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Coffee Growers' Indigenous Environmental Knowledge to Conserve Natural Resources during Coffee Production in Guji Zone of Southern Ethiopia

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Abstract

The purpose of this study is to investigate the role of indigenous environmental knowledge of Guji coffee farmers toward the conservation of coffee and other natural resources. The Guji Oromo are one of the ancient peoples that have been able to preserve many aspects of their way of life under the Gada system. For centuries, they used local environmental wisdom for coffee production, controlling the influence of human beings on the environment, and preserving the natural environment for the coming generation. However, the management of natural resources and the environmental awareness of coffee producers have not received enough attention from scholars. The Guji coffee growers' environmental and ethics (safuu) have never been fully studied. This research utilized both primary and secondary data sources. The study has been developed based on qualitative data sources. As a result, several circumstances, such as population pressure, conquest, regime changes, modern religion, and education, lack of familiarity with current technologies, and knowledge gaps are a few factors that affect Indigenous environmental knowledge and farmers' perception of the environment. The study's findings suggest that the environmental knowledge of coffee farmers benefited from the understanding and conservation of their local environment, effective knowledge of coffee cultivation, harvesting, and processing to raise soil fertility, protect plants from excessive environmental stress, and increase coffee yields.

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INTRODUCTION

Indigenous environmental knowledge (IEK) is sometimes called "village science" or "traditional ecological knowledge". Indigenous knowledge of the natural environment has been refined and transmitted across generations through traditional learning methods such as cultural practices, spiritual convictions, folktales, traditional songs, and -- proverbs. The Oromo community are obliged to value nature and natural environments through their religious beliefs, ethics, and traditions. Four concepts in Oromo's environmental wisdom illustrate the interconnection of the natural, spiritual, and human realms. These concepts encompass *Safuu* (moral and ethical order), *Uumama* (natural surroundings), *Waqaa* (creator of all),

and *Ayyaana* (spirit). *Waqaa* created everything, encompassing both individuals and natural resources. Thus, *Waqaa* bestowed upon them the principles of harmony and peaceful existence between humanity and the natural world through *seera duudhaa* (customary law) and *seera uumaa* (divine law). From the Oromo viewpoint, *Safuu* represents a moral concept that establishes the ethical basis for guiding how individuals ought to relate to the environment and coexist harmoniously within the natural world.

IEK is the systematic body of knowledge that local people develop via informal experimentation, life experiences, and close proximity to the environment in a particular culture. It also develops knowledge that has been gathered by indigenous peoples over many years, passed down through traditional methods of instruction, and influenced by values, ethics, and social standards. Furthermore, understanding the natural world, how human activity impacts it, and how important it is to protect it are all components of environmental knowledge. Additionally, IEK refers to understanding the environment, how human activity impacts it, and why protecting it is so important (Kelbessa, 2010). Natural environments like holy springs, mountains, trees, groves, and forests are significant to the daily lives of the community, which is why the Gada perspective endorses them. Thus, the efficiency of local organizations in rational management dictates the sustainability of natural resource usage in the long term (Abebe, 2021).

Numerous Western historians and philosophers have claimed that African indigenous knowledge (IK) is outdated, primitive, and has nothing to offer human civilization. However, advocates of IK have contested Western perspectives, arguing that contemporary environmental ethics are based on the environmental ethics of indigenous people. They contend that IK is a dynamic, adaptable system of problem-solving methods that evolves with time. Many academics contend that Oromo's environmental knowledge can provide a solid basis for contemporary environmental science and ethics. In order to improve their lives, locals organize their folk knowledge of flora and fauna, cultural beliefs, and history in a way that shows how they have dynamically come to see themselves in connection to their natural environment.

Therefore, I argue with the above scholars like Kelbessa, Desalegn, Asmarom, Jemjem and Dhadacha, Roba and some others that Oromo in general and the Guji in particular are naturalistic, possessing an innate appreciation for the environment, a green perspective, and inherent qualities of beauty. Their engagement with the natural environment can be interpreted through different lenses, including production systems, agricultural knowledge, belief systems, rituals, social activities, and more. However, IEK of coffee growers of coffee production at the grassroots level did not get enough attention from scholars. Therefore, the main objective of this study is to investigate the contribution of Guji coffee growers' IEK toward the conservation of coffee and other natural resources.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in the Guji zone, located in the Oromia Regional State of southern Ethiopia. As shown in Figure 1, the zone is an important area for coffee farming in the Oromia Regional State. The Guji Oromo

people reside in the southernmost areas, specifically the East Guji, West Guji, and Borana Zones. According to Guji traditions, the Girja regions within the Guji zone are viewed as the historical origin of the Guji Oromo (Roba, 2021). The Zone is divided into three ecological areas: high altitude, mid-altitude, and semiarid region (Debsu, 2009). The Guji Oromo are ancient people who have successfully preserved a significant aspect of their traditions and way of life through the Gada system. The Gada system is an indigenous philosophy and culture that has been maintained to this day by the Guji Oromo. According to Asmarom (1973), the system is an inherent institution that controls the people's politics, economy, culture, environment, and religion (Asmarom, 1973). Therefore, coffee production, harvesting, processing, and protecting the natural environment have all been planned for ages by Guji coffee producers through the adoption of traditional environmental knowledge.

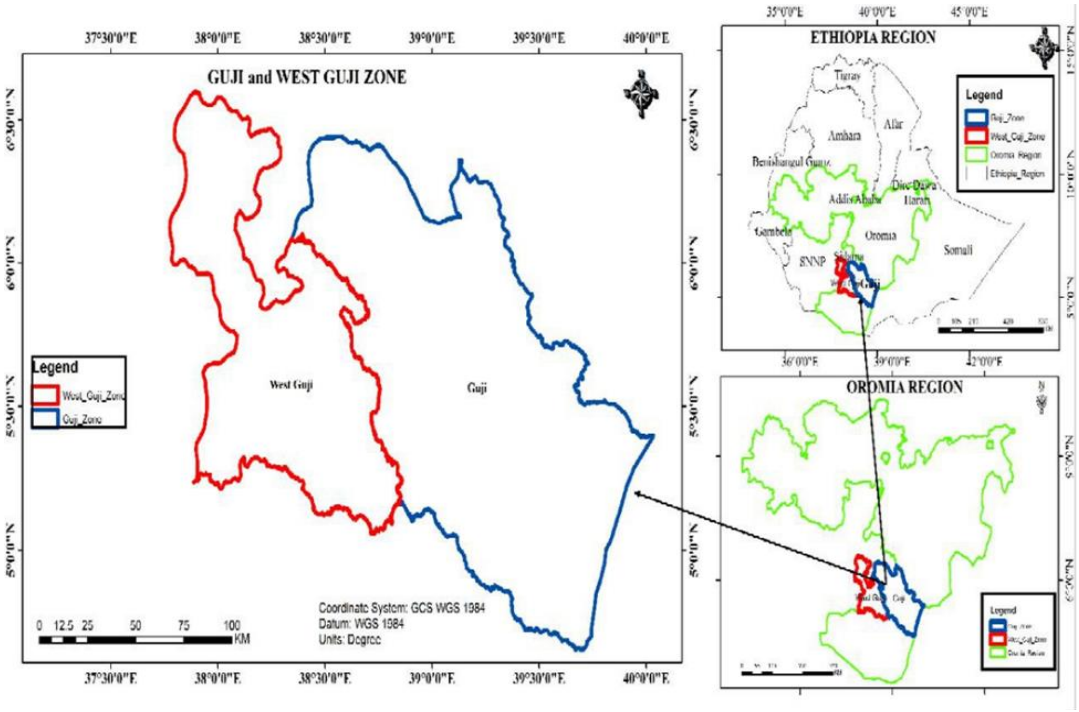

Figure 1. *Map of the Study Area*

Research Ethics (Informed Verbal Consent)

Ethical consideration is required in studies that have significant social significance. To guarantee the reliability, honesty, and transparency of the research process, we closely followed research ethics when conducting this study. We properly cited all sources to uphold intellectual property rights, and all data were acquired through approved channels. Before conducting in-person interviews with each participant, the goals of the study were communicated to them. Respondents' freedom of responding, ease of answering, and ability to leave the study at any moment must be prioritized. The researchers must notify them before beginning

any research delivery process. Additionally, the volunteers must be guaranteed that the researchers would keep the information they gave private. Therefore, the researchers and respondents would have verbally agreed upon informed consent.

Methodological Approach

The study took place in the Guji zone, involving approximately six districts in the process. This study has employed purposive sampling in the selection of the informants based on their potential practices of IEK. The zone and district administrators would be consulted first in order to select knowledgeable informants. Around 30 informants were chosen from the six districts of the Guji zone. *Abba Gadas*, local elders, elder women, religious leaders, youth, and coffee farmers were chosen as informants. The study employed a descriptive research framework and a qualitative approach, including in-depth interviews, key informant interviews, and focus groups. In-depth interviews were done in order to fully comprehend IEK in the community. Six key informants, considered knowledgeable elders within the *Gada* system, were also interviewed regularly. Four *Gada* leaders and community elders participated in focus group discussions (FGDs). Secondary data sources were collected by reviewing both published and unpublished materials. In this category, the initial effort began with examining IEK, environmental studies, and agricultural research hold significant value. Books, dissertations, journals, theses, and other published and unpublished data sources are valuable resources related to coffee production, climate change, and environmental protection. Interview data from oral sources were cross-checked with secondary and possibly dead files from the Guji zone. Immediately after the data collection process began, the concepts were sorted and grouped under related categories. Finally, the data were thematically organized and qualitatively analyzed.

RESULTS AND DISCUSSIONS

Environmental Understanding of the Guji Peoples

Guji is very rich in the diversity of fauna and flora, with fertile loam soil, a mild climate, and sufficient rainfall for cereal and cash crop production. Guji *Gada* rules for natural resource use were developed by the Guji General Assembly, *Me'ee Bokkuu*. The agenda of the overall resource management, economy, and environment has been the central issue of discussion and decision at the general assembly of *Me'ee Bokkuu* of Guji. Regulations concerning land, forests, wildlife protection, water usage, and various environmental factors have been updated every eight years. The established rules (*seera*) have been announced by *Abba Gada*, and the oral declaration by *Abba Gada* known as "*lalabbaa*" encompasses sociocultural norms, peace, and safety, as well as environmental concerns.

Yosep argued that the local farmers possess traditional indigenous methods for safeguarding and sustaining the environment. Indigenous communities are knowledgeable about the agroforestry system, traditional practices for healing illnesses in humans and animals, recognizing seeds, and various techniques for food and cash crop production in rural areas. The Guji community possesses extensive environmental knowledge for the conservation and management of natural

resources. The regulations within the *Gada* system and the *Waaqeffanna* faith have enabled the community to utilize their traditional methods for preserving the natural environment and handling agricultural products. As per Kelbessa, farmers possess knowledge about their resources, what is effective and what is not, the season they experienced, harvest, and how they process crops (Kelbessa, 2010).

In Guji Oromo culture, everything possesses its *woyyuu (safuu)*. For academics, the term *Woyyuu (safuu)* represents something sacred. On the other hand, the term *"safuu"* denotes a moral concept that serves as the ethical base for shaping individuals' perceptions of the environment. Thus, the core idea of *safuu* is that humans ought to coexist peacefully with all other beings in the natural world. Infringing upon *safuu* will impact the harmonious relationship among individuals, humanity, and the natural world. Local religious institutes have played a significant role in protecting the natural environment, demonstrating their alignment and harmony with nature. The Guji Oromo community safeguards particular species of plants, animals, and water following their faith. For the Guji, the environment serves as the foundation for their economy, aesthetics, culture, and religious practices (Kelbessa, 2005). Thus, the connections between people and nature for the Guji Oromo are ethically obligatory and culturally and historically profound.

As per the *Gada* system, forests are communal resources that everyone is responsible for protecting from deforestation. The entire community holds the ownership of the forest, and every member is accountable for its safeguarding. Anyone witnessing tree cuttings for unjustifiable reasons can either intervene to halt the action or notify *Luba* if they are unable to prevent the offender. Water and its resources are regarded as highly valued and safeguarded areas within the *Gada* system. Most celebrations, such as *Irreecha*, occur close to the edges of water bodies. Everyone in the community shares the duty to protect and wisely utilize all water sources, such as hand wells. Moreover, there is no charge for utilizing a body of water and it is not allowed to release any waste into it. Every member of the community is entitled to intervene against anyone violating these *Gada* principles and notify Luba of the wrongdoing along with the offender. The principal subsequently labeled the offender as *yakka malkaa* (an offense involving water resources).

Numerous studies have demonstrated that farmers rely on IEK for enhanced agricultural outputs, including animal husbandry, crop cultivation, and management of natural resources, among other areas. The use of IEK occurs throughout various farming seasons. Farming expertise has been a crucial asset in the agricultural industry. As reported by informants, this expertise encompasses land clearing, ploughing, choosing seed types for planting, harvesting, and storage, as well as recognizing weather patterns. Smallholder farmers continue to wish to utilize their traditional practices and technologies in agriculture, especially by using their indigenous seeds that are appropriate for their climate and avoiding chemical use, which is considered harmful to both the environment and consumers. These seeds are conserved locally and possess drought and pest resistance (Informants: Abba Gada Jilo Mandho, Abba Gada Aga Xenxano, and Girja Godana).

The regional farmers employ significant Indigenous knowledge, aiding in the cultivation of the coffee plant in highly suitable and environmentally appropriate conditions. For many years, small-scale farmers have depended on coffee cultivation as a source of financial earnings for their families. The conventional agricultural practices employed by the Guji have a minimal impact on the environment. Cultivation tools and techniques were basic and had minimal effects on the environment. The Guji would employ extra plots of land when farmland became infertile while leaving the original fallow until it recuperated. This type of rotating crop is less detrimental to soil fertility (Informants: Abba Gada Jilo Mandho, Abba Gada Aga Xenxano, Abebe G/ Wold, and Birhanu Fayisa).

In contrast, key informants believe that religious organizations, cultural customs, oral traditions, and traditional institutions all advocate for humanity's ethical responsibilities toward the natural world. According to the oral traditions of the Guji, the concept of human-environment relationships and the ethical responsibility of individuals towards the environment are passed down from the Guji ancestors. People think that harming the environment is robbing both the current and future generations. Thus, the foundation of environmental duty for the Guji people lies in morality, religion, culture, indigenous knowledge, and history, committing them to safeguard and preserve the environment for future generations. Similarly, as top informants disclose, environmental ethics represent the balanced connection between humans and their surroundings. The relationship is grounded not in consent but in the laws of nature. Life will be challenging without harmonious interactions between people and their environment, as the latter serves as the foundation for the economy, social matters, traditional customs, historical significance, and cultural aspects (Yigzaw, 2017, and informants: Abba Gada Jilo Mandho, Abba Gada Aga Xenxano, Abebe G/ Wold and Birhanu Fayisa).

As stated by Guji elders, their communities maintain a strong connection with the environment. Humans possess the ability to control their surroundings for daily living. Additionally, according to informants, when the connections between humans and the environment encounter various difficulties, individuals feel unhappy. Individuals feel pain when large trees are felled and animals are mistreated. Thus, the Guji people empathize with plants and animals during times of disaster and hardship similar to those experienced by humans. Animals should be utilized appropriately. For example, they ought to employ pack animals such as donkeys based on their capacity. They hold that God granted them the privilege to use animals appropriately, not in an abusive manner (Informants: Abba Gada Jilo Mandho, Abba Gada Aga Xenxano, and Girja Godana).

Traditional coffee farming demonstrates agroforestry by combining trees, fruits, vegetables, shrubs, cereals, and livestock, yielding economic, environmental, and social benefits. In Guji, there are four unique coffee cultivation systems: forest coffee, semi-forest coffee, garden coffee, and modern coffee farms. As a result, these coffee-growing techniques have been employed for centuries by smallholder farmers as traditional coffee farming practices. The natural environment of forest coffee has been advocated as a means to protect biodiversity. Bada Magada forest, Anferara forest, and other areas in the Guij

zone are acknowledged as vital hubs for preserving biodiversity and ecological variety. Forest coffee is a variety of wild coffee grown under the cover of indigenous forest trees and showcases a vibrant array of plant species. Coffee is grown in the forest by reducing competing understory vegetation and certain canopy trees. Coffee forests also feature a rich variety of birds, mammals, and many other wildlife species.

According to the informants, the coffee currently harvested in the south comes from the native wild coffee that grew there. For many years, farmers have developed forest coffee systems to improve yield and increase coffee density. Nonetheless, various factors contribute to wild coffee deforestation, which is linked to population increase, intensified land demand, new communities, logging operations, the conversion of forests to farmland, and inadequate rural development strategies. Currently, just a few districts, including Hambala Wamana, Girja, and Adola districts, grow forest coffee in the Guji zone. As a result, wild coffees are collected at least once a year, and the transition from a forest coffee system to a semi-forest coffee system impacts the floral composition and plant species variety in the forest. Semi-forest coffee refers to a coffee variety that is cultivated partially, whereas forest coffee is supervised by controlling tree overgrowth, removing undesirable plants, and replacing bare spots with naturally growing seedlings. It necessitated little human input, such as adjusting the shade, trimming, and weeding each year to aid in harvesting (Informants: Abebe G/ Wold, Birhanu Fayisa, Damsash Mashasha, and Muktar Hebo).

Garden coffee production denotes a variety of coffee farming situated close to farmers' homes, where it receives improved attention through continuous weeding, fertilization, and the loosening and softening of soil. It was ideal to mix different annual crops and multifunctional trees within these coffee fields. Modern coffee farms participate in coffee production after clearing land and systematically preparing the soil and seedlings for planting. Coffee trees are grown in cleared areas, though they frequently simplify forests by removing undesirable species from government coffee plantations. Some indigenous trees may be preserved in the area for windbreak, shade, or both purposes. It utilizes suitable techniques for soil preparation, sowing seeds, caring for young plants, sustaining mature trees, gathering crops, and processing. Their yield has increased thanks to improved scientific management practices, including better seedling spacing, appropriate mulching, fertilizer application, regular hoeing, manuring, stumping, weeding, pest management, shade modifications, and pruning utilized in this production approach (Informants: Abebe G/ Wold, Birhanu Fayisa, Damsash Mashasha, and Muktar Hebo).

Numerous studies have verified that ecological resources have been declining for an extended period. This is a result of declining soil fertility and water quality, loss of biodiversity, drought, poverty, wildlife depletion, and barren land. At present, the species extinction rate and resource depletion are seriously harming both humanity and other forms of life on Earth. Numerous coffee growers suffer a decline in their social and economic welfare when an ecosystem's species vanishes. For example, forest coffee systems have been recognized as effective in mitigating climate change and providing income for the impoverished rural population. Nevertheless, the traditional knowledge of

local communities has been overlooked for years, with both scholars and the government ignoring it. Consequently, IEK has garnered minimal focus, particularly regarding environmental protection and conservation amidst the era of environmental deterioration. Consequently, the main objective of this study is to determine the indigenous ecological knowledge (IEK) of coffee farmers and the methods they employ to protect their natural surroundings within the *Gada* system. This research thus contends that emphasizing the perspectives and experiences within the *Gada* system is essential for gaining a more profound insight into the Guji Oromo's understanding of their natural surroundings.

Factors Affecting Indigenous Environmental Knowledge of Guji Coffee Farmers

Until the end of the second half of the nineteenth century, Guji territory was collectively possessed by clans; they had a low population and ample land for agriculture and raising animals. People had the freedom to go wherever they wanted to go when their land for farming or grazing became unproductive. Environmental deterioration has been preserved to a minimum because of the strong *Gada* control system of low population density, a land ownership system, freedom of mobility, and traditional religious beliefs (Hussein, 2004). This indigenous ecological wisdom governs environmental preservation, resource allocation, and the stewardship and protection of natural resources. The management and utilization of natural resources are essential for guaranteeing their sustainable use. Consequently, the efficiency of local bodies in managing resources rationally influences the sustainability of natural resource utilization. IK is equally important for adjusting to ecosystem changes, managing environmental factors, and guaranteeing a supply of biological resources. Through this IK, coffee farmers understand their resources, what is effective and what is not, as well as the timing for planting, harvesting, and processing coffee. IEK systems are frequently tailored to align with local culture and environmental conditions, catering to the requirements of local populations as well as the quality and quantity of accessible resources (Abebe, 2021).

However, starting in the early 1890s, the Guji Oromo people started to decline due to the empire-building attempt that changed the rule of *Gada* to a feudal autocracy. The role of IEK began to be dismissed and underestimated. These conditions led to the marginalization of the Guji Oromo identity, customs, values, social structure, judicial system, and economic system that handled social and environmental issues (Abebe, 2021). As a result, the integration of Guji Oromo into the Ethiopian empire brought new changes in environmental degradation. It caused population growth, changes in the mode of life, changes in traditional land ownership, and their environmental knowledge was negatively impacted. Farmers in Guji encountered significant environmental deterioration, climatic shifts, and ecological challenges. The effects of this shifting environment led to a drop in agricultural productivity, erratic climate variations, frequent droughts, and outbreaks of diseases (McCann, 1995). So, understanding the factors affecting IEK of coffee farmers, and their reaction to the natural environment were the main focus of this study.

The government functionaries of the time did not favor the freedom of indigenous

religious practices carried out close to springs, sacred forests, some large trees, and other practices that are considered to be demonic (Kelbessa, 2001). Government-owned cattle ranches took the role of the old land tenure system. Furthermore, significant variations in rainfall and the regions' recurrent droughts have been making the issues worse (Beyene, 2017). Due to immigration from the north and neighboring areas, Guji's population has been increasing steadily. As more northern settlers were introduced into the Guji's region, more land was acquired, which continued to result in land alienation and economic exploitation. The *naftegna-gabbar* system also placed restrictions on the earlier Guji system of seasonal transhumance. A substantial percentage of the land in Guji was under the authority of *naftegnas* or Guji landlords. As a result, they were compelled to overgraze and overfarm certain regions which opened the way for deforestation, habitat fragmentation, and over-exploitation of species that significantly affected biodiversity. Therefore, the ability of local farmers to sustain environmental conservation is impacted by population pressure, deforestation, natural resource degradation, and the growth of cultivated land (Berisso, 1995).

Since 1974, the socialist government of Ethiopia has put into action several radical policies aimed at transforming the socioeconomic landscapes of rural regions. The implementation of initiatives like State Farm formation, villagization, and resettlement efforts has severely marginalized and impoverished Guji farmers by undermining their traditional agricultural and environmental safety standards (Berisso, 1995). Due to the resettlement and land policy of the Darg government, deforestation has increased. The government took ownership of all forests, and certain peasants cut down big trees that offered shade for coffee cultivation. During this time, environmental degradation has impacted climatic conditions and resulted in new diseases such as malaria and tuberculosis. The primary reasons for the widespread occurrence of malaria include environmental disruptions, specifically deforestation, migration of populations, and inadequate healthcare infrastructure (Kelbessa, 2001;Berisso, 1995).

Significant environmental issues encompass the swift transition of forests into agricultural land-use types and the excessive exploitation of forest resources to satisfy the increasing population's demands for food and energy. Informants indicated that the Guji farmers have experienced severe poverty and illness due to villagization, while various animal diseases led to hundreds of fatalities. Due to pollution, overgrazing, and soil erosion, the density of people and animals in the new communities adversely affected the environment and human health. Consequently, villagization notably affected the environment because of the overexploitation of local forests. Several initiatives were initiated by Darg to address environmental degradation on a national scale. These initiatives involved creating terraces, closing off hillsides, planting trees, constructing irrigation systems, and relocating people at the community level. The primary initiative implemented in Guji was tree planting, resulting in a significant quantity of tree seedlings being distributed throughout the Guji zone. From the government's perspective, this might be viewed as a success, whereas from the peasants' standpoint, it was a threat. The tree planting initiative needed land from farmers' groups. After the trees were planted, no livestock was permitted to graze, and no human intervention was allowed for

three to five years. Consequently, the strategy to address deforestation resulted in increased deforestation and impoverishment. Peasants do not gain from the trees that are planted (Berisso, 1995).

Local elders believe that the main factors contributing to the decline of traditional environmental protection methods in the study area are population pressure, changes in social norms, and the rise of modern religion. Furthermore, the onset of formal education and the incorporation of contemporary knowledge among today's generation have diminished the significance of indigenous environmental knowledge (Informants: Abba Gada Jilo Mandho, and Aga Xenxano). The emergence of modern world systems and the impact of globalization have much contributed to changing the long-established Guji coffee farmers IEK. Hence, the introduction of foreign cultures into the culture of the indigenous peoples has contributed to massive changes in indigenous people's philosophies.

As a result, IEK is now gradually disappearing and remains only in the memory of some old-age people. Among many factors, the rise of modern religion, population, pressure the introduction of modernity, global media, and modern education are agents of globalization. These factors have had almost no place for IK as it was assumed to be irrelevant, unscientific, and outdated. As per the respondents, due to the aforementioned factors, certain traditional practices and beliefs are increasingly diminishing in significance. Consequently, the growth of Christianity in the region has pushed aside the Guji indigenous belief system. Consequently, the environmental understanding of coffee farmers was influenced by a lack of familiarity with contemporary technology, modern beliefs, and modern education, and population pressure among other factors.

The Impact of Environmental Elements on Indigenous Coffee Farmers

The key elements impacting coffee production and productivity include ongoing drought, inconsistent rainfall patterns, elevated temperatures, strong winds, diminished soil fertility, and excessive rainfall. These factors significantly worsen berry disease; increased wilt leads to alternate bearing, flower loss, fruit quality reduction, and other harmful impacts. According to many specialists, the perfect temperature range for coffee Arabica lies between 180C and 240C. Excessive heat or excessive cold temperatures are detrimental to Arabica coffee. For example, growing coffee at temperatures above 24°C led to rapid plant growth, premature bearing, overproduction, early fatigue, die-back, susceptibility to diseases, deterioration of cup quality, limited flowering times, and issues with fruit development. Severely low temperatures are also detrimental to the coffee plant. Issues related to extreme temperatures can be somewhat alleviated by incorporating shade trees and applying mulch (Teketay, 1999).

Rainfall is the primary element influencing the distribution of coffee production. The rains ought to be evenly distributed throughout the year to get greater levels of both quantity and quality. For coffee cultivation, 1000–2000 mm of annual rainfall is excellent. It has a bimodal distribution, with the main rainy season being from June to October and the minor rains occurring from March to April. Although, coffee production drastically decreases when annual precipitation is less than 1000 mm. When annual precipitation

exceeds 2000 mm, quality is impacted by an increase in disease and nutrient loss in the soil. Similarly, fungal infections are more likely to produce leaf diseases. The distribution of sunlight and rainfall has a significant impact on the growth and ripening of flowering beans. Therefore, in the Guji zone rainfall fluctuation was one of the main factors affecting coffee production.

The wind can influence the growth and yield of coffee in various ways. Strong winds can harm coffee trees by breaking their branches. It could also impede the growth of flowers and fruits by reducing the leaf area. Chilly winds amplify the impact of low temperatures, intensifying the effects of what is known as cold diseases, while warm winds can lead to wilting or potentially fatal damage to coffee tree leaves. Consequently, both chilly and warm winds can diminish the growth and production of coffee. Thus, in areas where powerful winds are common, it is advisable to use windbreaks or sheltering trees to enhance crop production. Optimal Arabica coffee soil conditions include deep, well-drained, volcanic ash, loamy soil that is brown chocolate or reddish, rich in humus, sandy, and slightly acidic. Nonetheless, soils that are alkaline have high sand content, and lack humus are typically inappropriate for coffee cultivation. The soil found in the Guji zone is of volcanic origin, characterized by deep red-brown coloration, good drainage, and acidity (Teketay, 1999).

Typically, the immediate effects of climate change will lead to stressed coffee tree growth, restricted flowering and berry production, low yields, disease proliferation, and diminished quality of coffee beans. Farmers indicate that increased temperatures, heightened weather variability, extended dry seasons, and more intense weather events make it challenging to generate enough coffee for the market. Coffee farmers in the research area employed various climate change adaptation strategies, including changing cultivation practices, enhancing shade coffee production systems, diversifying income sources, utilizing more resistant cultivars, and implementing climate-smart agricultural practices alongside forest management techniques (Teketay, 1999).

The existing factors that are adversely impacting the production and productivity of coffee include coffee diseases, insect pests, weed species, and vertebrate animals. The primary types of coffee diseases recognized as constraints on coffee production are Coffee Berry Disease (CBD), Coffee Wilt Disease (CWD), Coffee Leaf Rust (CLR), and Coffee Insect Pests (CIP). Coffee Berry Disease (CBD) is a highly significant disease that leads to substantial reductions in coffee yield. The fungus responsible for it is Colletotrichum. The ailment was first identified in Ethiopia in 1971, and by 1978, it had already become prevalent in the coffee-producing areas of the country. Multiple studies indicate that the disease can lead to crop losses and impacts the plant at every stage, from blossoms to mature fruits and including leaves. Nonetheless, it would not affect the vegetative production part of the plant. Since 1978, the Jimma Research Center (JRC) has established CBD-resistant coffee seedlings in most coffee-producing regions. Nonetheless, CBD continues to present a significant risk to the coffee sector of our nation and diminishes production (Muller et. al, 2009).

Coffee Wilt Disease (CWD) represents the subsequent type of coffee disease. Gibberella xylariodes is a fungus that attacks coffee trees and causes CWD. It was found in Ethiopia in

1957/1958. This disease affects coffee plants via injuries caused by weeding, stumping, and pruning. Symptoms consist of leaves turning yellow, which ultimately dry out and drop off. Branches eventually die off, and after several months, the entire tree fades away and perishes. Unlike other diseases, CWD destroys the whole plant and can be transmitted through different management activities and water flow. Consequently, informants indicate that CBD and CWD are the primary challenges in Guji and the neighboring areas.

Coffee leaf rust (CLR), induced by the obligate parasitic fungus Hemileia vastatrix, is currently impacting every coffee-producing area globally. For coffee producers, CLR leads to significant financial deficits. It primarily occurs during very hot and very cold weather seasons. The forest coffee plant is the primary target of this disease. The initial visible signs appear as tiny, pale yellow dots on the leaf's upper surface. The areas gradually dry up and become brown in the middle. Though many elements influence cultural procedures, such as crop types, soil properties, rainfall distribution and amount, etc., competent cultural management is necessary to achieve disease control. Creating and expanding tolerable coffee types is the most practical and efficient path of action. This has been one of the primary concerns for numerous countries to find types resistant to coffee leaf rust.

Another prevalent disease is Coffee Insect Pests (CIP). According to several specialists, approximately 47 species of CIP are known to target coffee in Ethiopia. Compared to garden and semi-forest coffee farms, it is more well-known in the dense forest coffee production system. Termites are a harmful insect pest that consumes the bark or skin of trees. Additionally, they can open a door for a variety of bacterial and fungal infections, which causes a large loss of output (Fekede & Gosa, 2015).

As a result, the primary objective of the Guji Oromo's ancient laws and customs, which are deeply embedded in the *Gada* framework, is to save their environment and manage diseases, droughts, and climate change. Indigenous people's traditional methods of protecting the environment include social exclusion, sanctions, and the Guji Oromo's oral and customary laws. This seems to suggest that a variety of traditional methods preserve natural habitats in various cultural contexts. In this traditional governance structure, the seniors supervise communal activities, including environmental restrictions, and uphold customs that safeguard natural resources. Local communities keep a close eye on their surroundings and report any infractions of traditions about the preservation of natural heritage to the appropriate authorities. They safeguard holy natural sites that are maintained by rigorous customs and rituals by prohibiting destructive activity in particular locations. Some trees are protected from logging and are therefore revered because of their cultural value. Old tales and folklore emphasize the value of protecting the environment and the repercussions of disregarding these values.

The Environmental Values of Coffee Farmers under Shade Trees

Coffee is an example of an agroforestry system that offers ecosystem services to support the upkeep and restoration of strong social and biological systems. It is well known that bigger crops are planted above smaller ones to shield the latter from environmental

stresses such as wind, rain, sun, and erosion. The utilization of traditional methods in coffee cultivation leads to high levels of biodiversity, hence fostering a productive environment that benefits farmers in terms of income generation and support for conservation efforts (Adugna et al., 2011). Growing coffee beneath shade trees is a fundamental component of traditional organic coffee growing methods. Shade-grown coffee reduces the need for artificial fertilizers, provides habitat for fauna and flora, provides ecological services such as soil and water protection, moderates daytime temperature, reduces weed growth, reduction of frost damage, and minimizes soil and water erosion. Additionally, it helps mitigate coffee plants' recurring overbearing and eventual dieback.

Nonetheless, at times, too much shading causes reduced production and productivity of coffee. In the research region, coffee producers possess significant knowledge about methods to manage overbearing shade trees. These methods include thinning, pruning, and coppicing care. They implemented thinning techniques to lessen the dense shadow coverage on coffee plants, to minimize competition from shade trees with coffee plants, and to create a favorable environment for the coffee plants. Moreover, they often perform pruning to reduce the shade tree branches for improved growth and lumber production (Alemu, 2015; Aschalew, 2018).

In addition to environmental advantages, shade-grown coffee also has a strong contribution to the conservation of animals and other local wildlife if it is performed effectively. Coffee cultivated in an agroforestry system may also allow farmers to supplement their income by producing honey, ginger, and firewood (Kewessa et al., 2019). Guji coffee farmers favor shade-grown coffee because it produces better coffee yield and cup quality, protects against harmful environmental stress, protects soil fertility, and enables coffee plants to live longer (Aschalew et al., 2018). Therefore, the purpose of this research was to find out the impact of shade and open sun-growing coffee on coffee production, environment, coffee yield, quality, and the lives of coffee growers.

In contrast, as contemporary coffee plantations expanded, a significant portion of shaded coffee agroforests vanished, and shade coffee farms were substituted with open sun-growing techniques (Adugna et al., 2011). Coffee grown in full sunlight is produced on farms where trees have been cleared away. Research indicates that although sun-grown coffee yields the highest production, it also diminishes the variety of plants that sustain numerous insects and animals. It led to a significant reduction in the variety of migratory birds, resulting in excessive growth, dieback, and decreased lifespan of the coffee plant. This adversely affects the biodiversity in local regions and leads to additional environmental damage. These environmental damages also impact soil quality, leading to increased soil erosion on remodeled coffee farms where vegetation has been diminished. To maintain pace with the plants' swift growth rate, this method involves the frequent use of chemical pesticides and fertilizers. Fertilizers and pesticides utilized in farming damage soil and water resources by polluting the air and groundwater.

The farmers emphatically highlighted significant issues related to cultivating coffee without shade trees, such as rapid wilting of coffee plants, reduction in bean size, heightened weed issues, greater adverse impacts from heavy rainfall, increased frost

damage, escalated soil erosion, deterioration of soil fertility, and coffee leaves that easily turn yellow/red (Alemu, 2015). These resulted in droughts, diseases, pests, and erratic weather patterns, adversely impacting the quality of coffee beans. Indeed, as mentioned previously, the research findings indicated that coffee beans grown in shaded areas possess a higher quality and command a better market price compared to those cultivated in open settings. Nonetheless, higher coffee production is also achieved from sun-cultivated coffee plants. Therefore, the lifespan of a coffee plant is quite brief (Aschalew, 2018).

The Environmental Effects of Coffee Processing Waste Products

Wet and dry coffee processing byproducts are major production wastes that significantly contribute to the elevated pollution levels in coffee-producing areas, adversely affecting water, soil, and public health. These coffee-processing firms utilize poor management techniques due to insufficient technological and financial sustainability (Asrat et al, 2015). Large quantities of waste are generated during the wet processing phase when the coffee beans and cherries are separated. The significant volumes of processing byproducts like pulp and husk can harm local water bodies, disrupt aquatic ecosystems, impact the health of nearby residents, and also influence the financial gains from coffee production. Inadequate disposal of these byproducts leads to considerable contamination in coffee-producing areas and presents major environmental challenges (Murthy et al., 2012).

The wastewater released from coffee processing facilities constitutes a significant contributor to river pollution. These types of factories generate wastewater with a high level of organic pollutants. Contamination of water bodies poses significant environmental dangers. Additionally, the faulty disposal system of husk waste impacts the individuals residing near the processing facility. They experience serious health issues like eye discomfort, skin irritation, stomach issues, breathing difficulties, and nausea. Consequently, the coffee processing sectors generate significant quantities of dangerous waste that present a serious risk to the environment (Adugna, 2021, Asrat et al, 2015).

In certain coffee cultivation regions, individuals have found improved methods to make use of coffee production byproducts. As a result, various coffee-growing areas have sought to create indigenous strategies for handling coffee waste and utilizing it as a source material for producing compost, animal feed, beverages, vinegar, and biogas. This study primarily concentrates on methods for handling coffee waste to enhance awareness of the potential for optimizing coffee by-products and minimizing environmental pollution. Currently, in many coffee-producing regions, coffee husks and pulp can be combined with animal manure for composting and utilized as organic fertilizer in agricultural practices. Utilizing organic fertilizer enhances soil qualities, decreases the necessity for inorganic fertilizers, saves farmers money, and boosts coffee production (Murthy et al., 2012).

Moreover, coffee pulp, skins, and husks can be dehydrated and utilized as animal feed due to their rich nutrient content. However, the practicality of employing coffee pulp as animal feed is constrained since occasionally the cost of drying the pulp surpasses the

advantages. After two days of fermentation, the pulp is pasteurized with hot water, then drained, dried, combined with mushroom spores, and placed into plastic bags. The mushrooms sprout from the openings in the bags and are collected after three to four weeks. The mushroom serves dual purposes: it can be eaten fresh or dehydrated for sale. As a result, the revenue generated from mushroom cultivation is important for farmers (Murthy et al., 2012).

Water is widely utilized in the wet coffee processing sector for pulping, fermenting, and washing coffee cherries. Comprehending the different options for wastewater use, treatment, and recycling is essential for employing eco-friendly disposal methods. Without water recycling, the resources are jeopardized (Genanaw et al., 2021; Mosissa, 2016). As mentioned earlier, the quantity of coffee wastewater can negatively impact the environment if it is not properly treated before being discharged. This hostile environment promotes the growth of potentially dangerous bacteria, resulting in an unpleasant smell and a dreary look caused by toxic materials (Ijanu et. al., 2020).

To manage wastewater effectively and affordably, it is essential to control the volumes of wastewater discharged into a nearby river. The initial approach involves wastewater management techniques that recycle wastewater for use in production facilities. The water expelled from the coffee cherry extract represents another possible source for biogas generation. Coffee may still be dried with all the lower-grade waste heat from cooling and exhaust, and the generated biogas is ideally used to fuel an engine that generates electricity (Murthy et al., 2012). Currently, although attempts have been made in certain coffee-growing areas of the country to manage coffee waste, they have proven insufficient. Certain research results indicate that efforts have been initiated to utilize these residues for energy generation or the production of value-added compounds as methods to diminish their toxicity levels. Coffee waste from processing industries needs to be treated properly. Moreover, farmers are unaware of the sources and impacts of environmental pollutants that are both sustainable and recyclable (Asrat Ijanu., 2015).

CONCLUSIONS

For centuries, small-scale farmers in Guji have been employing IEK to preserve natural resources in coffee cultivation. It illustrates agroforestry by integrating trees, fruits, vegetables, cereal crops, and livestock to deliver social, economic, and environmental advantages. The traditional beliefs and ancient rules of the Guji coffee farmers focus on safeguarding their environment and addressing issues like disease, drought, and climate change. IK is essential for adjusting to ecosystem changes, managing environmental factors, and guaranteeing a steady supply of biological resources. The connections between people and the natural environment can be seen through various elements, such as production systems, agricultural wisdom, belief structures, rituals, and community activities. The traditional agricultural practices employed by the Guji farmers have minimal impact on the environment. It has not significantly harmed the environment. When agricultural land became unproductive, they would use additional plots, leaving the original land fallow until it recovered. Local communities closely monitor their surroundings and report any violations of

norms related to the preservation of natural heritage to the appropriate authorities. This IEK regulates environmental conservation, resource distribution, and management and conservation of natural resources.

However, IEK of coffee growers of coffee production at the grassroots level did not get enough attention from scholars. There are gaps in integration approaches, strong functional networks, and participatory traditional leadership for successful biodiversity conservation in the study areas. Conservation of natural resources and moral values has not been well studied and used in modern conservation practices. Moreover, since there is no adequate documented information about the Guji IK it mainly depended on the critical analysis of oral tradition. IK of people about their environment needs to be given due consideration in any conservation effort. However, Guji coffee farmers encountered significant environmental deterioration, climatic shifts, and ecological challenges from time to time. The effects of this shifting environment led to a drop in agricultural productivity, erratic climate variations, frequent droughts, and outbreaks of diseases. Farmers have also been severely disadvantaged and impoverished as a result of the adoption of programs like State Farm Formation, villagization, and relocation attempts throughout the Darg period, which have undermined their traditional agricultural and environmental safety norms.

Recommendations

The emergence of modern world systems and the impact of globalization have much contributed to changing the IEK of coffee farmers. Hence, the introduction of foreign cultures into the culture of the indigenous peoples has contributed to massive changes in indigenous people's philosophies. The study demonstrates that although IEK has had great potential to preserve coffee and other natural resources since ancient times, it might be sufficient to address the widespread depletion of natural resources that people are currently facing. Therefore, the primary conclusion of this study is that the conservation of natural resources in coffee production requires the integration of traditional and modern environmental knowledge for improved governance of the environment.

CRediT authorship contribution statement

Endalkachew Lelisa: Conceptualization, writing original draft, investigation, writing, review & Editing, supervision, **Tesema Ta'a:** Validation, formal analysis, data curation methodology, visualization.

Declaration of competing interest

The authors declare that there is no conflict of interest.

Data availability

Data will be made available on request.

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