FUNCiTREE

TECHNICAL BRIEF

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Cross-site analysis of farmer perceptions of AFS trees, their functions and traits

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Contents

1 Objectives of Workpackage 3

The aim of Work Package 3, "Farmer perception of AFS tree species and their traits", was to study the local knowledge about tree species found and used by farmers in the three FunciTree sites (Mali, Nicaragua and Senegal). This information was to be used in the project to compare and enrich scientific knowledge and help to build innovative, new trait-based functional AFS. WP3 results are the foundation for other WPs.

1.1 Overall objectives

The main objectives were:

1. To identify tree and shrub species found in the three project sites in both managed and natural land-uses.
2. To build a species by trait database where traits are defined by local knowledge
3. To build a species by AFS function database where trees are sorted by their capacity to provide specific functions according to local knowledge.
4. To explore relationships between traits and functions based on local knowledge across both African and Latin American sites.

1.2 Tasks objectives and deliverables

To reach these objectives, four tasks were defined:

Task 3.1 Species lists of the three sites built.

Botanists and agroforesters would conduct surveys, and literature reviews and database search of tree and shrub species found in managed, semi-natural and natural land uses in the regions. This inventory would be carried out by trained plant taxonomists at CIRAD (International herbarium, data base of flora dry South Saharan Africa), and CATIE (for Nicaragua) and locally. Botanists would inventory AFS with local landowners focusing primarily on the species composition of the systems. WP 3 would build a complete species list of locally available species including species which are not currently exploited in the study sites. Inventories of semi-natural and natural landuses (riparian forests, forest fragments, woodlands, woodlots and shrublands) would also be conducted and added to the species list.

Among the recent syntheses on trees of the Sahel, the field handbook of Arbonnier (2004) facilitated the identification of each of the 360 species found. Arbonnier's work includes an up-to-date inventory of the traditional uses of the different parts of plants for pharmaceutical, and human and animal food purposes. The survey will record species composition, abundance, location (CIRAD (coordination), CATIE, IER, ISRA (data collection at each site respectively). In addition to the identification of the species, a series of ecological features and geographical position (UTM, GPS) were the plants are collected was recorded.

Task 3.2 Local knowledge of species traits.

Task 3.2 formalized the local-knowledge based classification of regional tree and shrub species using the Agroecological Knowledge Toolkit (AKT) developed by the University of Bangor (http://akt.bangor.ac.uk/; Sinclair and Walker 1999). AKT permits rapid assessment of local knowledge regarding species and their traits in regard to the specific desired management functions that were identified in WP 2. Farmers were presented with the regional species pool and were asked to make general comments on these species with a particular focus on the traits of the species in the context of its local perception. AKT creates a knowledge base through semi-structured interviews with key informants. The knowledge is then broken down into unitary statements that are represented using a formal grammar. The process of representation requires iterative evaluation of the knowledge as it is inputted and therefore provides the basis for further questioning; the process of elicitation continues until no further knowledge is available permitting robust knowledge bases on trees and their traits to be created. The results will be compared

with the data expressed by the scientists, aiming to evaluating the differences of perception between the scientists and the population (Daget, 2003). (CIRAD (coordination), CATIE, ISRA, IER (data collection at each site respectively). Some initial comparisions of farmer perceptions of the shade provided by trees, and measures made by CATIE scientists in Nicargua show very close agreement as to the kind of shade projected by different species, and whether that shade is good for livestock or pasture productivity (two distinct services).

Task 3.3 Species traits and AFS function.

Task 3.3 used the same methodologies as Task 3.2 though the focus shifedt from the traits of the species, to the functional role that these species play in the provisioning of critical AFS functions including but not limited to fodder production and nutrition, drought tolerance and dry season productivity. Through a series of semi-structured interviews, farmers were presented with the list of species developed in task 3.1 and were asked to describe the capacity of these species to provide ecosystem services identified in WP2 as well as those services preidentified by the project as important (see above). Farmer workshops were held with larger farmer groups to validate the information collected through farmer interviews. During interviews, farmers were encouraged to describe the reasons for which a species is well-suited or not for the provisioning of specific services.

Task 3.4 Cross site comparisons.

The data collected in task 3.2 and 3.3 was compiled and relationships between locally important species traits and the capacity of the species to provide specific services was identified. Species were clustered by traits. Trait that farmers consistently identify as being related to the capacity or inability of a species to provide a particular service are be highlighted. Analysis occured 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 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.

From these tasks, we shall only comment on the three last deliverables as the first one, being the Database of regional species pools (Month 12) has already been described with details in the mid-term report (M18). The final version of this database is showed in Annex A (Total species: n = 428). In this report we shall detail the following deliverables:

3.2 Database of species traits as defined by local knowledge
3.3 Database of regional species pool and the capacity of these species to provide AFS functions based on local knowledge
3.4 Preliminary synthesis on cross-site analysis

1.3 Building the local knowledge data base on tree traits and functions

There was effort in the project to homogeneize methodologies, but different capacities and interests of the local teams on research methods and approaches, summed to the inevitable context-specific differences that lead to different scientific statements, resulted in some challenges in building a common database.

2 Methodology

The main differences in the methodological approach among the sites were:

- AKT method was fully applied in Rivas (Nicaragua) by a MSc student under the guidance of a PhD student already familiar with this tool. The database was then built in a full AKT format.
- In Mali, a MSc student with FUNCiTREE training on AKT allowed to use it to build statements on traits and functions, but the final database was then built in an Excel format
- In Senegal, a socio-economic approach was used for the interviews data where recorded through field surveys according to researchers skills.

These databases have been already presented in the mid-term report submitted in October 2010.

We have unfortunately also to mentionned that in Senegal, the main scientist responsible for WP3 surveys and work (Dr Astou SENE) deceased brutally in April 2011. No other colleague could take in charge the completion of the work in WP3, but the socio-economic data (WP 6) were completed by a young scientist at ISRA. At this date, the Senegalese database has not been completed and no analysis could be carried out on these data. The work has then been focused on Rivas (Nicaragua) and Tiby (Mali) databases. The lack of organised data from Senegal is of course, a loss of potential information on the local knowledge on traits and functions from the Potou site (Senegal) where the socio-economic context is characterized by a complex agrosylvopastoral system combining crop, livestock, orchard, and fishery activities. Nevertheless, the sites in Senegal and Mali share a large portion of common species (103 common species out of a total of 263 species identified) and there are also similarities between socio-ecosystems, which reduce slightly the importance of this scientific gap.

Several steps were organised to progress in the use of the databases:

- First, there were exchange of database files between Tiby and Rivas to try to homogenize traits and functions names, definition and hierarchies
- Databases were then reorganised and each team began to analyse their own databases to identify relationships between species, traits and functions; the share of functions between species; the identification of functional groups
- Another step was to build a common database to progress for cross site analysis. Specific meetings (telephone and physical) were organised between Catie, Mali and Cirad colleagues. A work plan was built in mid 2013 (Trondheim FunciTree final Meeting) but have still to be completed by October 2013. Results presented here are then still partial results.

3 Results

3.1 Tree Species list from the three sites defined from local knowledge surveys

Annex A shows a partial view of the species database table built from survey on tree species identified by local farmers on the three sites.

A total of 429 species were identified from the surveys carried out on the three sites (n=146 in Potou/Senegal; n=220 in Tiby/Mali; n=193 in Rivas/Nicaragua). From this total number, Figure 1 shows that common species between the 2 sites in the Sahel is 39% of total common species (103/263) which is not surprising as ecological conditions and the floras of the two sites situated in semi-arid zone are quite similar. Common species between the site in Rivas, Nicaragua and the two African sites is much lower, i. e. 6% with Potou in Senegal and 5% with Tiby in Mali, respectively.

Among all these species, only 11 species are common to the three sites. Table 1, below presents these species, which are all planted species, most of them imported and not native from the areas. Finally, the number of species which were mentionned with details for traits and functions during surveys are n=106 in Rivas, n=83 in Potou and n=70 in Tiby.

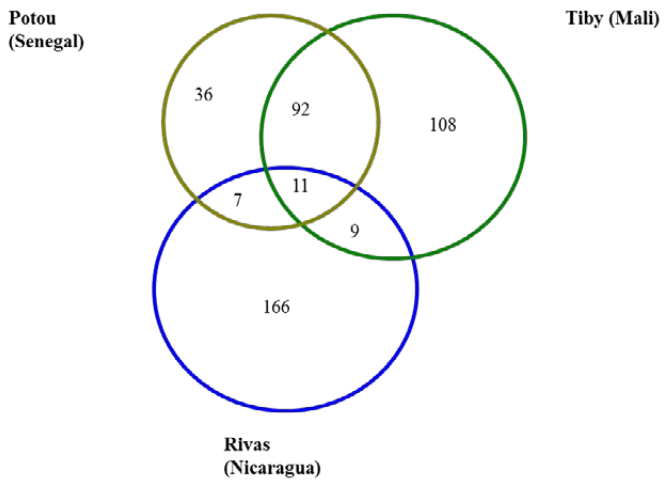


Figure 1: Distribution of the tree species identified in FUNCiTREE project through farm and local stakeholders surveys.

Table 1: Common species to the 3 FUNCiTREE sites (n = 11)

No.	Species Name
1	*Azadirachta indica*
2	*Calotropis procera*
3	*Citrus limon*
4	*Gliricidia sepium*
5	*Jatropha curcas*
6	*Mangifera indica*
7	*Prosopis juliflora*
8	*Psidium guajava*
9	*Tamarindus indica*
10	*Tecoma stans*
11	*Ximenia americana*

3.2 Tree functions and traits databases

A common structure of databases was agreed on and organised in Excel files. Species were listed in lines, whereas functions and traits were organised in columns. Functions were divided in several types of functions (Food, Fodder, Firewood, Animal medicine, Human pharmacopeia, Timber, etc…) with secondary divisions indicating the tree organ the function was related to (see example provided in Annex B). Traits were described with the same logical framework (see Annex C), some traits being described in relation to functions (for exemple provision of food: "Food") with description of traits related to these functions (e.g. acid fruits, bitter fruits, sweet fruits). Other traits were morphological traits related to organs, such as big or small leaves; thorny trees and shallow roots.

Despite this effort of standardization, several discrepancies occur in the way traits and functions have been named, organised and hierarchized depending on the sites. Therefore, and in order to progress toward cross site comparison, a proposal of common organisation was done (see Annex D)

The final common database has been built on these bases.

3.3 Analysis of tree traits and functions

Each of the research team in the two sites have run specific analysis on local knowledge about tree traits and functions. This has led to the following scientific papers. Cerdán et al. (2012) has been published and the others are under preparation (Clinquart et al.; Guérin et al) (see provisionary list below)

We give here some examples of results on this local knowledge for Rivas (Nicaragua) and Tiby (Mali).

An analysis of the share between species of the different functions fulfilled by trees according to farmers is presented in table 2. The most striking results from the comparision between Rivas and Tiby are the following:

- Many different functions are fulfilled by several tree species and several different species can contribute to the same function in both sites.
- Very few species (n=7) are unifunctional in Tiby (Table 3) whereas 22 of them are unifunctional in Rivas.
- Regarding production functions, the number of species involved in the two sites for each production function is similar except for income, pharmacopeia and other uses (domestic, religious) where none or very few species are involved in Rivas.
- Regarding services functions, stakeholders in Rivas mentioned lower number of species except for live fences and biodiversity conservation which might show more specific uses and more awareness in the region about the importance of the AF trees for biodiversity conservation.
- Socio-cultural functions are important in Africa but of no importance in the Nicaragua case study.

Table 2: Number of species quoted for each type of function in Tiby (Mali) and Rivas (Nicaragua)

Production functions ("provision-ing services")	Human food	Animal feed	Firewood	Timber	Income	Human pharmacopeia	Animal pharmacopeia	Various domestic uses	Magic-religious uses
No, of species in Tiby	32	46	49	35	42	55	14	17	8
No. of species in Rivas	28	41	41	35	0	15	0	-	0

Service functions ("regulating services")	Improvement of soil fertility	Antierosive action	Shade	Live fences	Dead fences	Biodiversity conservation
No. of species in Tiby	36	32	38	14	11	4
No. of species in Rivas	8	14	20	17	0	16

Socio-cultural functions	Land mark	Patrimony	Esthetic
No. of species in Tiby	21	10	2
No. of species in Rivas	0	0	0

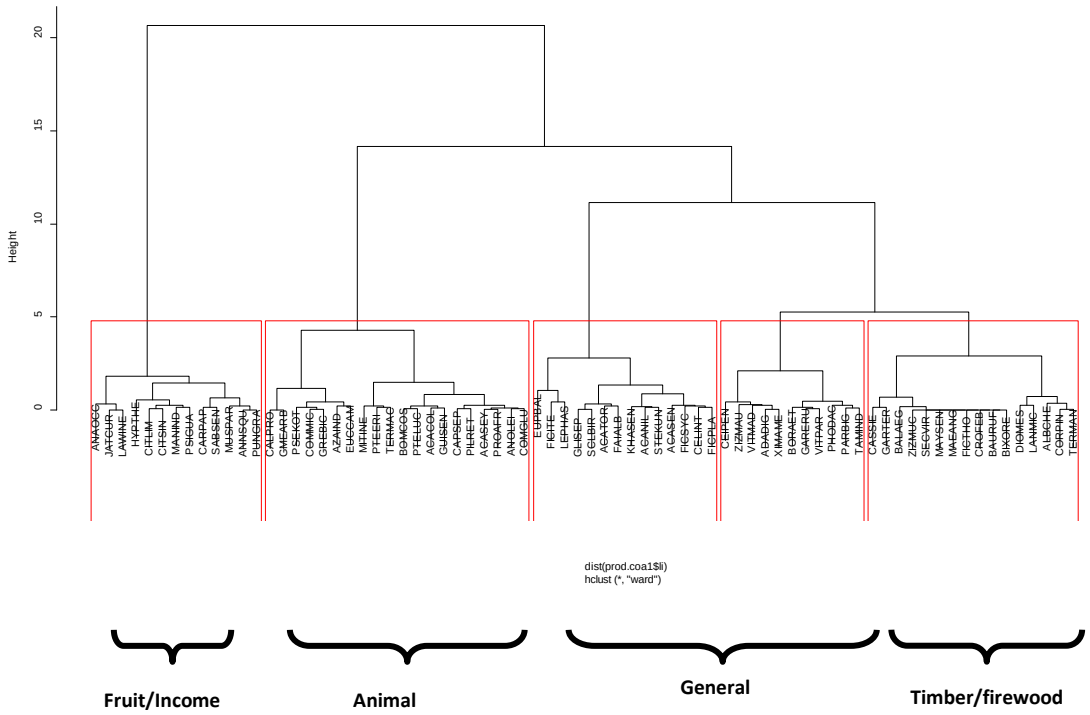
Table 3: Functions fulfilled by unifunctional species in Tiby (Mali)

Uni-functional 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

A clustering analysis based on production functions in Tiby and the resulting hierarchical classifications allow to group species in functional groups (Figure 2). A first group “food and income” appears, composed mostly of fruit species whose fruits can be both for self-consumption and marketed by the farmers. A second group “timber and firewood” emerges, such as a third group called “animal” here and composed of fodder species, some are used to prevent or treat livestock diseases. These three groups are well separated from each other and shows that species composing them are rather “specialized” in one or two main functions.

Another group can be distinguished with 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 2: Hierarchical classification resulting of the COA concerning production functions of tree species according to farmers in Tiby (Mali).



These analyses are still under development and discussion and shall lead in the coming months to the publication of a scientific paper.

3.4 Cross-site analysis

As mentioned above, we managed to organise databases and describe tree traits and functions with most common attributes but some discrepencies still remain. A remaining task is to finalize the common database between sites deciding of common language for traits and functions being still

different. During the final meeting in May 2013 in Trondheim, it was decided to organise cross-site comparison in the following way:

- Compare in detail the types of functions and traits described by stakeholders between sites (see preliminary work above)
- Describe the specific context of the sites (type of production systems, level of services, type of activities) which may lead to potential differences in the needs of the farmers and the communitites which, in turn, can be reflected on the kind of tree resources used, and could explain diffences in tree uses and desired functions.
- Compare common tree species in terms of traits and functions
- Compare functional groups (number, type and botanical composition) between sites as identified by researchers from surveys.

From this analysis, it would be worth also to carry on with some new discussions/surveys with farmers on functions identified in one site and not mentioned in the other. Theses discussions could lead to identify whether this correspond to site specific knowledge or the relative position of particular species in fulfilling a specific function.

This work on cross-site analysis has been planned to be completed before end of 2013 and will be a base for a scientific paper.

4 List of publications

Mosquera Andrade, Ditter Horacio. (2010). Local Knowledge on the goods and services provided by trees and shrubs in cattle production systems of Rivas, Nicaragua. Committee Members: Villanueva, C., I, Gutierrez, M. Ibrahim, and C. Cerdan. CATIE Master's Thesis.

Clinquart, P. (2010). Représentations et usages des espèces ligneuses: Une aproche par les traits fonctionnels pour une ingénierie des systems agroforestier en zones arides et semi-arides. Cas des parcs agroforestiers de la zone de Tiby au Mali. Committee members: Régis Peltier (CIRAD), Nicole Sibelet (CIRAD). Purpan MSc thesis.

Cerdán C.R., Rebolledo M.C., Soto G., Rapidel B., Sinclair F.L. 2012. Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems. Agricultural Systems 110: 119–130.

Clinquart, P., Ickowicz, A., Sibelet N., Dembele, A., Keita, S., Maiga, D., Mounkoro, B., Guerin H., Peltier, R. Defining functional groups of tree species according to rural stakeholders perceptions in the Sahel. (in preparation).

Guerin, H., Ickowicz, A., Bastianelli, D., Heislen, V., Ibrahim, M. Fodder funcion of trees and shrubs for domestic ruminants in arid areas: characterization with mutidimensional functional traits. (in preparation).

5 Annexes

5.1 ANNEX A. Extraction of common database for Potou, Tiby and Rivas.

Extraction of the completed and homogenized database on Funcitree tree species list for the 3 Funcitree sites (Potou/Senegal; Tiby/Mali; Rivas/Nicaragua)

Species register

Spec-nr	Spec-code	Spec-name	Family	Nomenclature	Synonym1	Synonym 2	Potou (Senegal)	Ségou (Mali)	Rivas (Nicaragua)
Species sequence number	*8-digits species code (first 4 letters of species name and first 3 letters of genus epitet)*			*Source for nomenclature*			*In list prepared by ISRA=1, othewise=0.*	*In list prepared by IER=1, othewise=0.*	*In list prepared by CATIE=1, othewise=0.*
1	Acac ata	*Acacia ataxacantha*	*Fabaceae*					1	1	0
2	Acac col	*Acacia collinsii*	*Fabaceae*					0	0	1
3	Acac ehr	*Acacia ehrenbergiana*	*Fabaceae*					0	1	0
4	Acac ery	*Acacia erythrocalyx*	*Fabaceae*		*Acacia pennata*			0	1	0
5	Acac etb	*Acacia etbaica*	*Fabaceae*					0	1	0
6	Acac far	*Acacia farnesiana*	*Fabaceae*					0	0	1
7	Acac hol	*Acacia holosericea*	*Fabaceae*					1	1	0
8	Acac lae	*Acacia laeta*	*Fabaceae*					0	1	0
9	Acac mac	*Acacia machrostachya*	*Fabaceae*					1	1	0
10	Acac mea	*Acacia mearnsii*	*Fabaceae*					0	0	1
11	Acac mel	*Acacia mellifera*	*Fabaceae*					0	1	0
12	Acac nil	*Acacia nilotica*	*Fabaceae*					1	1	0
13	Acac pen	*Acacia pennatula*	*Fabaceae*					0	0	1
14	Ac po.ca	*Acacia polyacantha ssp. campylacantha*	*Fabaceae*					1	0	0
15	Acac sen	*Acacia senegal*	*Fabaceae*					1	1	0
16	Acac sey	*Acacia seyal*	*Fabaceae*					1	1	0
17	Acac sie	*Acacia sieberiana*	*Fabaceae*					1	1	0
18	Ac to.ra	*Acacia tortilis ssp. raddiana*	*Fabaceae*		*Acacia raddiana*			1	1	0
19	Acac xan	*Acacia xanthophloea*	*Fabaceae*					0	1	0
20	Acro fra	*Acrocarpus fraxinifolius*	*Fabaceae*					0	0	1
21	Acro mex	*Acrocomia mexicana*	*Arecaceae*					0	0	1
22	Adan dig	*Adansonia digitata*	*Bombacaceae*					1	1	0
23	Afze afr	*Afzelia africana*	*Fabaceae*					0	1	0
24	Afze qua	*Afzelia quanzensis*	*Fabaceae*					0	1	0
25	Albi ant	*Albizia anthelmintica*	*Fabaceae*					0	1	0
26	Albi fer	*Albizia ferruginea*	*Fabaceae*					1	0	0
27	Albi gua	*Albizia guachapele*	*Fabaceae*					0	0	1
28	Albi leb	*Albizia lebbeck*	*Fabaceae*					0	1	1
29	Albi nio	*Albizia niopoides*	*Fabaceae*					0	0	1
30	Albi sam	*Albizia saman*	*Fabaceae*					0	0	1
31	Albi che	*Albizia chevalieri*	*Fabaceae*					0	1	0
32	Albi mal	*Albizia malacophylla*	*Fabaceae*					0	1	0
33	Allo rac	*Allophylus racemosus*	*Sapindaceae*					0	0	1
34	Allo afr	*Allophylus africanus*	*Sapindaceae*					0	1	0
35	Alnu nep	*Alnus nepalensis*	*Betulacea*					1	1	0
36	Alst boo	*Alstonia boonei*	*Apocynaceae*					1	0	0
37	Anac exc	*Anacardium excelsum*						0	0	1
38	Anac occ	*Anacardium occidentale*						0	1	0
39	Andi ine	*Andira inermis*						1	0	1
40	Anno gla	*Annona glaba*						0	0	1
41	Anno che	*Annona cherimola*						0	1	0
42	An gl;mi	*Annona glauca var. minor*						1	0	0
43	Anno hol	*Annona holosericea*						0	0	1
44	Anno mur	*Annona muricata*						1	0	1
45	Anno pur	*Annona purpurea*						0	0	1
46	Anno sen	*Annona senegalensis*						1	1	0
47	Anog lei	*Anogeissus leiocarpus*						0	1	0
48	Apei tib	*Apeiba tibourbou*						0	0	1
49	Apha sen	*Aphania senegalensis*						1	0	0
50	Aphe sca	*Aphelandra scabra*						0	0	1
51	Apop pan	*Apoplanesia paniculata*						0	0	1
52	Ardi rev	*Ardisia revoluta*						0	0	1
53	Arto het	*Artocarpus heterophyllus*						1	1	0
54	Aspa afr	*Asparagus africanus*						1	0	0
55	Astr gra	*Astronium graveolens*						0	0	1

5.2 ANNEX B. Extraction of Tiby and Rivas database on tree functions

I. Extraction of Tiby (Mali) 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			Trees for human consumption	Fruits for human consumption	Leaves for human consumption	Sprouts for human consumption	Butter for human consumption	Almonds for human consumption
N°	Common name (Bambara)	*Scientific name*						
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

II. Extraction of Rivas (Nicaragua) database on tree functions

Mosquera; Conocimiento Local Sobre Bienes y Servicios de stemas de Produccion Ganadera de Rivas Nicaragua. Tesis

tie.ac.cr; ditter282@yahoo.es

		Services/*Servicios*										Goods/*Bienes*			
		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	M
	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	T
	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	

5.3 ANNEX C. Extraction of Tiby (Mali) and Rivas (Nicaragua) database on tree traits related to functions

Local knowledge about functions and functional traits of tree species													
Data collected by Ditter Mosquera in 2010, Master thesis, CATIE.			Human food										
Tree species			Organoleptic qualities					Consistency					
N°	Common name	*Scientific name*	Bitter fruits	Acid fruits	Sweet fruits	Bitter leaves	Acid leaves	Fruits with few pulp	Fruits with dusty pulp	Fruits with firm pulp	Fibrous fruits	Fruits with knotty bark	Fruits with high water content
1	Acacia Amar	*Acasia spp.*	0	0	0	0	0	0	0	0	0	0	0
2	Acetuno	*Simarouba g*	0	0	0	0	0	0	0	0	0	0	0
3	aguacate	*Persea amer*	0	0	0	0	0	0	0	0	0	0	0
4	almendro	*Terminalia c*	0	0	0	0	0	0	0	0	0	0	0
5	Almendro de	*Andira inerm*	0	0	0	0	0	0	0	0	0	0	0
6	Aromo	*Acacia farne*	0	0	0	0	0	0	0	0	0	0	0
7	Brasil	*Haematoxilo*	0	0	0	0	0	0	0	0	0	0	0
8	Cachito	*Acacia farne*	0	0	0	0	0	0	0	0	0	0	0
9	Caimito	*Chrysophillu*	0	0	0	0	0	0	0	0	0	0	0
10	caoba	*Swietenia hu*	0	0	0	0	0	0	0	0	0	0	0
11	Capulin	*Muntingia ca*	0	0	0	0	0	0	0	0	0	0	0
12	Carao	*Cassia gran*	0	0	0	0	0	0	0	0	0	0	0
13	carbonero		0	0	0	0	0	0	0	0	0	0	0
14	Caucho	*Hevea brasil*	0	0	0	0	0	0	0	0	0	0	0
15	Cedro	*Cedrela odo*	0	0	0	0	0	0	0	0	0	0	0
16	ceibo	*Bombacopsi*	0	0	0	0	0	0	0	0	0	0	0
17	Chaperno	*Albiziaa adir*	0	0	0	0	0	0	0	0	0	0	0
18	Chilamate	*Ficus sp*	0	0	0	0	0	0	0	0	0	0	0
19	Chipilín	*Crotalaria lo*	0	0	0	0	0	0	0	0	0	0	0
20	Chiquirín	*Myrosperma*	0	0	0	0	0	0	0	0	0	0	0
21	Chocoyito		0	0	0	0	0	0	0	0	0	0	0
22	Cóbano	*Swietenia hu*	0	0	0	0	0	0	0	0	0	0	0

5.4 ANNEX D. Proposal of a common classification for Mali and Nicaragua concerning tree functions and functional traits

The titles of functions and/or functional traits that are used in each of both Excel file appear in the last two columns. The common classification proposed appears in the first column. For each function or functional trait, there is an in-ligne correspondance between titles of the original Excel files and titles of the common classification.

The red color means that the term, originaly used in the Excel file, has been replaced or deleted in the common classification. Originaly, such a term is a part of the title of a function or trait. Except for the red terms between brackets, that represent the title of a category of function or trait in the Nicaragua Excel file (goods, dis-services or propagation) not corresponding to the new common classification.

Functions		Common Excel sheet	Mali Excel sheet	Nicaragua Excel sheet
Products	***Human food***	- Fruits for human consumption - Leaves for human consumption - Sprouts for human consumption	- Fruits - Leaves - Roots	Fruit for human consumption
	Fodder	- Edible leaves for livestock - Edible fruits for livestock - Increase of animal milk production - Leaves fattening animals - Improvement of animal health	- Leaves - Fruits - Increase of milk production - Animal fattening (leaves) - Improvement of animal health	- Forage - Edible fruit for livestock
	Animal pharmacopy	- Treatment of chicken worms by branches - Treatment of intestinal parasites of ruminants by leaves - Treatment of intestinal parasites of ruminants by bark	- Treatment of chicken worms (branches) - Treatment of intestinal parasites of ruminants (leaves) - Treatment of intestinal parasites of ruminants (bark)	
	Firewood	- Firewood trees - Trees producing quality charcoal	- Firewood trees - Trees producing good quality charcoal	Fuelwood
	Timber	- Timber trees - Beams of houses - Perches of houses - Big perches of animal sheds - Small perches of animal sheds - Tool handles - Animal drawn carts - Furniture	- House beams - Intermediate perches of houses - Support perches of animal sheds - Intermediate perches of animal sheds - Tool handles - Animal drawn carts - Furniture	Timber
	Income source	- Sellable fruits on market - Sellable leaves on market - Sellable seeds on market - Sellable roots on market - Sellable gum on market - Sellable wood on market	- Fruits - Leaves - Seeds - Roots - Gum - Wood	

Functions		Common Excel sheet	Mali Excel sheet	Nicaragua Excel sheet
Products	***Domestic uses***	- Leaves for oil production - Seeds for oil production - Bark for rope making - Bark for dyeing - Leaves for dyeing - Leaves for basketry - Fruits for leather tanning - Gum for fixation of paints on houses - Nuts for houses waterproofing - Branches for toothpick - Stem leaves for body washing - Leaves for protecting houses from thunderbolts - Latex for making religious ink - Fruits for making ladles and calabashes	- Oil production (leaves) - Oil production (seeds) - Rope making (bark) - Dyeing (bark) - Dyeing (leaves) - Basketry (leaves) - Leather tanning (fruits) - Fixation of paints on houses (gum) - Waterproofing of houses (nuts) - Toothpick (branches) - Body washing (stem leaves) - Protect houses from thunderbolts (leaves) - Making of religious ink (latex) - Making of ladles and calabashes (fruits)	

	Human pharmacopy	- Medicinal trees - Butter for ointment - Butter for protection from cold - Butter for nostril protection against dust - Strengthening of bones by bark - Strengthening of teeth by branches - Energizing leaves - Energizing root bark - Antimalarial roots - Antimalarial bark - Antimalarial leaves - Antimalarial fruits - Laxative fruits - Treatment of constipation by fruits - Treatment of constipation by seeds - Treatment of constipation by roots - Treatment of diarrhea by fruits	- Ointment (butter) - Protection from cold (butter) - Nostril protection against dust (butter) - Strengthening of bones (bark) - Strengthening of teeth (branches) - Energizing properties (leaves) - Energizing properties (root bark) - Antimalarial properties (roots) - Antimalarial properties (bark) - Antimalarial properties (leaves) - Antimalarial properties (fruits) - Laxative (fruits) - Treatment of constipation (fruits) - Treatment of constipation (seeds) - Treatment of constipation (roots) - Treatment of diarrhea (fruits)	Medicinal

Functions		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Products	***Human pharmacopy***	- Treatment of diarrhea by bark - Treatment of diarrhea by leaves - Treatment of diarrhea by root bark - Treatment of stomachaches by leaves - Treatment of stomachaches by fruits - Treatment of stomachaches by bark - Treatment of stomachaches by roots - Treatment of stomachaches by root bark - Treatment of stomachaches by Tapinanthus - Treatment of stomachal diseases by fruits - Treatment of stomachal diseases by leaves - Treatment of stomachal diseases by bark - Treatment of stomachal abscesses by fruits - Treatment of stomach bloating by fruits - Leaves for retention of urine and feces - Leaves for prevention from gurgles of stomach - Treatment of clap by leaves - Treatment of clap by fruits - Treatment of clap by roots - Treatment of clap by bark - Treatment of clap by oil - Treatment of incontinence by Tapinanthus - Treatment of chest diseases by leaves - Treatment of cough by bark - Treatment of cough by root bark - Treatment of cough by seeds - Treatment of throat pains by fruits - Treatment of throat pains by leaves - Treatment of colds by leaves - Treatment of fever by leaves	- Treatment of diarrhea (bark) - Treatment of diarrhea (leaves) - Treatment of diarrhea (root bark) - Treatment of stomachaches (leaves) - Treatment of stomachaches (fruits) - Treatment of stomachaches (bark) - Treatment of stomachaches (roots) - Treatment of stomachaches (root bark) - Treatment of stomachaches (Tapinanthus) - Treatment of stomachal diseases (fruits) - Treatment of stomachal diseases (leaves) - Treatment of stomachal diseases (bark) - Treatment of stomachal abscesses (fruits) - Treatment of stomach bloating (fruits) - Containing oneself without going to the toilet (leaves) - Prevention from gurgles of stomach (leaves) - Treatment of clap (leaves) - Treatment of clap (fruits) - Treatment of clap (roots) - Treatment of clap (bark) - Treatment of clap (oil) - Treatment of incontinence (Tapinanthus) - Treatment of chest diseases (leaves) - Treatment of cough (bark) - Treatment of cough (root bark) - Treatment of cough (seeds) - Treatment of throat pains (fruits) - Treatment of throat pains (leaves) - Treatment of colds (leaves) - Treatment of fever (leaves)	

Functions		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Products	***Human pharmacopy***	- Treatment of dizziness by leaves - Treatment of dizziness by bark - Treatment of dizziness by branches	- Treatment of dizziness (leaves) - Treatment of dizziness (bark) - Treatment of dizziness (branches)	

		- Treatment of high blood pressure by leaves - Treatment of high blood pressure by bark - Treatment of cutaneous reactions by male inflorescences - Treatment of cutaneous reactions by oil - Treatment of skin diseases by bark - Treatment of vision diseases by latex - Treatment of vision diseases by leaves - Treatment of eyes yellowing by leaves and bark - Fruits preventing from eyes problems - Treatment of vision problems by Tapinanthus - Treatment of impotence by roots - Treatment of impotence by branches - Treatment of impotence by bark - Fruits for sexual stimulation - Protection from epidemic contaminations by Tapinanthus - Treatment of unknown diseases by bark - Treatment of unknown diseases by leaves and branches - Treatment of sudden and vary weakening diseases by leaves - Treatment of infantile diseases by leaves - Leaves for stopping bleedings of women giving birth - Leaves for clearing resting blood in vagina of women after childbirth - Decrease of child mortality by pregnant women by Tapinanthus	- Treatment of high blood pressure (leaves) - Treatment of high blood pressure (bark) - Treatment of cutaneous reactions (male inflorescences) - Treatment of cutaneous reactions (oil) - Treatment of skin diseases (bark) - Treatment of vision diseases (latex) - Treatment of vision diseases (leaves) - Treatment of eyes yellowing (leaves and bark) - Prevention from eyes problems (fruits) - Treatment of vision problems (Tapinanthus) - Treatment of impotence (roots) - Treatment of impotence (branches) - Treatment of impotence (bark) - Sexual stimulant (fruits) - Protection from epidemic contaminations (Tapinanthus) - Treatment of unknown diseases (bark) - Treatment of unknown diseases (leaves and branches) - Treatment of sudden and vary weakening diseases (leaves) - Treatment of infantile diseases (leaves) - Stopping of bleedings of women giving birth (leaves) - Clearing resting blood in vagina of women after childbirth (leaves) - Decreasing of child mortality for pregnant women (Tapinanthus)	
Functions		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Products	***Human pharmacopy***	- Fruits for improving health of the child of a pregnant woman who still suckles a previous one - Favoring birth of boys rather than girls by Tapinanthus - Treatment of boils by leaves - Treatment of body pains by bark - Treatment of headaches by bark - Treatment of headaches by branches - Treatment of headaches by roots - Treatment of dental pains by bark - Treatment of dental pains by fruits - Treatment of dental pains by leaves - Treatment of tooth decays by latex - Treatment of mouth pains by bark - Leaves for preventing from tasteless mouth - Treatment of knee pains by leaves - Treatment of knee pains by aerial roots - Treatment of feet pains by bark - Treatment of pains of foot arch by bark - Treatment of pains of foot arch by butter - Treatment of skin cracks of feet by leaves - Treatment of cuts by fruits - Treatment of burns by cambium	- Improvement of health of the child of a pregnant woman who still suckles a previous one (fruits) - Favoring birth of boys rather than girls (Tapinanthus) - Treatment of boils (leaves) - Treatment of body pains (bark) - Treatment of headaches (bark) - Treatment of headaches (branches) - Treatment of headaches (roots) - Treatment of dental pains (bark) - Treatment of dental pains (fruits) - Treatment of dental pains (leaves) - Treatment of tooth decays (latex) - Treatment of mouth pains (bark) - Prevention from tasteless mouth (leaves) - Treatment of knee pains (leaves) - Treatment of knee pains (aerial roots) - Treatment of feet pains (bark) - Treatment of pains of foot arch (bark) - Treatment of pains of foot arch (butter) - Treatment of skin cracks of feet (leaves) - Treatment of cuts (fruits) - Treatment of burns (cambium)	

Functions		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Services	***Soil fertilization***	Improvement of soil fertility	Improvement of soil fertility	Soil improvement
	Antierosive effect	- High antierosive effect - Windbreak - Fixation of river banks	- High antierosive effect - Windbreak - Fixation of river banks	- Erosion control - Windbreaks
	Shade	- Shade trees - Shade for livestock - Shade for pasture	Shade	- Shade for livestock - Shade for pasture
	Live fence	Live fence	Live fences	Posts for live fences (Goods)

	Dead fence	Dead fence	Dead fences	
	Drought tolerance	Drought tolerance		Drought tolerance
	Water resource protection	Water spring protection		Spring protection
	Biodiversity conservation	Biodiversity conservation		Biodiversity conservation
Sociocultural functions	***Landmark***	Landmark	Landmark	
	Inheritance	Inheritance	Inheritance	
	Esthetic	Esthetic	Esthetic	

Functional traits directly linked to tree functions		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Human food	***Organoleptic qualities***	- Sweet fruits - Acid fruits - Bitter fruits	- Sweet fruits - Acid fruits - Bitter fruits	- Sweet fruits - Acidic taste (dis-services)
	Physical caracteristics	- Large fruits - Fruits with few flesh - Fruits with a dusty flesh - Fruits with high water content - Fibrous fruits - Fruits with a knotty bark	- Fruits with few pulp - Fruits with a dusty mesocarp - Fruits with high water content - Fibrous fruits - Fruits with a knotty epicarp	Large fruits
	Health	- Fruits causing diarrhea - Fruits causing stomachaches - Fruits causing suffocation - Toxic fruits		- Causes diahrea (dis-services) - Causes stomachaches (dis-services) - Causes suffocation (dis-services) - Presence of toxins (dis-services)
Firewood		- High combustion ability - Low combustion speed - High calorific power - Low smoke emission - Fast drying speed	- High combustion ability - Low combustion speed - High calorific power - Low smoke emission - Quick drying wood	
Timber		- Very attacked by termite - Few attacked by termite - Very attacked by worms - Straight bole - Knotty wood - Rough wood - Colored wood	- Very attacked by termite - Few attacked by termite - Very attacked by worms - Straight bole - Knotty wood - High roughness	Colored wood

Functional traits directly linked to tree functions		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Common to firewood and timber		- High wood density - Low wood density - Hard wood - Soft wood - Long shelf life - High water content	- High hardness - Long conservation duration	- High wood density - Low wood density - Hard wood - Soft wood - High water content
Fodder	***Palatability***	- Palatable trees - High palatability - Low palatability	- High palatability - Low palatability	Palatable
	Prehensibility	- Fruits eaten only by big animals - Leaves eaten only by big animals - Creepers eaten only by big animals - Fruits eaten only by little ruminants - Leaves eaten only by little	- Palatable for big animals only (fruits) - Palatable for big animals only (leaves) - Palatable for big animals only (creepers) - Palatable for little ruminants only (fruits) - Palatable for little ruminants only (leaves) - Palatable for little ruminants only	

		ruminants - Tapinanthus eaten only by little ruminants	(Tapinanthus)	
	Composition	High vitamin content	High vitamin content	
Soil fertilization	***Decomposition of leaves***	High decomposition speed		Leaves rapidly decompose
	Productivity	Decrease of pasture productivity		Reduces pasture productivity (dis-services)
Shade		- Dense crown - Light shade	- Dense canopy	- Dense crown - Light shade

Transversal functional traits		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Morphological traits	***Entire tree***	- Creeping trees - Thorny trees - Epiphyte trees - Large trees - Crown with lot of ramifications - Trunk with lot of ramifications	- Creeping trees - Thorny trees - Epiphyte trees - High amount of ramifications (canopy) - High amount of ramifications (trunk)	- Produces spines (dis-services) - Large trees - Wide crown
	Leaves	- Small leaves - Big leaves	- Small leaves - Big leaves	- Small leaves
	Roots	- Deep roots - Shallow roots - Taproot and shallow roots - Variable depth of rooting - Abundant roots	- Deep roots - Shallow roots - Taproot and shallow roots - Variable depth of rooting	- Deep roots - Abundant roots
Physiological traits	***Spread***	- High growth ability - High growth speed - Spread by seeds - Spread by cuttings	- High regeneration ability - Propagation by cuttings	- Tree readily sprouts - Rapid growth - Reproduces by seeds (propagacion) - Reproduces clonally (propagacion)
	Number of seeds	- Fruits with few seeds - Fruits with numerous seeds - Fruits with one seed - Trees producing numerous seeds	- Fruits with few seeds - Fruits with numerous seeds - Fruits with one seed	- Produces an abundance of seeds
	Water needs	High water needs	High water needs	
Phenological traits	***Fruit ripening period***	- Start of the rainy season - First half of the rainy season - End of the rainy season - First half of the dry season - Start of the dry season	- Start of the rainy season - First half of the rainy season - End of the rainy season - First half of the dry season - Start of the dry season	
	Foliation	- Evergreen trees - Deciduous trees - Low foliation	- Evergreen trees - Low foliation	- Perennial tree - Deciduous tree (dis-services)
Transversal functional traits		**Common Excel sheet**	**Mali Excel sheet**	**Nicaragua Excel sheet**
Soil preferences		- Lowland trees - Upland trees - Trees of clayey soil - Trees of sandy soil - Variable soil preferences - Without soil preferences	- Lowland trees - Upland trees - Trees of clayey soil - Trees of sandy soil - Variable soil preferences - Without soil preferences	
Intraspecific differences		- Variable bark color - variable leaves color	- Variable bark color - variable leaves color	

FUNCiTREE

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An ecological framework for sustainable and adaptable agro-forestry systems in landscapes of semi-arid ecoregions.

Based on the principles of functional ecology, FUNCiTREE addresses the provision of multiple services of silvopastoral systems (SPS) in semi-arid regions in Africa and Central America. FUNCiTREE aims to provide farmers in the regions with a portfolio of regionally suitable tree species that are capable of providing multiple services. The project integrates theories and concepts from agroforestry and ecological science and will provide a scientifically based model for the design of modernized SPS.

NINA (Norway): The leading research center in Norway on applied ecology, emphasizing the interaction between human society, natural resources and biodiversity

CATIE (Costa Rica): A regional research and education centre about agricultural sustainability, environmental protection and poverty eradication

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CIRAD (France): Research on agro-ecosystems for international sustainable development, environmental, and climate research

CSIC (Spain): Research at the Arid Zones Research Station,

ISRA (Senegal): Priority areas relate to agronomic, animal and forest production, and rural economy

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