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Enset, the Underutilized Suitable Food Crop for Sustainable Agriculture and Guard against Famine in Ethiopia

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Abstract

Given the multi-benefits, enset cultivation has been continuously underutilized in Ethiopia. I assess multi-benefits of enset focusing on its sustainability and potency in famine reduction in Ethiopia by reviewing evidence on sustainability, hunger reduction, inputs cost and yields advantage ofenset. I find that enset is a first rated climate smart crop,superior in guarding the poor because of its highest yield, energy food supply, and costs advantages; but low in protein, lacks vitamin A. In contrast, its long-period maturity and cultural perceptions limit its expansion. Therefore, exploring and expanding early-maturing varieties, supplementing enset-growing areas with vitamin A and protein-rich food crops, and changing social-perceptions are vital important to guard against famine, and realize environmental sustainability through enset cultivation.

Keywords: 1.Climate smart 2. Enset 3. Environmental sustainability 4. Famine 5. Food supply

1. Introduction

Ethiopia the second most populous in Africa, with an estimated population of 102.4 million in 2016 (WFP, 2019, is still categorized as one of the seriously hunger affected countries in the world though the Hunger Index (GHI) score of the country has declined from 53.7 (extremely alarming) in 2000 to 26.2 in 2020. As of the GHI most recent data, the country hold 92th position among 107 countries in the world (Von Grebmer et al., 2020). Moreover, about 25.5% (26 million people) of the population was food insecure, and 23.5% of the population fell under national poverty line in 2016 (WFP, 2019). The hunger cost of child malnutrition is also a series problem in Ethiopia. The total annual cost of child undernutrition is estimated to 17% of country's earning in terms of GDP

(Gross Domestic Product) (African Union Commission, NEPAD Planning and Coordinating Agency, UN Economic Commission for Africa, 2014).

Food security is vastly exposed to climate shocks in Ethiopia since economies of the country extremely relies on climate-sensitive farming system (Alemu & Mengistu, 2019). Droughts and climate related calamities are substantial triggers that aggravate vulnerability to food insecurity and destabilized livelihoods in the country (WFP, 2019).Furthermore, despite climate changes believed to have only moderate influences crop productivities in Ethiopia, the future weather outcomes are expected to become more variable, suggesting that severe droughts and floods and have a greater effect on cereal production in the future than in the past (Thomas et al., 2019). On the other hand, enset and other indigenous crops that have long helped guard families against hunger due to its low production and high yields, and which are potential to improve food security, nutrition, and environmental sustainability are underutilized in the country. Consequently, the Ethiopia has been the major receiver of food aid and net food importer despite it is a center of diversity and domestication for various food crops.

Enset (Enseteventricosum (Welw.) Cheesman), occasionallynamed as false-banana, is a non-woody perennial plantindigenous to Ethiopia. Ensethas been domesticated about 10,000 years back in Ethiopia (Brandt et al., 1997; Jacobsen et al., 2018), currently it provides the staple food for about 20 million people in the Ethiopian Highlands(Borrell et al., 2019). Even if the wild grown of the genus *Enset*eare widely distributed all over Africa and Southern Asia, it is grown as a food crop in limited area of the southwest part of the country (Blench 2007) as cited in (Yemata, 2020).The distribution of enset cultivation is highly varied in Ethiopia based on environmental situations and social choices. Enset is plentiful to greatest extent in northern and eastern parties of the Southern Nations, Nationalities and Peoples Region (SNNPR), but is also a vital crop in parts Oromia and eastern Gambela regions (Borrell et al., 2020).

Although enset is largely produced for human food, it also used as animal feeds (Olango et al., 2015). Different parts of enset and processed products of several domesticated enset landraces provide socio-cultural, medicinal and economic benefits (Olango et al., 2015). Furthermore, its fibers used for making ropes, as well as the other strands the crop used forroofing and packaging.

Enset raises in fertile and well drained soils, with altitudes ranging from 1,200 to 3,100 meter above sea level (Brandt et al., 1997; Jacobsen et al., 2018). Despite it takes 4–7 years to fully grow after planting, enset can also be ripened at any stage (including when it is immature) and at any seasons of the year, and starch resulting from enset can also be stored over several years (Birmeta, 2004; Borrell et al., 2019). Enset also characterized as 'a tree against hunger' (Borrell et al., 2019; Brandt et al., 1997) because of its essential features for food security. These attributes were realized during the distressing starvations in 1984 in Ethiopia, where enset-growing areas stated little-to-

no food security problems(Borrell et al., 2019). Withstanding with drought and harsh environment stress is the most important attributes of enset(Borrell et al., 2019; Olango et al., 2015). Likewise, it grows under a wide ranges of agro-ecological zones (Jacobsen et al., 2018; Olango et al., 2015).

With relatively small inputs and farm management practices, enset has been stated to provide the highest yield as compared to other starch crops in Ethiopia (Borrell et al., 2019; Tsegaye & Struik, 2001). Enset can also capable to support a larger population per unit area than regions depending on cereals (Borrell et al., 2019). Despite its high potential and quality attributes in terms of sustainable food supply for long period, protecting against cyclical and periodic food deficits, with small farm input can be prolonged to other regions, where it grows as a wild crop, enset is limited to South-West Ethiopia (Borrell et al., 2019; Olango et al., 2015).

Given 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. 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).Moreover, in contrast to multiple qualities of enset, literatures are hardly existing in several important areas of enset(Borrell et al., 2019).

In an effort to increase the visibility of enset, the underutilized multi benefit plant to the research community and any develop programs, this paper aims to review the literature focused on enset, show its potential to improve food and nutritionsecurity, suitability for sustainable agriculture, and additional attributes. In so far as earlier review researches have largely been focused on some benefitsof enset as well as few in number, this paper will add values to existing literatures and serve as a significant knowledge base.

2. Methodology

Literature Search

I used all-inclusive approach comprising original research articles, peer-reviewed articles, working papers, project reports, fact sheets, database, and indexes from different sources to produce a broad review. The literature was collected via, Web of science, and Google scholar and so forth, largely focusing on more recent studies. The key words used were: enset production andproductivity, nutritional and food security improvement of enset, enset for environmental maintenance, enset for forage improvement, and sustainable agriculture, by-products and industrial uses of enset, medicinal benefits of enset, and food security status of Ethiopia.

I reviewed 17 peer reviewed journals, 1 book chapters, 8 International workshop papers, 6 reports, 2 working papers, and 2 fact sheets. Among the 17 peer reviewed journals, 14 are empirical studies, and 3 are literature reviews papers.

3. Findings

Based on the relations of the topics the review results were categorized into (1) enset for environmental sustainability (2) enset foods and their nutritional enhancement, (3) enset for food security improvement, (4), enset yield, (5) inputs and cost advantages of *enset*production (6)enset for forage improvement, (7)medicinal importance of Enset, and (8) industrial and alternativebenefits of enset.

3.1. Enset for environmental sustainability

The benefit of enset is not limited to meet the food security demand of current generations.It can also be recognized as an imminent food security plant since it has potential to sustain and maintain the quality of soil (Woldetensaye, 2016). The capability to deliver a long-term, food supply on continuous basis, with lowest off-farm input, is possibly the most remarkable features of enset.

On the other hand, as a perennial plant, enset does not need ploughing. The negligeable soil erosion involved in enset production is the key contribution of enset to sustainability (Brandt et al., 1997). Moreover, the wide shelter of enset's leaves interfere, divert, resize as well as minimize the energy of rainfall with which it could have hit the ground. Enset, therefore, helps to minimize soil erosion and considered as a soil building plant. Besides, the deep roots of enset permeates water to percolate and reduces surface overflow, saves more water in the soil and increase in groundwater. As a result, it enhances quantity, availability and lengthen the period of water flows to springs and minimizes the risk of long period drought (Brandt et al., 1997; Heuzé et al., 2017).

The cultures of enset (like leaf midribs, pseudostem sheath, pseudostem core) are easily convertible to crop nutrients that improves soil organic matter and nutrients. After harvesting, enset leaves can serves as mulching, which improves organic matter and soil conservation. Enset also reported to increase soil fertility than fields or pastures counterparts (Heuzé et al., 2017; Shank & Ertiro, 1996). Similarly, the research finding by Tamire and Argaw (2015)disclosed that enset improves soil maintenance under different agro-ecologies in Ethiopia. Moreover, the extended occurrence of its canopy has an ecological benefit comparable to forest (Admasu and Struik 2001) and offers shade to the coffee and other crops

Enset has vital benefit for the ecosystem amenities as it is an important food source for bees, and maintain soils. Moreover, enset is extremely important since it is capable to resist extensive drought (Willis, 2016). It withstands with drought due to its osmotic modification and water holding capacity (Fetene & Yemata, 2016). Upon extreme drought, therefore, enset looks to be a first-rated crop to be encouraged to overcome forthcoming climate change, pest and pathogen outbreaks adverse effects on future food security and supply in Ethiopia. Because of such features, ensetis commonly recognized to have the ability to be a climate-smart plant of the future(Willis, 2016).

3.2. Enset foodsfor nutritional improvement

Enset is a staple food crop that preserved preferably suited to fill food shortage gap, usually in Ethiopia (Tsegaye, 2002; Yemata, 2020). Enset also consumed as a cooked vegetable in different area of Southeast Asia, and its flowering part is also eaten in Malawi as a fun (Yemata, 2020). The types of traditional food products resulting from enset (including yogurts, cakes, dumplings and porridges) are reported to exceeds 20 in Ethiopia (Fanta & Satheesh, 2019). However, the major foods items obtained from Enset involves, *Kocho, Bulla,* and*Amicho*(Forsido et al., 2013; Yemata, 2020).*Kocho*, the most predominant product, rich in starch product prepared by fermenting the pulp (from scraping the pseudostem and crushing the corm) wrapped in enset leaves in an underground pit inside the enset home garden (Borrell et al., 2020). *Bulla* is dehydrated product of the juice from the decortication of the pseudostem and corm, and *Amicho,* the boiled corm enset(Forsido et al., 2013; Yemata, 2020).

Enset is rich in carbohydrates with minimum amount of essential amino acids, like methionine and isoleucine (Jacobsen et al., 2018). In area where enset is staple food, it mainly used for meal, on average 0.5 kg is consumed per person daily,and provides 68% of the total energy intake, 20% protein, 28% iron, but no vitamin A (Jacobsen et al., 2018; Negash & Niehof, 2004). Among the commonfoods items resulting from enset, *kocho* and *bulla* are superior energy sources. *Kocho* provides 400 kcal/100 g energy (Bosha et al., 2016) , and like *kocho*, *bulla* also has of about 395 kcal/100 g energy, but amicho has less energy (333 kcal/100 g) (Daba & Shigeta, 2016; Fanta & Satheesh, 2019). The energy value of enset is similar to potato (Mohammed *et al.*, 2013), and the low content of amino acids of the enset meal is frequently supplemented with protein from milk, meat or leguminous, like peas and beans(Bvenura & Afolayan, 2015; Jacobsen et al., 2018). Similarly, nonappearance of vitamin A is compensated by vegetable like cabbage in most enset-cultivating farm households (Jacobsen et al., 2018). Furthermore, the low compositions of fats and proteins in enset diet is highly preferred by people who require low-fat meals. *Kocho* and *amicho* are populous for their fiber content also essential for cholesterol regulation and help to constipation avoidance (Fanta & Satheesh, 2019).

On the other hand, the research finding by Gibson et al.(2008) indicated that pregnant women who depended on enset as a staple food had higher vitamin B-12 levels than their maize- based peers in southern Ethiopia. In addition, chemical analysis of vitamin B-12 level for the enset- diet group were found to exceeds twofold of the standard set by WHO/FAO the mean requirement for a pregnant women (Gibson et al., 2008).Enset-based diet therefore, contributes on pregnant woman and infants' nutritional improvements through minimizing the risk of vitamin B-12 deficit.

3.3. Enset for food security enhancement

Enset-based agriculture is the economic mainstay for Southern parties of Ethiopian (McKnight Foundation, 2013). Despite enset is wild growing across several parties of East and Southern Africa, its farming system hasn't virtually known outside of these areas. It is the starch-riched staple of the Ethiopian Highlands, where its unique characters improve the food security for estimated 20 million people (Borrell et al., 2019). Enset's resilience and adaptability has got it the designation of "The Tree Against Hunger"(Borrell et al., 2020; Brandt et al., 1997).

Despite enset-cultivating areas are characterized small land size and the largest overcrowded population in the count (Tsegaye and Struik 2001), they tended to experience low levels of food insecurity or face no food security challenges as compared to non-enset growing areas in the country (Borrell et al., 2019)For example, the share of food insecure households was highest for Amhara region, non-enset growing region with (36%) of food insecure households in 2016, while the share of food insecure households was the lowest for Southern Nations, Nationalities, and People Region (SNNPR), the largest enset-growing region, with (8.4%) of food insecure households for the same period. Likewise, Amhara region found to be the least in terms of adult average kilocalorie intake per day, at 2398 kcals per adult per day (related to countrywide mean of 3008 kcals), while SNNPR had the highest kcal intake per adult at 3558 kcals for the forementioned period (WFP, 2019).

The big difference across enset-cultivating and non-enset cultivating regions in terms of food insecurity and kilocalorie intake implies the highest value contribution of enset for food security improvement.In general, given the conducive adaptable of enset to different agro-ecologies, it has potential to expand to elsewhere in Southern and East Africa and guarantee smallholders' food security (Borrell et al., 2020).

3.4. Enset yield

Enset is reported to be second most produced crop and the fourth highest yield per hectare crop in 2017/18 cropping season in Ethiopia. According to data obtained from Ethiopia's Central Statistics Agency (CSA, 1995–2017), the area for enset land cover and its yield has increased with about 46%, and 12 fold over last two decades respectively (Borrell et al., 2020). The productivity of *kocho*, in unit per area of land, in terms of eatable dry weight and energy, by far exceeds any crops produced in the country

(Tsegaye and Struik 2001). Furthermore, Enset provides up to 4,000 calories or 20 folds of calories generated by cereal per square meter per year. It renders about 20% of national carbohydrate requirements, only from 300,000 ha of land due to its higher yield per area of land.

The productivity of enset per unit area of land is significantly higher than that of other common Ethiopian staples such as cereals, potato, sweet potato and banana. The annual enset yield per plant is estimated to 50.3 kg (involving of 27 kg Kocho, 23 kg amicho and 1 kg bulla)(Borrell et al., 2019). The high productivity of the crop aids to overcome food security problems in densely populated areas (Christensen Fund, 2014). Enset production is therefore, believed to have higher potential in sustaining the population as compared to other crops, in highly populous areas with resource poor situations in Ethiopia or elsewhere in the world given conducive agroecology for enset cultivation.

3.5. Inputs and cost advantages of *enset*production

Enset is commonly produced with a little cost when compared different crops as it requires no cash outlays, and minimum labor and land for production. Considering zero cash outlay for production and opportunity cost of labor, the total cost of production for one metric ton of *kocho* is estimated to $51 USD (Christensen Fund, 2014).

Furthermore, *enset* offers food security with little cost. Although enset-growing areas are recognized as the poorest and leading densely populous areas in the country, they have the highest daily caloric consumption, and expend the lowest cost per kilo of food of any zone (Christensen Fund, 2014). Similar source also confirms that the most *enset*-producing areas (SNNPR and Oromia) found to have the largest daily caloric consumption and lowermost expenditure per unit of diet(Berhane et al., 2011)

3.6. Enset for forage improvement

Enset is an imperative animal fodder particularly during dry seasons due to its high-water content (85 to 90%) and upon limited animal fodder supply. The leaf of enset recognized as a good source of animal feedstuff, holding 13% protein (the highest protein concentration fodder existing in Ethiopia), 20% crude fiber and 10% sugar. Additionally, the high sugar content of enset leaves make it appropriate for ensilage (Mohammed et al., 2013). It also possesses more than adequate levels of potassium, magnesium, zinc and manganese, with no toxicity effects for ruminants, but it was completely scarce in P, Na, Cu, Co and Se. Enset leaves are commonly appropriate fodder for ruminants. However, enset leaves alone are not sufficient to be optimal ruminants and it seeks be supplemented additional feed comprising some minerals and energy to be balance feeds (Mohammed et al., 2013).

Enset corm provide 17 of 20 amino acids, which is similar or more level of amino acids as compared to potato. The pseudostem provide higher level of soluble carbohydrates (80%) and starch (65%), but low protein level (4%). Hence it seeks to be complemented with protein and complementary amino acids; for instance from beans, which are appropriate to intercrop with enset(Mohammed et al., 2013).

3.7. Medicinal importance of Enset

Enset is culturally considered as an important medicinal crop in Ethiopia. Different types of enset are stated to have curative and cultural importance for anticipating, healing, and therapeutic benefits. Few types enset are supposed to serve as a medicine among enset cultivating society. Accordingly, sweetie, a type enset is largely used for curative for a person suffering from bone-related problems in Areka area. Similarly, the boiled *corm* and *bulla* of*tayo*(*Werkie-bidu* called in West Shoa Zone), a type of enset with a light red pseudostem and midrib with deep green leaf is consumed with milk for joint dislocation, inflammation, and broken bone fractures treatments. It also offers the same function for animals when it is fed with salt (Daba & Shigeta, 2016; Tsehaye & Kebebew, 2006).

Additionally, in area where enset is not a common, like the central highlands and cities, *bulla* is consumed by a mother who born baby for strengthening and immediate return to normal health (Daba & Shigeta, 2016).

3.8. Industrial and alternative benefits of enset

In addition to its a main dietary starch source, medicinal, environmental rehabilitation benefits, enset also serve as a multipurpose industrial crop and has the potential to produce different other valuable by-products (Gessesse, 2016). The starch from enset has crucial function in numerous industrial processessuch as food, pharmaceuticals, cloth, paper, and adhesives products (Gebre-Mariam, 2016). The high-quality fiber of enset can be used for the production of specialty papers, such as currency notes, and tea bags, that require durable fibers. However, traditionally processing has been the major holdup for its widespread usage (Gessesse, 2016).

Fiber which is obtained from the pseudostem and leaves, mainly as a byproduct of *kocho* production (Borrell et al., 2020; Yemataw et al., 2018) is used to make sacks, ropes, sieves and mats. The leaf sheath, petioles and midrib of enset are used for compost preparation and fire fuel. The leaves of enset are also used for packaging *kocho*, butter, honey, making mattresses and pillows, and coating the fermentation pits for *kocho*. Leaves and midribs are also used for mulching, houses, and fencing construction (Borrell et al., 2020).

4. Conclusions and policy implications

Ethiopia, the second most populous in Africa is currently categorized as one of the seriously hunger affected countries in the world, with higher yearly hunger cost. Droughts and climate related calamities are substantial triggers that aggravate vulnerability to food insecurity and destabilized livelihoods in the country.

Despite investing in native crops (like enset) and agro-ecological measures can be the solution to reduce hunger, improve nutrition, and ensure environmental sustainability in Ethiopia, more than a quarter of the population suffers from high level food insecurity. Different development endeavors have largely focused on cereal crops productivity improvement with less or no attention paid to enset and other indigenous crops that have long guarded families against famine to regain self-sufficiency in food in the country. Consequently, still the country is a major receiver of food aid and net food importer.

This paper presents a review on how Enset, the underutilized food crop suits to sustainable agriculture and guard families against famine. To do this, I have synthesized the empirical findings on environmental sustainability, hunger reduction andnutritional improvement, inputs cost and high yields advantage ofenset over the other crops produced in Ethiopia.

In addition to its contribution to soil fertility enhancement than pastures, and its cultures soil organic matter improvement after harvest, enset also offers a vital ecological and ecosystem amenity benefits. Moreover, its extreme harsh environmental tolerance, osmotic modification and water holding capacity makes enset a first-rated climate-smart crop to be encouraged to overcome forthcoming climate change outbreaks adverse effects on future food security and supply in Ethiopia.

Presently, enset provides the staple food for about 20 million people in the Ethiopian Highlands. It contributes up to 4,000 calories or 20 folds of calories generated by cereal per square meter per year though it is low in protein and lacks vitamin A. Whilst non-enset growing areas tended to experience the highest levels of food insecurity, the lowest levels of food insecurity have been recorded in enset-cultivating areas (the most populous areas with resource poor situations and holding the smallest unit of land per a household) in Ethiopia. This is mainly due to the fact that high productivity and kilocalorie content of enset, low production cost and the lowest cost per unit of enset-food. Its potential in saving families against hunger under drought and harsh environment conditions was realized during the distressing starvations in 1984 in Ethiopia, where enset-growing areas stated little-to-no food security problems. Because of such essential features, enset has got the designation of “The Tree Against Hunger”. Similarly, enset-based diet, contributes on pregnant woman and infants’ nutritional improvements through minimizing the risk of vitamin B-12 deficit.

Furthermore, enset is an imperative animal fodder particularly during dry seasons due to its high-water content (85 to 90%) upon limited animal fodder supply. The leaf of enset recognized as a good source of animal feedstuff, holding 13% protein (the highest protein concentration fodder existing in Ethiopia), 20% crude fiber and 10% sugar.

In addition, few types enset (such sweetie and *tayo*) are largely used for curative for a person and animal suffering from joint dislocation, and broken bone fractures. Besides to these benefits, it has crucial function in food, pharmaceuticals, cloth, paper, and adhesives products processing industrials as well as its fiber can be used for the production of specialty papers, sacks, ropes, sieves and mats. The leaf sheath, petioles and midrib of enset are used for compost preparation and fire fuel. The leaves of enset are also used for packaging *kocho*, butter, honey, making mattresses and pillows, and coating the fermentation pits for *kocho*, mulching, houses, and fencing construction.

In general, given the multi benefits, adaptable of enset to different agro-ecologies, and its potency to expand to elsewhere in Southern and East Africa, enset cultivation has been continuously underutilized and almost confined to the southwest part of the country due to cultural perceptions politics, and history reasons.

Thus, focusing on enset expansion and production improvement will be imperative in view of the emerging food crisis and the future changes in climate with the associated problems of temperature rise, increasing drought, and the sudden changes in extreme environmental variations. In this scenario, the innate advantages of harsh environment tolerance and sustainability, adaptability to different agro-ecologies and climate resilience of enset to such extreme and unpredictable variations are recognized. Enset also has a great potential for guarding families against famine and contributing to forage improvements despite it is low in protein, lacks vitamin A and takes 4-7 years for maturity.

Therefore, exploring and expanding early maturing enset varieties via research discovery or technology that shorten the maturity periods of enset, supplementing enset-growing areas with important components of the enset system (protein-rich food crops like haricot bean and vitamin A enriched vegetable such as cabbage) as well as bringing changes in social perceptions on enset and expanding enset to non-enset producing potential areas through media promotion and extensions are vital important to improve food security, nutrition, and environmental sustainability over the long-term.

Declaration of competing interest
None

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None

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