International Journal of Plant & Soil Science

Volume 37, Issue 11, Page 190-203, 2025; Article no.IJPSS.147403
ISSN: 2320-7035

Ethnobotanical Studies, Conservation, Uses of Plant Species and its Impact on Vegetation, A Case Study of Agadez Locality, Niger

ALI Ado [a*], YAHAYA Maman [b], KARIM Saley [b], MAHAMANE ALI [c] and SAADOU Mahamane [c]

[a] National School of Engineering and Energy Sciences, University of Agadez, P.O. Box 199, Niger.
[b] Department of Biology, Faculty of Science and Technology, Dan Dicko Dan Koulodo University of Maradi, P.O. Box 465, Maradi, Niger.
[c] Department of Biology, Faculty of Science and Technology, Abdou Moumouni University of Niamey, Garba Mounkaila Laboratory, P.O. Box 10662, Niamey, Niger.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i115834

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/147403

Original Research Article

Received: 05/09/2025
Published: 13/11/2025

ABSTRACT

Climate change, combined with over exploitation of plant resources, impacts plant density and diversity in arid environments. To collect data, an individual ethnobotanical survey was conducted among 90 people in the Agadez locality, including 30 people per village of both sexes, to identify the various activities that impact vegetation, the different management methods, the most important species to the local population, and the contribution of income from plant resources to the

**Corresponding author: E-mail: aaliadok@gmail.com;*

Cite as: *ALI Ado, YAHAYA Maman, KARIM Saley, MAHAMANE ALI, and SAADOU Mahamane. 2025. "Ethnobotanical Studies, Conservation, Uses of Plant Species and Its Impact on Vegetation, A Case Study of Agadez Locality, Niger". International Journal of Plant & Soil Science 37 (11):190–203. https://doi.org/10.9734/ijpss/2025/v37i115834.*

promotion of socio-economic activities. This study shows that wood cutting is the activity that has the greatest impact on vegetation. A survey of people confirmed that 98% reported a decrease in vegetation cover, and 18 species have been recorded as extinct. The five extinct species with accounts for more than 1/3 of the frequency are *Guiera senegalensis* J. F. Gmel., *Leptadenia pyrotechnica* (Forsk.) Decne., *Piliostigma reticulatum* (DC.) Hochst. Among the practices learned by the population for plant conservation, assisted natural regeneration (ANR) is the most widely taught and the most widely practiced for conservation and improvement of tree density. Fifteen plant species are used for human consumption, 15 plant species are used as fodder, and 32 species are used in pharmacopoeia. Income from plant resources contributes to improving the people's livelihood.

Keywords: Species; use value; ecosystem service; Agadez.

1. INTRODUCTION

According to a recent study, more than 80% of the Earth's surface is directly affected by human activities that profoundly alter ecological conditions within habitats, the distribution of habitats across the landscape, and the functioning of populations and their interactions (Pascal, 2010). These disturbances result in the overexploitation of plant resources and lead to the decline in vegetation cover and biodiversity. In the Sahelian zone of West Africa, and in Niger in particular, plant species play a central role in the lives of rural communities. They provide many products and services that are used by the population. They not only provide ecological functions and a source of fodder and energy, but also support food, health, social, and economic benefits (Larwanou et al., 2010).

In Niger, local populations are dependent on products derived from natural vegetation, such as wood and non-wood forest products (NWFPs), which are the main source of income, medicinal products, and food supplements, especially in rural areas. However, irregular rainfall, repeated droughts, desertification, and demographic pressure on natural resources have led to profound changes in farming practices, which in turn have led to an impact on natural resources.

According to Habou (2016), the excessive exploitation of certain plant species that are linked to socio-economic values, is one of the factors contributing to the degradation of vegetation, especially in the Sahelian and Sudanian zones of West Africa. In arid and semi-arid areas, the physical appearance of vegetation and the characteristics of the land surface affect the spatial change in infiltration and runoff of rainwater (Albergel, 1988). Vegetation associations in this zone are often linked to habitat degradation because they establish themselves in areas with the highest runoff (Ichaou et al., 1997; Ludwig et al., 2005).

The decline in vegetation cover following tree felling exposes the soil to the combined and multiple effects of wind and water erosion (Moussa et al., 2011). The idea of conserving species diversity, taking into account the needs and concerns of local populations, has become an undisputed reality since 1992 at the Earth Summit (Inoussa et al., 2013). Despite this awareness, the atmosphere of biodiversity poses a threat to humans (Sinsin and Kampmann, 2010). This is why studying the state of flora and vegetation in relation to environmental parameters not only allows us to study environmental conditions but also to analyze the consequences of vegetation on environmental variability. It also allows local communities to be informed about environmental changes through the scientific development of sustainable management (Abdourhamane, 2016; Alhassane, 2018). Indeed, according to Melom et al. (2015), knowledge of the state of flora and vegetation in a given area is an effective means of supporting sustainable development policies. A necessary solution to this accelerated degradation and its management methods in the urban commune of Agadez is presented in this study.

2. MATERIALS AND METHODS

The study area and its characteristics: The study was conducted in the Agadez region, specifically in the urban commune located in the northern part of the country between latitude 16°56”44” North and longitude 7°57”42”. It has an arid tropical climate, with a rainy period between June and September. It is part of the Sahelian zone, which receives some rain from the African monsoon. The hottest season begins in April and lasts until June, just before the rain

arrives. However, rainfall is often scarce, even in the wettest month. The city is located in the middle of Niger at an altitude of 500 meters. On average, the temperature is 69.6°F in the coldest month (January) and 95.6°F in the hottest month (June). In 2023, rainfall was 110 millimeters. This is a desert area. Rainfall can be as low as 0 mm in the months with the least rainfall (January, February, March, October, November, December), and can reach up to 50 mm in the rainiest month (August).

Sampling: Simple random sampling was carried out in three (3) villages in the municipality. Thirty (30) people in each village were surveyed. A total of 90 people were questioned. Each form contains the respondent's sociodemographic information, such as their first and last names, occupation, age, gender, and the name of the village where they live.

Data collection: Ethnobotanical data were collected through surveys conducted in the villages. The survey was conducted using a pre-established questionnaire. This questionnaire included closed and open-ended questions to achieve the objective of this study. Ethnobotany is the discipline that studies natural sciences with the aim of studying the use of riparian flora by various human groups (Ramade, 2008). For this work, the individual survey method was used. The questionnaire presented to all social groups of the populations interviewed includes: (i) perception of vegetation change, (ii) list of extinct species and that have appeared, (iii) activities impacting vegetation, (iv) ecosystem services provided by vegetation, (v) plant resource management. A total of 90 people (men and women) between the ages of 20 and 80 were interviewed. The data captured the information about the locality, the date on which the survey took place, the age, occupation, and identity of the respondent, local perceptions of vegetation, ecosystem services, and local management of plant resources.

Data processing: The data collected during the survey were encoded in Excel and then processed and analyzed using the same software. This made it possible to determine the importance of species using values determined by informants, such as use value.

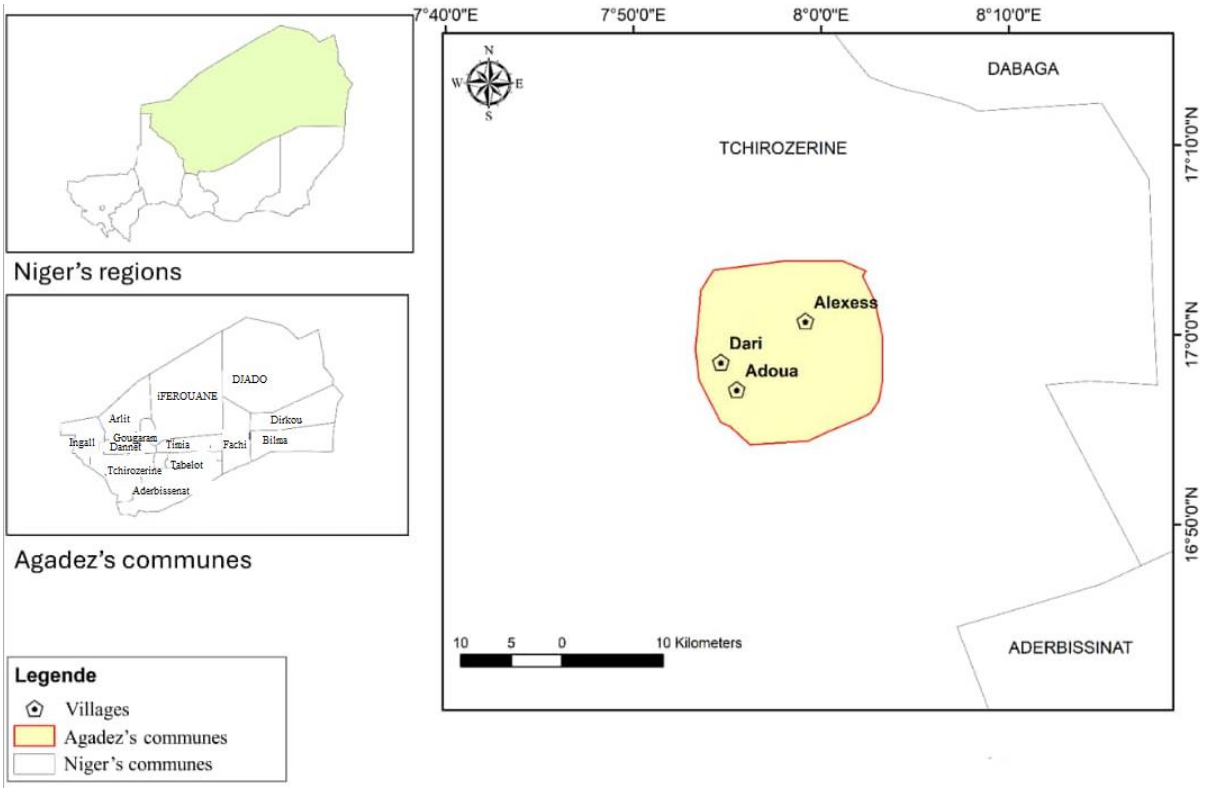

Fig. 1. Study area within Agadez region

Citation frequency: For each category of use, we analyzed the citation frequency (CF).

$$CF = \frac{\textbf{Number of citations of the species}}{\textbf{Total number of respondents}} \times \mathbf{100}$$

Use value:

The use value (UV) is the quotient between the number of citations of a given species in a presumed use category and the total number of informants questioned. The use value shows the species generally exploited in a given category. It also reveals a significant idea of the degree of pressure exerted on the species. The use value is defined by the formula below:

UV = (∑U) / (N)

U: frequency of citations mentioning the use of the species for a given purpose;
N: total number of pieces of information received.

The total use value of the species:

This consists of identifying the species that have the greatest value in a given environment based on the cumulative use values in all areas where they are used. The total use value of each species is determined by measuring the sum of all the use values of the assumed species within the different areas of use. The total use value of a species is calculated using the following equation:

TUV = ∑p1 UV

TUV: corresponds to the total use value of the assumed species k;
UV: indicates the use value of species k for a given category of use;
P: corresponds to the frequency of areas of use or categories of use covered by the species.

Frequency of citation of organs used:

For each species considered, this frequency shows the organs or parts of the plant most commonly used in a given category of use. This frequency of citation of organs used by type of area of use varies from 0 to 100. The number 0 shows that the organ is not used, and the number 100 indicates that the organ is used by all respondents. The frequency of citation of parts used by the plant (organs) and by the type of category of use is given by the following equation:

F = S / (N) X 100

F: is the calculated response frequency; S: is the frequency of citations of use of the part in question; N: is the total number of informants.

The overall rate of use of an organ or part of a species in a given category is determined by first finding the cumulative frequency of use of that same part or organ of the species for all species exploited for the same selected domain. This cumulative rate is then divided by the total cumulative frequency of all parts used in the assumed domain.

FT = CF / (TCF) X 100

FT: the general value of use of the part (organ) in a given category of use;
CF: the cumulative frequency of use of the organ in question for all species exploited in the same category;
TCF: the sum of the cumulative rates of all parts or organs of the species exploited in the area in question.

3. RESULTS

Perception of vegetation: The figure illustrates the views of respondents on the state of vegetation cover in the past and present in this municipality. Of the 90 people surveyed, 98% confirmed that the vegetation in the municipality of Agadez has declined compared to previous years (Fig. 2).

Extinct species: Extinct species in the municipality of Agadez are listed below. These species are classified according to their frequency (Table 1) from highest to lowest frequency. The species: *Guiera senegalensis* J. F. Gmel., *Leptadenia pyrotechnica* (Forsk.) Decne., *Piliostigma reticulatum* (DC.) Hochst., *Acacia senegal* (L.) Willd., *Faidherbia albida* (Del.) A. Chev., *Acacia chrembergiana* Hayne., *Euphorbia balsamifera* Ait., *Commiphora africana* (A. Rich.) Engl. are extinct species with high frequencies. A total of 18 species have been recorded as extinct.

Activities impacting vegetation: The majority of respondents believe that plant biodiversity in the municipality is deteriorating and is currently undergoing a sharp decline. This degradation of

species is largely the result of multiple and complex factors, including human activities and natural factors. Plants have many uses, including human and animal food, human and animal health, wood for energy, and construction. Excessive tree cutting (for firewood, service wood, and timber) is the activity that has the greatest impact on vegetation (Fig. 3).

Species that have appeared: According to the municipality's population, no species have appeared or been introduced in the 10 years since *Prosopis juliflora* was introduced to counteract desertification. This species is used because it is resistant to the most extreme ecological conditions and has a rapid regeneration capacity.

Ecosystem services:

Species used in human food: Fig. 4 below shows the plant species used in human food. It consists of many plant species, and the commonly consumed are Phoenix dactylifera L., Moringa oleifera Lam., Leptadenia hastata (Pers.) Decne., Hyphaene thebaica (L.) Mart., Zizyphus mauritiana Lam., Zizyphus spina-christi (L.) Desf., and Maerua crassifolia Forsk.

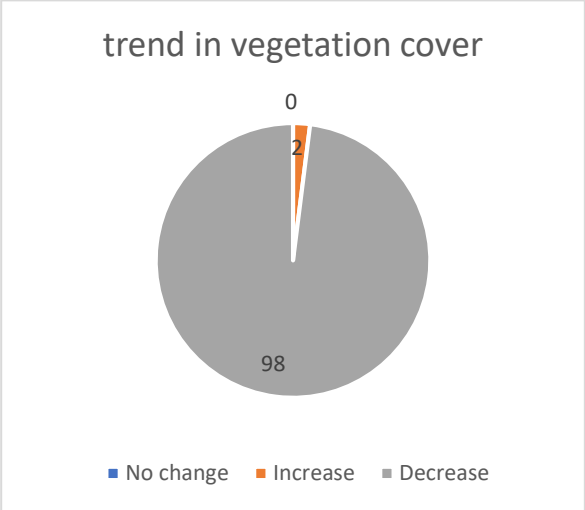

Fig. 2. Perception of respondents on the vegetation cover change

Table 1. Extinct species recorded

Extinct species	Frequency of citation
Guiera senegalensis J. F. Gmel	10.78
Leptadenia pyrotechnica (Forsk.) Decne.	8.77
Piliostigma reticulatum (DC.) Hochst.	8.77
Acacia senegal (L.) Willd.	8.27
Faidherbia albida (Del.) A. Chev.	8.27
Acacia chrembergiana Hayne.	7.77
Euphorbia balsamifera Ait.	6.27
Commiphora africana (A. Rich.) Engl.	6.02
Balanites aegyptiaca (L.) Del.	4.51
Bauhinia rufescens Lam.	4.26
Annona senegalensis Pers.	4.01
Tamarindus indica L.	3.76
Zizyphus mauritiana Lam.	3.76
Combretum glutinosum Perr.	3.51
Acacia nilotica (L.) Willd. ex Delile	3.01
Sclerocarya birrea (A. Rich.) Hochst.	3.01
Zizyphus spina-christi (L.) Desf.	2.76
Adansonia digitata L.	2.51
Total: 18 species	100

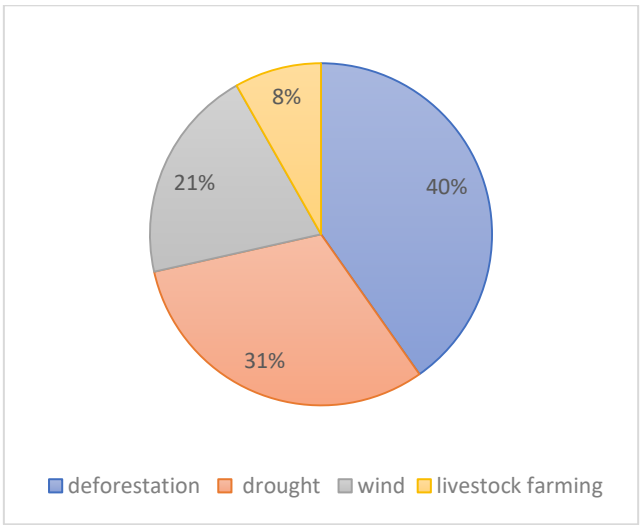

Fig. 3. Activities impacting vegetation

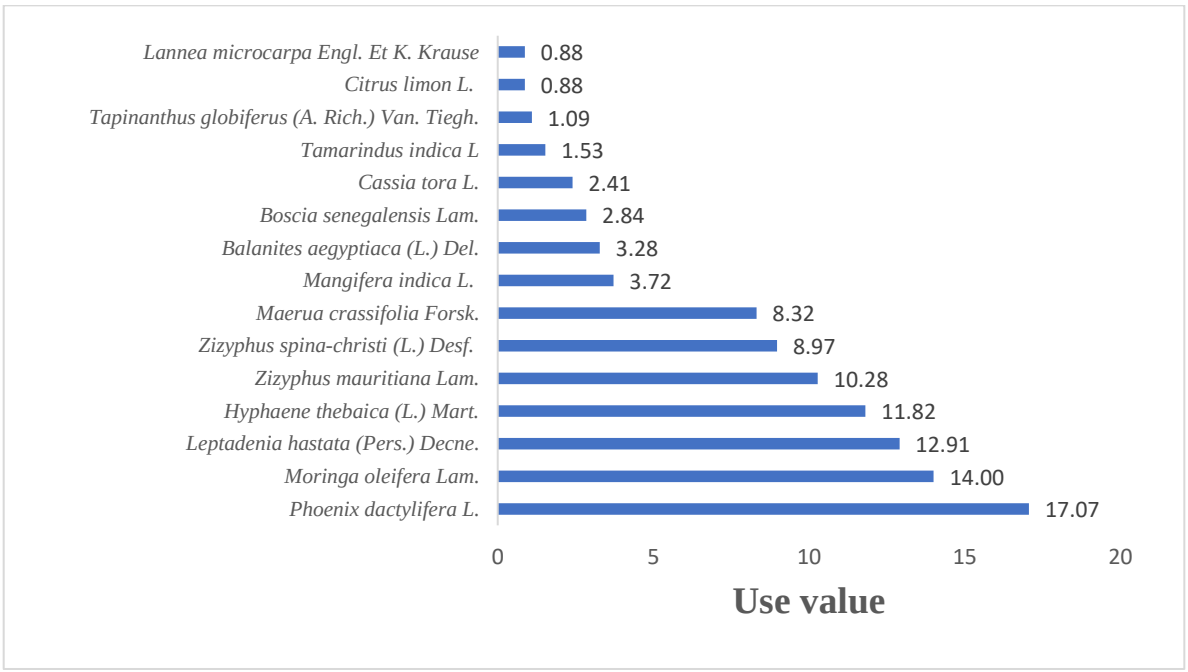

Fig. 4. Species consumed in human food

Species used in animal feed: According to the population, the plant species most appetizing to animals are the following: Acacia tortilis (Subsp.) Savi., Boscia senegalensis Lam., *Boerhavia repens* L., *Prosopis juliflora* (Sw.) DC., Maerua crassifolia Forsk., Panicum turgidum Forsk., Tribulus terrestris L., Faidherbia albida (Del.) A. Chev., with their respective frequencies of 17.57%, 11.94%, 11.04%, 10.81%, 10.59%, 9.91%, 7.21%, and 5.18%. Figure 5 below illustrates the plants most consumed by animals.

Species used in human health: Fig. 6 shows the species used in human health. Only the species with the highest citation frequencies are shown. The most commonly used species are: *Acacia nilotica* (L.) Willd. ex Delile., *Balanites aegyptiaca* (L.) Del., Acacia chrembergiana Hayne., Maerua crassifolia Forsk., Salvadora persica L., Zizyphus mauritiana Lam., Acacia senegal (L.) Willd., with their respective frequencies of 18.18%, 15.34%, 10.23%, 7.95%, 7.95%, 5.56%, and 5.11%.

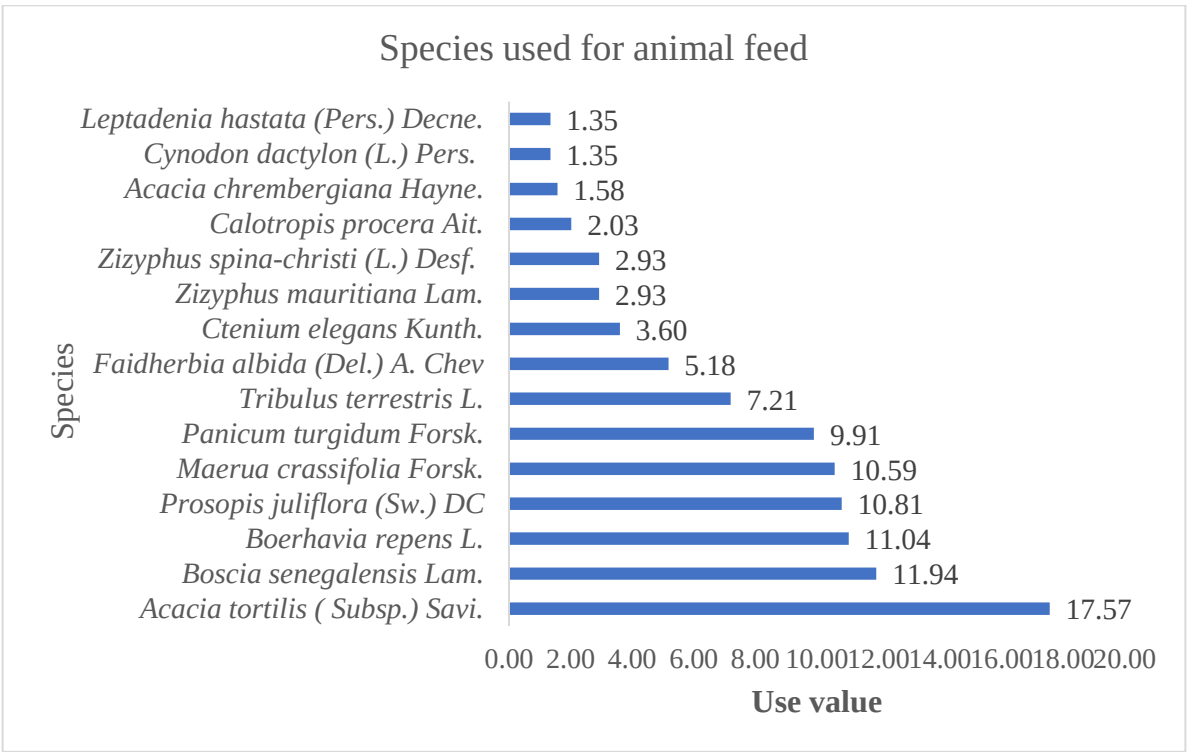

Fig. 5. Species used in animal feed

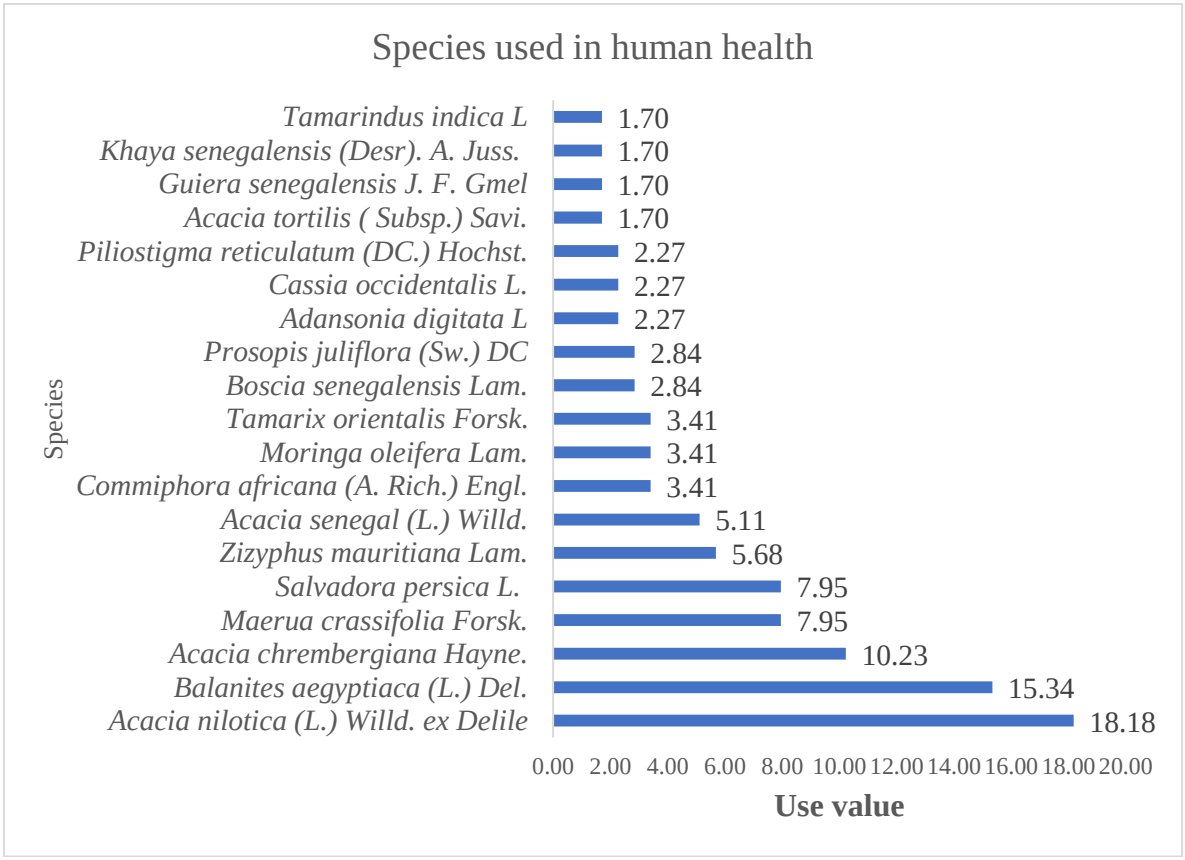

Fig. 6. Species used in human health

The most frequently treated diseases in human health are hemorrhoids, wound healing, stomachache, gastric ulcer, and fever, with respective frequencies of 26.78%, 10.88%, 10.04%, 8.37%, and 7.95% (Fig. 7).

Species used in animal health: The species most commonly used for animal care are: Boscia senegalensis Lam., Hibiscus sabdariffa L., Tamarix orientalis Forsk., Maerua crassifolia Forsk., with respective frequencies of 22.99%, 20.69%, 9.20%, and 8.05% (Fig. 8).

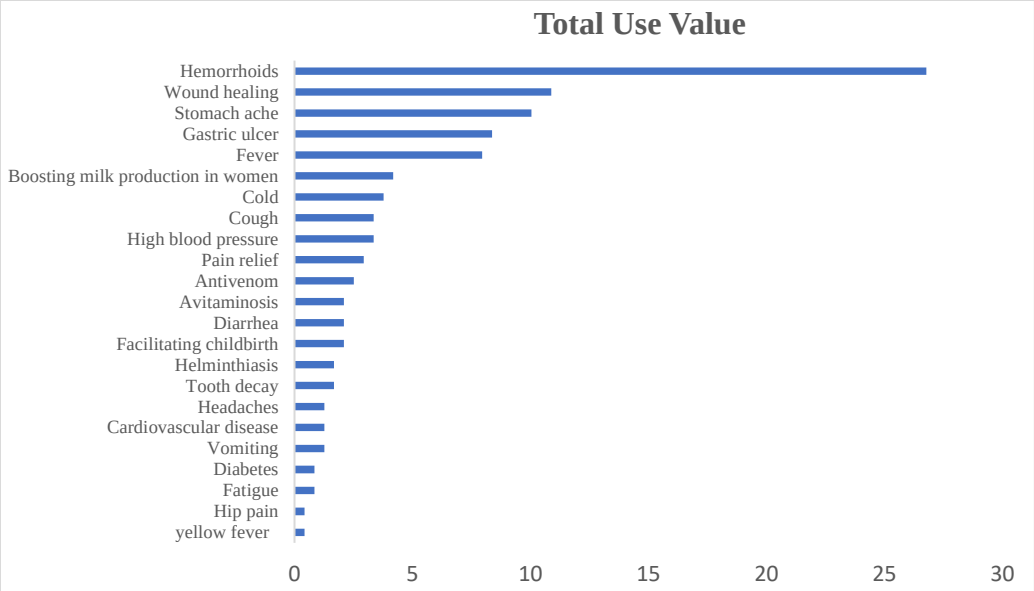

Fig. 7. Diseases treated in human health

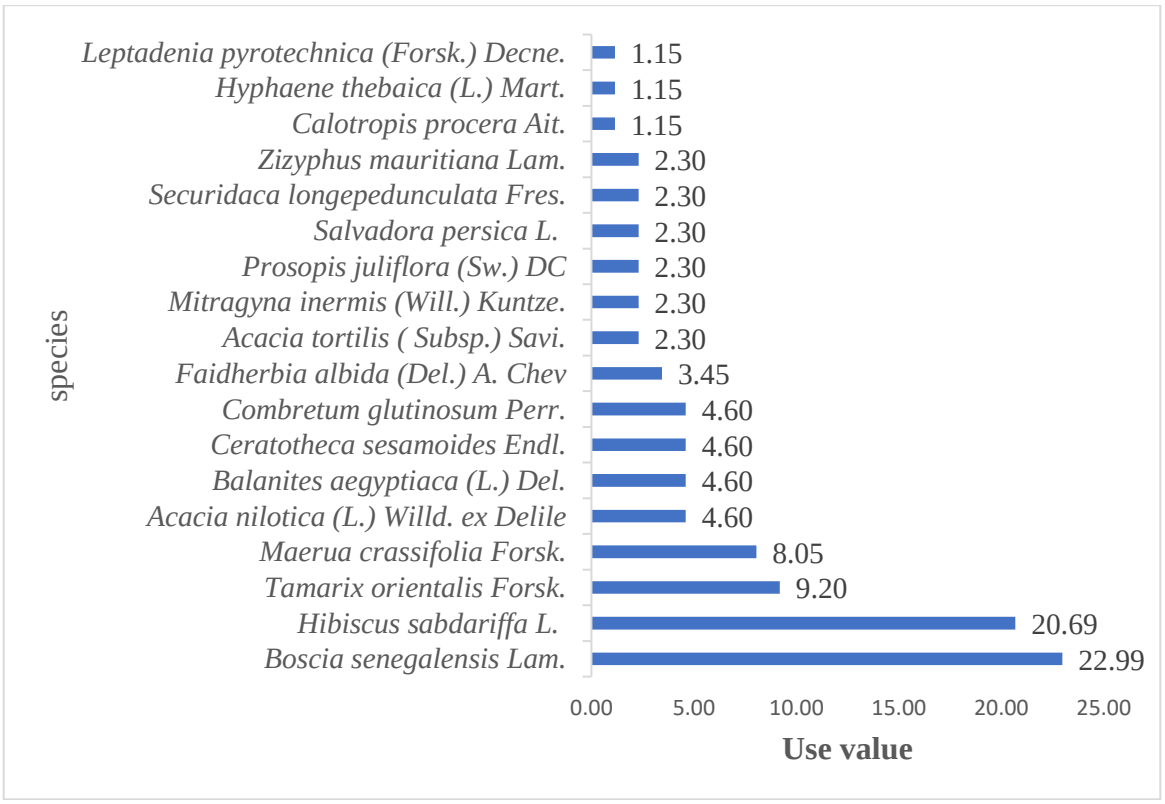

Fig. 8. Species used in animal health

The most commonly treated diseases in animal health are constipation, hypertension, cough, wounds, diarrhea, lice, and appetite, with respective frequencies of 22.73%, 20.45%, 13.64%, 10.23%, 9.09%, 6.82%, and 5.68% (Fig. 9).

Species used in construction: The species most commonly used in construction are: Prosopis juliflora (Sw.) DC., Calotropis procera Ait., Acacia tortilis (Subsp.) Savi., Hyphaene thebaica (L.) Mart., Phoenix dactylifera L., with respective frequencies of 26.71%, 24.53%, 18.01%, 17.39%, and 6.83% (Fig. 10).

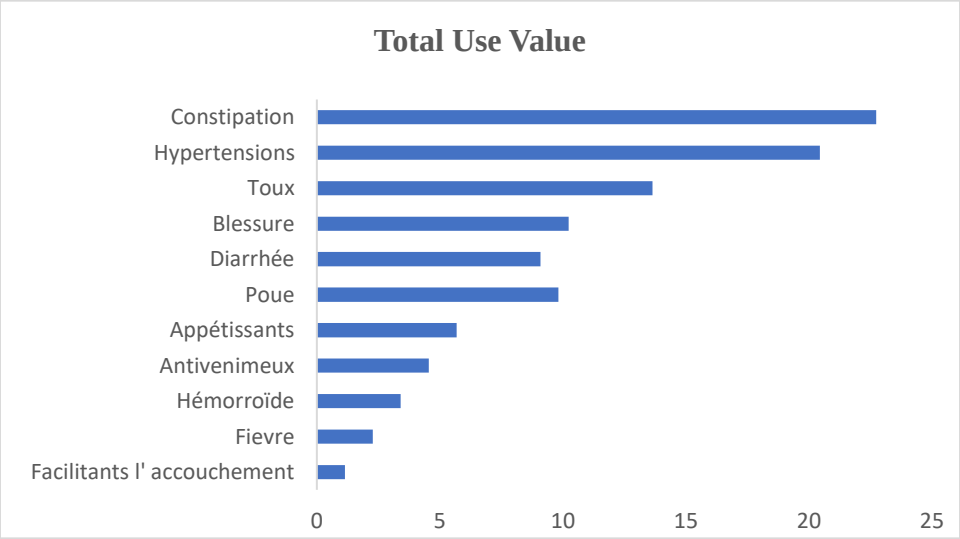

Fig. 9. Total use value in animal health

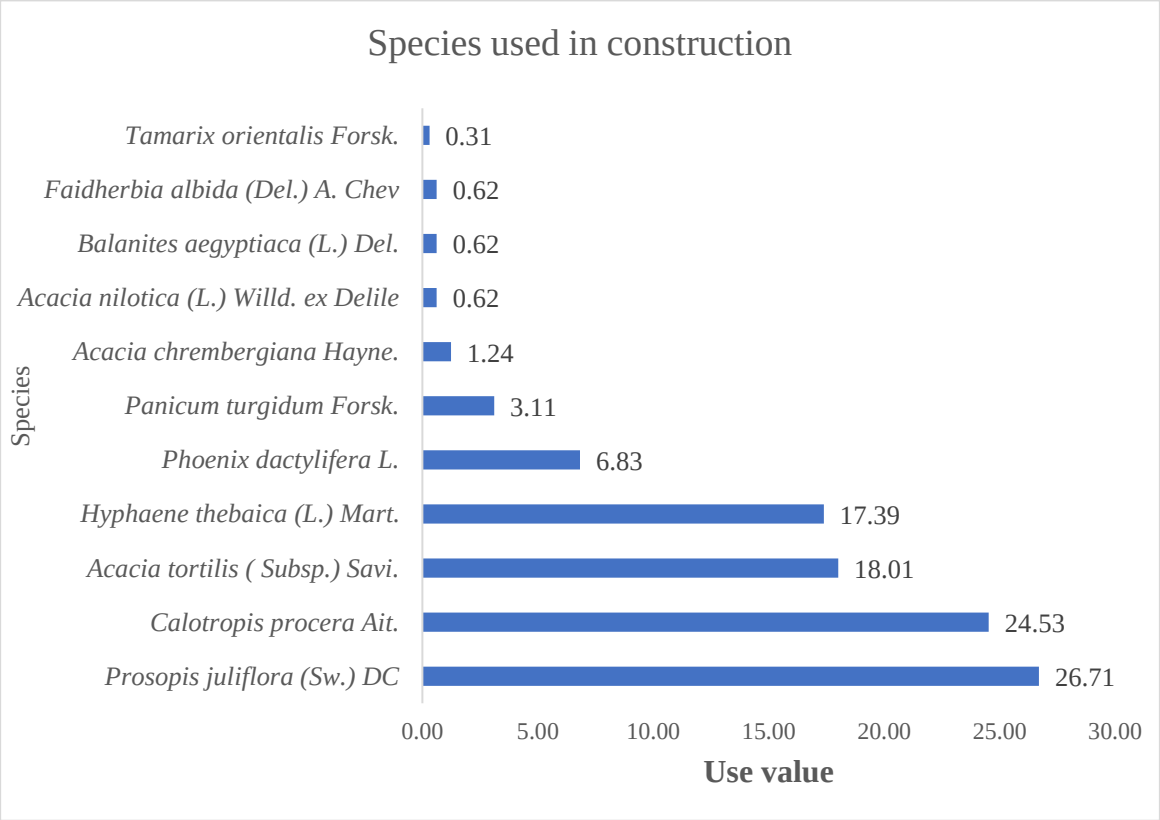

Fig. 10. Species used in construction.

Species used in crafts: The most commonly used species in crafts are: Hyphaene thebaica (L.) Mart., and Panicum turgidum Forsk., with respective frequencies of 57.24% and 40.69% Fig. 11.

Species used in rituals: The species used in rituals are: Acacia nilotica (L.) Willd. ex Delile., Commiphora africana (A. Rich.) Engl., Zizyphus mauritiana Lam., with respective frequencies of 50%, 25% and 25% Fig. 12.

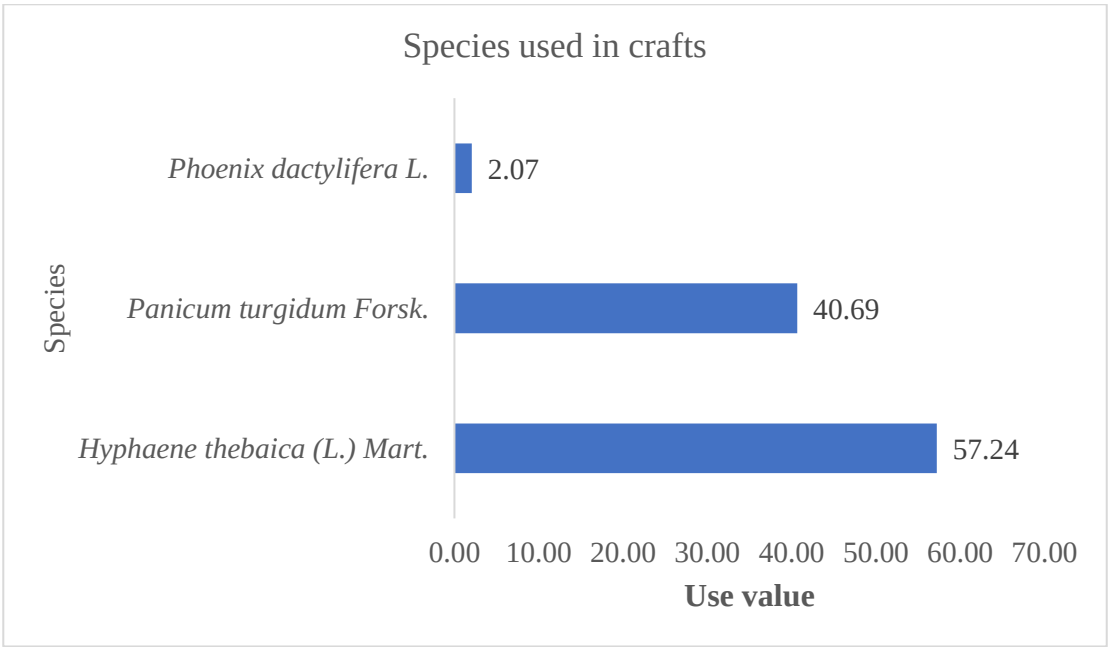

Fig. 11. Species used in crafts

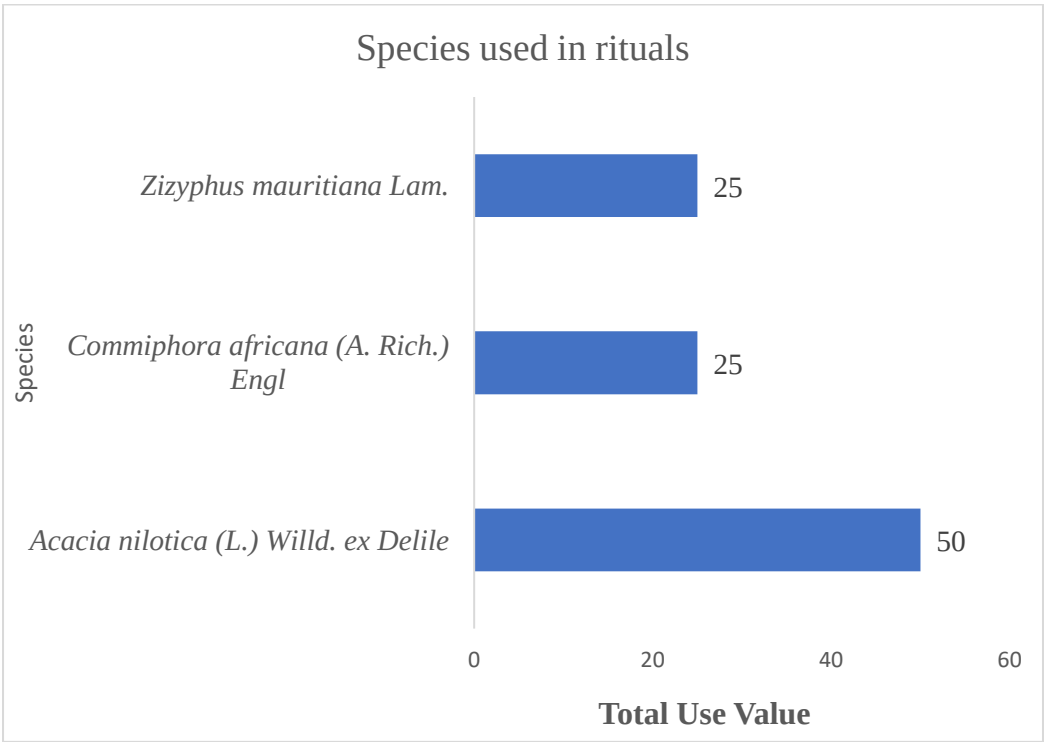

Fig. 12. Species used in rituals

Plant resource management:

Local practices for conserving plant species: Assisted natural regeneration (RNA) is the most common practice in the municipality for conserving vegetation. Tree planting is also a practice carried out by many people to improve vegetation (51.14%), while pruning and monitoring are the least common practices among the population (Fig. 13).

Learned practices for conserving plant species: RNA is the practice learned by the municipality's population with a frequency of 49.40%. Dune fixation, half-moons, and benches are also the least known learned practices by the population, with frequencies of 26.51%, 15.66%, and 8.43%, respectively (Fig. 14).

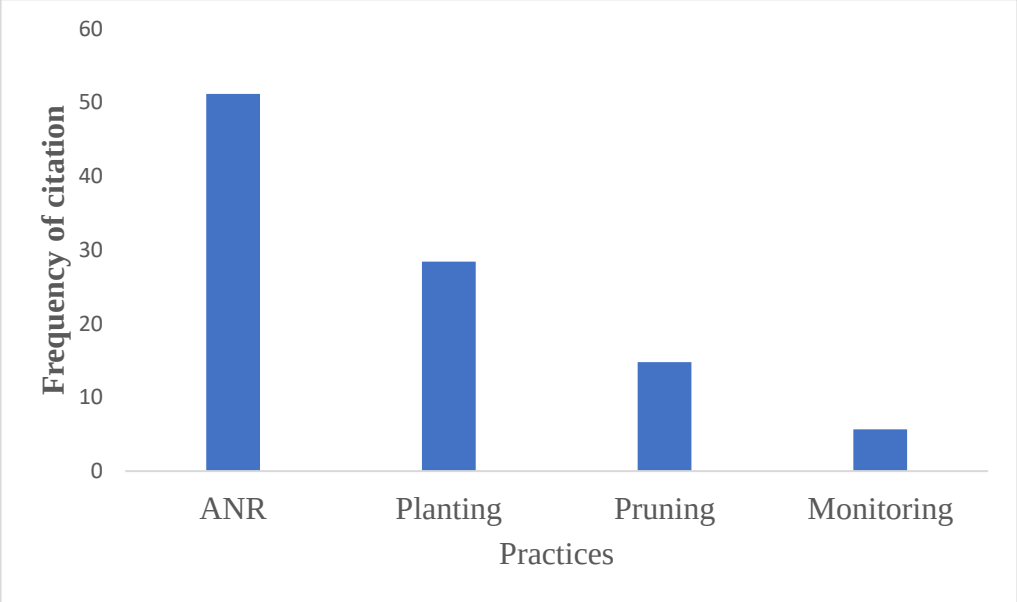

Fig. 13. Local practices for the conservation of plant species

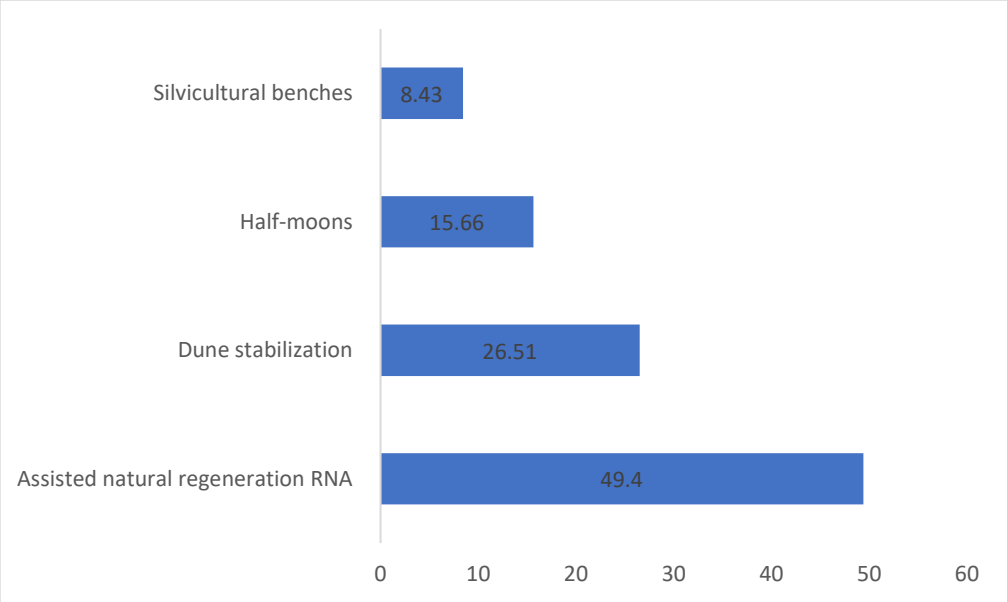

Fig. 14. Practices learned to conserve plant species

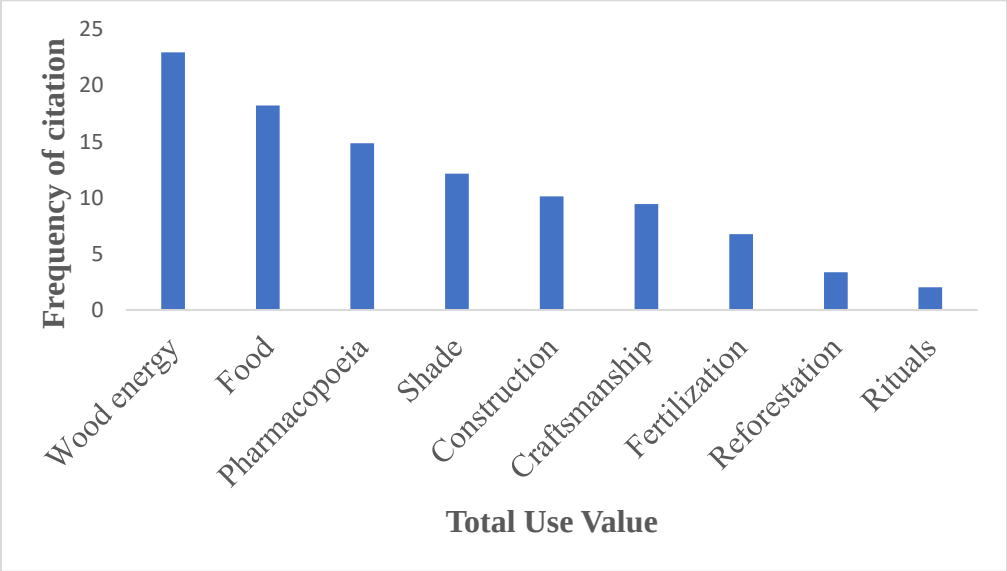

Fig. 15. Reasons for conserving plant species

Reasons for conserving plant species: The reasons for conserving plant species are as follows: wood energy, food, medicine, shade, construction, crafts, rituals, and to combat desertification. This is evidenced by the fact that Prosopis juliflora (Sw.) DC is the most widely planted species in the municipality for construction, animal feed, shade, fencing, timber, and fuel wood. The presence of certain trees in fields (gardens) also contributes to better agricultural productivity (Fig. 15).

4. DISCUSSION

The ethnobotanical study reveals that almost half of the species recorded in the study area have become extinct or are in the stages of becoming extinct (31 species), including 18 extinct species and 13 species threatened with extinction. Similar results were reported by Danjimo et al. (2003) in their study conducted around the village of Gouré and in Dallol Bosso, where 30 plant species out of the 250 species assessed had disappeared, and 27.2% (68 species) were threatened with extinction. This percentage of extinction is significantly higher than the regional threat level in West Africa, where it is 1.5% (Juffe-Bignoli et al., 2012). The cutting of wood from certain plant species, such as those of socio-economic importance, is one of the factors disrupting the plant community, especially in the Sahelian and Sudanian zones of West Africa (Habou, 2016). It should be noted that the Sahelian zone has experienced similar droughts in recent decades (1913, 1914, 1972, 1983, 1984) (Borton et al., 1994). This rainfall deficit has led to deficiencies in the soil water balance. This has resulted in poor water absorption by vegetation. In the urban commune of Agadez, excessive logging and scarce rainfall have led to the extinction of certain plant species, fragmented certain ecological habitats, weakened the resistance of species, and promoted the growth of certain plant species. Indeed, since the 1990s, the decline or even disappearance of certain forest species has been reported (Saadou, 1990). This loss of plant biodiversity was much closely linked to rainfall, because for several decades, countries in the Sahel region have been facing a rainfall deficit (Sene, 2000). The destruction of land in the Sahel is mainly linked to poor management, overexploitation, and failure to restore soil constituents (Savadogo et al., 2015). The consequence has been a lack of regeneration of certain species (Delwaulle, 1973), as well as poor resource management. This effect is felt by the entire population surveyed who have lived through these periods and confirms the regressive trend in vegetation development and their overexploitation of these resources. Throughout history, civilization has been on a constant search for natural resources (Fisher et al., 2009). Food, health, construction, crafts, and rituals are the areas mostly affecting the plant species, and the unsustainable way of exploiting these species is not conducive to maintain the species abundance and thus, causes the plant to become disabled or even die. This is why, today, the history of rapid population growth of which the growth rate in the Agadez region is 3.6% per

year (NIS, 2020), has become an undisputed reality in terms of the use of plant species, with uncontrolled exploitation of these species to meet daily needs, without realizing that this can cause short- or long-term damage to the environment in which they live. In the study area, the data obtained and analyzed clearly show that plant species play a vital role in meeting the needs of local populations. The floral species have significant socio-economic value for the population. It has been proven that the local populations in this area are more interested in the seven categories of services identified, namely human and animal food, human and animal health, construction, crafts, and rituals. These results corroborate with the findings of Cheikh Youssef et al. (2011), according to whom the consensus factor for the different categories of tree use is high on average in the arid and semi-arid zones of Africa. In addition, it should be noted that the frequency of use of species depends on these categories of identified services and the type of plant preferred by the population, as well as the parts of the plant that are used.

5. CONCLUSION

This study is part of a broader study of the vegetation and management of plant resources in the landscape ecosystem of the urban commune of Agadez, to provide information on the current state of flora, ecosystem services, and the threats to the biodiversity. It has contributed to a better understanding of the floristic composition. This study has also provided insight into the different categories of plant species used by the population, as well as the different ways in which these resources are managed by the population.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Abdourhamane, H. (2016). *Floristic, ecological, phytosociological and ethnobotanical study of the classified forests of Dan Kada Dodo and Dan Gado in Niger* (Doctoral thesis). Dan Dicko Dankoulodo University of Maradi.

Albergel, J. (1988). *Genesis and predetermination of floods in Burkina Faso: From square meter to square kilometer: Study of hydrological parameters and their evolution* (Doctoral thesis, University of Paris 6).

Alhassane, A., Chaïbou, I., Karim, K., Soumana, I., Mahamane, A., & Saadou, M. (2018). Flora and structure of woody stands in natural pastures in the Maradi Region, Niger. *Afrique Science, 14*(5), 171–189.

Barton N. (1994). A Q-system case record of cavern design in faulted rock. Tunnelling in Difficult Conditions. Torino.

Cheikhyoussef, A., Mapaure, I., & Shapi, M. (2011). The use of some indigenous plants for medicinal and other purposes by local communities in Namibia with emphasis on the Oshikoto region: A review. *Research Journal of Medicinal Plant, 5*(4), 406–419.

Danjimo, B., Ahmed, I., & Tougiani, A. (2003). Inventories of endemic plant species that have extinct or are endangered. In M. Gandah & B. Danjimo (Eds.), *Semiannual report, July to December*, DMP/INRAN, Niamey (pp. 27–34).

Delwaulle, J. C. (1973). Results of six years of observations on erosion in Niger. *Revue Bois et Forêts des Tropiques, (150)*, 47–58. https://doi.org/10.19182/bft1973.150.a19182

Fisher, B., Turner, R. K., & Morling, P. (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics, 68*, 643–653.

Habou, R. (2016). *Characterization of natural stands of Pterocarpus erinaceus Poir. and development of sustainable management standards in Niger and Burkina Faso (West Africa)* [Doctoral thesis].

Ichaou, A., d'Herbès, J. M., Ambouta, J. M. K., & Peltier, R. (1997). Comparative productivity of structured forests in the Nigerien Sahel: Implications for forest management. *John Libbey Eurotext*, 119–130.

Inoussa, T. M., Morou, I. T., Gbègbo, M. C., & Sinsin, B. (2013). Structure and floristic composition of dense dry forests in the Kouffé Mountains region of Benin. *Journal of Applied Biosciences, 64*, 4787–4796.

Juffe-Bignoli D., Darwall, W.R.T. (2012) Assessment of the socio-economic value

of freshwater species for the northern African region. Malaga, ES, and Gland, CH: IUCN. iv, 84p. : ill., maps https://portals.iucn.org/library/node/10192

Larwanou, M., Oumarou, I., Snook, L., Danguimbo, I., & Eyog-Matig, O. (2010). Silvicultural and cultural practices in agroforestry parklands following a north–south rainfall gradient in the Maradi region of Niger. *Tropicultura, 28*(2), 115–122.

Ludwig, M. D., & Gilmore, G. (2005). The pragmatic gravity of the semantic compositionality of news headlines: Violating Grice's principle as a linguistic model to calibrate the communicative weight of that gravity. In *Modern news editing*. Wiley-Blackwell.

Melom S. , MbYNGONE E., Bechir A. B., Ratnan N. et MAPONGMETSEM P. M. (2015). Floristic and Ecological Characteristics of Plant Commumties of Massenya in Chad (Central Africa. Journal of Animal &Plant Sciences..25(1): 37 99-3813

Moussa IB, Descroix L, Maiga OF, Gautier E, Adamou MM, Esteves M, Yéro KS, Abdou MM, Mamadou I, Breton EL, Abba B. 2011. Changes in land use and their hydrogeomorphological consequences on a Sahelian endorheic watershed. *Sécheresse*, 22: 13-24.

Pascal M. (2010). Long-term anthropogenic and ecological dynamics of a Mediterranean landscape: Impacts on multiple taxa. Landscape and Urban Planning sell Engineering, Urban Landscape, Land Use Change, Environmental Sciences, Biological Diversity. https://doi.org/10.1016/J.LANDURBPLAN.2010.03.007

Publication, http://www.m.elewa.org/JAPS. ISSN 2071-7024

National Institute of Statistics. (2020). *Analysis reports on the results of the 4th Niger 2012 national population and housing census: Socio-demographic characteristics of households, status, and structure of Niger.* https://www.stat-niger.org

Ramade, F. (2008). *Encyclopedic dictionary of natural sciences and biodiversity.* Dunod.

Saadou, M. (1990). *The vegetation of drained environments in Niger east of the Niger River* (Doctoral thesis). University of Niamey.

Savadogo O. M, K. Ouattara, J. Barron, I. Ouedraogo, L. Gordon , E. Enfors and N. P. Zombre. (2015). status des écosystèmes sahéliens : reverdissement, perte de la diversité et qualité des sols. Afrique SCIENCE 11(5) 433 - 446.

Sene, E. (2000). Trees, food production and the fight against desertification. *Unasylva, 51*(200), 150.

Sinsin, B., & Kampmann, D. (Eds.). (2010). *Biodiversity Atlas of West Africa: Volume 1 (Benin).* Cotonou & Frankfurt/Main. ISBN 978-3-9813933-0-9.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/147403