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A Review Paper

A Review on Oromo Traditional Ecological Knowledge: A Beacon for Sustainable Conservation

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Abstract

This review examines the scope and significance of Oromo Traditional Ecological Knowledge (TEK) and its relevance to contemporary biodiversity conservation. Grounded in the Indigenous Gadaa system and the ethical principle of Safuu, Oromo TEK offers a holistic framework that integrates ecological, spiritual, and governance dimensions. A qualitative synthesis was conducted using thematic content analysis of over 100 sources, including peer reviewed articles, ethnographies, institutional reports, and grey literature. The literature was retrieved through systematic searches in databases such as JSTOR, Scopus, and Google Scholar, focusing on TEK related practices and conservation values. The analysis revealed key practices such as seasonal grazing (Caffaa), agroforestry, sacred grove preservation (Caaysa), selective harvesting, traditional fire management, and beekeeping. Spiritual rituals like Irrecha and the Gadaa governance system were found to reinforce sustainable land use, biodiversity protection, and community resilience. Despite its effectiveness, Oromo TEK faces threats from epistemic marginalization, colonial legacies, climate change, and exclusion from formal policy frameworks. Looking forward, integrating Oromo TEK with scientific conservation offers a promising pathway for inclusive, adaptive, and culturally grounded environmental governance. Future efforts should prioritize community led documentation, gendered knowledge transfer, digital archiving, and incorporation of TEK into education and policy. Co-production of knowledge with Indigenous communities can strengthen ecosystem stewardship, enhance climate resilience, and ensure the long term survival of biocultural heritage. By recognizing Oromo TEK as a dynamic and living system, conservation can move beyond top-down models toward more equitable and sustainable outcomes.

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1. Introduction

The Oromo make up the majority of Ethiopia's population and are the most populous ethno Nation in Northeast Africa (ESS, 2024). They speak the Cushitic branch of the Oromo language, known as Afaan Oromoo (Oromo Language), which, after Arabic, Swahili, and Hausa, is the fourth most spoken language in Africa (Lodhi, 1993). From the middle of the sixteenth century to the middle of the nineteenth century, the Oromo dominated their lands, and no one from any civilization could exert pressure upon them (Tibebu, 1995). Pastoralism and agriculture were both part of their ancient way of life, which showed a great regard and awareness of the natural environment (Gebretsadik, 2023). Though Christianity and Islam had influence, the traditional Oromo practice that is a form of monotheism with a high god called Waaqa has persisted until today (Rikitu, 1998; Megersa, 2005).

The Oromo people of Ethiopia have a rich ecological knowledge system, deeply rooted in their traditional Gadaa system, which has significantly contributed to biodiversity and ecosystem conservation (Nagara, 2018; Tuma, 2018; Gabayo, 2020; Bedada, 2021). The Gadaa system is a complex socio political and cultural institution that governs various aspects of Oromo life, including environmental management, recognized by UNESCO as an intangible cultural heritage (UNESCO, 2016). The Oromo worldview is anchored in the concept of "Safuu," which represents the interconnectedness of all elements of nature, including humans (Megersa, 2005; Kelbessa, 2005). This holistic perspective fosters respect for the environment and promotes sustainable practices that maintain ecological balance (Kelbessa, 2005, 2014).

Traditional Ecological Knowledge (TEK) is a cumulative, adaptive system of knowledge, practices, and beliefs developed over generations through cultural transmission and lived experience (Gadgil et al., 2000; Berkes, 2012). It encompasses language, naming and classification systems, resource use practices, social norms, and spiritual values (UNESCO, 2002). TEK is dynamic, place specific, and holistic, often integrating ethical and spiritual dimensions in understanding ecosystems and human–environment interactions (Tengo et al., 2014). Its emphasis on relational knowledge and adaptability underscores its importance in biodiversity conservation and sustainable development.

TEK represents the cumulative wisdom of indigenous communities regarding plants, animals, and ecosystems, developed over generations through close interaction with nature. TEK promotes sustainable resource use, biodiversity conservation, and climate resilience, often resulting in lower deforestation rates and healthier ecosystems (Alves et al., 2022). For instance, the Kayapo of Brazil have safeguarded Amazonian biodiversity for centuries (Allegretti, 2005), while the Gamo people of Ethiopia use terracing, crop rotation, and agroforestry to sustain soil fertility and biodiversity (Samberg et al., 2010). Similarly, the Maasai of Kenya and Tanzania apply rotational grazing and selective breeding to manage livestock (Kereto et al., 2022), and the Oromo possess a deep knowledge system guiding environmental stewardship (Alemayehu & Doda, 2020).

TEK also strengthens cultural identity and empowers communities to adapt to climate variability (Nutall, 2007; Harisha et al., 2016). However, modernization, formal education, urbanization, and climate change threaten TEK's continuity. These forces can disconnect younger generations from traditional practices and devalue indigenous knowledge systems (Berkes, 2012; Dawson et al., 2021). Urban development and ecosystem degradation further hinder the transmission of TEK (Tengö & Belfrage, 2020). Integrating TEK with scientific approaches fosters inclusive, resilient environmental management

and supports both cultural preservation and biodiversity (Gadgil et al., 2000; Tengö et al., 2014).

Ecosystem degradation and biodiversity loss are significant environmental issues that threaten the foundation of life on Earth (Barnosky et al., 2011; Arora et al., 2018). Biodiversity loss is the rapid decline in the diversity of life on Earth, including plants, animals, and microorganisms (Cardinale et al., 2012). Ecosystem degradation is a threat to the general health, structure, or function of an ecosystem, caused by factors like pollution, habitat loss, and climate change (Klappenbach, 2020). These problems have extensive ramifications, including impacting human wellbeing, food security, and health (Kilpatrick et al., 2017). The United Nations Biodiversity Convention aims to slow humanity's war with nature, while healthy ecosystems are essential for economic endeavors like fishing, tourism, and agriculture (UNCED, 1992; Kilpatrick et al., 2017). Planetary health and stable ecosystems are crucial for controlling water cycles, preventing global warming, and preserving soil fertility (Nyssen et al., 2009; UNEP, 2021).

The Oromo communities in Ethiopia have a rich traditional ecological knowledge (TEK) that is crucial for biodiversity conservation and ecosystem health. They have a deep understanding of ecological relationships and sustainable resource management practices (Chibsa, 2010; Alemayehu &Doda, 2020; Beyene & Bellis, 2020). However, the publication of an organized review of Oromo TEK for sustainable conservation is scant. This paper aims to review the insights and practices of Oromo TEK, highlighting their potential for effective conservation and the argument for integrating this knowledge with modern scientific approaches for more culturally sensitive strategies.

2. Materials and Methods

2.1. Data collection

The literature was retrieved through systematic searches in databases. Over 100 relevant sources were retrieved through comprehensive searches in academic databases, including JSTOR, Web of Science, Scopus, Google Scholar, and PubMed. Additionally, governmental and institutional repositories, such as the Ethiopian Science and Technology Commission (ESTC) and various university digital libraries, were consulted.

The search strategy employed a combination of keywords, including “Oromo culture,” “traditional ecological knowledge,” “ethnobotany,” “ethnoecology,” “rangeland management,” “agriculture,” “forestry,” “water management,” “climate change,” “conservation,” and “sustainable development.” Literature was screened based on predefined inclusion and exclusion criteria. Only materials that specifically focused on Indigenous ecological practices among the Oromo or closely related Cushitic speaking groups were included. Priority was given to works published in English between 1990 and 2024 to ensure both historical and contemporary relevance.

Studies were excluded if they lacked empirical grounding, did not center on TEK or Oromo communities, or were duplicates across platforms. For example, general reviews of Indigenous knowledge systems retrieved from Web of Science (e.g., Berkes, 1993; Gadgil et al., 1995) were excluded unless they made direct reference to East African or Oromo contexts. Low quality or methodologically outdated entries, particularly those from Google Scholar, were filtered out during a credibility assessment phase. The final dataset was analyzed thematically to extract patterns related to ecological practices, ethical principles, institutional frameworks, and conservation implications within Oromo TEK.

2.2. Data analysis

The review employed a qualitative synthesis approach to analyze and integrate data regarding

Oromo TEK from multiple scholarly sources. The process included thematic content analysis of books, peer reviewed journal articles, institutional reports, and grey literature. The identified materials were assessed for credibility, applicability, and contextual alignment with the review's objectives.

Thematic coding was used to extract recurring concepts, practices, and principles associated with Oromo TEK, particularly focusing on its environmental, governance, and spiritual dimensions. Comparative analysis was employed to evaluate the intersections and distinctions between Oromo TEK and modern scientific conservation frameworks. This facilitates the identification of complementary strategies and integration pathways

An interpretive synthesis was used to organize the findings into logical domains, such as core TEK principles, ecological applications, institutional frameworks (such as the Gadaa system), and conservation implications. Through this synthesis process, the sociopolitical challenges to Oromo TEK's integration into contemporary conservation paradigms as well as its practical advantages were both expressed.

3. Results and Discussions

3.1. Core Principles of Oromo TEK

The Oromo people possess a rich cultural heritage rooted in a deep reverence for the natural world. Their TEK, encompassing beliefs, behaviors, and social institutions, reflects this relationship and contributes significantly to biodiversity conservation (Kumsa, 1997; Berkes, 2012; Bekele, 2015). This knowledge system is not only spiritual and philosophical but also practical, informing sustainable environmental practices that maintain ecological balance and community well being.

Oromo TEK is grounded in the belief that all elements of nature, plants, animals, rivers, mountains, and forests are interconnected and sacred. Nature is viewed as a living entity deserving of respect and protection (Kassam & Gemechu, 1994; Kassaye, 2018). This worldview encourages an ethical approach to resource use, guided by the principle of Safuu, which promotes harmony between humans and their environment.

The Oromo people follow a holistic perspective that recognizes the intrinsic value of all life forms and supports the sustainable use of natural resources (Kelbessa, 2005, 2010). Their practices such as rotational grazing, controlled burning, and selective harvesting reflect sophisticated systems of resource management that allow regeneration and long-term ecological resilience (Legesse, 2000; Tesema et al., 2006).

Equally important is the principle of intergenerational equity, which emphasizes the responsibility to preserve natural resources for future generations. The Oromo pass down ecological knowledge through oral traditions, rituals, and customary laws that reinforce stewardship and sustainable practices (Kelbessa, 2001, 2014).

Spirituality also plays a central role. Natural features such as trees, rivers, and mountains are often regarded as sacred, and rituals and ceremonies reaffirm the Oromo’s spiritual connection to the land (Kelbessa, 2005; Annette, 2011). This spiritual reverence reinforces the ethical obligations embedded in their environmental practices.

Over generations, the Oromo have accumulated and transmitted ecological knowledge through lived experience and cultural observation (Getahun, 2016; Kassaye, 2018). This knowledge forms the foundation of their environmental ethics and guides daily interactions with the landscape

Together, these principles demonstrate a profound environmental ethic and a culturally embedded framework for conservation. Understanding these foundational values is essential for appreciating the depth of Oromo TEK and its potential to inform sustainable resource management and biodiversity protection in Ethiopia and beyond.

3.2 Key Domains and Conservation Applications of Oromo TEK

3.2.1 Seasonal Grazing Practices “Caffaa”

The Oromo people have traditionally practiced a form of pastoralism where their herds are moved between grazing areas on a regular basis. This transhumance system prevents overgrazing in any one area while also permitting pasture regeneration (Alemayehu & Doda, 2020; Gabayo, 2020).

The Caffa system, a traditional Oromo grazing method that includes seasonal rotation and regulated herd sizes, helps to preserve soil health and stop land degradation. These techniques help to maintain the balance of vegetation, prevent overgrazing, and promote the regeneration of grasslands, which supports the biodiversity of flora and fauna (Negatu, 2011; Kassaye, 2018; Gabayo, 2020). For instance, compared to continuously grazed areas, areas managed by Oromo pastoralists showed lower erosion and a higher soil organic matter content (Desta et al., 2004). This demonstrates how well these methods work to encourage sustainable land use.

By rotating cultivation plots and allowing fallow periods, the Caffa system creates a mosaic of land at various stages of regeneration (i.e., promotes habitat heterogeneity). Compared to monoculture farming, a greater variety of plant and animal species can find refuge and resources in these diverse habitats. Oromo farmers use sustainable agricultural practices, such as terracing and crop rotation, to prevent soil erosion and maintain soil fertility. Leaving land fallow allows for the natural decomposition of organic matter, enriching the soil and promoting healthy plant growth. This, in turn, supports diverse populations of soil organisms and improves soil health, which is crucial for a functioning ecosystem (Dagnachew et al., 2019; Gabayo, 2020).

3.2.2. Sacred Groves ("Caaysa")

The Oromo people have a custom of establishing protected zones or sacred groves in which human activity is limited or controlled. These places help to preserve biodiversity by acting as refuges for a variety of plant and animal species (Kelbessa, 2001; Sinha et al., 2011; Mergo, 2014; Berkes, 2012; Berhanu, 2017). According to studies, compared to unprotected areas, sacred groves (also known as "caaysa") have substantially higher biodiversity. A study that took place in southwestern Ethiopia reported that sacred groves contained a much richer diversity of plant species compared to nearby disturbed areas (Wassie et al., 2009; Admassie et al., 2020). This suggests that these protected areas serve as crucial refuges for various plant life.

Sacred groves provide vital habitat for numerous animal species. Many studies have found that the diversity of bird species in sacred groves is higher than that of the adjacent farmlands (Kühnert et al., 2019; Benedetti et al., 2021; Bhagwat et al., 2005). This demonstrates how ranges of animal populations are supported by these groves. The strict bans on human activity within Waqeffanna, the indigenous religion of the Oromo people, protect these areas from habitat destruction, including deforestation and overgrazing (Kelbessa, 2005; Annette, 2011; Bekele, 2015). This allows mature forests with complex ecosystems that support a wide variety of plants and animals to grow unhindered. Furthermore, sacred locations in fragmented habitats can act as stepping stones or connecting corridors, promoting gene flow and movement.

3.3. Oromo Agroforestry Practices

The Oromo people's centuries old agroforestry techniques provide a unique and sustainable approach to land management in the Horn of Africa. Oromo agroforestry systems integrate a variety of tree species with crops and cattle to produce diverse and productive landscapes (Tesemma, 2007; Asfaw & Lemenih, 2010). This integration promotes ecological balance and reduces vulnerability to diseases and pests (Lemenih & Kassa, 2014).

Oromo agroforestry practices are based on traditional ecological knowledge (Berkes et al., 2000; Tesemma, 2007). This information guides tree species selection and management, guaranteeing that they are appropriate for local climates and customs (Lemenih & Kassa, 2014; Tesemma, 2007). Lemenih & Kassa (2014) state that Oromo agroforestry practices significantly contribute to soil and water conservation. Several studies emphasize that Oromo agroforestry systems encourage diverse vegetation structure that supports a range of plant and animal species, aiding in biodiversity conservation (Kelbessa, 2005; Tesema, 2007; Lemenih & Kassa, 2014; Bekele, 2015). Additionally, this biodiversity supports pollination and natural pest control (Tesemma, 2007; Asfaw & Lemenih, 2010). Local livelihoods are supported by the variety of goods and services offered by Oromo agroforestry systems (Lemenih & Kassa, 2014; Mebrate et al., 2021). While livestock and crops help to generate revenue and provide food security, trees supply timber, fuelwood, fodder, fruits, and other non-timber forest products (Tesemma, 2007; Asfaw & Lemenih, 2010). Tesemma (2007) highlights that trees promote water infiltration and retention through their deep roots and serve as windbreaks, which reduce soil erosion.

The successful application of Oromo agroforestry techniques is hampered by challenges such as restricted market access, problems with land tenure, and a lack of expertise and know how (Lemenih & Kassa, 2014; German et al., 2010). Clear land rights and laws, capacity building programs, and improved infrastructure can help remove these obstacles and promote long term investments in agroforestry practices in the Horn of Africa (German et al., 2010; Mebrate et al., 2021).

3.3.1 Selective Harvesting and Sustainable Use

Oromo customs and values are centered on respect for nature and the interdependence of all living things (Hoben, 1995; Berkes, 2012). This respect directs their use of resources, ensuring that harvesting is done in a way that maintains the long-term productivity and health of ecosystems (Berkes et al., 2000). Tesemma (2007) claims that Oromo communities practice selective harvesting, taking only mature members of a species and leaving enough for regrowth. This approach preserves biodiversity and ensures that resources will be available for future generations (Dalle et al., 2006).

Indigenous knowledge and traditional ecological awareness form the foundation of Oromo customs (Hoben, 1995; Berkes, 2012). This information ensures the sustainable use of resources by guiding the selection of species, timing, and harvesting techniques (Warren, 1991). This information helps in ensuring that resources are used sustainably.

Oromo communities usually create clear laws, such as "kill only enough for food" and "take only what you need," to remind them not to overhunt, overharvest, or overfish in order to guarantee equitable access and prevent overexploitation (Tesemma, 2007; Asfaw & Lemenih, 2010). Customary law is often the source of these rules, which are enforced by institutions ingrained in the community (Bedada, 2021). Accordingly, Oromo communities (Hoben, 1995; Teklehaymanot, 2009) use all fuelwood, building materials, food, medicine, and other natural resources. This range

of uses reduces the strain on any one resource and promotes sustainable management practices.

Oromo selective harvesting practices contribute to biodiversity conservation by maintaining a range of ecosystems and species populations (Tesemma, 2007; Bekele, 2015). This diversity enables many ecosystem services, including water regulation, pest control, and pollination (Benedetti et al., 2021). Oromo practices ensure the long-term sustainability of natural resources by preventing overexploitation and promoting regeneration (Hoben, 1995; Berkes et al., 2000). This approach ensures that resources will be available for future generations and supports environmental sustainability.

Oromo communities rely on natural resources for their livelihoods, and sustainable harvesting practices provide them with a consistent supply of food, money, and other essentials (Dalle et al., 2006; Tesemma, 2007). This contributes to food security and poverty reduction in rural areas (Asfaw & Lemenih, 2010). The Oromo people's selective harvesting methods are deeply rooted in their cultural identity and traditional beliefs (Hoben, 1995; Bekele, 2015). These traditions serve as an archive of traditional wisdom and assist in the preservation of cultural heritage.

Demand from population growth may affect natural resources, making sustainable collection methods more difficult (Tesemma, 2007; Teklehaymanot, 2009). Effective resource management requires modifying traditional approaches and creating novel solutions (Berkes et al., 2000). Overexploitation and unsustainable harvesting methods may result from the commercial demand for some natural resources (Hoben, 1995; Asfaw & Lemenih, 2010). Controlling commercial harvesting and ensuring adherence to community-based management techniques are essential.

The impact of climate change on the availability and distribution of natural resources may present challenges for sustainable harvesting practices (Dalle et al., 2006; Tesemma, 2007). Promoting climate resilient resource management and adapting practices to changing environmental conditions are essential (Berkes, 2012).

3.3.2 Oromo Beekeeping Practices

Beekeeping among the Oromo serves both ecological and economic roles by supporting crop pollination, enhancing biodiversity, and providing honey as a nutrient rich food and income source (Lietaer, 2009; Ayana, 2018; Dekebo et al., 2019). Rooted in traditional knowledge, Oromo beekeeping practices promote sustainable honey production, habitat preservation, and the protection of bee colonies (Gemeda et al., 2022). Hives are typically placed near natural forests, helping maintain flowering plant diversity and prevent deforestation (Dekebo et al., 2019). These practices contribute to ecosystem health and community livelihoods by reducing poverty and improving dietary diversity. However, they are increasingly threatened by habitat loss and modernization. Integrating traditional knowledge with sustainable practices offers a path to conserving bee populations and biodiversity while enhancing rural resilience (Chala et al., 2012; Ayana et al., 2023).

3.3.3 Traditional Fire Management

The Oromo pastoralist lifestyle relies heavily on diverse grazing lands maintained through traditional fire management. Controlled burning clears excess vegetation, stimulates fresh, nutrient rich grass growth, attracts herbivores, and maintains habitat diversity (Tessema et al., 2006; Oba, 2009; Laris, 2011). These practices, rooted in Oromo environmental ethics, help reduce wildfire risks, enhance pasture quality, and support biodiversity (Keno, 2021; Assefa et al., 2020). Periodic burning also limits woody plant

encroachment, preserving the balance between grasslands and woodlands essential for sustainable pastoral livelihoods (Teshome et al., 2018). Methods include clearing brush, reducing fuel loads, and promoting grassland regeneration. However, the success of these practices depends on proper timing and technique, as mismanagement can lead to ecological damage and uncontrolled fires. Therefore, safeguarding traditional knowledge and transferring it to younger generations is crucial for ensuring the continued benefits of this system (Hunde et al., 2017; Asfaw et al., 2013).

3.3.4 Water Conservation in the Context of "Irrecha"

Oromo TEK places a strong emphasis on conserving water resources and maintaining a harmonious relationship with nature (Baxter, 2000; Berhanu, 2017). Building water reservoirs and safeguarding watersheds are examples of traditional practices that are frequently led by indigenous institutions such as the Gadaa system (Tesemma, 2007; Bedada, 2021). This is demonstrated by the yearly Irrecha Thanksgiving ceremony, which represents appreciation for Waaqa's (God's) gifts and a restoration of ecological harmony (Bekele, 2015). According to the Oromo belief system, the community's prudent management of natural resources, especially water, reflects their respect for Waaqa, a high God connected to the sky, rain, and fertility (Baxter, 2000; Berkes, 2012).

As evidenced by the celebration of Irrecha after the spring harvest, Oromo environmental values are deeply embedded in cultural expressions. Reaffirming the sacredness and usefulness of water, ritual cleansing with water symbolizes spiritual renewal (Bekele, 2015). By strengthening the link between water, sustenance, and divine favor, offerings made to Waaqa during Irrecha ceremonies promote sustainable use. The wealth of indigenous ecological knowledge may help the region's current approaches to sustainable management of water resources (Baxter, 2000; Berkes et al., 2000). Sacred groves, protected forest areas with little human activity, were also reported to provide clean water. Oromo pastoralists adhere to traditional grazing paths to maintain vegetation cover and prevent overgrazing close to significant water sources in order to maintain hydrological integrity (Belayneh, 2016).

3.3.5 The Oromo Gadaa System: A Social Framework for Environmental Stewardship

The Oromo people have long practiced the Gadaa system, a complex sociopolitical organization. It has a cyclical leadership structure that promotes collective governance and accountability by distributing authority among age-based groups every eight years (Legesse, 1973, 2000; Baxter, 2000; Jalata, 2012; Geleta, 2020). This system guarantees that leaders are people with years of experience and a thorough understanding of sustainable resource management, and it is based on indigenous ethical standards (Beyene & Bellis, 2020; Assefa & Birmeta, 2021). Certain societal responsibilities, such as environmental stewardship through afforestation, soil conservation, and water management techniques, are delegated to different age groups (Hassen, 2018; Megerssa, 2005; Getahun, 2016).

In the Gadaa hierarchy, elders have a great deal of power and make decisions based on long term ecological sustainability. They carry out and uphold traditional practices that support biodiversity conservation and ecosystem resilience, such as riverbank management, rotational grazing, and sacred grove preservation (Chibsa, 2010; Tiki et al., 2014). For example, Heera Bosonaa (Laws of the Forest), a set of rules intended to protect forest resources by prohibiting unauthorized tree cutting and punishing violators, is a crucial Indigenous Knowledge element within the Gadaa framework among the Hararghe Oromo,

strengthening community-based conservation ethics (Beyene & Bellis, 2020; Tura, 2014).

The Gadaa system also contributes significantly to conflict resolution and maintaining social cohesion through equitable resource distribution and dispute resolution processes (Jalata, 2012; Tiki et al., 2014; Hassen, 2018). Modern political and legal systems, shifting land uses, and generational shifts are all putting pressure on it, though. It requires integrated documentation, cultural education, and policy support to remain relevant for sustainable development and biodiversity conservation (Berkes, 2012; Megerssa, 2005; Assefa & Birmeta, 2021).

3.3.6. Oromo Spirituality and Environmental Protection

The spirituality of TEK is based on the concept of "Ayyaana," a spiritual force that governs the natural world. It emphasizes the interconnectedness of all living beings and the importance of maintaining ecological balance (Megersa, 2005; Kelbesa, 2005, 2010, 2014). Key principles include: respect for all forms of life, including plants, animals, and water sources, avoidance of overexploitation and pollution conservation of sacred sites and natural resources, and contributions to biodiversity conservation (Ta'a, 2012; Kassaye, 2018; Alemayehu & Doda, 2020).

According to a study conducted among the Hararge Oromo in eastern Ethiopia, five fundamental principles of prayer that treat God, women, and environmental subjects equally address harmony and strong interaction among all living environments. According to Beyene & Bellis (2020), these are Waaqni wayyu (the God is respectful), Lafti wayyu (the Earth is respectful), Dubartiin wayyu (the female is respectful), Gaarri wayyu (the mountain is respectful), and Lagni wayyu (the river is respectful). This spiritual bond encourages resource conservation and deters behavior that could upset the ecosystem's balance (Kelbesa 2010, 2014). A sense of reverence for nature is fostered by the belief that Waaqa is the creator. The creation of Waqeffanna, a designated area protected for religious reasons, reflects this. Numerous plant and animal species are preserved in these sanctuaries, which turn into havens for biodiversity.

Tree symbolism, a belief that reveals forests and trees belong to God, humanity, and wild creatures, contrasts with a utilitarian perspective that emphasizes the immediate benefits that trees would provide in terms of monetary values or other services. This belief has coincided with the idea that there are inextricable links between natural features, cultural elements, and supernatural views (Roba, 2019, 2021). Some natural trees, such as *Cordia africana* Lam., *Euclea divinorum* Hiern, and *Maesa lanceolata* Forssk., among Guji Oromos, are symbolically linked to a number of indigenous practices and events, such as the ritual of avoiding bad omens, the ceremonial of idiotism, the resolution of homicide cases, and the display of legendary power (Roba, 2021). Despite certain man-made threats, the strong bond between local customs and native trees has been strengthened by the symbolic association between native trees and indigenous rituals (Regassa et al. 2019). Therefore, understanding a century of ecologically conscious human activity and protecting native trees depends heavily on the culture of tree symbolism (Oviedo et al. 2005; Singh 2017).

3.3.7 Ethnobiological Knowledge

The Oromo people's deep relationship with their environment is reflected in their TEK, which encompasses extensive botanical and ecological insights (Kassam, 2009; Berhanu, 2017). This knowledge not only supports biodiversity conservation but also reveals intricate ecosystem relationships (Bekele, 2015; Berkes, 2012). Oromo TEK includes over 300 medicinal plant

species used to treat illnesses ranging from minor ailments to serious conditions like malaria (Giday et al., 2009). For example, *Ruta chalepensis* is used for wounds, and *Tagetes minuta* for intestinal ailments. Additionally, more than 50 wild edible plants are consumed, especially in times of food scarcity (Addis et al., 2005), highlighting their role in nutrition and food security.

Plants also hold spiritual significance. *Juniperus procera* and *Olea europaea* subsp. *cuspidata* are used for purification, while *Commiphora myrrha* and *Boswellia papyrifera* are burned as ceremonial offerings. Coffee (*Coffea arabica*) is central to prayers and rituals, and *T. minuta* is believed to offer protection when planted near homes (Jima & Bekele, 2019).

Animals are equally important in Oromo TEK. Cattle symbolize wealth, while camels serve as transport, and elephants represent fertility. Animal products are used medicinally, and livestock health is maintained with plant-based remedies (Kumsa & Abebe, 2009). Insects such as termites and caterpillars are valued as food and livestock feed. Bees are essential for honey, and insects are recognized for their ecological roles and symbolic meanings in folklore (Yirgu, 2016; Losey & Vaughan, 2006).

3.3.8 Oromo TEK Against Climate Change

Oromo TEK promotes the planting of trees and the conservation of forests, which act as carbon sinks and contribute to climate change mitigation (Berkes et al., 2000; Bekele, 2015; Mekonnen & Taye, 2016; Berhanu, 2017). Climate change poses a significant threat to Ethiopia's environment and the livelihoods of the Oromo people (Simane et al., 2017; IPCC, 2014).

Nonetheless, Oromo TEK, which has its roots in the idea of living in balance with the environment, provides insightful ideas that can support initiatives to mitigate climate change (Baxter, 2000; Bedada, 2021). Traditional Oromo methods, such as rotational grazing in the lowlands and terracing in the highlands, for instance, improve soil health and stop erosion. According to Hurni et al. (2006) and Tesemma (2007), this lessens land degradation, a significant cause of greenhouse gas emissions. Oromo communities' sacred groves, or "caaysa," are frequently home to a wide variety of trees. These sanctuaries serve as organic barriers against climate extremes and aid in the sequestration of carbon (Mekonnen & Taye, 2016; Benedetti et al., 2021).

Oromo communities have been able to understand seasonal changes and weather patterns for generations (Orindi & Nyong'o, 2007; Berkes, 2012). In light of a changing climate, this information may be essential for modifying resource management plans and agricultural methods. However, communities and policymakers must work together and communicate effectively in order to integrate Oromo TEK with scientific climate change mitigation strategies (Berkes et al., 2000; Tesemma, 2007). Likewise, acknowledging the importance of TEK systems and enabling Oromo communities to engage in decision making can result in more culturally relevant and long-lasting solutions (Berhanu, 2017; Bedada, 2021). Therefore, we can build a more resilient future for the Oromo people and the environment by bridging the gap between traditional wisdom and scientific approaches.

3.3.9 Community Based Conservation; Stewardship and Management

Traditional wisdom and cultural norms are the foundation of the Oromo community's strong sense of stewardship for their lands. Institutions of traditional governance, especially the Gadaa system, support sustainable land management techniques, fair access to natural resources, and group decision making (Megersa, 1993; Kelbessa, 2005; Abdu & Robinson, 2017). Members of

society are instilled with a sense of ecological responsibility and accountability, and this community-oriented model reinforces environmental ethics.

Empirical studies have shown that such community-based approaches can produce significant conservation results. For example, studies conducted in Bale, Ethiopia, show that conservation initiatives led by the Oromo community were effective in halting illegal logging and safeguarding significant wildlife corridors, thereby preserving biodiversity and bolstering local livelihoods (Bassi & Abbink, 2018). In other parts of Ethiopia, it has been demonstrated that combining participatory forest management techniques with regional customs enhances ecological resilience and social cohesion (Gebrehiwot et al., 2019). These findings highlight the significance of indigenous institutions in achieving sustainable natural resource governance.

3.4. Comparative analysis of Oromo TEK and Modern Science

As presented in Table 1, Oromo TEK emphasizes the interconnection of all living things and sees the environment as a networked system. This all-encompassing viewpoint encourages sustainable practices and a profound comprehension of ecological linkages (Ayana, 2018). The cultural and spiritual beliefs of the Oromo people are fundamental to Oromo TEK. This knowledge, which has been gathered and transmitted throughout generations, provides important insights on local ecosystems and how to manage them (Hunde, 2017; Tsegaye, 2020). Over millennia, Oromo TEK has changed to adapt to shifting environmental circumstances. Communities can modify their methods to guarantee long term sustainability owing to this adaptability (Oba, 2009; Tolera, 2024).

However, due to its oral transmission and lack of documentation, a large portion of Oromo TEK is vulnerable to loss and misinterpretation (Ayana & Hunde, 2021; Gemechu & Tsegaye, 2022). Cultural practices and beliefs can have an impact on traditional knowledge systems, which may result in biases and inaccuracies (Oba & Tolera, 2013; Hunde and Tsegaye, 2014). Despite years of testing and improvement, Oromo TEK frequently lacks the thorough scientific evidence needed by contemporary science (Ayana et al., 2023; Tolera et al., 2024).

Table 1. Key distinctions between Oromo Traditional Ecological Knowledge (TEK) and modern science

Feature	Oromo TEK	Modern Science	References
Approach to the environment	Holistic, interconnected	Reductionist, analytical	Ayana 2018
Source of knowledge	Indigenous, passed down through generations	Scientific research, peer-reviewed publications	Hunde 2017; Tsegaye 2020
Adaptability	High, evolves with changing conditions	Moderate, requires rigorous testing and validation	Oba 2009; Tolera 2024
Documentation	Limited, mostly oral tradition	Extensive, written and published	Ayana and Hunde, 2021; Gemechu and Tsegaye, 2022
Potential bias	Influenced by cultural beliefs	Strives for objectivity and neutrality	Oba and Tolera, 2013; Hunde and Tsegaye, 2014
Scientific validation	Limited, often based on experience	Rigorous testing and validation processes	Ayana et al., 2023; Tolera et al., 2024

3.5. Integration of Oromo TEK and Modern Sciences

Oromo TEK practices do not replace scientific approaches; they complement them. Traditional knowledge offers valuable insights into local ecosystems and species behavior, which can inform science (Moller et al., 2003). The general comparison of Oromo TEK and modern Science compiled from several sources and presented in Table 1 outlines some of the differences that could help to understand the two knowledge systems. The different modes of thinking, transmitting, and expressing knowledge are not mutually exclusive for either system. Dominance of one mode within a cultural group does not prevent many individuals in that same group from being highly functional in another mode. Social change is occurring within Western society and among traditional cultures such that new values and ways of thinking are emerging for both. Combining scientific data with traditional knowledge creates a richer picture of the ecosystem, leading to conservation that is more strategies that are effective. Additionally, integrating TEK allows for the development of conservation plans that are culturally sensitive and resonate with local communities, fostering greater participation and ownership (Sultan et al., 2024).

Traditional practices, practiced over generations, may offer valuable insights for building resilience against environmental changes and promoting adaptation (Hiwasaki et al., 2014). The synthesis of both systems can provide a more comprehensive understanding of ecosystems and lead to conservation that is more effective strategies (Figure 1).

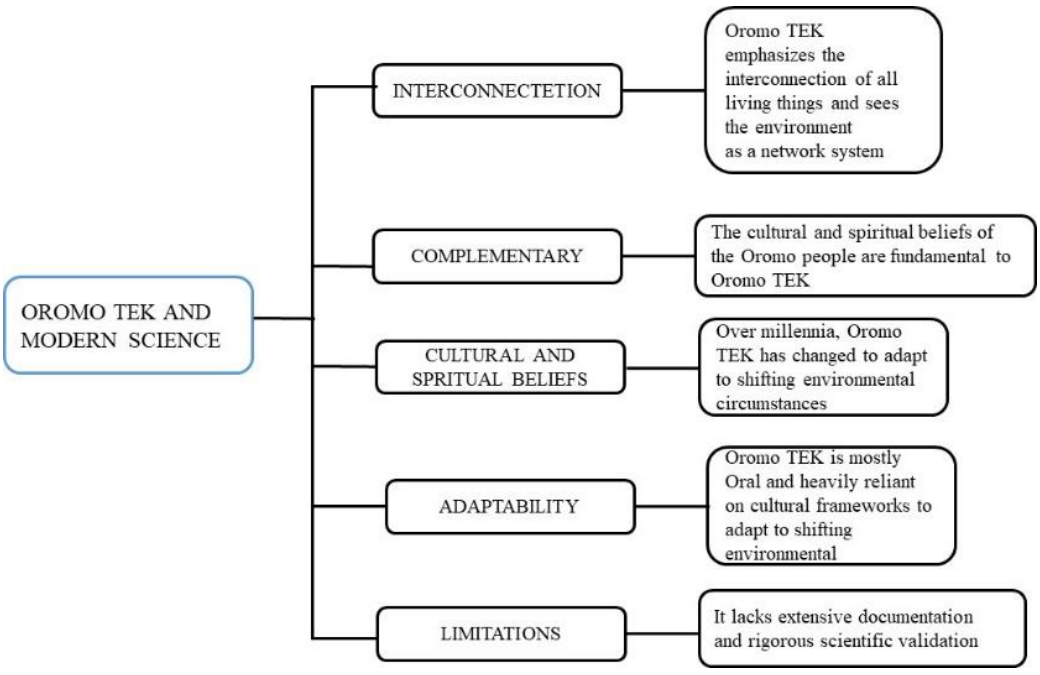

Figure 1: Conceptual framework, illustrating the integration of Oromo TEK with modern Science

3.6. Challenges in Integration

The TEK of the Oromo people offers vital contributions to biodiversity conservation, rooted in generations of sustainable land stewardship.

However, this knowledge system faces rapid erosion due to epistemic marginalization, colonial legacies, and systemic exclusion from formal institutions (Foucault, 1980). TEK is often dismissed for not aligning with dominant scientific paradigms, a situation worsened by land use changes such as deforestation, agricultural expansion, and infrastructure development. These disrupt culturally protected landscapes like sacred groves and indigenous grazing systems (Wassie et al., 2009; Mergo, 2014; Alemayehu & Doda, 2020), especially when state policies disregard customary laws (Dalle et al., 2005).

Rapid population growth and increasing livestock pressure further degrade traditional practices such as seasonal communal grazing under the Gadaa system, leading to overgrazing and rangeland decline (Angassa & Oba, 2008; Belayneh, 2016; Abdu & Robinson, 2017; Beyene & Bellis, 2020). Communication barriers and a lack of institutional platforms often hinder collaboration between indigenous knowledge holders and modern conservationists (Senanayake, 2006; Johnson et al., 2016; Keno, 2021). Externally imposed policies frequently marginalize local voices and dismiss traditional systems as outdated (Nadasdy, 2003; Ogbonmwan, 2008; Kassahun et al., 2018; Melaku, 2015).

Furthermore, conflicting conservation goals such as grazing bans undermine indigenous livelihoods, highlighting the need for context specific, culturally informed strategies (Tripathi & Bhattarya, 2004; Fernandez Gimenez et al., 2006). The dynamic, orally transmitted nature of TEK complicates its formal recognition, while concerns over intellectual property and biopiracy create hesitancy around knowledge sharing (Posey & Dutfield, 1996; Ayana & Hunde, 2021).

Addressing these challenges requires inclusive, participatory conservation approaches that empower local communities, recognize indigenous institutions, and support intergenerational knowledge transfer through culturally appropriate frameworks.

3.7. Collaboration Opportunities: Prospects and Viewpoints

The extensive environmental knowledge possessed by the Oromo people provides a strong foundation for collaborative partnerships with conservation organizations, government agencies, and academic institutions. These collaborations offer promising opportunities for co-producing knowledge, enhancing conservation effectiveness, and promoting cultural revitalization. One significant opportunity lies in the co creation of community-based conservation strategies that integrate Oromo TEK with scientific methods. Joint research initiatives can generate context specific insights while fostering mutual learning and respect. These efforts not only improve biodiversity outcomes but also empower local communities to participate in environmental governance.

Preserving knowledge and facilitating intergenerational transfer are critical future priorities. Documentation projects, ranging from community led archives to digital platforms, can safeguard oral histories, sacred practices, and ecological knowledge for future generations. Educational outreach that incorporates TEK into both formal and informal curricula can further reinforce environmental ethics and cultural pride among Oromo youth. Developing ecotourism centered on sacred landscapes, traditional practices, and biodiversity hotspots offers a viable livelihood strategy. Responsible tourism can generate income, raise awareness about Indigenous stewardship, and provide incentives for conservation.

Additionally, Payment for Ecosystem Services (PES) schemes represent a new mechanism to recognize and reward Oromo communities for maintaining ecosystem functions through

traditional land use. These schemes can align conservation incentives with local values. Joint advocacy at national and international levels can help ensure that conservation policies reflect the worldviews, priorities, and rights of Oromo communities. Moving forward, inclusive platforms for dialogue and decision making are critical for developing culturally respectful, ecologically sound, and socially just conservation models. These collaborations hold transformative potential for both ecological sustainability and Indigenous empowerment.

4. Conclusions

Oromo Traditional Ecological Knowledge (TEK) is a rich, adaptive system of environmental understanding deeply rooted in the Oromo people's cultural and spiritual life. Guided by principles such as respect for nature, intergenerational responsibility, and a holistic worldview, it has supported sustainable land use and biodiversity conservation for generations. Practices such as sacred grove protection, rotational grazing, and indigenous agroforestry exemplify its ecological relevance. Cultural institutions such as the Gadaa system and rituals such as Irrecha further integrate environmental stewardship with governance and spirituality.

Despite its value, Oromo TEK faces growing threats from land use change, urbanization, socio economic shifts, and climate change. These pressures risk eroding both cultural heritage and the community's ability to adapt to environmental challenges. While TEK offers crucial insights into sustainability, it may not fully address complex, global issues such as invasive species or rapid climate change. Thus, it should be seen not as an alternative but as a complementary system to modern science.

A co productive and pluralistic conservation model grounded in mutual respect, intercultural dialogue, and equitable participation is essential. Such an approach can foster inclusive, adaptive, and locally grounded environmental governance. To enhance the integration of Oromo TEK, future efforts should prioritize gendered knowledge transmission, cross cultural comparisons, digital documentation, ecosystem service valuation from indigenous perspectives, and policy alignment. Public education and institutional recognition are also vital. Ultimately, Oromo TEK is not merely a legacy of the past but a living knowledge system with transformative potential for sustainable futures.

Acknowledgement

We extend our deepest gratitude to the Oromo people for their unwavering commitment to preserving and practicing Traditional Ecological Knowledge (TEK) across generations. This review stands as a tribute to their enduring legacy and a call to recognize, respect, and elevate Indigenous knowledge in contemporary conservation efforts.

Declaration of Competing Interest

The authors of this review article declare that there is no conflict of interest.

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