Ethnobotanical use and conservation assessment of medicinal plants sold in markets of Burkina Faso

Lassané Ouédraogo, Josef Endl, Pierre Alexandre Eric Djifaby Sombié, Hanno Schaefer and Martin Kiendrebeogo

Research

Abstract

Background: A comprehensive survey on the trade and use of medicinal plants in Burkina Faso was carried out with the aim of identifying the most relevant species and their conservation status.

Methods: Interviews of 30 medicinal plant traders in six major cities was carried out and the data on medicinal plant species were recorded using a structured questionnaire.

Results: A total of 104 medicinal plant species, belonging to 39 families and 81 genera were reported to treat various health problems. Most of the medicinal plant species found in the markets were used for gastrointestinal diseases (46%), e.g., Pteleopsis suberosa (Combretaceae) and Bauhinia rufescens (Fabaceae). The combination of fidelity level and preference ranking identified Gardenia sokoensis, Combretum micranthum and Maytenus senegalensis as particularly important species for treatment of malaria. Four species found in local markets are listed as vulnerable in the IUCN red list of threatened species (Afzelia africana, Vitellaria paradoxa, Khaya senegalensis and Tapinanthus globiferus). For many species that are traded in large quantities sufficient data for precise assessment of their conservation status do not yet exist. Some species such as Securidaca longipedunculata and Zanthoxylum zanthoxyloides are already rare in nature and sold at high price on the stalls.

Conclusions: There is an urgent need to collect distribution data for the medicinal plant species of Burkina Faso and design conservation plans in order to preserve their natural populations.

Keywords: Ethnobotanical survey; Medicinal plants; Conservation status; Traditional knowledge; Diseases; Burkina Faso

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Background

Traditional medicine has played a key role in many developing countries and continues to do so (World Health Organization, WHO 2004). In this area, it is estimated that more than 80% of the people rely on plants for their primary healthcare requirements (Senthilkumar et al. 2013).
In West African countries, particularly in Burkina Faso, traditional medicine and pharmacopoeia remain the main source of primary health care for an estimated 70% of the population (Zerbo et al. 2011). The main reasons for this dependence on herbal medicine are its therapeutic efficacy, accessibility and low costs compared to modern medicine and that it is deeply intertwined with traditional beliefs (Benoît 2008).

But the increased use of herbal medicines has also negative consequences. It propels safety concerns to both national health authorities and the general public, mostly due to misidentification, substitution of rare species with cheaper plant material from species which are more readily available and infection of herbs with fungi (Kool et al. 2012). In addition, it could negatively impact natural plant resources when exploitation is performed in an unsustainable way (WHO 2004).

Meticulous documentation, sustainable use and conservation efforts are therefore essential. Traditional medicine practitioners are officially recognized by the authorities of Burkina Faso in order to regulate their activities in collecting and selling medicinal plants (“Assemblée Nationale”, AN 1994). These regulations are recorded in two national codes of Burkina Faso. In the Public Health Code recipes and use of medicinal plants are described (AN 1994). In the Forest Code traditional use rights are recognized for the benefit of local residents, allowing picking of fruits and harvesting of medicinal plants (AN 1997). Most of the medicinal plants are sold in urban markets (Cunningham 2014) and market surveys have become an efficient way of acquiring data on local consumption and conservation status of medicinal plant species (Idu et al. 2010).

It seems necessary to inform on the composition of medicinal plants traded in Burkina Faso, the quantities sold, the provenance of the plant material and the indigenous uses for disease treatment. Documentation of traditional uses of medicinal plants sold in the markets is important for several reasons. The identification of local names, scientific names and indigenous uses of plants not only preserves indigenous knowledge but also contributes to future research in order to improve the safety and efficacy of medicinal plants in the treatment of various ailments (Tugume et al. 2016). This will facilitate the integration of herbal medicine into the main health care system. In addition, this knowledge will support the conservation of cultural traditions and help to preserve the diversity of wild plant resources.

The knowledge on traditional medicinal uses of plants is disappearing at an alarming rate in Burkina Faso mainly because this information is only orally transmitted to the younger generation. Many of these custodians die before passing on the information to the next generations. The importance of saving this traditional knowledge is convincingly demonstrated by the fact that an estimated 25% of prescription drugs and 11% of drugs considered essential by WHO are based on active compounds first isolated from wild plants (Maroyi et al. 2011). Thus, a thorough knowledge of traditionally used medicinal plants could help to fully exploit their potential for discovering new sources of drugs and promote the sustainable use of these natural resources in Burkina Faso.

Therefore, we conducted this study on medicinal plant trade in the main local markets in six major cities (Ouagadougou, Fada, Dédougou, Léo, Ouahigouya, and Bobo-Dioulasso) of Burkina Faso. The study aims to deliver a comprehensive list of the medicinal plants together with their suggested applications. To assess the conservation status of each species, the provenance and estimated quantities of plant material offered by the sellers was documented and compared to International Union for Conservation of Nature (IUCN) red list status. Finally, we provide suggestions how to avoid overexploitation of selected species in order to preserve them for the benefit of future generations.

## Materials and Methods

### Study sites

The study focused on 18 markets of six cities in different climatic and vegetation zones of Burkina Faso. Selected cities for the survey were Ouagadougou, Ouahigouya, Fada N’Gourma, Dédougou, Bobo Dioulasso, and Léo (Figure 1). The target cities were chosen randomly in the four agro-ecological zones defined by Fontès and Guinko (2012). The three biggest markets of each city were selected as study sites. Ouagadougou and Ouahigouya are located in the Sahelian zone dominated by shrub savanna with annual rainfall less than 600 mm. Dédougou and Fada N’Gourma belong to the northern Sudanese zone of the country where woody and shrubby savannas dominate and rainfall ranges from 600-900 mm. Bobo-Dioulasso and Léo are located in the southern Sudanese zone with open forests and islands of dense dry forest with rainfall up to 900 mm (MAHRH 2007).
Figure 1. Ethnobotanical surveys sites

**Data collection**
This survey targeted herbal traders selling medical plants in the markets. Herbal traders in the surveyed markets belonged mainly to the following ethnic groups: Mossi, Dioula, Gourmantché, Gourounsi, and Fulfudé (FAO 1996). Interviews were conducted in the local language using guided semi-structured questionnaires according to the procedure described by Martin (1995) with slight modification (see in appendix 1 an example questionnaire). The survey was conducted from December 2015 to January 2016. For each market the representative of the sellers of medicinal plants was consulted, who suggested the traders with the most experience in the field of medicinal plant trade or application. Markets were visited once and 1-2 medicinal plant vendors or traditional healers, who agreed to participate in the survey were interviewed per market, summing up to a total of 30 interviews at 18 local markets. The traders chosen provided information on local names of the plants, plant parts used, quantities offered, prices, plant provenances, methods of preparation, and diseases/symptoms targeted. Botanical samples were acquired from all participants of the survey.

**Species identification**
Plant identification was partly carried out in the markets based on field manuals for plant identification encompassing trees, shrubs and lianas from West African dry zones (Arbonnier 2000). In addition, voucher specimens of all plant species were identified at the herbarium “Herbier National du Burkina Faso” (HNBU).

**Estimation of plant quantities offered and prices**
The quantities of plant samples sold in the markets were determined using common estimates based on the hand-circumference of bundles (Figure 2) (Martin 1995) and prices were recorded according to this unit.

**Species use value**
The use value of a certain plant species for treating a given category of disease was assessed by asking nine key informants. These were selected on the following criteria i) wide range of plants offered, ii) long experience in medicinal plant trade or application and iii) consent to supply the information. They were asked to assign a value between 1 and 10 (10 for the most frequently used plant) to the ten most available medicinal plant species (Martin 1995). Values assigned to each species were summed up for all informants to get an overall rank value. The species were then ranked in descending order.
The frequency of citation was calculated according to Dossou et al. (2012) in order to identify the species most valued by the traders.

\[
Fc = (Nc/Ns) \times 100 \% 
\]

Where, \(Fc\) = frequency of citation in percentage; \(Nc\) = number of traders citing the species and \(Ns\) = total number of traders surveyed.

By convention, a low frequency (≤30%) indicates that the species is little known and little used. A frequency range between 30 and 60% denotes that the species is moderately known and moderately used, while a range between 60 and 100% reveals that the species is very well known and widely used.

**Informant consensus factor (FIC)**
The informant consensus factor was calculated according to Uddin and Hassan (2014).

\[
FIC = (N_{ur} - N)/(N_{ur} - 1) 
\]

Where \(N_{ur}\) = number of use reports for a specific ailment category from vendors in the markets and \(N\) = number of species listed in each category from all vendors.

The FIC values can range from 0 (lowest level) to 1 (highest level). FIC values are low when plants are randomly selected or if there is no consensus among informants on their use for the treatment of a certain disease category or if there is no exchange among informants. Values are close to 1 if a large proportion of sellers prefer certain species for a specific disease category or if information is exchanged between informants. In short, medicinal plants with high FIC are believed to be effective in treating a certain disease category.

The main purpose of FIC is to select disease categories for which there is consensus on the use of plants among the informants and to identify species with particular importance in a culture.

**Fidelity level (FL)**
The fidelity level (FL) is defined as the ratio between the number of informants who independently suggested the use of a species for the same particular disease and the total number of informants who mentioned the plant for any use (Andrade-Cetto and Heinrich 2011).

\[
FL = (I_p/I_u) \times 100 \% 
\]

Where, \(I_p\) = number of informants using the medicinal plants for a specific disease and \(I_u\) = number of informants reporting the use of the species for any ailment.

**Conservation status of medicinal plants in the markets**
The conservation status of all species recorded was assessed on the basis of the IUCN red list database (IUCN 2018).

**Data analysis**
Data collected were tabulated and analyzed by using Microsoft Excel. For calculation of the informant consensus factor the ailments/symptoms treated by the medicinal plants were grouped into 13 different categories according to the Economic Botany Data Collection Standard with slight modifications (Iwu 1993).
Results

Information on vendors and plant taxa sold
Of the 30 vendors interviewed in 18 markets, women predominated, accounting for 87% of the vendors. The age of the informants ranged between 45 and 64 years. Twenty vendors were affiliated to an association involved in the field of traditional medicine and ten vendors had no affiliation. Half of the informants had received formal training from private schools and non-governmental organizations involved in the area of medicinal plants.

In total, 104 species of medicinal plants distributed in 39 families and 81 genera could be identified in the survey (Table 1). The dominant plant families were Fabaceae (16 species), followed by Rubiaceae (7 species), and Combretaceae (5 species). Twenty-one species were present in at least 50% of the stalls, 38 species were sold only by 3% of the vendors (Table 1). The highest numbers of different medicinal plant species were encountered in the two largest cities of Burkina Faso, in Ouagadougou (n=48) and Bobo-Dioulasso (n=40). The most unique species collection in relation to the total number of species offered was found in the cities of Fada N’Gourma and Léo: approximately 50% of the species offered in these two cities were only found there.

Plant parts, provenance and growth forms of plants used for herbal preparations
The most commonly used plant parts were leaves with a proportion of 47.0% of all nominations (Table 2), followed by stem bark (34.0%) and roots (17.2%). Inflorescences, gums and seeds were rarely used. In many cases, more than one part of the same plant species was used, for instance often leaves, stem bark and roots of the same species were employed to prepare remedies. Most of the medicinal plants sold on the stalls came from the savanna (86.3% of the samples, Table 3). The species collected in the forests included only trees with a proportion of 2.6%. Ligneous material from fields or gardens, respectively, and herbs from gardens comprised only a very small proportion of the material found in the markets.

Only rarely medicinal plant species sold in the markets came from cultivated sources, such as hedgerows (Bauhinia rufescens Lam., Vachellia nilotica (L.) P.J.H. Hurter & Mabb.), or home gardens (B. rufescens, Cymbopogon citratus (DC.) Stapf, Moringa oleifera Lam.).

Medicinal plants recipe preparation and administration
We recorded six types of methods for recipe preparation, namely decoction, trituration, infusion, cataplasm, calcination and crushed mixture with water. Decoction was the most common method of preparation (87.5%), followed by trituration (14.4%) and infusion (12.5%) (Figure 3). The medicinal plant preparations were administered through different routes including drink, bath, gargle, purgative, application, massage, inhalation, toothbrush, instillation and enema. The main mode of administration was the drink (65.4%) followed by the bath (35.6%) (Figure 4).

Range of ailments treated by medicinal plants
According to the information supplied by the vendors a total of 31 conditions were treated with medicinal plants. In order to calculate various ethnobotanical indices these conditions were classified into 13 disease categories. First the number of species used for treatment of a certain disease categories was analyzed (Table 4). The largest number of plant species was used for treatment of gastrointestinal diseases (48.1%) followed by malaria (19.2%), general pathology symptoms (18.3) dermatosis and respiratory diseases (each 17.3%). The range of disease categories treated by a particular species varied from 1 to 4. The species for which the most diverse healing potential was assigned by the traders were Phyllanthus amarus Schum. & Thonn. (gastrointestinal diseases, hemorrhoids, liver disorders, arthritis) and Moringa oleifera Lam. (gastrointestinal diseases, malaria, general pathology symptoms, cardiovascular diseases).

Factor of informant consensus (FIC)
For this factor calculation, the 13 disease categories as defined in Table 4 were used. Exceptional high consensus about plant usage among informants was found for childhood illnesses (FIC=0.9) and cardiovascular diseases (FIC=0.8) followed by respiratory diseases, general pathology symptoms, arthritis and other infections (each FIC=0.7) (Table 5). Very low FIC values (≤0.4), as observed for urogenital and internal organ diseases, indicate that informants mostly disagreed on which plants to use for these diseases. The most important plants used for the category of childhood illnesses were Lepidagathis anobrya (Pers.) Decne. Waltheria indica L., and Ocimum basilicum L. (Table 1). For the category of cardiovascular diseases, Mitragyna inermis (Willd.) Kuntze was the species most cited.
Table 1. List of medicinal plants reported in the markets of six cities of Burkina Faso

| Family, Scientific name | Local name | City | Provenance | Part used | Preparation | Aliment/ Symptoms Treated | Administration | Frequency of citation (%) | Estimated quantity by hand-circumference (average quantity offered by the vendors) | Price by hand-circumference [FCFA] |
|-------------------------|------------|------|-------------|-----------|-------------|--------------------------|---------------|---------------------------|---------------------------------------------------------------------------------|----------------------------------|
| *Acanthaceae*           |            |      |             |           |             |                          |               |                           |                                                                                 |                                  |
| *Hygrophila auriculata* (Schum.) Heine 2243 | Kocenkoéré (M) | 2 | H NI Sb | Trituration | Respiratory diseases | Drink | 10 | Two hands-circumference of stem | 100 |
| *Lepidagathis anobrya* Nees 540 | Gnuy-nakida (M), Gonwounouman (D) | 1,2,3 | H NI L | Decoction | Growth retardation, stomachache | Drink | 50 | One hand-circumference of plant | 50 |
| *Amaranthacae*          |            |      |             |           |             |                          |               |                           |                                                                                 |                                  |
| *Alternanthera nodiflora* R. Br. 2055 | Sibgponré (M) | 1 | H NI L | Cataplasm | Growth retardation | Purgative | 17 | One hand-circumference of plant | 50 |
| *Pupalia lappacea* (L.) Juss. 5599 | Nwestabdo (M) | 1 | H NI L | Calcination | Wound healing stomachache | Application | 3 | One hand-circumference of plant | 50 |
| *Anacardiaceae*         |            |      |             |           |             |                          |               |                           |                                                                                 |                                  |
| *Anacardium occidentale* L. 2010 | Finzani(D) | 2 | Li NI Sb | Infusion | Hypertension | Drink | 7 | One hand-circumference stem bark | 50 |
| *Lannea acida* A. Rich. 2596 | Sabtulga (M), Eberg (G) | 3,4 | Li NI Sb | Decoction | Stomachache, ulcer | Drink | 3 | One hand-circumference stem bark | 50 |
| *Lannea velutina* A. Rich. 8203 | Wâamsâbga (M) | 6 | Li NI L, Sb | Decoction | Tonic | Bath | 3 | Two hands-circumference of leafy stem | 50 |
| *Sclerocarya birrea* (A. Rich.) Hochst. N360 | Noabega (M) | 2,4 | Li NI Sb | Decoction, infusion | Dysentery, Ulcer | Drink | 50 | One hand-circumference of stem bark | 50 |
| *Annonaceae*            |            |      |             |           |             |                          |               |                           |                                                                                 |                                  |
| *Annona senegalensis* Pers. 2083 | Sunsung (D), Barkudga (M) | 1,2,3,5 | Li NI L, Sb, R | Decoction, calcination | Wound healing, stomachache, somniferous malaria | Drink, bath, application, enema | 67 | One hand-circumference of leafy stem | 50 |
| Plant Family       | Species Name                  | Accession Number | Other Names | Use | Application Method | Circumference |
|-------------------|-------------------------------|------------------|-------------|-----|---------------------|---------------|
| **Apocynaceae**   | Baissea multiflora A.DC.     | 8403             | Nonguem taaba, Nongsego (M) | Decoction | Tonic, diarrhea | Drink 10 |
|                   | Nonguem taaba, Nongsego (M)  | 8403             |             |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
|                   | Wound healing, stomachache   | Drink, enema    |             |     |                     |               |
|                   | Drink 10 |                     |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Nongsego (M) |               |               |     |                     |               |
|                   | 8403 |                     |               |     |                     |               |
|                   | Li/La N, Sb, R                | Decoction        |             |     |                     |               |
### Cochlospermaceae

| Species                              | Use (M) | Li | L | R | Treatment                                                                 |
|--------------------------------------|---------|----|---|---|----------------------------------------------------------------------------|
| *Cochlospermum planchonii*           | Sons-raaga | 5  | Li | Li | R | Decoction Malaria Drink, bath 17 One hand-circumference of the root 50 |
| *Cochlospermum tinctorium*           | N'dribala (D) | 2  | Li | Ni | L, R | Decoction Malaria, ulcer Drink, bath 17 Two hands-circumference of leafy stem 100 |

### Combretaceae

| Species                              | Use (M) | Li | L | Sb | Treatment                                                                 |
|--------------------------------------|---------|----|---|----|----------------------------------------------------------------------------|
| *Anogeissus leiocarpa* (DC.) Guili. & Perr. | Siiga (M) | 2  | Li | Ni | Sb | Decoction Respiratory diseases Drink 33 Two hands-circumference of stem bark 50 |
| *Combretum aculeatum* Vent. 1904      | Guilga (M) | 1,4,6 | Li | Ni | L | Decoction Dental pain Gargle 50 Two hands-circumference of leaf 50 |
| *Combretum adenogonium* Steud. ex A. Rich. 2244 | Daygoubwala (Gsi), Kwigenga (M) | 5,6 | Li | Ni | L, Sb | Decoction Dysentery Drink 3 Two hands-circumference of leaf 50 |
| *Combretum glutinosum* Perr. ex DC. 2283 | Kuenga (M), Lifapelugu (G) | 4  | Li | Ni | L | Decoction Stomachache, liver trouble Drink 3 Two hands-circumference of leaf 50 |
| *Combretum micranthum* G. Don 346     | Raandga (M) | 2,3,4 | Li | Ni | L | Decoction Malaria Drink 50 Two hands-circumference of leaf 50 |
| *Combretum paniculatum* Vent. 2250    | Kudgunlungu (M) | 3  | Li | Ni | L | Decoction Hemorrhoids Drink 7 Two hands-circumference of leaf 50 |
| *Combretum sericeum* G. Don 340       | Vopopwao (Gsi) | 6  | Li | Ni | L, Sb | Decoction General fatigue Bath 3 Two hands-circumference of leaf 50 |
| *Guiera senegalensis* J.F. Gmel. 1921 | Wilim-wiga (M) | 1,2,3 | Li | Ni | L, Sb | Decoction Malaria, diarrhea, cold, sinusitis Drink, bath 50 Two hands-circumference of leaf 50 |
| *Pteleopsis suberosa* Engl. & Diels 1876 | Guinga (M), Gnonlifou (D) | 1,2,4,5 | Li | Ni | L, Sb | Decoction Dysentery, stomachache, cough, hemorrhoids Drink 67 Two hands-circumference of leaf 50 |
| *Terminalia avicennioides* Guill. & Perr. 2091 | Kondre (M) | 2  | Li | Ni | L, Sb, R | Decoction Liver trouble, heartache, diarrhea Drink 50 Two hands-circumference of leaf 50 |
| Terminalia macroptera Guill. & Perr. | Koon-d-poko (M) | 1 | Li | Ni | R | Decoction | Hemorrhoids | Enema | 3 | One hands-circumference of root | 50 |
|--------------------------------------|----------------|----|----|----|----|------------|-------------|--------|---|------------------------------|----|
| **Ébenaceae**                        |                |    |    |    |    |            |             |        |   |                              |    |
| Diospyros mespiliformis Hochst. ex A. DC. | Gaaka (M) | 1,4 | Li | Li | L, Sb, R | Decoction | Wound healing, sexual impotence, parasite infections | Drink, bath | 17 | Two hands-circumference of leaf | 50 |
| **Euphorbiaceae**                    |                |    |    |    |    |            |             |        |   |                              |    |
| Euphorbia hirta L.                   | Wal-bisum (M) | 1 | H | Ni | L, Sb, R | Maceration, decoction | Dysentery, respiratory diseases | Drink | 7 | One hand-circumference of plant | 50 |
| **Fabaceae**                         |                |    |    |    |    |            |             |        |   |                              |    |
| Afzelia africana Smith ex Pers.      | Kankalga (M), Tiëlgué (Gsi) | 6 | Ni | Li | Sb, R | Decoction | Stomachache | Drink | 3 | One hand-circumference of stem bark | 50 |
| Alysicarpus glumaceus (Vahl) DC.     | Rabgo (M)      | 5 | Hs | Ni | L | Decoction | Diarrhea | Drink | 3 | One hand-circumference of the plant | 50 |
| Bauhinia rufescens Lam. 6045         | Tipohéga (M)   | 1,2 | Li/He | Ni | L, Sb, R, Fr | Trituration | Cold, sinusitis, tonic | Fumigation, bath | 50 | One hand-circumference of leaf | 50 |
| Burkea africana Hook. 1994           | Kasi-sané (M)  | 6 | Li | Li | Sb | Decoction, infusion | Cough, heart diseases | Drink | 3 | One hand-circumference of stem bark | 50 |
| Cassia alata L. 220                  | Colbata (D)    | 2 | Li | Ni | L | Decoction, trituration | Skin disorders, liver diseases | Drink, application | 3 | One hand-circumference of leafy stem | 50 |
| Cassia italica (Mill.) Lam. ex F.W. Andrews 232 | Panedmantliga (M), Bali bali (D) | 1 | Li | Ni | L | Decoction | Stomachache, skin disorders | Drink, bath | 17 | One hand-circumference of leafy stem | 50 |
| Cassia nigricans Vahl 2223           | Zander-kuka (M) | 1 | Li | Ni | L | Decoction, trituration | Wound healing, stomachache | Enema, application | 10 | One hand-circumference of leafy stem | 50 |
| Cassia occidentalis L. 5375          | Balambala (D)  | 5 | Li | Ni | L, Sb | Decoction | Tonic, stomachache | Bath | 13 | One hand-circumference of leafy stem | 50 |
| Species                | Collector(s) | Quantity | Preparation | Applications                                         | Dosage | Application Preparation |
|-----------------------|--------------|----------|-------------|------------------------------------------------------|--------|--------------------------|
| Cassia sieberiana DC. | Samdiani (G), Kumbr-saka (M) | 1,3,4 | Li, Ni, L, Sb, Root | Decoction, trituration Stomachache, malaria, kidney diseases, sexual impotence | 50 | One hand-circumference of leafy stem 50-100 |
| Cassia singueana Del. | Djéponsré (M) | 1 | Li, Ni, L, R | Decoction Stomachache | 10 | One hand-circumference of leafy stem |
| Detarium microcarpum Guill. & Perr. | Kadga (M) | 4 | Li, Li, L, Sb | Decoction Headache, stomachache | 3 | One hand-circumference of leafy stem |
| Dichrostachys cinerea (L.) Wight & Arn. | Susutga (M) | 6 | Li, Ni, R | Decoction Respiratory diseases | 3 | One hand-circumference of stem bark |
| Entada africana Guill. & Perr. | Sennogo (M) | 2 | Ni, Li, Sb | Decoction, maceration Cold, sinusitis, cough | 3 | Two hands-circumference of stem bark |
| Faidherbia albida (Del.) A. Chev. | Zaanga (M) | 1,2,3 | Li, Ni, L | Decoction Kidney diseases, malaria | 3 | One hand-circumference of leafy stem |
| Senegalia macrostachya (Rchb. ex DC.) Kyal & Boatwr. | Zamenga (M) | 1 | Li, Ni, Le | Decoction Headache | 3 | Two hands-circumference of leafy stem |
| Senegalia senegal (L.) Britton | Gompélga (M) | 1 | Li, Ni, L, Sb | Decoction Diarrhea, hemorrhoids | 3 | Two hands-circumference of leafy stem |
| Vachellia nilotica (L.) P.J.H. Hurter & Mabb. | Pegengá (M) | 1,3,6 | Li, Ni, Fr, Fr, Sb | Decoction Stomachache, hemorrhoids, cough | 27 | Two hands-circumference of stem bark 100 |
| Parkia biglobosa (Jacq.) R. Br. ex G. Don | Rondo (M) | 1,3 | Li, Ni, Sb, Fr | Decoction, calcination, trituration Wound healing, hemorrhoids | 27 | Two hands-circumference of stem bark |
| Piliostigma reticulatum (DC.) Hochst. | Bâguendé (M) | 1,2,3,4 | Li, Ni, L | Decoction, infusion Cold, sinusitis Inhalation, enema | 50 | Two hands-circumference of leafy stem |
| Piliostigma thonningii (Schum.) Milne-Redh. | Bag gnanga (M), Nabali (G) | 4 | Li, Ni, L | Decoction Diarrhea, dysentery | 40 | Two hands-circumference of leafy stem |
| Pterocarpus erinaceus Poir. | Noëka (M) | 1 | Li, Ni, Re, R | Decoction Diarrhea | 13 | Two hands-circumference of stem bark |
| Plant Name                                | Common Name     | Authors           | Code  | Genus          | Species          | Decoction Type | Condition                  | Drink, bath, enema | Hand circumference | Notes   |
|-------------------------------------------|-----------------|-------------------|-------|----------------|------------------|----------------|----------------------------|-------------------|--------------------|---------|
| *Tamarindus indica*                       | Pouaga (M)      | 5326              | 1,2,3,5 Li NI Sb, S | Decoction    | Stomachache, wound healing | 33             | One hand-circumference of seed | 50                |                    |         |
| *Tephrosia bracteolata*                   | Sanri (M)       | 2352              | 1     | H NI L        | Decoction        | Dental pain, headache | Bath             | 3                  | One hand-circumference of the plant | 50    |
| **Lamiaceae**                             |                 |                   |       |               |                  |                |                            |                   |                    |         |
| *Hyptis specigera*                        | Rounroungu (M)  | 2232              | 1     | H NI L        | Decoction        | Malaria, dental pain | Bath, gargle, enema | 10                 | One hand-circumference of the plant | 50    |
| **Leonotis nepetaefolia**                 | Barakourouni (M) | 145               | 5     | H NI I        | Decoction        | Cold, sinusitis    | Bath             | 20                 | One hand-circumference of the plant | 50    |
| **Ocimum americanum**                     | Yulu-yuga (M)   | 145               | 1,2   | H NI L, Sb, Fl| Decoction, infusion| Indigestion, diarrhea, rheumatism | Bath, inhalation | 40                 | One hand-circumference of the plant | 50    |
| **Ocimum basilicum**                      | Yulin-gnuuga (M)| 779               | 1,2   | H NI L        | Decoction        | Children fears     | Bath             | 33                 | One hand-circumference of the plant | 50    |
| **Vitex cuneata**                         | Andga (M)       | 6190              | 1     | Li NI L       | Decoction        | Diarrhea          | Drink            | 3                  | Two hands-circumference of leafy stem | 50    |
| **Vitex doniana**                         | Koto (D), Anda (M) | 6189             | 2     | Li NI L       | Decoction        | Hypertension       | Drink            | 3                  | Two hands-circumference of leafy | 50    |
| **Lauraceae**                             |                 |                   |       |               |                  |                |                            |                   |                    |         |
| *Cassitya filiformis*                     | Naam-kaboul (M), Sanguidjo (D) | 586 | 1,2,6 | H/La NI L, Sb | Decoction, infusion | Stomachache     | Drink, bath | 50                 | One hand-circumference of the plant | 50    |
| **Loranthaceae**                          |                 |                   |       |               |                  |                |                            |                   |                    |         |
| *Tapinanthus globiferus*                  | Soto (Fu)       | 2875              | 6     | Li, Pp NI L, Sb | Decoction        | Diarrhea          | Bath             | 7                  | One hand-circumference of leafy stem | 50    |
| **Lythraceae**                            |                 |                   |       |               |                  |                |                            |                   |                    |         |
| *Lawsonia inermis*                        | Lalé (M)        | 3012              | 1,2,3,6 | Li NI Sb | Decoction | Kidney | Purgative | 3 | One hand-circumference of leafy stem | 50    |
| **Malvaceae**                             |                 |                   |       |               |                  |                |                            |                   |                    |         |
| *Grewia mollis*                           | Mounou mouka(M) | 287               | 3     | Li NI Sb      | Decoction        | Growth retardation | Drink, purgative | 3                  | One hand-circumference of leafy stem | 50    |
| Plant Name                                      | Common Name                          | Varyamdém (M) | Decoction or Trituration | Disease(s)                      | Treatment | Hand Circumference |
|------------------------------------------------|--------------------------------------|---------------|--------------------------|---------------------------------|-----------|-------------------|
| Waltheria indica L.                           | Yaryamdem                            | 1,3,5         | Decoction, Trituration   | Growth retardation              | Bath, application | 50                |
| Sida alba L.                                  | Zoaaga (M)                           | 3             | Decoction                | Pitting edema                   | Enema     | 7                 |
| Wissadula amplissima (L.) R. E. Fries. var. rostrata (Sch. & Th.) | Gomtilaon-go (M)                     | 1,3           | Decoction                | Cold, sinusitis                 | Bath      | 13                |
| Meliaceae                                      |                                      |               |                          |                                 |           |                   |
| Khaya senegalensis (Desr.) A. Juss. 303        | Kuka (M)                             | 3             | Decoction, maceration    | Malaria                         | Drink, bath | 10                |
| Pseudocedrela kotschyi (Schweinf.) Harms 72    | Sigdre (M)                           | 2,3           | Decoction, calcination   | Hemorrhoids, tiredness, tooth pain | Drink, massage, brush | 40                |
| Trichilia emetica Vahl 2577                   | Sula fizan (D), Kinkirs-taanga (M)   | 2,6           | Decoction, Trituration   | Hemorrhoids, malaria            | Drink     | 10                |
| Moraceae                                       |                                      |               |                          |                                 |           |                   |
| Ficus gnaphalocarpa (Miq.) Steud. ex A. Rich. 5584 | Kamsogo (M), Kankoabou(G)            | 2,4           | Decoction                | Malaria                         | Bath      | 3                 |
| Ficus platyphylla Del. 8283                   | Kansaogo (M), Kankanga (M)           | 3             | Decoction                | Stomachache, malaria            | Drink, bath | 3                 |
| Moringaceae                                    |                                      |               |                          |                                 |           |                   |
| Moringa oleifera Lam. 7071                    | Arzan tiiga (M)                      | 2             | Decoction, infusion, Trituration | Dysentery, malaria, stomachache, general fatigue, hypertension | Drink     | 7                 |
| Ochnaceae                                      |                                      |               |                          |                                 |           |                   |
| Lophira lanceolata Van Tiegh. ex Kesy 738     | Mana (D), Malanga (Fu)               | 6             | Trituration              | Skin disorders                  | Application | 3                 |
| Family       | Species                                | Common Names                  | Uses                                      | Drink, bath | One hand-circumference of stem bark | Plant Part Used |
|--------------|----------------------------------------|-------------------------------|-------------------------------------------|-------------|-------------------------------------|-----------------|
| Olacaceae    | *Ximenia americana* L.                 | Lenga (M)                     | 2,3 Li Ni Sb Trituration Stomachache, wound healing | 10          | 50                                  | 8203N360        |
| Phyllantaeae | *Phyllanthus amarus* Schum. & Thonn.   | Woompon-ré (M)                | 1 H Ni L Sb R Decocotion Cataplasm, infusion Hemorrhoids, diarrhoea, gout, stomachache, liver diseases | 17          | 50                                  | 6134            |
| Plantaginaceae | *Scoparia dulcis* L.                  | Tim tim (D), Kafré-mandé (M) | 2,5 H Ni L, Sb, R Decocotion Cough, Jaundice, syphilis | 17          | 50                                  | 3163            |
| Poaceae      | *Andropogon gayanus* Kunth 20          | Pittou (M), Waga ou Karsabin (D) | 2 H /F Ni L Decocotion Cough, malaria | 10          | 100                                 | 191            |
|              | *Bambusa vulgaris* Schrad.ex J.C. Wendl. 3025 | Nasar-tanwilga (M)           | 2 H Ni L Decocotion Malaria Bath | 3           | 50                                  | 3025            |
|              | *Cymbopogon citratus* (DC.) Stapf 3011 | Citronnelle (Fu)             | 4 H/Ga Ni L Decocotion Cold, sinusitis, general fatigue | 3           | 50                                  | 8377            |
|              | *Cymbopogon giganteus* Chiov. 8377    | Kuwere (M)                    | 2 H Ni L, R Decocotion Prostate diseases Drink | 3           | 50                                  | 5969            |
|              | *Cymbopogon schoenanthus* (L.) Spreng. 5969 | Saabi (D)                    | 2 H Ni L, Sb, R Trituration Skin disorders Application | 3           | 50                                  | 15              |
| Polygalaceae | *Securidaca longipedunculata* Fres. 862 | Pelga (M)                    | 2,3 Li Ni R Infusion Ulcer, liver diseases, respiratory diseases Enema, inhalation | 10          | 300                                 | 862             |
| Rubiaceae    | *Crossopteryx febrifuga* (Afzel. ex G. Don) Benth. 15 | Kumbr-wâaga (M)             | 4 Li Li L, Sb Fr Decocotion Tonic Drink | 3           | 50                                  | 15              |
| Plant Name | Common Name | Part Used | Diameter | Preparation | Treatment | Notes |
|------------|-------------|-----------|----------|-------------|-----------|-------|
| *Fadogia agrestis* Schweinf. ex Hiern 286 | Bit koon-bré (M) | L, Sb | Decoction | Rheumatism | Bath | 17 | One hand-circumference of stem bark | 50 |
| *Feretia apodenthera* Del. 5374 | Mounouna (M) | L, Ni | Decoction | Stomachache | Drink | 3 | Two hands-circumference of leafy stem | 50 |
| *Gardenia erubescens* Stapf & Hutch. 2 | Susuba (M) | L, Ni | Decoction | Healing of umbilical cord wounds | Enema | 7 | One hand-circumference of leafy stem | 50 |
| *Gardenia sokotensis* Stapf & Hutch. 8211N360 | Tang-ra-kwenga (M), Toukôrôgoulé (D) | L, Ni | Decoction | Tonic, malaria, wound healing, stomachache | Drink | 67 | One hand-circumference of leafy stem | 50 |
| *Gardenia ternifolia* Schum. & Thonn. 2018 | Râmbrêzûnga (M) | Fr, Ni | Decoction | Tonic | Bath | 10 | One hand-circumference of fruit | 50 |
| *Mitragyna inermis* (Willd.) Kuntze 823 | Yilga (M) | L, Sb | Decoction | Malaria, tiredness, hypertension | Drink | 50 | Two hand-circumference of fruit | 50 |
| *Nauclea latifolia* Smith 2858 | Gouinga (M) | L, Ni | Decoction, infusion | Wound healing, stomachache | Drink | 40 | Two hand-circumference of fruit | 100 |
| *Sarcocephalus latifolius* (Smith) Bruce 2059 | Goinga(M) | Sb, Ni | Decoction | Wound healing, stomachache | Drink | 50 | One hand-circumference of stem bark | 50 |
| **Rutaceae** | | | | | | |
| *Zanthoxylum zanthoxyloides* (Lam.) Zepern. & Timler 3061 | Rapèka (M) | Sb, R | Decoction | Stomachache, dental pain, sickle-cell disease | Drink | 17 | One hand-circumference of root bark | 200 |
| **Sapindaceae** | | | | | | |
| *Paullinia pinnata* L. 2118 | Nusanu (M), Brodinburu (D) | L, Sb, R | Decoction | Malaria, general fatigue, stomachache | Drink | 67 | One hand-circumference of leafy stem | 200 |
| **Sapotaceae** | | | | | | |
| *Vitellaria paradoxa* Gaertn. f. 4683 | Taanga (M) | Sb, Ni | Decoction, trituration | Cold, sinusitis, wound healing, stomachache hemorrhoids | Drink, bath, inhalation | 67 | One hand-circumference of stem bark | 50 |
### Solanaceae

| Plant Name       | Local Name | Provenance       | Part Used | Application | Disease | Application | Dosage | Measurement |
|------------------|------------|------------------|-----------|-------------|---------|-------------|--------|-------------|
| Physalis angulata L. | Poapoa raaga (M) | 1 H Ni L | Trituration | Skin disorders | | 3 | One hand-circumference of the plant | 50 |
| Lantana camara L. | Nasar luili sibi (M) | 1,2 H Ni L, Sb, R | Decoction, infusion | Hypertension | Drink | 3 | One hand-circumference of the plant | 50 |
| Tectonia grandis L.f. | Teck (F) | 1 Ni Li L | Decoction, maceration | Ulcer | Drink | 3 | Two hands-circumference of leaf | 50 |

### Verbenaceae

| Plant Name       | Local Name | Provenance       | Part Used | Application | Disease | Application | Dosage | Measurement |
|------------------|------------|------------------|-----------|-------------|---------|-------------|--------|-------------|
| Lantana camara L. | Nasar luili sibi (M) | 1,2 H Ni L, Sb, R | Decoction, infusion | Hypertension | Drink | 3 | One hand-circumference of the plant | 50 |
| Tectonia grandis L.f. | Teck (F) | 1 Ni Li L | Decoction, maceration | Ulcer | Drink | 3 | Two hands-circumference of leaf | 50 |

### Vitaceae

| Plant Name       | Local Name | Provenance       | Part Used | Application | Disease | Application | Dosage | Measurement |
|------------------|------------|------------------|-----------|-------------|---------|-------------|--------|-------------|
| Cissus quadrangularis L. | Kilounoarou (G) | 4 Li/La Ni Sb | Cataplasm | Tiredness | Massage | 3 | One hand-circumference of stem bark | 50 |

### Zygophyllaceae

| Plant Name       | Local Name | Provenance       | Part Used | Application | Disease | Application | Dosage | Measurement |
|------------------|------------|------------------|-----------|-------------|---------|-------------|--------|-------------|
| Balanites aegyptiaca (L.) Del. | Kyegelega (M) | 1 Li Ni Fr, Sb | Decoction | Stomachache, hemorrhoids | Drink | 33 | One hand-circumference of leafy stem | 50 |

### Legend:

- **Local name:** D Dioula, G Gourmantché, Gsi Gourounsi, F French, M Mooré, Fu Fulfuldé.
- **Provenance:** Li ligneous, H Herbaceous, La Liana, Pp Parasitic plant, F Field, Ga Garden, He Hedgerow, Cw Coast watercourse, NI: No Information.
- **Part used:** L Leaf, Sb Stem bark, B Bark, R Root, S Seed, G Gum, Fr Fruit, I Inflorescence, Sa Sap, Re Resin, Fl Flora
- **City:** Ouagadougou (1), Bobo Dioulasso (2), Ouahigoua (3), Fada (4), Dedougou (5), Léo (6).
Table 2. Plant parts sold in the market for ailment treatment

| Plant part used | No. of plants parts | % of plant parts |
|-----------------|---------------------|------------------|
| Leaves          | 76                  | 47.0             |
| Stem bark       | 55                  | 34.0             |
| Root            | 28                  | 17.2             |
| Inflorescence   | 1                   | 0.6              |
| Gum             | 1                   | 0.6              |
| Seed            | 1                   | 0.6              |

The total number of species for calculation of percentages was 162

Table 3. Source of medicinal plants

| Habitat           | No. of species | % of species |
|-------------------|----------------|--------------|
| Savanna           | 101            | 86.3         |
| Forest            | 3              | 2.6          |
| Savanna and forest| 9              | 7.7          |
| Savanna and field | 1              | 0.9          |
| Savanna and garden| 3              | 2.6          |

The total number of species for calculation of percentages was 117

Figure 3. Percentage of species used for various recipe preparations. The total number of species for calculation of percentages was 104. Some species were used for multiple recipe preparations.

Figure 4. Percentage of species used for various administration modes. The total number of species for calculation of percentages was 104. Some species were used for multiple administration modes.
| Ailment categories          | Specific condition                  | No. of plants species (n = 104) | % of total species |
|----------------------------|-------------------------------------|---------------------------------|--------------------|
| Gastrointestinal diseases  | Dysentery, ulcer, diarrhea, stomachache | Adansonia digitata (1), Afzelia africana (2), Alysicarpus glumaceous (3), Annona senegalensis (4), Baissaea multiflora (5), Balanites aegyptiaca (6), Boswellia daishi (7), Cassia italica (8), Cassia nigricans (9), Cassia occidentalis (10), Cassia sieberiana (11), Cassia singueana (12), Cassytha filiformis (13), Cochlospermum tinctorum (14), Combretum adnegonium (15), Combretum glutinosum (16), Detarium microcarpum (17), Diospyros mespiliformis (18), Euphorbia hirta (19), Ficus platyphylla (20), Feretia apodenthera (21), Gardenia sokotensis (22), Guiera senegalensis (23), Heliotropium indicum (24), Lannea acida (25), Lepidagathis anabrya (26), Maytenus senegalensis (27), Moringa oleifera (28), Nauclea latifolia (29), Ocimum americanum (30), Paulinia pinnata (31), Phyllanthus amarus (32), Pilostigma thonningii (33), Pteleopsis suberosa (34), Pterocarpus erinaceus (35), Pupalia lappacea (36), Saba senegalensis (37), Sarccephalus latifolius (38), Sclerocarya birea (39), Securidaca longipedunculata (40), Senegalia senegal (41), Tamarindus indica (42), Tapinanthus globiferus (43), Tectonia grandis (44), Terminalia avicennioides (45), Vachellia nilotica (46), Vitellaria paradoxa (47), Vitex vulnaria (48), Ximenia americana (49), Zanthoxylum zanthoxyloides (50) | 48.1 |
| Malaria                    | -                                   | Andropogon gayanus (1), Annona senegalensis (2), Bambusa vulgaris (3), Cochlospermum planchonii (4), Cochlospermum tinctorum (5), Combretum micranthum (6), Gardenia sokotensis (7), Guiera senegalensis (8), Cassia sieberiana (9), Faidherbia albida (10), Ficus gnaphalocarpa (11), Ficus platyphylla (12), Hyptis specigera (13), Khaya senegalensis (14), Leptadina hastate (15), Maytenus senegalensis (16), Mitragyna inermis (17), Moringa oleifera (18), Paulinia pinnata (19), Trichilia emetica (20) | 19.2 |
| General pathologies        | Headache, tiredness, cold, insomnia, fatigue | Annona senegalensis (1), Bauhinia rufescens (2), Cissus quadrangularis (3), Combretum sericeum (4), Cymbopogon citratus (5), Detarium microcarpum (6), Entada africana (7), Guiera senegalensis (8), Leonotis nepetaefolia (9), Maytenus senegalensis (10), Mitragyna inermis (11), Moringa oleifera (12), Paulinia pinnata (13), Pilostigma reticulatum (14), Pseudocedrela kotschyi (15), Senegalia macrostachya (16), Tephrosia bracteolate (17), Vitellaria paradoxa (18), Wissadula amplissima (19) | 18.3 |
| Dermatitis                 | Skin disorders, wound healing        | Annona senegalensis (1), Boswellia dalzielli (2), Cassia alata (3), Cassia italica (4), Cassia nigricans (5), Diospyros mespiliformis (6), Gardenia sokotensis (7), Lophira lanceolata (8), Cymbopogon schoenanthus (9), Nauclea latifolia (10), Parkia biglobosa (11), Physalis angulata (12), Pupalia lappacea (13), Saba senegalensis (14), Sarccephalus latifolius (15), Vitellaria paradoxa (16), Tamarindus indica (17), Ximenia americana (18) | 17.3 |
| Respiratory diseases       | Respiratory disorder, sinusitis, cough | Andropogon gayanus (1), Anogeissus leiocarpus (2), Bauhinia rufescens (3), Burkea africana (4), Cymbopogon citratus (5), Dichrostachys cinerea (6), Entada africana (7), Guiera senegalensis (8), Euphorbia hirta (9), Hygrophila auriculata (10), Leonotis nepetaefolia (11), Pilostigma reticulatum (12) | 17.3 |
| Disease Type                      | Plants                                      | Fidelity Level |
|----------------------------------|---------------------------------------------|----------------|
| Hemorrhoids                      | Balanites aegyptiaca (1), Combretum paniculatum (2), Parkia biglobosa (3), Phyllanthus amarus (4), Pseudocedrela kotschyi (5), Pteleopsis suberosa (6), Scoparia dulcis (7), Senegalia Senegal (8), Terminalia macropera (9), Trichilia emetica (10), Vachellia nilotica (11), Vitellaria paradoxa (12) | 11.5 |
| Internal organ diseases          | Cassia alata (1), Cassia sieberiana (2), Chrysanthemum americanum (3), Combretum glutinosum (4), Faidherbia albida (5), Lawsonia inermis (6), Securidaca longipedunculata (7), Phyllanthus amarus (8), Terminalia avicennioides (9) | 8.7 |
| Cardiovascular diseases          | Anacardium occidentale (1), Burkea africana (2), Heliotropium indicum (3), Lantana camara (4), Mitragyna inermis (5), Moringa oleifera (6), Terminalia avicennioides (7), Vitex doniana (8) | 7.7 |
| Infections (excl. malaria)       | Combretum aculeatum (1), Cynanchum viminalis (2), Maytenus senegalensis (3), Tephrosia bracteolata (4), Hyptis specigera (5), Hyptis specigera (6) | 5.8 |
| Child diseases                   | Alternanthera nodiflora (1), Gardenia erubescens (2), Grewia mollis (3), Lepidagathis anobrya (4), Ocimum basilicum (5), Waltheria indica (6) | 5.8 |
| Urogenital diseases              | Cassia sieberiana (1), Cymbopogon giganteus (2), Diospyros mespiliformis (3), Leptadenia hastate (4), Scoparia dulcis (5) | 4.8 |
| Arthritis                        | Fadogia agrestis (1), Phyllanthus amarus (2), Ocimum americanum (3) | 2.9 |
| Blood diseases                   | Hippocratea africana (1), Zanthoxylum zanthoxyloides (2) | 1.9 |

**Fidelity Levels (FL) of plant species**

The FL values reflect the concordance between informants in using a particular plant species for treating a specific disease in relation to the total numbers of use reports of that particular species for treating any disease. The highest fidelity level of all plant species was attributed to *Gardenia sokotensis* Stapf & Hutch. (FL=80%) used for treatment of malaria (Table 7). This was followed by *B. rufescens* for usage as tonic and *Pteleopsis suberosa* Engl. & Diels for treatment of stomachache (FL=77% for both species). Two other species, *C. micranthum* and *Maytenus senegalensis* (Lam.) Exell exhibited also rather high-fidelity levels in treatment of malaria (FL=75% for both species).

**Presence of species in the markets and prices demanded**

The species most frequently offered in the stalls (present in ≥67% of all stalls) were *Annona senegalensis* Pers., *G. sokotensis*, *Paulinia pinnata* L., *P. suberosa* and *V. paradoxa* (Table 8). As prices of the medicinal plants varied somehow from one market to market, we give an average price estimate in Table 1 for a one hand-circumference quantity. For the majority of species prices were 50 FCFA for a bundle of one hand-circumference. Higher prices were demanded for some species which were rarely commercialized, like *Chrysanthemum americanum* (L.) Vatke, *Securidaca longipedunculata* Fres., and *Zanthoxylum zanthoxyloides* (Lam.) Zepern. & Timler (up to 300 FCFA for a one hand-circumference bundle). However, rarity is not the only condition for being a highly valued species, as found for *P. pinnata* which was offered in 67% of the markets and priced for 200 FCFA per bundle.

**Conservation status of species encountered in the markets**

For only 19% of the species encountered in the markets an estimation of the IUCN conservation status is available (IUCN 2018). Within the 20 most frequently commercialized species nine are qualified in the category Data Deficient, as there are currently not sufficient data for a precise evaluation of the extinction risk. Ten species have a stable population status and one (*V. paradoxa*) is assessed by IUCN as vulnerable (Table 8). Three additional species found in the markets have a vulnerable status: *Afzelia africana* Smith ex Pers., *Khaya senegalensis* (Desr.) A. Juss. and *Tapianthus globiferus* (A.Rich.)
Van Tiegh. These species were rarely present in the stalls (frequency of citation ≤10%).

Table 5. Informant consensus factor (FIC) about ailment treatment by medicinal plants

| Ailment category          | N_u | N   | FIC |
|---------------------------|-----|-----|-----|
| Child diseases            | 48  | 6   | 0.9 |
| Cardiovascular diseases   | 38  | 8   | 0.8 |
| Respiratory diseases      | 68  | 19  | 0.7 |
| Infectious diseases (excl. malaria) | 21  | 7   | 0.7 |
| General pathology symptoms| 71  | 21  | 0.7 |
| Arthritis                 | 8   | 3   | 0.7 |
| Dermatosis                | 52  | 21  | 0.6 |
| Malaria                   | 45  | 19  | 0.6 |
| Gastrointestinal disease  | 125 | 50  | 0.6 |
| Hemorrhoids               | 26  | 11  | 0.6 |
| Blood diseases            | 3   | 2   | 0.5 |
| Urogenital diseases       | 8   | 5   | 0.4 |
| Internal organ diseases   | 12  | 9   | 0.3 |

N_u = Number of use reports by category from vendors in the markets. N = Number of species listed in each category from all vendors. FIC = Informant Consensus Factor

Table 6. Rank value assigned by key informants for the 10 preferred medicinal plants

| Medicinal plant species       | Part used | Ailment / Symptoms treated | Key informants (n=9) | Value / 90 | Rank |
|-------------------------------|-----------|-----------------------------|----------------------|------------|------|
| *Combretum micranthum*        | Leaf      | Malaria                     | A 8 B 10 C 9 D 10 E 8 F 9 G 10 H 10 I 82 | 1st        |
| *Vitellaria paradoxa*         | Stem, bark| Cold, sinusitis, wound healing, hemorrhoids | A 10 B 8 C 9 D 10 E 8 F 8 G 6 H 7 I 77 | 2nd        |
| *Vachellia nilotica*          | Fruit, stem, bark | Stomachache, hemorrhoids, cough | A 9 B 8 C 10 D 10 E 10 F 8 G 7 H 77 | 3rd        |
| *Gardenia sokotensis*         | Leaf      | Tonic, malaria, wound healing, stomachache | A 8 B 10 C 8 D 10 E 8 F 6 G 10 H 6 I 74 | 4th        |
| *Maytenus senegalensis*       | Leaf, root| Malaria, diarrhea, dental pain, headache | A 10 B 8 C 10 D 7 E 9 F 8 G 5 H 6 I 10 | 5th        |
| *Lepidagathis anobrya*        | Leaf      | Growth retardation, stomachache | A 8 B 9 C 10 D 6 E 8 F 7 G 10 H 5 I 6 | 6th        |
| *Pteleopsis suberosa*         | Leaf, stem, bark | Dysentery, stomachache, cough, hemorrhoids | A 7 B 8 C 10 D 8 E 8 F 7 G 5 H 8 I 67 | 7th        |
| *Paullinia pinnata*           | Leaf, stem, bark, root | Malaria, general fatigue, stomachache | A 8 B 6 C 8 D 9 E 7 F 5 G 7 H 8 I 65 | 8th        |
| *Bauhinia rufescens*          | Leaf, stem | Cold, sinusitis, tonic | A 8 B 10 C 9 D 5 E 6 F 5 G 8 H 7 I 64 | 9th        |
In a similar investigation performed in Burkina Faso, the knowledge on medicinal plants is still present in the community. Remedies against ailments and rich traditional knowledge on medicinal plants is still present in the community. In a similar investigation performed in another country of the Sahel zone, North Sudan, only 44 plant species could be identified for medicinal uses (Suleiman 2015). The most represented plant families in our study were Fabaceae, Combretaceae, and Rubiaceae. A high rate of utilization of these plant families has also been reported in other studies on medicinal plant use in Burkina Faso (Zerbo et al. 2011; Ky et al. 2009). Fabaceae was also the most represented plant family in an ethnobotanical study in Togo which highlights the importance of this family in traditional medicine (Agbodexa et al. 2015). The plant parts preferably used for medicinal recipes were leaves followed by barks and roots. In previous investigations in other regions of Burkina Faso (province of Kadiogo and Kouritenga), leaves were also the predominant plant parts collected (Tapsoba and Deschamps 2006; Nadembega et al. 2011). The high utilization rate of leaves could be attributed to the ease with which they can be obtained in large quantities compared to other plant parts and the abundance of bioactive compounds usually found in leaves (Tugume et al. 2016; Nadembega et al. 2011). Large quantities of roots and barks were also collected for recipe preparations. If not properly controlled, this destructive harvesting practice certainly threatens the survival of numerous medicinal plant species in the long term (Bhattarai 1997).

### Table 7. Fidelity levels of most common species used

| Medicinal plant species                  | Therapeutic use  | Io  | Iu  | FL [%] |
|-----------------------------------------|------------------|-----|-----|--------|
| *Gardenia senegalensis*                 | Malaria          | 16  | 20  | 80     |
| *Bauhinia rufescens*                    | Tonic            | 20  | 26  | 77     |
| *Pteleopsis suberosa*                   | Stomachache      | 10  | 13  | 77     |
| *Combretum micranthum*                  | Malaria          | 15  | 20  | 75     |
| *Maytenus senegalensis*                 | Malaria          | 18  | 24  | 75     |
| *Vitellaria paradoxa*                   | Sinusitis        | 15  | 20  | 75     |
| *Vachellia nilotica*                    | Stomachache      | 18  | 25  | 72     |
| *Lepidagathis anobrya*                  | Growth retardation| 11 | 16 | 69 |
| *Paulinia pinnata*                      | Stomachache      | 10  | 20  | 50     |
| *Annona senegalensis*                   | Stomachache      | 10  | 20  | 50     |

Io = Number of informants who suggested the use of a species for the same major ailment; Iu = Total number of informants who mentioned the species for any use.

### Discussion

#### Informant characteristics

Women by far prevailed in the trade of medicinal plants in the studied markets in Burkina Faso. In Africa, this trade is commonly dominated by women (Van Andel et al. 2012). The average age of vendors of medicinal plants was about 54 years. This relatively high age may be attributed to two reasons: In Africa herbalists of higher age (>50) are commonly estimated to have acquired more knowledge in the area of medicinal plants (Tugume et al. 2016). Until recently this knowledge has traditionally been passed to the young generation by oral communication, but nowadays younger people have little interest in learning and practicing this activity.

Most of the traditional healers were affiliated with an association in the field of medicinal plants. These associations possess a formal authorization from the government to exercise this activity.

#### Diversity of medicinal plant species and plant parts used

The high number of species recorded (104) proves that Burkina Faso has a diverse flora used as remedies against ailments and rich traditional knowledge on medicinal plants is still present in the community. In a similar investigation performed in

| species                  | bark, root, fruit | Wound healing, stomachache, somniferous malaria |
|--------------------------|-------------------|------------------------------------------------|
| *Annona senegalensis*    | Leaf, stem, bark, root | 8, 6, 4, 6, 4, 10, 4, 6, 50, 10^n |

Ranks given to a medicinal plant are based on its efficacy in treating a special ailment according to the informant. Highest number (10) for a medicinal plant is given when informants considered the plant being most effective in healing an ailment and lowest (1) for the least effective.

| Medicinal plant species                  | Therapeutic use  | Io  | Iu  | FL [%] |
|-----------------------------------------|------------------|-----|-----|--------|
| *Gardenia senegalensis*                 | Malaria          | 16  | 20  | 80     |
| *Bauhinia rufescens*                    | Tonic            | 20  | 26  | 77     |
| *Pteleopsis suberosa*                   | Stomachache      | 10  | 13  | 77     |
| *Combretum micranthum*                  | Malaria          | 15  | 20  | 75     |
| *Maytenus senegalensis*                 | Malaria          | 18  | 24  | 75     |
| *Vitellaria paradoxa*                   | Sinusitis        | 15  | 20  | 75     |
| *Vachellia nilotica*                    | Stomachache      | 18  | 25  | 72     |
| *Lepidagathis anobrya*                  | Growth retardation| 11 | 16 | 69 |
| *Paulinia pinnata*                      | Stomachache      | 10  | 20  | 50     |
| *Annona senegalensis*                   | Stomachache      | 10  | 20  | 50     |
Table 8. Frequency of citation of medicinal plant species most commonly encountered on market stalls and corresponding conservation status according to the IUCN Red List

| No. | Medicinal plant species          | Frequency of citation (%) | IUCN Conservation status |
|-----|----------------------------------|---------------------------|--------------------------|
| 1   | Annona senegalensis             | 67                        | LC                       |
| 2   | Gardenia sokotensis             | 67                        | DD                       |
| 3   | Paulinia pinnata                | 67                        | DD                       |
| 4   | Pteleopsis suberosa             | 67                        | LC                       |
| 5   | Vitellaria paradoxa              | 67                        | VU                       |
| 6   | Bauhinia rufescens              | 50                        | LC                       |
| 7   | Cassia sieberiana               | 50                        | LC                       |
| 8   | Cassytha filiformis             | 50                        | DD                       |
| 9   | Combretum aculeatum             | 50                        | LC                       |
| 10  | Combretum micranthum            | 50                        | LC                       |
| 11  | Guiera senegalensis             | 50                        | LC                       |
| 12  | Lepidagathis anobrya            | 50                        | DD                       |
| 13  | Maytenus senegalensis           | 50                        | DD                       |
| 14  | Mitragyna inermis               | 50                        | DD                       |
| 15  | Pliostigma reticulatum          | 50                        | LC                       |
| 16  | Saba senegalensis               | 50                        | DD                       |
| 17  | Sclerocarya birrea              | 50                        | LC                       |
| 18  | Terminalia avicennoides         | 50                        | DD                       |
| 19  | Vachellia nilotica var. adansonii | 50                     | LC                       |
| 20  | Waltheria indica                | 50                        | DD                       |

DD = data deficient; LC = least concern; VU = vulnerable

As can be expected the most varied range of species was offered in the two largest cities of Burkina Faso, Ouagadougou and Bobo Dioulasso. Most of the species were found in at least two markets. The most unique medicinal plant panels with numerous plants not found in other markets were offered in the cities Fada N’Gourma and Léo. Whether this reflects specific cultural or social differences linked to these regions is beyond the scope of this study.

**Herbal medicine preparation and administration**

Decoction is by far the most common method of preparation, as already described in previous ethnobotanical studies in Burkina Faso (Zerbo et al. 2011; Tapsoba and Deschamps 2006). Water is the cheapest and the most available solvent for rapid extraction of active ingredients, but some of the active metabolites of plants can be degraded by extraction performed at high temperatures (Kasali et al. 2014). Decoction by boiling or shaking herbas uses large quantities of plant material and may thus contribute to overexploitation of species (Tugume et al. 2016). Drinking was the main route of administration, which is common practice for treatment of ailments in families (Togola et al. 2005).

**Quantitative analysis of the field study for highlighting the most important plants**

One of the objectives of this investigation was to identify plants that are of particular importance for the treatment of certain diseases. For this, a set of ethnobotanical indices was used for quantitative analysis of the results of the structured interviews performed with the herbalists.

The factor of informant consensus (FIC value) is particularly useful for selecting the categories of diseases for which medicinal plants are traditionally used. By applying this tool, researchers can identify the main diseases in a community grouped by the categories for which medicinal plants are used. The highest FIC value was found for childhood illnesses, followed by cardiovascular diseases. The most cited species for the treatment of childhood diseases was the herbaceous plant, *Lepidagathis anobrya* (Acanthaceae). This species is particularly used for the cure of growth retardation and stomach pain in children. *Ocimum basilicum* (Lamiaceae), a globally estimated herb, was also often cited by the vendors for the treatment of children fears. Cardiovascular diseases come in second in the disease ranking. As a remedy against this ailment, the vendors particularly mentioned *Mitragyna inermis* as being highly effective against hypertension. These results are in line with those of Konkon et al. (2008) who demonstrated that the anti-hypertensive activity of *M. inermis* is due to the presence of triterpenes.

In addition to the factor of informant consensus, the fidelity level was applied to the data of our field study for selecting important individual plants. Using this
tool, the species *Gardenia sokotensis*, *Combretum micranthum* and *Maytenus senegalensis* ranked as the best candidates for treatment of malaria. These three species were also among the favorites when we asked vendors to perform a preference ranking of the ten most valued plants in terms of frequency of use and effectiveness against malaria.

Thus, the combination of fidelity level and preference ranking highlights *G. sokotensis*, *C. micranthum* and *M. senegalensis* as particularly important species for treatment of malaria. *G. sokotensis* is described as containing multiple chemical compounds including saponosides, alkaloids, triterpens and sterols (Ouédraogo 1998). Previous studies have already described the anti-plasmodial efficacy of *G. sokotensis* and *M. senegalensis* (Ouédraogo 1998; Willcox et al. 2011). Extracts from *C. micranthum* have already been tested clinically and have demonstrated partial parasite clearance and very efficient fever clearance after seven days of treatment (Willcox et al. 2011). The high frequency of citation of these three species also demonstrates the high prevalence of malaria in Burkina Faso. According to WHO (2009) and several other studies (Ky et al. 2009; Zizka et al. 2015), malaria is a major threat to the population of Burkina Faso, with 3.5 million recorded cases in 2008 (thereof 50% of the children under 5 years).

The results of our field study highlight the value of traditional knowledge in detecting plant species containing pharmacological effective substances with potential to treat this important disease. We thus strongly encourage the development of plant material derived from *G. sokotensis*, *C. micranthum* and *M. senegalensis* into standardized phytotherapeutical drugs. This can be done quickly and cheaply and ensures the access to complementary medicine for the poorest people in remote areas. The use of alternative active substances might also delay the development of resistance to current standard drugs. As all three plants have a long tradition in the treatment of malaria by traditional healers in Burkina Faso and Mali (Zizka et al. 2015; Haidara et al. 2016), severe toxicological and safety issues are not to be expected.

In the present survey, combinations of plants for the treatment of diseases were not reported by the vendors. In contrast, treatment of several diseases with a single plant seems to be common practice. For example, *Hippocratea africana* (Wild.) Loes. or *Vitex doniana* Sweet were used to treat sickle-cell disease and hypertension, while *Euphorbia hirta* L. was used for the treatment of dysentery and respiratory troubles. Some medicinal plants were used to treat three or more types of diseases. An example for this is *Mitragina inermis*, which by the informants was mainly mentioned for hypertension treatment but was also recorded to treat malaria, wounds and stomach aches. This is substantiated by several studies that have reported positive effects of *M. inermis* against stomachache, malaria, diabetes, dysentery, venereal diseases and mental disorders (Sourabie et al. 2013). According to Tugume et al. (2016), the use of a plant to treat several ailments is probably attributed to the presence of many metabolites in this plant and also to the observation that the same molecule can be active against different pathologies.

**Conservational aspects**

In Burkina Faso, most of the plants sold in the markets are collected in the savanna by traditional health practitioners, sellers or collectors. Whereas the traditional health practitioners are instructed to collect herbal material in a sustainable manner by government, numerous uncontrolled collectors represent a serious risk for medicinal plant species (Nadembega et al. 2011). This risk is also increased by the fact that most plant parts are collected from ligneous species in the savannas (Kristensen et al. 2003; Moyo et al. 2015). Savanna trees are often overexploited because of their multiple usages, not only for medicine products, but also for domestic energy, timber for construction, seeds for food preparation or fodder for animals. The *Vitellaria paradoxa* tree is such a multi-purpose species that was among the most cited species encountered in the markets and plant material was sold in large quantities in nearly 70% of the stalls at a relatively low price (one hand-circumference of stem bark for 50 FCFA). Unsustainable collection of the stem bark of this tree by local drug collectors could lead to the disappearance of this species in the savanna. In addition to the bark collected for preparation of remedies, the nuts of this tree are also intensively collected by local women to obtain oil used for food and for preparation of cosmetics products. This impacts the reproduction of the tree populations from seeds and thus further increases the extinction pressure on this species. It is classified by the IUCN as a vulnerable species. According to forest villagers and our own observations in the field, *V. paradoxa* is now in fact a very rare plant found in the savanna area. Some other species as *Securidaca longipedunculata* and *Zanthoxylum zanthoxyloides* are already diminished in their native environment (own observations). They were rarely offered in the stalls and their prices greatly exceeded the ones for readily available species converting them into a highly profitable natural resource. Three additional tree species which are assessed as vulnerable by IUCN (*Afzelia africana*, *Tapianthus globiferus*, *Khaya*...
The diversity of species is used as remedies for many regions of Burkina Faso demonstrates that a high threat status of natural populations of medicinal plants. Increased efforts are therefore necessary to preserve the integrity of natural populations of these species regarding their low conservation status. One remedy could be the cultivation of these species in home gardens or nurseries. Our field study could help to focus future conservation efforts and to identify promising candidates for further experimental and clinical research with the objective for developing these plants into standardized drugs.

Declarations

List of abbreviations: AN: Assemblée Nationale; HNBU: Herbier National du Burkina Faso; IUCN: International Union for Conservation of Nature; MAHRH: Ministère de l’Agriculture de l’Hydraulique et des Ressources Halieutiques; WHO: World Health Organization

Ethics approval and consent to participate: All participants were asked for their free prior informed consent before interviews were conducted.

Consent for publication: Not applicable.

Availability of data and materials: Raw data can be requested from the corresponding author.

Competing interests: The authors declare that they have no competing interests.

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Authors’ contributions: LO designed and performed the field study and together with JE wrote the paper. PAEDS and HS contributed to the drafting of the paper. MK reviewed the final version of the manuscript.

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