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Deliverable 4.1 A list of suitable shrub species

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I. Executive summary

Two different methodologies were employed to create a suitable list of shrubs and trees for project countries. First, extensive consultations with local stakeholders and farmers were held through community, village and field visits. PRA in each site also identified utilized and preferred species by farmers. Second, an extensive literature search was conducted covering electronic catalogues and databases, search engines and relevant scientific journals in Mali, Burkina and Senegal. Consultation of producers allowed us to compare their local knowledge about indigenous species with literature. This comparison revealed that quantitative impact of shrubs and trees on yield and other productivity parameters were not well appreciated by the local populations.

The literature search resulted in a total of 284 references reporting on species that are relevant for crops, human and animal uses. About 300 references were found to be irrelevant and excluded. This resulted in a Microsoft Excel list of shrub and tree species addressing specifically their uses, parts of plant used, crop associated and impact on soil nutrients (soil fertility). Both reference list and extended Excel list of shrub and tree species are available upon request. Most references were from Senegal (128 references) followed by Burkina Faso (108 references) and Mali (48 references). In total, the established list included 135 trees and shrubs (Mali n=24 species, Burkina Faso n=44 species, Senegal n=56 species). The literature review illustrated greater number of species in Senegal and Burkina Faso than in Mali where *Gliricidia sepium* was the predominant species studied. Although the Malian agroforestry systems are dominated by *Vitellaria paradoxa*, *Parkia biglobosa*, *Piliostigma reticulatum*, *Guiera senegalensis* there were almost no references dealing with these species in Mali. Fifteen species commonly studied in Mali, Burkina Faso and Senegal were: *A. nilotica*, *A. senegal*, *A. seyal*, *Adansonia digitata*, *Anacardium occidentale*, *Anogeissus leiocarpa*, *Balanites aegyptiaca*, *Combretum glutinosum*, *Faidherbia albida*, *Guiera senegalensis*, *Moringa oleifera*, *Parkia biglobosa*, *Pterocarpus erinaceus*, *Sclerocarya birrea* and *Vitellaria paradoxa*. Different parts of these species were used but the leaf was the most used part of plants. In Mali, soil fertilization (at 69%) was the most studied topic, while In Burkina Faso, the focus was mostly for feeding animal and human (59% of total uses reported). In Senegal, the uses of trees and shrubs reported were equally balanced between disease treatment, fertilization, fodder (animal) and feeding (human).

The research on the impact of shrubs/trees on associated crops yield was scarce. In Mali, some studies provided the yields of crop associated to shrubs/trees but without providing the results of the control (without shrubs/trees). This make difficult to assess the real impact of these species on crop productivity. Some on-station studies conducted in Senegal by Diakhaté *et al.*, (2016) and Bright *et al.*, (2017), reported yield increases by the presence the shrub (*G. senegalensis* and *P. reticulatum*) without any fertilization. Moreover, the references concerning soil nutrients studying *G. senegalensis*, *Parkia biglobosa*, *Piliostigma reticulatum* and *Vitellaria paradoxa* showed higher contents of carbon, nitrogen and phosphorus under the canopy compared to outside shrub effect. The literature review revealed that there is very limited scientific knowledge on the impact of shrubs and trees on crop production. Most of the studies only report on effect of one species on soil or crops. This result reinforces the importance of SustainSahel approach of assessing the existing systems with more than one species.

The deliverable will be disseminated with producers and other stakeholders in collaboration with WP2 team, using focus group discussions and innovation platforms. At the scientific level, dissemination will take place by means of a peer-reviewed publication summarizing the main outcomes of the literature search.

2. Literature study and local consultation

The main purpose of this literature study was to evaluate the existing knowledge on shrub and tree species in Sahel which are integrated into arable fields for the improvement of agroecosystem productivity (crop, soil fertility, human uses, animal health, environment). The study also aimed at assessing the current knowledge and understanding on the agroforestry systems in Sahel.

2.1. Methodology

The process of co-creation of suitable shrub species relied on several sources of inputs from various actors:

1. Extensive meetings with stakeholders in each location. SustainSahel partners in each location held several general meetings in each site (see pictures below) as well as visited a large number of farms and consulted the farmers and other stakeholders. The minutes of these meetings are available upon request.
2. WP2 PRA (MARF in French) reports identified the species that are preferred by the population at each site. Please refer to the MARF reports for the list of species.
3. WP3 also identified several species that are used or preferred by farmers in Mali and Senegal.

The participatory process

The participatory process in each site was designed in several stages where different actors were involved.

First stage was the appointment of the site facilitators by WP2. These site facilitators were in close contact with WP4, 5 and 6. Site facilitators were selected by the farmer organizations.

In the second stage, WP4 representatives and site facilitators asked the government representatives in each site to organize a stakeholder meeting. In the project countries, it is mandatory to first approach the government representatives first because approaching the other stakeholders and farmers. These meetings included farmers, as well as other value chain actors, majors, regional government representatives etc. SustainSahel project was introduced to the larger community. Already during these meetings, many constraints to adoption of CLS systems, as well as species selection were discussed. The participants suggested villages where the SustainSahel activities can potentially be implemented.

The third stage involved contacting the village chiefs in these suggested villages and visiting them collectively. Each village was visited several times by international and national teams including members of different WPs. In each instance, large group of villagers (women, youth and other groups) were present and we ensured that their opinions were heard. There were targeted questions to women and youth. These discussions were facilitated by the site facilitators and national research teams. The dialogue was informal and the team avoided to be seen as a donor or government officials. We put emphasis on collective decision making to solve the problems in the community. The initial discussions included topics outside of agriculture. Youth migration, education opportunities, labor availability were some of the topics that were discussed.

SustainSahel objectives were communicated to the community. These WP4 focused meetings were not structured in a way that WP2, 3 or 6 were designed. The intention was not to over burden the community with structured interviews. WP2 and 3 (also WP6 in collaboration with WP2) were already collecting data in parallel. The main purpose was to discuss with the farmers what types of agricultural challenges they were facing; how they try to solve these issues; what do they think about integration of shrubs and trees in their cropping systems and where we could have trials and demonstration plots.

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Fourth stage was about finalizing the selection of species and type and location of the trials and the demonstration fields. To achieve this, international and national teams visited the same villages again and had extensive discussions on the species selection and the trial design with the villages. People involved in this process were the field owners, sometimes chief, site facilitators and other interested villagers. The process took part in the main village square and also directly in the fields suggested by the farmers. Farmers introduced their fields, their crop rotation and shrub and tree species and where/how SustainSahel activities can be established.

The whole introduction, discussion and selection process took around nine months.

WP4 combined all these sources of information and created a list of species to be tested in each site. It is to be noted that, the primary focus of SustainSahel is to benefit crop, soil and livestock. Therefore, priority was given to species that satisfy this core criteria. Nevertheless, we also included social, cultural, medicinal and food values of these shrubs in this deliverable, as well as in the PRA reports.



Co-creation of shrub and tree selection process in Ouarkohk and Niakhar, Senegal.



Co-creation of shrub and tree selection process in Koulikoro and Sikasso Mali



Co-creation of shrub and tree selection process in Saria and Yilou Burkina Faso.

Table 1 shows the species mentioned and preferred by the farmers. These species are recorded in PRA reports for each site. Reports are available upon request.

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Scientific name	Common name (English)	Use/Operation
<i>Piliostigma reticulatum</i>		Pods used in livestock feed, Protects the soil against runoff Maintains soil moisture
<i>Faidherbia albida</i>		Leaves enrich the soil, Pods for animal feed
<i>Vitellaria paradoxa</i>	Shea	Nuts for human consumption and shea butter production Main tree in the agroforestry park
<i>Parkia biglobosa</i>		Food product. Processing of the seed into "soubala" mustard for cooking Nitrogen fixing species, ideal for agroforestry parklands
<i>Mangifera indica</i>	Mango	Food product, cash crop
<i>Eucalyptus camaldulensis</i>	Eucalyptus	Production of service wood. But not to be used in the fields (depletes the soil and dries up water points)
<i>Gmelina arborea</i>		Construction and carpentry Animal feeding
<i>Pterocarpus erinaceus</i>	Vene	Animal feeding, fertiliser and household goods. Protected tree not planted. It pumps water and is kept in the field for lopping
<i>Pterocarpus lucens</i>		Animal feeding, Protected tree not planted. It pumps water
<i>Azelia africana</i>		Animal feeding, carpentry
<i>Daniellia oliveri</i>		Animal feeding, carpentry
<i>Ficus sycomorus</i>		Animal feeding
<i>Isobornia doka</i>		Animal feeding, housekeeping
<i>Terminalia macroptera</i>		Animal feed, firewood
<i>Anogeissus leocarpa</i>		Animal feed, fertilizer, crafts
<i>Vitex barbata</i>		Animal feeding
<i>Pericopsis laxiflora</i>		Animal feed, crafts
<i>Combretum molle</i>		Animal feeding
<i>Andersonia digitata</i>	Baobab	Human food (fruits and leaves),
<i>Khaya senegalensis</i>	African Mahogany	Animal feeding, carpentry
<i>Tamarindus indica</i>	Tamarind	Human food (fruits and leaves)
<i>Jatropha curcas</i>	Jatropha	Nuts for oil production, biofuel, hedgerows for erosion control
<i>Anacardium occidentale</i>	Cashew tree	Human food (fruit), hedgerows
<i>Lannea microcarpa</i>		Human food (fruit), crafts
<i>Diospyros mespiliformis</i>	Ebony	Human food (fruit), artisana. Protected tree not planted. It pumps water and is kept in the field for lopping. Treatment of diseases with seeds
<i>Moringa oleifera</i>	Moringa	Human food (leaves), Animal feeding, medicinal use (leaves and fruits)

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<i>Gliricidia sepium</i>	Gliricidia	Fertilizer species, animal feeding
<i>Lawsonia inermis</i>	Henna	Fertilizer species, cultural use (ink), hedgerows
<i>Acacia radiana</i>	Umbrella thorn acacia	Animal feeding
<i>Balanites aegyptiaca</i>	Desert date	Animal feeding
<i>Ziziphus mauritiana</i>	Jujubier, Jujube	Human food (fruit)
<i>Azadiracta indica</i>	Neem	Medicinal, Pest control, shading, animal feeding
<i>Acacia senegalensis</i>	Gum arabic tree	Gum production, fertilizer species, animal feeding
<i>Guiera senegalensis</i>	Guiera	Biomass used for mulch to improve soil structure, increase fertility and prevent erosion

Based on the consultation with farmers, stakeholders, as well as the literature review and researchers' expert knowledge, WP4 selected the species listed below.

Table 2: Number of plants distributed to producers (species chosen by farmers)

Species	Quantity of plants distributed
<i>Acacia mellifera</i>	102
<i>Acacia raddiana</i>	40
<i>Balanites aegyptiaca</i>	48
<i>Detarium microcarpum</i>	355
<i>Faidherbia albida</i>	80
<i>Neocarya macrophylla</i>	16
<i>Piliostigma reticulatum</i>	15
<i>Ziziphus mauritiana</i>	75
TOTAL	731

Table 3: Seeds or cutting made available for producers (chosen by farmers)

Species	Quantity	Sites
<i>Acacia mellifera</i>	500 g (graine)	Pépinière communautaire De Ourkhokh
<i>Acacia raddiana</i>	2,5 Kg (gousse)	
<i>Faidherbia albida</i>	3 kg (gousses)	
<i>Ziziphus mauritiana</i>	400 g (graine)	
<i>Pennisetum purpureum</i>	100 boutures	
<i>Acacia mellifera</i>	500 g (graine)	Pépinière communautaire De Sanghai
<i>Acacia raddiana</i>	2,5 Kg (gousse)	
<i>Faidherbia albida</i>	3 kg (gousses)	
<i>Ziziphus mauritiana</i>	400 g (graine)	
<i>Pennisetum purpureum</i>	100 boutures	

Table 4: Selected species for experiments in WP4

Country	Site	Species used
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Mali	Koulikoro	Faidherbia albida, Leucaena leucocephala, Piliostigma reticulatum, Guiera senegalensis, Gliricidia sepium
	Sikasso	Leucaena leucocephala
Senegal	Niakhar	Guiera senegalensis Faidherbia albida
	Ouarkhokh	Combretum glutinosum, Combretum glutinosum, Acacia tortilis ssp. Raddiana, Balanites aegyptiaca Guiera senegalensis, Acacia radiana
	Tambacounda	Piliostigma reticulatum
Burkina Faso	Yilou	Vitellaria paradoxa, Balanites aegyptiaca, Piliostigma reticulatum, Combretum micranthum, Guiera senegalensis
	Saria	Piliostigma reticulatum, Guiera senegalensis, Azadirachta indica, Vitellaria paradoxa, Khaya senegalensis, Guiera senegalensis, Piliostigma reticulatum
	Gampéla	Vitellaria paradoxa, Balanites aegyptiaca, Piliostigma reticulatum, Combretum micranthum, Guiera senegalensis

Leucaena leucocephala was selected in Sikasso site because farmers expressed their interest in fast growing species which can be used as soil amendment and also feed for livestock. It is not included in the WP2 survey results because farmers did not mention this species by name but just expressed their need for certain characteristics. According to farmers, there are no fast growing species in their ecology with such characteristics. Their demand is related to their past experience with ORM4Soil project, where Gliricidia sepium was promoted as soil and livestock supplement. Based on their positive experiences, IER researchers suggested Laucaena to farmers. Farmers already had experience with Gliricidia and wanted to test another species. Both Gliricidia and Laucaena are exotic species.

2.1.1. Literature search

The literature search was carried out in each of the project countries. In Burkina Faso and Mali the search was focused on the locally available literature in libraries or other online sources, in Senegal, on the other hand both local, regional and international sources were investigated. It considered publications that were published between 1983-2021 and was conducted in both, English and French.

The literature search was carried out primarily in university libraries such as the digital platforms and physical libraries of each country. Detailed list of all sources (libraries, online libraries, online databases and journal names are listed in the table in Appendix 1. The research was based on the following keywords: trees; shrubs; sahel; agroforestry; crop association. Combinations of keywords in levels 1-3 with/out keywords of level 4 were used. The table listing the keywords are presented in Appendix 2.

2.1.2. Selection process of references

Each partner country had designated a team responsible of this task. Prior to the start of this task, meetings were held between the teams from the three countries to identify the relevant criteria to be reported from the literature in a spreadsheet. Literature was also shared among the teams of the three countries to optimize the scientific coverage of the subject studied. The literature review gave priority to local bibliographic resources in order to improve the knowledge of the state of the art of the work done locally

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on the subject. Local bibliographic references are often not available in international databases and many of these local references are only in print form.

The literature search resulted in a total of 284 references reporting on species that are relevant for crops, human and animal uses. Details, from 284 references, of tree/shrub species such as full scientific name, common name, synonyms, type (tree/shrub), family, country of study (Senegal, Burkina Faso, Mali), region (Sahel or Sudano-Sahelian), phenology, origin (native or introduced), use (feeding, and/or disease prevention, and/or disease treatment and/or soil fertilization and/or C sequestration), parts used (Leaves, fruits, pods, spines, wood, gum, flowers, barks), forage species, associated crops and it's yields if available, trees/shrubs density if available, season used (dry and/or wet), opportunities, constraints, reference and type of publication have been tabulated and analyzed in Microsoft Excel. However, some references that addressed studies for more than one species were duplicated in the database to exploit all information for each species. So, the number of studies (457) is different to the total number of references (284). All literature sources were entered into Mendeley reference manager system. In total, around 300 irrelevant literature sources were excluded from this task, but classified in a library to be used for other aspects of the project.

Most of the studies reported on qualitative parameters such as type of use, parts used. Particularly the local literature lacked quantitative information on the contribution of trees/shrubs to crop yields in agroforestry systems and soil fertility, as well as the optimal density of trees/shrubs to optimize their effects for example. This is an important finding for determining the treatments for the field trials of SustainSahel. Our scientific questions and investigations are being designed in a way that would provide answers to many of the questions on the crop and soil responses to existing and the innovative systems introduced by SustainSahel.

2.1.3. Selected literature

2.1.3.1. Type of publication

The studies from Mali, Burkina and Senegal, exploited were mostly field studies (on-farmers fields) (57%), followed by experimental study (on experimental station) (25%) and survey (14%). Other type of references was minor such as review and technical sheet.

Table 5: publication type of selected references (total n=457)

Type of publication	Number of references per species ⁽¹⁾
Communication	1
Experimental_study	72
Field_study	161
Field_study_and_survey	1
In_vitro_experiment	1
Mémoire	1
Not_spécifié	2
Review	2
Survey	41
Technical_manual	2
Total	284

(1) A study can concern more than one species.

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The repartition of references per country is shown in figure I. Most references were from Senegal (128 references) followed by Burkina Faso (108 references) and Mali (48 references).

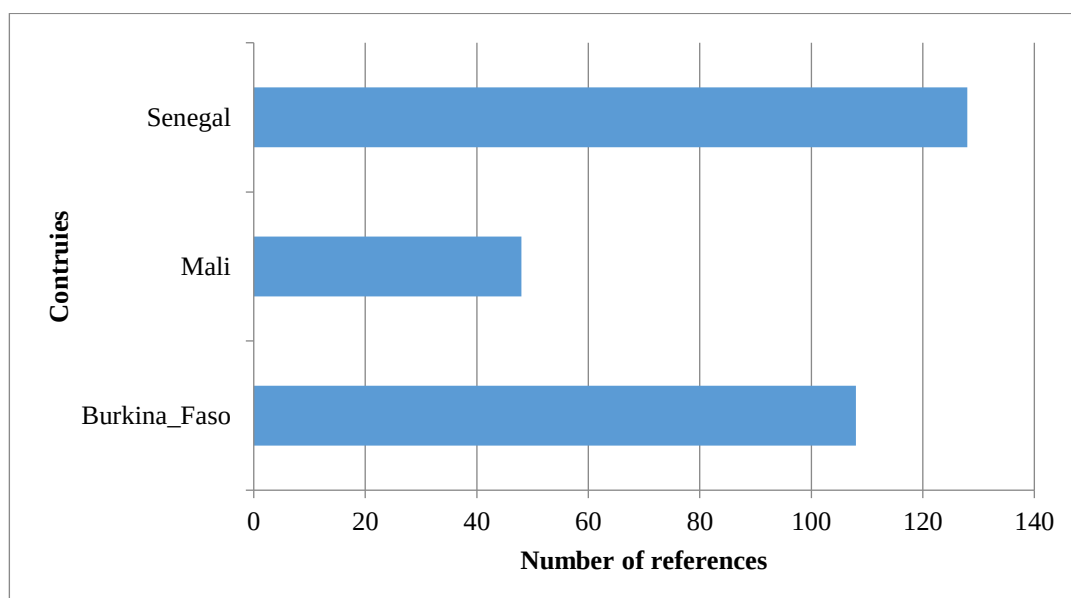


Figure I: Number of references covered in the reviewed literature per country

2.2. Results

2.2.1. Identified browse species (trees and shrubs)

In total, the established list of browse species contains 135 trees and shrubs (Mali n=24, Burkina Faso=44 species, Senegal n=56 species). The literature review revealed more diversified species in Senegal and Burkina Faso than in Mali where *Gliricidia sepium* was the predominant species found in references. Although the Malian agroforestry production systems is dominated by *Vitellaria paradoxa*, *Parkia biglobosa*, *Piliostigma reticulatum*, *Guiera senegalensis* and several other species, there are only few studies on the most dominant trees and shrubs. *Gliricidia sepium* is a recently introduced species and most of the studies on its effect are very recent. This highlights the urgent need to for scientific studies assessing the most common species impact on the crop production and soil quality.



Figure 2: Number of studies per species in Mali

In Burkina Faso, there are substantially more studies than that is available in Mali on the most common species found in the landscape. Studies in Burkina Faso cover both common shrub and tree species *Vitellaria paradoxa*, *Parkia biglobosa*, *Piliostigma reticulatum*, *Guiera senegalensis* and *Faidherbia albida*. In Senegal, on the

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other hand, studies on the tree species *Vitellaria paradoxa*, *Parkia biglobosa* are rare. Most of the publications in Senegal are on *Piliostigma reticulatum*, *Guiera senegalensis* and *Faidherbia albida*.

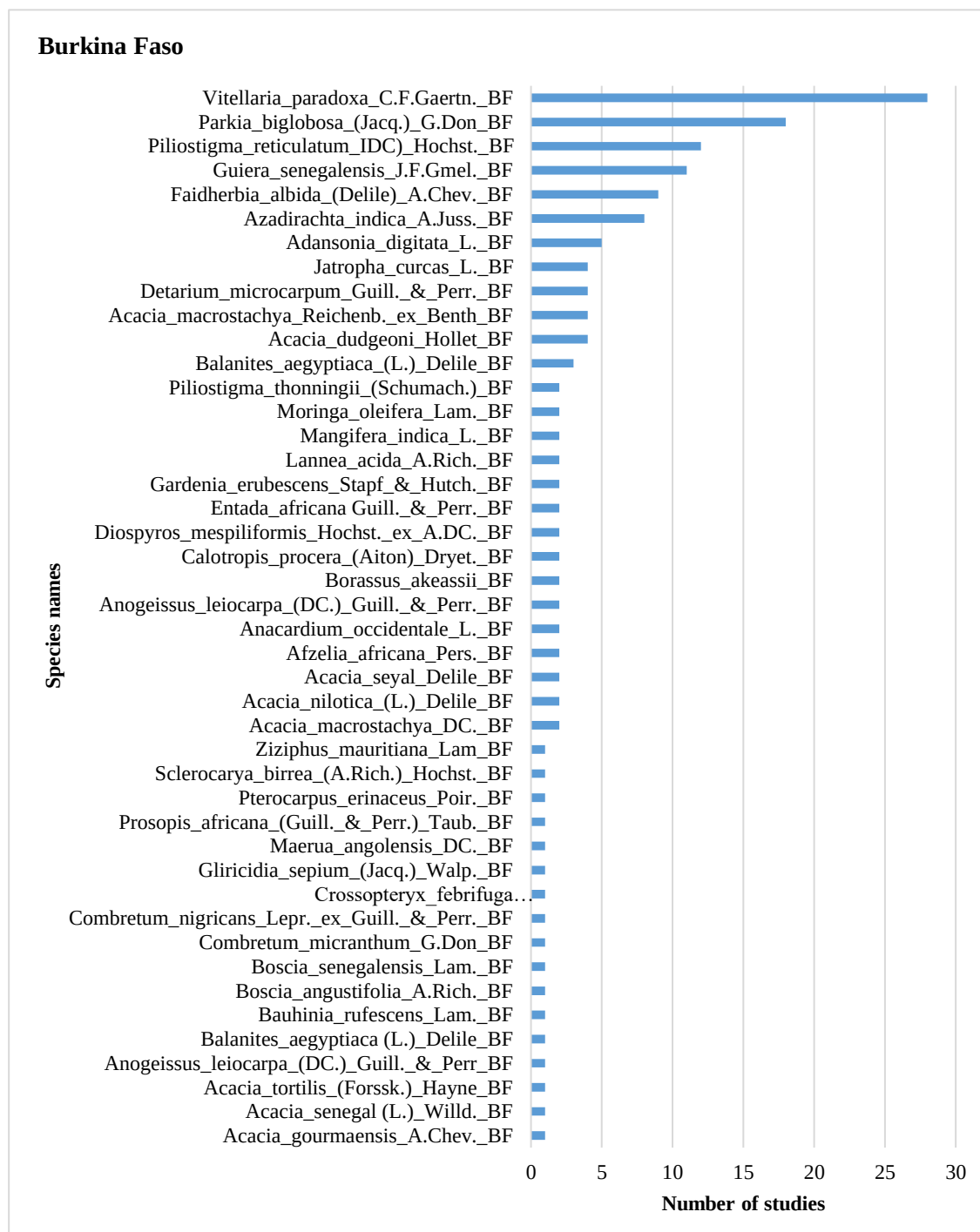


Figure 3: Number of studies per species in Burkina Faso

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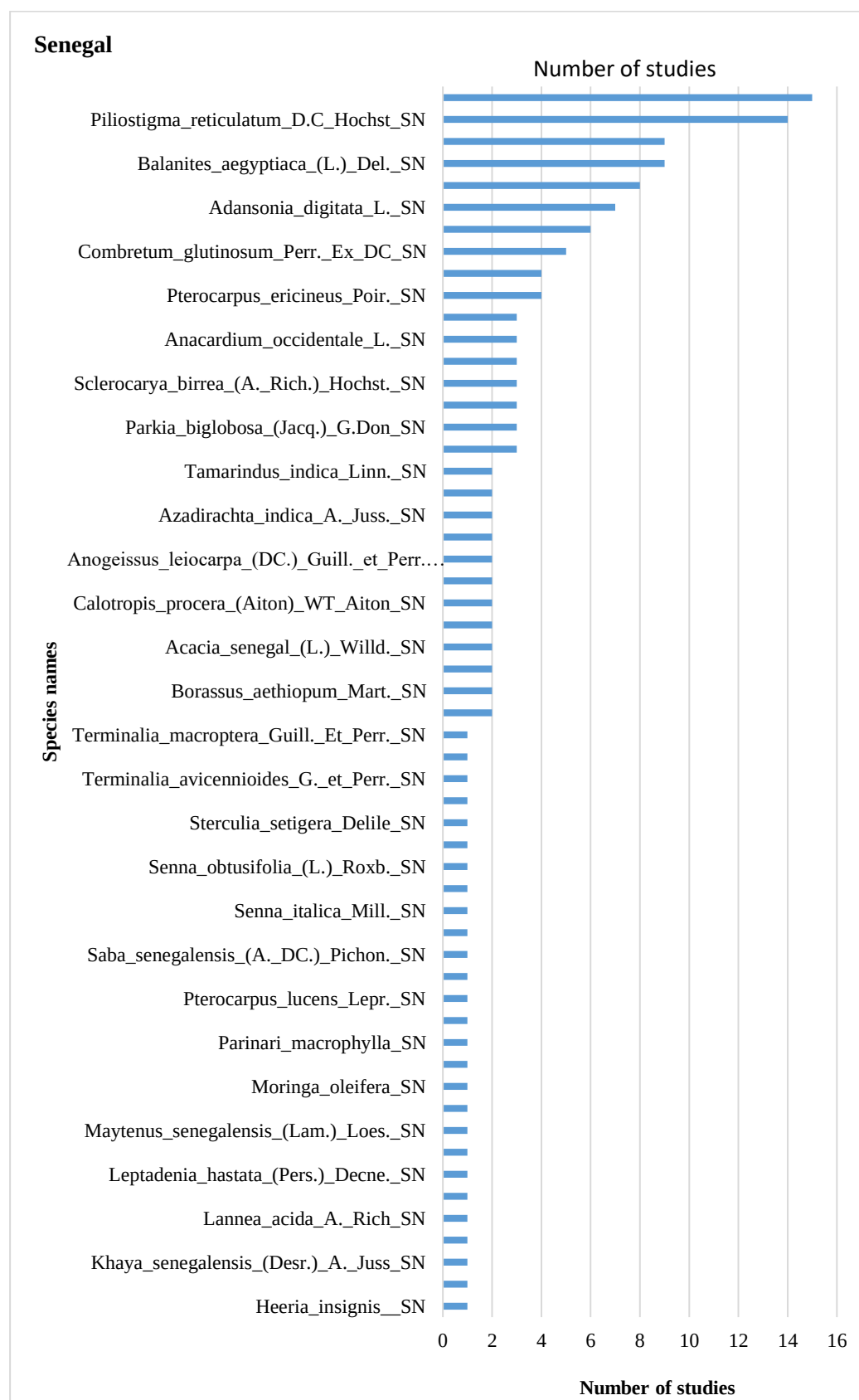


Figure 4: Number of studies per species in Senegal

2.2.2. Species commonly studied in three countries

Fifteen species were commonly studied by Mali, Burkina Faso and Senegal and were: *Guiera senegalensis* (n=25 studies), *Vitellaria paradoxa* (n=20 studies), *Adansonia digitata*, *Balanites aegyptiaca*, *Faidherbia albida*, *Combretum glutinosum* with n= 11 studies. The species *Parkia biglobosa* *Acacia seyal*, *A. nilotica*, *A. senegal*, *Anacardium occidentale*, *Anogeissus leiocarpa*, *Pterocarpus erinaceus*, *Sclerocarya birrea*, *Moringa oleifera* have been less studied (between n=8 and n=4). The number of studies per species was different in countries. *G. senegalensis* and *V. paradoxa* were more studied in Senegal and Burkina Faso.

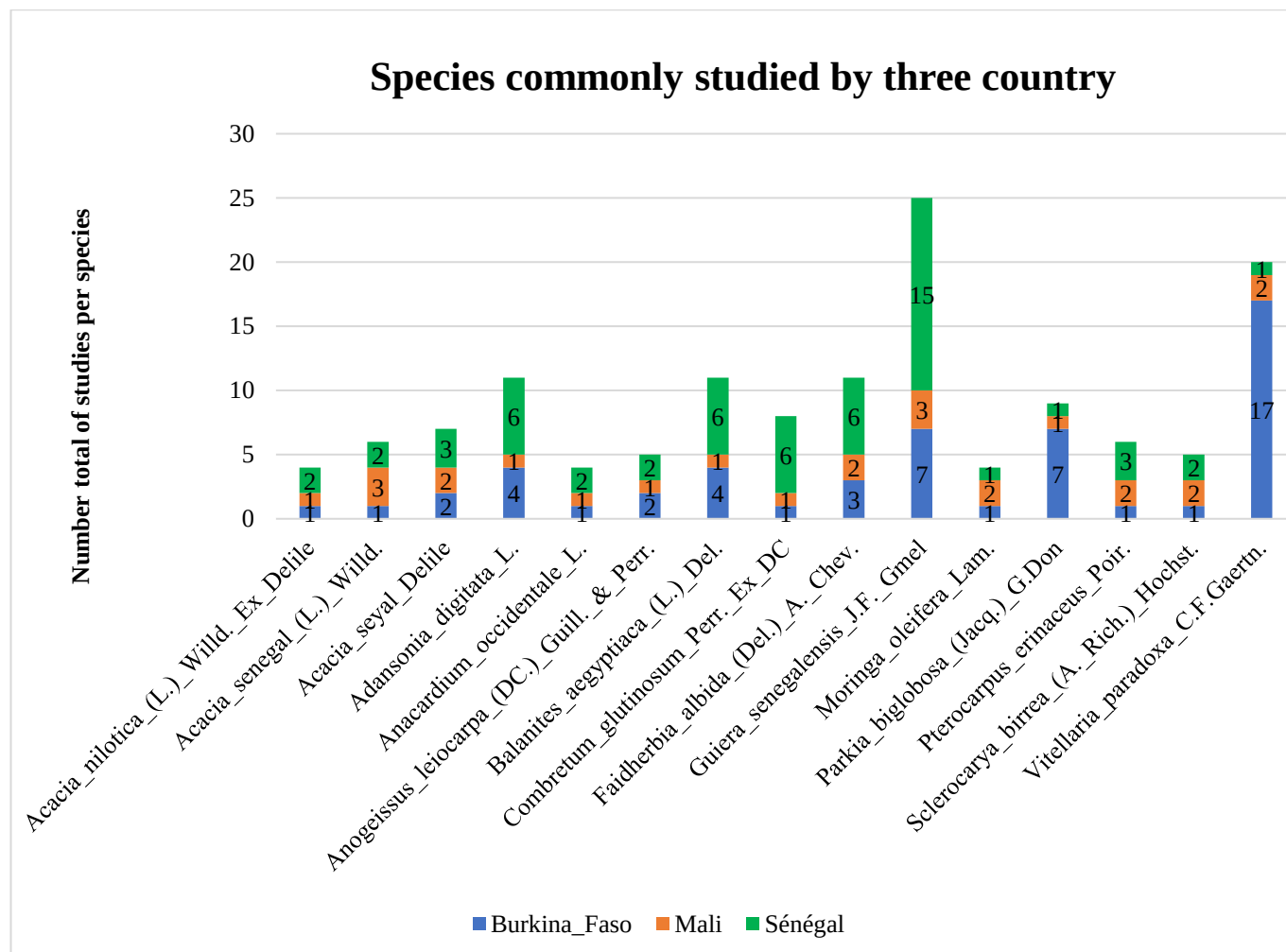


Figure 5: Number of studies per species studied commonly in the three countries

2.2.3. Parts of trees and shrubs used

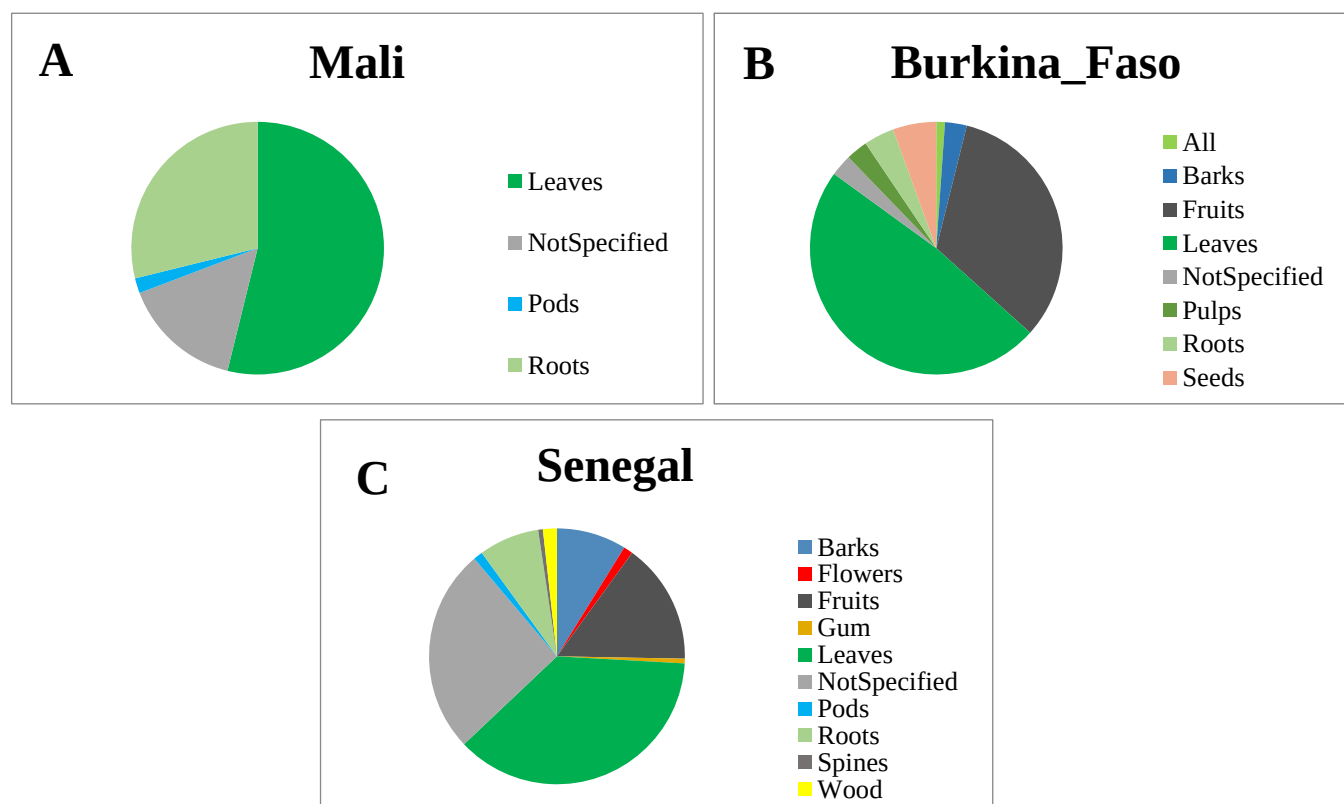


Figure 6: Repartition of parts of plants used in Mali (A), in Burkina Faso (B) and in Senegal (C).

The shrubs/trees presented diverse uses. In Senegal and Burkina Faso, figures 6C and 6B showed that all parts of plants are used (bark, flower, fruit, gum, leaf). This corroborates with the fact that the publications exploited in these two countries dealt with more species than those from Mali. However, the leaves are the part of plants most used in all countries at n=28 studies, n=87 studies, n=63 studies.

2.2.4. Trees and shrubs uses

The main purpose of this literature search was to identify trees and shrubs species that could be integrated in arable fields and also to review the available knowledge on the management and impact of these systems on crop productivity and soil quality. Other benefits/uses such as carbon sequestration, disease treatment, fertilizer, and fodder use were also recorded and will be analyzed along with the crop and soil data.

In Mali, soil fertilization (at 69%) was the most studied impact from the species such as *Acacia angustissima*, *A. cole*, *A. holosericea*, *A. tortilis*, *A. seyal*, *Albizia lebbek*, *Bauhinia reticulata*, *Cajanus cajan*, *Cassia sieberiana*, *Combretum lecardii*, *Faidherbia albida*, *Gliricidia sepium*, *Prosopis africana*, *Pterocarpus erinaceus*, *Sclerocarya birrea*, *Senna spectabilis*, *Vitellaria paradoxa*.

In Burkina Faso, the focus was mostly for feeding animal and human (59% of total uses reported). Most studied species were *Acacia_macrostachya*, *A. senegal*, *A. nilotica*, *A. seyal*, *A. dudgeoni*, *A. gourmaensis*, *Adansonia digitata*, *Azadirachta indica*, *Afzelia africana*, *Anogeissus leiocarpa*, *Anacardium occidentale*, *Balanites aegyptiaca*, *Boscia angustifolia*, *Combretum nigricans*, *Combretum micranthum*, *Crossopteryx febrifuga*, *Detarium microcarpum*, *Diospyros mespiliformis*, *Faidherbia albida*, *Gardenia erubescens*, *Gliricidia sepium*, *Guiera*

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senegalensis, *Lannea acida*, *Maerua angolensis*, *Mangifera indica*, *Moringa oleifera*, *Piliostigma reticulatum*, *Pterocarpus erinaceus*, *Sclerocarya birrea*, *Vitellaria paradoxa*, *Parkia biglobosa*, , *Ziziphus mauritiana*.

In Senegal, the uses of trees and shrubs reported were equally balanced between disease treatment, fertilization, fodder (animal) and feeding (human). As it can be seen in figures 2, 3, 4 there were more diversity of species and the purpose of uses in literature references of Senegal than in Burkina Faso and Mali.

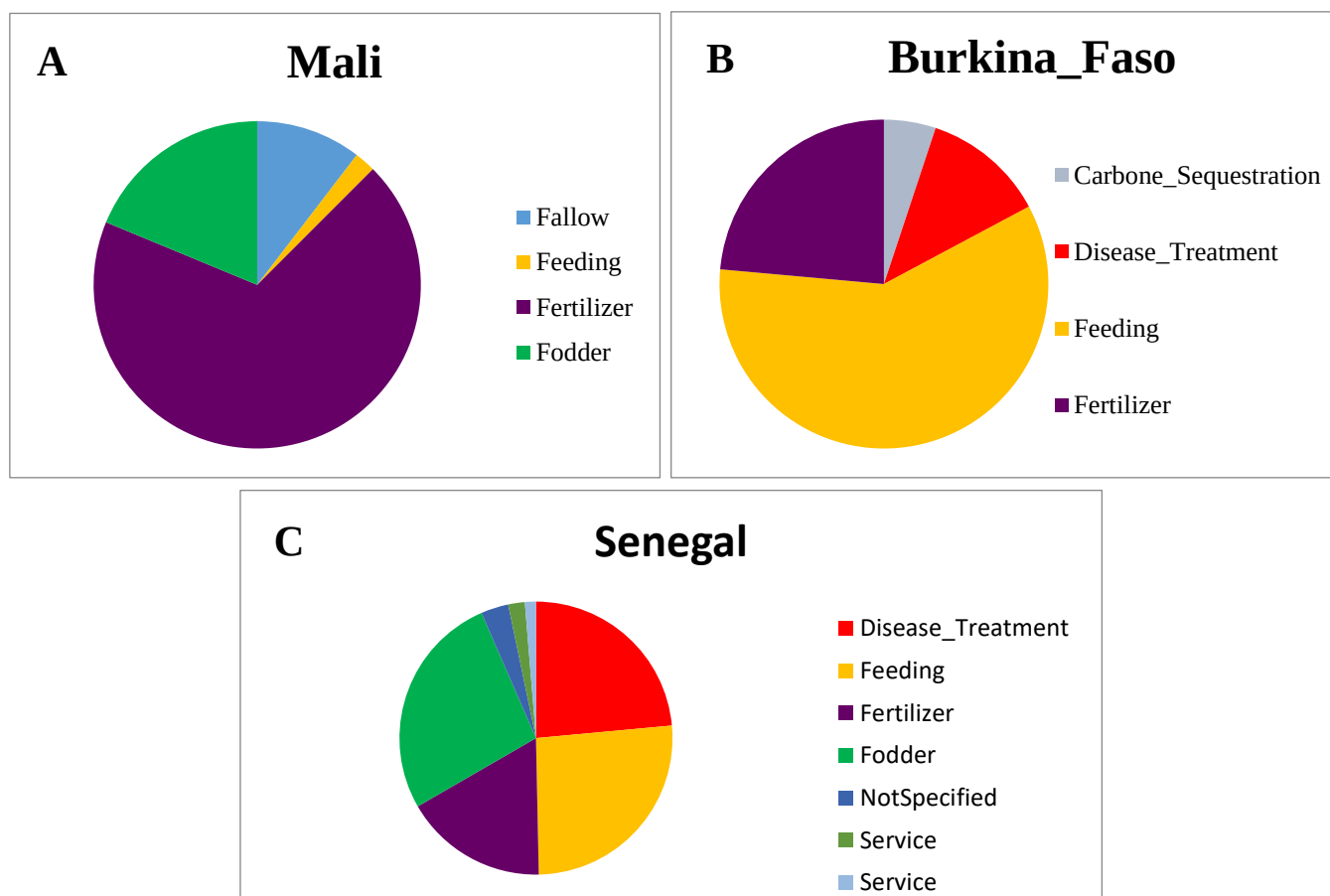


Figure 7: Repartition of uses of shrubs/trees in Mali (A), in Burkina Faso (B) and in Senegal (C).

2.2.5. Yields of crops associated to shrubs/trees

Information concerning the impact of shrubs/trees on associated crops yield was scarce. In Mali, some studies provided the yields of crop associated to shrubs/trees (Figure 8) but without providing the results of the control (without shrubs/trees). This makes it difficult to assess the real impact of these species on crop productivity. The figure shows that the largest study of crop yield in relation to the shrub was *Gliricidia sepium*.

Some studies (Diakhaté *et al.*, (2016) and Bright *et al.*, (2017)) in Senegal, reported the yields of groundnut and millet associated and/or not to *Guiera senegalensis* and *Piliostigma reticulatum* (Figure 9). The yields were increased by the presence the shrub without fertilization. The density of shrubs was an average of 1200 plants per hectare.

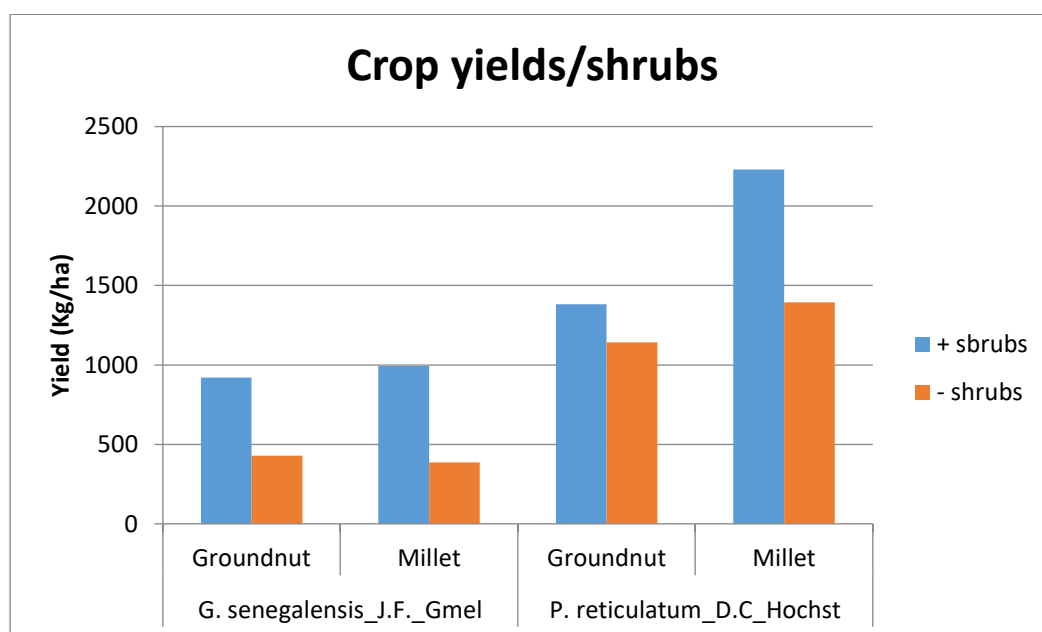


Figure 8: Effect of the presence or absence of shrubs on crop yields at the long-term research station in Niore, Senegal (Diakhaté *et al.*, 2016; Bright *et al.*, 2017)

2.2.6. Impact of shrubs on soil nutrients

The references concerning soil nutrients using *G. senegalensis*, *Parkia biglobosa*, *Piliostigma reticulatum* and *Vitellaria paradoxa* show higher contents of carbon, nitrogen and phosphorus under the canopy. Carbon levels were significantly higher under the *P. biglobosa* compared to other species. Unfortunately, soil nutrients analysis have not been widely reported in the literature reviewed.

Table 6: Impact of shrubs and trees on soil nutrients (Bayala et al., 2007; Diakhaté et al., 2016; Bright et al., 2017)

Soil nutrient *	P (µg.g-1)		N (mg.g-1)		C (mg.g-1)	
	+shrub	-shrub	+shrub	-shrub	+shrub	-shrub
<i>G. senegalensis</i> _J.F._Gmel	ND	ND	ND	ND	7,85	4,55
<i>P. biglobosa</i> _(Jacq.)_G.Don	ND	ND	ND	ND	11,76	4,25
<i>P. reticulatum</i> _D.C._Hochst	84	81,3	0,3552	0,3117	10,1	7,52
<i>V. paradoxa</i> _Gaertn._F.	ND	ND	ND	ND	6,5	4,1

* Soil nutrient in the presence (+ shrub) or absence (- shrub) of shrub

3. Dissemination activities related with the Deliverable

The information collected in this deliverable will be disseminated with producers and other stakeholders. This dissemination will be supported by WP2 for focus group discussions and innovation platforms. The results of the deliverable will be shared using adapted communication for each target group. The deliverable will be also combined with the deliverable of WP5 and WP6 to collectively analyze all data collected. At the scientific level, dissemination will take place by means of a peer-reviewed publication summarizing the main outcomes of the literature search combined with a meta-analysis of the collected data. It is planned to submit the manuscript the last Quarter of 2021 to an international peer-reviewed journal.

4. Appendix

Appendix I: Information sources used for the literature searches

Libraries	Electronic catalogues and databases	Search engines	Scientific journals (in alphabetical order)
♦ Library of Rural Development Institute (IRD) ♦ Library of Nazi BONI university ♦ Library of Institute of the Environment and Agricultural Research (INERA)	♦ Publication database of the World Agroforestry Centre (ICRAF) ♦ Publication database of the the Development Research Institute ♦ Cheikh Anta Diop University of Dakar (UCAD): www.bibnum.ucad.sn ♦ www.univ-senegal.scholarvox.com	♦ Google Scholar ♦ Research Gate ♦ CAB Direct	♦ Agriculture, Ecosystems and Environment ♦ Agriculture and Allied Sciences ♦ Agroforestry ♦ Agroforestry Systems ♦ AJOL (African journal online) ♦ Biodiversity and Conservation ♦ Cahiers Agricultures ♦ Environmental and Experimental Botany ♦ Ethology ♦ Ethology, Ecology and Evolution ♦ Ethnobotany Research and Applications ♦ Frontiers in Plant Science ♦ Forests ♦ Journal of Ethnopharmacology ♦ Journal of Ethnobiology and Ethnomedicine ♦ Plant and Soil ♦ Plant Ecology and Diversity ♦ Plants ♦ PloS One ♦ Sécheresse ♦ Sustainability ♦ Trees ♦ Advances in Agroforestry ♦ Afrique SCIENCE ♦ Agroforest Systems ♦ Bois et Forêts des Tropiques ♦ International Journal of Biological and Chemical Sciences. ♦ International Journal of Current Research ♦ International Journal of Innovative Science and Research Technology ♦ Journal of Apply Biosciences. ♦ Journal of Animal & Plant Sciences ♦ Journal of forestry research ♦ Journal of Plant Studies ♦ Journal of Stored Products and Postharvest Research ♦ New Forests ♦ Nutrient Cycling in Agroecosystems ♦ Outlook on Agriculture ♦ Pakistan Journal of Nutrition ♦ Scientific Reports ♦ Sécheresse ♦ Silva Fennica

Deliverable 4.1 A list of suitable shrub species

Appendix 2: Search terms used for the literature searches

English	Synonyms	Français	Level
Shrubs		Arbustes	1
Trees		Arbres	1
Parts used			
Forage	Fodder	Fourrage	2
Animal health		Santé animale	2
Traditional medicine		Médecine vétérinaire traditionnelle	2
Utilization	Use Exploitation	Utilisation	2
Sahel		Sahel	3
Sudano-Sahel		Sudano-Sahel	3
Senegal		Sénégal	3
Burkina Faso		Burkina Faso	3
Mali		Mali	3
West Africa		Afrique de l'Ouest	3
Local knowledge	Indigenous knowledge	Savoir local	4
Seasonality		Saisonalité	4
Phenology		Phénologie	4
Pruning		Élagage	4

5. References

Bayala J., Balesdent J., Marol C., Zapata F., Teklehaimanot Z., Ouedraogo S.J. (2007) – Relative contribution of trees and crops to soil carbon content in a parkland system in Burkina Faso using variations in natural ^{13}C abundance. *Nutrient Cycling in Agroecosystems*, **76**, 161–169.

Bright M.B., Diedhiou I., Bayala R., Assigbetse K., Chapuis-Lardy L., Ndour Y., Dick R.P. (2017) – Long-term *Piliostigma reticulatum* intercropping in the Sahel: crop productivity, carbon sequestration, nutrient cycling, and soil quality. *Agriculture, Ecosystems & Environment*, **242**, 9–22.

Diakhaté S., Gueye M., Chevallier T., Diallo N.H., Assigbetsé K., Abadie J., Diouf M., Masse D., Sembène M., Ndour Y.B. (2016) – Soil microbial functional capacity and diversity in a millet-shrub intercropping system of semi-arid Senegal. *Journal of Arid Environments*, **129**, 71–79.