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Traditional ecological knowledge and its role in biodiversity conservation: a systematic review

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In various parts of Africa, scholars have paid a great deal of attention to TEK, focusing mainly on their role in biodiversity conservation or natural resource management. Despite individual efforts made so far, the consolidated information about the role of TEK in biodiversity conservation remains uncertain in Africa. A systematic literature search on the role of TEK in biodiversity conservation was conducted on ISI Web of Science (WoS), Scopus and Google Scholar databases. The search produced 40 papers in 12 countries in Africa that were published between 2001 and 2022. Majority of studies on TEK (40%; *n* = 16) reported in the reviewed literature were from West Africa and no study was found in North Africa. The study found the regular use of different but interrelated forms of TEK in Africa. These include taboos and totems, customs and rituals, rules and regulations, metaphors and proverbs, traditional protected areas (social institutions), local knowledge of plants, animals and landscapes, and resource management systems. Although these forms of TEK have great potential for *in situ* natural resource management, metaphors and proverbs were found to be least addressed (*n* = 4) component of TEK. Despite TEK having played a significant role in biodiversity conservation in present-day Africa, the traditions are being threatened by changing cultural mores and practices (including Christianity and Islam), formal education, modernisation and new political dispensations. The findings of this study demonstrate that large geographic areas remain unexplored and this may hide part of the narrative. Reviewed literature suggests that metaphors and proverbs are least represented. New studies should be dedicated towards filling these gaps. Based on these findings, recommendations are provided to improve management practices for TEK in Africa.

KEYWORDS

traditional ecological knowledge, natural resource management, biodiversity conservation, sacred natural sites, taboos, preservations

1 Introduction

For centuries, indigenous peoples around the globe have had traditional knowledge of their local environment not only to sustain themselves but also to maintain their cultural identity. Even though traditional knowledge has existed for thousands of years, it has only been recognised by the Western scientific community over the past five decades as a valuable source of ecological information (Johnson, 1992). This knowledge is variously labelled as indigenous technical knowledge, ethno-ecology, local knowledge, folk knowledge, traditional knowledge, traditional ecological knowledge (hereafter TEK), and people's science (Berkes, 2008; Joa et al., 2018). Although several terminologies are used in different areas, TEK is probably the most common term in the literature. According to Johnson (1998), TEK gained

international recognition in the eighties through the publication of reports titled *World Conservation Strategy* by the International Union for the Conservation of Nature and Natural Resources and *Our Common Future* by the World Commission on Environment and Development. These reports highlighted the significance of using the environmental expertise of local people in managing natural resources. Moreover, in September 1991, recognising the importance of TEK in planning and decision-making for sustainable development, the United Nations Educational, Scientific and Cultural Organization Canada Man and the Biosphere Programme and the Canadian Environmental Assessment Research Council jointly sponsored the International Workshop on Indigenous Knowledge and Community Based Resource Management (Berkes, 1993). Since then, increased appreciation of the existence of TEK has produced a burgeoning field of research.

The literature suggests that there is no single comprehensive and universally acceptable definition of TEK. Although there is no such definition, over the past five decades, the definition of Berkes has been widely used. He defined TEK as "a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 1993, p. 3). This definition concurs with the observations of most scholars—namely, that such a knowledge system is dynamic, cumulative, evolving, place-based and geographically specific (Johnson, 1998; Charnley et al., 2007). TEK is rooted in social institutions (governing through customary rules, prohibitions and sanctions) (Osemeobo, 2001; Adom et al., 2016; Sinthumule and Mashau, 2020). It also encompasses worldviews or cosmology (beliefs, spirituality, sacred objects) of local people (Melaku Getahun, 2016; Kosoe et al., 2020) that shape environmental perceptions, factual observations and experiences, as well as resource management systems and practices (Joa et al., 2018). These have been assimilated through observation, demonstration, imitation, learning by doing and interaction with the environment (Fongod et al., 2014; Reniko, et al., 2018).

Although TEK has been used for local decision-making in a variety of fields including agriculture (Siahaya et al., 2016), health services (Isaac et al., 2018), disaster risk management (Islam et al., 2018), and weather or climate services (Hosen et al., 2020), this study focuses on the role of TEK in biodiversity conservation. Over the past four decades, the number of published studies on the significance of traditional knowledge for biodiversity conservation has constantly increased (see Joa et al., 2018; Mavhura and Mushure, 2019; Das et al., 2021). This is not surprising because international conventions and organisations that include the World Bank (World Bank, 1998) and the Millennium Ecosystem Assessment Report (Millennium Ecosystem Assessment, 2005) have recognised the importance of TEK in biodiversity conservation. Similarly, Article 8 (j) of the United Nations Convention on Biological Diversity requires all contracting parties to "respect, preserve, and maintain innovation and practices of indigenous and local communities related to sustainable use of biological diversity" (United Nations, 1992 p. 6). These organizations have recognized TEK practices because TEK is not only rich and diverse, but also ecologically sensitive. As a result, incorporating such knowledge in modern natural resource management may help to achieve various Sustainable Development Goals in a more comprehensive and eco-friendly manner (Das et al., 2021).

The importance of TEK in biodiversity conservation is not only limited to a specific area or continent, but it is also widespread and is frequently reported in many parts of the world including the Pacific Northwest (Charnley et al., 2007), Europe (Hernández-Morcillo et al., 2014), Canada (Houde, 2007), China (Jiao et al., 2012), India (Das et al., 2021), Ecuador (Becker and Ghimire, 2003), and the Philippines (Camacho et al., 2016). A wealth of research on the significance of TEK in natural resource management has also been done in various countries in Africa (see Hens, 2006; Ntoko and Schmidt, 2021; Taremwa et al., 2022). Despite the growing awareness of the importance of TEK for biodiversity conservation, to date, no review has been published on the topic in Africa. As a result, there is no consolidated information about the role of TEK in biodiversity conservation. This study reviews the current status of TEK in biodiversity conservation in Africa. The study seeks to answer the following questions: What are the existing forms of TEK that are used to conserve or manage biodiversity or natural resources in Africa? How have TEK practices contributed to biodiversity conservation in Africa? What are the challenges of TEK in Africa? and, how have these challenges affected the conservation of biodiversity?

2 Methodology

To examine the role of TEK in biodiversity conservation in Africa, a systematic review of academic literature was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines that include the identification, screening, eligibility, and inclusion of relevant literature (Tricco et al., 2018). A peer-reviewed literature search addressing TEK in biodiversity conservation in Africa was performed using ISI Web of Science (WoS), Scopus and Google scholar databases in October 2022. These three databases were chosen because they cover a wealth of local, regional and international journals from a variety of disciplines including natural, social and interdisciplinary sciences. Importantly, they also facilitate a transparent and replicable literature search. The title search string used in this study comprised of "TEK" OR "indigenous knowledge" OR "local knowledge" OR "local ecological knowledge" OR "indigenous knowledge systems" AND "biodiversity conservation" OR "nature conservation" OR "environmental conservation" OR "natural resource management". No limitations were placed on the year, language, subject area or country of publication. This resulted in 22 articles on WoS, 15 on Scopus and 38 on Google Scholar and all articles were published in English (Figure 1). Google Scholar search focused on the first 300 results (Haddaway et al., 2015).

Records from WoS, Scopus and Google Scholar databases were exported to Mendeley reference management software and duplicates were detected and removed by comparing the search results from the three databases. The study systematically searched for case studies reporting on the role of TEK and biodiversity conservation/preservation in African states. Articles from WoS, Scopus and Google Scholar were screened by reading the title and abstract and those articles that report TEK and biodiversity

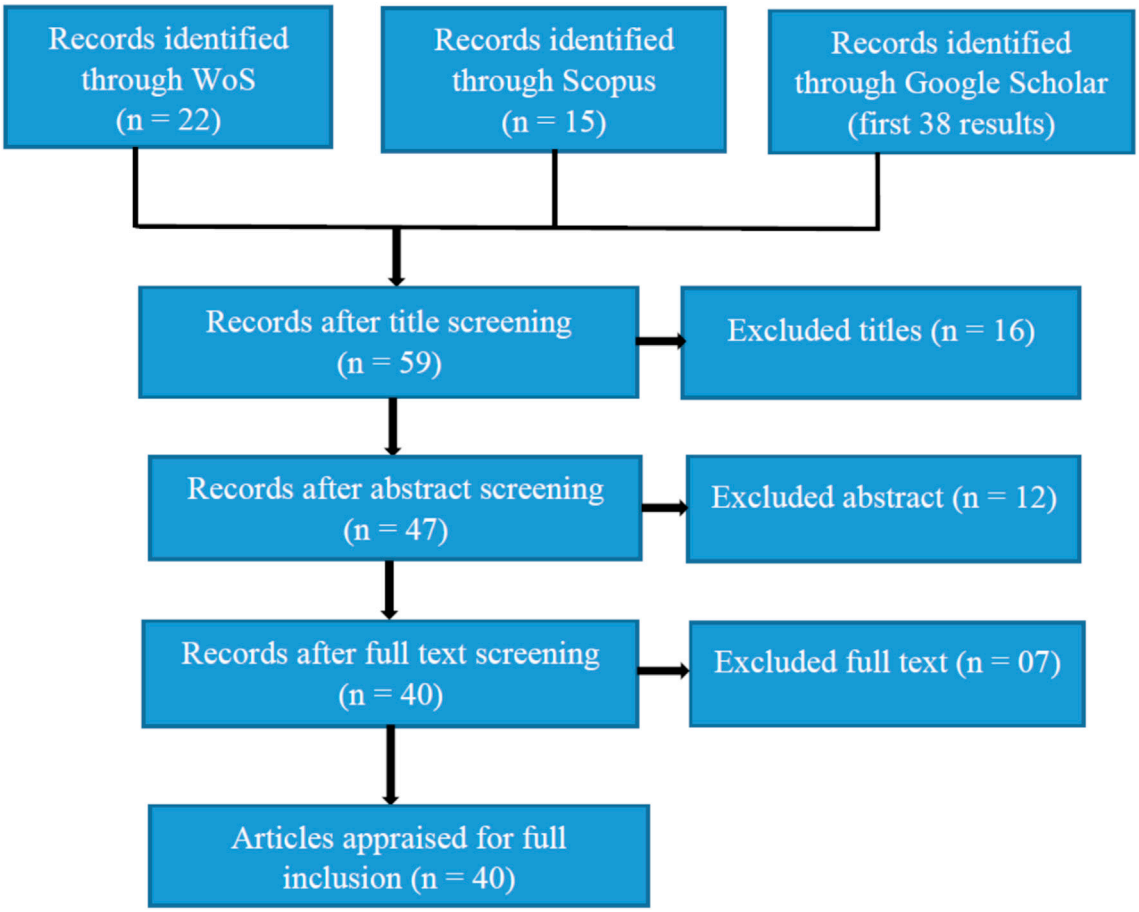

FIGURE 1
PRISMA diagram presenting the systematic scoping review.

conservation were included. After reading the titles of articles, 16 articles were excluded and 59 articles remained for further analysis. We further excluded 12 articles after reading the abstracts of the remaining articles, and we were left with 47 articles. The remaining (n = 47) articles were selected for detailed full-text reading and further screened into n = 40 publications. The remaining 40 articles were found eligible and were therefore included for analysis as they explicitly examined the interrelation of TEK and biodiversity conservation (Figure 1).

The 35 papers were excluded for one or more of the following reasons: they were not about Africa, they did not address the role of TEK in biodiversity conservation, and some analyse TEK in a context other than conservation or natural resource management. Conference papers, dissertations, and records classified as "note" or "erratum"were excluded from this review. Conference articles were excluded because they often consist of incomplete results and most of them have results that have not been reviewed by experts. In addition, unpublished technical reports commissioned by government institutions or Non-Governmental Organisations were also excluded from this study because there is a lack of comprehensive national databases which would have allowed a systematic search for these. Inductive and iterative coding was applied to summarise study results and synthesise findings (see Thomas et al., 2012). Although the review was not exhaustive, it provided an indicative account of what the literature says regarding the role of TEK towards biodiversity conservation in Africa.

3 Results

3.1 The geographic spread and methods used in TEK publications

Although TEK is common in many parts of Africa, research on TEK and biodiversity conservation tends to have been concentrated on a few geographic locations, particularly in western, eastern and southern Africa. As a result, there is a gap in knowledge on TEK in northern and central Africa. In countries where studies on TEK have occurred, they often give a detailed description of interrelated forms of TEK that are used to promote biodiversity conservation. Regarding specific countries, the largest number of analyses focused on Ghana (n = 9), Zimbabwe (n = 5), Ethiopia (n = 5), Nigeria (n = 5), South Africa (n = 4), Kenya (n = 2), Tanzania (n = 2), Rwanda (n = 2), Cameroon (n = 2) and Zambia (n = 2). Other countries represented in the analysis of the results of this study

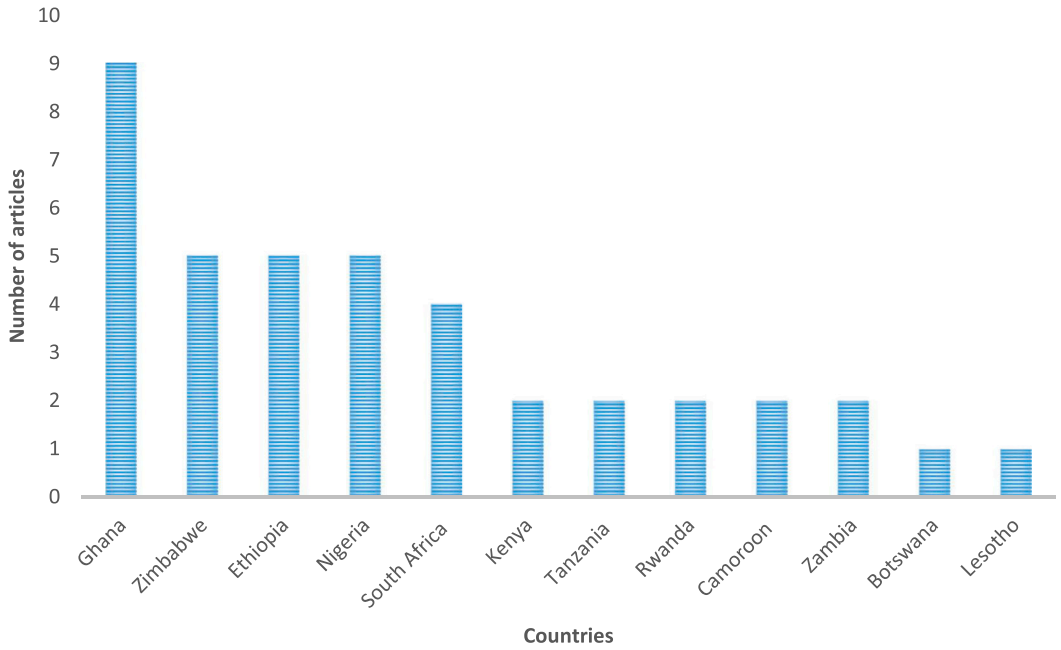

FIGURE 2
Number of published articles in each country.

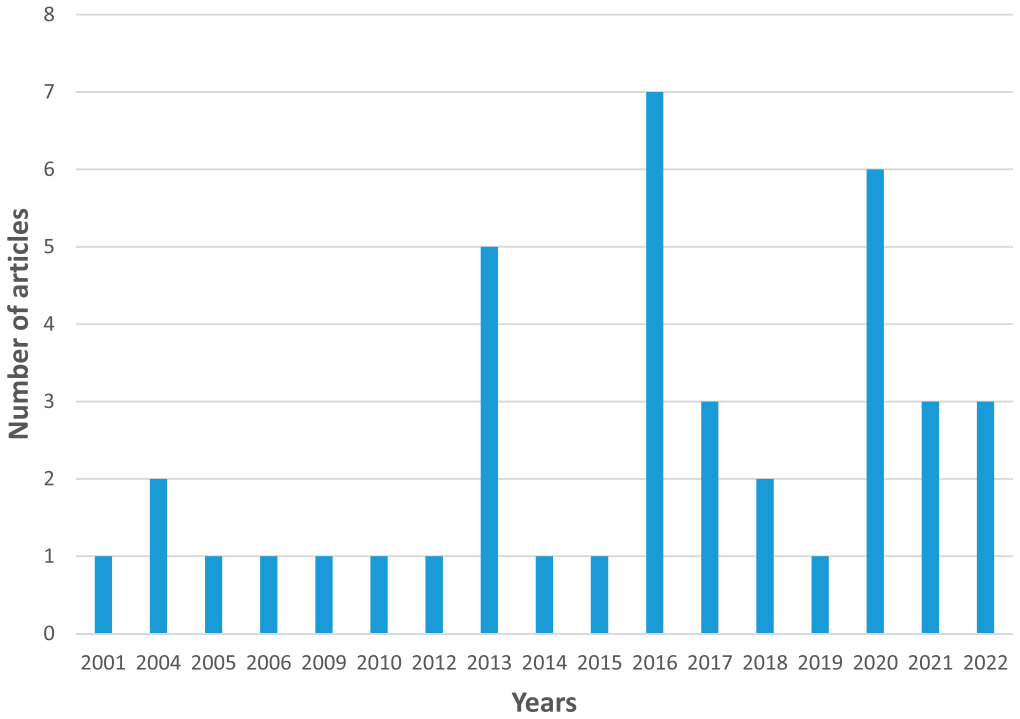

FIGURE 3
Number of published articles that address the issue of traditional ecological knowledge (TEK) in peer-reviewed journals.

TABLE 1 Different methods used to collect data related to TEK and biodiversity conservation in Africa.

	Data collection methods	Number of times		Data collection methods	Number of times		Data collection methods	Number of times
Qualitative methods	Interviews	05	Qualitative and quantitative methods	Questionnaire and FGD	03	Quantitative method	Questionnaires	01
	Interviews and observation	04		Questionnaire, interviews and FGD	03			
	Interviews and FGD	02		Questionnaire, interviews, FGD and observation	03			
	Interviews, FGD, and observation	02		Questionnaires, interviews and tree inventories	01			
	Interviews, observation, and documents	01		Questionnaire, interviews, FGD and documents	01			
	FGD	01		Questionnaires and interviews	01			
	Interviews and documents	01		Questionnaires, FGD and observation	01			
	Interviews, FGD and documents	02		Interviews, FGD and tree inventories	01			
	Interviews and tree inventories	01		Questionnaire, FGD and plant inventories	01			
	Interviews, FGD, document and observation	01		Questionnaire, interviews, FGD and tree inventories	01			
	FGD, observation and tree inventories	01						
Total		**21**			**16**			**01**

Bold values represent the total number of each method used.

included Botswana (n = 1) and Lesotho (n = 1) (Figure 2). Thus, most studies on TEK were conducted in West Africa (40%; n = 16) and no studies were found in North Africa.

The articles were published between 2001 and 2022, with the highest number being published in 2016 (n = 7), followed by 2020 (n = 6). The majority of publications (80%; n = 32) were published between 2013 and 2022 (Figure 3). The majority of the publications (98%; n = 39) presented a case study whereas only one paper presented a review. A great majority of reviewed articles (95%; n = 38) were conducted at the local level, with the only exceptions of Hens (2006); Mapira and Mazambara (2013) that conducted their studies at national scales. The majority of studies relied on qualitative data (60%; n = 24), while 13 articles (32%) were based on a mixture of qualitative and quantitative data, one publication used quantitative data (Ochieng et al., 2021), and the remaining two articles by Hens (2006); Selemani (2020) did not describe the methodologies that were used to collect data.

Qualitative data were collected mainly through interviews, and a combination of observation, focus group discussions and synthesis of documents whereas quantitative and qualitative data were collected through questionnaires, and a combination of interviews, focus group discussions, documents and observations (Table 1). In addition, Ochieng et al. (2021) used questionnaires only to collect quantitative data. Other studies combined social science research methods (interviews, questionnaire, focus group discussions, documents and observations) with biophysical science such as plant identification and recording (Kaschula et al., 2005; Fongod et al., 2014; Fadhilia, et al., 2016; Irakiza et al., 2016; Constant and Tshisikhawe, 2018; Kefalew et al., 2022). While 11 (28%) of reviewed studies lack information on how data was analysed, data on 10 studies (25%) were analysed qualitatively (thematic analysis), 9 studies (22%) were analysed quantitatively (statistical analysis), and the remaining 10 studies (25%) were analysed both qualitatively and quantitatively. The software that were commonly used to analyse quantitative data include Statistical Package for Social Sciences (SPSS) for Windows (IBM SPSS Inc., Chicago, United States) (Phuthego and Chanda, 2004; Ayaa and Waswa, 2016; Kosoe et al., 2020; Sinthumule and Mashau, 2020; Tarenwa et al., 2022), MAXQDA software (Ntoko and Schmidt, 2021), Stata® version 15 (StataCorp LLC) (Ochieng et al., 2021) and Microsoft Office Excel (Kefalew et al., 2022).

In terms of sampling, 10% (n = 4) of published papers did not indicate the sampling methods used to select respondents (TEK holders), 90% (n = 36) of studies indicated their selection process. Of the 36 publications, 11 used purposive, 9 used random, 9 relied on purposive and random sampling, 4 used purposive and snowball,

2 used convenience, and the remaining one relied on a combination of purposive, random and convenience sampling approach. The selection criteria of respondents varied from one study to another. The majority of the studies (n = 17) exclusively targeted individuals who were knowledgeable about indigenous practices including custodians of sacred sites, traditional leaders, spiritual leaders, pastoralists, herders, traditional healers, herbalists, farmers, village elders, fishermen, hunters, rainmakers, and assemblymen (formal government representative at the community level). This is not surprising because TEK or *pockets of social–ecological memories* (Barthel et al., 2010) within specific settings is with certain individuals, mainly elders who have acquired such knowledge over long period of time (Kefalew et al., 2022). Studies that were done to gather information from all residence or communities have targeted households' heads.

3.2 Existing forms of knowledge used for biodiversity conservation

Globally, various scholars have divided TEK elements into specific categories or management systems for efficient environmental management. In Africa, various scholars have reported the use of different (categories) but interrelated forms of TEK in the current research. These include taboos and totems, customs and rituals, rules and regulations, metaphors and proverbs, traditional protected areas, local knowledge of plants, animals and landscapes, and resource management systems. These categories of analysis in traditional knowledge and management systems are based on a knowledge-practice-belief framework introduced by Berkes (1999). This section explains how these categories of TEK are used to conserve biodiversity in various countries in Africa.

3.2.1 Taboos and totems

The study found that 78% (n = 31) of the reviewed papers address the importance of taboos and totems in biodiversity conservation. Taboos are unwritten, orally transmitted informal institutions, where traditional local norms rather than official rules regulate human behaviour (Colding and Folke, 2001). Taboos are used to provide complete protection to threatened plants and animal species, both in time and space (Colding and Folke, 1997), or the entire forest or ecosystem (Osei-Tutu, 2017) by prohibiting their killing or destruction and detrimental use by all members of a human community (Diawuo and Issifu, 2017). For instance, in the Sacred Forest in South Africa, collecting even dry and fallen wood or twigs, the cutting plants and hunting are taboo (Sinthumule and Mashau, 2020). At Okorobi village in Ethiope East Local Government Area in Nigeria is the "*Obi*" pond popularly called *Obi* Lake where harvesting of fish is strictly prohibited (Rim-Rukeh et al., 2013). Similarly, the Ndola Forest in Tanzania is considered sacred and is only used for cultural purposes and no one is allowed to harvest anything from the forest (Fadhilia, et al., 2016). Taboos may be imposed on a daily, weekly, or seasonal basis (Sambe et al., 2021) and may apply to different individuals based on age, gender or status (Hens, 2006). For instance, Tuesdays and Fridays in Ghana are often set aside and people and the ecosystem are expected to rest. In addition, many lagoons have long periods during which no fishing is allowed. This resting period coincides with the period when fish lay their eggs (Asante et al., 2017; Shanunu et al., 2022).

Similarly, in Nigeria, Jimoh et al. (2012) also found that a taboo forbids women from hunting on certain days and the implication is that this reduces pressure on biodiversity and regulates their use. In Zimbabwe, it is taboo for women of childbearing age to visit the sacred hills during their menstrual period. This helps in protecting the plant species because villagers are deterred from approaching the sacred hills (Mavhura and Mushure, 2019). Violating local taboos may lead to retribution by spirits. For instance, in Ghana, Diawuo and Issifu (2017) reported cases where people suffered from a variety of misfortunes such as death, barrenness, disappearance and mental disorientation for violating cultural taboos. Similarly, violating cultural taboos in the Sacred Forest in South Africa may lead to blindness, deaf, madness or disappearance and never be seen again (Sinthumule and Mashau, 2020). As a result, the taboo has preserved the forest, wildlife and natural resources allowing the area to remain pristine. The communities who have taboos in their culture do not necessarily perceive them as instruments of resource conservation, however, they play an important role in conservation of natural resource (Sinthumule and Mashau, 2020). Local communities were found to have positive attitudes towards taboos in Ghana (Boafo et al., 2016) and South Africa (Sinthumule and Mashau, 2020) in natural resource management. Similarly, based on the perceptions of the respondents in Ghana, Kosoe et al. (2020) reported that taboos were found to be very effective in conserving biodiversity.

When taboos are applied to certain animal or vegetation kingdoms which are held to be in a special relationship with a particular clan in a society, such a species is referred to as a totem (Hopkins, 1918). Totems can be defined as the practice of symbolically identifying humans with non-human objects (usually animals or plants) (Jary and Jary, 1995). Totemism is common among the Tonga people in Zambia (Kanene, 2016), the Teso people of Busia County in Kenya (Ayaa and Waswa, 2016), Ndebele in Zimbabwe (Ngara and Mangizvo, 2013), Bokwaongo and Mapanja communities in Cameroon (Ntoko and Schmidt, 2021) and Fian, Vogoni and Sing communities in Ghana (Kosoe et al., 2020). Such practices reduce competition for some edible mammals, birds, reptiles, insects, or plants because it is prohibited for one to eat his or her totem animal or plant (Mapira and Mazambara, 2013). For example, most people in the Fian community in Ghana regard the baobab tree as a totem; hence, it is forbidden for people to cut them (Kosoe et al., 2020). Similarly, during hunting operations in the Hurungwe district in Zimbabwe, zebras are not killed at will because they are associated with territorial spirits. This is because chief Mujinga is of the *dube* (zebra) totem so by killing a zebra one would have disrespected the chieftainship of the area (Reniko, et al., 2018).

In Ughelli (North Local Government Area), the iguana (a reptilian species) is found in large populations. Situated in the Orogun kingdom, people may not kill or eat an iguana as it is revered as the Orogun people's totem animal (Rim-Rukeh, 2013). Similarly, those members of the community whose totem is the buffalo, eland, lion, elephant, leopard, baboon, kudu, or species such as birds, snakes and ants will not be killed or trapped (Mapira and Mazambara, 2013; Ntoko and Schmidt, 2021). In Zambia, members of a particular clan will go to the extent of guarding their totem against being killed by other clans who may not consider it sacred

(Kanene, 2016). Violation of totemism is feared because of the nasty consequences that the offender would face like one risked losing teeth or some catastrophe would befall him or her for violating this taboo (Mapira and Mazambara, 2013; Reniko, et al., 2018; Kosoe et al., 2020).

3.2.2 Customary laws and regulations

Natural resources are critical to the lives and livelihoods of local communities, particularly in developing nations. To avoid ecological destruction and degradation, natural resources are protected through customary laws and regulations that help to facilitate common agreement on the use or non-use of a particular ecosystem service (Boafo et al., 2016; Asmamaw et al., 2020). These rules and regulations do not function independently; they usually complement other aspects of TEK such as taboos, sacred sites and resource management systems. Half of the reviewed papers ($n = 20$) address the importance of customary rules and regulation in natural resource management. In Kenya, the Teso community developed rules and regulations that ensure the sustainability of wildlife, streams, water pans and wells as well as the associated vegetation in their places (Ayaa and Waswa, 2016). For instance, harvesting of young plants for medicinal use is prohibited and thus there are strict rules that only allow the harvesting of mature plants for medicinal purposes (Ayaa and Waswa, 2016).

Traditionally, it is a widespread offence to kill fertile and pregnant game in Ghana. The killing is restricted to male and older animals. This practice ensures continued population growth of their wildlife resources (Hens, 2006). In Nigeria, Jimoh et al. (2012) identified seven customary rules that regulate the use of resources. One of the rules is that the *Chans* in the *Oban* sector have traditional laws against the use of poisonous herbs and chemicals in the harvesting of fish in streams and rivers (Jimoh et al., 2012). This approach is significant to avoid the overharvesting of fish.

Among the Tonga people in Zambia, traditional leaders historically did not allow the harvesting of fruit trees for firewood and this practice continue in the 21st century (Kanene, 2016). Similarly, in the Mount Cameroon region, the traditional authority held by elders play a vital role in biodiversity conservation and enhancing local livelihoods. For instance, non-indigenes are not allowed to harvest medicinal plants or timber from forest ecosystems (Ntoko and Schmidt, 2021). In addition, traditional councils encourage residents to plant tree species that have medicinal and socio-economic value. This has contributed to the conservation of important fauna (*Loxodonta, Pan troglodytes, Tragelaphus scriptus, Galagidae*) and flora (*Raphia hookeri* and *Cordia millenii*) species (Ntoko and Schmidt, 2021). Traditional rules and regulations on natural resources are achieved through strict sanctions and fines that are charged to offenders who are found to have violated such rules and regulations (Jimoh et al., 2012; Boafo et al., 2016; Mavhura and Mushure, 2019; Asmamaw et al., 2020). In Ethiopia, fines can be in the form of cash or (in extreme cases) via exclusion from public services (Asmamaw et al., 2020). In Zimbabwe, penalties can be in the form of livestock or buckets of grain to the traditional leaders (Mavhura and Mushure, 2019), whereas in Ghana, penalties can be money or livestock, public flogging, and, in extreme cases, expulsion from the village (Boafo et al., 2016). Fears of violating the rules and regulations have played a significant role in protecting plants and animal species.

3.2.3 Customs and rituals

The study found that only 53% ($n = 21$) of the reviewed articles address the importance of customs and rituals in natural resource management. According to Boafo et al. (2016: 30), "customs and rituals are specific social behaviours, practices, and ceremonies performed regularly by individuals or specialised people within the communities". The use of customs and rituals in conserving forest and natural resources is popular among the Nharira community in Zimbabwe (Mavhura and Mushure, 2019), Venda people in South Africa (Constant and Tshisikhawe, 2018; Sinthumule and Mashau, 2020), and Kpalgun and Yoggu communities in Ghana (Boafo et al., 2016). In addition, customs and rituals are common among the Zigi communities in Tanzania (Fadhilia, et al., 2016) and Zeyse, Zergula and Ganta communities in Southern Ethiopia (Gandile et al., 2017). In many African countries, customs and rituals are an annual event performed on sacred hills and in forests for rainmaking, thanking the ancestors for a good harvest, peace and for protecting them (Mavhura and Mushure, 2019; Sinthumule and Mashau, 2020). These customs can also involve celebrating the new harvest season by sharing staples with neighbours (Boafo et al., 2016). In some cases such as in Ethiopia, customs and rituals are performed when there are crises like illness, death, crop failure and drought (Asmamaw et al., 2020).

When these rituals are performed, traditional leaders are informed about the event before it happens (Mavhura and Mushure, 2019). Thus, customs and rituals do not function independently; usually, they complement other aspects of TEK such as taboos, customary laws and regulations, and sacred sites (Sinthumule and Mashau, 2020). Among the Zigi communities in Tanzania, Lake Nanthondu is used to treat infertile women. Infertile women are taken to the lake and bathe to ask the gods to enable them to conceive and bear children. Kyala, which is the source of the Zigi River, was and still is respected for this purpose (Fadhilia, et al., 2016). This has contributed to the conservation of the lake and no other activities are carried out in the area. In Zimbabwe, the rainmaking and thanksgiving ceremonies that are held in the hills contribute to the sacredness of the Chirozva and Daramombe hills (Mavhura and Mushure, 2019).

Since no hunting or collection of fuelwood are allowed on the Chirozva Hill Forest and Daramombe Mountain Range, these provide a refuge for plant and animal species which would otherwise have been extinct in the area (Mavhura and Mushure, 2019). In the same manner, the rituals that are performed in the Sacred Forest in South Africa help in maintaining the potency of the sacred forest (Sinthumule and Mashau, 2020). As Sinthumule and Mashau (2020) have noted, customs and rituals have not only contributed to the conservation of forests but have also enhanced the provision of goods and services derived from the sacred forest for the wellbeing of people.

3.2.4 Traditional protected areas

The most frequently ($n = 32$) addressed component of TEK is traditional protected areas [also called sacred natural sites (SNS)]. This is related to worldviews (people spiritual beliefs, sacred objects, rituals and ceremonies and superstitions) (Irakiza et al., 2016; Melaku Getahun, 2016). Many of the communities in African countries maintain SNS which are used as places of worship and for other rituals. These areas include sacred groves (Hens, 2006;

TABLE 2 Types of sacred natural sites in Africa.

Type of sacred natural sites	Example	Source
Sacred groves, sacred woods or sacred forests	Buhanga Sacred Forest, Rwanda	Irakiza et al. (2016)
	Mgbe Sacred Forest (Eten Mgbe), Nigeria	Jimoh et al. (2012)
	Vogoni Sacred (palm) Grove, Ghana	Kosoe et al. (2020)
	the Sacred Forest, South Africa	Sinthumule & Mashau (2020)
	Church Forest, Ethiopia	Asmamaw et al. (2020)
	Ndola Sacred Forest, Tanzania	Fadhilia, et al.(2016)
	Chiumbulu Sacred Forest, Zimbabwe	Mapira & Mazambara (2013)
Sacred hill or mountain	Chidoma and Nyanhekwe Sacred Hill, Zimbabwe	Ngara & Mangizvo (2013)
Sacred water	Fundudzi Lake, Phiphidi Waterfall, South Africa	Mutshinyalo & Siebert (2010)
	Zigi River, Tanzania	Fadhilia, et al. (2016)
	Mysterious water-spring in Buhanga, Rwanda	Irakiza et al. (2016)
	Lake Kariba (Zambezi River), Zimbabwe	Mapira & Mazambara (2013)
Sacred caves	Tshatshingo Potholes, South Africa	Mutshinyalo & Siebert (2010)

Sambe et al., 2021), church forests (Asmamaw et al., 2020), sacred forests (Jimoh et al., 2012; Fadhilia, et al., 2016; Sinthumule and Mashau, 2020), sacred hills or mountains (Mapira and Mazambara, 2013), caves (Irakiza et al., 2016), and rivers and water bodies (Kanene, 2016) (Table 2). According to Hens (2006), SNS range from a few square metres to several hectares—and the larger ones often form distinct elements in the landscape. It is believed that such forests, water bodies, hills or mountains, are inhabited by a deity or *numina*, commonly called nature spirits (Rim-Rukeh et al., 2013; Sambe et al., 2021). The spiritual deities regulate and protect the forests and the resources they house (Hens, 2006; Jimoh et al., 2012; Mapira and Mazambara, 2013; Ngara and Mangizvo, 2013; Kanene, 2016; Reniko, et al., 2018). In SNS, rituals, ceremonies, prayer, offerings and meditation are performed regularly by the custodians to either consult or appease the spirits or ancestors. The rituals and offerings that are performed help to keep the spirits alive in SNS (Mapira and Mazambara, 2013; Sinthumule and Mashau, 2020; Sambe et al., 2021).

Entering SNS, farming, hunting, burning, cutting or harvesting of resources (including gathering of firewood) are prohibited (Hens, 2006; Mutshinyalo and Siebert, 2010; Ayaa and Waswa, 2016; Asante et al., 2017; Ntoko and Schmidt, 2021) and may lead to retribution (Irakiza et al., 2016). Thus, offenders may be punished by the spirits (Reniko, et al., 2018). Although SNS are not necessarily seen as tools of natural resource conservation by the custodians of these areas, they nevertheless play a key role in conserving biodiversity (Sinthumule, 2022). People were found to have positive attitudes towards SNS with no cases of poaching and illegal wildlife trade, deforestation and veldt fires as in the case of Chirozva and Daramombe sacred hills in Zimbabwe (Mavhura and Mushure, 2019). For instance, in Rwanda, a total of 45 botanical taxa belonging to 28 families were reported to be used by the local community, however, villagers would not dare to enter the Buhanga Sacred Forest to harvest some of the species for fear of angering some spirits. It is believed misfortunes may fall on offenders (Irakiza et al., 2016). Similarly, in Nigeria and South Africa, it is believed that if non-member (i.e., non-custodian) enters the sacred forest, they may not find their way out (Jimoh et al., 2012; Sinthumule and Mashau, 2020), whereas in Zimbabwe, transgressors may disappear forever (Mapira and Mazambara, 2013). This practice has contributed to the conservation of biodiversity. For instance, in Oju Local Government Area of Benue State in Nigeria, Sambe et al. (2021) found that sacred groves and sacred landscapes have contributed to the conservation of fauna and flora species that include: *Smutsia gigantea, Elgaria coerulea, Ceyx erithaca, Milvus aegyptius, Centropus steerii*, *Ophiophagus hannah, Vitellaria paradoxa, Khaya grandifoliola* and *Abies balsamea*. Sinthumule and Mashau (2020) found that this type of governance and its associated taboos have allowed the the Sacred Forest to emulate "explicit nature conservation"; these sites thus serve as refugia of biodiversity as compared to the surrounding areas. Similarly, in Sefwi Wiaswo Sacred Grove in Ghana near the border of Ivory Coast, Hens (2006) found that the grove was dominated by a comparatively virgin tropical forest, whereas the hinterland had suffered deforestation.

3.2.5 Metaphors and proverbs

Metaphors and proverbs mostly pertain to words of caution that villagers (mainly elders and leaders) instill in their children and peers about conservation and wise use of natural resources. Thus, they make people (particularly younger generations) aware of the need to protect the forests and other natural resources (Mavhura and Mushure, 2019). The ethical or moral lessons through proverbs that are given to the younger generation encourage sustainable utilisation of resources (Asante et al., 2017) and help to maintain ecologically sound management practices (Berkes et al., 2000). Only 10% (n = 4) of the reviewed papers mention proverbs as a form of knowledge used for biodiversity conservation in Africa. Although there are four papers that have mentioned proverbs as a form of TEK, the examples of how proverbs are used to encourage protection

TABLE 3 Proverbs as a form of knowledge used for biodiversity conservation in Ghana and Zimbabwe.

Country	Proverbs	Meaning	Source
Ghana	• *duako gye mframa a ebu*	• If a tree stands in the path of the wind alone, it falls	Asante et al. (2017)
	• *dua ko ntumi nyɛ kwae*	• A single tree cannot make a forest	
	• *Adidi daa yɛ kyɛn adidi prɛko*	• It is not good to eat all that you have in a day	
	• *ɔkɔm bɛba o, ɔkɔm bɛba o, wo sum brɔdeɛ a sum kwadu na ɔkɔm bɛba*	• It is important to preserve both plantain and banana for moments of scarcity	
Zimbabwe	• *Kuyevedza kwemaruwa kunobva mumidzi*	• The beauty of flowers come from the roots	Mavhura and Mushure (2019)
	• *Totenda maruva tadya Chakata*	• We can only believe in the fruit tree after we have seen its fruits	
	• *Ruva rasvava harikwedzi uchi*	• A wilting flower does not attract bees	

TABLE 4 Lists of plants and animal species and their significance to communities.

Plant species	Uses	Country	Source
Acanthus montanus	Remedy for fever	Cameroon	Fongod et al. (2014)
Annickia chlorantha	Malaria related complications and body pains		
Bidens pilosa	For cough and fever		
Aloes species	Diarrhoea	Rwanda	Irakiza et al. (2016)
Thalictrum rhynchocarpum	Snakebites		
Prinus africana	Dysentery and stomach aches		
Vitex keniensis	Mosquito repellent	Kenya	Ayaa and Waswa (2016)
Anthocleista grandiflora	High blood pressure	South Africa	Constant and Tshisikhawe (2018)
Combretum erythrophyllum	Pregnancy problems		
Terminalia sericea	Treats diarrhoea in young babies		
Sclerocarya birrea	Food		
Moringa stenopetala	Treat malaria	Ethiopia	Gandile et al. (2017)
Acacia seyal Del	Headache	Ethiopia	Kefalew et al. (2022)
Achyranthes aspera L	Abdominal pain in women after birth		
Acmella caulirhiza Del	Loose tooth		
Psidium guajava	Food	Zimbabwe	Mujuru et al. (2020)
Aloe vera	Allergies, diabetes, ulcers, diarrhoea		
Animal species	Importance	Country	Source
Giant bullfrog	Indicator of rain	Lesotho	Mokuku and Mokuku (2004)
Swallows	Indicates rain		
Tortoise and ostrich	Symbol of coming of rain	Kenya	Ochieng et al. (2021)

of natural resources were only explained in two papers by Asante et al. (2017); Mavhura and Mushure (2019). The other two papers have only mentioned proverbs as a form of TEK without giving examples how it contributes to the protection of natural resources. The reviewed literature suggest that in Ghana (Asante et al., 2017) and Zimbabwe (Mavhura and Mushure, 2019), proverbs use metaphoric representations of biodiversity resources such as plants and animals as the main characters in relaying the wise axioms (Table 3). They also demonstrate that a unique, harmonious interpersonal relationship exists between human beings and the biodiversity resources in nature and this must not be marred by the activities of the former (Asante et al. (2017).

Metaphors and proverbs also relate the living with the non-living. As a result, this relationship gives justification for protecting certain animals, plants or SNS as in the case of protecting the Chirozva and Daramombe Sacred Hills in Zimbabwe (Mavhura and

Mushure, 2019). Importantly, this encourages the youth to adhere to their tradition.

3.2.6 Local knowledge of plants, animals and landscape

Local knowledge about plants, animals and their landscape is the body of factual, specific observations that TEK holders have generated over a long period. This face of TEK consists of the recognition, naming and classification of discrete components of the environment (Houde, 2007). It also presents synthesised data such as the anatomy of species, species abundance (Kefalew et al., 2022) and the dynamics of ecosystems (see Houde, 2007). Indigenous communities in Africa have extensive knowledge about the interaction of plants, animals and people within their ecosystem (Melaku Getahun, 2016; Kefalew et al., 2022). This knowledge has been acquired over a long period through observing, experiencing and experimenting (Berkes et al., 2000). The benefits or importance of plants and animals species recorded in the reviewed literature varies from one study to another (Table 4).

For instance, Mujuru et al. (2020) documented about 149 medicinal plant species belonging to 115 genera and 61 families that are used for treating about 32 diseases and disorders around five biodiversity hotspots in Zimbabwe. In addition, about 89 wild food plants that are used by the communities are also documented. The study found that cultural or traditional knowledge plays an important role in valuing species, which further assisted in the conservation and management of those species (Mujuru et al., 2020). Irakiza et al. (2016) also documented 45 plant species that are used by local communities in Rwanda. Of the 45 species, 38 plant species are categorised into 34 genera and 19 families are found to have medicinal value, which further assisted the management of natural resources. Similarly, in south and southwest Cameroon, Fongod et al. (2014) recorded 52 species of ethnomedicinal plants belonging to 30 families. The study found that traditions, beliefs, customs and cultural rights have played a significant role in the preservation of such species. The local people particularly elders from northwestern Tanzania also have a rich culture of traditional herbal plants which has contributed to the protection of those species (Selemani, 2020). The literature also suggests that local knowledge of some species accumulated over a long period by communities has protected the species because they are believed to have powers to cause dreadful consequences for humans if destroyed (Fongod et al., 2014). In the highlands of Lesotho, Mokuku and Mokuku (2004) documented a list of plants, birds, reptiles, amphibians and insects that are well protected because they are perceived to have powers to cause certain terrifying consequences for humans if destroyed, seen or encountered. For instance, cutting *Gnidia burchelii, Senecio asperulus* and *Euphorbia clavarioides* for firewood was associated with bad luck (Mokuku and Mokuku, 2004). On the one hand, trees such as oreteti (*Ficus thonningii*) and oloirien (*Olea africana*) in Kenya were considered sacred trees which once cut, so the belief went, could result in the spirit of death coming to the household (Ochieng et al., 2021). On the other hand, indigenous trees such as *Melia volkensii* (locally known as elirat) and *Markhamia lutea* (known as eswaat) besides being medicinal in nature are also associated with good luck and wealth and thus are found planted in nearly all homesteads and are never easily interfered with unless for building purpose (Ayaa and Waswa, 2016). Some tree species are considered sacred and are believed to harbour evil spirits and are protected for that reason (Rim-Rukeh et al., 2013). For instance, among the Zigi communities in Tanzania, *Adansonia digitata* and *Sterculia apendiculata* are believed to harbour spirits, whereas *Ficus* sp., *Sterculia appendiculata*, *Diospryos mespilformis, Albizia gumifera* and *Erythrina absyssinica* are considered sacred species (Fadhilia, et al., 2016). As a result, these species are protected from any use, including for medicinal purposes, because people are afraid to be affected by evil spirits.

In addition, some species are believed to have abilities to communicate messages to humans, for instance, if a spotted dikkop (a species of bird) is heard in the village in Lesotho, it is believed to be giving a warning about death. Also in Lesotho, it is believed that seeing a giant bullfrog or toad bring rain (Mokuku and Mokuku, 2004). This means that people are not expected to kill giant bullfrog because if they kill them, then there will be no rain. Similarly, in Kajiado County in Kenya, the presence of tortoise and ostrich is believed to be a symbol of coming of rain and killing them would mean no rainfall which might result in prolonged periods of drought—leading to the death of livestock and people (Ochieng et al., 2021). These knowledge and belief systems contributes to the conservation of those individual species wherever they occur. Local knowledge of some indicator species has also allowed them to be protected by local communities (Phuthego and Chanda, 2004). For instance, in Botswana, the blossoming of *Acacia erioloba* heralds the wet season and marks the end of the winter season. *Acacia tortilis* and *Terminalia sericea* are usually the first species to shed leaves which mark the beginning of winter (Phuthego and Chanda, 2004). These species are protected because of the important role they play in the environment which contributes to biodiversity conservation.

3.2.7 Resource management systems

The study found that 63% (n = 25) of the reviewed papers have addressed methods for land and resource use, conservation and adaptation in Africa. Systems for the management of resources refer to the strategies for ensuring the sustainable use of local natural resources such as pest management, resource conservation, multiple cropping patterns, and methods for estimating the state of resources (Houde, 2007). In terms of agriculture, on Mount Cameroon, shifting cultivation was widely practised as it helped the soil to regain its fertility. Depending on the individual farmer, a piece of land could be abandoned for more than 10 years (Ntoko and Schmidt, 2021). When farmers clear new areas for crops, they do not cut down important trees such as leguminous trees (e.g., *Albizia lebbeck*) and medicinal plants (e.g., *Prunus africana* and *Entandophragma angolense*) (Ntoko and Schmidt, 2021). They believe that shifting cultivation protects the soil and boosts reforestation and biodiversity. Intercropping has been found to be an important practice for the Tonga people in Zambia. For example, a maize field can be intercropped with pumpkins, groundnuts, cucumbers, watermelons and sweet grass. Intercropping helps to preserve the soil and its nutrients (Kanene, 2016). In Tanzania, the types of crops cultivated by Zigi communities in the forest ecosystem are those which do not require clearing the forest but need more forest cover to provide shade and control wind

movement, such as for the growing of cardamom (*Elettaria cardamomum*) and black pepper (*Piper nigrum*). These crops are found to yield better and more when covered with forest and this approach contributes to the conservation of the forest ecosystem (Fadhilia, et al., 2016).

Among the Iteso people, members mandated with harvesting medicinal plants were encouraged to administer some treatment on the harvested part through practices such as the application of cow dung to accelerate the callus formation as well as the re-growth of the cambium layer of the affected tree (Ayaa and Waswa, 2016). Similarly, the digging of only secondary roots rather than the main (tap) root of the medicinal plants is also allowed to protect these plants from any form of damage (Ayaa and Waswa, 2016). For the sustainable utilisation of woodland resources in tropical savannas, cutting the branches of trees rather than the whole tree is found to be the best way to promote coppice among the communities in Bushbuckridge region of the Limpopo Province in South Africa (Kaschula et al., 2005). In the same manner, selective harvesting of plant species is common among the Venda people in Limpopo Province in South Africa (Constant and Tshisikhawe, 2018). While other trees are cut for fuelwood or to prepare fields for agriculture, the Tonga people in Zambia have generally ensured that wild fruit trees are left intact (Kanene, 2016). This management of wild fruit trees has contributed to their conservation. As a management strategy, reptiles such as snakes, frogs and toads that inhabited ponds, rivers and wells are protected from any harm by the Teso community in Kenya owing to the belief that they helped maintain/sustain the lives of these important water points (Ayaa and Waswa, 2016). In terms of hunting, the Basarwa in Botswana practised selective hunting as a management strategy to ensure that breeding and pregnant wildlife are not hunted and this ensured continued population growth of wildlife resources (Phuthego and Chanda, 2004). Among pastoral and agro-pastoral communities in Tanzania, traditional enclosures (deferred grazing systems) and pastoral mobility are among the important indigenous practices used for the rehabilitation of degraded rangelands and the conservation of fragile ecosystems (Selemani, 2020).

3.3 Challenges of traditional ecological knowledge

TEK in present-day Africa is threatened by changing cultural mores and practices (including Christianity and Islam), formal education, modernisation, and new political dispensations (Phuthego and Chanda, 2004; Diawuo and Issifu, 2017). The conversion from animist practices to Christianity, in particular, has reduced the ideological and popular support for TEK (Diawuo and Issifu, 2017; Sambe et al., 2021). For instance, many local people in Nigeria have embraced Christianity and hence now shun the traditional religion and its taboos (Jimoh et al., 2012). In Botswana, the Lutheran and Catholic churches were cited to have trained rural people to disregard or neglect the TEK as inferior and insignificant (Phuthego and Chanda, 2004). Thus, many people have abandoned traditional taboos, customs and rituals in favour of Christianity. Similarly, in Ghana TEK practices that include taboos, customs and traditions have been relegated to the background and are regarded by many, especially Christians, as fetishes and useless, demonic and satanic (Kosoe et al., 2020). Religious leaders including pastors, priests, imams and traditional authorities are encouraged to preach on sections of the Bible and belief mediums other than those based on TEK (Diawuo and Issifu, 2017).

Related to Christianity is formal education. Colonisation and Westernisation through formal education are responsible for disrupting certain rich traditional systems relevant to natural resource management (Mapira and Mazambara, 2013; Diawuo and Issifu, 2017). According to Phuthego and Chanda (2004), formal education is rooted in western values that are often in disagreement with local culture. For instance, Belhag and El-Kabir (1986) (cited by Diawuo and Issifu, 2017) noted that early missionaries in Africa "condemned African customs and institutions and taught social norms of nineteenth-century Europe as though they crystallised a moral code of universal validity". This practice has marginalised, diluted and transformed people, particularly school children and those affiliated with Christianity so that they disregard TEK (such as taboos) and now view the latter as inferior (Mapira and Mazambara, 2013). This was in line with their selfish goals of imperialism. Modernisation and advances in science and technology are also threatening the cultural systems of indigenous people in many parts of Africa (Diawuo and Issifu, 2017; Kosoe et al., 2020). For instance, in the Ashanti region of Ghana, some of the perceived reasons for neglecting TEK in the management of public forests include that, TEK is perceived as barbaric, unscientific, inhumane and outdated (Asante et al., 2017). As a result, the younger generation is thus influenced to devalue their culture and adopt new lifestyles and technology. Modernisation sees TEK belief systems, worship and practices as rather inimical to the growth, unity, peace and cohesion of communities (Diawuo and Issifu, 2017).

Modern political systems has also emerged as a factor diluting the use of TEK in natural resource management. Although modern political systems has been welcomed and celebrated after decades of colonialism, it also has its challenges affecting TEK (Jimoh et al., 2012). Modern political systems guarantees the basic freedom and human rights of all individuals (Phuthego and Chanda, 2004). As a result, many traditional rulers have lost their power over the villagers because the power is now vested in politicians (who are mainly elites). If offenders particularly in rural areas feel that they have been mistreated by the community leaders in trying to enforce the traditional laws, they could sue the community and in many cases, the court rules in their favour (Jimoh et al., 2012). Thus, community leaders have lost the power to enforce compliance with taboos within their domains. As a result, the presence of forest guards and the creation of village forest management committees has weakened the role of traditional councils in forest resource management as in the case of Cameroon (Ntoko and Schmidt, 2021). In addition, non-indigenes no longer seek permission from the traditional council before collecting timber and medicinal plants thereby eroding the sacredness and effectiveness of traditional treatment (Ntoko and Schmidt, 2021).

4 Discussion and conclusion

This review study has focused on the geographical extent, existing forms of knowledge used for biodiversity conservation, and challenges affecting TEK. Regarding the physical extent of

these factors, the results of this study have shown that although three databases were used in this review, the results of this study only focused on 12 African countries with no study in North Africa. Thus, the findings of this study demonstrate that large geographic areas were left unexplored and new studies should be dedicated towards filling this gap. When it comes to the existing forms of knowledge used for biodiversity conservation, even though there is variation in research methodology, analysis of reviewed literature suggests that social institutions and worldviews or cosmology have been relatively extensively addressed. The use of social institutions in natural resource management is diverse and not unique in Africa; rather, it is also common in other parts of the world. For instance, the implementation of taboos has been used in the Himalayas in India (Negi, 2010), Indonesia (Iskandar and Iskandar, 2017), and Iran (Plieninger et al., 2020) as powerful pillars for conserving forests and sacred groves. In Indonesia, for example, it is taboo for the Baduy people in local communities to cultivate in areas with mature forests. This taboo has contributed to the protection of the forest ecosystem (Iskandar and Iskandar, 2017). In locations including Ghana and the Indian Himalayas, taboos may be imposed on a daily, weekly, or seasonal basis and may apply to different individuals based on age, gender or status (Janaki et al., 2021). Local communities adhere to taboos for fear of retribution or supernatural punishment by ancestral spirits (Torri and Herrmann, 2011).

As Barre et al. (2009) have noted, even those people who do not believe or adhere to the social taboo practice also avoid the destruction of forests or sacred groves to avoid dealing with traditional authorities. Although this practice is not meant for biodiversity conservation but for traditional and cultural purposes, it has contributed to the protection of natural resources in many parts of the world (Samakov and Berkes, 2017). Related to taboos are customary rules and regulations that have been used in many parts of Africa to protect the ecosystem from destruction and degradation. In a study of understanding indigenous knowledge in sustainable management of natural resources in China, Juanwen et al. (2012) found that a variety of rules and regulations designed and enforced by the locals have been used for the conservation of Fengshui forests. This TEK that has been passed from one generation to another has made villagers abide by these regulations which made enforcement effective. In reducing the pressure on resources within ecosystems, customary rules and regulations have also been used in India (Bisht and Sharma, 2005), the Pacific region (Techera, 2015), the Philippines (Camacho et al., 2016) and New Zealand (Ulluwishewa et al., 2008). Such systems have also played a critical role in managing SNS. As Bhagwat and Rutte (2006) have noted, SNS are found in all continents except Antarctica. As in Africa, various rites and rituals are periodically performed in SNS to consult or appease the spirits, and hunting, fishing, or harvesting of resources is a taboo (see Luo et al., 2009; Rim-Rukeh et al., 2013; Iskandar and Iskandar, 2017). This has made SNS repositories of local biodiversity. For instance, in Meghalaya in India, about 395 species have been reported to occur in sacred groves, constituting 14% of endemic flora. It was reported that at least 50 rare and endangered plant species of Meghalaya species are confined to sacred groves (Das et al., 2021).

This review has also demonstrated that the spiritual values of local communities are the foundations of their commitment to protect their local ecosystem and of their motivation to actively engage in the conservation of sacred forests and other natural sites. Although Kalland (2000) claims that a spiritual relationship with nature does not guarantee the wellbeing of the environment, in many African societies, TEK of indigenous people is often synonymous with spirituality (Irakiza et al., 2016), and this has contributed to the protection of natural resources. Similarly, traditional and ancestral spiritual beliefs were also found to be common in Asian countries including Thailand (Chunhabunyatip et al., 2018), India (Torri and Herrmann, 2011) and China (Luo et al., 2009). The shared system of local beliefs also played a critical role in maintaining long-term social–ecological resilience in Spain (Gómez-Baggethun et al., 2012) and New Zealand (Ulluwishewa et al., 2008). For instance, Maori people in New Zealand have had a close spiritual relationship with the forests through *Tane Mahuta*, the god of forests which has contributed to the conservation of the forest ecosystem (Ulluwishewa et al., 2008). As in Africa, some species are also considered sacred. The Baima Tibetans in China also have sacred flora and fauna. For instance, the giant panda is the main protected animal because the Baima Tibetans believe that the giant panda is a being that has a spirit. It is believed that if anyone tries to capture or kill a giant panda, such a person will be punished by spirits (Luo et al., 2009). These beliefs have contributed towards protecting the giant panda. Thus, indigenous spiritual beliefs provide philosophical principles of ethical responsibility and social norms of reciprocity and respect for ecosystem integrity that promote ecologically sustainable behaviour (Torri and Herrmann, 2011). Although the use of social institutions in natural resource management is diverse in Africa, this study found that metaphors and proverbs were least addressed component of TEK from the reviewed literature. As a result, new studies should be dedicated towards understanding the role of metaphors and proverbs in biodiversity conservation.

The review of this study has also demonstrated that local communities in Africa have local knowledge of plants, animals and their landscapes. This is not unique to indigenous people in Africa; rather, indigenous people all over the world have relied on local environments for food, medicines, energy and shelter. Their reliance on natural resources has made them familiar with plants, animals and their landscapes (Gadgil et al., 1993). For instance, in Eastern Albania, Pieroni et al. (2014) documented 84 botanical taxa used for the treatment of both humans and livestock whereas in Nepal, Uprety et al. (2012) recorded 81 species that were mainly consumed as food (fruits and vegetables) and used for medicinal purposes. In Spain, local ecological knowledge was also found useful in collecting extensive data on animal abundance (Anadón et al., 2009). As Kunwar et al. (2009) have noted, knowledge holders are mostly elders as opposed to young people. Although species are protected by rules and regulations as well as taboos in various parts of the world, commercialisation, unsustainable harvesting and unhealthy competition among collectors are the biggest threat (Uprety et al., 2012).

In addition, shifting cultivation and intercropping have for generations also emerged as an important management system for the protection of soil and vegetation in many parts of Africa. Similar results were also found in Indonesia where the Dayak

people base their practices on a shifting cultivation system of rice intercropped with other foods, while at the same time maintaining forest succession after abandonment (Siahaya et al., 2016). Shifting cultivation (locally known as Jhum) is also common in India and has contributed to sustainable land use and natural resource management by the tribal communities (Das et al., 2021). Among the traditional communities in Myanmar, they avoid the choice of water resource areas and very steep slope areas as shifting cultivation plots. In addition, after harvesting their crops, they abandon shifting cultivation plots, leaving the land fallow for over 15 years. This approach has not only protected the soil from erosion but has also allowed the forest to recover (Thet et al., 2020).

The analysis of reviewed literature suggests that despite TEK facing many challenges, these diverse forms of knowledge developed over generations are still being applied by local communities in many parts of Africa and have great potential for *in situ* conservation of biodiversity. However, this is not conclusive proof given that large geographic areas remain unexplored and this is likely to hide part of the narrative. To ensure that TEK is not lost in communities, parents and grandparents should be encouraged to share their knowledge of TEK with their children and grandchildren, thereby helping to pass this knowledge to younger generations. Universities should collaborate with governments to systematically collect and document all forms of TEK for the current and future generations. Government should also work on policies and projects that can ensure that young indigenous people can learn about TEK and their indigenous beliefs, culture and traditional practices via mobile devices (including cell phones, iPads and laptops) that are loaded with the information. There is also the need for the government to initiate programmes on radio and television to discuss TEK practices and their role in improving livelihoods, sustaining biodiversity and providing ecosystem services. This must reach the youth who otherwise appear to be more interested in listening to the radio or watching television. Furthermore, constitutions and various government departments in Africa should not only recognise TEK but also work towards protecting these practices.

Author contributions

The author confirms sole responsibility for the following: study conceptualisation and design, data collection and analysis, interpretation of results, and manuscript preparation.

Conflict of interest

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

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