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Deliverable 6.1 Review on utility of selected shrub-foliage

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Table of Contents

1. EXECUTIVE SUMMARY	4
2. MATERIAL AND METHODS.....	5
2.1. Ethnobotanical surveys	5
2.2. Bibliographic study	7
2.2.1 Literature search.....	7
2.2.2 Selection process	7
2.2.3 Selected literature.....	7
3. RESULTS	8
3.1 Crop-livestock farmers' stated preferences for shrub foliage	8
3.2 Identified browse species (trees and shrubs) in the bibliographic study	9
3.3 Use of trees and shrubs for livestock feeding and veterinary health care (bibliographic study) 10	
3.4 Nutritional profile of browse species and their impact on animal performance (bibliographic study)	11
3.5 Leaf phenology (bibliographic study)	13
4. DISSEMINATION ACTIVITIES RELATED WITH THE DELIVERABLE.....	14
5. APPENDIX	15
6. REFERENCES.....	17

I. Executive summary

Ethnobotanical surveys and an extensive literature search were conducted to identify the most preferred and regionally important shrub foliage in Senegal, Burkina Faso, and Mali. Over 600 crop-livestock farmers in Koulikoro (Mali), Ouarkhokh (Senegal), as well as Saria and Yilou (Burkina Faso) were approached in personal interviews to assess their preferences for shrub foliage and their feeding practices. Based on the stated preferences, a list of relevant shrubs and trees for ruminant livestock feeding was established for each partner country. The literature review covered electronic catalogues and databases, search engines and relevant scientific journals. This resulted in the screening of 1465 publications, of which 894 were further processed and entered into Mendeley reference manager system. A total of 141 studies were classified as relevant and reviewed to establish the list of browse species. This resulted in a Microsoft Excel list of shrub and tree species with special importance for livestock feeding and animal health management. For each study, botanical details of the species, country, plant parts used, livestock species, and nutritional aspects were tabulated and analyzed.

According to agropastoralists in Koulikoro, the most preferred browse species of sheep are *Pterocarpus lucens* (47%), *P. erinaceus* (44%) and *Ficus sycomorus* (42%). Other important browse species are *Khaya senegalensis* and *Entada africana* (18% each). The most frequently cited browse species for sheep in Burkina Faso were *Faidherbia albida* (41%), *Lannea microcarpa* (35%), *Vitellaria paradoxa* (25%), *Balanites aegyptiaca* (23%) and *Ficus sycomorus* (20%). In Senegal, agropastoralists mentioned *B. aegyptiaca*, *Acacia tortilis* ssp. *raddiana*, *A. digitata* and *Guiera senegalensis* as most preferred trees and shrubs of sheep. Regarding the three SustainSAHEL target countries, Burkina Faso turned out to be the country most often covered in the publications of the literature review. The Sudano-Sahel region was with 48 publications more often studied than the Sahel region (34 publications). In total, 153 tree and shrub species were recorded, which belong to 37 botanical families. Leguminosae is the dominating family, representing 34.4% of the browse species. The most often studied species are *Balanites aegyptiaca* (L.) Delile, *Pterocarpus erinaceus* Poir., *Faidherbia albida* (Delile) A.Chev. and *Acacia senegal* (L.) Willd. It was possible to allocate the tree and shrub species to six leaf phenology classes, which range from short deciduous to evergreen according to the lengths of the foliated period. Nearly all studied trees and shrubs (n=142; 92.8%) are used as livestock feed, whereas 57 species have also ethno-veterinary uses. The by far most important plant parts used in livestock feeding are leaves, followed by fruits and pods. For animal health care, the most often used plant parts are leaves, bark and roots. Preference studies indicated *Afzelia africana* Pers., *Detarium microcarpum* Guill & Perr., *Ficus sur* Forssk., *F. albida*, *P. erinaceus*, and *Pterocarpus lucens* Guill. & Perr. as the most highly valued browse species by farmers. Overall, the literature study pointed out knowledge gaps, particularly referring to nutritional characteristics of browse species, which offer a good starting point for further project activities.

Based on the comparison of the results of the ethnobotanical surveys on one hand and the literature study on the other hand, we identified six browse species that are of special interest for the goals of SustainSAHEL, because either (i) farmers in all countries highlighted their usefulness, or (ii) the literature review revealed substantial knowledge gaps. The respective species are: *Bauhinia reticulata* D.C., *F. albida*, *Guiera senegalensis* J.F.Gmel., *Khaya senegalensis* (Desv.) A.Juss., *P. erinaceus*, and *P. lucens*. These species will be assessed in more detail in subsequent experiments of WP6 (feeding trials, decomposition experiments). Since the decomposition experiment aims to include recalcitrant leaf material, *Vitellaria paradoxa* C.F.Gaertn. with its rather low feeding value will be also incorporated in this trial. By means of feedback workshops, results of Task 6.I will be disseminated to stakeholders in the target regions during the next visit of UNI KASSEL members to the study sites. A meta-analysis will be conducted to publish the outcome of this literature review as a peer-reviewed publication in an international journal.

2. Material and methods

As planned in the DoA, WP6 contributed key questions on livestock and browse fodder to WP2 for the participatory rural appraisal (PRA). However, during the implementation of the PRA by WP2, only a few of these questions were asked, due to limited time availability in the field and due to the very ambitious set of questions coming from all partners (please also refer to D2.1, “Synthesizing findings on features of CSL systems and their connections with the farming systems”). Therefore, own ethnobotanical surveys and a bibliographic study were conducted by WP6 to identify the most suitable shrub foliage types that can be used as animal feed complement to increase animal performance and improve animal health.

2.1. Ethnobotanical surveys

2.1.1 Study area and sampling of households

In total, 517 crop-livestock farmers were approached in personal interviews in 2021, of which 131 farmers in 5 villages in 2 communes in Koulikoro region (Mali), 120 and 185 farmers in 4 villages in 1 commune in Yilou region and 6 villages in 3 communes in Saria region (Burkina Faso), respectively, and 81 farmers in 19 villages in Ouarkhokh commune (Senegal). Random (Mali, Senegal) and snowball (Burkina Faso) sampling technique were used to select households for the ethnobotanical surveys. Nearly half of the interviews in Burkina Faso were conducted with women and widows, while in Senegal and Mali, the interviews were mostly conducted with men. Youth was only included in Burkina Faso (n=4). The ethnic background of interviewed households was homogenous in Burkina Faso (all Mossi), whereas households in Senegal and Mali belonged to various ethnic groups, namely Fulani and Wolof in Senegal, and Fulani, Bamara, Sonrhäi, Bozo and Maure in Mali. No information was obtained about the immigration status of participating households (Table 1).

Permissions to conduct the ethnobotanical surveys were obtained the institution of the respective supervisors in Burkina Faso and Senegal; in Mali, the ethnobotanical survey was related to the baseline survey of WP2. In each country, participating households were informed about the purpose of the study and strict anonymization of all information was ensured; oral consent to conduct the interviews was obtained from each household.

2.1.2 Areas covered in the questionnaire

A structured questionnaire was used to classify livestock keepers' feeding practices, and to identify the most preferred shrub foliage (as stated by the livestock keepers) in each study site. Ethnobotanical surveys in each country targeted cattle as well as small ruminants, and covered the use of shrubs and trees as animal feed, human food, animal/human medicine, and for soil fertility. In addition, the surveys in Burkina Faso included the use of shrubs and trees for income generation and construction. Finally, household-related questions completed the survey questionnaire in all countries, complemented by income-related questions in Senegal and Burkina Faso. No areas with gender-specific questions were targeted except commercialization of shrub/tree products and wood energy use in Senegal. In the following table, details about the sampling, ethical considerations, gender and intersectional issues covered in the ethnobotanical surveys are summarized for each country (Table 1).

Deliverable 6.1 Review on utility of selected shrub-foliage

Table 1: Details about the sampled households and areas covered in the ethnobotanical surveys

Country	Burkina Faso	Mali	Senegal
PhD student	Linda Cletchio Gabriella TRAORE	Mamadou COULIBALY	Aminata BEYE
Permission for survey obtained via WP2 or separately?	From institution of PI of WP6 in Burkina Faso	Related to WP2	From institution of PI of WP6 in Senegal
Sampling method	Snowball sampling	Random sampling	Random sampling
Respondents informed about purpose of study and anonymization of information?	Yes	Yes	Yes
Consent (oral) obtained from respondents to conduct the interview?	Yes	Yes	Yes
Communes and villages	Saria: 6 villages in 3 communes; Yilou: 4 villages in 1 commune	Communes: Méguetan and Doumba Villages: Feyta, Mafeya, Doumba, Tientiguila, Tanabougou	19 villages in Ouarkhokh commune
Immigrants (from distance > 100 km)	No information	No information	No information
Interviews conducted, thereof a) Women b) Widows c) Persons <20 yrs old	205 92 12 4	131 0 11 0	81 10 2 0
Ethnic groups	Mossi	Fulani, Bambara, Sonrhai, Bozo, Maure	Fulani, Wolof
Animal species targeted in survey	Sheep, goats, cattle	Sheep, goats, cattle	Sheep, goats, cattle
Household information	Members, age, gender?, marital status	Members, age, gender, marital status	Members, age, gender, marital status
Income related questions	Yes (main economic activities)	No	Yes
Use of trees/shrubs	Animal feed, animal medicine, human food, human medicine, soil fertility, income generation, construction	Animal feed, animal medicine, human food, human medicine, soil fertility	Animal feed, animal medicine, human food, human medicine, soil fertility
Areas with gender-specific questions	None	None	Commercialization, wood energy
Areas with youth-specific questions?	None	None	None

For data collection and recording, the open-source mobile data collection platform ODK was used. Collected data was imported into Excel for data cleaning and analysis.

2.2. Bibliographic study

2.2.1 Literature search

The literature search was conducted during November and December 2020, and included information sources listed in Appendix 1. It considered publications that were published between 1995-2020 and was conducted in both, English and French. Combinations of keywords in levels 1-3 with/out keywords of level 4 were used (Appendix 2). Due to the low number of literature sources related to animal health management, an additional search was realized for the keyword trees/shrubs + gastrointestinal nematodes (GIN) + tannins in the databases Web of Science and Google Scholar.

2.2.2 Selection process

All literature sources were entered into Mendeley reference manager system. In total, 1465 literature sources from the online searches were used for the selection process by two reviewers with a combined fluency in English and French. Based on the abstract and first screening of the full text including tables and graphs, all literature sources were classified into three broad categories:

- 1) **Relevant:** Literature sources related to the use of trees/shrubs for livestock feeding and/or animal health care, and related to the chemical composition of parts of trees/shrubs, with a regional focus on the agro-ecological zone (AEZ) of the study sites in the three partner countries;
- 2) **Potentially relevant:** Literature sources related to the use of trees/shrubs for livestock feeding and/or animal health care, but outside the regional focus areas, or studies that provided additional information on relevant tree species (e.g. ecology, propagation techniques);
- 3) **Irrelevant:** Literature sources not related to the use of trees/shrubs for livestock feeding and/or animal health care, and outside the regional focus area.

In total, 574 irrelevant literature sources were identified and excluded from further processing. The literature sources belonging to category 1 and meeting the following criteria were finally retained: Experimental studies evaluating the effect of trees/shrubs on livestock performances and feed intake, the chemical composition, anti-nutritional factors, digestibility and degradability of trees/shrubs; studies evaluating farmers' preferences for trees/shrubs for livestock feeding and/or animal health care; inventories determining the distribution and composition of trees/shrubs; reviews on agroforestry systems and the use of trees/shrubs for livestock feeding and/or animal health care. This last step resulted in a total of 141 studies that were reviewed to establish the list of browse species that are relevant for livestock feeding and animal health management.

The 141 selected literature sources were reviewed in full by one of the two reviewers. Details on tree/shrub species name (full scientific name, common name), family, country (Burkina Faso, and/or Mali, and/or Senegal, other) and region (Sahara, and/or Sahel, and/or Sudano-Sahel), phenology (short deciduous, medium deciduous, long deciduous, semi-deciduous, evergreen, reversed deciduous), origin (native, introduced), use (feeding, and/or disease prevention, and/or disease treatment), parts used, livestock species (sheep, and/or goats, and/or cattle, other), season used (dry and/or wet), chemical composition, feed energy content, digestibility and degradability of nutrients, anti-nutritional factors (phenols, and/or glycosides, and/or proteins, others), feed intake, opportunities and constraints, were tabulated and analyzed in Microsoft Excel.

2.2.3 Selected literature

Most of the publications were based on data collection in the field, including surveys of farmers (49 studies), experimental studies (40 studies), as well as field studies (39 studies); a minor part of the selected

Deliverable 6.1 Review on utility of selected shrub-foliage

publications were not based on original research in the field, such as review articles, calculations, technical manuals and pure *in vitro* experiments (Table 2). On average, the selected studies included 6.2 browse species.

Table 2: Study type of selected publications (total n=141)

Study type	Studies (n)
Survey	49
Experimental study	40
Field study	39
Review	6
Survey and experimental study	3
Experimental study and <i>in vitro</i> experiment	1
<i>In vitro</i> experiment	1
Technical manual	1
Calculations	1

Regarding the geographical focus of the studies, Burkina Faso was the country most often studied (44 studies), followed by Senegal (26 studies) and Mali (17 studies, Figure 1). Eight studies covered all three countries. Also 44 studies from countries different to the three aforementioned were included, since they provided relevant information. The Sudano-Sahel (48 studies) was more often studied than the Sahel (34 studies) and the Sahara (2 studies). Twenty-seven studies included multiple regions, and 28 studies were unspecified.

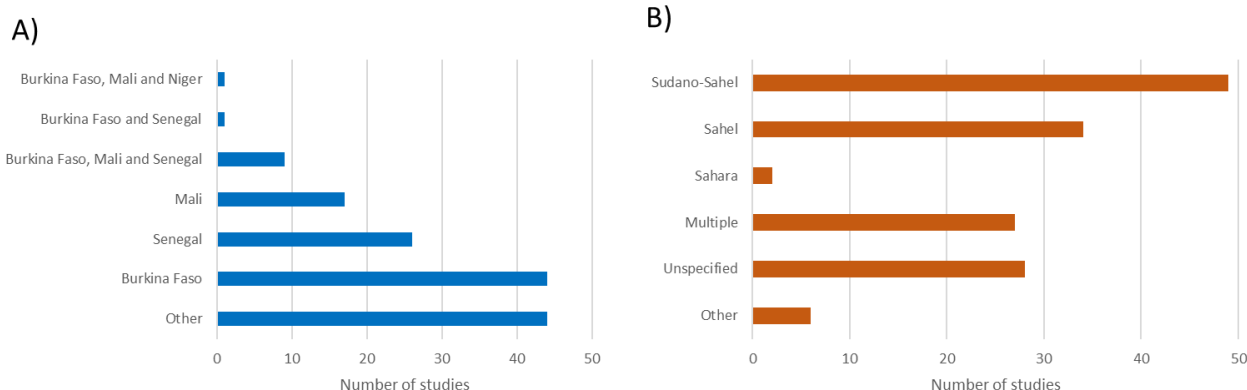


Figure 1: Countries (left) and regions (right) covered in the reviewed literature (total n=141)

3. Results

3.1 Crop-livestock farmers' stated preferences for shrub foliage

In the following, we will focus on the presentation of the results for farmers' stated preferences of sheep for shrub foliage. These data were needed to properly plan subsequent feeding and digestibility trials that were conducted end 2021 – begin 2022 within WP6 in all partner countries. These feeding trials were conducted with sheep due to various practical and scientific reasons. Firstly, sheep are of high economic relevance for farmers in the study countries. Furthermore, given their small size, sheep require less feed and space than cattle, and hence experimental costs are lower, which is of particular importance for experiments in developing countries. In addition, the handling of sheep is associated with significantly lower risk of injury to personnel running experiments than the handling of cattle. Lastly, there are

Deliverable 6.1 Review on utility of selected shrub-foliage

numerous articles that provide scientific evidence that for a very wide spectrum of questions of animal nutrition and feed digestion, sheep can be used as a model for cattle as well as for goats, e.g. Boval et al., 2003; Chishti et al., 2019; Ortíz-Domínguez et al., 2021; and Tedeschi et al., 2010. Certainly, the interview data obtained with respect to the importance of shrub/tree foliage for feeding and health care of cattle and goats, will also be evaluated in detail as activities in WP6 progress.

The results of the ethnobotanical surveys showed that most preferred browse species by sheep in Mali are *Pterocarpus lucens* (47%), *P. erinaceus* (44%) and *Ficus sycomorus* (42%). Other important browse species are *Khaya senegalensis* and *Entada africana* (18% each). According to crop-livestock farmers in Burkina Faso, sheep prefer foliage of *Faidherbia albida* (41%), *Lannea microcarpa* (35%), *Vitellaria paradoxa* (25%), *Balanites aegyptiaca* (23%) and *F. sycomorus* (20%). In Senegal, agropastoralists mentioned *B. aegyptiaca*, *Acacia tortilis ssp. raddiana*, *Adansonia digitata* and *Guiera senegalensis* as trees and shrubs most preferred by sheep (Table 1).

Table 1: Shrub foliage preferred by sheep in each study site (>10% of respondents).

Burkina Faso	Mali	Senegal
<i>Balanites aegyptiaca</i>	<i>Entada africana</i>	<i>Acacia tortilis ssp. raddiana</i>
<i>Faidherbia albida</i>	<i>Ficus sycomorus</i>	<i>Adansonia digitata</i>
<i>Ficus sycomorus</i>	<i>Khaya senegalensis</i>	<i>Guiera senegalensis</i>
<i>Lannea microcarpa</i>	<i>Pterocarpus erinaceus</i>	
<i>Vitellaria paradoxa</i>	<i>Pterocarpus lucens</i>	

3.2 Identified browse species (trees and shrubs) in the bibliographic study

In total, the established list of browse species contains 153 trees and shrubs. The majority of browse species (n=105) were investigated in <6 studies each, and only 29 browse species had been covered in >10 studies (Figure 2). The most commonly studied browse species are *Balanites aegyptiaca* (L.) Delile (41 studies), followed by *Pterocarpus erinaceus* Poir. (37 studies), *Faidherbia albida* (Delile) A.Chev. (35 studies) and *Acacia senegal* (L.) Willd. (32 studies).

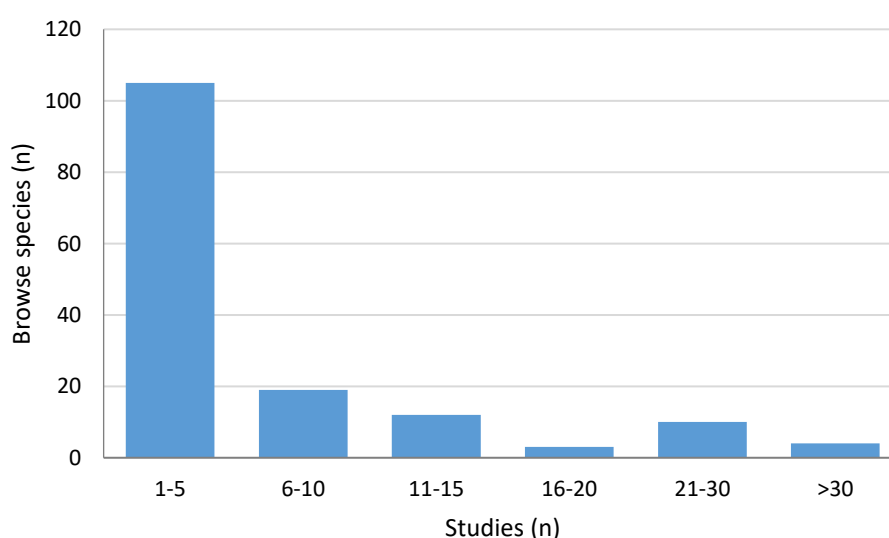


Figure 2: Frequency of studied browse species (total n=153)

The identified browse species belong to 37 botanical families. The Leguminosae were by far the most important family, with in total 53 (34.4%) browse species. The Combretaceae were the second most important family, including 12 (7.8%) browse species. Eight (5.2%) browse species each belong to the family Capparaceae and Rubiaceae, seven (4.5%) species each to the Anacardiaceae, the Malvaceae and the Moraceae, and six (3.9%) browse species to the Apocynaceae. All other families included one to four browse species each, and were hence of minor importance. Most of the studied browse species (n=116) are native to the project countries, only 37 browse species are introduced species.

3.3 Use of trees and shrubs for livestock feeding and veterinary health care (bibliographic study)

Nearly all studied trees and shrubs (n=142; 92.8%) covered in the selected publications are used as livestock feed, of which 46 species are also used as ethno-veterinary medicinal plants. Only 11 trees and shrubs are uniquely mentioned as ethno-veterinary medicinal plants and not used for livestock feeding. These include *Boswellia dalzielii* Hutch., *Carapa procera* DC., *Euphorbia balsamifera* Aiton, *Euphorbia officinarum* L., *Haloxylon scoparium* Pomel (Pomel) Iljin., *Ricinus communis* L., *Salsola imbricata* Forssk., *Salsola tetrandra* Forssk., *Searsia tripartita* (Ucria) Moffett, and *Tamarix aphylla* (L.) H.Karst.

For 79 species from the database, information on the parts used as livestock feed are available from the selected publications. The main plant part used as livestock feed are the leaves of trees and shrubs (n=71 browse species; 89.9%). Only the leaves of *Acacia dudgeoni* Holland, *Acacia polyacantha* Willd., *Acacia sieberana* DC., *Annona senegalensis* Pers., *Bauhinia thonningii* Schum., *Diospyros mespiliformis* Hochst. ex A.DC., *Terminalia macroptera* Guill. & Perr., and *Ziziphus abyssinica* Hochst. ex A.Rich. are not consumed by ruminants. Next to leaves, fruits (n=35 browse species) are an important livestock feed. Pods (n=11 browse species), twigs (n=8 browse species) and branches (n=7 browse species) are less consumed. Flowers (*Acacia seyal* Delile, *Guiera senegalensis* J.F.Gmel.), shoots (*Acacia senegal* (L.) Willd., *Balanites aegyptiaca* (L.) Delile) and young plants (*Balanites aegyptiaca* (L.) Delile), bark (*Adansonia digitata* L.), as well as the hulls, seeds and stems (*Acacia senegal* (L.) Willd.) are only marginally used for livestock feeding. In total, 10 of the selected publications assessed the importance of (preference for) 72 trees and shrubs as livestock feed. According to these publications, 16 species are highly valued as fodder trees (Figure 3). The most highly valued browse species are *Azizelia africana*, *Detarium microcarpum* (1 study each), *Ficus sur* (1 out of 2 studies), *Faidherbia albida*, *Pterocarpus erinaceus* (3 out of 7 studies each), and *Pterocarpus lucens* (2 out of 5 studies). Some studies identified *Adansonia digitata* (2 out of 6 studies), *Cordyla pinnata*, *Khaya senegalensis* and *Sterculia setigera* (1 out of 3 studies each) as some of the most important browse species, while other studies reported that they are less highly valued as fodder trees. Compared to the aforementioned species, the remaining six browse species in Figure 3 tend to be less highly valued; yet, they are considered important fodder trees in at least one of the studies that have been considered. These are *Bauhinia reticulata* (1/4 studies), *Grewia damine* (1/4 studies), *Parkia biglobosa* (1/4 studies), *Ziziphus jujuba* (2/8 studies), *Acacia nilotica* (1/5 studies), and *Balanites aegyptiaca* (1/5 studies).

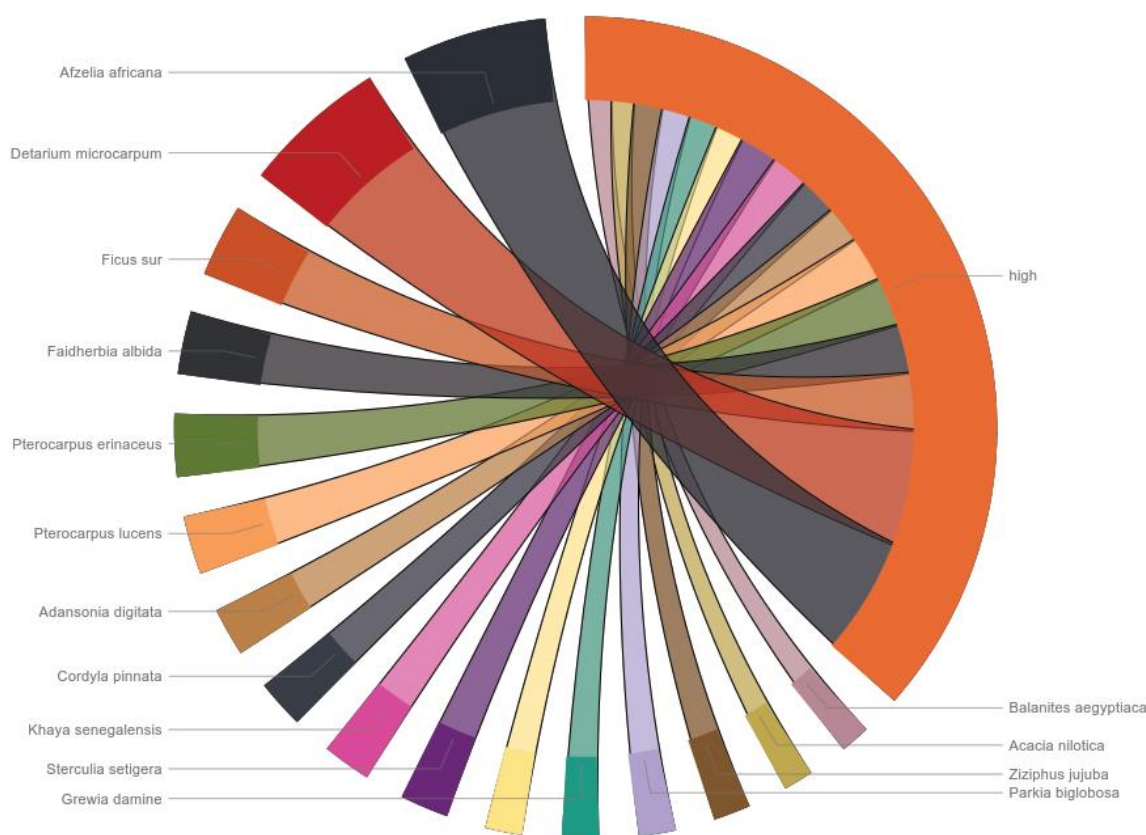


Figure 3: Highly valued browse species (based on farmers' preference scores, ranking exercise or number of mentions and observations in 10 selected publications)

For all 57 ethno-veterinary species identified, information on the parts used to cure or prevent animal diseases is available. The most important plant parts used for animal health care are the leaves ($n=29$ species; 50.9%), the bark ($n=28$ species; 49.1%) and the roots ($n=12$ species; 21.2%). All other parts used are less important (fruits: $n=8$ species; aerial parts and seeds: $n=5$ species each). Finally, the use of twigs (*Bombax costatum* Pellegr. & Vuillet, *Leptadenia lancifolia* (Schumach. & Thonn.) Decne.), flowers (*Acacia tortilis* (Forssk.) Hayne, *Bombax costatum* Pellegr. & Vuillet), shoots (*Balanites aegyptiaca* (L.) Delile), hulls (*Adansonia digitata* L.), and wood (*Tamarix aphylla* (L.) H.Karst.) has been rarely reported.

3.4 Nutritional profile of browse species and their impact on animal performance (bibliographic study)

The dry matter (DM) and the organic matter (OM) digestibility, as well as the content of crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and condensed tannins of the leaves of trees and shrubs determine their suitability as supplementary livestock feed and their impact on animals' feed intake and body weight development. Hence, the trees and shrubs ($n=53$) studied in at least five of the selected publications have been evaluated for their nutritional profile based on the values in the selected publications or in the Feedipedia database (Feedipedia, 2021). Depending on the extracted values, the trees and shrubs have been grouped into high, medium and low for each variable. Complete information on the nutritional characteristics could be found for six of the selected 53 trees or shrubs,

Deliverable 6.1 Review on utility of selected shrub-foliage

namely *Acacia* (*A.*) *macrostachya*, *A. nilotica*, *A. senegal*, *Balanites aegyptiaca*, *Faidherbia albida*, *Ziziphus jujuba*. This largely limits the comprehensive evaluation of the plant species.

The DM/OM digestibility and nutrient/fiber contents of the leaves of the selected trees and shrubs are generally poor. Only *Leucaena leucocephala* and *Moringa oleifera*, and partially *Boscia senegalensis* and *Calotropis procera*, have a comparatively high DM digestibility. For the latter, the OM digestibility is also high, although there are also reports that it can be low. With regard to the CP content of the leaves, six browse species have a clearly high content. The results on the CP content of six other browse species are not fully clear, with the CP content ranging from medium to high (n=5) and from low to high (n=1). Furthermore, the fiber (NDF, ADF) contents of the leaves of 12 trees and shrubs are favorable from a nutritional point of view. Finally, the leaves of 3 trees contain low amounts of condensed tannins, which is also considered advantageous in livestock nutrition, while 12 trees and shrubs contain relatively high amounts of condensed tannins, which can have advantages for animal health management (Figure 4). Overall, *Combretum micranthum*, *Calotropis procera*, *Maerua crassifolia*, *Faidherbia albida* and *A. senegal* score positively on at least four of the evaluated variables.

The impact of feeding leaves of trees and shrubs was systematically evaluated in eight of the selected publications. In total, 11 browse species were included in these feeding trials. A clearly negative impact on feed intake and body weight development has been determined for *Guiera senegalensis* (70% of DM offered) and *Leucaena leucocephala* in adult goats (10% and 30% of DM offered) and partially in adult sheep (10% of DM offered) in an on-station feeding trial in Burkina Faso. The supplementation of leaves of *A. senegal*, *Azelia africana*, *Combretum aculeatum*, *Ficus sycomorus*, *F. thonningii*, *Khaya senegalensis*, *Mangifera indica*, *Pterocarpus erinaceus* and *Pterocarpus lucens* to animal diets had no negative impact on small ruminants' feed intake and body weight development.

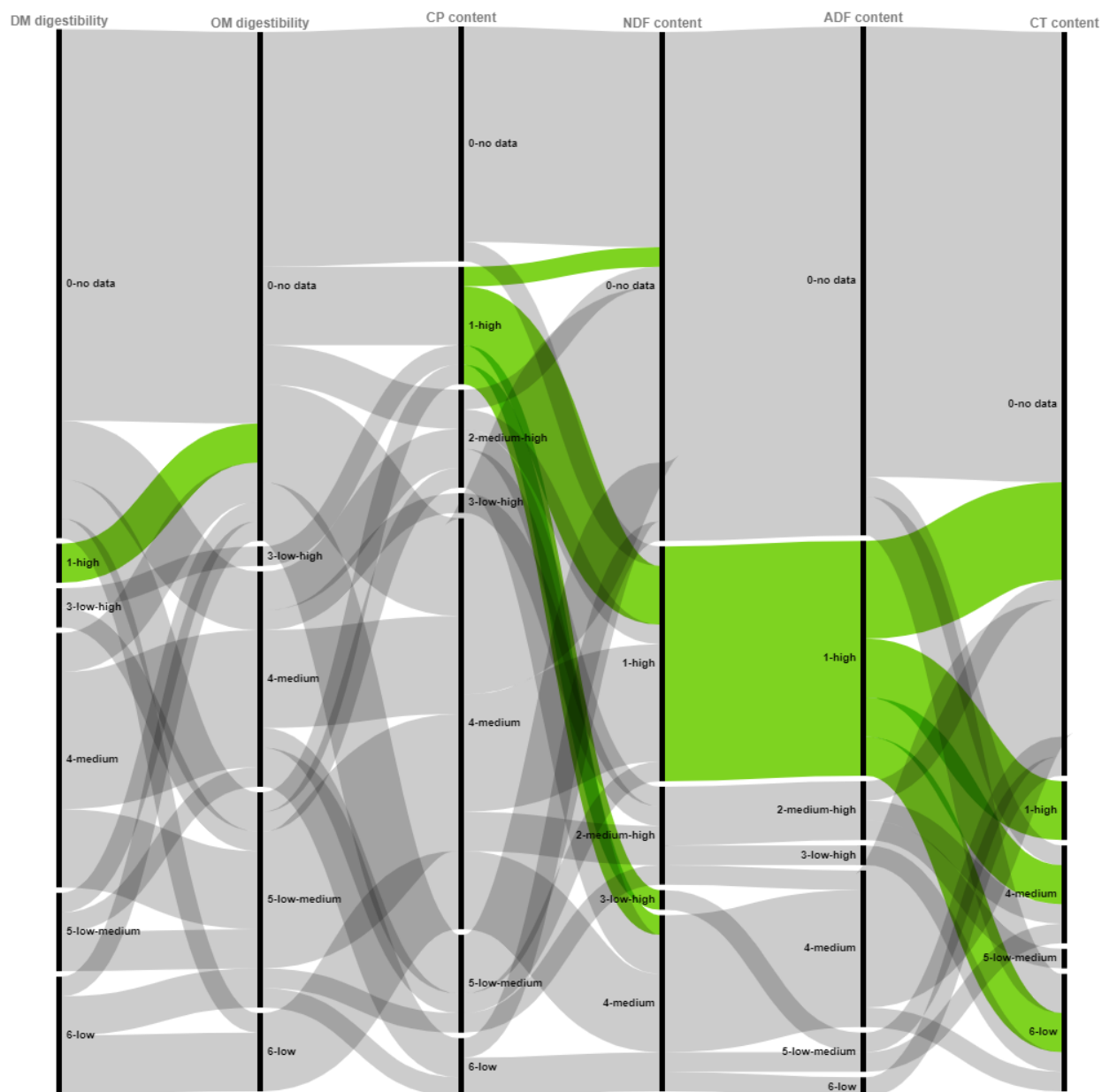


Figure 4: Nutritional profile of 53 selected browse species. DM: dry matter, OM: organic matter, NDF: neutral detergent fiber, ADF: acid detergent fiber, CT: condensed tannins. Green: high (positive) score.

3.5 Leaf phenology (bibliographic study)

Trees and shrubs can be broadly distinguished into deciduous and evergreen species, but depending on the length and timing of the foliated period, a more precise definition of deciduousness is possible. This allows for more accurate information on the seasonal availability of leaf biomass. Based on the studies of De Bie et al. (1998) and Brandt et al. (2016) we were able to allocate the identified tree and shrub species to six different leaf phenology classes, which are representative for the Sahel and Sudano-Sahel ecoregions: i) short deciduous; ii) medium deciduous; iii) long deciduous; iv) semi-deciduous; v) evergreen and vi) reversed deciduous (Appendix 3). Short deciduous tree and shrub species have a relatively short foliated period of approximately three months only. Altogether 16 species from our database could be allocated

Deliverable 6.1 Review on utility of selected shrub-foliage

to this group; for example, different *Acacia* species and kapok (*Bombax costatum*). Medium deciduous species have an average foliage duration of five months, and with 26 species, this group was the most represented. Common species in this group are *Pterocarpus* species, néré (*Parkia biglobosa*), and several *Acacia* species. Long deciduous species are foliated for a period of about seven months, and were represented by 12 species, among them baobab (*Adansonia digitata*) and several *Acacia* species. Semi-deciduous species are foliated during most parts of the year, since leaf shedding is followed by immediate sprouting. We could allocate nine species to this group, among them *Guiera senegalensis*, *Vitellaria paradoxa* and *Ziziphus jujuba*. Twenty-five species could be identified as evergreen, such as *Balanites aegyptiaca*, *Khaya senegalensis* and *Tamarindus indica*. Evergreen species are foliated during the entire year, since new leaves replace old leaves continuously. Only one tree species (*Faidherbia albida*) belongs to the class reversed deciduous. This species has the particularity that it is foliated during the dry season, but sheds its leaves with the onset of the rainy season.

4. Dissemination activities related with the Deliverable

During their next visit to the SustainSAHEL study sites, WP6 members involved in Task 6.1 will disseminate the main results to local stakeholders. It is foreseen to conduct a feedback workshop with farmers at each study site. The focus of the workshops / group discussions will be on recommended shrub and tree species with high fodder value and/or the potential to be used for veterinary treatments. 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. Results of Task 6.1 will also feed into Tasks 6.2 and 6.3, in which feeding trials and decomposition experiments will be set-up with selected shrub and tree species.

5. Appendix

Appendix I: Information sources used for the literature searches

Electronic catalogues and databases	Search engines	Scientific journals (in alphabetical order)
♦ Kasseler Recherche-, Literatur- und Auskunftportal (KARLA) ♦ WorldCat ♦ Publication database of the World Agroforestry Centre (ICRAF)	♦ CAB Direct ♦ Google Scholar ♦ ResearchGate ♦ Scopus ♦ Web of Science	♦ 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

Deliverable 6.1 Review on utility of selected shrub-foliage

Appendix 2: Search terms used for the literature searches

English	Synonyms	Français	Synonyms	Level
Shrubs		Arbustes		1
Trees		Arbres		1
Livestock feeding	Livestock nutrition	Alimentation de bétail	Nutrition animale	2
Woody fodder	Ligneous fodder	Fourrages ligneux		2
Forage	Fodder	Fourrage		2
Animal health		Santé animale		2
Veterinary phytotherapy		Phytothérapie vétérinaires		2
Traditional veterinary medicine		Médecine vétérinaire traditionnelle		2
Ethnomedicine		Éthnomédecine		2
Utilization	Use Exploitation	Utilisation	Exploitation	2
Leguminous		Légumineuse		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
Dry subhumids		subhumides secs		3
Nutritional value		Valeur nutritionnelle		4
Gastrointestinal nematodes		Nématodes gastrointestinales		4
Local knowledge	Indigenous knowledge	Savoir local		4
Virtues and valorization		Vertus et valorization		4
Seasonality		Saisonalité		4
Phenology		Phénologie		4
Pruning		Élagage		4

Appendix 3: Leaf phenology of tree and shrub species

Short deciduous	Medium deciduous	Long deciduous	Semi-deciduous	Evergreen	Reversed deciduous
<i>Acacia ataxacantha</i>	<i>Acacia ehrenbergiana</i>	<i>Acacia dudgeoni</i>	<i>Cordia mixa</i>	<i>Acacia aneura</i>	<i>Faidherbia albida</i>
<i>Acacia senegal</i>	<i>Acacia erythrocalyx</i>	<i>Acacia nilotica</i>	<i>Diospyros mespiliformis</i>	<i>Acacia angustissima</i>	
<i>Acacia laeta</i>	<i>Acacia macrostachya</i>	<i>Acacia sieberana</i>	<i>Ficus thonningii</i>	<i>Balanites aegyptiaca</i>	
<i>Acacia seyal</i>	<i>Acacia polyacantha</i>	<i>Acacia tortilis</i>	<i>Guiera senegalensis</i>	<i>Boscia senegalensis</i>	
<i>Annona senegalensis</i>	<i>Albizia chevalieri</i>	<i>Adansonia digitate</i>	<i>Prosopis africana</i>	<i>Borassus aethiopum</i>	
<i>Bombax costatum</i>	<i>Anogeissus leiocarpus</i>	<i>Cassia sieberana</i>	<i>Pterocarpus santalinoides</i>	<i>Cadaba farinosa</i>	
<i>Combretum micranthum</i>	<i>Boswellia dalzielii</i>	<i>Gardenia erubescens</i>	<i>Vitellaria paradoxa</i>	<i>Calotropis procera</i>	
<i>Commiphora africana</i>	<i>Burkea africana</i>	<i>Gardenia ternifolia</i>	<i>Ximenia americana</i>	<i>Capparis fascicularis</i>	
<i>Cordyla pinnata</i>	<i>Combretum aculeatum</i>	<i>Isobertia doka</i>	<i>Ziziphus jujuba</i>	<i>Capparis sepiaria</i>	
<i>Crateva adansonii</i>	<i>Daniellia oliveri</i>	<i>Terminalia avicennioides</i>		<i>Celtis integrifolia</i>	
<i>Crossopteryx febrifuga</i>	<i>Detarium microcarpum</i>	<i>Terminalia laxiflora</i>		<i>Combretum glutinosum</i>	
<i>Dalbergia melanoxylon</i>	<i>Dichrostachys cinerea</i>	<i>Terminalia macroptera</i>		<i>Combretum nigricans</i>	
<i>Euphorbia balsamifera</i>	<i>Entada africana</i>			<i>Ficus glumosa</i>	
<i>Feretia apodanthera</i>	<i>Grewia damine</i>			<i>Ficus sycomorus</i>	
<i>Pteleopsis suberosa</i>	<i>Grewia flavescens</i>			<i>Ficus ingens</i>	
<i>Strychnos spinosa</i>	<i>Lannea acida</i>			<i>Ficus platyphylla</i>	
	<i>Lannea velutina</i>			<i>Hyphaene thebaica</i>	
	<i>Lonchocarpus laxiflorus</i>			<i>Khaya senegalensis</i>	
	<i>Parkia biglobosa</i>			<i>Leptadenia lancifolia</i>	
	<i>Pericopsis laxiflora</i>			<i>Maerua crassifolia</i>	
	<i>Pterocarpus erinaceus</i>			<i>Ozoroa insignis</i>	
	<i>Pterocarpus lucens</i>			<i>Salvadora persica</i>	
	<i>Securidaca longipedunculata</i>			<i>Sarcocephalus latifolius</i>	
	<i>Sclerocarya birrea</i>			<i>Saba senegalensis</i>	
	<i>Sterculia setigera</i>			<i>Tamarindus indica</i>	
	<i>Stereospermum kunthianum</i>				

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