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Contribution of edible indigenous woody plants as a coping strategy during drought periods in the southeast lowveld of Zimbabwe: a review

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Climatic change related extreme events such as droughts negatively affect local communities in the semi-arid savanna ecosystems. This study mainly records and analyses local knowledge on the use of edible indigenous woody plant species by local communities during drought periods, as a coping strategy, in southeast lowveld of Zimbabwe. Secondary data on utilization of edible indigenous woody plants were gathered from literature sources focusing mainly on the southeast lowveld parts of Zimbabwe and covering the period 2000–2019. Quantitative ethnobotanical data analysis involved computing the frequency of citation (FC), relative frequency of citation (RFC) and family importance value (FIV) to determine the local significance of indigenous woody plant species. A total of 23 species from 12 families were recorded as being used during drought periods with key species including baobab (*Adansonia digitata*), bird plum (*Tamarindus indica*), corky-monkey orange (*Strychnos cocculoides*) and black monkey orange (*Strychnos madagascariensis*). Major use categories were food, medicine, and livestock feed. The study findings points to the need for embracing indigenous woody plants as a buffer against drought in semi-arid parts of the savanna. Future projects should focus on developing innovative strategies such as value addition and promoting sustainable use and restoration of non-wood forest products as part of livelihood diversification under drought situations.

KEYWORDS

climate change, drought, edible indigenous woody plants, local knowledge, resilience, woody species

1 Introduction

The role of edible indigenous woody plants is increasingly being recognized, especially as part of a cocktail of climate change related coping strategies, particularly in developing nations where some communities remain heavily dependent on natural resources (Sintayehu, 2018; Qin et al., 2020). Some of the effects of climate change include increased frequency and severity of droughts and floods (Brazier, 2015; Markus et al., 2019). The effects of droughts have been considered to be among the greatest challenging climate change related hazard in African countries due to the relatively low mechanization level (FAO, 2016; Ngcamu and Chari, 2020). Drought mainly results in household level food insecurity among subsistence agriculture dependent communities (Mwerera et al., 2010; Mbolanyi et al., 2017; Whitney et al., 2018). African indigenous communities are increasingly becoming conscious of the alterations in their living conditions due to climate change (Mugambiwa and Tirivangasi, 2017; Chikosi et al., 2019). These changes include vulnerability to poverty, hunger, malnutrition, declining biodiversity and elevated disease risks (Wheeler and Von Braun, 2013; Mugambiwa, 2018). However, despite being aware of climate change related hazards, local communities remain the most affected and vulnerable to droughts and its related challenges due to factors such as lack of effective adaptation and community resilient strategies (Nangoma, 2007).

Drought has no universal definition as it has diverse meanings based on different specialized fields including meteorological, agricultural, hydrological and socio-economic disciplines (Mishra and Singh, 2011; Jiménez-Donaire et al., 2020). In this review, focus is on meteorological droughts, which refers to months or years with precipitation that is below average (Maliva and Missimer, 2012); agricultural drought which refers to times when crop losses are caused by dry soils (Orimoloye et al., 2022); hydrological drought referring to times when water bodies have low levels and little flow (Van Loon, 2015; Eslamian et al., 2017) and socio-economic drought where reduced precipitation and associated physically accessible water have an impact on human activities (Nairizi, 2017). These forms of drought have been observed to closely impact on human activities and livelihoods (Marengo et al., 2017; Jiménez-Donaire et al., 2020).

According to Masih et al. (2014) in recollection, several intense and persistent droughts have been documented,these include the ones experienced in northwest Africa in 1999–2002 and in western Africa (Sahel) in the 1970s and 1980s and the 1991/1992 severe drought experienced in Southern Africa. Most of Southern Africa was devastated by the 1991–1992 drought, resulting in water shortages and the mortality of tree species and wild animals (Eldridge, 2002). The 1991/1992 drought impacted on agricultural production leading to crop losses and over a million cattle (*Bos taurus*) were lost in Zimbabwe (Magadza, 1994). Also, the drought in southeast Africa 2001–2003 and the 2010–2011 drought in eastern Africa (Horn of Africa) caused significant harvest failure, declining pasture conditions, a reduction in the amount of water available, and livestock losses (UNOCHA UNOHA, 2011). Even now many countries in Africa are experiencing frequent droughts (Spinoni et al., 2019). This predominance of drought affects rural livelihoods mostly dependent on rain fed agriculture and force people to resort to edible wild indigenous plant resources that are locally available and easily accessible as food supplements (Chagumaira et al., 2016).

The use of edible wild indigenous plant resources such as fruits in the semi-arid parts of Africa is an essential aspect of many rural communities especially in times of crises (Addis et al., 2005; Akinnifesi et al., 2006; Nyanga et al., 2013; FAO, 2016). This includes African countries such as Zimbabwe whose part of landscapes is constituted by semi-arid areas. Edible indigenous wild plants are available during times of drought and famine as they are not easily affected by environmental shocks, as such they contribute to some form of coping during harsh conditions (Mudzengi et al., 2017). Although the consumption of edible wild plants has a long tradition, today it forms part of the survival strategies adopted by people during harsh periods (Neudeck et al., 2012). For instance, the global comparison study conducted by the Center for International Forestry Research (CIFOR) characterized non-timber forest products (NTFPs) in Africa primarily as a component of a coping mechanism (Shiva and Verma, 2002; Sunderland et al., 2004) especially in drought prone areas like the Zimbabwe's southeast lowveld.

Consistent with the coping strategies, local ecological knowledge (LEK) on utilization of edible indigenous woody plants is regarded as a fountain of knowledge during hardships (Quave and Pieroni, 2015) and is a credible source of information (Charnley et al., 2007; Hernández-Morcillo et al., 2013). This acknowledgment is also revealed in international conventions, such as Article 8(j) of the Convention on Biological Diversity (CBD), which mandates that the parties to a contract respect, retain, innovate, and use indigenous and local communities' knowledge, practices, and innovations when they relate to biodiversity conservation and sustainable usage (UN., 1992). Therefore, the practices and site-specific ecological knowledge of individuals who work in and depend on natural areas for their livelihoods are vital (Joa et al., 2018; Nalau et al., 2018; Paloniemi et al., 2018).

Based on the highlights by the Intergovernmental Panel on Climate Change (IPCC., 2007) that drought events in arid and semi-arid regions are on the increase, this study focused on the edible indigenous woody plants which are useful for humans and livestock to cope with droughts. To achieve that focus the study assessed the use and availability of edible indigenous woody plant species by local communities during drought periods in southeast lowveld of Zimbabwe as a way of promoting resilience. This study intended to: (i) to profile edible indigenous woody plant species used during drought periods in the South East Lowveld (ii) estimate the ethnobotanical importance of the edible indigenous woody plant species used during drought periods and (iii) establish key families of edible indigenous woody plants used during drought periods in the southeast lowveld of Zimbabwe.

2 Materials and methods

2.1 Study area

The study was conducted in the southeast lowveld of Zimbabwe, an area categorized by below average and unpredictable rainfall, with an average annual rainfall ranging from 250 to 500 mm (Mugandani et al., 2012; Chanza and Musakwa, 2022), and quite poorly dispersed. The average maximum temperature is between 28 and 32°C (Mugandani et al., 2012), however high temperatures of up to up to 39°C can be recorded in summer (Manatsa et al., 2020). The south-east lowveld is mostly rural and its human population in 2022 was approximately 1 485 090 (ZimStat., 2022). It is dominated by the Shangaan/Tsonga and Shona communities (Maringira and Sutherland, 2010). The drought-tolerant woody species that make up the majority of the

10.3389/fclim.2024.1339587

TABLE 1 Species utilized during drought periods in the southeast lowveld of Zimbabwe.

Species	English common names	Local name (Shangaan/Shona)	Family	Plant part	Use	References	IUCN threat status
Adansonia digitata L.	Baobab	Mabuwu/muwu	Malvaceae	1 2 5	hf lf fw cr	Mudzengi et al., 2017	Least concern
Phyllogeiton discolor (Klotzsch) Herzog	Bird plum	Munyii	Rhamnaceae	1 2	hf hm lf	(Mudzengi et al., 2017; Mero Dowo et al., 2018)	Least concern
***Diospyros mespiliformis* Hochst. ex A.DC.**	Jackal berry	Musuma/tithoma	Ebenaceae	1 2	hf hm lf fw cr	(Mudzengi et al., 2017; Ngorima, 2006; Mero Dowo et al., 2018)	Least concern
***Euclea natalensis* A.DC.**	Natal guarri, large-leaved guarri	Mushangura	Ebenaceae	1 4	hf hm fw	Ngarivhume et al., 2015	Least concern
Ficus lutea Vahl	Giant-leaved fig	Mukuyu	Moraceae	1	hf vm	Gandure et al., 2010	Least concern
Ficus sycomorus L.	Sycomore fig	Muonde/mikuwa	Moraceae	1	hf	Mudzengi et al., 2017; Mero Dowo et al., 2018	Least concern
Flueggea virosa (Roxb. ex Willd.) Royle	Snow-berry	Musosoti	Phyllanthaceae	1	hf	Mero Dowo et al., 2018	Least concern
Grewia flavescens Juss	Sandpaper raisin	Mubhubhunu	Malvaceae	1	hf vm	Mero Dowo et al., 2018	Least concern
Hyphaene petersiana Klotzsch ex Mart.	Illala palm	Murara	Arecaceae	1 3	hf cr	(Mukamuri et al., 2013; Mero Dowo et al., 2018; Ngorima, 2006)	Least concern
Lannea edulis (Sond.) Engl.	Wild grape	Mutsambatsi	Anacardiaceae	1	hf	Mero Dowo et al., 2018	Least concern
Lannea schweinfurthii var. *stuhlmannii* (Engl.) Kokwaro	False marula	Musvimwa	Anacardiaceae	1	hf hm	Mero Dowo et al., 2018	Least concern
Mimusops zeyheri var. ***laurifolia*** Engl.	Red milkwood	Hlatsva/chechete	Sapotaceae	1	hf	(Mudzengi et al., 2017; Mero Dowo et al., 2018)	Least concern
Parinari curatellifolia Planch. ex Benth.	Hissing tree, Mobola plum	Mushumwi	Chrysobalanaceae	1	hf hm	(Mukamuri et al., 2013; Masocha et al., 2017; Gandure et al., 2010)	Least concern

(Continued)

TABLE 1 (Continued)

Species	English common names	Local name (Shangaan/Shona)	Family	Plant part	Use	References	IUCN threat status
Piliostigma thonningii (Schumach.) Milne-Redh.	Monkey bread, Camel's foot tree	Musekesa	Fabaceae	1	hf	Ngorima, 2006	Least concern
Salvadora persica L.	Mustard tree	Dhungulu pokwe	Salvadoraceae	1	hf lf	(Mudzengi et al., 2017; Mero Dowo et al., 2018)	Least concern
Sclerocarya birrea (A.Rich.) Hochst.	Marula	Mupfura/mufura/ukanyi	Anacardiaceae	1 2 3 4 5	hf hm lf inc cr	Braedt and Campbell, 2001; Shackleton et al., 2002b; Ngorima, 2006; Gandure et al., 2010; Maroyi, 2013; Kugedera, 2016; Masocha et al., 2017; Mudzengi et al., 2017; Mero Dowo et al., 2018	Least concern
Strychnos madagascariensis Poir	Black monkey orange	Mukwakwa	Loganiaceae	1	hf lf	Gandure et al., 2010	Least concern
Strychnos madagascariensis Spreng. ex Baker	Spiny monkey orange	Mutamba	Loganiaceae	1	hf lf fw	Macheka et al., 2022	Least concern
Thespesia garckeana F.Hoffm.	Snot apple	Mutohwe	Malvaceae	1	Inc	Saka et al., 2007; Macheka et al., 2022	Least concern
Uapaca kirkiana Müll.Arg.	Wild loquat	Mushuku	Phyllanthaceae	1	hf	Macheka et al., 2022	Least concern
Xanthocercis zambesiaca (Baker) Dumaz-le-Grand	Nyala berry	Muhlaru/musharo	Fabaceae	1 2	hf hm lf vm fw cr	Mudzengi et al., 2017; Mero Dowo et al., 2018	Least concern
Ximenia americana L.	Small sour-plum	Munhengeni	Olacaceae	1	hf	Mero Dowo et al., 2018	Least concern
Ximenia caffra Sond.	Large sour-plum	Munhengeni	Olacaceae	1	hf	Mero Dowo et al., 2018	Least concern

hf, human food; hm, human medicine; lf, livestock feed; vm, veterinary medicine; inc, income; cr, crafting; fw, firewood.

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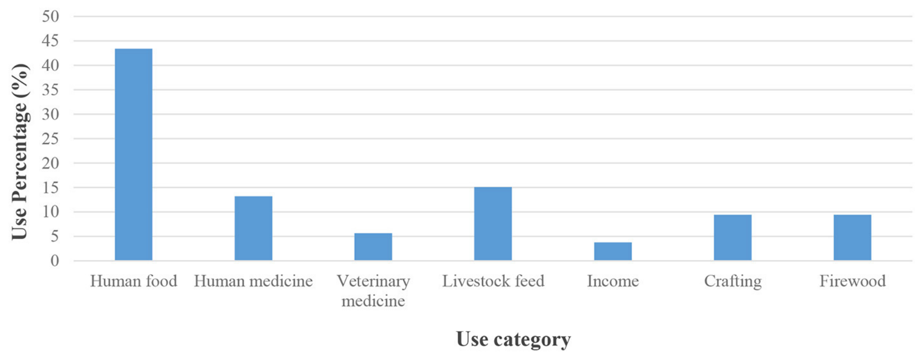

FIGURE 1
Percentage of woody species used in each use category.

vegetation are Acacia tree species, Commiphora spp., White syringa (*Kirkia acuminate*), baobab (*Adansonia digitata*), and mopane (*Colophospermum mopane*) (Zhou, 2004; Chapungu et al., 2014). Part of the vegetation type consist of miombo woodland dominated by zebra wood (*Brachystegia spiciformis*) and mnondo (*Julbernadia globiflora*) (Chapungu et al., 2014). In addition, the region is home to the hissing tree (*Parinari curatellifolia*), a bush savanna with a continuous or irregular pattern of grass cover. It also consists of silver terminalia (*Terminalia sericea*) and wild syringa (*Burkea africana*), which are primarily found on upland soils and well-drained middle slopes (Zhou, 2004).

2.2 Data collection

This study is based on a desktop review of literature on edible indigenous woody plants and their use during droughts in Zimbabwe. An analysis of journal articles, book chapters, books, academic theses, and reports on Google Scholar, Plosone, Elsevier Science Direct covering issues on how edible indigenous woody plants are used as a source of livelihood during drought was conducted. Literature search was confined to studies within the period 2000 up to 2022 as this coincided with an increasing trend in scientific research in indigenous knowledge and natural resource management (Cruikshank, 2001). The study focused mainly on edible indigenous woody plant species. In searching literature, the primary methods for choosing the articles for review were key word and key phrase searches. The key phrases which guided this review include, "wild food plants" + Zimbabwe, "indigenous woody plants" + Zimbabwe, "indigenous tree and shrub" + Zimbabwe, "medicinal plant" + Zimbabwe, "ethnobotany" + Zimbabwe, "non-timber forest products" + Zimbabwe, "indigenous woody plants + drought, contribution of indigenous plants during drought, indigenous plants as sources of food security during drought periods, wild food plants/wild edible plants, wild fruits and drought adaptation". Journals that contain information related to the key words were then used in drawing conclusions. Thirteen journal papers in all were included in this research on the utilization of woody indigenous food plants in the southeast lowveld of Zimbabwe.

The International Union for the Conservation of Nature (IUCN) red list criteria was used to have an understanding on the conservation status of utilized woody species in this study (Texier et al., 2021; Verspagen and Erkens, 2023). The IUCN Red List tool was accessed on https://www.iucnredlist.org. In this study the IUCN criteria was adopted as it is a suitable basis to define the status of species (Grace, 2023).

2.2.1 Data analysis

Quantitative ethnobotanical indices were used for analyzing data. The techniques employed in these computations were modified from Tardío and Pardo-de-Santayana (2008), Vitalini et al. (2013) and Fakchich and Elachouri (2021). Frequency of Citation (FC) was calculated as the frequency of mentioning for a single botanical species by studies. It is the number of times a plant was reported by different studies. FC was calculated as follows:

$$FC = (\text{Number of times a particular species was mentioned}) / (\text{total number of times that all species were mentioned}) \times 100.$$

By dividing the FC by the total number of citations (N), the RFC was calculated. FIV is determined by applying the method to count the proportion of research that mention a certain family.: FIV= (FC (family)/N). However, this was modified by calculating the number of plants that constitutes each botanical family and dividing it by the total number of plants found in this study (Mpofu et al., 2022).

3 Results

3.1 Plant species utilized during drought periods in the southeast lowveld

Findings from the literatures search identified a total of 23 species (Table 1) which are utilized during drought periods in the southeast lowveld of Zimbabwe (Figure 1).

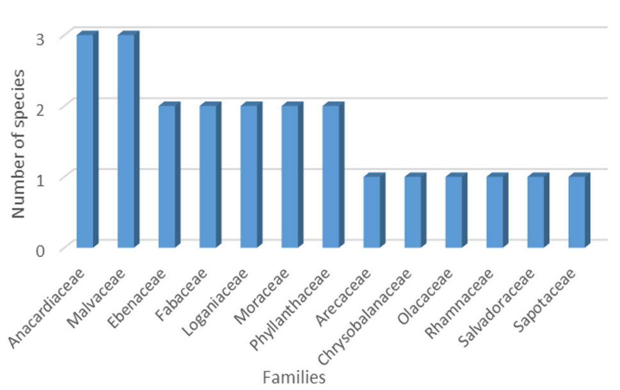

FIGURE 2
Edible indigenous plant families and their respective numbers in the southeast lowveld of Zimbabwe.

3.1.1 Use categories of edible indigenous woody plants

There are seven use categories found in this study; the use category for human food has the greatest number of species, while the use category for handicraft has the fewest. The use categories and the proportion of woody species used in each use category are displayed in Figure 1. It seems that for the local population, human food is the most common use category (43.4%) in the southeast lowveld of Zimbabwe. It is followed by human medicine (13.2%), livestock feed (15.1%), crafting and firewood (9.43 %) respectively, veterinary medicine (5.7%) and income (3.8%).

3.2 Ethnobotanical importance of edible indigenous woody plant species

Utilizing the indices proposed by Tardío and Pardo-de-Santayana (2008), secondary data was used to compute the local significance of edible indigenous woody plant species in the area (Table 2). Frequency of citation (FC) and Relative frequency of citation (RFC) were adopted in this study (Youmsi et al., 2017; Semenya and Maroyi, 2020; Gamage et al., 2021). Plants that were commonly reported as being utilized during drought periods in Zimbabwe's southeast lowveld were identified using the Species Frequency of Citation (FC) method.

The Relative Frequency of Citation (RFC) scales ranges from zero, where no citations are found to support the essentiality of the plant, to one, when all citations do support the importance of the plant.

3.3 Key families of edible indigenous woody plants used during drought periods in the southeast lowveld

3.3.1 Family importance value (FIV)

The local significance of the families of wild species is indicated by the family importance value (FIV). The percentage of informants who mentioned a particular family was used to compute the FIV (Vitalini et al., 2013).

With three (3) species each, the families Loganiaceae, Phyllanthaceae, and Malvaceae had the greatest number of species used. Large families consisting of multiple species are often the ones with the greatest number of species. One species each represented the remaining families (Figure 2).

3.4 Plants used during drought periods and their Family Importance Value (FIV)

The Family Importance Value (Figure 3) was calculated to emphasize the significance of plant families in the present study. With a FIV of 0.13, the families Anacardiaceae and Malvaceae were highest, followed by five other families with a FIV of 0.08. Six families—the Aracaceae, Chrysobalanaceae, Olacaceae, Rhamnaceae, Salvadoraceae, and Sapotaceae families—had the lowest FIV, which was 0.04. Whereas a low FIV value indicated that the families had species with few citations, a high FIV value indicated that the families contained plants that were frequently mentioned in ethnobotanical studies as useful during dry spells.

4 Discussion

The results of the study indicated that indigenous communities in the southeast lowveld used a range of woody plant species during periods where there was a drought. This observation demonstrates the broad knowledge of the locals regarding multiple uses of plants, similar observations were indicated by Luitel et al. (2014). The plants were used as food, timber and also as veterinary medicine, this has been reported from other previous studies (Rajbhandari et al., 2001; Baral and Kurmi, 2006). It is a clear indication that local communities derive different goods from the indigenous woody plants which they use to fulfill different requirements (Luitel et al., 2014).

The study's conclusions showed that local communities employ local ecological knowledge on indigenous woody plant food sources as a way of coping with droughts. The study revealed that similar to other provinces in Zimbabwe, local communities in the southeast lowveld still consume a wide range of edible indigenous fruits during drought periods. Some species revealed to be consumed as drought coping strategies in this study such as *Sclerocarya birrea, Adansonia digitata* are also similar to findings from other studies in Zimbabwe. It has been noted in Zimbabwe's Middle Zambezi Biosphere reserve (Kupika et al., 2019) that *Piliostigma thornningii*, *Diospyros mespiliformis* and *Parinari curatellifolia* fruits were being consumed during periods of food shortages and drought.

Due to its direct correlation with the number of informants noting the use of the plant species, the Relative Frequency of Citation (RFC) value indicates which plants were reported by the greatest number of informants. According to Sansanelli et al. (2017), species with an RFC value near 1 are considered to be of greater community importance. These species should also be given priority for conservation because overharvesting may jeopardize their populations for chosen applications. Because marula trees are considered multipurpose trees and are crucial to smallholder

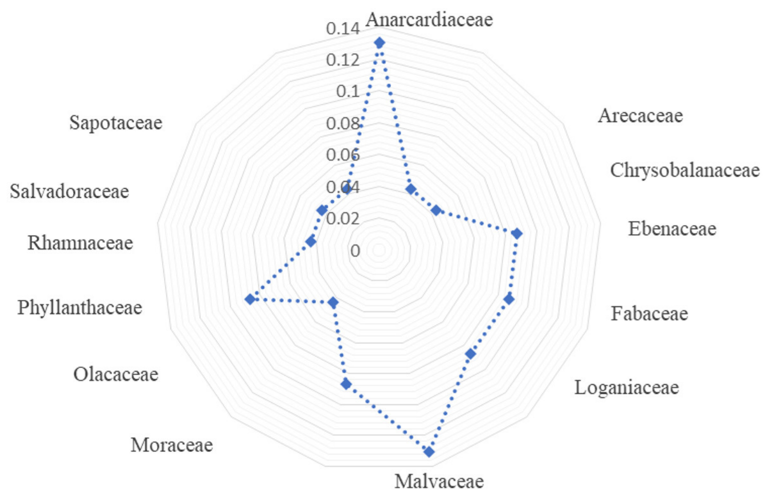

FIGURE 3
Family importance value of edible indigenous woody plants in the southeast lowveld of Zimbabwe.

farmers in arid and semi-arid regions, they were the most often cited species in our survey (Maroyi, 2009; Kugedera, 2016).

According to research, marula trees significantly improve livelihoods in southern Africa, including Botswana, Namibia, South Africa, and Mozambique (Shackleton et al., 2002a), as well as in central Zimbabwe (Maroyi, 2013). The southeast lowveld's high citation rate for marula consumption may be due to the area under study having a large concentration of fruit trees. They function as an emergency food supply during times of food scarcity since they are well suited to their particular ecosystems and frequently survive during drought circumstances even when staple crops fail (Nkosi et al., 2020). Plant species can be valued differently depending on how easy they are to process, how nutritious they are, and how they taste when consumed (Maroyi, 2011). However, the variety of species, as well as the infrequent availability and preference of plant products, mostly control the frequency and scope of consuming woody plants as food.

However, the findings of this study are not similar to those by Munsaka (2019) in the Tonga community of Zimbabwe Binga. In the study *Bauhinia thonningii* and *Faidherbia albida* were categorized as famine foods with and other species such as *Strychnos* species, *Berchemia discolor* and *Adansonia digitata* are not considered as famine foods. According to Fentahun and Hager (2009), different plants are utilized by different communities and the importance of species depends on local practices.

There is a specific preference for using different plant parts for particular use categories, this preference of different plant parts shows that indigenous knowledge is quite specialized when it comes to utilization of plant parts (Luitel et al., 2014). Fruits were the most frequently utilized plant part in this study, as they represent the most significant edible component. This could also be because they taste great right out of the wild, where they are easily accessible and can be eaten without any preparation (Abera, 2022). Consequently, fruits provide the inhabitants in the research region with key sources of vital vitamins and minerals. This result is consistent with research conducted in Southern Ethiopia (Abera, 2022) that found fruits to be the most often used plant parts overall. According to Luitel et al. (2014), the reason why fruits and seeds are used the most is their accessibility. Based on empirical evidence, leaves of native plants can serve as viable food sources in semi-arid regions (Njau, 2005). This study, however, does not support the use of woody plant leaves as a food source during dry spells, as this has not been highlighted.

Generally, from the study results, Fabaceae species is mostly used for animal feed and medicine. This is consistent with observations made by Maphosa and Masika (2010) reporting that species belonging to the Fabaceae family are used to cure a variety of animal disorders, including ailments brought on by internal and external parasites as well as bacterial diseases. One of the families in this study with the greatest FIV is the Malvaceae family, which has been found to include more species with edible fruits and leaves (Hahn et al., 2018). The greater capacity of woody plants in the Malvaceae family to adapt to a larger range of factors and conditions may be the reason for the high number of wild edible plants that have been observed (Hahn et al., 2018). Thus, we concluded that this makes them available during periods of drought. Similarly, studies performed in Ethiopia (Tebkew et al., 2014; Teklehaymanot, 2017) indicated that the families of wild food plants, Malvaceae, Fabaceae, and Rhamnaceae, were comparatively greater in number. However, in this study, the family Rhamnaceae was amongst those families with a low FIV.

According to Thornton et al. (2007) the livelihood systems which include livestock component were also vulnerable to climate variability. This is so because fodder production for livestock is under threat due to climate change which is depleting grazing availability (Doumbia et al., 2014) and livestock mortalities are on the increase (Thornton et al., 2011) Indigenous plants contribute to livestock resilience during drought by compensating nutritive deficiencies and indigenous plant species are being used for browse and fodder during drought periods (Chirwa et al., 2008). In this review, the common indigenous food plants being used as feed for livestock in the lowveld of Zimbabwe are

TABLE 2 Frequency of Citation and Relative Frequency of Citation of edible indigenous woody plants.

Species	FC	RFC
A. digitata	1	0.023
B. discolor	2	0.045
D. mespiliformis	3	0.068
E. natalensis	1	0.023
F. lutea	1	0.023
F. sycomorus	2	0.045
F. virosa	1	0.023
G. flavescens	1	0.023
H. pertisiana	3	0.068
L. edulis	1	0.023
L. stuhlmanii	1	0.023
M. zeyheri	2	0.045
P. curatellifolia	3	0.068
P. thonningii	1	0.023
S. Birrea	10	0.227
S. madagascariensis	1	0.023
S. persica	2	0.045
S. spinosa	1	0.023
T. garckeana	2	0.045
U. kirkiana	1	0.023
X. americana	1	0.023
X. caffra	1	0.023
X. zambesiaca	2	0.045

Tamarind, Baobab, Monkey orange and Marula. These species are playing a greater role in ensuring resilience of livestock based rural livelihoods. Chitura et al. (2018) highlights that traditional ethnoveterinary medication based on medicinal plants and wild fodder plants can assist communities in coping with environmental and socioeconomic disruptions in livestock systems. Veterinary medicine from indigenous plants has been indicated to contribute toward improved animal health thus it's uses during drought periods (Oyda, 2017).

5 Conclusion

LEK highlighted that woody indigenous food plants are being utilized in various ways as coping strategies during droughts. This offers chances and ideas for resource conservation that is both sustainable and versatile, as well as modern approaches to protecting natural and cultural variety. Greater efforts are needed to develop methods to monitor changes and document LEK on the use and availability of indigenous food plants. There is also need for the inclusion of both cultural and biological diversity in terms of food security during drought periods. The use of edible indigenous woody plants would directly impact on their growth and ability to cope with drought. Harvesting intensity can lead to further structural degradation potentially resulting in biodiversity loss in the future. The present study points to the need for embracing indigenous woody plants as a buffer and develop innovative strategies to value add with the mandate to provide diverse livelihood opportunities that help communities cope with increased frequencies of drought situations. It is therefore important to come up with sustainable utilization measures which ensure the derivation of edible indigenous woody plant resources while ensuring sustainability for future use and conservation.

Author contributions

RC: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. OK: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – review and editing. EG: Conceptualization, Methodology, Supervision, Validation, Writing – review and editing. NM: Conceptualization, Supervision, Validation, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Abera, M. (2022). Ethnobotanical study of wild edible plants and their indigenous knowledge in Sedie Muja District, South Gondar Zone, Northwestern Ethiopia. *Am. J. Plant Sci.* 13, 241–264. doi: 10.4236/ajps.2022.132015

Addis, G., Urga, K., and Dikasso, D. (2005). Ethnobotanical study of edible wild plants in some selected districts of Ethiopia. *Hum. Ecol.* 33, 83–118. doi: 10.1007/s10745-005-1656-0

Akinnifesi, F., Waibel, H., and Mithöfer, D. (2006). *The Role of Food From Natural Resources in Reducing Vulnerability to Poverty: A Case Study From Zimbabwe*. Hannover: Verein für Socialpolitik, Ausschuss für Entwicklungsländer.

Baral , S.R. an d Kurmi, P. P. (2006). *Compendium o f Medicinal Plants in Nepal*. Kathmandu: Rachan a Sharma.

Braedt, O., and Campbell, B. M. (2001). NTFP commercialisation in Zimbabwe. *ETFRN News* 42–44.

Brazier, A. (2015). *Climate Change in Zimbabwe: Facts for Planners and Decision* Makers: *Konrad-adenauer-stiftung*.

Chagumaira, C., Rurinda, J., Nezomba, H., Mtambanengwe, F., and Mapfumo, P. (2016). Use patterns of natural resources supporting livelihoods of smallholder communities and implications for climate change adaptation in Zimbabwe. *Environm. Dev. Sustainab.* 18, 237–255. doi: 10.1007/s10668-015-9637-y

Chanza, N., and Musakwa, W. (2022). Ecological and hydrological indicators of climate change observed by dryland communities of malipati in Chiredzi, Zimbabwe. *Diversity* 14, 541. doi: 10.3390/d14070541

Chapungu, L., Takuba, N., and Zinhiva, H. (2014). A multi-method analysis of forest fragmentation and loss: the case of ward 11, Chiredzi District of Zimbabwe. *Afr. J. Environm. Sci. Technol.* 8, 121–128. doi: 10.5897/AJEST2013.1556

Charnley, S., Fischer, A. P., and Jones, E. T. (2007). Integrating traditional and local ecological knowledge into forest biodiversity conservation in the Pacific Northwest. *For. Ecol. Manage.* 246, 14–28. doi: 10.1016/j.foreco.2007.03.047

Chikosi, E. S., Mugambiwa, S. S., Tirivangasi, H. M., and Rankoana, S. A. (2019). Climate change and variability perceptions in Ga-Dikgale community in Limpopo Province, South Africa. *Int. J. Clim. Chang. Strateg. Manag.* 11, 392–405. doi: 10.1108/IJCCSM-01-2018-0004

Chirwa, P., Syampungani, S., and Geldenhuys, C. (2008). The ecology and management of the Miombo woodlands for sustainable livelihoods in southern Africa: the case for non-timber forest products. *South. For.* 70, 237–245. doi: 10.2989/SF.2008.70.3.7.668

Chitura, T., Muvhali, P., Shai, K., Mushonga, B., and Kandiwa, E. (2018). Use of medicinal plants by livestock farmers in a local municipaity in Vhembe district, South Africa. *Appl Ecol Environ Sci.* 16, 6605. doi: 10.15666/aeer/1605_65896605

Cruikshank, J. (2001). Glaciers and climate change: perspectives from oral tradition. *Arctic* 54, 357–480. doi: 10.14430/arctic795

Doumbia, S., Jalloh, A., and Diouf, A. (2014). "AfricaInteract: enabling research-to-policy dialogue for adaptation to climate change in Africa: review of research and policies for climate change adaptation in the health sector in West Africa," in *Working Paper-Future Agricultures* (Brighton).

Eldridge, C. (2002). Why was there no famine following the 1992 Southern African drought*? IDS Bullet*. 33, 79–87. doi: 10.1111/j.1759-5436.2002.tb00047.x

Eslamian, S., Ostad-Ali-Askari, K., Singh, V. P., Dalezios, N. R., Ghane, M., Yihdego, Y., et al. (2017). A review of drought indices. *Int. J. Const. Res. Civil Eng.* 3, 48–66.

Fakchich, J., and Elachouri, M. (2021). An overview on ethnobotanico-pharmacological studies carried out in Morocco, from 1991 to 2015: systematic review (part 1). *J. Ethnopharmacol.* 267, 113200. doi: 10.1016/j.jep.2020.113200

FAO (2016). "Agriculture Organization, 2014," in *Livestock Primary*. Rome: Food and Agriculture Organization of the United Nations.

Fentahun, M. T., and Hager, H. (2009). Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. *Food Secur.* 1, 207–219. doi: 10.1007/s12571-009-0017-z

Gamage, D. G. N. D., Dharmadasa, R. M., Abeysinghe, D. C., Wijesekara, R. G. S., Prathapasinghe, G. A., and Someya, T. (2021). Ethnopharmacological survey on medicinal plants used for cosmetic treatments in traditional and ayurveda systems of medicine in Sri Lanka. *J. Evid. Based Complementary Altern, Med,* 2021, 5599654. doi: 10.1155/2021/5599654

Gandure, S., Drimie, S., and Faber, M. (2010). Food security indicators after humanitarian interventions including food aid in Zimbabwe. *Food Nutr. Bull.* 31, 513–523. doi: 10.1177/156482651003100405

Grace, M. (2023). Assessing species conservation status: the IUCN red list and green status of species. *Living Planet.* 333, 19. doi: 10.1017/9781108758826.019

Hahn, K., Schmidt, M., and Thiombiano, A. (2018). The use of wild plants for food: a national scale analysis for Burkina Faso (West Africa). *Flora et Vegetatio Sudano-Sambesica* 21, 25–33. doi: 10.21248/fvss.21.57

Hernández-Morcillo, M., Plieninger, T., and Bieling, C. (2013). An empirical review of cultural ecosystem service indicators. *Ecol. Indic.* 29, 434–444. doi: 10.1016/j.ecolind.2013.01.013

IPCC. (2007). *Climate Change 2007: Synthesis Report*. Geneva: IPCC.

Jiménez-Donaire, M., d,. P., Tarquis, A., and Giráldez, J. V. (2020). Evaluation of a combined drought indicator and its potential for agricultural drought prediction in southern Spain. *Nat. Hazards Earth Syst. Sci.* 20, 21–33. doi: 10.5194/nhess-20-21-2020

Joa, B., Winkel, G., and Primmer, E. (2018). The unknown known–A review of local ecological knowledge in relation to forest biodiversity conservation. *Land Use Policy* 79, 520–530. doi: 10.1016/j.landusepol.2018.09.001

Kugedera, A. (2016). *Cultivation Practices and Utilisation of Marula (Sclerocarya birrea (L)) by Smallholder Farmers of Vuravhi Communal Lands in Chivi, Zimbabwe*. (Msc Thesis), Washington DC: Bindura University of Science Education.

Kupika, O. L., Gandiwa, E., Nhamo, G., and Kativu, S. (2019). Local ecological knowledge on climate change and ecosystem-based adaptation strategies promote resilience in the Middle Zambezi Biosphere Reserve, Zimbabwe. *Scientifica,* 2019, 15. doi: 10.1155/2019/3069254

Luitel, D. R., Rokaya, M. B., Timsina, B., and Münzbergová, Z. (2014). Medicinal plants used by the Tamang community in the Makawanpur district of central Nepal. *J. Ethnobiol. Ethnomed.* 10, 1–11. doi: 10.1186/1746-4269-10-5

Macheka, L., Manditsera, F. A., Ngadze, R. T., Mubaiwa, J., Nyarugwe, S., Bangira, C., et al. (2022). Agro-ecological distribution and consumption of wild harvested edible insects, fruits, and vegetables in rural Zimbabwe. *Future Foods* 6, 100187. doi: 10.1016/j.fufo.2022.100187

Magadza, C. (1994). Climate change: some likely multiple impacts in Southern Africa. *Food Policy* 19, 165–191. doi: 10.1016/0306-9192(94)90068-X

Maliva, R., and Missimer, T. (2012). *Aridity and Drought Arid Lands Water Evaluation and Management* Cham: Springer, 21–39.

Manatsa, D., Mushore, T. D., Gwitira, I., Sakala, L. C., Ali, L. H., Chemura, A., et al. (2020). *Revision of Zimbabwe's Agro-Ecological Zones*. Zimbabwe: Government of Zimbabwe.

Maphosa, V., and Masika, P. J. (2010). Ethnoveterinary uses of medicinal plants: A survey of plants used in the ethnoveterinary control of gastro-intestinal parasites of goats in the Eastern Cape Province, South Africa. *Pharm. Biol.* 48, 697–702. doi: 10.3109/13880200903260879

Marengo, J. A., Torres, R. R., and Alves, L. M. (2017). Drought in Northeast Brazil—past, present, and future. *Theor. Appl. Climatol.* 129, 1189–1200. doi: 10.1007/s00704-016-1840-8

Maringira, G., and Sutherland, G. (2010). *Women and Food Security in Zimbabwe*: Available online at: wwwconsultancyafrica. com (accessed 30 March, 2010).

Markus, M., Cai, X., and Sriver, R. (2019). *Extreme Floods and Droughts Under Future Climate Scenarios*. Basel: MDPI, 1720.

Maroyi, A. (2009). Traditional homegardens and rural livelihoods in Nhema, Zimbabwe: a sustainable agroforestry system. *Int. J. Sustain. Dev. World Ecol.* 16, 1–8. doi: 10.1080/13504500902745895

Maroyi, A. (2011). An ethnobotanical survey of medicinal plants used by the people in Nhema communal area, Zimbabwe. *J. Ethnopharmacol.* 136, 347–354. doi: 10.1016/j.jep.2011.05.003

Maroyi, A. (2013). Traditional use of medicinal plants in south-central Zimbabwe: review and perspectives. *J. Ethnobiol. Ethnomed.* 9, 31. doi: 10.1186/1746-4269-9-31

Masih, I., Maskey, S., Muss,á, F., and Trambauer, P. (2014). A review of droughts on the African continent: a geospatial and long-term perspective. *Hydrol. Earth Syst. Sci.* 18, 3635. doi: 10.5194/hess-18-3635-2014

Masocha, M., Dube, T., Skidmore, A., Holmgren, M., and Prins, H. (2017). Assessing effect of rainfall on rate of alien shrub expansion in a southern African savanna. *Afr. J. Range Forage Sci.* 34, 39–44. doi: 10.2989/10220119.2017.1311943

Mbolanyi, B., Egeru, A., and Mfitumukiza, D. (2017). Choice options to meet household food security in the cattle corridor of Uganda. *Environm. Nat. Res. J.* 15, 19–29. doi: 10.14456/ennrj.2017.2

Mero Dowo, G., Kativu, S., and de Garine-Wichatitsky, M. (2018). Local perceptions of tree diversity, resource utilisation and ecosystem services provision at the periphery of Gonarezhou National Park, Zimbabwe. *Forests, Trees Livelih.* 27, 1–21. doi: 10.1080/14728028.2017.1358676

Mishra, A. K., and Singh, V. P. (2011). Drought modeling–a review. *J. Hydrol.* 403, 157–175. doi: 10.1016/j.jhydrol.2011.03.049

Mpofu, M. C., Mugumbate, G., Gomo, C., Mashingaidze, A. B., Chikwambi, Z., and Murungweni, C. (2022). Tuberous plants with active compounds against helminths in livestock: a systematic review. *Ethnobotany Res. Applicat.* 24, 1–36. doi: 10.32859/era.24.5.1-36

Mudzengi, C. P., Murwira, A., Zengeya, F. M., and Murungweni, C. (2017). Screening key browse species in a semi-arid rangeland. *Cogent Food Agricult.* 3, 1285854. doi: 10.1080/23311932.2017.1285854

Mugambiwa, S. S. (2018). Adaptation measures to sustain indigenous practices and the use of indigenous knowledge systems to adapt to climate change in Mutoko rural district of Zimbabwe. *Jàmbá.* 10, 1–9. doi: 10.4102/jamba.v10i1.388

Mugambiwa, S. S., and Tirivangasi, H. M. (2017). Climate change: A threat towards achieving'Sustainable Development Goal number two'(end hunger, achieve food security and improved nutrition and promote sustainable agriculture) in South Africa. *Jàmbá.* 9, 1–6. doi: 10.4102/jamba.v9i1.350

Mugandani, R., Wuta, M., Makarau, A., and Chipindu, B. (2012). Re-classification of agro-ecological regions of Zimbabwe in conformity with climate variability and change. *Afr. Crop Sci. J.* 20, 361–369.

Mukamuri, B., Chirozva, C., Matema, C., Matema, S., and Nzuma, T. (2013). "Ethnic heterogeneity and its implications for natural resources management on the edge," in *Transfrontier Conservation Areas: People Living on the Edge*, J. A. Anderson, M. de Garine-Wichatitsky, D. H. M. Cumming, U. Dzingirayi, and K. E. Giller *(*London: Routledge, Taylor and Francis), 89–105.

Munsaka, C. (2019). *Examination of the Perceived Contribution of Edible Indigenous Plants in Combating Food and Nutrition Insecurity in the Tonga Community of Zimbabwe*.

Mwerera, R. L., Majaliwa, J. G. M., and Isubikalu, P. (2010). "Climate change adaption strategies among agricultural communities in Uganda: the case of Kabale and Nakasongla districts," in *Second RUFORUM Biennial Meeting 20–24* (Entebbe).

Nairizi, S. (2017). *Drought and Water Scarcity*. New Delhi: International Commission on Irrigation and Drainage.

Nalau, J., Becken, S., Schliephack, J., Parsons, M., Brown, C., and Mackey, B. (2018). The role of indigenous and traditional knowledge in ecosystem-based adaptation: a review of the literature and case studies from the Pacific Islands. *Weather, Climate, Soc.* 10, 851–865. doi: 10.1175/WCAS-D-18-0032.1

Nangoma, E. (2007). *National Adaptation Strategy to Climate Change Impacts: A Case Study of Malawi: Human Development Occasional Papers (1992-2007)*. Human Development Report Office (HDRO), UNDP.

Neudeck, L., Avelino, L., Bareetseng, P., Ngwenya, B. N., and Motsholapheko, M. (2012). The contribution of edible wild plants to food security, dietary diversity and income of households in Shorobe Village, northern Botswana. *Ethnobotany Res. Appl.* 10, 449–462. doi: 10.17348/ERA.10.0.449-462

Ngarivhume, T., van't Klooster, C. I., de Jong, J. T., and Van der Westhuizen, J. H. (2015). Medicinal plants used by traditional healers for the treatment of malaria in the Chipinge district in Zimbabwe. *J. Ethnopharmacol.* 159, 224–237. doi: 10.1016/j.jep.2014.11.011

Ngcamu, B. S., and Chari, F. (2020). Drought influences on food insecurity in Africa: a Systematic literature review. *Int. J. Environ. Res. Public Health* 17, 5897. doi: 10.3390/ijerph17165897

Ngorima, G. T. (2006). *Towards Sustainable use of Marula (Sclerocarya birrea) in the Savannah Woodlands of Zvishavane District, Zimbabwe*. Parktown: University of the Witwatersrand.

Njau, P. (2005). "Contritibution of non-wood forest products (NWFP) to the livelihood of the communities surrounding Nyang'oro Forest RESERVE in Iringa District," in *Special Project*, 58.

Nkosi, N. N., Mostert, T. H. C., Dzikiti, S., and Ntuli, N. R. (2020). Prioritization of indigenous fruit tree species with domestication and commercialization potential in KwaZulu-Natal, South Africa. *Genet. Resour. Crop Evol.* 67, 1567–1575. doi: 10.1007/s10722-020-00932-5

Nyanga, L. K., Gadaga, T. H., Nout, M. J., Smid, E. J., Boekhout, T., and Zwietering, M. H. (2013). Nutritive value of masau (Ziziphus mauritiana) fruits from Zambezi Valley in Zimbabwe. *Food Chem.* 138, 168–172. doi: 10.1016/j.foodchem.2012.10.016

Orimoloye, I. R., Belle, J. A., Orimoloye, Y. M., Olusola, A. O., and Ololade, O. O. (2022). Drought: a common environmental disaster. *Atmosphere* . 13, 111. doi: 10.3390/atmos13010111

Oyda, S. (2017). Review on traditional ethno-veterinary medicine and medicinal plants used by indigenous people in Ethiopia: practice and application system. *Int. J. Res.* 5, 109–119. doi: 10.29121/granthaalayah.v5.i8.2017.2193

Paloniemi, R., Hujala, T., Rantala, S., Harlio, A., Salomaa, A., Primmer, E., et al. (2018). Integrating social and ecological knowledge for targeting voluntary biodiversity conservation. *Conservat. Let.* 11, e12340. doi: 10.1111/conl.12340

Qin, P., Xu, H., Liu, M., Du, L., Xiao, C., Liu, L., et al. (2020). Climate change impacts on Three Gorges Reservoir impoundment and hydropower generation. *J. Hydrol.* 580, 123922. doi: 10.1016/j.jhydrol.2019.123922

Quave, C. L., and Pieroni, A. (2015). A reservoir of ethnobotanical knowledge informs resilient food security and health strategies in the Balkans. *Nature Plants* 1, 1–6. doi: 10.1038/nplants.2014.21

Rajbhandari, M., Wegner, U., Jülich, M., Schoepke, T., and Mentel, R. (2001). Screening of Nepalese medicinal plants for antiviral activity. *J. Ethnopharmacol.* 74, 251–255. doi: 10.1016/S0378-8741(00)00374-3

Saka, J. D. K., Kadzere, I., Ndabikunze, B. K., Akinnifesi, F. K., and Tiisekwa, B. P. M. (2007). "Product development: nutritional value, processing and utilization of indigenous fruits from the Miombo ecosystem," in *Indigenous Fruit Trees in the Tropics: Domesficafion, Ufilizafion and Commercializafion* (Wallingford: CABI), 288–309.

Sansanelli, S., Ferri, M., Salinitro, M., and Tassoni, A. (2017). Ethnobotanical survey of wild food plants traditionally collected and consumed in the Middle Agri Valley (Basilicata region, southern Italy). *J. Ethnobiol. Ethnomed.* 13, 1–11. doi: 10.1186/s13002-017-0177-4

Semenya, S., and Maroyi, A. (2020). Assessment of useful alien plant species cultivated and managed in rural home gardens of Limpopo province, South Africa. *Scientifica* 2020. doi: 10.1155/2020/3561306

Shackleton, S., Campbell, B., Wollenberg, E., and Edmunds, D. (2002a). Devolution and community-based natural resource management: Creating space for local people to participate and benefit. *Nat. Res. Persp.* 76, 1–6.

Shackleton, S. E., Shackleton, C. M., Cunningham, T., Lombard, C., Sullivan, C. A., and Netshiluvhi, T. R. (2002b). Knowledge on Sclerocarya birrea subsp. caffra with emphasis on its importance as a non-timber forest product in South and southern Africa: a summary: Part 1: Taxonomy, ecology and role in rural livelihoods. *Southern African Forestry Journal, 2002*(194), 27-42. doi: 10.1080/20702620.2002.10434589

Shiva, M., and Verma, S. (2002). *Approaches to sustainable forest management and biodiversity* conservation: International Book Distributors.

Sintayehu, D. W. (2018). Impact of climate change on biodiversity and associated key ecosystem services in Africa: a systematic review. *Ecosyst. Health Sustainab.* 4, 225–239. doi: 10.1080/20964129.2018.1530054

Spinoni, J., Barbosa, P., De Jager, A., McCormick, N., Naumann, G., Vogt, J. V., et al. (2019). A new global database of meteorological drought events from 1951 to 2016. *J. Hydrol.* 22, 100593. doi: 10.1016/j.ejrh.2019.100593

Sunderland, T. C., Harrison, S. T., and Ndoye, O. (2004). "Commercialisation of non-timber forest products in Africa: history, context and prospects," in *Forest Products, Livelihoods and Conservation. Case Studies of Non-Timber Forest Product Systems* (Bogor: CIFOR), 1–24.

Tardío, J., and Pardo-de-Santayana, M. (2008). Cultural importance indices: a comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain). *Econ. Bot.* 62, 24–39. doi: 10.1007/s12231-007-9004-5

Tebkew, M., Asfaw, Z., and Zewudie, S. (2014). Underutilized wild edible plants in the Chilga District, northwestern Ethiopia: focus on wild woody plants. *Agricult. Food Secur.* 3, 1–16. doi: 10.1186/2048-7010-3-12

Teklehaymanot, T. (2017). An ethnobotanical survey of medicinal and edible plants of Yalo Woreda in Afar regional state, Ethiopia. *J. Ethnobiol. Ethnomed.* 13, 1–26. doi: 10.1186/s13002-017-0166-7

Texier, N., Dauby, G., Bidault, E., Lowry Ii, P. P., Ikabanga, D. U., and Stévart, T. (2021). An efficient method for defining plant species under High Conservation Value (HCV) criterion 1 based on the IUCN Red List criteria: a case study using species endemic to Gabon. *J. Nat. Conserv.* 62, 126027. doi: 10.1016/j.jnc.2021.126027

Thornton, P. K., Herrero, M. T., and Ericksen, P. J. (2011). "Livestock and climate change," in *Livestock Exchange Issue Brief.*

Thornton, P. K., Herrero, M. T., Freeman, H., Okeyo Mwai, A., Rege, J., Jones, P. G., et al. (2007). Vulnerability, climate change and livestock-opportunities and challenges for the poor. *J. Semi-Arid Trop. Agric. Res.* 1.

UN. (1992). Convention on biological diversity. *Environ. Policy Law*. 22, 251–258.

UNOCHA and UNOHA (2011). *United Nations Office Humanitarian Affairs: Humanitarian Report East Africa*. Nairobi: UNOCHA.

Van Loon, A. F. (2015). Hydrological drought explained. *Wiley Interdiscipl. Rev.: Water* 2, 359–392. doi: 10.1002/wat2.1085

Verspagen, N., and Erkens, R. H. (2023). A method for making Red List assessments with herbarium data and distribution models for species-rich plant taxa: lessons from the Neotropical genus Guatteria (Annonaceae). *Plants, People, Planet* 5, 536–546. doi: 10.1002/ppp3.10309

Vitalini, S., Iriti, M., Puricelli, C., Ciuchi, D., Segale, A., and Fico, G. (2013). Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—an alpine ethnobotanical study. *J. Ethnopharmacol.* 145, 517–529. doi: 10.1016/j.jep.2012.11.024

Wheeler, T., and Von Braun, J. (2013). Climate change impacts on global food security. *Science* 341, 508–513. doi: 10.1126/science.1239402

Whitney, C. W., Bahati, J., and Gebauer, J. (2018). Ethnobotany and agrobiodiversity. *Ethnobiology Letters* 9, 90–100. doi: 10.14237/ebl.9.2.2018.503

Youmsi, R. D. F., Fokou, P. V. T., Menkem, E. Z., Bakarnga-Via, I., Keumoe, R., Nana, V., et al. (2017). Ethnobotanical survey of medicinal plants used as insects repellents in six malaria endemic localities of Cameroon. *J. Ethnobiol. Ethnomed.* 13, 1–14. doi: 10.1186/s13002-017-0155-x

Zhou, M. (2004). Performance of varieties N14 and NCo376 in the South East Lowveld of Zimbabwe. *Proc. South Afr. Sugarcane Technol. Assoc.* 78, 153–160.

ZimStat. (2022). "Population and housing census. Preliminary report on population figures," in *2022 Population and Housing Census*. Harare: ZimStat.