba, Nyeko
Mycorrhiza assemblages in relation to restoration stages and selected soil properties in Mabira Forest reserve, Uganda (Student: Sebuliba, E)	MSc. thesis	4.3	2009	MU	Sebuliba
Genetic structure of Albizia gummifera and its adaptation to associated mycorrhiza (Student: Nantongo J.)	MSc. thesis	4.4	See WP3, D3.4,3.6,3.7		
Characterisation of edaphic conditions in degraded landscape to predict forest restoration suitability in Vohimana (presented at 3rd FOREAIM Steering Committee meeting, 2008)	Oral presentation	4.2, 4.3	2008	UA	Isabelle Ratsimiala Ramonta
Characterisation of edaphic conditions in degraded landscape to predict forest restoration suitability in Vohimana (Student: Rakotondraina Misa L.)	MSc. thesis	4.3	2008	UA	Isabelle Ratsimiala Ramonta
Characterisation of edaphic conditions in degraded landscape to predict forest restoration suitability in Vohimana (presented at 4rd FOREAIM Steering Committee meeting, 2009)	Poster presentation	4.6	2009	UA	Isabelle Ratsimiala Ramonta
Test of effectivity and genetic structure of Albizia gummifera in Madagascar (Student: Tera Fredo Gilbert, 2009)	MSc.thesis (in redaction)	4.3	December2009	UA	Isabelle Ratsimiala Ramonta
Fungal communities variations with plant communities in Kedowa Forest reserve, Kenya	Scientific publication	4.3	2009	KEFRI, CEH	Lesueur
Characterization of edaphic conditions in natural plantations and fallow lands in Kenya (Kedowa, Rift Valley)	Poster presentation	4.6	2007	IRD, CIRAD, KEFRI	Assigbetsé
Diversity and activities of soil microfauna and microorganisms affected by forest management (Kedowa, Kenya)	Scientific publication in prep	4.6, 4.3	2010	IRD, CIRAD, KEFRI	Assigbetsé

Bridging restoration and multi-fonctionality in degraded forest	Folder	4.8	November2009	UA	All team of Foreaim
Nodulation and responsiveness of Albizia spp. and other legumes in relation to landuse change in Kenya	Scientific publication in prep	4.3	2010	IRD, KEFRI, CEH, MU	Wilson
Abundance and diversity of mycorrhiza in Mabira Forest Reserve (MFR)	Scientific publication in prep	4.8	2010	MU, CEH	Sebuliba,
Determination of the best mycorrhiza application rate for enhancing Calliandra sp. and Maesopsis sp. tree growth	Scientific publication in prep	4.8	2010	MU	Sebuliba,
Mycorrhiza Assemblages in relation to restoration stages and selected soil properties in Mabira forest reserve	Power point Presentation at FOREAIM 3rd steering committee	4,8	2008	MU	Sebuliba,
Abundance and Diversity of Absucular Mycorrhiza In Mabira Forest Reserve, Uganda	Poster presentation at World Congress of Agroforestry, Nairobi Kenya, 23-28 August 2009	4,8	2009	MU CEH	Sebuliba,

PUBLISHABLE RESULTS WP5 - Examining the effects of differing vegetative covers, enrichment planting, agroforestry and other remedial treatments on losses of soil, plant nutrients and organic matter from degraded agricultural, agroforestry, fallow and forested landscapes.

Publishable result title and reference (authors journal)	Type of publication (article, student report, booklet, etc)	Deliverables concerned	Date of publication	Project Partners involved	Corresponding scientist
Soil hydrological properties of Mabira forest reserve	Conference presentation. Soil Science Society of East Africa	5.2	2006	Makerere University	Majaliwa J.G.M
Soil hydrological properties of Mabira forest reserve J Hydrology Majaliwa J.G.M, Nakileza, B., Eilu, G., Wilson, J.,. Kizza, C.L	Scientific paper	5.2	In prep.	Makerere University/CEH	Majaliwa J.G.M
Effect of land use on properties of soils within and around Mabira forest reserve. Tillage Majaliwa J.G.M, Nakileza, B., Eilu, G., Wilson, J. Kizza, C.L	Scientific paper	5.2	In prep.	Makerere University/CEH	Majaliwa J.G.M
Role of the forest reserve in stability of the Mabira watershed Majaliwa J.G.M, Nakileza, B., Eilu, G., Wilson, J.. Kizza, C.L	Scientific paper	5.2	In prep,	Makerere University / CEH	Majaliwa J.G.M
Soil and nutrient losses from Mabira forest Kizza C.L	MSc thesis submitted and passed	5.2	Jan 2010	Makerere University	
Soil and nutrient loss from Mabira forest reserve along a regeneration chronosequence Kizza, C.L, Majaliwa J.G.M, Nakileza, B., Eilu, G., Kansiime F, Wilson J	Conference poster (World Agroforesty Congress, Nairobi)		August 2009	Makerere University	

Soil and nutrients losses from restored Mabira forest reserve blocks. Kizza, C.L , Majaliwa J.G.M, Nakileza, B., Eilu, G., Wilson, J.	scientific paper (Agroforestry Journal)	5.2	In prep	Makerere University / CEH	Kizza, CL
Contribution of Mabira Forest reserve to non-point pollution abatement Majaliwa J.G.M, Kizza, C.L , et al	Scientific paper	5.2	In prep		Majaliwa J.G.M
How to control erosion on farm	Booklet / handout	5.3 and 7	2009	Makerere University	
Landuse in the Mabira Forest Reserve and implications for erosion and nutrient balance	Briefing note	5.3 and 7.	2009	Makerere University	Majaliwa J.G.M
Forest roles on the soil protection against erosion in Vohimana, Madagascar. A, Nicolas	Technical report	5.2	2009	FOFIFA	Nicolas, A.

PUBLISHABLE RESULTS WP 6 –Improving human well-being by developing market access and economic benefits for local populations

Publishable result title and reference (authors journal)	Deliverable title	Main characteristics (format etc…)	Date of publication	Partner involved	Corresponding scientist
	D6.2				
KenyaWP6EconomicsOfRestoration2008.doc Growth, yield, and economic benefits from four potential indigenous species for restoration of Mau Forest in Kenya. Paper presented to FOREAIM Regional held on 24th to 30th April 2008 in Makerere University. Kampala, Uganda. Mugabe Robert Ochieng1, Joshua K. Cheboiwo2 and Joram Mbinga3	D6.2a	Foreaim internal report	Draft April 2008 Final report expected September 2008	KEFRI	J. Cheboiwo
	D6.3 :				
Kenya Markets for forest products-FOREAIM.doc Analysis of potential markets for products	D6.3a	Foreaim internal report	March 2008oreaim	KEFRI	J. Cheboiwo

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[3] Senior Research Officer, WP3 Leader, Kenya Forestry Research Institute, Londiani RRC Email: kefri-ln@africaonline.Co.ke or jmbinga@yahoo.com

Publishable result title and reference (authors journal)	Deliverable title	Main characteristics (format etc…)	Date of publication	Partner involved	Corresponding scientist
from Mau forests Mugabe O. Robert4 and Joshua K. Cheboiwo5					
UgandaFOREAIM wp 6 2008 draft report.doc Economic potential of main restoration species in Mabira Forest Reserve, Central Uganda A Draft Progress Report on deliverable Six of Work Package 6	D6.3c	Foreaim internal report	April 2008 Final report expected sept 2008	MAK	M. Tweheyo, N. Turyahabwe
	D6.4.				
MadagascarMémoire Elyse Prunus version finale.doc Rahelisoa Elysée. 2006. Importance de l'exploitation de Prunus africana dans l'activité économique des paysans. Cas de l'exploitation de Prunus africana dans la forêt de la commune de Moramanga.	D6.4a	MSc thesis	Sept 2006	CIRAD	P. Montagne
Riche Maïwenn. 2007. Etude des filières de plusieurs espèces forestières de réhabilitation des terroirs agroforestiers du triangle Moramanga – Vohimana – Didy, Madagascar	D6.4b	MSc thesis	Oct 2007	CIRAD	P. Montagne
Razafitsiarovana NH., 2006	D6.4c	MSc thesis	Dec 2006	CIRAD	P. Montagne

[4] Student School of Natural Resource Management Moi University, Email mugabero@yahoo.com

[5] Principal Research Officer , Co-PI WP6 Economics and Benefits from Forestry Restoration, Kenya Forestry Research Institute, Londiani RRC Email: kefri-ln@africaonline.Co.ke or jkchemangare@yahoo.com

Publishable result title and reference (authors journal)	Deliverable title	Main characteristics (format etc…)	Date of publication	Partner involved	Corresponding scientist
Fonctionnement de la filière huile essentielle et pérennisation d'une espèce forestière endémique menacée de disparition : Ravensara aromatica à Madagascar					
Raveloarison Rindra Nirina., 2006. La conversion forestière: la régression de la forêt naturelle et la dynamique des plantations d'eucalyptus en forêt d'Ankeniheny, sur l'axe Moramanga - Anosibe An'Ala et entre Moramanga et Ambatondrazaka.	D6.4d	MSc thesis	April 2007	CIRAD	P. Montagne
POTENTIAL MARKET ACCESS AND SOCIAL ECONOMIC BENEFITS FOR WOOD AND NON WOOD FOREST RESOURCES BY COMMUNITIES LIVING ADJACENT TO WEST MAU FORESTS Martha Mukonyi6 and Joshua K. Cheboiwo7	D6.4e	MSc thesis	Dec 2007 Final expected sept 2008	KEFRI	J. Cheboiwo
THE MARKETING STRUCTURE FOR WOOD AND NON-WOOD FOREST PRODUCTS OBTAINED FROM MABIRA FOREST RESERVE	D6.4f	Foreaim internal report	April 2008 Final expected September 2008	UNIV MAKERERE	T. Barongo

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Publishable result title and reference (authors journal)	**Deliverable title**	**Main characteristics (format etc…)**	**Date of publication**	**Partner involved**	**Corresponding scientist**
MadagascarRavelona, Maafaka. 2007. La filière illicite du bois d'œuvre dans la région Alaotra-Mangoro	D6.4g	Foreaim internal report	Décembre 2008	CIRAD UNIVTA	P. Montagne
MadagascarRapport_restaurationKarpe.doc Le cadre juridique du commerce du bois et des produits forestiers non ligneux issus des zones de restauration Karpe et Randrianarison	D6.5	Foreaim internal report	Nov 2007	CIRAD UNIVTA	P. Karpe
UgandaD 6.5 Legal aspects.doc Report on legal and judicial aspects for trade in the wood and NWFP produced from restoration areas		Foreaim internal report	May 2007	MAK	M. Tweheyo, N. Turyahabwe
CBDBoisNON Oeuvre2.doc Sustainable management of non-timber forest resources	D 6.8	Foreaim internal report	May 2008	MAK	M. Tweheyo,
REVIEW OF THE POTENTIAL ELIGIBILITY OF TREE PLANTING IN RESTORATION ACTIVITIES TO CDM Mugabe O. Robert and Joshua K. Cheboiwo		Foreaim internal report	April 2008	KEFRI	J. Cheboiwo
Timber exploitation in Madagascar: from legal to clandestine passing through illegal The case of the classified forest of Ambohilero, rural commune of Didy **Carole Andrianirina** **Pierre Montagne** **Georges Rakotovao,**		Poster	2009	ESSA AGRO CIRAD FOFIFA DRFP,	**Pierre Montagne**

Publishable result title and reference (authors journal)	**Deliverable title**	**Main characteristics (format etc…)**	**Date of publication**	**Partner involved**	**Corresponding scientist**
Exploitation illicite de bois d'oeuvre et rendement matière de première transformation **Carole Andrianirina** **Pierre Montagne** **Georges Rakotovao,**		Poster	2009	ESSA AGRO CIRAD FOFIFA DRFP,	**Pierre Montagne**
Agroforestry and charcoal making for forests restoration and improvement of local population's livelihoods Pierre Montagne, Maafaka Ravelona, Nicole SIBELET, Mnason Tweheyo,		Poster	2009	ESSA AGRO CIRAD FOFIFA DRFP,	**Pierre Montagne**

PUBLISHABLE RESULTS WP7 – Effective tools for uptake by stakeholders of sustainable restoration strategies

Publishable result title and reference (authors journal)	Type of publication (article, student report, booklet,	Deliverables concerned	Date of publication	Project Partners involved	Corresponding scientist
Comment optimiser la participation des acteurs de la forêt de mau dans la lutte contre la dégradation forestière Daniel Kubler	Master of science thesis agroparistech	D7.1	2007	Cirad KEFRI	
elaboration of a National reports on forest restoration strategies and implementation – FFRH-Kenya	Technical book	D7.8	2010	KEFRI	J Kimiti
elaboration of a National reports on forest restoration strategies and implementation – FFRH-Uganda	Technical book	D7.8	2010	University of Makerere	G Eilu
elaboration of a National reports on forest restoration strategies and implementation – FFRH-Madagascar	Technical book	D7.8	2010	FOFIFA University of Antananarivo	B. Rakouth H Randrianjafy
MIRANA: a socio-ecological model for assessing sustainability of community-based regulations Sigrid Auberta,b, Jean-Pierre Müllera, Julliard Ralihalizarab	Communication in International Congress on Environmental Modelling and Software Modelling for Environment's Sake, Fifth Biennial Meeting, Ottawa, Canada David A. Swayne, Wanhong Yang, A. A. Voinov, A. Rizzoli, T. Filatova (Eds.)		2010	CIRAD	Sigrid Aubert