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Advancing the understanding of Indigenous and Local Knowledge practices in mangrove ecosystem sustainability in the Mono Transboundary Biosphere Reserve in West Africa (Benin Republic-Togo)

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Introduction: The participation of Indigenous peoples and local communities (IPLCs) is essential for biodiversity conservation and natural resource management, as they have in-depth, alternative strategies and cross-generational knowledge on how to conserve local biodiversity and sustain ecosystem resilience. Despite the different understandings of their associated knowledge in conservation practices, the perceived contribution of their knowledge in the form of rituals, taboos, and totems has proven to be useful in natural resource management. Nevertheless, the various threats facing Indigenous practices pose significant challenges in the quest for ecosystem sustainability.

Methods: Based on the availability of Indigenous knowledge, its use in conservation practices, and the relationship between Indigenous peoples and nature, we used the Mono Transboundary Biosphere Reserve (MTBR) that extends across the Togo and Benin Republic boundary as a case study. From March to April 2024, we conducted mixed-method research by documenting what is understood and considered Indigenous and Local Knowledge in mangrove conservation practices in the Benin Republic and Togo, factors threatening its use, and mapping the main knowledge holders in the reserve. A total of 70 Indigenous and Local Knowledge holders were interviewed through semi-structured interviews and surveyed in eight villages in the Mono Transboundary Biosphere Reserve.

Results: We found that the understanding of Indigenous knowledge in the MTBR is grounded in Vodoun principles and philosophies. Its practices are used by the village chiefs, Vodoun priests, cultural guardians, and traditional healers in the form of beliefs, taboos, totems, customs, rituals, and rules applied in conserving the local biodiversity and sustaining the cultural values of mangrove ecosystems. Our findings showcase the rich connections between the knowledge and practices of IPLCs and ecosystem conservation, emphasizing the need for preserving the region's rich biocultural diversity. However, the death of Indigenous practice holders, migration, western knowledge, and Christianity are halting the effective use of Indigenous practices, which in turn negatively impact mangrove ecosystem sustainability in the reserve.

Conclusion: We conclude that the future of Indigenous practices in mangrove ecosystem sustainability in Benin Republic and Togo in West Africa is full of

uncertainty, putting the mangrove ecosystem at risk of future degradation. By documenting these practices, we hope to highlight their importance in preserving biocultural diversity and encourage further studies to explore Indigenous pathways to strengthen mangrove ecosystem stewardship in the reserve.

KEYWORDS

Indigenous peoples, practices, Vodoun, mangroves, biodiversity conservation, biocultural diversity

1 Introduction

Indigenous and Local Knowledge (ILK) has emerged as a topic of interest globally and has become increasingly recognized as a critical tool for enabling sustainability. Whilst not simple to define, ILK broadly refers to the expressions, practices, beliefs, understandings, insights, and expressions of Indigenous peoples generated over centuries of profound interaction with a particular territory (Grey, 2014). Other terms commonly used in the literature include "Indigenous knowledge," "traditional knowledge," "traditional forest knowledge," "local ecological knowledge," "traditional ecological knowledge" (Boafo et al., 2016), "Indigenous technical knowledge," "local knowledge," and "rural knowledge" (Masinde and Bagula, 2011). The understanding of what ILK is or should be in Africa is context-specific. Regardless of the differences in terminology, there is a prevailing agreement that these knowledge systems have developed over multiple generations and are preserved by IPLCs. We have opted to use the term ILK in this paper because it provides a broader scope for exploring the complexity of the different recognized knowledge systems.

There is an increasing global agreement on the fundamental role played by ILK in ecosystem sustainability (Donato-Kinomis, 2016; Kanene, 2016; Weber and Barron, 2023). In Africa, some studies have revealed the merits of rehabilitating degraded ecosystems based on ILK identified by IPLCs (Heneidy and Waseem, 2007). As a result, international bodies and national organizations are beginning to realize the importance of ILK in conservation practices (Sinthumule and Mashau, 2020). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) recognizes that ILK contributes extensively to sustainability across Africa (Hill et al., 2020). The IPBES Global Assessment (GA), for example, is the first global-scale assessment to engage systematically with ILK and issues of importance to IPLCs (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). Such recognition of the crucial role of Indigenous practices has sparked scientific interest over the last decade.

However, Indigenous knowledge and practices face multiple threats and, as a consequence, are progressively dying out (Inman, 2024). There is no universal definition available of ILK (Horsthemke, 2004; Mazzocchi, 2006), which leads to a lack of understanding and threatens the recognition and protection of practices that may vary regionally. In the West Africa region, especially in the Benin Republic and Togo, there is no formal definition of ILK in conservation practices, although definitions of ILK in the literature are sometimes formulated by scholars or professionals who do not belong to the local community (Nadasdy, 1999; Huntington, 2000). Consequently, the voices of Indigenous peoples are often ignored in the definition of their own knowledge systems and thus may not be incorporated into conservation strategies that are inherently driven by their practices. By giving a voice to IPLCs in this study, we aim to fill such a gap by providing a more comprehensive understanding of ILK in conservation practices in the Benin Republic and Togo, and contribute to the literature on ILK in a broader context.

Integrating ILK into conservation practices and communicating its importance to a greater audience is stifled by transformations in Indigenous cultural practices influenced by colonization, industrialization, and globalization (Makwara, 2013; Maunganidze, 2016). The spread of Christianity and the adoption of colonial Western science have significantly impacted the use of ILK in Africa (Kakiso, 2023). For instance, among the Nandi people in Kenya, the introduction of Western cultural norms led to decreased adherence to Indigenous practices and, therefore, altered the community's relationship with the environment (Bomett et al., 2024). The Himba people in Namibia are also facing significant cultural transformation brought by many outside factors, such as modernization, globalization, and Christianity, which prevent the use of their knowledge in responding to the environmental pressures (Inman, 2024). Our work expands on previous research by Kakiso (2023), Bomett et al. (2024), and Inman (2024) to provide a more complete picture of the outside factors that affect the use of Indigenous practices in the Benin Republic and Togo.

The majority of ILK, particularly in Africa, is undocumented (Kugara et al., 2021), and when the primary custodians or main actors of the knowledge pass away, the generational collection of information and practices is lost (Makwara, 2013). In this context, there is an urgent need to identify key practitioners of ILK to prioritize communication at a local level to formally document community practices in conservation management strategies (Sillitoe and Marzano, 2009; Merçon et al., 2019; Kugara et al., 2021). This is particularly important following the findings of the IPBES Africa Assessment, demonstrating that Africa's rich biocultural diversity was one of its most critical assets, but also that it was facing many threats (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2017). In many African regions, Indigenous practices and important ILK actors or practitioners have been documented (Selemani, 2020; Kakiso, 2023; Bomett et al., 2024) in a manner to inform conservation policy and decision-making processes in the district of Aleta Wondo in Ethiopia (Kakiso, 2023), which has led to locally adapted and resilient Indigenous practices being incorporated into management strategies throughout the country (Abate, 2016). However, in the Benin Republic and Togo, such an understanding is lacking.

Recent studies in the Benin Republic, for instance, are only descriptive of the perceived effectiveness of Indigenous practices in forest conservation (Djagoun et al., 2022) and sustainable use of mangrove ecosystems (Gnansounou et al., 2024). Little focus has been placed on documenting Indigenous practices, their main actors, and the associated outside factors that affect the use of ILK (Lawin et al., 2016; Gbaguii et al., 2016; International Union for Conservation of Nature, 2021). Therefore, this study seeks to fill the gap in knowledge about practitioners of Indigenous knowledge and the different Indigenous practices toward environmental conservation in the Benin Republic and Togo in West Africa.

The West African region has 139 marine and coastal protected areas, with a total of 6 million hectares, of which nearly 90% nationally designated marine protected areas (two in the Benin Republic and none in Togo) (Merceron et al., 2024). The MTBR is a marine and coastal protected area that extends across the Togo and Benin Republic border in West Africa. The MTBR was created in 2017 by the United Nations Educational Scientific and Cultural Organization (UNESCO) as part of a regional marine protected areas network, with the primary objective to protect and sustainably manage coastal resources, especially mangrove ecosystems, to enhance coastal resilience. The reserve is locally managed by IPLCs organized in the Association for Community Biodiversity Conservation Area (ACCB) in collaboration with the National Wildlife Reserve Management Center of the Benin Republic and the Ministry of Environment in Togo. This management approach has been effective in managing important coastal resources (Nunan et al., 2015; Gnansounou et al., 2022a), but has shortcomings in conserving locally and culturally significant use of the resources, because of extensive illegal exploitation of mangroves and associated marine life in the reserve and regionally (Aheto et al., 2016; Padonou et al., 2021; Adjonou et al., 2023). Overharvesting and illegal, unreported, and unregulated fishing (Gnansounou et al., 2022b) have consequently contributed to the loss of 30% of mangrove cover (Padonou et al., 2021) and are likely to continue this trend while potentially exacerbating IPLC's vulnerability to added stressors such as climate change, food insecurity, and loss of biocultural heritage (Teka et al., 2019; Sunkur et al., 2023).

In coastal areas where local livelihoods face threats, resource users, especially IPLCs can be motivated to work together to enact change (Aheto et al., 2016). The MTBR was strategically selected as a case study as it is well-known for its diversity of Indigenous groups that use their local deities and cultural practices for mangrove ecosystem sustainability (Gnansounou et al., 2024). Such a diverse array of Indigenous groups shares culture and a way of life that are passed down from one generation to another in conservation practices (Kouchade et al., 2017). Moreover, studies on coastal resources, particularly mangroves in the MTBR, are still nascent, and the crucial contribution of Indigenous practices from IPLCs remains insufficiently explored. For instance, a recent comparative study between sacralized and non-sacralized mangrove areas in the reserve demonstrated that the former has resulted in limitation of resource extraction, such as fish collection, and illegal cutting for firewood, and increased the mangrove cover (Gnansounou et al., 2024). However, such a study lacked documentation of the practitioners and their associated knowledge that led to the perceived success of the application of ILK in mangrove conservation in the reserve. The purpose of this study is to provide a reference point for understanding ILK from the perspective of IPLCs, mapping the practitioners and their associated knowledge, and exploring the threats associated with ILK in potentially mitigating some of the impacts that mangrove ecosystems face in the MTBR.

The objectives of this study are to:

1) Elaborate on the current concept and practices of ILK from Indigenous and local peoples' perspectives in the MTBR in West Africa.
2) Document the threats associated with the use of ILK in the MTBR in West Africa.
3) Map the different practitioners of ILK in the MTBR in West Africa.

2 Materials and methods

2.1 Study area

The MTBR is one of the two transboundary reserves in Benin, situated (Long: 1.6249 and Lat: 6.5748) in the south-west of Benin and Togo, covering an area of 346,285 ha (United Nations Educational Scientific and Cultural Organization, 2018) with 12,257 ha of total marine area (World Bank, 2017). The reserve is a unique regional biodiversity hotspot, bringing together marine, terrestrial, and lagoonal ecosystems. The reserve shelters a population of about two million inhabitants (World Bank, 2017) and is designated a RAMSAR site as part of the international treaty for the conservation and sustainable use of wetlands. As such, the reserve is a wetland of international importance and recognized for its ecological significance. In addition, the MTBR is classified as a managed resource protected area under category VI of the International Union of Conservation of Nature (IUCN). Such a category allows for natural resource conservation with a wider range of human activities that are compatible with conservation goals. The reserve has a tropical and humid climate with two dry and two rainy seasons. Annual rainfall in the reserve varies between 850 and 1250 mm (Adjonou et al., 2023). Between December and April, the average maximum temperature is 31.25 °C, while between July and September, the average lowest temperature is 28 °C. Climate is projected to change with a severe impact on the ecosystem of mangroves in the MTBR (Sinsin et al., 2018).

2.2 Research methodology

2.2.1 Village selection in the MTBR

The villages in this study were selected based on two criteria. First, we used the Global Mangrove Watch data in March 2024 to identify the areas where mangrove ecosystems are present in the reserve. We then projected the coordinates of all villages in the reserve to identify those in or close enough to mangrove areas that they would likely use these resources. The villages located in or near the mangrove ecosystem were visited, and a preliminary meeting was organized with the village's Indigenous leaders. These meetings were organized following the assumption that village

chiefs knew the community members, especially the practitioners of local knowledge, who could provide a depth of understanding of the Indigenous practices and associated threats in the reserve. Second, in each village, we first asked Indigenous leaders to score from 1 to 5 (with 1 as low and 5 as the highest) the interaction and dependency of the community members on mangrove ecosystems. We also asked them if they made use of any practices that helped them ensure the sustainable use of mangrove resources, or not. The main guiding question was, "Do you know of anyone in the village who makes use of Indigenous practices in conserving mangroves?". The aim of these entry meetings with Indigenous leaders was to explore the likely connection between Indigenous practices and mangrove conservation in the study area. Among the villages in the MTBR in Togo located close to mangrove ecosystems and connected with Indigenous practices, only two fell within our criteria of selection, Agbanankin and Agonkpamè. The villages where mangroves have no connection to Indigenous practices were not considered in this study. In the Benin Republic side of the reserve, only six villages -Aguonguèkpè, Avlo, Bopa Center, Dohi, Houakpè-Daho, and Nazoumè fit our selection criteria (Figure 1).

2.2.2 Participant selection

In each village, we used snowball sampling to invite the participants referred by the village chiefs and Indigenous leaders to participate (Gnansounou et al., 2022b). Snowball sampling is a method in which the participant refers at least one more potential participant to the researcher, and so on (Cohen and Arieli, 2011; Bhattacherjee, 2012). The goal of the sampling was not to reach a representative sample, but rather was more exploratory in nature by targeting specific knowledge (ILK) holders. Therefore, participants in this study are not representative of all Indigenous and local peoples in the reserve, but only of those using their knowledge in mangrove conservation and restoration. Following the sampling process, only 70 participants self-identified as Indigenous and Local Peoples (ILPs) and Non-Indigenous and Local Peoples (NILPs) and users of ILK in mangrove conservation and therefore were considered for inclusion in this study.

In this study, we refer to ILPs, as people who are descended from and identify with the original inhabitants of the region (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2018). NILPs in this study are described as those who have no record of original inhabitants, but now permanently reside in the study area. NILPs were considered participants in this study as they self-described as practitioners of ILK and followed similar practices as ILPs, relating to people and the environment (United Nations, 2020). There are few records of Indigenous women's involvement among the selected participants (Table 1), primarily because of their restricted access to Indigenous practices stemming from certain cultural and social barriers that are discussed further.

2.2.3 In-depth interviews

We employed semi-structured, in-depth interviews lasting on average an hour with each participant. The interview occurred in the selected villages from March to April 2024. During the interview, all participants were asked the same questions. The questions included their demographic details and socio-economic profiles, as well as the definitions they used to describe ILK in the MTBR (see Supplementary material). Participants were also asked to record their level of agreement on the different actors or practitioners of Indigenous practices and the associated threats using a five-point Likert scale: "very strong, strong, medium, low, none" (Kibonde, 2020). By threat, we refer to anything likely to negatively impact Indigenous practices. The participants were then asked to identify any person within the villages who is a holder and practitioner of ILK.

Prior to their participation in the interview, the study's objective was explained to all selected participants, and both verbal and written consent were received. The interview guide was developed in English and discussed in both French and two local languages, Xweda and Fon. Although the primary researcher is from the Benin Republic and can speak the local languages, a local translator was recruited in each village to assist in translating some keywords to the participants to ensure they understood what was asked. In addition, Indigenous women who participated in the research were interviewed far away from their households to avoid their husbands influencing their responses. The same principle was applied to the few young people who participated in this research to avoid the influence of elders on their responses. This study received ethics approval protocol number H23/08/37 from the Human Research Ethics Committee (Non-Medical) of the University of the Witwatersrand in South Africa.

2.2.4 Participant observations

Additional data were collected in August 2024 by visiting sacred areas, fishing and water points, convents, and shrines where Indigenous practices are applied or observed in the villages. Indigenous ceremonies and social events, such as the initiation to local deities, namely "Zangbéto," cultural dances, and public flogging for failure to comply with Indigenous rules and regulations, were attended by the research team in the field. The data collected were in the form of field notes and photographs, which included examples of Indigenous practices and their level of applicability in the study villages. We asked practitioners to provide examples of Indigenous practices and associate the level of applicability in their village using three levels of rating: (++) Strong applicability; (+) Actively observed; (–) No longer applicable/Not frequently observed. The main questions asked to participants during the visit were "Can you give an example of any Indigenous practices in your community?" and "What is the degree of applicability of each Indigenous practice example in your community?". Those data were summarized by providing valuable descriptive context for understanding the available Indigenous practices and their level of applicability in the reserve.

2.3 Data analysis

2.3.1 Occurrence of keywords in defining ILK and expressions of Indigenous practices from participants

The definition of ILK from the participants in the MTBR was captured as audio recordings during the interview stage. A detailed transcript of each recording was completed and

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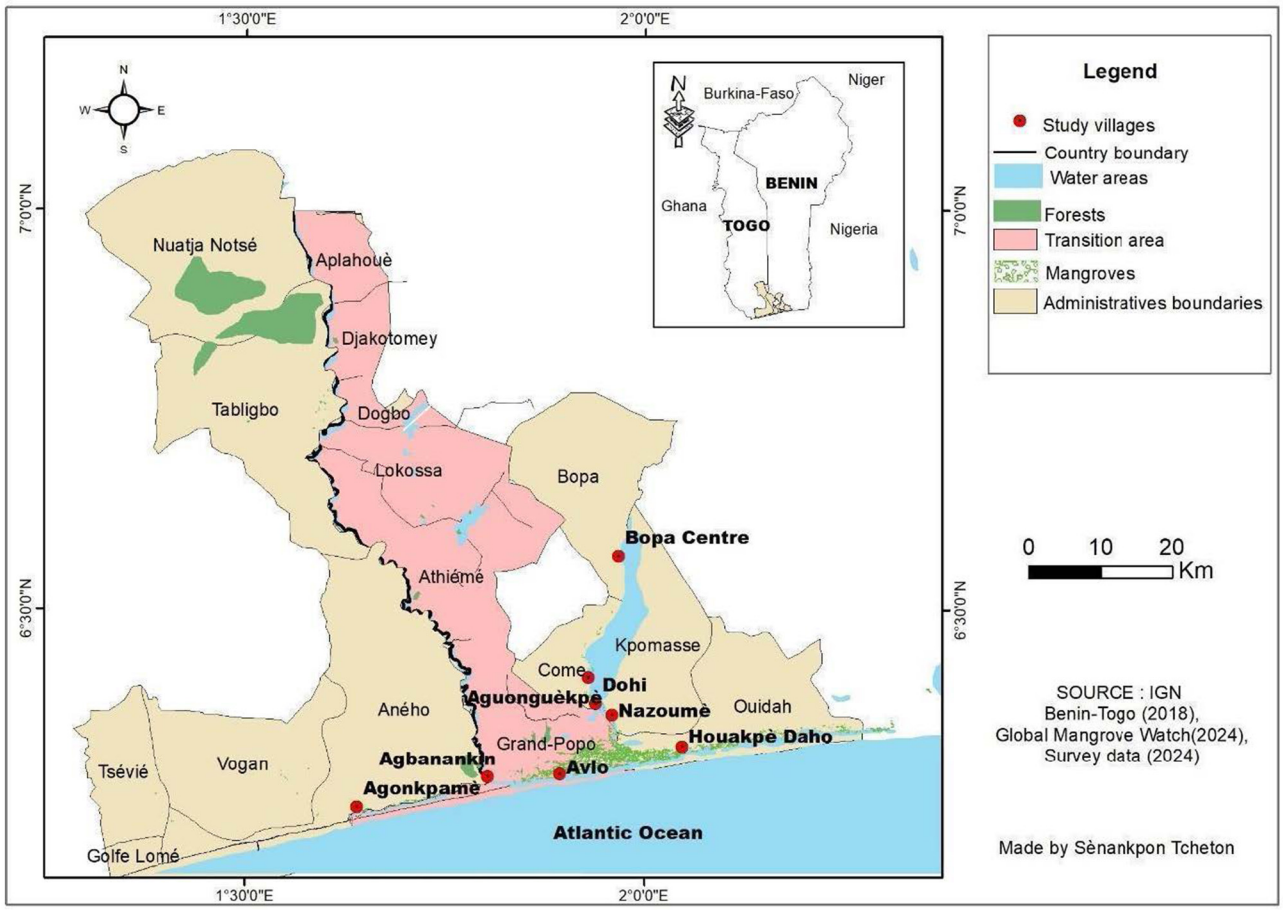

FIGURE 1
Map of the Mono Transboundary Biosphere Reserve with the selected villages.

translated from Xweda, Fon, Mina, and French to English by the primary researcher. Transcripts of the ILK definitions and the field notes from the field observations on ILK practices in mangrove ecosystems were systematically coded using inductive reasoning. Inductive coding involves a method of data analysis where the researcher reads and interprets unprocessed textual data to identify concepts or themes (Chandra and Shang, 2019). We employed the inductive coding method in our research (Thomas, 2006) as it tackles a new area of interest related to the use of ILK in the Benin Republic and Togo, which currently needs more scientific understanding. We expanded the coding using thematic content analysis. The coding of the transcripts was undertaken by the first researcher and reviewed and checked by the secondary researcher to avoid misinterpretation and minimize bias. We coded the transcripts and looked for themes that emerged related to the understanding of ILK. Keywords were retrieved from the themes (Inman, 2024), and those that emerged strongly related to ILK definitions are shown in a word cloud to demonstrate stronger and weaker associations using direct words from participants. Words that emerged often are presented with larger font sizes (Inman, 2024) and are located closer to the center.

To explore the expressions of the Indigenous practices and the extent to which they are being applied in the study villages, we conducted further coding. We coded the types of practices and then collapsed them into five categories (Beliefs, Taboos, Totems, Rules and Regulations, Customs and Rituals) (Table 2) to show how they are being expressed and to what extent they are being applied in conserving mangrove ecosystems and sustaining cultural values (Supplementary material). For example, participants stated "we believe that Vodoun protects our ecosystems," which expressed Indigenous practices being in the form of a belief. Additionally, totems were categorized following statements such as, "in our community, it is a totem that local people kill a crocodile."

We then coded how these expressions were being applied, i.e., for conservation or for cultural values, or not. Participants describe cultural values as the distinctive fundamental principles that underpin the existence of the study villages, which may affect the attitudes of community members by limiting tolerance for deviancy and heightening the pressure to adhere to socially accepted modes of thought and behavior. By mangrove ecosystems, they refer to the unique interaction between plants, animals (vertebrates and invertebrates), and water in their communities. For example, "no one should enter to cut mangrove" and "in our culture, women should not wash menstrual diapers in the water as this could break the link we have with the water spirit" are, respectively, applied for mangrove conservation and cultural value. Once we grouped

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TABLE 1 Socioeconomic characteristics of the participants.

Characteristic	ILPs, $N = 65$[a]	NILPs, $N = 5$[a]
Age	55.98 (15.07)	56.00 (9.38)
Residence duration	58.49 (36.02)	44.80 (16.28)
Gender		
Female	9 (14%)	2 (40%)
Male	56 (86%)	3 (60%)
Main occupation		0 (0%)
Chief	4 (6.2%)	
Chief advisor	6 (9.2%)	0 (0%)
Craftsmen	1 (1.5%)	0 (0%)
Cultural guardian	4 (6.2%)	1 (20%)
Farmer	2 (3.1%)	1 (20%)
Fisher	9 (14%)	0 (0%)
Hunter	1 (1.5%)	0 (0%)
Teacher	0 (0%)	1 (20%)
Salt producer	0 (0%)	1 (20%)
Traditional healer	8 (12%)	0 (0%)
Vodoun priest	30 (46%)	1 (20%)
Level of education		
None	11 (17%)	3 (60%)
Primary school	33 (51%)	1 (20%)
Secondary school	18 (28%)	1 (20%)
University	3 (4.6%)	0 (0%)
Ethnic group		
Fon	3 (4.6%)	0 (0%)
Mina	21 (32%)	0 (0%)
Xwedah	20 (31%)	4 (80%)
Xwlah	14 (22%)	0 (0%)
Yoruba	7 (11%)	1 (20%)
Country of origin		
Benin	49 (75%)	5 (100%)
Togo	16 (25%)	0 (0%)

[a]Mean (SD); *n* (%).

all the practices to understand the ways in which they are being expressed and applied, we conducted confirmatory fieldwork where participants recorded the extent to which Indigenous practices that were identified and their expressions are still being practiced or applied using three levels of rating: (++) Strong applicability; (+) Actively observed; (–) No longer applicable/Not frequently observed. Descriptive statistics were computed using the levels of rating in R version 4.3.2 Software to determine the level of applicability per village (see Supplementary Table 1 for an example of the coding process).

TABLE 2 Definitions and categories of the common types of Indigenous practices.

Categories	Understanding from IPLCs in the MTBR
Beliefs	Beliefs are understood as the feeling of being convinced of the existence or non-existence of certain conceptual entities (Usó-Doménech and Nescolarde-Selva, 2016).
Taboos	Participants in this study consider taboos as "avoidance rules," something forbidden or prohibited from use or practice.
Totems	Totems are believed by the participants to have a spiritual significance that cannot be violated or broken.
Rules and Regulations	Rules and regulations are enacted by Indigenous authorities to promote a good relationship between the local communities and mangrove ecosystems.
Customs and Rituals	Customs and rituals are perceived by the participants as practices or ceremonies performed by a designated cultural guardian or traditional practitioner on a regular basis or upon the request of the village chief.

2.3.2 Main actors using ILK and the associated threats

To understand who the main actors or practitioners of Indigenous practices are, and the threats associated with the use of ILK in the MTBR, participants were asked during the interview stage to state who the main actors are and then rate the extent to which they practice ILK on a five-point likert scale ("very strong, strong, medium, low, none"). The same process was used, where we asked participants to list the threats during the interview and then rate the threats on the same scale. We calculated the frequencies using the Tidyverse and Plotly R packages in R version 4.3.2 software (R Core Team, 2023). A conceptual model illustrating the methodological approach used from data collection to data analysis in this research is presented in Figure 2.

3 Results

3.1 Understanding of ILK from IPLCs' perspectives in the MTBR

Several keywords emerged strongly in understanding ILK from IPLCs' perspectives during our analysis. As shown in Figure 3, the keywords that emerged strongly are practices, generations, Vodoun, beliefs, spirituality, interactions (between local people and their ancestors), and tradition. Participants in this study cannot conceptualize ILK without first thanking their ancestors in the past generations for passing on the knowledge through different practices grounded in Vodoun. Considered a supreme spiritual entity in the Benin Republic and Togo, some participants have adopted Vodoun as their religion and believe in its power to intercede between the past and current generations. The understanding of ILK from the participants in the MTBR is further grounded in Vodoun principles, rules, and philosophies. As reported by one of the participants, "Most of the Indigenous and cultural practices that you will observe in our community are an accumulation of what our grandfathers have been doing for decades. They taught us how to do it, and this is strongly

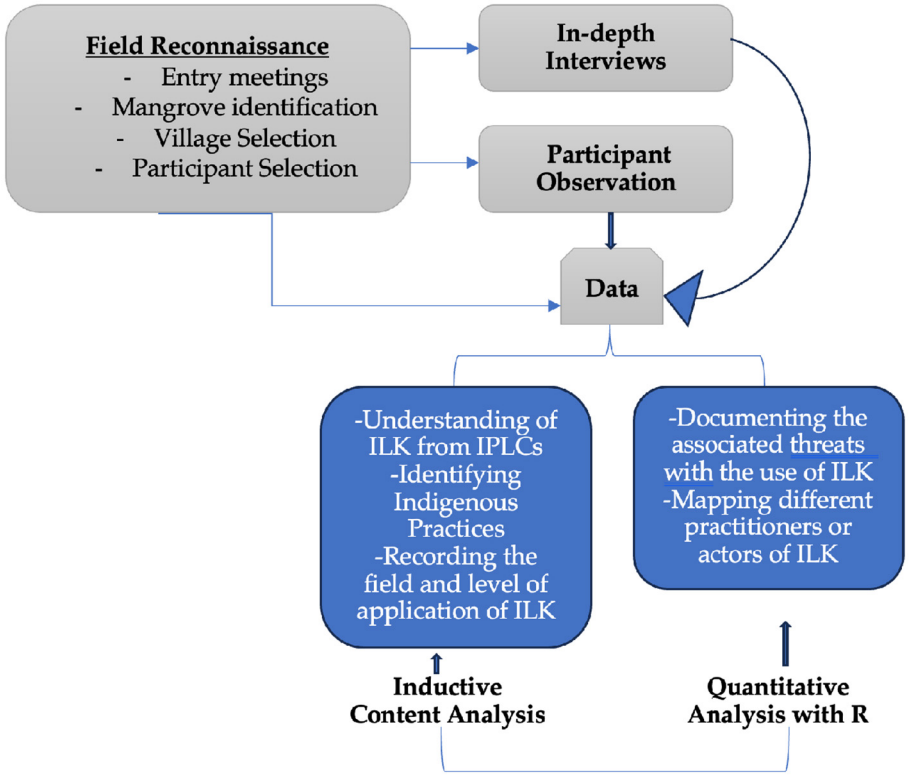

FIGURE 2
Conceptual model of the methodological research approach applied in the study.

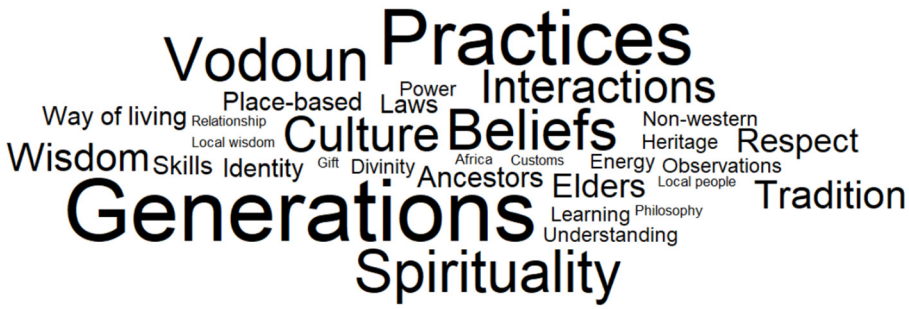

FIGURE 3
Occurrence of keywords that emerged in defining ILK from IPLCs' perspective.

linked to spirituality and beliefs. I am a cultural guardian, and all my Indigenous interest is centered around Vodoun beliefs and practices." (Benin, Houakpè-Daho, Male). Participants refer to the knowledge as place-based and mention respect as an associated element of the transmission and learning of ILK. In the study villages, elders are valued and seen as the custodians of wisdom and knowledge, and therefore, showing them due respect is crucial for the learning and transmission of ILK. As pointed out by one of the participants, "Indigenous practices are our everyday life, and one cannot live such a life with disrespect to the knowledge and the elders" (Benin, Bopa Center, Male).

Based on the keyword occurrences as shown in Figure 3, it is clear that the understanding of ILK has multiple associations, ranging from the spiritual dimensions and beliefs to practices grounded in Vodoun principles. These apply at the community level for diverse decision-making processes and are transmitted from one generation to another. Some of the definitions provided by participants in this study are quoted in Table 3.

Table 3 illustrates that there is a general understanding of practices as being a crucial component of what ILK stands for in the MTBR. Therefore, understanding those practices and their level of applicability at the community level is needed.

TABLE 3 Definition of ILK by the participants.

Participants	Profile	Definition
Male, Agonkpamin, Togo	Cultural guardian[a*]	"Our knowledge can be defined as the unique heritage that we benefited from our grandparents, and we have a huge responsibility to transfer its use to the next generation."
Male, Nanzoumè, Benin	Chief[b*]	"ILK can be referred to as our cultural identity. Such knowledge encompasses the spiritual dimension and practices that can only be used in our community."
Male, Houakpè-Daho, Benin	Vodoun priest[c*]	"The knowledge is related to our entire culture and divinities. These are our beliefs, which are grounded in Vodoun principles, rules, and philosophies."
Male, Agbanankin, Togo	Traditional healer[d*]	"We refer to ILK as a cultural and spiritual setting of skills, beliefs, practices, and experiences that have been used by our grandparents for local decision-making regarding human wellbeing and community development."
Female, Bopa-Center, Benin	Local women representative (Salt and charcoal producers.)	"ILK is our way of living in connection to our charcoal production practices, ancestors, and the surrounding environment. The knowledge employs some rules and regulations that we respect to maintain the relationship between us and our grandfathers."
Female, Agbanankin, Togo	Vodoun priest	"We cannot talk about our knowledge without mentioning Vodoun. This is central to what we know and have been doing and practicing for years. This is the culture that we inherent in the form of skills and practices from our grandfather."
Female, Avlo-Center, Benin	Vodoun priest	"Giving a single definition to ILK is wrong as the knowledge entails various cultural practices, beliefs, spirituality, traditional rituals, and customs from various community members in our village."

[a*] Individual entrusted with the preservation and transmission of a community's heritage, values, and traditions.
[b*] Individual representing the village on a political and administrative point.
[c*] Religious leader within the Vodoun entities.
[d*] Practitioner of Indigenous medicine and spiritual healing.

3.2 Indigenous practices and their level of applicability in the MTBR

Several Indigenous practices were recorded in this study. Participants identified Indigenous practices in the form of beliefs, taboos, totems, customs, rituals, and rules that are applied in conserving mangrove ecosystems (plants, animals, and water) and sustaining cultural values (Table 4). In Table 4, we highlight examples of ILK practices, indicate their area of application (cultural values, mangrove conservation), and how they are expressed in each of the villages.

3.2.1 Indigenous practices ingrained as beliefs in the MTBR

Participants in this study believe that local deities act as spiritual guardians in conserving biodiversity and protecting community members. Such a belief has led IPLCs in the MTBR to regard nature with deep respect and consideration. For example, the water spirit is believed to be a spiritual entity that is consulted annually by the cultural guardians in each village to make decisions on the favorable period for fishing. As reported by one of the participants, "The respect and applicability of the decision made by consulting the water spirit is important to us as we know when and where to do fishing to ensure the availability of fish throughout the year" (Benin, Nanzoumè, Male).

3.2.2 Indigenous practices as a strong connection to taboos and totems in the MTBR

Community taboos in the MTBR are set as strategies for reducing the over-harvesting of plant and animal species in the mangrove ecosystems. In the study villages, it is forbidden to fish during the seven days chosen by the local deities each year to honor and invoke the blessing of the water spirit. Those days are chosen using the oracle "FÂ" which is a common way of communicating with the ancestors or the local deities to appease the water spirit. The oracle communicates through a unique and complex system of 256 symbols that predict the future of fish species in the ecosystem and provide further guidance for the sustainable use of aquatic resources. The 7-day break can also be extended to 2 weeks or more in case the water spirit is not satisfied with the sacrifices made by the cultural guardians to invoke its blessing. Such a period reduces the anthropogenic pressures on mangrove ecosystems and gives the needed tranquility for living organisms such as fish, crabs, turtles, and snails to reproduce. Under no circumstances is any community member allowed to go fishing or do any mangrove-related activities during this period. Failure to comply with such a taboo in the village often results in sanctions depending on the degree of the offense. As reported, "In case of non-compliance, the person will encounter all sorts of difficulties in life until the appropriate sacrifices are made. For fishermen, for instance, their fishing net can get stuck in the water and no longer come out. Women cannot even draw water from the well in our village, or can no longer sell in the village" (Benin, Nanzoumè, Male).

Moreover, harvesting activities or cutting of mangrove trees in a sacred area are also regarded as taboo. Participants reported that

TABLE 4 ILK practices and the level of applicability in the studied villages in the MTBR.

Examples of ILK practices used by local communities in the MTBR	Field of application	Level of applicability in the villages							
		Agba	Agon	Aguo	Avlo	Bopa	Dohi	HouD	Nazo
Beliefs									
-Vodouns as the main guide to conservation	Mangrove Cons*	++	++	++	++	++	++	++	++
-There is a water spirit that no one can defy	Cultural values	++	++	++	++	++	++	++	++
-Deities as spiritual guardians of people and nature	Cultural values	++	++	++	++	++	++	++	++
Taboos and totems									
-No black pots close to the water	Cultural values	_	_	+	+	+	+	+	+
-No pooping in the water	Cultural values	+	+	++	++	++	++	++	++
-No killing of crocodiles (*Crocodylus suchus*)	Mangrove Cons	_	_	+	_	+	++	+	+
-No hunting of monkeys	Mangrove Cons	+	+	+	+	+	+	+	+
-No entry in an area surrounded by three flags (white, black, red)	Mangrove Cons	+	+	+	++	+	++	+	++
-No cutting of mangrove trees in a sacred area	Mangrove Cons	+	+	++	++	++	++	++	++
-No fishing for the 7 days chosen by the deities each year	Mangrove Cons	_	_	+	_	_	+	+	+
-No fishing and hunting during the days of prayers for the gods of water and earth	Cultural values	+	+	+	+	+	++	+	++
-No washing of menstrual pads in the water	Cultural values	++	++	++	++	++	++	++	++
-No closeness to the water for women in menstrual period	Cultural values	+	+	+	+	+	+	+	+
-No selling of fish from the water by women in menstrual period	Cultural values	_	_	+	_	_	+	_	+
-No closeness to the water (at least 90 days) for women who have just given birth	Cultural values	_	_	+	_	_	++	_	+
Customs and rituals									
-Communicate with ancestors to appease the water spirits through the oracle "FÂ"	Cultural values	++	++	++	++	++	++	++	++
-Yearly festival to celebrate the gods for more fish and a good harvesting season	Mangrove Cons	_	_	_	+	_	+	_	_
-Yearly consultation of the oracle "FÂ" for biodiversity conservation and community wellbeing	Mangrove Cons	+	_	+	_	_	+	_	_
-Rainmaking ceremonies	Cultural values	+	_	+	_	+	+	+	+
Rules and regulations									
-No one dares to oppose the voice of the ancestors through the Vodoun Zangbéto "Gardien de nuit."	Cultural values	+	+	+	++	+	++	+	++
-Always seek permission from the chief before any fishing or hunting activities	Cultural values	+	+	+	+	_	++	+	++
-No fishing and hunting during the forbidden days	Mangrove Cons	+	+	+	++	+	++	+	++
-No use of fine-mesh fishing nets and fishing of small fish	Mangrove Cons	+	+	+	+	+	++	+	+
-No fishing in the area dedicated to the reproduction of fish species	Mangrove Cons	+	+	+	+	+	++	+	+

Cons* = Conservation; Agbanankin (Agba), Agonkpamè (Agon), Aguonguèkpè (Aguon), Avlo (Avlo), Bopa Center (Bopa), Dohi (Dohi), Houakpè-Daho (HouaD), and Nazoumè (Nazo).
[] Study villages in Togo; [] Study villages in Benin Republic.
(++) Strong applicability; (+) Actively observed; (_) No longer applicable/Not frequently observed.

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those different totems and taboos of plants or animal species within the mangrove ecosystems in their communities contribute to the conservation of endangered species. The violators of the totems are said to invite misfortunes, bad luck, mystic diseases, and, in some cases, death for themselves and the community. As reported by one participant, "I remember that community member who is now lacking his mental abilities after failing to respect some taboos in the community. His case is often presented as an example to further violators who might want to break any Indigenous rules, taboos, and totems" (Benin, Dohi, Male).

In the study villages, the entry of any community member into an area surrounded by white, black, and red flags is totemic. Each of those flags represents a local deity. The white goes for Ahounga, while the black and red go for Agboé and Hèviosso, respectively. For instance, in Dohi, those local deities are believed to work together under the Avlékété to prevent community members from overexploiting mangrove ecosystems and water resources.

The West African crocodile (*Crocodylus suchus*) is regarded as a god and a revered animal that must not be hunted or killed for food or any other purposes. A crocodile is believed to be a spiritual entity that transmits the request or message from IPLCs to their ancestors and the water spirit. Therefore, the killing of crocodiles is seen as the communication being broken between IPLCs and the water spirit.

3.2.3 Indigenous practices performed as customs and rituals in the MTBR

In the MTBR, customs and rituals are performed as a way of communicating with the ancestors to appease the water spirit through the oracle "FÂ." The oracle communicates through a unique and complex system of 256 symbols that predict the future of the relationship between humans and the mangrove ecosystems (Figure 4). In case such a future reveals a complex and uncertain relationship between humans and the ecosystems, sacrifices of poultry or sheep are performed to appease the ancestors and pray to the gods. Rainmaking ceremonies are also performed by individuals on a weekly, monthly, or seasonal basis. Permission from the village chief is required to perform any rituals or ceremonies.

3.2.4 Indigenous practices in the form of rules and regulations in the MTBR

In the study villages, when local livelihoods are threatened and depleted, local communities, through Indigenous authorities, are spurred into collective action to set rules and regulations aimed at governing the sustainable use of natural resources. For instance, when fishermen inform the community leaders that particular fish species are becoming scarce or when the local fish resellers (women) notify the authorities that some fish are missing from the market for buyers, Indigenous leaders restrict the use of fine-mesh fishing nets and prohibit fishing in designated breeding areas for fish species. In addition, catching small fish is not allowed, and fishermen are urged to release any small fish they catch in their nets back into the water. The same rule applies to the over-harvesting of non-timber mangrove forest products and the cutting of trees. "In the event of an offense, the village chiefs decide the fate of the offenders. They can be flogged or, alternatively, pay a penalty, which consists of offering a sheep as a sacrifice to the gods. The sanction also depends on the seriousness of the committed offense" (Benin, Dohi, Male).

3.2.5 Applicability of Indigenous practices in the MTBR

The level of applicability informs the extent to which Indigenous practices are strongly applied, actively observed, or no longer applicable in the villages. In the MTBR, the Benin Republic and Togo share a similar cultural identity and practice a common traditional religion. This reflects the similarity observed in the level of applicability of beliefs in both countries (Table 4). For instance, the firm belief in local deities and the water spirit as spiritual guardians of community members and mangrove conservation is shared as a common belief and strongly applied in all the study villages in the Benin Republic and Togo. This can inform what strategies seem to be most effective in conservation and may be more likely to be shared across generations.

Moreover, the proximity of the villages in each country may explain the observed consistency in the level of applicability of Indigenous practices. For instance, Nanzoumè, Aguonguèkpè, and Dohi in the Benin Republic and Agbanankin and Agonkpamè in Togo, respectively, share the same level of consistency in applying Indigenous knowledge in the different fields of application. The level of applicability may also be explained by the extent to which actors or practitioners in each country are involved in Indigenous practices. The applicability of customs and rituals is declining compared to the other Indigenous practices in the MTBR. Such a decline is due to several threats that are associated with the practices.

3.3 Threats associated with the use of ILK in the MTBR

Several threats to Indigenous practices were identified by the participants in this study. The results suggest that the death of knowledge holders, foreign culture and religion, Western knowledge, and migration are the main threats associated with the use of Indigenous practices in the MTBR (Figure 5). As reported by the participants, some of the Indigenous practice holders are individualistic and possessive about their knowledge, and unfortunately, when they pass away, the knowledge that has been accumulated for decades is not transmitted to the next generation. Consequently, some Indigenous practices in the form of rituals or customs are disappearing in the study villages. For instance, in Nanzoumè, a ritual was performed by an individual using a stone under the rain to ask the gods for availability throughout the year to provide mangrove ecosystem services. Today, such a ritual no longer exists; instead, sacrifices to the gods are performed yearly for the same request.

The introduction of foreign cultures and religions, namely Christianity, has led to a rapid decline in the use of Indigenous practices and the respect of some of the totems, taboos, and local beliefs. IPLCs in the MTBR are told by Christians that their ancestral practices used in sacralizing and protecting mangrove to

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FIGURE 4
Consultation of the oracle FÂ: The position of three rosaries is one sign of communication (Photograph taken in the field, Benin). More information on the possible combination of the rosaries, their meanings, and the 256 symbols can be found in the book "Le FA, Une géomancie divinatoire du golfe du Bénin (pratique et techniques), Remy Hounwanou" (Hounwanou, 1984).

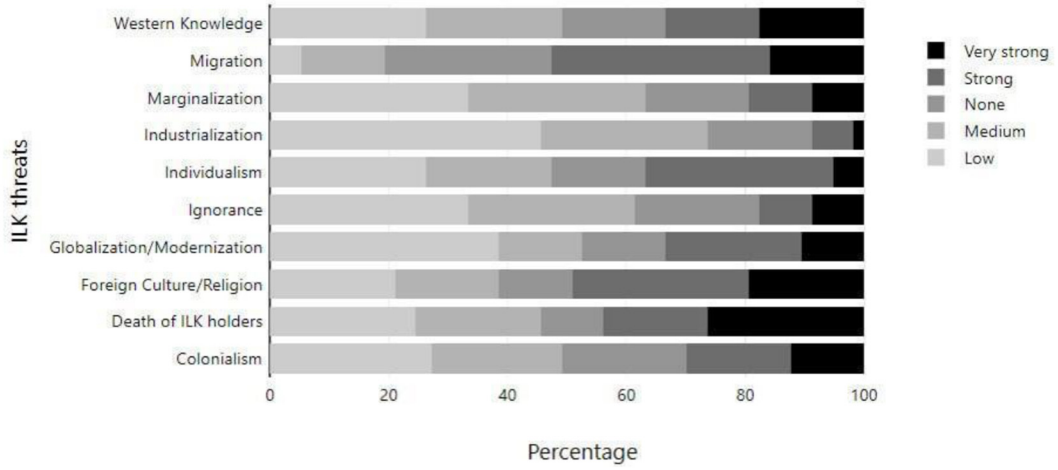

FIGURE 5
Potential threats of Indigenous practices identified by the participants in the studied villages in the MTBR: The death of knowledge holders, foreign culture and religion, Western knowledge, and migration are the main threats associated with the use of Indigenous practices in the MTBR. Industrialization comes low as an ILK threat identified in the MTBR.

prevent further illegal cutting and overexploitation are diabolic and should be left out. Such a narrative has caused a serious disinterest in the use of Indigenous knowledge in conservation practices in the MTBR. As reported, "Christianity, which is progressively taking ground in our villages, is destroying the precious connection people had with their traditions. Young people are not interested in our legacy, and this is making us question the future of Indigenous practices" (Togo, Agonkpamin, Female).

However, in Avlo Center, Indigenous peoples believe that the connection between humans and mangrove conservation can only be sustained through Indigenous practices and not by any form of Christianity or Western knowledge. As reported, "We believe in

what we see and do in our village. If we want more fish, we perform sacrifices; if we want to conserve mangroves, we sacralize them using our local deities. We do not see how prayers and the Bible can increase the fish stock in the water and protect our mangroves" (Benin, Avlo, Male). Participants refer to Western knowledge as any form of knowledge that is brought to them from outside and not grounded in their culture, beliefs, and traditions.

Migration has also been reported as the main threat to Indigenous practices sustaining mangrove ecosystems in the MTBR. Some Indigenous practice holders, in the quest for job opportunities and better living conditions, migrate to the city center and, therefore, leave behind their commitment and respect for Indigenous practices in conservation. The reality is that they often forget the skills and practices if they return to the community. As reported, "There are no job opportunities in our communities. Some people leave the village to find something to do and provide for their families. Unfortunately, when they come back after some time, they adopt new habits and lifestyles that do not reflect our cultural values and are no longer interested in Indigenous practices" (Togo, Agonkpamin, Male).

3.4 Main actors or practitioners involved in the use of ILK in the MTBR

In the study villages, the use of Indigenous practices is not spread equally among practitioners. As reported by the participants, all village members are requested to comply with the use of Indigenous practices in the form of beliefs, totems, taboos, rules, and regulations. However, Indigenous practices in the form of customs and rituals are only held and performed by a certain set of practitioners, such as the village chiefs, the Vodoun priests, the traditional healers, and the cultural guardians (Figure 6). The village chiefs are regarded as experienced practitioners and, therefore, are called out for guidance. They are paramount in all rituals and ceremonies. Vodoun priests, for instance, are known by the community members as the main leaders of rituals, as they can communicate with the ancestors and perform sacrifices to appease the water spirits and the gods. They are also recognized as the leading practitioners in sacralizing mangroves in the villages to contribute to their conservation. Cultural guardians are the leading actors who apply their knowledge to ensure the protection, preservation, and promotion of the cultural heritage and values associated with mangrove ecosystems. Their practices help reconnect the village members to mangrove ecosystems. Traditional healers are respected in the study villages as they value mangrove ecosystems, especially some plants, for the benefit of the village members. Their practices entail rituals using some parts of domesticated trees, such as leaves, roots, and flowers, to treat diseases among village members.

Some categories of practitioners, such as fishermen, hunters, farmers, and salt producers, are underrepresented in this study for diverse reasons (Figure 6). For instance, in some villages such as Dohi, Nanzoumè, Houakpe-Daho, and Avlo Center, fishermen are no longer allowed to use their Indigenous method collectively known as "Acadjas" in fishing. Acadjas are refuge traps for fish, which are built by individuals with plant branches and installed in shallow, sheltered waters of the mangrove ecosystems. The restriction by the Indigenous authorities to continue with such Indigenous fishing practices was made to stop the unsustainable use of fish and the over-cutting of mangrove trees. The same restriction applies to hunters in study villages, as most of the animals are totemic. Moreover, participants reported that farming is not well-developed as the soil has a high concentration of salt, causing stress for the crops. Consequently, farmers are no longer seen as the main actors in Indigenous practices.

Indigenous women in the study villages are known as salt producers, and their practices do not entail the use of Indigenous knowledge in the form of rituals or ceremonies. Some socio-professional categories, such as community chiefs, chief advisors, cultural guardians, traditional healers, and Vodoun priests, have been set for decades in the MTBR exclusively for males and are not appropriate for females due to some degree of spirituality that is involved and the extent of Indigenous practices that are restricted only to men. Men are then regarded as the custodians and main practitioners of Indigenous knowledge. Women are constrained by their menstrual cycles to perform some rituals and respect some Indigenous rules, as they are seen in those periods as not pure and therefore cannot communicate with the gods. Such a belief reflects on the level of participation of Indigenous women in this study. The few women recorded in this study are salt producers and Vodoun priests. As reported by one of the participants, "In our community, women cannot understand the sensitivity of Indigenous practices and therefore cannot handle the secret around it. They do not know how to keep secrets. Women are also constrained by their menstrual cycles to lead Indigenous practices" (Togo, Agbanankin, Male).

4 Discussion

4.1 Understanding Indigenous and Local Knowledge and practices in the MTBR

In this study, we found that the understanding of ILK differs from one participant to another, and one cannot refer to ILK in the MTBR without emphasizing where the knowledge is from and how this is being learned and transmitted through practices and beliefs. Vodoun, as a traditional and cultural religion in the Benin Republic and Togo, is central to the understanding of ILK. This is because followers of such a religion believe in the existence of spiritual entities that significantly impact the sustainability of ecosystem services through local beliefs and customary laws (Djagoun et al., 2022). Several studies have defined ILK without making any connection to such a religion (Senanayake, 2006; Mapara, 2009; Maunganidze, 2016; Tharakan, 2017; Hari, 2020). This emphasizes a serious knowledge gap encountered in establishing what constitutes "Indigenous" in the African cultural context (Tharakan, 2017). As demonstrated in other studies, there is no universal definition available of ILK (Horsthemke, 2004; Mazzocchi, 2006), and researchers have debated without consensus on the most appropriate use of themes to establish what IPLCs know (Williams et al., 2020).

Nonetheless, many of the definitions of ILK found in existing literature involve the Indigenous conservation methods used by

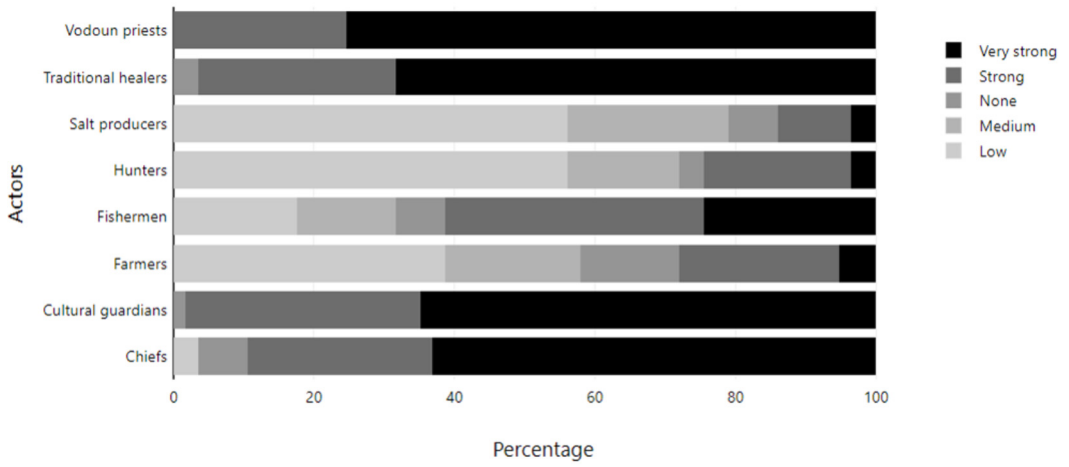

FIGURE 6
ILK practitioners in the study villages in the MTBR: Vodoun priests, traditional healers, cultural guardians, and village chiefs come very strongly as actors and practitioners of ILK, while some categories of practitioners, such as fishermen, hunters, farmers, and salt producers, are underrepresented as actors of ILK in the MTBR.

IPLCs in relation to local biodiversity, nature, climate change, and sustainability (Horsthemke, 2004; Makwara, 2013; Maunganidze, 2016; Mekonen, 2017). According to Houde (2007), the word "Indigenous" is used to point out that such knowledge is embedded in a system that is unique to a particular community or ethnic group. This makes the understanding of ILK context-specific, as the Indigenous practices of conserving nature may differ from one region to another around the world. In Europe, ILK is known as Traditional Ecological Knowledge, referring to all types of knowledge about the natural environment derived from the traditions of a group of people (Hernández-Morcillo et al., 2013). The same terminology is also used in Canada by First Nations' Indigenous people to express their knowledge in conservation practices (Houde, 2007).

In the MTBR, the Indigenous conservation practices identified by the participants are in the form of beliefs, taboos, totems, customs, rituals, and rules and regulations. Those conservation practices are specific to the reserve, as a similar study in the Pacific Northwest revealed other conservation practices, such as broadcasting seeds and transplanting bulbs, that have successfully accounted for habitat heterogeneity and land resource conservation (Charnley et al., 2007). The use and contribution from IPLCs through taboos, beliefs, and totems may be understood as the result of their unique connection with places and all forms of life (Redvers et al., 2023). This may also be explained by the deep respect they have for nature and their tradition of conservation (United Nations Environment Programme, 2017). In the African context, our results are broadly aligned with several other studies in Nigeria, Ethiopia, and Ghana that stressed the use of ILK in the form of beliefs, taboos, and totems in the conservation of natural resources and maintaining the integrity of ecosystems (Jimoh et al., 2012; Cardelús et al., 2013; Osei-Tutu, 2017; Allison, 2019). In similar studies, the taboos and totems are reported as a central element in conserving biodiversity around the religious shrines of Bangladesh (Mukul et al., 2012), and are described as instruments for the protection of the remaining Indigenous forest in South Africa (Sinthumule and Mashau, 2020).

In this study, we found that crocodiles (*crocodylus suchus*) are highly valued animals and should not be hunted for food or other reasons. While crocodiles are not titled with any spiritual meaning in other regions of Africa, such as in Zimbabwe (Utete, 2021) and in the lower Senegal river basin (Brito et al., 2011), in Kpalgun and Yoggu villages in Northern Ghana, the same species are seen as totemic creatures, as they guided the migration of IPLCs to cross rivers (Boafo et al., 2016). Crocodiles were known as "God under a tree" in ancient Egypt, and worshiped as divine beings for guaranteeing prosperity and fertility for people (Fahmy and Aboelmagd, 2024). In African cultures, crocodiles are associated with different meanings. In Southern Africa, particularly in South Africa and Zimbabwe, the Ngwenya clan takes its name from the crocodile as a sacred and powerful animal (Ndimande-Hlongwa, 1998). The conservation of such iconic species, especially as they face threats from anthropogenic activities (Ouedraogo et al., 2022), offers important potential for conservation practices.

In the MTBR, we also found that any harvesting activities or cutting of mangrove trees in a sacred area are regarded as totemic, while in other sacred areas in Zimbabwe, including Chirozva and Daramombe hills, the local communities are permitted to harvest fruits and medicinal plants (Mavhura and Mushure, 2019). Such contrary findings may be explained by the level of applicability of Indigenous practices in each country. For instance, the level of applicability of Indigenous practices in forest management in Eastern Nigeria (Chukwuone et al., 2020), and South-central Ethiopia (Tamene et al., 2024) is influenced by a range of socio-demographic factors. In the MTBR, the proximity of the villages in each country may explain the observed consistency in the level of applicability of Indigenous practices. In other African communities, the level of applicability is influenced by external factors such as the Western culture, globalization, colonialism, and the death or migration of the knowledge holders (Mapara, 2009; Maweu, 2011; Mbah et al., 2021; Bomett et al., 2024). Those external

factors are identified in other studies as threats to Indigenous practices in Africa (Cassidy et al., 2011; Risiro and Tshuma, 2013; Jauhiainen and Hooli, 2017).

Our findings supported the interplay among biological and cultural diversity within the MTBR, shaped by IPLCs' unique interaction with nature. This is well-known in the literature as "Biocultural diversity" which recognizes that human societies have developed unique ways of interacting with the natural world, resulting in a diversity of knowledge, beliefs, practices, and values that are intimately linked to the biodiversity of their environment (Maffi, 2005). In the MTBR, those practices have been developed for ages and used in valuing biodiversity and sustaining cultural values. This result aligns with the broader consensus in the field, which supports that IPLCs in Africa undertake valuation of nature in their places and territories in accordance with their own knowledge and practices to enable sustainable outcomes (Martin et al., 2022). In South and North America, several studies have addressed the need to protect biocultural diversity with a holistic and integrative approach where IPLCs and stakeholders are fully considered in decision-making processes (Otamendi-Urroz et al., 2025). Ignoring the crucial contribution of IPLCs with their associated knowledge may limit their direct influence on biocultural diversity research priorities and outcomes (Asase et al., 2021).

4.2 Threats to Indigenous practices in mangrove ecosystems in the MTBR

The death of knowledge holders, foreign culture and religion, Western knowledge, and migration are the main threats associated with the use of Indigenous practices in the MTBR. The death of the knowledgeable older generation has been identified in many studies in Africa as the main threat leading to the fast eroding of Indigenous practices (Eyong, 2007; Makwara, 2013; Kugara et al., 2021). This is because some knowledge holders privatize their knowledge (Makwara, 2013; Maunganidze, 2016) until they die without passing on the baton to the next generation (Oyelude, 2023). Consequently, the Indigenous practices that have been accumulated for decades in natural resources conservation practices remain inaccessible to other community members, conservationists, and scholars (Chigwada and Ngulube, 2023). The migration of Indigenous knowledge holders to other places in search of better opportunities also poses a risk to the disappearance of Indigenous practices in the communities, with a serious implication for mangrove conservation. As supported by Nepal (2021), by migrating, they eventually lose interest in the Indigenous practices they were born into. In Africa, Indigenous practices are losing their relevance in contributing to local biodiversity and sustainability due to migration and the death of the knowledgeable older generation. Given the tight association between biodiversity conservation and cultural heritage on the continent (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2017), the loss of ILK poses a significant threat to the rich biocultural diversity on the continent and is something that needs to be addressed urgently before more knowledge is lost that cannot be regained.

Christianity as a foreign religion has not been helpful either. Many Indigenous knowledge holders in the MTBR are now converting to Christianity, leaving behind their Indigenous heritage. The reality is that evangelists and protestant religions have oriented some Indigenous practice holders in the area by convincing them that their practices go against the principles of biblical philosophy. They are taught that the only way to make heaven is to abandon their Indigenous practices and follow Jesus Christ. A similar pattern has been observed among the Aawanbo people in Namibia, where the introduction of Christianity has eradicated their connection with nature and profoundly transformed certain Indigenous practices toward environmental conservation (Inman, 2024). Generally viewed as a product of colonialism, Western knowledge is rapidly taking place within Indigenous communities in the MTBR, with a significant influence on local culture. This aligns with the research by Selemani (2020) in Tanzania, where young people are transforming their traditional culture, beliefs, and local lifestyles to meet Western models. Such influence by Western knowledge has also been observed among Igbo tribes in Nigeria (Ekwueme and Onah, 2019).

Those threats to Indigenous practices identified in this study have serious implications for ecosystem sustainability among Indigenous communities in Africa. As demonstrated by Fabiano et al. (2021), when ILK is threatened, and some local practices are lost, environmental and ecological degradation often ensues. Natural resources may no longer be protected by IPLCs through their practices, putting local biodiversity at risk (Brosi et al., 2007). In the Benin Republic, ILK and practices have been assisting researchers and ecologists in identifying the ecological range and distribution of endangered plant species (Fandohan et al., 2011) and promoting the sustainable use of mangrove ecosystems (Gnansounou et al., 2024) for decades. In Ethiopia, the quality of the environment has been successfully sustained by adapting local practices of IPLCs from various parts of the country (Kakiso, 2023). Recently, scientists have warned humanity about the diverse implications for biodiversity conservation if the threats to Indigenous practices around the world persist (Fernández-Llamazares et al., 2021).

4.3 Community members and Indigenous practices in the MTBR

Our study highlighted that community members in general, especially the village chiefs, the Vodoun priests, the traditional healers, and the cultural guardians, are known as the main holders of Indigenous knowledge in the form of customs and rituals in coping with adverse environmental conditions that might occur in their localities. This is consistent with Cheikhyoussef et al. (2011), who argued that those community members have substantive knowledge needed in ecosystem management. In fact, they are valued and respected as the primary holders of Indigenous practices in weather forecasting, agricultural planning, and disaster preparedness (Makwara, 2013). The Maasai Indigenous communities, particularly traditional healers and cultural guardians in Kenya and Tanzania, possess extensive knowledge that helps them predict weather patterns

and make informed decisions about natural resource management (Konstantinidis, 2024). There is clear evidence that those community members and their associated knowledge have the potential to act in coping with adverse environmental conditions and promote sustainability at the local level. However, as reported by the participants in this study, the application of such knowledge is not spread equally among actors and practitioners.

As in many places, ILK is context-sensitive as its use varies depending on the practitioners and the circumstances. There are practitioners who possess, develop, and use ILK more than others (Jauhiainen and Hooli, 2017). Traditional healers come first in line of defense against most diseases (Horsthemke, 2004). Their knowledge is not only applied to cultural traditions but also to community healthcare (Cheikhyoussef et al., 2011). Farmers who are not well-represented as practitioners in this study were found to be pioneers in using Indigenous practices to adapt to climate variability and climate change in Uganda (Orlove et al., 2009). The understanding of Indigenous knowledge practitioners is crucial if we want to document the remaining practices toward environmental conservation.

Notably, the exclusion of women from many practices could further influence the loss of knowledge and interrupt a potential pathway for intergenerational knowledge dissemination. In the MTBR, women have restricted access to Indigenous practices stemming from cultural and social barriers and the degree of spirituality involved in ILK. In the West African region, the balance between Indigenous and customary beliefs and gender inclusion is an ongoing challenge (Aluko, 2018) as social norms and practices restrict women's rights and empowerment opportunities in conservation (Bouchama et al., 2018). As culture is fluid, given the strengthening of women's rights and equality, potentially in the future, there is a stronger role that they can play in preserving ILK for conservation in the region. Therefore, encouraging their inclusion in decision-making processes for conservation can make a significant contribution toward sustainability.

5 Conclusion and recommendations

Historically, IPLCs have sustainably cared for Africa's natural ecosystems. In the MTBR, the various forms of Indigenous practices, identified in the form of beliefs, taboos, totems, customs, rules, and regulations, have provided an alternative way of halting the extensive exploitation of mangrove resources. However, the death of knowledge holders, the introduction of foreign cultures and religions within the local communities, the influence of Western knowledge, and the deliberate or forced emigration of IPLCs are obstructing the successful implementation of ILK practices in mangrove conservation practices in the MTBR. As a result, the future of Indigenous practices in mangrove ecosystem sustainability in the Benin Republic and Togo in West Africa is full of uncertainty, putting the ecosystem at risk of severe degradation. Creating a future where we can rely on Indigenous practices for the benefit of mangrove ecosystems is crucial. This is the starting point for building a shared comprehension and commitment that allows radical transformations toward sustainability. Consequently, further studies are encouraged to explore Indigenous pathways and visions needed to sustain a desirable future for the use of Indigenous practices to sustain mangrove ecosystems in the reserve.

Furthermore, policymakers should promote a bottom-up perspective by including more IPLCs and their knowledge in policy formulation and implementation, as everyone's voice matters concerning planetary crises such as biodiversity loss. They should also make more effort to integrate such knowledge as part of the local primary and secondary formal educational curricula or develop educational programs on ILK for children within the local communities. For instance, broadcasting ILK practices on national and local radios and televisions through cartoons and documentary movies might help promote the knowledge and its associated benefits for the living environment at an early stage. We also invite the government, policymakers, and local communities to reinforce their collaboration in establishing some Indigenous practices learning centers where children and young people can have digital access to the knowledge.

6 Limitations of the study

- Access: In the MTBR, access to some participants knowledgeable of Indigenous practices was not granted to the research team in the field. Although those participants were referred to us as Indigenous and holders of Indigenous practices, they refused to share their knowledge as they now consider themselves Christians and therefore condemn most Indigenous practices. Even though we acknowledge that their knowledge and contribution might enhance the quality of the findings, our results remain valid for the scientific audience, and we respect their choice not to share their knowledge, as is their right.
- Cultural: We were limited to a cultural barrier as sharing some key knowledge practices requires a prior initiation of the research team to Vodoun. As religion shapes individual lives and beliefs, we do not consider such initiation timely and appropriate, and therefore it is possible that we might have missed some key information on Indigenous practices. Nonetheless, this is unlikely to have significantly influenced the results.
- Time: We were constrained by time and resources from investigating how Indigenous practices are applied to other ecosystems within the reserve. We therefore encourage further research to investigate and compare how such knowledge is used and applied to other ecosystems within the reserve.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Human Research Ethics Committee (Non-Medical) of the University

of the Witwatersrand in South Africa. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

ST: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Funding acquisition. AM-P: Methodology, Supervision, Writing – review & editing. DA: Supervision, Writing – review & editing. LP: Supervision, Writing – review & 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.

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References

Abate, T. (2016). Contribution of indigenous knowledge to climate change and adaptation response in Southern Ethiopia. *J. Earth Sci. Clim. Change* 7:377. doi: 10.4172/2157-7617.1000377

Adjonou, K., Padonou, E. A., Idohou, R., Kolawolé, M. A., Bindaoudou, I. A.-K., Valère, S., et al. (2023). "How far the mono transboundary biosphere reserve protects biodiversity in the Dahomey-Gap Corridor, West Africa?" in *Land-Use Management - Recent Advances, New Perspectives, and Applications*, eds. S. Lousada and U. Iyer-Raniga (Madeira: IntechOpen). doi: 10.5772/intechopen.112884

Aheto, D., Kankam, S., Okyere, I., Mensah, E., Osman, A., Jonah, F., et al. (2016). Community-based mangrove forest management: implications for local livelihoods and coastal resource conservation along the Volta estuary catchment area of Ghana. *Ocean Coast. Manag.* 127, 43–54. doi: 10.1016/j.ocecoaman.2016.04.006

Allison, E. (2019). Deity citadels: sacred sites of bio-cultural resistance and resilience in Bhutan. *Religions* 10 :268. doi: 10.3390/rel10040268

Aluko, Y. (2018). Women's Use of indigenous knowledge for environmental security and sustainable development in Southwest Nigeria. *Int. Indig. Policy J.* 9, 1–23. doi: 10.18584/iipj.2018.9.3.2

Asase, A., Mzumara-Gawa, T. I., Owino, J. O., Peterson, A. T., and Saupe, E. (2021). Replacing "parachute science" with "global science" in ecology and conservation biology. *Conserv. Sci. Pract.* 4:517. doi: 10.1111/csp2.517

Bhattacherjee, A. (2012). *Social Science Research: Principles, Methods, and Practices, 2nd Edn.* Tampa, FL: Textbooks Collection.

Boafo, Y. A., Saito, O., Kato, S., Kamiyama, C., Takeuchi, K., and Nakahara, M. (2016). The role of traditional ecological knowledge in ecosystem services management: the case of four rural communities in Northern Ghana. *Int. J. Biodivers. Scie. Ecosys. Serv. Manag.* 12, 24–38. doi: 10.1080/21513732.2015.1124454

Bomett, M., Nyamwaka, E., Okeche, P., and Onyambu, M. (2024). Shadows of change: influence of western culture on indigenous knowledge practices and the conservation of the physical environment among the Nandi of Kenya. *East Afr. J. Arts Soc. Sci.* 7, 432–444. doi: 10.37284/eajass.7.1.2075

Bouchama, N., Ferrant, G., Fuiret, L., Meneses, A., and Thim, A. (2018). *Gender Inequality in West African Social Institutions*. Paris: OECD.

Brito, J. C., Campos, J. C., Goncalves, D., Martínez-Freiría, F., Sillero, N., Boratynski, Z., et al. (2011). Status of Nile crocodiles in the lower Senegal River basin. *Crocodile Specialist Group Newslett.* 30, 7–10.

Brosi, B. J., Balick, M. J., Wolkow, R., Lee, R., Kostka, M., Raynor, W., et al. (2007). Cultural erosion and biodiversity: canoe-making knowledge in Pohnpei, Micronesia. *Conserv. Biol.* 21, 875–879. doi: 10.1111/j.1523-1739.2007.00654.x

Cardelús, C. L., Scull, P., Hair, J., Baimas-George, M., Lowman, M. D., and Eshete, A. W. (2013). A preliminary assessment of ethiopian sacred grove status at the landscape and ecosystem scales. *Diversity* 5, 320–334. doi: 10.3390/d5020320

Cassidy, L., Wilk, J., Kgathi, D., Bendsen, H., Ngwenya, B., and Mosepele, K. (2011). Indigenous knowledge, livelihoods and government policy in the Okavango Delta, Botswana. Rural Livelihoods Risk. *Polit. Econ. Access Nat. Resour. Okavango Delta Botsw.* 75–98.

Chandra, Y., and Shang, L. (2019). "Inductive coding," in *Qualitative Research Using R: A Systematic Approach*, eds. Y. Chandra and L. Shang (Singapore: Springer Nature), 91–106. doi: 10.1007/978-981-13-3170-1_8

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

Cheikhyoussef, A., Shapi, M., Matengu, K., and Ashekele, H. M. (2011). Ethnobotanical study of indigenous knowledge on medicinal plant use by traditional healers in Oshikoto region, Namibia. *J. Ethnobiol. Ethnomedicine* 7:10. doi: 10.1186/1746-4269-7-10

Chigwada, J., and Ngulube, P. (2023). Stakeholders in the acquisition, preservation, and dissemination of indigenous knowledge projects. *Inf. Dev*. 02666669231192851. doi: 10.1177/02666669231192851

Chukwuone, N. A., Adeosun, K. P., and Chukwuone, C. A. (2020). Socioeconomic factors affecting households' use of indigenous forest management practices in managing non-wood forest products: evidence from forest communities in Nigeria derived savannah. *Heliyon* 6 :e05281. doi: 10.1016/j.heliyon.2020.e05281

Cohen, N., and Arieli, T. (2011). Field research in conflict environments: methodological challenges and snowball sampling. *J. Peace Res.* 48, 423–435. doi: 10.1177/0022343311405698

Djagoun, C. A. M. S., Zanvo, S., Padonou, E. A., Sogbohossou, E., and Sinsin, B. (2022). Perceptions of ecosystem services: a comparison between sacred and non-sacred forests in central Benin (West Africa). *For. Ecol. Manag.* 503:119791. doi: 10.1016/j.foreco.2021.119791

Donato-Kinomis, X. (2016). *Indigenous Knowledge Systems and Practices in Teaching Science*. Mandaluyong City.

Ekwueme, C. S., and Onah, T. C. (2019). The influence of modernity on igbo traditional religion and cultural values. *Int. J. Manag. Soc. Sci. PEACE Confl. Stud.* 2.

Eyong, C. T. (2007). *Indigenous Knowledge and Sustainable Development in Africa: Case Study on Central Africa*.

Fabiano, E., Schulz, C., and Martín Brañas, M. (2021). Wetland spirits and indigenous knowledge: implications for the conservation of wetlands in the Peruvian Amazon. *Curr. Res. Environ. Sustain.* 3 :100107. doi: 10.1016/j.crsust.2021.100107

Fahmy, M. F., and Aboelmagd, A. (2024). The symbolism of the Crocodile under the Tree in Ancient Egypt. *Minia J. Tour. Hosp. Res. MJTHR* 18, 28–41. doi: 10.21608/mjthr.2024.304664.1170

Fandohan, A. B., Assogbadjo, A. E., Kakaï, R. G., and Sinsin, B. (2011). Geographical distribution, tree density and fruit production of *Tamarindus indica* L. Fabaceae across three ecological regions in Benin. *Fruits* 66, 65–78. doi: 10.1051/fruits/2010043

Fernández-Llamazares, Á., Lepofsky, D., Lertzman, K., Armstrong, C.G., Brondizio, E.S., Gavin, M.C., et al. (2021). Scientists' warning to humanity on threats to indigenous and local knowledge systems. *J. Ethnobiol.* 41, 144–169. doi: 10.2993/0278-0771-41.2.144

Gbaguii, A., Faouziath, S., Orobiyi, A., Dansi, M., Akouegninou, B., and Dansi, A. (2016). Connaissances endogènes et perceptions paysannes de l'impact des changements climatiques sur la production et la diversité du niébé (*Vigna unguiculata* (L.)Walp.) et du voandzou (*Vigna subterranea* (L) Verdc.) au Bénin. *Int. J. Biol. Chem. Sci.* 9:2520. doi: 10.4314/ijbcs.v9i5.23

Gnansounou, S. C., Sagoe, A. A., Mattah, P. A. D., Salako, K. V., Aheto, D. W., and Glèlè Kakaï, R. (2022a). The co-management approach has positive impacts on mangrove conservation: evidence from the mono transboundary biosphere reserve (Togo-Benin), West Africa. *Wetlands Ecol. Manag.* 30, 1245–1259. doi: 10.1007/s11273-022-09894-0

Gnansounou, S. C., Salako, K. V., Sagoe, A. A., Mattah, P. A. D., Aheto, D. W., and Glèlè Kakaï, R. (2022b). Mangrove ecosystem services, associated threats and implications for wellbeing in the mono transboundary biosphere reserve (Togo-Benin), West-Africa. *Sustainability* 14:2438. doi: 10.3390/su14042438

Gnansounou, S. C., Salako, K. V., Visée, C., Dahdouh-Guebas, F., Glèlè Kakaï, R., Kestemont, P., et al. (2024). The role of local deities and traditional beliefs in promoting the sustainable use of mangrove ecosystems. *For. Policy Econ*. 160:103145. doi: 10.1016/j.forpol.2023.103145

Grey, S. (2014). "Indigenous knowledge," in *Encyclopedia of Quality of Life and Well-Being Research*, ed. A. C. Michalos (Dordrecht: Springer Netherlands), 3229–3233. doi: 10.1007/978-94-007-0753-5_1448

Hari, C. A. (2020). *The Relevance of Indigenous Knowledge Systems in Local Governance toward Environmental Management for Sustainable Development: A Case of Bulawayo City Council*. Laliptur: Zimbabwe. doi: 10.3126/qjmss.v2i1.29024

Heneidy, S., and Waseem, M. (2007). Rehabilitation of degraded coastal Mediterranean rangelands using *Panicum turgidum* Forssk. *Acta Bot. Croat*.

Hernández-Morcillo, M., Hoberg, J., Oteros-Rozas, E., Plieninger, T., Gómez-Baggethun, E., and Reyes-García, V. (2013). Traditional ecological knowledge in Europe: status quo and insights for the environmental policy agenda. *Environ.: Sci. Policy Sust. Dev.* 56, 3–17. doi: 10.1080/00139157.2014.861673

Hill, R., Adem, Ç., Alangui, W. V., Molnár, Z., Aumeeruddy-Thomas, Y., Bridgewater, P., et al. (2020). Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. *Curr. Opin. Environ. Sustain.* 43, 8–20. doi: 10.1016/j.cosust.2019.12.006

Horsthemke, K. (2004). 'Indigenous knowledge' – conceptions and misconceptions. *J. Educ.* 32, 31–35.

Houde, N. (2007). The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. *Ecol. Soc.* 12:2. doi: 10.5751/ES-02270-120234

Hounwanou, R. T. (1984). *Le fa: une géomancie divinatoire du golfe du Bénin (pratique et technique)*. Lomé: Nouvelles Editions africaines.

Huntington, H. (2000). Using traditional ecological knowledge in science: methods and applications. *Ecol. Appl.* 10, 1270–1274. doi: 10.1890/1051-0761(2000)010[1270:UTEKIS]2.0.CO;2

Inman, E. N. (2024). "There are no true himbas anymore": exploring the dynamics of the himba culture and land use in the face of change in Kunene Region, Namibia. *Sustainability* 16:1582. doi: 10.3390/su16041582

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2017). *Work programme of the Platform: Indigenous and Local Knowledge Systems Indigenous and Local Knowledge Systems* (deliverable *1(c)*). Bonn: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2018). *Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Africa of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, eds. E. Archer, L. E. Dziba, K. J. Mulongoy, M. A. Maoela, M. Walters, R. Biggs, et al. (Bonn, Germany: IPBES Secretariat).

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

International Union for Conservation of Nature (2021). *Evaluation et hiérarchisation des menaces portant sur la biodiversité au Bénin*. Gland: Laboraty of Applied Ecology.

Jauhiainen, J. S., and Hooli, L. (2017). Indigenous knowledge and developing countries' innovation systems: the case of Namibia. *Int. J. Innov. Stud*. 1, 89–106. doi: 10.3724/SP.J.1440.101007

Jimoh, S., Emmanuel, T., Alarape, A., Obioha, E., and Adeyemi, A. (2012). The Role of traditional laws and taboos in wildlife conservation in the oban hill sector of cross River National Park (CRNP), Nigeria. *J. Hum. Ecol. Delhi India* 39, 209–219. doi: 10.1080/09709274.2012.11906513

Kakiso, T. (2023). Endangered indigenous knowledge: assessing locally adopted tree conservation practices in Aleta Wondo district, Sidama regional state, Ethiopia. *Heliyon* 9:e15401. doi: 10.1016/j.heliyon.2023.e15401

Kanene, K. M. (2016). Indigenous practices of environmental sustainability in the Tonga community of southern Zambia. *Jàmbá J. Disaster Risk Stud*. 8:7. doi: 10.4102/jamba.v8i1.331

Kibonde, S. (2020). Indigenous knowledge and conservation of medicinal plants in Rungwe district, Tanzania. *OALib J.* 7, 1–10. doi: 10.4236/oalib.1106545

Konstantinidis, G. (2024). *Indigenous Knowledge Systems and Sustainability: Case Studies from Various Indigenous Communities Around the World*.

Kouchade, S. A., Adomou, C. A., Dassou, G. H., and Akoegninou, A. (2017). Facteurs socioculturels et environnementaux déterminant la connaissance des plantes utilisées pour les soins infantiles au Sud du Bénin. *Int. J. Biol. Chem. Sci.* 11, 1272–1287. doi: 10.4314/ijbcs.v11i3.27

Kugara, S., Tapiwa, A., Kugedera, A. T., Chivhenge, E., Museva, T., and Sakadzo, N. (2021). *The Role of Indigenous Knowledge Systems (IKS) in Climate Change In Handbook of Research on Protecting and Managing Global Indigenous Knowledge Systems 2022*. New York, NY: IGIGlobal Publishers. doi: 10.4018/978-1-7998-7492-8.ch001

Lawin, I. F., Laleye, O. A. F., and Agbani, O. P. (2016). Vulnérabilité et stratégies endogènes de conservation des plantes utilisées dans le traitement du diabète dans les communes de Glazoué et Savè au Centre-Bénin. *Int. J. Biol. Chem. Sci*. 10, 1069–1085. doi: 10.4314/ijbcs.v10i3.14

Maffi, L. (2005). Linguistic, cultural, and biological diversity. *Annu. Rev. Anthropol.* 34, 599–617. doi: 10.1146/annurev.anthro.34.081804.120437

Makwara, C. (2013). *Indigenous Knowledge Systems and Modern Weather Forecasting: Exploring the Linkages*.

Mapara, J. (2009). *Indigenous Knowledge Systems in Zimbabwe: Juxtaposing Postcolonial Theory*.

Martin, A., O'Farrell, P., Kumar, R., Eser, U., Faith, D. P., Gomez-Baggethun, E., et al. (2022). "Chapter 5: the role of diverse values of nature in visioning and transforming towards just and sustainable futures," in *Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, eds. M. Christie, P. Balvanera, U. Pascual, B. Baptiste, and D. González-Jiménez (Bonn, Germany: IPBES Secretariat).

Masinde, M., and Bagula, A. (2011). ITIKI: bridge between African indigenous knowledge and modern science of drought prediction. *Knowl. Manag. Dev. J.* 7, 274–290. doi: 10.1080/19474199.2012.683444

Maunganidze, L. (2016). A moral compass that slipped: indigenous knowledge systems and rural development in Zimbabwe. *Cogent Soc. Sci.* 2:1266749. doi: 10.1080/23311886.2016.1266749

Mavhura, E., and Mushure, S. (2019). Forest and wildlife resource-conservation efforts based on indigenous knowledge: the case of Nharira community in Chikomba district, Zimbabwe. *For. Policy Econ.* 105, 83–90. doi: 10.1016/j.forpol.2019.05.019

Maweu, J. M. (2011). Indigenous ecological knowledge and modern western ecological knowledge: complementary, not contradictory. *Thought Pract.* 3, 35–47. doi: 10.4314/tp.v3i2

Mazzocchi, F. (2006). Western science and traditional knowledge: despite their variations, different forms of knowledge can learn from each other. *EMBO Rep.* 7, 463–466. doi: 10.1038/sj.embor.7400693

Mbah, M., Ajaps, S., and Molthan-Hill, P. (2021). A systematic review of the deployment of indigenous knowledge systems towards climate change adaptation in developing world contexts: implications for climate change education. *Sustainability* 13:4811. doi: 10.3390/su13094811

Mekonen, S. (2017). Roles of traditional ecological knowledge for biodiversity conservation. *J. Nat. Sci. Res.* 7:21.

Merceron, T., Clément, T., Gabrié, C., Staub, F., Ba, T., and Traore, M. S. (2024). *State of West African Marine Protected Areas 2022*. Gland, Switzerland: IUCN. doi: 10.2305/BXRM8651

Merçon, J., Vetter, S., Tengö, M., Cocks, M., Balvanera, P., Rosell, J. A., et al. (2019). From local landscapes to international policy: contributions of the biocultural paradigm to global sustainability. *Glob. Sustain.* 2:e7. doi: 10.1017/sus.2019.4

Mukul, S. A., Rashid, A. Z. M. M., and Uddin, M. B. (2012). The role of spiritual beliefs in conserving wildlife species in religious shrines of Bangladesh. *Biodiversity* 13, 108–114. doi: 10.1080/14888386.2012.694596

Nadasdy, P. (1999). The politics of tek: power and the "integration" of knowledge. *Arct. Anthropol.* 36, 1–18.

Ndimande-Hlongwa, N. (1998). A semantic analysis of Zulu surnames. *Nomina Afr.* 12, 88–98.

Nepal, T. (2021). An overview of threats to traditional ecological knowledge. *Int. J. Humanit. Soc. Sci.* 9, 1–4.

Nunan, F., Hara, M., and Onyango, P. (2015). Institutions and co-management in East African inland and Malawi fisheries: a critical perspective. *World Dev.* 70:203–214. doi: 10.1016/j.worlddev.2015.01.009

Orlove, B., Roncoli, C., Kabugo, M., and Majugu, A. (2009). Indigenous climate knowledge in southern uganda: the multiple components of a dynamic regional system. *Clim. Change* 2010, 243–265. doi: 10.1007/s10584-009-9586-2

Osei-Tutu, P. (2017). Taboos as informal institutions of local resource management in Ghana: why they are complied with or not. *For. Policy Econ.* 85, 114–123. doi: 10.1016/j.forpol.2017.09.009

Otamendi-Urroz, I., Quintas-Soriano, C., Hanspach, J., Requena-Mullor, J. M., Lagies, A. S., and Castro, A. J. (2025). Exploring biocultural diversity: a systematic analysis and refined classification to inform decisions on conservation and sustainability. *Ambio* 54, 1581–1597. doi: 10.1007/s13280-025-02168-y

Ouedraogo, I., Oueda, A., Hema, M. E., Shirley, M. H., and Kabre, B. G. (2022). Impact of anthropogenic activities on the abundance of *Crocodylus suchus* (Saint-Hilaire 1807) within the Nazinga Game Ranch, Burkina Faso. *Open J. Ecol.* 12, 788–803. doi: 10.4236/oje.2022.1212046

Oyelude, A. A. (2023). Indigenous knowledge preservation as a sign of respect for culture: concerns of libraries, archives and museums. *Insights* 36:628. doi: 10.1629/uksg.628

Padonou, E. A., Gbaï, N. I., Kolawolé, M. A., Idohou, R., and Toyi, M. (2021). How far are mangrove ecosystems in Benin (West Africa) conserved by the Ramsar convention? *Land Use Policy* 108:105583. doi: 10.1016/j.landusepol.2021.105583

R Core Team (2023). *R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna. [WWW Document]*. Available online at: https://www.r-project.org/ (Accessed Feb 6, 2025).

Redvers, N., Aubrey, P., Celidwen, Y., and Hill, K. (2023). Indigenous peoples: traditional knowledges, climate change, and health. *PLoS Glob. Public Health* 3:e0002474. doi: 10.1371/journal.pgph.0002474

Risiro, J., and Tshuma, T. (2013). *Indigenous Knowledge Systems and Environmental Management: A Case Study of Zaka District, Masvingo Province, Zimbabwe*.

Selemani, I. S. (2020). Indigenous knowledge and rangelands' biodiversity conservation in Tanzania: success and failure. *Biodivers. Conserv.* 29, 3863–3876. doi: 10.1007/s10531-020-02060-z

Senanayake, S. G. J. N. (2006). Indigenous knowledge as a key to sustainable development. *J. Agric. Sci.* 2, 87–94. doi: 10.4038/jas.v2i1.8117

Sillitoe, P., and Marzano, M. (2009). Future of indigenous knowledge research in development. *Fut. Fut. Indig. Knowl.* 41, 13–23. doi: 10.1016/j.futures.2008.07.004

Sinsin, B., Assogbadjo, A. E., Tenté, B., Yo, T., Adanguidi, J., Lougbégnon, T., et al. (2018). *Inventaire floristique et faunique des écosystèmes de mangroves et des zones humides côtières du Bénin (Organisation des Nations Unies pour l'Alimentation et l'Agriculture)*. FAO. Available online at: http://www.fao.org/3/i8402fr/I8402FR.pdf

Sinthumule, N. I., and Mashau, M. L. (2020). Traditional ecological knowledge and practices for forest conservation in Thathe Vondo in Limpopo Province, South Africa. *Glob. Ecol. Conserv.* 22:e00910. doi: 10.1016/j.gecco.2020.e00910

Sunkur, R., Kantamaneni, K., Bokhoree, C., and Ravan, S. (2023). Mangroves' role in supporting ecosystem-based techniques to reduce disaster risk and adapt to climate change: a review. *J. Sea Res.* 196, 1385–1101. doi: 10.1016/j.seares.2023.102449

Tamene, S., Negash, M., Makonda, F. B., and Chiwona-Karltun, L. (2024). Influence of socio-demographic factors on medicinal plant knowledge among three selected ethnic groups in south-central Ethiopia. *J. Ethnobiol. Ethnomed.* 20:29. doi: 10.1186/s13002-024-00672-1

Teka, O., Houessou, L. G., Djossa, B. A., Bachmann, Y., Oumorou, M., and Sinsin, B. (2019). Mangroves in Benin, West Africa: threats, uses and conservation opportunities. *Environ. Dev. Sust.* 21, 1153–1169. doi: 10.1007/s10668-017-0075-x

Tharakan, J. (2017). *Indigenous Knowledge Systems for Appropriate Technology Development*. London. doi: 10.5772/intechopen.69889

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *Am. J. Eval.* 27, 237–246. doi: 10.1177/1098214005283748

United Nations (2020). *Indigenous Peoples at the United Nations | Division for Inclusive Social Development (DISD) [WWW Document]*. Available online at: https://social.desa.un.org/issues/indigenous-peoples/indigenous-peoples-at-the-united-nations (Accessed Feb 6, 2024).

United Nations Educational Scientific and Cultural Organization (2018). *Mono - Man and the Biosphere Programme (MAB) [WWW Document]*. Available online at: https://www.unesco.org/en/mab/mono-0 (Accessed Feb 6, 2024).

United Nations Environment Programme (2017). *Indigenous people and nature: a tradition of conservation [WWW Document]*. Avaiable online at: https://www.unep.org/news-and-stories/story/indigenous-people-and-nature-tradition-conservation (Accessed December 12, 2024).

Usó-Doménech, J. L., and Nescolarde-Selva, J. (2016). What are belief systems? *Found. Sci.* 21, 147–152. doi: 10.1007/s10699-015-9409-z

Utete, B. (2021). A review of the conservation status of the Nile crocodile (*Crocodylus niloticus* Laurenti, 1768) in aquatic systems of Zimbabwe, Global Ecology and *Conservation* 29, 2351–9894. doi: 10.1016/j.gecco.2021.e01743

Weber, E. J. W., and Barron, E. S. (2023). Coloniality and indigenous ways of knowing at the edges: emplacing Earth kin in conservation communities. *N. Z. Geogr.* 79, 132–137. doi: 10.1111/nzg.12367

Williams, P., Sikutshwa, L., and Shackleton, S. (2020). Acknowledging indigenous and local knowledge to facilitate collaboration in landscape approaches—lessons from a systematic review. *Land* 9:331. doi: 10.3390/land9090331

World Bank (2017). *Réserve de Biosphère transfrontalière du Delta du Mono*. Washington, DC: World Bank.