Enset (Enset ventricosum): An underutilized food crop for suitable Agriculture, Biodiversity conservation, and Food security in Ethiopia

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Abstract

Enset (Ensete ventricosum (Welw.) Cheesman), a perennial monocarpic species of the Musaceae family, is an underutilized yet essential food source. Indigenous to Ethiopia, it is exclusively domesticated in that region, despite the existence of wild populations in other parts of Africa. Enset serves as an essential component for over 20 million Ethiopians, supporting food and livelihood stability. The pseudostem and corm are utilized to produce Kocho (fermented flatbread), Bulla (a dehydrated starch product), and Amicho (boiled corm), offering a variety of dietary choices. In addition to nutrition, enset farming methods provide various ecological advantages, such as soil conservation, conservation of agrobiodiversity, and enhanced tolerance to drought and climatic fluctuations. Nevertheless these benefits, the crop continues to be little investigated and inadequately promoted at both national and international levels. Enhancing its potential by scientific innovation, advanced processing technologies, and legislative support could support sustainable agriculture, biodiversity protection, and food security.

Keywords: Biodiversity, Enset, food security, suitable agriculture, underutilized

Introduction

Enset ventricosum, also known as Enset, is a perennial crop that is indigenous to Ethiopia (Aneseyee et al., 2022a). It represents a valuable resource that is not being used to its full potential in the fields of biodiversity conservation, sustainable agriculture, and food security, especially in the central region of Ethiopia (Sahle et al., 2021; Kibatu et al., 2025). Enset is still widely ignored in strategies for agriculture and food security, despite the fact that it has the potential to be a valuable resource (Senbeta et al., 2022). The purpose of this introduction is to explain the various advantages of growing enset and to highlight the importance of enset cultivation in improving agricultural sustainability, conserving biodiversity, and strengthening food security, (Wambui, 2024). This study aims to promote the greater adoption and integration of enset into agricultural practices by investigating the ecological and socioeconomic benefits it provides. In doing so, it hopes to make a contribution to the sustainability and resilience of food systems in the region (Negash, 2001).

The "false banana," which is the more common name for the plant enset, is a member of the genus ensete and belongs to the family Musaceae. The carbohydrate-rich underground corm and the pseudostem of the enset plant are typically harvested before the plant becomes entirely mature. Depending on the genotype and the altitude, the harvesting can take place as early as three years after planting, but it is always completed prior to or just as the plant is about to flower (Olango, Tesfaye, Catellani, & Pè, 2014; Birmeta et al., 2004). Although the enset plant has a geographic distribution that extends to a number of different parts of sub-Saharan Africa and Asia, where it grows as a wild species, it is only cultivated for agricultural purposes in the central, southern, and southwestern regions of Ethiopia, where it is grown using farming practices that are traditional to the indigenous people there (Borrell et al., 2019; Hemade, 2025). It is worth noting that enset ventricosum is undoubtedly the most important crop in Ethiopia. It is responsible for guaranteeing the food security of more than one-fourth of the country's population and supporting the livelihoods of those living in rural areas (Brandt et al., 2020; Kudama et al., 2022).

Enset enhances soil quality by incorporating organic matter, mitigating erosion, improving moisture retention, recycling nutrients, and stabilizing the soil via its extensive root system (Dilebo, 2025; Senbeta et al., 2022). It is a perennial crop, which means that it does not necessitate tilling, and its broad plant canopy intercepts rainfall, which reduces the amount of erosion that occurs as a result. As a result of the increased infiltration of water and the decreased runoff from the surface, which both come about because of the deep roots, there is a greater amount of water in the soil and in the aquifers (Cárceles Rodríguez et al., 2022; Feleke & Tekalign, 2022). The effective length of the dry season can be reduced in part by increasing the amount of water, the availability of water, and the duration of flow to springs Furthermore, the soil's organic matter and fertility are both increased as a result of enset culture (Bayu, 2016). Following the harvesting of the corm and pseudostem, enset leaves can be utilized for mulching, which improves soil protection and increases the amount of organic matter in the soil (Kudama et al., 2022). In addition, empirical studies have quantified enset's significant contributions to soil and ecosystem services, including reducing erosion, improving soil organic matter, and enhancing moisture retention, particularly within mixed farming systems (Gadana, 2021; Borrell et al., 2020). There have been reports that enset improves soil fertility to the extent that it reaches a level that is higher than that of the fields or pastures that are next to it (Kudama et al., 2022).

The enset farming system is a unique indigenous agroforestry technique in which enset is cultivated as a perennial crop, typically organized in circular formations around the homestead (Olango et al., 2014; Borrell et al., 2020). This technique involves the cultivation of enset alongside several companion crops, including as coffee, root and tuber crops, legumes, vegetables, and fruit trees, which predominate the main agricultural plots. This integrated system ensures a reliable food supply while enhancing ecological resilience through the judicious use of soil, water, and nutrient resources (Borrell et al., 2020; Borrell et al., 2019; Mellise, 2017). The system demonstrates significant inter-specific diversity, marked by numerous crop species within a single agricultural unit, and intra-specific diversity, resulting from the wide variety of enset landraces grown by families. This diversity improves household food security, strengthens resilience to environmental shocks, and contributes to the preservation of agrobiodiversity in the region.

As different literature reported that, its high importance in the diet of contemporary Ethiopians and act as a famine buffer, enset has been so neglected partly due to cultural perceptions, politics, and history (Sirany, Tadele, Hibistu, et al., 2022). Additionally, enset has been continuously underutilized as the development agendas of Western aid agencies still emphasis on cereal grains like maize (Brandt et al., 1997; Borrell et al., 2019).

Enset is essential for sustaining biodiversity in tropical settings, especially in Ethiopia, where it serves as a staple crop (Kusse et al., 2021). The cultivation of this species supports an extensive variety of plant species and enhances the ecological stability of agroforestry systems (Kusse et al., 2021). Enset-based agroforestry systems, exemplified in Southern Ethiopia, are essential for biodiversity conservation and offer an environmentally friendly framework for integrating food production with environmental management (Beyene, 2021). The subsequent sections explain the essential functions of enset in sustaining biodiversity (Wondimu & Kebede, 2022). Enset farming systems are acknowledged for their resilience and multifunctionality, providing several ecosystem services that support biodiversity and improve environmental stability. The aim of this paper is to previous studies on enset and highlight

its enormous potential as an underutilized food crop for sustainable agriculture, biodiversity conservation, and food security. Additionally, the purpose of this work is to increase the visibility of enset within the scientific community.

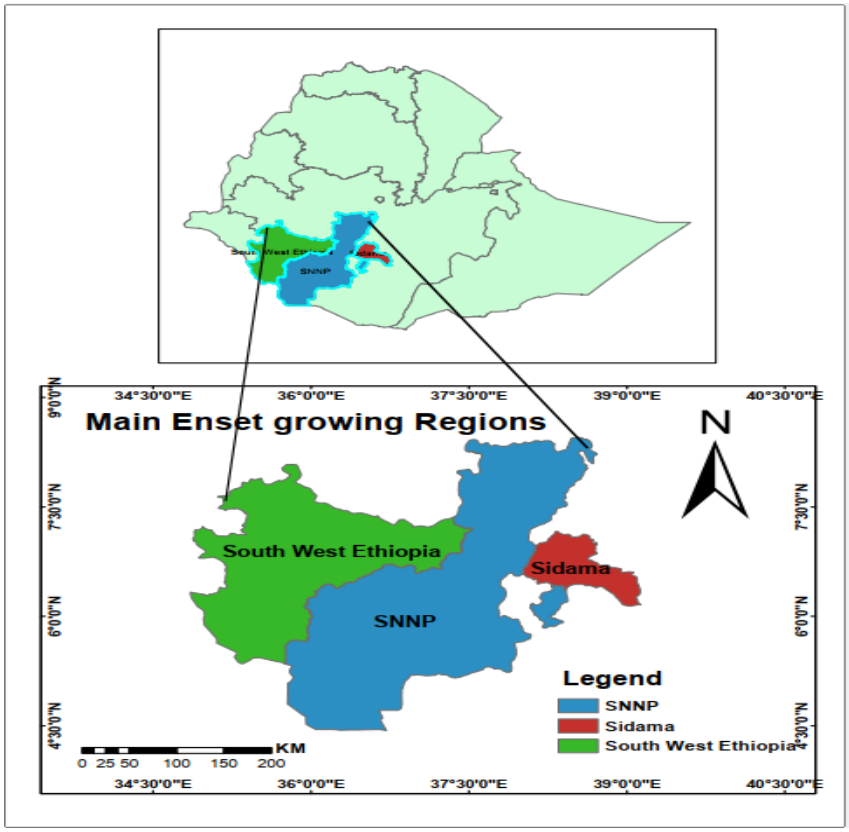
Methodology

Literature Search

A comprehensive literature analysis was conducted utilizing a holistic methodology that integrated many sources, including original research articles, peer-reviewed journals, working papers, project reports, fact sheets, databases, and other relevant indexes. Priority was given to acquiring recent and outstanding studies to guarantee current insights. The literature review was predominantly performed using reputable international databases including Scopus, Web of Science, PubMed, and Google Scholar, augmented by institutional repositories and alternative sources when required.

A collection of specific keywords and Boolean operators was utilized to direct the search, including: “Enset as an underutilized food crop,” “enset for sustainable agriculture,” “enset and biodiversity conservation,” “enset farming system,” and “food security status in Ethiopia.” Further cross-referencing was conducted by examining the references of appropriate articles to identify research not indexed in the primary databases. The selection criteria emphasized research that provide empirical evidence, theoretical insights, or case-based assessments concerning enset's significance in agriculture, biodiversity, and food security. This systematic method ensured the review included both the depth and scope of existing information, while also highlighting research gaps that need additional scientific investigation.

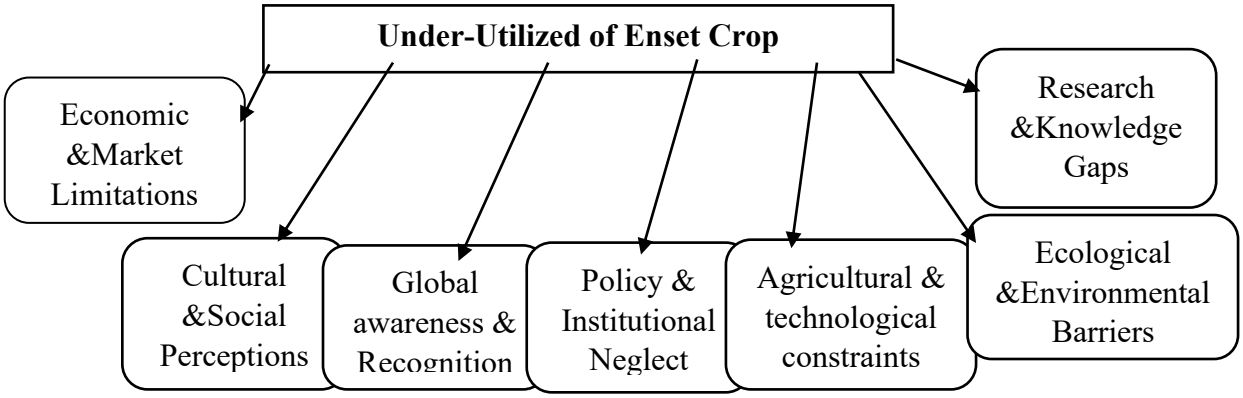
Fig. 1 Map of the Study



Findings

Under-Utilization of Enset (*Ensete ventricosum*)

The major challenges Under-Utilization of Enset include land shortage, recurrent drought, disease, lack of improved clones for yield, disease resistance landrace, drought tolerance, labour shortage, inadequate processing and storage technologies, traditional agronomic practices, financial constraints, long maturity, and food scarcity/starvation (Tenaye & Geta, 2009).



Enset is a plant that is still not used to its full potential in Ethiopia, despite enset is a plant that is still not used to its full potential in Ethiopia, despite the fact that it has the ability to make a significant contribution to food security, resilience, and ecological sustainability in the country. The rationale behind this is complex and includes a variety of dimensions, including those that are socio-cultural, economic, institutional, and ecological. The key reasons for its limited adoption and utilization are examined in the sections that follow.

Cultural and Social Perceptions

The cultivation of enset is closely associated with the customs and traditions of the communities that make up Central and Southern Ethiopia, especially those of the Hadiya, Gurage, Kambeta, Sidama, and Wolayta people (Dilebo et al., 2022). Nevertheless, when it comes to locations outside of them, enset is typically considered to be a meal that is distinctive to a certain region or "ethnic group," which limits its broader adoption. In urban areas, meals derived from enset, such as kocho and bulla, are frequently considered to be "traditional" or undesirable when contrasted to cereals such as wheat or teff (Yemata, 2020). Demand and consumption are constrained as a result of these views, which restrict its attractiveness, particularly among younger generations.

Agricultural and Technological Limitations

The cultivation of enset necessitates a long-term management strategy, a labor-intensive processing system, and a large amount of indigenous expertise (Garedew et al., 2017). It does not generate profits in the short term, which is different from grains. This discourages farmers who are in need of urgent livelihood. The cultivation of enset is made more difficult due to the absence of technologies for mechanized harvesting and processing, (Tsegaye & Struik, 2002). In addition, there is still a limited supply of genotypes that are resistant to disease, new agronomic packages, and enhanced plant varieties. In comparison to crops that are supported by considerable technological developments, these challenges reduce enset's competitiveness (Dejene, 2024).

Gaps in Research and Knowledge

Enset is occasionally described to as "Ethiopia's tree against hunger," but it has not been the subject of sufficient scientific research (Kidane et al., 2021). The amount of research that has been conducted on breeding programs, soil management, pest and disease control, and value chain development is insufficient. Genetic diversity is another area that lacks research (Sthapit et al., 2008; Salgotra & Chauhan, 2023). Additionally, there is a dearth of adequate documenting of the indigenous knowledge that is associated with cultivation and processing, and it is not well incorporated into formal research. This lack of awareness is a challenge to the development of the crop, and it also makes it less appealing to both farmers and politicians together.

Restrictions on the Economy and the Market

The majority of the enset that is cultivated is for household consumption, and just a small portion of it is sold for profit (Feyisa et al., 2022; Morrow et al., 2023). Its economic advantages are diminished because of the absence of contemporary storage techniques, the absence of value-added processing, and the absence of well-established markets for the purchase and sale of various goods and services (Blomme et al., 2023). Farmers are less motivated to participate in more extensive trading due to the challenges that they often face when it comes to transportation of enset items that are substantial (Dinbore et al., 2025). On the other hand, grains are more appealing and profitable since they have well-established marketplaces and value chains. The lack of integration in the value chain is an additional factor that limits the economic viability of enset (Haji et al., 2022).

Neglect of Policy and Institutions

Throughout history, the primary focus of agricultural policies in Ethiopia has been on the development of cereals (wheat, maize, and teff) and cash crops (khat and coffee),(Khairo et al., 2005). This means that the country's native crops, such as enset, have received less attention. As a general rule of thumb, the cultivation of enset is not included on the priority agendas of extension services, research funds, or development projects (Brandt et al., 2020). Consequently, enset continues to be overlooked in the national food security policy, even though it is capable of withstanding drought and is able to provide household nutrition during times when crops fail, (Weerakoon et al., 2023; Pawlak & Kołodziejczak, 2020).

Challenges Associated with the Environment and Ecology:

There are a number of factors that hinder the growth of enset, even though it has the capacity to flourish in a wide range of agro-ecological conditions, (Merga et al., 2019). These factors include, but are not limited to, competition from other crops, land scarcity, and population pressure. Smallholder farmers may often opt for crops that reach maturity relatively fast in an effort to meet the urgent food needs of their families (Negash, 2001). This results in a reduction in the quantity of land that may be used for perennial crops like enset. Furthermore, the development of illnesses like bacterial wilt (Xanthomonas campestris pv. musacearum) causes a significant decrease in productivity and discourages new people from joining the movement (Geberewold, 2019).

Enset for suitable agriculture

The advancement of environmentally friendly farming practices depends on the fact that enset is able to withstand both drought and disease (Geberewold, 2019). It is able to survive in locations that have a restricted supply of water due to its unique physiological adaptations, which is beneficial to farmers because it means that they can grow crops with less irrigation, which is an important component of water conservation (Ingrao et al., 2023). As a result of the fact that enset has a natural resistance to a number of diseases, there is a reduced requirement for chemical pesticides, and the soil ecosystem is in better condition (Tewodros & Tesfaye, 2014). This aspect of the enset plant contributes

to the practice of sustainable agriculture by promoting biodiversity and minimizing the amount of pollutants in the environment. It is possible to develop crop varieties that are more resilient and sustainable by doing research on the disease resistance of enset (Woyesa & Kumar, 2022).

How does Enset's (Enset ventricosum) contribute to sustainable agriculture practices?

Enset's distinctive physiological and morphological adaptations, which let it to conserve water and endure in water-scarce environments, are responsible for its drought tolerance (Rachel R. et al.,2025). By allowing farmers to grow crops in regions with scarce water supplies, this supports sustainable agricultural practices (Senbeta et al., 2022). By improving other crops' drought resistance, breeding programs can benefit from an understanding of these systems. Eset is a desirable crop for water saving initiatives because of its drought resistance, which allows it to flourish with little watering. By lessening the demand on water resources, particularly in regions with limited water supplies, enset cultivation can support sustainable agriculture (Dilebo, 2025). Additionally, this method promotes water conservation in farming, which benefits the environment and other crops.

Furthermore, enset's vast root system aids in soil stabilization and erosion control, both of which are essential for preserving productive land and avoiding sedimentation in waterways (Woldesenbet et al., 2020). This enset farming feature lowers the risk of floods and landslides while maintaining soil quality, which promotes sustainable agriculture. Enset farming, which effectively conserves soil, can guarantee agricultural lands' long-term productivity (Dobo et al., 2018). Enset is a potentially useful crop for adjusting to the difficulties brought on by climate change, such as the increased frequency of extreme weather events, because of its resistance to disease and drought (Rachel et al., 2025). Farmers can improve the resilience of their agricultural systems to climatic variability and support sustainable agriculture by integrating enset into their farming operations (Belay et al., 2022). In light of climate change, this can support sustainable livelihoods and food security. Furthermore, enset naturally resists several diseases, lowering the need for artificial pesticides and promoting a more robust soil environment (Nagarajan, 2025). By reducing environmental contaminants and fostering biodiversity, this enset feature supports sustainable agriculture. Researching the disease resistance of enset can help create crop types that are more resilient and sustainable (FAO, 2016).

Enset, as a staple crop in numerous locations, exhibits drought tolerance and disease resistance, hence enhancing food security through the provision of reliable yields in adverse situations (Morrow et al., 2023). This facet of enset production promotes sustainable agriculture by ensuring a dependable nutritional source for local people, thereby bolstering their resilience against food shortages and price fluctuations (Abdi et al., 2024). Enset can significantly contribute to ensuring food security, particularly in regions susceptible to climate change and economic disruptions. The economic feasibility of enset cultivation, attributed to its drought resilience and disease resistance, can enhance sustainable agriculture by guaranteeing the economic sustainability of farming operations for farmers (Senbeta et al., 2022). This may promote the adoption of enset cultivation, supporting local economies and facilitating rural development. Economic sustainability is essential for ensuring long-term viability of agricultural systems and the livelihoods they sustain (Urugo et al., 2024).

Integrating enset into agroforestry systems helps diversify agricultural income, enhance soil quality, and promote biodiversity (Fahad et al., 2022). This method supports sustainable agriculture by enhancing ecological interactions and synergies within various components of the agroecosystem. Enset's drought resistance and disease resilience render it an appropriate species for incorporation into agroforestry, thereby enhancing the resilience and sustainability of agricultural systems (Wambui, 2024). The cultivation of enset can enhance biodiversity by offering habitat for beneficial insects and microorganisms, and by integrating into agroecosystems that maintain balance in the environment (Gebre, 2015). This facet of enset cultivation promotes sustainable agriculture by preserving ecosystem services vital for agricultural yield and environmental well-being (Borrell et al., 2020). Promoting biodiversity via enset agriculture can also foster stronger and more adaptable agricultural ecosystems (Sahle et al., 2022). Integrating enset into agricultural systems helps enhance crop diversification, which is vital for sustainable agriculture (Sirany, Tadele, Aregahegn, et al., 2022). Diversified farms exhibit greater resilience to environmental pressures and market volatility, hence ensuring consistent incomes for farmers (Lin, 2011). The distinctive attributes of enset provide it a significant enhancement to varied agricultural systems, enabling more sustainable and resilient farming techniques (Ndlovu et al., 2024; Dibaba, 2023).

Enset's role in promoting Biodiversity and ecosystem services

Enset contributes significantly to biodiversity by offering food security and genetic variation. Ethiopian enset farming has resulted in the discovery of many landraces with unique physical features and agronomic qualities (Haile et al., 2023; Dilebo et al., 2023). These landraces contribute to the overall genetic diversity of enset, which is important for its adaptation and resilience to environmental changes (Dilebo et al., 2023; Olango, Tesfaye, Catellani, & Pè, 2014). Enset is also cultivated alongside other food crops, resulting in diverse farming systems that enhance food crop diversity and self-reliance (Dilebo et al., 2022; Guy et al., 2023). Additionally, enset landraces are maintained and conserved by local farmers through traditional farming practices, ensuring the preservation of on-farm diversity (Dilebo et al., 2023). The indigenous knowledge associated with enset cultivation and management is crucial for understanding the cultural, social, and economic values of enset and its production system. Overall, enset contributes to biodiversity by providing a diverse range of landraces, promoting food crop diversity, and preserving indigenous knowledge and farming practices (Olango, Tesfaye, Catellani, & P, 2014; Sahle et al., 2021; Tsegaye & Struik, 2002). Smallholder farmers gain food security and self-reliance by growing enset in mixed subsistence systems. Enset production systems increase farm food crop diversity by diversifying crops, co-staples, and animals (Blomme et al., 2023; Sahle et al., 2022).

Genetic studies have shown that enset exhibits high levels of genetic variation within populations and regions, indicating the presence of unexplored diversity that can be utilized for improving enset (Smyth et al., 2011; Sobisevich et al., 2019). Indigenous knowledge and local practices play a crucial role in maintaining and managing enset genetic resources, leading to the maintenance of on-farm landrace diversity (Olango, Tesfaye, Catellani, & P, 2014; Yemataw et al., 2016). The development of molecular markers and genomics resources for enset further supports the understanding and conservation of its genetic diversity. Enset, also known as the Ethiopian banana, has several ecological benefits for the surrounding environment. Firstly, enset is a purely natural plant-based dye that can be used as a colorant in offset ink, reducing pollution and harm to the environment (Nuraga et al., 2022; Muzemil et al., 2021;

Gaikwad et al., 2022). Overall, enset cultivation and the associated indigenous knowledge contribute to the promotion and conservation of biodiversity in Ethiopia (Olango et al., 2015; Nuraga et al., 2022).

According to different research findings, enset cultivation contributes significantly to biodiversity and agro-ecological sustainability. With an inherent ability to thrive in diverse ecological zones, enset enhances the resilience of local agricultural systems (Garbole, 2025). Its cultivation encourages a harmonious relationship between humans and their environment, promoting sustainable farming practices that are attuned to the unique characteristics of the Ethiopian Highlands (Blomme et al., 2023; Negash & Niehof, 2004).

Enset for food security

Enset is one of the most important crops in Ethiopia for food and nutritional security, as well as an income source (Aneseyee et al., 2022). In addition, it is significant in terms of socioeconomic and cultural factors, making it one of the most important food and livelihood security crops in the country. The plant is capable of enduring severe environmental conditions that most plants are unable to survive in, and it is also recognized for its adaptability and resistant habit. More than 20% of Ethiopia relies on enset for their livelihood (Borrell et al., 2019).

The primary factors that contribute to the scarcity of food in Ethiopia include natural disasters including floods, drought, instability, and violence, all of which are significant issues in the country (Feyisa et al., 2022). The deterioration of these variables has led to large-scale relocation along the borders of Somalia, Oromia, and SNNPR. In order to tackle the issue of food insecurity, the government of Ethiopia is taking on a strong leadership role by instituting programs that respond to the wide range of requirements of families who are in a disadvantaged position (Masayoshi, 1989). It is making significant investments and successes, most notably through its productive safety net program. The impact of enset extends far beyond the scope of food security. It gives women power throughout the entire production cycle, from the planting and harvesting of crops to the processing and marketing of products (Mengesha et al., 2022). In Ethiopia, the enset plant is considered to be far more than simply an agricultural commodity. Its abundance is considered a symbol of wealth and rank in some communities, and it is closely connected to the social and cultural characteristics of the towns (van Hoof et al., 2021). This is demonstrated by the fact that its influences include social standing, which is determined by land ownership, as well as characteristics of rituals that represent abundance, fertility, and even spiritual connection. It also has an influence on food culture through the way in which food is prepared (Yemata, 2020).

Enset cultivation contributes to food security by offering a consistent and year-round food source. Unlike some seasonal crops (Sherka & Tsehay, 2025). Enset provides a reliable food supply, helping mitigate the impact of seasonal variations and potential agricultural uncertainties. Enset, often referred to as the "false banana" due to its visual resemblance to the banana plant, is a staple food that forms a substantial part of the local diet (Michler & Josephson, 2017). The various edible parts of the enset plant, including the corm and pseudo-stem, provide a valuable source of carbohydrates, particularly in the form of starch (Sahle et al., 2021; Feyisa et al., 2022b).

Enset cultivation contributes to food security by providing substantial food security services to small-holder farmers in the southern Ethiopian highlands (Blomme et al., 2023). Enset is a key food security crop in Southern Ethiopia, where almost 20 million people rely on it for survival (Yigbeta et al., 2023). Enset-based food systems serve as a staple food for millions of households and possess unique crop traits that make it resilient to a wide range of environmental conditions (Morrow et al., 2023). Enset is a multipurpose crop that delivers various provisioning services, including food, feed, and fuel, and it is resistant to drought, flood, and frost (Nuraga et al., 2022). The cultivation of enset ensures food availability and food security, especially with population growth, and it acts as a buffer and adaptation strategy in the face of shocks or change (Aneseyee et al., 2022). Enset farming systems are sustainable and require less tillage and few off-farm inputs, making them resilient to global change.

Enset was estimated to be Ethiopia's second most produced crop and fourth highest yield per hectare crop during the 2017/18 cropping season. According to statistics from Ethiopia's Central Statistics Agency (CSA, 1995-2017), the area of enset land cover and yield have expanded by around 46% and 12-fold during the previous two decades, respectively (Borrell et al., 2020). Kocho's production in terms of eatable dry weight and energy per unit area of land much outperforms that of any other crop grown in the country. Furthermore, enset delivers up to 4,000 calories per square meter each year, which is 20 times the calories supplied by cereal. It provides around 20% of national carbohydrate requirements from only 300,000 acres of land (Kudama, 2021).

Enset has a much better yield per unit area of land than other typical Ethiopian staples such as grains, potatoes, sweet potatoes, and bananas. The annual enset production per plant is expected to be 50.3 kilograms (including 27 kg Kocho, 23 kg amicho, and 1 kg bulla) (Borrell et al., 2019). Crop production helps to address food security issues in densely inhabited regions (Porter et al., 2015). Given suitable agro-ecology for enset agriculture, enset production is thought to offer a larger potential for population sustainability than other crops in very populous places with resource scarcity in Ethiopia or elsewhere in the globe (Kudama, 2021). Moreover, enset-derived food items are a main component of daily meals for most households, complemented by other crops produced on the farm. Enset cultivation ensures food availability and food security, especially with population growth. Enset-based food systems have been identified as strategic for household food security, and the area of mature enset significantly improves estimates for food security indicators (Morrow et al., 2023; Senbeta et al., 2022).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethics Declaration

Ethical approval was not required for this study as it did not involve human participants or animals.

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