FUNCiTREE

REPORT

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Functional Diversity: An ecological framework for sustainable and adaptable agro-forestry systems in landscapes of semi-arid and arid eco-regions

Report 36 months

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ORGANIZATION:
FUNCiTree consortium

LIST OF CONTRIBUTORS:
Armas, Cristina
Barton, David N.
Bocary, Kaya
Bitchibaly, Kounkandji
Buurman, Peter
Casanoves, Fernando
Clinquart, Pierre
DeClerck, Fabrice
Diouf, Mayécor
Diop, Papa M.
Fall, Dioumacor
Gaye, Abibou
Guerrin, Hubert
Hoosbeek, Marcel
Ibrahim, Muhammad
Ickowicz, Alexandre
Ndiaye, Ibrahim
Nantoume, Hamidou
Pugnaire, Francisco
Rocha, Lester
Rusch, Graciela M.
Sánchez, Dalia
Skarpe, Christina
Thaler, Phillipe
Traoré, El Hadji
Villanueva, Cristóbal
Yossi, Harouna

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Graciela M. Rusch

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CONTACT INFORMATION
Graciela M. Rusch Graciela.rusch@nina.no

Norwegian Institute for Nature Research www.nina.no

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Abbreviations

AF: Agroforestry

AFS: Agroforestry systems

AKT: Agroecological Knowledge Toolkit

BBN: Bayesian Belief Network

CATIE: Centro de Agricultura Tropical de Investigación y Enseñanza

CIRAD: Centre International de Recherche Agronomique pour le Développement

CSIC: Consejo Superior de Investigaciones Científicas

ICRAF: World Agroforestry Centre

IER: Institut d'Economie Rurale, Mali

ISRA: Institut Senegalais de Rechercher Agricoles

MVP: Millennium Villages Project

MCA: Multi-criteria analysis

NINA: Norwegian Institute for Nature Research

RCN: Research Council of Norway

VER: Verifiable Emission Reduction

WP: Workpackage

WUR: Wageningen University

1 Objectives

The overall objective of FUNCiTree is to improve the understanding of the socio-cultural, economic and ecological limitations to the adoption of good agro-forestry practices in livestock production systems in the semi-arid tropics in order to expand and improve the practice of socio-economically and ecologically sustainable livestock production in marginal semi-arid areas. The core of the work falls into three natural categories and implementation is structured into three sub-programs accordingly. The first (WP 1, 7 & 8) addresses issues of management, co-ordination, dissemination, and the ensuring of positive concrete impacts from the insights gained from the work; the second (WP 2-4) analyses various properties of current AF livestock production systems in semi-arid regions across a range of ecological and socio-economic conditions including: i) the social, economic and ecological causes of the adoption/non-adoption of AFS functions in areas with and without organised AF outreach programmes (WP 2), ii) the farmer perceptions of AFS tree functions (WP3), and iii) the ecological functions of AFS trees, including the adaptive variability of trees species along aridity gradients, the effects on soil fertility, and the interaction with livestock and with under-storey vegetation (WP4). The third category (WP 5-7) deals with a synthesis and projections for knowledge-based management of AF systems locally and across semi-arid regions.

1.1 Objectives for the reporting period

The technical objectives of the work in this reporting period (18 to 36 months) refer to deliverables those stated in workpackages 2-7:

(WP2) Deliverables 2.1 and 2.2 in WP 2 were reported in the 18-months report. The aim of the activities in WP 2 in this period was of synthesis, dissemination and informing activities of other work packages.

(WP3) Deliverables 3.1, 3.2 and 3.3. in WP 3 were reported in the 18-months report. The aim of the activities in WP 3 in this period was to consolidate a database on farmer perceptions of the AFS tree traits and the services for cross-site comparisons, publication and synthesis to inform other work packages.

(WP4) To consolidate a data base on AFS tree ecological functional attributes (WP4).

(WP5) To conduct a cross-regional synthesis of functional trait portfolios of AFS based on tree functional diversity in relation to local and household needs.

(WP6) To conduct exploratory economic analysis and start survey of farm production systems.

(WP7) To promote participatory improvement of AFS and technologies

Specifically, the objective of WP 2 was to synthesize the data from the inventory of AFS practiced in the study sites on the adoption of regional agroforestry systems (AFS) to produce scientific publications, and to inform the collection of data in WP 4, the socio-economic analysis in WP 6, and the demonstration activities in WP 7.

The aim of WP3 in this period was to consolidate the data bases on local knowledge generated at the sites for synthesis and dissemination, and to provide cross-site standards of AFS functions based on local knowledge to enable cross-site comparisons.

The species lists and the AFS functions identified in WP 3 were the basis for the selection of tree species on which the traits and ecological functions linked to critical ecosystem services were measured and assessed in WP 4. Eco-physiological traits were measured in the three sites, some laboratory analysis are being processed. The data base has been constructed and the majority of the data have been entered and quality-checked. Work on a series of publications is ongoing.

WP 5 had one objective for the reporting period: a synthesis of eco-physiological and knowledge base traits.

WP 6 had two main objectives for the reporting period: (1) to produce a probability assessment of the financial feasibility models and (2) to conduct a multi-functionality assessment of AF farms.

In this reporting period, WP 7 would establish the protocols for the demonstration activities.

WP 8 had two main objectives: (1) the production of compatible databases for comparative analyses and (2) the production of dissemination material.

2 Work progress and achievements during the period

In this section we present a summary of achievements of the tasks with deliverable deadlines within the reporting period (WPs 2 - 8) and of tasks in the WPs that are in progess.

2.1 Farmer's perceptions of agroforestry system (AFS) tree species and their traits (WP3)

Tasks 3.1, 3.2 and 3.3 were reported in the 18-months report (Rusch et al. 2010). These tasks dealt with the compilation of a tree species list for the three sites, surveys about the local knowledge of species traits and or the agroforestry functions they perform. During the reporting period we report Task 3.4

CROSS-SITE COMPARISONS OF TREE TRAITS AND FUNCTIONS BASED ON LOCAL KNOWLEDGE (TASK 3.4, MONTH 30)

The goal of this task is to understand the universality of traits and function relationships with the ultimate goal of designing modernized regionally explicit AFS with improved capacities to provide multiple AFS functions. The data collected in tasks 3.1 to 3.3 were compiled and the relationships between locally important species traits and the capacity of the species to provide specific services were identified. Species were clustered by traits. Traits that farmers consistently identify as being related to the capacity or inability of a species to provide a particular service are highlighted. The analysis was conducted both at the site level, and more importantly across sites to compare whether regionally distinct farming communities share similar classification schemes for AFS species. The 'agroecological knowledge toolkit' (AKT) methodology that was used in one of the West African sites (Ségou) and in Rivas enabled the development of knowledge bases that are comparable. This allowed local and scientific knowledge to be compared and evaluated. Although the functions in the Potou site (Senegal) may to some extent be specific because of the variety of stakeholders and agroforestry systems in the area (combining crop, livestock, orchard and fishery activities), the socio-ecological systems in both West African sites are similar and share a large pool of species (103 common species out of a total of 263 species identified). These similarities will enable to draw broad patterns of similarities and differences between the sites in West Africa and Central America.

Results

The functions fulfilled by species according to the farmers in Ségou are summerized in Table 1. The most important differences with the Rivas site is that in the West African site, a larger variety of functions is fulfilled by trees and that several different species can contribute to the same function. Very few species are unifunctional (Table2).

Table 1: Number of species quoted for each of function in Ségou (West Africa)

Provision functions	Human food	Animal feed	Firewood	Timber	Income	Human pharmacopeia	Animal pharmacopeia	Various domestic uses	Magic-religious uses
Number of species	32	46	49	35	42	55	14	17	8

Supporting functions	Improvement of soil fertility	Antierosive action	Shade	Live fences	Dead fences	Biodiversity conservation
Number of species	36	32	38	14	11	4

Socio-cultural functions	Land mark	Patrimony	Esthetic
Number of species	21	10	2

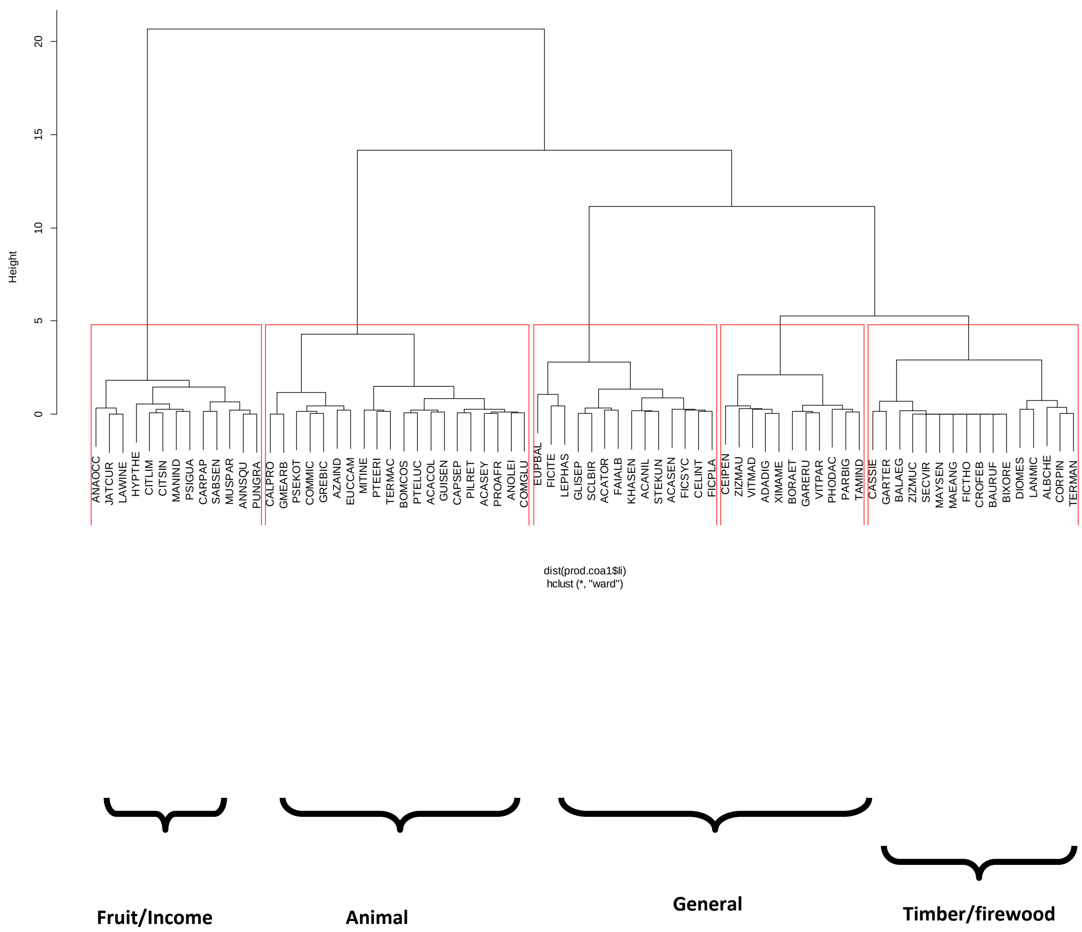
Table 2 : Functions fulfilled by unifunctional species in Ségou (West Africa)

Unifunctional species	**Function fulfilled**
Acacia colei	Firewood
Bixa orellana	Domestic use (food condiment)
Carica papaya	Human food
Delonix regia	Shade
Gmelina arborea	Timber
Maerua angolensis	Human pharmacopeia
Maytenus senegalensis	Human pharmacopeia

Species could be grouped according to the functions they perform in the socio-ecological system (Fig. 1). A first group “food and income” is composed primarily of fruit species whose fruits can be both consumed and marketed. A second group of species fulfill primarily the function of timber and firewood provision, and a third group “animal” includes fodder species and others used to to prevent or treat livestock diseases. These three groups are well separated from each other, which shows that despite that each species generally fulfil various functions (Table 1), many of them are primarily associated with one or two main functions.

A fourth group can be distinguished by a more generalist functionality. It makes the interface between the groups “food and income” and “animal”. It is notably composed of symbolic species such as the baobab (*Adansonia digitata*), the African locuste bean tree (*Parkia biglobosa*), the tamarind (*Tamarindus indica*), the shea-butter tree (*Vitellaria paradoxa*) and the jujube tree (*Ziziphus mauritiana*).

Figure 1: *Hierarchical classification resulting of the COA concerning production functions of tree species according to farmers in Tiby (Mali)*



These analyses are ongoing; a series of cientific papers is planned (see Annex 1 – list of forthcoming publications).

2.2 Identification of ecological functional attributes, synergies and trade-offs within tree species (WP 4)

The core activities in WP 4 during the reporting period have been the collection of tree traits, of ecological effect functions, and of the biophyisical characteristics of the sampling locations. Secondly, a consolidated database with data from the three sites has been developed. The following achievements have been reached:

1) Land-form/soil maps for the three sites (Buurman & Hoosbeek 2009; Buurman & Hoosbeek 2010; Bitchibaly 2011; Bitchibaly et al. 2012).

2) Field data of a set of eco-physiological traits associated with tree species water economy, the maintainance of soil fertility, forage provision, and the interactions with the understorey vegetation.

3) Field data of the effects of trees on micro-climate and light conditions, soil moisture and nutrient contents, animal preference, and the production of understorey vegetation.

4) Data retrieved and collated from existing databases (CIRAD data-base on tree organs chemistry and World Agroforestry Centre data-base on wood density).

DRY SEASON PRODUCTIVITY, DROUGHT TOLERANCE AND WATER USE EFFICIENCY (TASK 4.1, MONTH 25)

Trees were selected and trait measurements were conducted following a common protocol (Table 2). A majority of the traits were assessed in all sites. The data have been collated in the trait base (Annex 2)

***Table 2**: List of plant functional trait variables measured to assess tree water use economy in Potou, Ségou and Rivas including a description, unit of measure, and the source of data used.*

Trait	Description	Unit	Source
Whole plant			
TH	Tree height	M	Measurements, Literature
CH	Canopy height	M	Measurements
HLB	Height to the lowest branch	M	Measurements
C-D	Canopy diameter	M	Measurements
CD	Canopy density	%	Measurements
CS	Canopy shape	m/m	
DBH	Diameter breast height	Dm	Measurements
PH	Crown phenology	-	Literature
Leaf traits			
LA	Leaf area	mm^2	Measurements
SLA	Specific Leaf Area	mm^2mg^{-1}	Measurements
LDMC	Leaf Dry Matter Content	$mg\ g^{-1}$	Measurements
LRWC	Leaf relative water content	%	Measurements
LAI	Leaf Area Index	-	Measurements
DIFN	Transmitted light	%	Measurements
PL	Petiole length	Mm	Measurements
TS	Leaf tensile strength	Nmm^{-1}	Measurements
LT	Leaf thickness	Mm	Measurements
LN	Leaflet number	-	Measurements
Root traits			
SRL	Specific root length	Mm^2mg^{-1}	Measurements
RD	Root density	$g\ cm^{-3}$	Measurements
Twig traits			
TDMC	Twig dry matter content	$mg\ g^{-1}$	Measurements
TRWC	Twig relative water content	%	Measurements
δO^{18} δC^{13}	Isotopic signal		Measurements
WD	Wood density	$mg\ mm^{-3}$	Existing D-bases

Preliminary findings (Olivero 2010, Diouf et al. in progress) suggest that there are specific traits associated with responses to climatic stress, and that species can be grouped according to different strategies of water use that indicate different mechanisms of coping with rainfall seasonality (ranging from a strategy of resource acquisition to resource conservatism) which are likely associated with use of different water sources. This question will be elucidated with the analysis of isotopes that is partially completed.

MAINTENANCE OF SOIL FERTILITY (TASK 4.2, MONTH 30)

The activities in this task have consisted in: (1) the production of a land-form/soil map for the case studies in Ségou as a basis for the tree-traits and soil effects assessments (the maps for Potou and Rivas were produced during the previous reporting period, (2) sampling and chemical analysis of soils under trees and in the open and (3) finalized a study of soil carbon sources in Rivas.

The soil maps have been digitased and are available at FUNCiTree's map web portal http://wms.nina.no/FunciTree/ and three reports produced (Buurman et al. 2010a, 2010b and Bitchibaly et al. 2012).

The chemical analysis show in all cases a significant positive net effect of trees on soil organic carbon and in most cases of minerals (P, K), but the content of total N varies. N content was, in addition not always associated with leguminous species as is often assumed (Casals et al. in prep., Fall et al. in prep).

FODDER PRODUCTION AND NUTRITIVE VALUE (TASK 4.3, MONTH 30)

During the reporting period, an animal selectivity study was conducted in Potou (Heislen 2011) and in Rivas in the previous period (Pérez 2011). Data on nutrient content and digestibility were retrieved from a CIRAD data base and prepared to be entered in the FUNCiTree trait-data base (Annex 2). The material in the studies of animal preferences in Rivas and Potou is being prepared for peer-reviewed publications.

INTERACTIONS WITH THE UNDER-STOREY VEGETATION (TASK 4.4, MONTH 30)

During the reporting period, the effects of trees on the micro-climate under the trees, the productivity and the composition of the understorey vegetation, and the effect of trees on animal movements, have been assessed (Zapata 2009, Sotelo 2012, Ramírez 2012, Diouf et al. in prep.). Two distinct patterns emerge when comparing the sites in Central America and West Africa. Trees in Central America appear to have a consistent negative effect of understorey productivity, particularly during the rainy season, but the net effect varies among species (ranges between 5 to 30% decrease compared to the open grassland). In contrast, the effect of trees in the Sahelian AFS had either a positive (facilitation) or neutral effect on understorey productivity. The results reinforce hypotheses that predict a switch from competitive to facilitation effect along a stress gradient. The positive responses observed in the Sahelian sites do not always match the general perception of the role of trees. A few species are generally considered to have positive effects on the understorey. In contrast, farmers in the Central America site do have the notion of a trade-off between different services provided by silvopastoral trees. Usually, positive effects such shade for animals, and the provision of materials and fuel are contrasted with decreased pasture productivity. However, this effect appears to be marked only in the rainy season, when forage production is probably not the major production constraint. The role of trees as providers of forage in the dry season appears to be undervalued.

ANALYSIS OF ECO-PHYSIOLOGICAL TRAITS TRADE-OFFS AND SYNERGIES ACROSS ENVIRONMENTAL GRADIENTS AND REGIONS (TASK 4.5, MONTH 36)

These analyses are ongoing. Considerable effort has been directed to consolidate a trait and effects data base with the data collected from the three sites and from existing data-bases. The data-base structure follows Kattge et al. (2011) and has been designed to ensure compatibility with the largest global trait database (the TRY base http://www.try-db.org/TryWeb/About.php) (Annex 2).

2.3 Cross-regional synthesis of functional trait portfolios and modeling of modern multifunctional AFS based on tree functional diversity in relation to local and household needs (WP 5).

This work package consists of three tasks, and task 5.1 deals with activities to be reported during this period. Tasks 5.2 and 5.3 are activities to be conducted during the third and last phase of the project

Cross regional analysis of ecophysiological traits, farmer selected traits, and agro-forestry tree species (Task 5.1, month 30)

The aim of this task is to pool the species and trait data from all species found in the three research sites and to cluster them into trait-based functional groups using specific traits that have clear impact on the AFS function in question.

During the reporting period a significant effort was placed in collecting trait data from each of the three sites. At the moment, the major data collection effort on the trees found in each of the three sites has been completed. During the past several months, a significant effort has been made in entering the data into a standardized database, and verifying for consistency in data collection across sites. The current database has been unified for the Mali and Senegal sites, the Nicaragua data is currently being entered. Once all data have been entered, we will proceed to complete the cross regional comparison of ecophysiological traits, farmer selected traits and agroforestry tree species. This output is currently behind schedule; however this delay has not had a negative effect on deliverables 5.2 and 5.3, due in the next reporting period, which have been able to proceed independently.

Several clear results can be highlighted form the completed work and work in progress. The significance of progress made on objective 5.1 should not under-emphasized. This trait database is one of the first to combine species by trait data from three distinct tropical and sub-tropical countries, combining information from both quantitavely measured traits in the field and extensive surveys of local knowledge. Preliminary results from Nicaragua indicate a high degree of agreement between species x trait x function as understood by local knowledge, and by ecological knowledge.

In regards to the studies between species traits and the provision of single ecosystem services, several novel insights have also been elucidated. First and foremost, as suspected, the evidence shows that species found in pasture systems are diverse in their capacity to provide specific services. For example, farmers largely manage shade within their farming systems. Data collection from more than 60 species in Rivas demonstrates that some tree species have little effect on light transmitted through the canopy, what farmer have identified as “shade for pasture” functional types, while other species largely intercept light, reducing pasture productivity but providing quality shade for livestock – farmers equate this as “shade for livestock” functional types. In the Sahel, trees to have a positive effect on soil organic matter, nutrient content and moisture, and some have a clear facilitative function on the ground vegetation, increasing production, whereas other trees have a neutral effect. There are also clear distinctions in the water use economy between functional groups, with one group generally maintaining lower leaf water content levels and low interseasonal fluctuations and another with marked differences in water contents between the dry and rainy seasons. These differences may indicate the use of different water sources.

In the study of cattle movement in pastures in Rivas, we were surprised to find that shade had little impact on livestock movement during the dry season; animals responded to daily changes in heat stress rather than seasonal changes. This study emphasized the importance of maintaining shade through out the year rather than simply focusing on dry season shade. In all sites, it is emphasized that interventions need to focus on dry season forage options that remain one of the most limiting factors for mitigating the effects of seasonal droughts in the region. The studies of nutritional diversity provided by forage species in Rivas highlighted some divergence from farmer local knowledge. Species that farmers suggested had little forage potential were both found to be nutritious as well as preferred by livestock.

MODELS OF TRAIT-BASED AFS DESIGNED TO PROVIDE SINGLE ECOSYSTEM FUNCTIONS (MONTH 42).
The activities in this task have started but the final report is due in the next period. Significant progress has been made on this output. In Rivas nine studies have been completed on the relationship between species traits and the provision of specific ecosystem services and in Ségou and Potou traits and functional effects have been assessed for approximately 120 trees in each site. These include: 1) species traits and drought adaptation strategies of dominant species, 2) analysis of species nutritional traits and forage preference by livestock, 3) analysis of dry season sprouting ability of forage trees in silvopastoral systems (Rivas), 4) functional diversity of riparian forest and the provision of hydrological services (Rivas), 5) canopy traits and soil improvement of isolated trees in pastures, 6) canopy traits and livestock shade preferences (Rivas), 7) canopy traits and light regulation, 8) root traits, micorrhization and soil nutrient turnover, 9) canopy traits and water use efficiency, and 10) canopy traits and net primary production of understorey. No further studies of species traits and function are currently envisioned for Rivas and Potou, rather we expect to use the results of these individual studies to contribute to deliverable 5.3. An assessment of understorey productivity to complement existing secondary data is planned in Ségou during the rainy season 2012.

MODELS OF AFS DESIGNED TO PROVIDE MULTIPLE ECOSYSTEM FUNCTIONS (TASK 5.3, MONTH 42)
The activities in this task have started but the final report is due in the next period. They are currently ongoing in the Rivas site, where the work builds on outcomes produced by the studies in 5.2 to develop an index of silvopastoral system multifunctionality. The study combines an evaluation of globally recognized ecosystem services such as carbon sequestration and habitat for biodiversity, regionally recognized services such as water quality, and field based services such as shade for livestock, pasture productivity, fuel wood and timber provision, resilience to drought, and animal nutrition. The result of this work will be an agglomerative index of pasture multifunctionality, but more importantly will permit a consideration of the trade-offs between the provision of one service versus another.

2.4 Socio-economic implications of tree functional portfolios at the household and local scales (WP 6)

WP 6 has conducted two tasks during the reporting period, with one deliverable (D 6.3) due in month 36, and the other (D 6.4) due in the next reporting period.

AGRONOMIC FINANCIAL FEASIBILITY ANALYSIS. (TASK 6.3 MONTH 36)
The aim of this task was to specify and parametrise farm production models. During the period farm household surveys have been carried out in Ségou, Potou and Rivas, with the aim of obtaining data on

financial, socio-economic, and environmental knowledge variables determining the adoption of multi-functional trees on farms. In Ségou the survey fieldwork was led by a M.Sc. student with support by surveyor team from IER. In Rivas, the survey fieldwork was carried out by a M.Sc. student and in Potou by ISRA using fieldworkers.

From a methodological point of view we have decided to carry out financial feasibility analysis jointly and in the same modelling tool of Bayesian Belief networks. This will allow us to move more directly to integrated quantitative analysis discussed under Task 6.4 below. This approach will allow us to address some deviations we have had in the fieldwork relative to plan that are discussed below.

In the Ségou site, a M.Sc. thesis was completed. "Trees for Livelihoods. Insights into Practice and Adoption of Agroforestry in Tiby, Mali" by Siri Lena Tholander, Centre for Development and Environment, University of Oslo. The M.Sc. thesis contains a number of simpler Bayesian network applications addressing probability of adoption, including some proxy variables for financial feasibility.

In Rivas, a M.Sc. thesis was completed. "Análisis (ex ante) de adopción de árboles en el trópico seco de Nicaragua" (Ex ante analysis of the adoption of trees in the arid tropics of Nicaragua) by Álvaro Salazar, CATIE. The M.Sc. thesis contains an integrated model using Bayesian networks with explicit consideration of financial feasibility of multifunctional trees in a dedicated sub-model/network. Significant results for this deliverable include the implementation of a Bayesian belief network in this case integrating information from WP3-4-5-6. The model and its applications have yet to be published outside the thesis itself.

In addition, WP6 has been responsible for a technical brief on "A Review of the cost-effectiveness and performance of selected Verifiable Emission Reduction (VER) carbon offsets" (Abebe et al. 2011). The brief follows up analysis conducted on the financial feasibility of carbon offsets for the Ségou case study (Barton et al. 2010). It addresses the requirements of demand for voluntary carbon offsets from agroforestry projects, using FunciTree projects as a demonstration case. Barton et al. 2010 and Abebe et al. 2011 have provided inputs to the demonstration activities planned in Ségou under WP7.

INTEGRATING QUANTITATIVE MODELS AND EXPERT OPINION IN THE ASSESSMENT OF MULTI-FUNCTIONALITY OF AFS (TASK 6.4 MONTH 40)

During the period most progress has been made in applying Bayesian belief networks to a 'new' modelling approach that has been developed by the FUNCiTree project in order to combine farmer and expert knowledge on species traits, functionality, and farm socio-economic characteristics. Instead of modelling adoption probabilities at the household level as a cause-effect model, we have explored the characteristics of Bayesian networks to do diagnostic analysis, taking advantage of Bayesian Network software capabilities to support inductive reasoning. This was not originally foreseen in the workplan. It has meant that we have shifted emphasis away from multi-criteria analysis (MCA) techniques outlined in the DoW, to focus most of our effort on implementing Bayesian networks. This has been most successful in the period in the Rivas case, as explained below.

2.5 Participatory improvement of AFS and technologies (WP 7)

WP7 will merge the products from WPs 2-4 and WP 5-6 to develop participatory field trials of modernized trait-based AFS. Farmers will be presented with the tree portfolio of locally available tree and shrub species for integration in field trials. WP 7 will in addition apply participatory modeling techniques based on the methodolgoies used and developed in the assessments conducted under WPs 2, 3 and 6.

Here we report on the activities with a delirable due within this reporting period.

REPORTS ON THE ESTABLISHMENT OF FIELD TRIALS IN THE THREE FIELD SITES. (DELIVERABLE 7.1 MONTH 36)

The three sites have prepared a protocol for the demonstration activities (Villanueva et al. 2012, Gaye et al. 2012 and Yossi et al. 2012) with particular aims adapted to the local context and needs. In the Senegal and Mali the activities have been planned in cooperation with the Millennium Villages Programme and integrated within their extension activites.

In **Rivas**, Nicaragua the demonstrations have three aims: (1) To demonstrate multi-functionality in paddocks, with a practical description about their establishment, (2) to construct in a participatory way, silvopastoral models of farms based on the preferences of farmers in three different communities Mata de Caña, Cantimplora, y La Chocolata, Belén, Rivas, and (3) to validate farmers' preferences about the tree traits and their functions in the silvopastoral system.

Two parcels have been established to demonstrate paddock multi-functionality. The intial composition of the paddocks consisted of live fences and dispersed trees and they have been enriched with forage and fruit trees that are complementary to the existing compositon.

The demonstration parcels are primarily based on studies conducted on tree forage nutrition value and animal preferences (Pérez 2011), tree biomass availability and resprouting capacity (Lombo 2012), pasture forage production seasonality (Ospina et al. 2012), and *ex ante* analysis of the adoption of trees in the seasonally-dry tropics in Nicaragua (Salazar 2012).

Two participatory modeling excercises have been developed and will be conducted in the last phase of the project. The first one consists in modeling and validation of ecosystem services provided by the different trees in the demonstration parcels. The models will highlight the complementarity of functions of the trees that farmers prioritize and the consequences of particular choices on productive and ecological functions. The second exercise will consist in the design of scenarios of multi-functional silvopastoral systems considering the socio-economic conditions of the famer and will recommend particular combinations of trees tailored-made for the different production systems.

In **Potou**, Senegal, the activities will be conducted within systems in the Millennium Village Project located in the rural community of Leona, dept. of Louga. These systems aim at the sustainable production of a variety of foods, forages, fuelwood and timber, and many other products for domestic use. The objective of FUNCiTree WP 7 is to develop multi-functional AF technologies based on tree and shrub traits. The participatory modality of the experiments will enable ownership by the rural population and wide diffusion. A number of sites have been selected for the demonstration of different functions, a detailed description of the activities is provided in Gaye et al. 2012:

1. *Animal nutrition*: Forage Banks in Ndialakhar Peul (zone Diéri) and Ndiayène Peul (zone Niayes)

Species water use economy and tolerance to drought mechanisms: Enrichment with species drought tolerant: Ndialakhar Peulh, Wakhaldiam (zone Diéri) et Wékhé (Niayes).

2. *Soil fertility*: Wakhal Diam, Ndiayène wolof (zone Diéri) and Wékhé (zone Niayes)
3. *Soil and crop protection*: Syer (70 farmers, community parcels, 4ha), Wakhal Diam (community parcels (2ha) managed by women groups), Ndiayène Wollof (2ha parcel, 1 farmer) et à Gabane Wollof (community parcel, 4ha with 83 farmers). These parcels are cultivated for potatoes, onions, and fruits (papaya, Zizyphus, etc).
4. *Assisted Natural Regeneration (ANR) for multiple functions*: Community Nature Reserve 20 ha, 9 villages (zone Niayes).

In Ségou, Mali, the assessments in WP 2-4 enabled to identify specific functions of trees to meet the needs of food, energy, income generation, delimitation of paddocks and farms and protection of cropland from roaming animals. The use of trees and shrubs for forage production and in pharmacopeia is also of extreme importance in rural areas where financial resources are rare and traditions have considerable weight. At the same time, complementary inventory studies in the area show a limited occurrence of the majority of the valuable species that can fulfill the needs of the local population. This is the background agains which the participative demonstration and management activities have been planned.

The main activities are articulated around the following aspects:

1. The production of 1000 plants of each of 7 species (*Adansonia digitata, Acacia albida, Anogeissus leiocarpus, Pterocarpus erinaceus, Prosopis africana, Combretum glutinosum* and *Ficus gnaphalocarpa*) will be used in a vast demonstrative campaign about the possitiblities of domestication of these valuable species. The plantations will be under the management of the communities but taking into consideration the choices of the farmers.
2. A series of chemical analysis will be conducted on the organs of the main forage species to be tested on small ruminants (goats, sheep) with a set of famers and compared with other food sources.

These two activites will be the basis for the domestication and the rational exploitation of a number of species of value for the population in their own territories.

3. With the aim to reinforce the socio-economic and environmental services of the agroforestry systems, through the plantation of valuable species, FUNCiTree will contribute to a participatory program of regeneration through Assisted Natural Regeneration (ANR)

A communitary and participative approach will be fundamental in all the interventions in the rural areas, with the farmers with the aim to responsabilize, provide training in good management practices, and coordinate the execution of the activites. All the activities will be based on production techniques of a diversity of species, the plantation and the management of the plants by the farmers. In the area of intervention of the Millennium Villages Project, there area already 6 village nurseries and trained foresters that have been formed and already been used through the project by other partners (for example ICRAF). For a full description of the demonstration protocol see Bocary et al. 2012.

2.6 Dissemination (WP 8)

COMPATIBLE DATA-BASES FOR INTEGRATIVE ANALYSIS (TASK 8.2)

Databases. WPs 3 and 6. In Rivas and Ségou, the local knowledge bases were built on AKT methodology (Walker & Sinclair 1998) which is especially designed to organize agroecological knowledge data. The local knowledge databases compiled for Rivas and Ségou were made compatible by homogenizing traits and functions names, definition and hierarchies. The databases were then reorganised and each team began to analyse their own databases to identify relationships between species, traits and functions. Particular attention is paid to shared functions between species and the identification of functional groups based on local knowledge.

A second step was to build a common database to progress for cross site analysis. A common structure of databases was agreed on and organised in Excel files. A common hierarchy of function typologies was developed for whole trees (e.g. food, fodder, firewood, animal medicine, human pharmacopeia, timber) with secondary divisions according to tree organs (e.g. fruits, leaves, bark, see Annex 3). Tree traits were described with the same logical framework. Traits are associated with functions at a coarse (e.g. food) and finer (e.g. acid fruits, bitter fruits, sweet fruits) level. Others are morphological traits related to organs (e.g. big or small leaves; thorny trees, shallow roots). The compatibilization of the typologies was further refined in order to advance towards cross site comparisons. A draft of a common data organisation framework is presented in (Annex 4).

The structure of the base to store the eco-phisiological trait base collected in WP 4 has been developed in SQL language with a Microsoft Access interface. It has been developed following the format proposed by Kattge et al. (2011) for trait bases, which ensures flexibility and compatibility with current the global bases such as the TRY base. A diagram of the base structure is shown in Annex 2. At the moment the majority of the data collected in Ségou and Potou have been entered and quality checked. The data from Rivas have been quality checked and standardized, and have been partially entered. Considerable effort has been spend in homologation of variable nomenclature, measurement units, and documentation.

DISSEMINATION MATERIAL AND EVENTS (DELIVERABLE 8.2 MONTHS 24 & 48)

Several studies conducted in the project have been published as MSc thesis (the list is shown in Annex 5). The list of ongoing publications is shown in Annex 1. We have promoted:

1. joint publication across FUNCiTree partners
2. both discipline-specific and inter-disciplinary analysis and publications
3. scientific publications with local relevance published in the local language.

FUNCiTree special volumes are planned:

1. On ecological and production functions of agroforestry systems in seasonally dry systems is planned to be produced in 2012 in Agroforestry Systems.
2. Agroforestería de las Américas (journal published by CATIE)
3. CONAGAN (Nicaragua). (Annex 6).
4. Cahiers d’agriculture or Bois et Forêts des Tropiques

3 Project management

3.1 Consortium management tasks and achievements

Project communication flow

Communication flow in the project has been ensured by:

1- Management of the project webpage http://funcitree.nina.no/ and the sharepoint domain with access restricted to FUNCiTree participants. The tool is used to share documents produced by the project, literature references (with corresponding pdf files), contact information of project participants (e-mails).

2- The web-map portal has been used to upload and share GIS data. They are made available for all partners for visualization online, and can also be downloaded in GIS and pdf formats. http://wms.nina.no/FunciTree/

3- Translation from English to French of research protocols and manuals.

4- Maintained contact between partners, WP coordinators and project coordination mainly via e-mail, telephone or internet communcation.

5- At the case study sites, purchase of equipment, and organisation of field logistics (project office with lodging and laboratory facilities).

6- The partners have purchased voluntary cerfiticates to offset carbon emissions produced by international travelling in the project (Annex 7).

Project meetings and workshops

A project meeting was held in Almería, hosted by CSIC in February 2011 with the participation of all partners (see agenda in Annex 9). In this meeting break-out sessions were held to discuss publications and the plans for the second and third phases of the project. The steering committee met at that occasion as well (see agenda in Annex 8).

The core of the activities in the reporting period have consisted in the collection of field data, based on the protocols and agreed activities in phase I. Therefore, more focus was put in this reporting period in workpackage-wise communication, smaller workshops, research visits, onsite supervision of MSc students and joint field trips with the participation of various partners. The activities are described in Table 3.

3.2 Project planning and status

Most of the activities have been conducted according to the plan. There is some delay in some of the deliverables which are explained below, with a description of the measures taken to ensure the fulfilment of all project objectives.

The compatibilization of the site databases has been accomplished in WP 3 and is being finalized for the data generated in WP 4 (July 2012). The databases to be produced in WP 4 had to be delivered by month 24. The majority of the data were collected and digitised by that time, except for some delays in Mali that were foreseen in the previous report because of the need of additional training of the Mali team in eco-physiological measurements. These were overcome by a substantial effort in onsite training and guidance by the Senegalese team. This partly resulted in that some of the sampling scheduled for the rainy season 2010 in Senegal, had to be postponed to 2012. Also, during the course of this field period, one of the ISRA researchers obtained a scholarship in Spain, under the supervision of CSIC partners, which partly reduced the capacity of the team for data collection. To solve this problem, new staff was incorpared to the team in July 2011. The development of a consolidated trait database with data from the three has therefore been delayed. Also, data cross-checking and quality control, and the ambition to make a thoroughly documented database that is flexible and compatible with global databases has required considerable effort and resources. We think this is an investment that is worth to ensure the accessibility and maintainance of the data after the completion of FUNCiTree. These delays have slowed the cross-site comparisons and the full analysis of trait-based portfolios in WP 5, however, preliminary analysis have been conducted and evaluated to design the demonstration activities (WP 7). The data base is planned to be operational in July 2012, and the complete datasets will be used in the demonstration activities consisting of participatory scenario modelling which will include the results from the portfolio analysis in WP 5 and WP 6.

***Table 3**: Meetings, workshops, research visits*

Meetings and workshops	Location and dates	Description
II Project meeting	Almería, 25-29th May 2010	Hosted by CSIC. 22 participants, See agenda in Annex 9.
WP 6. Training in Bayesian Belief Networks. Data organisation.	Oslo, 1 week February 2012	Hosted by NINA. Research visit from ISRA.
WP 4. Field trip	Ségou, August 2011	Hosted by IER. Visit from WUR. Soil mapping.
WP 4. Field trip	Ségou, rainy and dry seasons 2011 and 2012	Hosted by IER. Several visits from ISRA. Eco-physiological traits sampling.
WP 4. Field trip	Potou, July 2010	Hosted by ISRA. Visits by IER, CSIC and NINA. Eco-physiological traits sampling.
WP 4. Field trip	Rivas, March 2012	Hosted by CATIE. Visit by CSIC. Eco-physiological (isotope) traits sampling.
WP 4. Conference	Managua, Nicaragua 12-13 April	Hosted by CATIE, jointly with SILPAS project. 49 participants from academia and research institutes, extension practicioners, government officials, private sector, NGOs.
Steering Committee meetings		
SC – meeting IV	Almería	Hosted by CSIC. All partners. Annex 8.

Regarding WP 6, there has been a delay in finalizing deliverable 6.2: Quantitative assessment of the financial feasibility and livelihoods impacts of 'model' agro-forestry systems planned for month 24. The delay is due to different factors, particularly in the West African cases. In Nicaragua, the quantitative questions on financial issues have been successfully implemented, with sufficient data to build a model. In Mali the survey was designed to sample from households also selected for the mid-term socio-economic survey of the Millennium Village Project (MVP). Most socio-economic background data describing households was left out of the FunciTree survey in order to focus questions on farmer knowledge of tree multi-functionality, with the aim of importing the MVP data but lateron, access to the MVP household level data was not granted by Columbia University's Review Board. With the present results in WP6-Mali it will be possible to validate information on multifunctional tree knowledge and use, but not on financial feasibility of trees as a functional of socio-economic household characteristics, as part of WP7. In Senegal, the household survey was carried out coordinated by a senior researcher at ISRA. The survey was partially complete when the senior researcher in charge passed away after a short period of illness in April 2011. ISRA located a replacement and the survey was completed by November 2011, with data cleaning conducted by January 2012. Based on a joint assessment with their new researcher we found that the quantitative questions, including those addressing financial feasibility of multifunctional trees, were only partially successful. With the present results in WP6-Senegal it will be possible to validate information on multifunctional tree knowledge and use, but not on financial feasibility of trees as a functional of socio-economic household characteristics, as part of WP7. During the period we have redesigned a possible follow-up survey to collect financial data.

Regarding deliverable 6.3. “Comparative analysis of techniques for ranking agro-forestry systems based on multiple traits, multiple functions and multiple farm objectives (month 36)”, a training course on Bayesian belief networks was held in Senegal September 2010 for researchers from the three teams (2 researchers from Mali, 4 from Senegal, 1 from Nicaragua) in preparation for this task. The different teams have had varying success with implementing the Bayesian belief network software in their case studies due in part to factors beyond their control (see above). In the case of Senegal, all ISRA researchers that originally participated in the training have left the project. For this reason the new WP6 researcher from ISRA participated in a 1-week training in February 2012 in Oslo.

Scientific exchange among participants will be fostered by workpackage leaders and the project coordination for the preparation of publications, other dissemination material and the demonstration activiites. The location of the final project meeting will be decided on the next Steering Committee meeting in July 2012.

3.3 Challenges met in the reporting period

Language

As reported earlier, in the FUNCiTree consortium some participants use other working languages than English (French and Spanish), and have varying degree of command of English, which poses communication challenges and requires extra efforts during meetings, workshops and the general communication within the project. However, all partners have participants with good command of both French and English and a good part of the participants manage French and English or Spanish and English relatively well. Hence communication has been good, despite demanding extra effort. Translations of material and extra efforts of individual team members with good command of both English and French or English and Spanish have contributed to the good flow of activities in the project, including those related to administrative reporting.

Team capacity about methods

In addition to the training imparted in the previous reporting period, extra training on BBN methods has to conduct the anlyses in WP 6 has been imparted in Oslo in February 2012 as explained in the previous section (see alsoTable 3.1).

Regarding the ecophysiological traits and the effects of trees to be measured in WP 4, The IER team had insufficient expertise in this field to conduct the sampling, and the language problem has also been a barrier to communicate the procedures clearly. To solve this problem we organized joint field trips in Senegal with partipants from ISRA, IER, CSIC and NINA to discuss, agree and implement common sampling protocols. As explained above, researchers at ISRA, Senegal have guided the field-work in Mali by joining the IER team in several field campaigns.

Organisation of field activities
In some periods with many field activities going on at the same time, there was some limitation of resources, mainly availability of transport, but also field assistants and translators. These inconveniences were solved generally in a satisfactory way, although the effectiveness in the use of time in the field can be improved with better planning.

Reporting
The reporting process has improved enormously. The main reasons of delays in the previous report have been solved: 1) Non-European partners are unfamiliar with EC's reporting structure system, including online reporting systems, 2) much of information is provided in English, which is a challenge for both Spanish and French native speakers, particularly at the administration level. All partners have prepared the administrative and technical reports in time.

Cooperation with other projects
FUNCiTree sites in Potou and Ségou were chosen to be in the project area of the Millennium Villages Project (MVP) under the coordination of the Earth Institute, Columiba University, USA. The MVP site coordinators have been most cooperative assisting with the organisation of site visits and at times, with the logistics. Both in Potou and Ségou, FUNCiTree offices are located close to the MVP offices. The demonstration activities (WP 7) have been designed and planned jointly with the MVP in both sites.

CATIE and NINA cooperate in other projects with funding from the Research Council of Norway (SILPAS and Multifunctional-Landscapes). The databases generated in these projects have been made available for FUNCiTree.

Dissemination activities
During this reporting period, most of the activities have been concentrated on data collection. Sixteen MSc theses have been completed since the start of the project, 9 have been completed since the previous reporting period (Annex 5). Several activities have been organized locally, in some occasions with the participation of the students to disseminate FUNCiTree results and approaches. They have been directed to farmer and community organisations, schools at various levels, NGOs, organisations engaged in extension services, national authorities, the academia and the private sector.

4 References

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5 Annexes

5.1 Annex 1 – List of forthcoming publications

5.2 Annex 2 – FUNCiTree trait database structure

5.3 Annex 3 – Extraction of Tiby (Mali) and Rivas (Nicaragua) database on tree functions

Local knowledge about functions and functional traits of tree species in the agroforestry parklands of Tiby area, Segou region, Mali. Data collected by Pierre Clinquart from May to June 2010, Master thesis, CIRAD.			Human food					
Tree species								
N°	Common name (Bambara)	*Scientific name*	Trees for human consumption	Fruits for human consumption	Leaves for human consumption	Sprouts for human consumption	Butter for human consumption	Almonds for human consumption
1	Dogo iri	*Acacia colei*	0	0	0	0	0	0
2	Boina, Boiné	*Acacia nilotica*	0	0	0	0	0	0
3	Patuku	*Acacia senegal*	0	0	0	0	0	0
4	Zadjé	*Acacia seyal*	0	0	0	0	0	0
5	Baki	*Acacia tortilis ssp. raddiana*	0	0	0	0	0	0
6	Zira	*Adansonia digitata*	1	1	1	0	0	0
7	Yégéré	*Albizia chevalieri*	0	0	0	0	0	0
8	Somo	*Anacardium occidentale*	1	1	0	0	0	0
9	Toubabou Sunsu	*Annona squamosa*	1	1	0	0	0	0
10	Galama	*Anogeissus leiocarpus*	0	0	0	0	0	0
11	Iri cunamani, Sa irini, Sumaya irini	*Azadirachta indica*	0	0	0	0	0	0
12	Zekené	*Balanites aegyptiaca*	1	1	0	0	0	0
13	Gessemé, Shiflé irini	*Bauhinia rufescens*	0	0	0	0	0	0
14	Diafarané	*Bixa orellana*	0	0	0	0	0	0
15	Bumbu	*Bombax costatum*	0	0	0	0	0	0
16	Sebé	*Borassus aethiopium*	1	1	0	1	0	0
17	Fogo fogo	*Calotropis procera*	0	0	0	0	0	0
18	Ndi	*Capparis sepiaria*	0	0	0	0	0	0
19	Mandjé	*Carica papaya*	1	1	0	0	0	0
20	Sinjan	*Cassia sieberiana*	1	1	0	0	0	0
21	Bana, Bané	*Ceiba pentandra*	1	1	0	0	0	0
22	Gamiah	*Celtis integrifolia*	1	1	0	0	0	0
23	Leburu kumuni	*Citrus limon*	1	1	0	0	0	0
24	Leburu ba	*Citrus sinensis*	1	1	0	0	0	0
25	Irini blé, Tangara	*Combretum glutinosum*	0	0	0	0	0	0
26	Golobé	*Combretum micranthum*	0	0	0	0	0	0
27	Dugura, Duguré	*Cordyla pinnata*	1	1	0	0	0	0
28	Balembo	*Crossopteryx febrifuga*	0	0	0	0	0	0
29	Toubabou Néré	*Delonix regia*	0	0	0	0	0	0
30	Sunsu	*Diospyros mespiliformis*	1	1	0	0	0	0
31	Matolatun irini	*Eucalyptus camaldulensis*	0	0	0	0	0	0
32	Sinjiba	*Euphorbia balsamifera*	0	0	0	0	0	0
33	Balanzan	*Faidherbia albida*	1	0	0	0	0	0
34	Djatigifa iri, Zeré, Zerenijé	*Ficus iteophylla*	0	0	0	0	0	0
35	Gaba	*Ficus platyphylla*	1	1	0	0	0	0

Mosquera; Conocimiento Local Sobre Bienes y Servicios de stemas de Produccion Ganadera de Rivas Nicaragua. Tesis	Services/*Servicios*										Goods/*Bienes*		
tie.ac.cr; ditter282@yahoo.es	Shade/Sombra		Nutrition										
Especie	Sombra para el ganado	Sombra para el pasto	Forraje	Frutos al. Animal	Rompeviento	protec. de fuentes de agua	control de erosión	Mejoramiento de suelos	protec. Biodiversidad	Resistencia a sequía	Cerca viva	Leña	Medicinal
Species	Shade for Livestock	Shade for Pasture	Forrage	Edible Fruit for Livestock	Windbreaks	Spring Protection	Erosion Control	Soil Improvement	Biodiversity Conservation	Drought Tolerance	Posts for Live Fences	Fuelwood	Medicinal
Acasia spp.	1	0	1	1	1	0	0	0	0	0	1	0	0
Simarouba glauca	0	0	1	0	0	0	0	0	0	0	0	1	0
Persea Americana	0	0	1	1	0	0	0	0	0	0	0	0	0
Andira inermis	1	1	1	0	0	0	0	0	0	0	0	0	0
Acacia farnesiana	0	0	1	0	0	0	0	0	0	1	0	0	0
Haematoxilon brassiletto	0	0	1	1	0	0	0	0	0	0	0	0	0
Acacia farnesiana	0	0	1	0	0	0	0	0	0	0	0	1	0
Chrysophillum cainito	0	0	1	0	0	0	0	0	0	0	0	0	0
Swietenia humilis	0	0	1	0	0	0	0	0	0	0	0	0	0
Muntingia calabura	0	0	1	0	0	1	0	0	1	0	0	0	0
Cassia grandis	0	0	1	1	0	0	0	1	0	0	0	1	0
	0	0	1	0	0	0	0	0	0	0	0	1	0
Hevea brasiliensis	0	0	1	1	0	0	0	0	0	0	0	0	0

5.4 Annex 4 – Extraction of Tiby (Mali) and Rivas (Nicaragua) d-bases on tree traits related to functions

Local knowledge about functions and functional traits of tree species in the agroforestry parklands of Tiby area, Segou region,										
Data collected by Pierre Clinquart from May to June 2010, Master										
Tree species			Organoleptic qualities					Consis		
N°	Common name (Bambara)	***Scientific name***	Bitter fruits	Acid fruits	Sweet fruits	Bitter leaves	Acid leaves	Fruits with few pulp	Fruits with dusty pulp	Fruits with firm pulp
1	Dogo iri	*Acacia colei*	0	0	0	0	0	0	0	0
2	Boina	*Acacia nilotica*	0	0	0	0	0	0	0	0
3	Patuku	*Acacia senegal*	0	0	0	0	0	0	0	0
4	Zadjé	*Acacia seyal*	0	0	0	0	0	0	0	0
5	Baki	*Acacia tortilis ssp. raddiana*	0	0	0	0	0	0	0	0
6	Zira	*Adansonia digitata*	0	0	1	0	0	0	1	0
7	Yégéré	*Albizia chevalieri*	0	0	0	0	0	0	0	0
8	Somo	*Anacardium occidentale*	0	1	1	0	0	0	0	0
9	Toubabou Sunsu	*Annona squamosa*	0	0	1	0	0	0	0	0
10	Galama	*Anogeissus leiocarpus*	0	0	0	0	0	0	0	0
11	Iri cunamani, Sa irini, Sumaya irini	*Azadirachta indica*	0	0	0	0	0	0	0	0
12	Zekené	*Balanites aegyptiaca*	0	0	1	0	0	0	0	1
13	Gessemé, Shiflé irini	*Bauhinia rufescens*	0	0	0	0	0	0	0	0
14	Diafarané	*Bixa orellana*	0	0	0	0	0	0	0	0
15	Bumbu	*Bombax costatum*	0	0	0	0	0	0	0	0
16	Sebé	*Borassus aethiopium*	0	1	1	0	0	0	0	0
17	Fogo fogo	*Calotropis procera*	0	0	0	0	0	0	0	0
18	Ndi	*Capparis sepiaria*	0	0	0	0	0	0	0	0
19	Mandjé	*Carica papaya*	0	0	0	0	0	0	0	0
20	Sinjan	*Cassia sieberiana*	0	0	0	0	0	1	0	0
21	Bana, Bané	*Ceiba pentandra*	0	0	0	0	0	0	0	0
22	Gamiah	*Celtis integrifolia*	0	0	1	0	0	1	0	0
23	Leburu kumuni	*Citrus limon*	0	1	0	0	0	0	0	0
24	Leburu ba	*Citrus sinensis*	0	0	0	0	0	0	0	0
25	Irini blé, Tangara	*Combretum glutinosum*	0	0	0	0	0	0	0	0
26	Golobé	*Combretum micranthum*	0	0	0	0	0	0	0	0
27	Dugura	*Cordyla pinnata*	0	0	0	0	0	0	0	0
28	Balembo	*Crossopteryx febrifuga*	0	0	0	0	0	0	0	0
29	Toubabou Néré	*Delonix regia*	0	0	0	0	0	0	0	0
30	Sunsu	*Diospyros mespiliformis*	0	0	0	0	0	0	0	0
31	Matolatun irini	*Eucalyptus camaldulensis*	0	0	0	0	0	0	0	0
32	Sinjiba	*Euphorbia balsamifera*	0	0	0	0	0	0	0	0
33	Balanzan	*Faidherbia albida*	0	0	0	0	0	0	0	0
34	Djatigifa iri, Zeré, Zerenijé	*Ficus iteophylla*	0	0	0	0	0	0	0	0
35	Gaba	*Ficus platyphylla*	0	0	0	0	0	0	0	0
36	Toro	*Ficus sycomorus ssp. gnaphalocarpa*	0	0	0	0	0	0	0	0

5.5 Annex 5 – MSc theses completed during the course of FUNCiTree

Chávez, W. 2011. Diversidad funcional y capacidad de amortiguamiento de los bosques ribereños de la sub cuenca Gil González, Departamento Rivas, Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba.

Chloé, M. 2010. Estrategias campesinas, estrategias agroforestales. Evolución de los sistemas de producción en Rivas, Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba.

Clinquart. 2010. Representations et usages des especes ligneuses: Une approche par les traits fonctionells pour une ingnierie des systemes agroforestiers en zone arides et semi-arides. PURPAN, Montpellier.

Cosiaux, A. 2011. Etude de la résistance à la cavitation de dix espèces ligneuses fourragères des systèmes agro-forestiers de la région de Louga au Sénégal. Université de Montpellier 2.

Heislen, V. 2011. Approche fonctionelle de la contribution des ligneux aus regimes de bovins au paturage de saison seche au Sahel. Université de Montpellier 2, Montpellier.

Malle, D. 2010. Le rôle des ligneux fourragers dans l'alimentation des animaux dans la zone d'intervention du Projet FUNCiTree, Bamako, Mali.

Mosquera, D. H. 2010. Conocimiento local sobre bienes y servicios de especies arbóreas y arbustivas en sistamas de producción ganadera de Rivas, Nicaragua. MSc. CATIE, Turrialba.

Niemeyer, R. 2011. Does vegetation matter? Measuring effects of vegetation on water movement in soils in dry tropical Nicaragua. MSc. University of Idaho.

Olivero, S. 2011. Functional traits approach to assess the ecological processes of drought tolerance and water use efficiency in silvopastoral systems in Rivas Department, Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba.

Pérez, N. 2011. Rasgos funcionales nutricionales de especies leñosas en sistemas silvopastoriles y su contribución a la sostenibilidad de la ganadería bovina en la época seca en el departamento de Rivas, Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba.

Ramírez, I. A. 2012. Efecto de la cobertura arb´orea sobre el movimiento, comportamiento y preferencia de ´arboles por vacas lecheras en Rivas, Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba.

Remme, R. 2011. Soaked silvopastoral soils: Soil organic carbon, nitrogen and soil respiration during the rainy season in the silvopastoral system of Rivas, Nicaragua. MSc. Wageningen UR, Wageningen.

Salazar, Á. 2012. Análisis (ex ante) de adopción de árboles en el trópico seco de Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica.

Sotelo, M. 2012. Efecto de las características y rasgos funcionales de los árboles en la intercepción y distribución de la radiación solar y la temperatura ambiental durante la epoca lluviosa en pasturas de Rivas, Nicaragua. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba.

Tholander, S. L. 2011. Trees for livelihoods. Insights into practice and adoption of agroforestry in Tiby, Mali. Master of Philosophy in Culture, Environment and Sustainability. University of Oslo, Oslo.

5.6 Appendix 6 – Proposed contributions to the special volumen of the journal CONAGAN

STATE OF TREE RESOURCES IN CATTLE RAISING FARMS AND THEIR CONTRIBUTION TO THE SUSTAINABLE PRODUCTION IN RIVAS, NICARAGUA (IN SPANISH)

Editors: Dalia Sánchez, Muhammad Ibrahim, Cristobal Villanueva, Fabrice De Clerck

Editorial: Graciela Rusch

Articles

1) State of tree resources in cattle raising farms in the Municipality of Belén, Rivas, Nicaragua. *Dalia Sanchez et al.*

2) Local knowledge of woody species in cattle raising farms and their role in improving farm production. *Ditter Mosquera et al.*

3) The role of trees on soil fertility. *Pilar Bucheli et al.*

4) The relationsheip between tree cover and pasture production. *Graciela Rusch et al.*

5) The contribution of trees to reduce cattle heat stress. *Muhammad Ibrahim et al.*

6) The potential of forage woody species as cattle feed in the dry season. *Cristóbal Villanueva et al.*

7) The importance of trees in the provision of ecosystem services. *Fabrice De Clerck et al.*

8) Incentives and innovative mechanisms to promote tree cover in cattle raising farms. *Claudia Sepúlveda.*

Interviews

1) Farmer interviewEntrevista a un productor
2) Interview to the Dr. José Roberto Alejo, Major of the Municipality of Belén.

News and Opinions

Announcement VII Latin American Congress on Agroforestry for Sustainable Husbandry. Belem do Pará. Brasil 8 -10 noviembre 2012. More information at: http://www.viicongressolatinoamericanosapps.com/es/

Time schedule

Activity	Date
First draft submission	04-July
Revised draft to authors	30-July
Second draft submission	20-August
Final editing	01 October

Instructions to authors:

The article should be not more tan 5 pages long (including graphs, figures, tables, illustrations). Photos should be prepared in JPG format and high resolution. Please, use type Times New Roman 12. (Simple language)

Readers: farmers, extension practitioners, local government officials, universities and research institutes, farmer organisations.

5.7 Annex 7 – Scolel Te carbon offset certificates

5.8 Annex 8 – Steering Committee meeting IV agenda

Call

Steering Committee Meeting IV

Expected attendees: P. Buurman, F. DeClerck, P. M. Diop, A. Gaye, H. Guérin, B. Kaya, I. N'Diaye, F. Pugnaire and G. M. Rusch (chair).

Place: Almería, Spain.

Date: Tuesday February 22nd 2011.

Time: 16:00 – 18:30

Agenda item	Person responsible	Comments
1. Meeting minutes	To be designated	
2. Minutes SC meeting 2010/06-24	G M Rusch	Item 2, attached
3. Midt-term technical report	G M Rusch	Review of reporting process.
4. Midt-term financial reports	M Tingstad	Review of reporting process.
5. Data use & publication policy	G M Rusch/ F DeClerk	Annex II Grant Agreement, attached. Vancouver Convention – ethical considerations for authorship and contributorship
6. Use of carbon-off-sets funds	G M Rusch	Technical Brief 1
7. Other matters		

5.9 Appendix 9 – Project meeting II agenda, Almeria.

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