Review article – Thematic Issue

Dietary diversity associated with different enset [*Ensete ventricosum* (Welw.) Cheesman]-based production systems in Ethiopia

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Summary

Introduction – **A large diversity of enset-based production systems exists in Ethiopia. Enset is cultivated in combination with multipurpose trees, coffee, vegetables (kale), root and tuber crops, and various cereals. In combination with roots and tubers, the cultivation of enset supports some of the most densely populated rural areas of Ethiopia.** *Problem statement* – **Enset is a starchy staple crop, high in carbohydrates, but low in vitamins and protein content. When enough enset plants are available on a farm, poor households do not go hungry, but their diets lack some essential nutrients. In general, most enset-based households can have a balanced diet, if they are able to supplement enset with protein from legumes and/or animal products. However, the very poor households tend to fall back on *kocho*, bean sauce, cabbage and taro, with little daily variation and low dietary diversity throughout the year.** *Recommendations* – **Sustainable intensification and diversification efforts are urgently needed to improve whole farm productivity and nutritional/dietary diversity in enset-based regions. In addition, research on food fortification and food supplementation of enset-based meals with nutrient-rich foods derived from, *e.g.*, legumes and green leafy vegetables is urgently needed. The bioavailability and bio-efficacy of the enriched meals also need to be studied.**

Keywords
enset, *Ensete ventricosum*, Ethiopia, *kocho*, multipurpose tree, nutrition security, nutritional value, staple crop

Résumé

Diversité alimentaire associée aux différents systèmes de production à base d'ensète [*Ensete ventricosum* (Welw.) Cheesman] en Ethiopie.

Introduction – **Une grande diversité de systèmes de production à base d'ensète existe en Ethiopie. L'ensète est cultivé en association avec des arbres à usages multiples, du café, des légumes (chou frisé), des racines et tubercules et diverses céréales. En association avec les racines et les tubercules, la culture d'ensètes subvient aux besoins des populations de certaines des zones rurales les plus densément peuplées d'Ethiopie.** *Problématique* – **L'ensète est une culture vivrière contenant de l'amidon, riche en glucides, mais pauvre en vitamines et en protéines. Lorsque l'ensète est disponible en quantité suffisante sur une ferme, les ménages pauvres ne souffrent pas de la faim, mais leur régime alimentaire manque de certains éléments nutritifs essentiels. En général, la plupart des ménages dont l'alimentation est à base d'ensète arrivent à avoir un régime alimentaire équilibré s'ils le complètent avec des protéines d'origine végétale (légumineuses) et/ou animale. Cependant, les ménages très pauvres ont tendance à se rabattre sur le *kocho*, la sauce aux haricots, le chou et le taro, avec peu de variations quotidiennes et une faible diversité de régimes alimentaires tout au long de l'année.** *Recommandations* – **Des efforts durables d'intensification et de diversification visant à améliorer la productivité de l'ensemble de l'exploitation et la diversité nutritionnelle/alimentaire dans les régions à base d'ensète sont indispensables. En outre, des recherches sont nécessaires en priorité sur l'enrichissement et la supplémentation alimentaires des repas à base d'ensète avec des aliments riches en nutriments, dérivés par exemple des légumineuses et de légumes verts. La biodisponibilité et la bioefficacité des repas enrichis doivent également être étudiées.**

Significance of this study

What is already known on this subject?

- A large diversity of enset-based production systems exists in Ethiopia. Enset is cultivated in combination with multipurpose trees, coffee, vegetables (*e.g.*, kale), root and tuber crops, and various cereals.

What are the new findings?

- Enset-based households can have a balanced diet, if they are able to supplement enset with protein from legumes and/or animal products. However, the very poor households tend to fall back on *kocho*, bean sauce, cabbage and taro, with little daily variation and low dietary diversity throughout the year.

What is the expected impact on horticulture?

- Improved whole farm productivity and nutritional/dietary diversity in enset-based regions can be achieved through sustainable intensification and diversification efforts tailored to various types of farmers.

Mots-clés
arbre multi usages, culture vivrière, ensète, *Ensete ventricosum*, Ethiopie, *kocho*, sécurité nutritionnelle, valeur nutritionnelle

Introduction

Enset (order *Scitamineae*, family *Musaceae*) can be found throughout Asia, sub-Saharan Africa and Madagascar (Baker and Simmonds, 1953; Simmonds, 1958), but it has only been domesticated in Ethiopia starting from around 10,000 years ago (Brandt *et al.*, 1997). Enset-based cultivation is one of the four major agricultural systems in Ethiopia, which includes pastoralism, shifting cultivation and grain-based cultivation (Westphal, 1975). Enset is an important crop in south and southwestern Ethiopia, with high cultural significance and able to supply long-term, sustainable food security with few off-farm inputs (Negash, 2001; Tsegay, 2002; Olango *et al.*, 2014).

With its robust leaves and broad pseudostem (up to 1 m diameter), enset is closely related to banana (*Musa* spp.), but it is taller, reaching up to 10 m (Westphal, 1975). In contrast with banana, enset fruits are not edible. Rather, the pseudostem and underground corm or rhizome are processed and used as food. Full maturity is reached after 4 to 12 years, depending on the landrace and altitude, with higher altitudes significantly increasing the duration of the cropping cycle (Negash, 2001). Domesticated enset grows in soils that are sufficiently fertile and well drained, and at altitudes ranging from 1,200 to 3,100 m above sea level (m a.s.l.) (Brandt *et al.*, 1997). Optimal cultivation conditions are found where annual rainfall ranges from 1,100 to 1,500 mm, at altitudes between 2,000 and 2,750 m a.s.l. and temperature averages between 10 and 21 °C (Brandt *et al.*, 1997). Low temperature limits cultivation of enset particularly at higher altitudes, whereas water availability is a restrictive factor for altitudes below 1,200 m a.s.l. Although landraces adapted to highlands can be cultivated in lowlands and *vice versa*, farmers claim that some landraces are specifically adapted to particular ecosystems (Olango *et al.*, 2014).

In combination with root and tuber crops, the cultivation of enset provides food self-sufficiency to some of the most densely populated rural areas of Ethiopia, indicating that the human carrying capacity of enset-based farming systems is likely higher than that of other crops and cropping systems with the same agroecology and inputs (Brandt *et al.*, 1997; Tsegay, 2002). Enset forms an integral part of the diet for 20% of the Ethiopian population, or at least 20 million people, concentrated in the highlands of south and southwestern Ethiopia (Brandt *et al.*, 1997; Sabura *et al.*, 2016). The total land area covered by enset-based farming systems is unknown. CSA (2011) stated that 300,000 ha of land is covered by enset-based farming systems. By contrast, BODEP (1996) refers to an estimated 576,000 ha covered by the perennial enset-based agroforestry systems of the south and southwestern highlands of Ethiopia. Clearly, hundreds of thousands of hectares are devoted to enset-based farming in Ethiopia, though the exact extent remains to be evaluated.

Distinctive enset production systems can be categorized based on environmental, agronomic and cultural criteria, and the level of importance given to enset within each cropping system (Westphal, 1975; Brandt *et al.*, 1997). Additional variation is observed due to wealth of farming households, farming skills, landholding size and availability of resources (Brandt *et al.*, 1997).

This review looks at the nutritional potential of enset-based farming systems and their potential to meet the dietary requirements of farming households in south and southwestern Ethiopia.

Nutritional value of enset

The stability of enset-coffee home gardens depends on enset ability to feed more people per unit area of land than any other crop grown in Ethiopia (Tsegaye, 2002), while providing multiple outputs, and maintaining and improving the resource base through positive ecological effects such as shading, soil erosion control, and improvement of organic matter (Woldu, 1997). Enset is a starchy staple crop, high in carbohydrates, but low in vitamins and protein content, with low levels of essential amino acids, such as methionine and isoleucine (Kusin, 1973; Besrat *et al.*, 1979). When enough enset plants are available on a farm, poor households do not go hungry, but their diets lack essential nutrients (*i.e.*, protein and vitamins) (Negash and Niehof, 2004). In all enset-growing areas, enset is the most frequently served main meal, with a daily average consumption of 0.5 kg, which provides 68% of the total energy intake, 20% protein, 28% iron, but no vitamin A (Pijls *et al.*, 1995; Negash and Niehof, 2004).

Enset is prepared either as *kocho* (fermented and bread-like food, a fermented product of the corm and pseudostem), *bulla* (dehydrated juice collected during decortication of the pseudostem and grating of the corm, thereafter rehydrated from concentrate and prepared as pancake or porridge), or *amicho* (boiled corm pieces, eaten like potato). Various enset-based recipes include the addition of spices, milk, maize flour, butter, beans or cabbage (Olango *et al.*, 2014).

Although there are slight variations between enset-growing regions, the main process of harvesting for the production of *kocho* includes scraping the parenchymatous pseudostem and crushing the corm, which is followed by fermentation of the pulp mixture in fermentation pits. During scraping, which is carried out by women, the juice (*bulla*) will be collected as a moist sticky substance into a small pit lined with enset leaves (Tsegay, 2002). The corm is grated, using animal bone or a wooden tool, to form smaller pieces, which is then mixed with the scraped pseudostem and buried in a 1 m^3 pit, lined with enset leaves, to ferment for a period of 2–3 months (Tsegaye, 2002). Urga *et al.* (1996) reported that *kocho* fermentation procedures reduce toxicity of plant raw materials, while contributing to flavour. Some loss of protein and dry matter is associated with the fermentation process (Besrat *et al.*, 1979; Tsegay, 2002), possibly due to the permeability of fermentation pit walls and the long duration of fermentation in the pit, which allows leaching of water-soluble proteins and amino acids (Tsegay, 2002). Recommendations from research on fermentation processes and pits (*e.g.*, using plastic containers) have not yet been adopted by farmers. The protein content of unfermented samples ranges from 1.75 to 6.16%, whereas the result obtained from samples fermented for 30 days ranges between 1.69 and 4.63% (Besrat *et al.*, 1979).

Between 16 and 37 kg of *kocho* and 19 kg of *bulla* can be harvested per mature 4- to 6-year old plant (Tsegaye, 2002). This is roughly equivalent to an annual yield of 4.5 to 10.3 t ha^{-1} when taking into account planting density and number of years to harvest. The calorie content of *kocho* per 100 g of edible material is approximately 200 kcal, or 57% lower than the corresponding value for food grains (tef, wheat, barley and maize), which is estimated at 350 kcal 100 g^{-1} (Urga *et al.*, 1996). However, the energy yield per area and unit of

Table 1. Cropping system diversity in selected enset-based farming zones in Ethiopia.

Farming zones	Staple crops (carbohydrate sources)	Additional foods	Cash/other crops	Sources
Gurage	Enset, few cereals, maize. Enset dominant for all households	Milk, cheese, meat, spiced yoghurt, butter, kale; pumpkin, haricot bean, banana	Khat, coffee, eucalyptus	Spring, 1996
Hadiya	Enset, wheat, barley, teff, sorghum, maize. In some areas cereal > enset, in others enset is dominant	Faba bean, haricot bean, field peas, potatoes, and kale, butter	Coffee, eucalyptus, bamboo, khat	Spring, 1996
Sidama	Enset, maize, taro. Enset dominant in all households	Maize, taro, haricot bean, kale, avocado, orange, banana, sugar cane, yam, taro; cereals, legumes and animal products are purchased	Many trees, coffee, khat	Spring, 1996
	Enset, maize	Beans, cabbage (kale), avocado, banana, pumpkin, rhamnus	Coffee, khat	Abebe, 2005
West Shewa	Enset	Wheat and barley	Coffee, khat, cabbage, faba beans, wheat, barley, many trees	Bacha and Taboge, 2003
Northwest Wolayta	Enset	Maize, teff		Sandford and Kassa, 1994

time for enset (1,450 kcal m^{-2} $year^{-1}$) is higher than that of other common Ethiopian staples such as cereals, Irish potato, sweet potato and banana, but lower than that of cassava (Pijls *et al.*, 1995; Table 1). These characteristics have earned it the title of most efficient Ethiopian crop (Tsegaye and Struik, 2001).

The nutritive value of enset is similar to potato (Mohammed *et al.*, 2013), and it is often complemented with protein from milk, meat or leguminous vegetables, like peas and beans (Abebe *et al.*, 2006; Bvenura and Afolayan, 2015). As a reliable and important source of energy, the combination of enset with leguminous crops or animal protein ensures a diet lacking only vitamin A, which is provided throughout the year by the popular cabbage and kale in most enset-growing households (Negash, 2001).

Diversity of the enset crop

Production diversity is a key component of agrobiodiversity, characterized by the diversity of the crops as well as the intrinsic diversity of each crop. Enset plants are vegetatively propagated, whereby the mother plant produces clonal daughter plants. Farmer selection of plants with desirable characteristics has allowed the development of different landraces. Worede (1991) defined a landrace as "a crop population that has not been bred as a variety by scientists, but which farmers have adapted to local conditions through years of natural and artificial selection". Farmers recognize numerous landraces that they distinguish by their appearance and use (Olango *et al.*, 2014; Zippel and Alemu, 1995).

Enset is genetically diverse, with different landraces preferentially used for different purposes (Shumbulo *et al.*, 2012; Yemataw *et al.*, 2016, 2018). Despite its significance, enset lacks a well-established descriptor list and formal taxonomic classification (Bekele and Shigeta, 2011). Farmers easily recognize more than 50 different landraces of enset based on morphological traits such as stem and leaf colour, leaf orientation, and pseudostem and leaf size (Brandt *et al.*, 1997; Tsegay and Struik, 2002; Olango *et al.*, 2014; Yemataw *et al.*, 2016), whereby most landraces have multiple purposes (Shumbulo *et al.*, 2012). There may be 50 to 100 different vernacular names (representing 50 to 100 enset landraces) for landraces within a single district with an area of less than 1,000 km^2 holding a quarter of a million people from a single ethnic group (Zippel and Alemu, 1995; Yemataw *et al.*, 2016). Where enset is the main staple crop, farmers acknowledge the importance of enset diversity for production stability and they are generally better able to differentiate between landraces (Tsegay, 2002). Individual farmers may grow as many as 18–28 different landraces within one backyard plantation (Zippel and Alemu, 1995; Yemataw *et al.*, 2014, 2016). Wealthier farmers tend to have more enset plants and a higher diversity of landraces compared to poorer farmers (Brandt *et al.*, 1997; Negash, 2001; Tsegaye, 2002).

There are significant differences between cultivated and wild enset types regarding nutritional content. Boscha *et al.* (2016) compared nutritional and chemical properties of three landraces with three wild enset groups and identified significant differences depending on genotype for all components analyzed. The three cultivars scored generally higher than the three wild genotypes for protein, fat, sugar and minerals (notably the amount of iron), while the wild enset had a larger fraction of starch. For fat and sugar, differences reduced after fermentation. The variation in chemical composition and perceived quality (colour, texture, taste and overall) among wild and cultivated enset genotypes suggests potential for breeding (Boscha *et al.*, 2016). In addition, variation in nutritional and chemical properties between landraces ('Ferezae', 'Ado' and 'Tuzuma') has been reported (Bezuneh, 1984). Wide morphological and genotypic variation has been observed in wild enset populations, possibly reflecting variation in nutritional and chemical properties (Birmeta *et al.*, 2004; Yemataw *et al.*, 2018).

Diversity of enset-based cropping systems and dietary diversity

Dietary diversity is a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals (FAO, 2010). Dietary diversity is a result of the diversity of crops cultivated, foods purchased and wild foods foraged by the household for consumption, which may differ depending on cultural preferences, prevailing ecosystem characteristics, and access to market and household income.

In Ethiopia, farms produce on average more than 10 different crop and livestock species (Sibhatu *et al.*, 2015). Asfaw and Nigatu (1995) identified a total of 162 crop species cultivated throughout southern, western, eastern and central Ethiopia. Seventy-eight percent of these were food crops, of

Table 2. Enset production systems (adapted from Brandt *et al.*, 1997).

Production systems	Importance of enset	Ethnic groups (zones)	Livestocks	Uses of enset
Enset	Primary staple	Sidama, Gurage	Cattle for manure	*Kocho*
Enset, cereals, roots/tubers	Co-staple	Gamo, Hadiya, Wolayta, Ari	Cattle/oxen for manure, ploughing cereal fields	*Kocho, amicho*
Cereals, enset, roots and tubers	Secondary staple (food security)	Oromo	Livestock for transport and ploughing, less for manure; ploughing and hoe used for cereal fields	*Kocho, amicho*
Roots and tubers, cereals, enset	Minor staple	Sheko	Hoe-based shifting cultivation, livestock of minor importance	*Amicho*

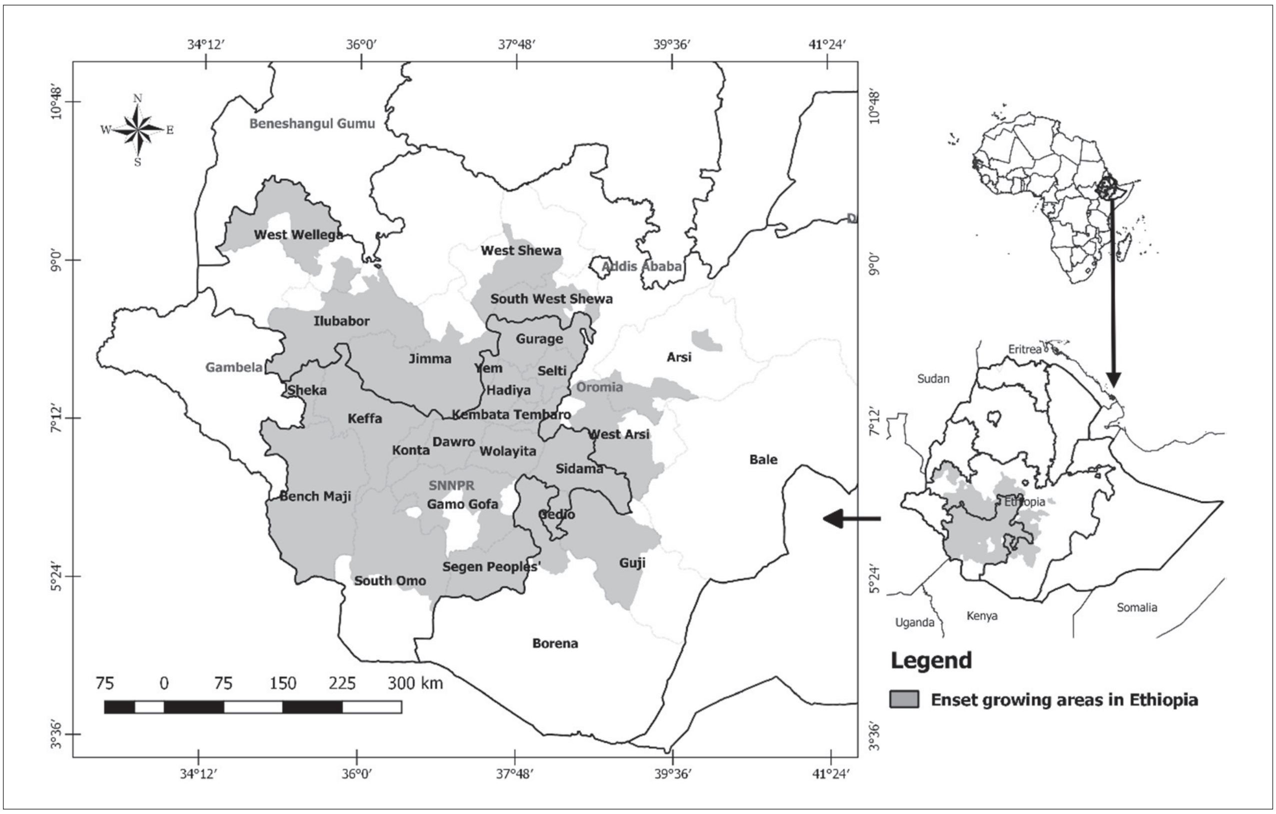

Figure 1. Enset-growing areas of southern and southwestern Ethiopia and administrative zones mentioned in this paper.

which maize and enset were the most common and 41% were fruits and vegetables. A total of 6 cereal crops, 14 pulse crops, 12 root and tuber crops (incl. enset), 35 fruit crops, 31 vegetable crops, 18 spices, herbs and shrubs, and 10 nuts, oils and sugar crops were recorded. Non-food crops (22%) included fragrant plants or spices and plants grown for their utility as medicines or narcotics, or for non-food oil purposes.

The spatial and temporal arrangement of crops in home-gardens varies between localities, and a wide range of crop combinations are observed, with perennials and annuals intercropped in a multistory agroforestry-type system, which essentially function as a living pantry.

Different authors have categorized the diverse enset-based production systems into different sub-systems.

Brandt *et al.* (1997) divided enset-based production systems in south and southwestern parts of Ethiopia into four sub-systems (Table 2; Figure 1). In the first sub-system, enset is the main staple crop for farming households where livestock, particularly cattle, play an important role (Table 2; Brandt *et al.*, 1997). It is cultivated in highly populated areas in dense plantations and fertilized by manure. The main use of enset in this production system is for household consumption and local markets. The other three enset production systems (with reduced importance of enset) also rely on other staple crops, with cereals, roots and tubers of variable importance (Table 2; Brandt *et al.*, 1997).

Most of these enset-based farms are derived from forest, whereby farmers clear away the undergrowth to plant enset and coffee, leaving the upper story trees, resulting in multistory agroforestry systems, which have remained relatively stable for centuries (Figures 2 and 3) (Kippe, 2002). Abebe (2005) focused on production systems in Sidama zone of the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) in southcentral Ethiopia (Figure 1). The enset – coffee based farms in this zone, were categorized into sub-systems depending on the relative importance of maize, sweet potato, pineapple and khat [*Catha edulis*] (Abebe, 2005; Table 3). The main drivers of the different sub-systems are access to a highway and altitude (Abebe, 2005). The first sub-system (enset – coffee – maize) is characterized by difficult access to roads. Enset makes up the bulk of the diet, supplemented by maize, and coffee is the main cash crop. In the following sub-system (enset – coffee – maize – sweet po-

Figure 2. Enset agroforestry system around Dila in Southern Ethiopia (Source: Guy Blomme).

Figure 3. Enset intercropped with coffee around Dila in Southern Ethiopia (Source: Guy Blomme).

tato), the latter becomes an important additional component of the cropping system, where the soil is suitable to cultivate this crop, and coffee remains the most important cash crop. A third sub-system (enset – coffee – maize – khat) is found where road access and soil suitability allow the cultivation of khat. Here, the proportion of coffee is reduced to accommodate for the khat as an important cash crop. The proportion of farm devoted to enset remains the same, but more of the land allotted to food crops is now devoted to maize, to complement enset production, as enset is less productive in this third sub-system. The fourth sub-system (enset – coffee – maize – pineapple – khat) includes pineapple and khat. Addition of the last two crops increases the share of new cash crops compared with the first sub-system (Abebe, 2005). Access to roads clearly improves profitability, expressed as monetary annual yield per hectare, of the farming system per hectare (Table 3).

As described above, maize is an important co-staple in enset-based cropping systems (Figure 4). Throughout Ethiopia, maize represents the largest share in total cereal production, accounting for 17% of the per capita calorie intake in 2004–2005, even though a considerable amount is imported each year, primarily via food aid programs (Demeke, 2012). Ethiopia's import of maize was reported as 54,466 tons in 2009, compared to an average of 35,016 tons in the previous 5 years (Demeke, 2012). Although maize was documented in Ethiopia in 1623, its popularity in southwest, enset-based farming systems of Ethiopia dates from 1950 to 1975 (McCann, 2001). Maize is an integral component of the cropping system with regional diversity patterns of local specialization for maize only, enset only, or mixed maize and enset cultivation. In 2005, the average share of land planted to maize was 16% with some sites allocating up to 40% of land to maize (Abebe, 2005).

Although enset is drought tolerant, it matures slowly, requires extensive processing and substantial amounts of manure, and produces fewer kcal kg^{-1} than maize (Quinlan *et al.*, 2015). Maize, by contrast, is often promoted by extension ser-

Table 3. Enset-coffee production systems in the Sidama zone of the SNNPRS (adapted from Abebe, 2005).

Characteristics	Production systems			
	Enset, coffee, maize	Enset, coffee, maize, sweet potato	Enset, coffee, maize, khat	Enset, coffee, maize, sweet potato + pineapple
Altitude (in m a.s.l.)	1,800–2,000	1,710–1,740	> 1,800	1,520–1,730
Coffee-enset coverage (in %)	65	35	21	52
Main food crop coverage (in %)	Enset (25), supplemented by maize	Enset (13), supplemented by maize and sweet potato (34)	Enset (20), supplemented by maize (29)	Enset (22), supplemented by maize and sweet potato (18)
Main cash crop coverage (in %)	Coffee (40)	Coffee (22)	Coffee (11), khat (14)	Pineapple (9), khat (6), coffee (30)
Livestock (#)	Medium (2)	Medium (2)	High (> 3)	Low (< 2)
Species richness (# of crop and tree species)	High (41)	Highest (43)	Low (25)	Medium (30)
Annual yield in monetary value[z] (in US$ ha^{-1})	230	190	338	322
Main drivers of the production system	Remote location	Soil quality	Road access High population density Soil quality enset is less productive here	Road access (highway), soil quality (moisture)

[z] The exchange rate for 23 November 2016 was used to calculate the conversion of Birr to US$.

FIGURE 4. Young enset plants intercropped with maize (Source: Guy Blomme).

vices as a means to achieve self-sufficiency, maturing rapidly and providing more kcal kg^{-1}. Yet, maize is prone to failure in dry years and requires external inputs, notably chemical fertilizer (Quinlan, 2015). Maize therefore jeopardizes, to some extent, the integrity and stability of the perennial agroforestry type enset-based systems, particularly when farmers are advised to grow maize in a continuous area to facilitate cultivation and efficiency of fertilizer use (Abebe, 2005).

Structurally farms are built of several units, defined by the crops that dominate in each particular unit (Abebe, 2005). Different studies have looked at production diversity of enset-based farming systems, relating it to dietary diversity to some extent (*e.g.*, Sandford and Kassa, 1994; Asfaw and Nigatu, 1995; Spring, 1996; Bacha and Taboge, 2003; Abebe, 2005; Table 1):

- In the Sidama zone, SNNPRS of Ethiopia, 78 crops were identified, of which 15 were found in half of the farms visited, and enset, maize and coffee were found in all (Abebe, 2005). Other key species include beans, cabbage, avocado, banana, pumpkin, rhamnus (used for dyes and oils) and khat (Abebe, 2005). Genetic diversity was also represented within crop species, particularly for enset and coffee, whereby 42 landraces of enset were identified and 26 cultivars of coffee (Abebe, 2005). Households cultivated a minimum of 6 enset landraces and 3 coffee cultivars in each farm (Abebe, 2005). In the Sidama zone, crops such as maize, yam, taro, haricot beans, and kale are intercropped with the early stages of enset. Enset may also function as a shade crop and be intercropped with coffee. Trees include *Cordia africana, Millettia ferruginea* and fruit trees like avocado and orange; sometimes banana and sugar cane. People prefer enset products to other foods, consuming it year round. When coffee is harvested, farmers will purchase cereals, legumes and animal products to mix with *kocho*. Supplementing diet with cereal is reserved mostly for richer households (Spring, 1996).
- In the Gurage zone, enset is mostly consumed together with milk, cheese, meat and kale, with households purchasing cereals and vegetables in the lent season when animal products are not consumed. Milk is more plentiful in July and August (rainy season months) when the cows give birth (Spring, 1996).
- In the Hadiya zone, different regions are recognized where either enset or cereals are the main staple crops. Cereal crops include wheat, barley, teff and sorghum, and occupy on average between 13 and 65% of the total farm area. Other crops include faba bean, haricot bean, field peas, potatoes, maize and kale. Farmers grow coffee, eucalyptus trees, bamboo and khat as cash crops or for household use (Spring, 1996).
- Bacha and Taboge (2003) studied farming systems of the West Shewa zone, where they found that rugged conditions leave only a small portion of the land suitable for farming. The resulting land shortage and fragmentation, due to population increase, is a considerable constraint. The establishment of multipurpose trees on hilly mountain tops, which are less favourable for farming, contributes to food security in the region. Enset is intercropped with coffee, khat, cabbage, faba beans, wheat and barley and numerous multipurpose tree species, including *Junipers, Eucalyptus, Podocarpus fascatus, Hegnia abyssinica, Olea africana, Vernonia amygdalina, Maesa lanciolata, Justicia schimperiana, Myrica salicifola, Sapium ellipticum* and *Oxytenanthera abyssinica*. Eucalyptus, Junipers and Podocarpus are usually grown far from the enset fields due to their allelopathic effects.
- In the Northwest Welaita region, Sandford and Kassa (1994) found maize, teff and enset as the most significant staple crops. Maize has food security and market value, teff has cultural value and food security value. Teff is seldom sold, but when it is, it has the highest market value of the three crops. Enset has a low market value and is seldom sold in Welaita; for food security, enset is comparable to maize, especially considering the year-round harvest potential. Enset also holds important cultural value. Some farmers commented that enset was becoming a bit less reliable due to bacterial wilt.

A household survey conducted by Negash (2001) examined the types and frequency of foodstuffs consumed by households in the Southwestern parts of SNNPR state of Ethiopia. The author stratified households according to wealth status, whereby lower class households represented 35% of the households studied; 47% of the households were middle-class and 18% were upper class. Lower class was defined as households with very few resources, earning less than 500 Ethiopian Birr (approximately 61 US$) annually, less than 0.5 ha of land and no oxen or livestock. Lower class households have less than 600 enset plants and lower clonal diversity (max 5 clones). Upper class households by contrast, earn over 1,000 Birr annually, cultivate more than 2 ha of land and 10 livestock. Negash (2001) observed, irrespective of wealth status, that each household consumes enset at least twice a day, in combination with cabbage, beans, taro, meat, milk, cheese and eggs. So, livestock products play an important role in the diet of these households. But not all households own livestock. Particularly, the poorest families have little to no cattle, often share-raising them through loan from wealthier farmers (Spring, 1996), and 56% of the households owned between 0–4 cattle (Negash, 2001; Spring, 1996; Tsegaye and Struik, 2002). Indeed, a strong correlation was observed between dietary diversity and socio-economic status of the households interviewed, with wealthier households eating a more diverse and sufficient diet during the week, with more affluence during the harvest season. Poorer households, on the other hand, tend to fall back on *kocho*, bean sauce, cabbage and taro, with little daily variation and low dietary diversity throughout the week (Negash, 2001). Many children from agrarian families that are dependent on an enset diet are nutritionally inferior compared to children not dependent on such a diet (Kusin, 1973). This is because children from enset-dependent households have less opportunity to eat meat and dairy products, which are often consumed during visits to the market. Children more often remain at the homestead or spend long days at school (Kusin, 1973; Negash, 2001).

When landholding size decreases, due to population increase for example, farmers are faced with critical decisions regarding food security. Enset plays a key role in determining cropping strategies. If a household has sufficient enset plants of different levels of maturity, they will focus more on crops with a higher market value, such as cereals; if this is not the case, they will turn their attention towards food crops (Rahmato, 1996). Culturally and psychologically, it is the number of enset plants that will determine the household's decision regarding crop diversification and crop-mix in each particular season (Rahmato, 1996). Negash (2001) concluded from her study that a high number of enset plants and clonal diversity are important for food security, while annual income, landholding size and number of livestock are more important in the context of livelihood security, and thus also food security.

Abebe (2005) observed that households are sometimes forced to switch to annual crops, if the enset yield is insufficient to cover family consumption requirements, *e.g.*, when land holding size is too small to allow harvest of more mature plants. Furthermore, when the number of livestock is low, enset yields will also be negatively affected by the lack of available manure (Abebe, 2005). So, often, a shift from enset to annual crops is most pronounced for poor farmers with land constraints (Abebe, 2005). On the other hand, cereal farmers, who are frequently confronted with a hunger gap when harvest of cereals is low, are known to grow enset as an insurance against hunger (Shank and Eritro, 1996), and most farming households will retain a few plants as security against harder times (Brandt *et al.*, 1997; Rahmato, 1996).

Nutritionally, farmers devote about half of the farm to energy-producing staple crops, such as cereals, enset, root and tuber crops (Abebe, 2005). The average area devoted to cabbage is less than 2%, but this is sufficient to cover household consumption needs. Richer farmers are mostly able to allocate larger plots of land to bean production, while supplementing their diet with meat and eggs (Abebe, 2005). By contrast, poor households are more prone to protein deficiency, due to the inadequate amount of land devoted to bean production and suboptimal yields of 1,000 kg ha^{-1}. The introduction of higher yielding vegetables and pulses may thus enhance nutritional wellbeing while improving the efficiency of the agro-forestry system (Abebe, 2005).

The importance of household income and cash crops for dietary diversity

Dietary diversity benefits from the diversity of the agricultural production system. Dietary diversity depends on purchased, foraged and cultivated crops, whereby the diets of farming communities located more remotely will be more dependent on the cultivated crops than those of communities who are able to benefit from road and market access. Improved access to agricultural markets and off-farm income often has a larger impact on dietary diversity than increased production diversity, as households with higher cash incomes tend to buy more diverse foods from the market (Sibhatu *et al.*, 2015a).

In remote subsistence households, where food is only produced for home consumption, the relationship between production and dietary diversity might be more closely related. However, pure subsistence farms are rare in reality and most households are involved in market interactions to some extent (Sibhatu *et al.*, 2015b). Even in Ethiopia where the degree of commercialization is still relatively low, farm households acquire 55% of the foods consumed from the market (Sibhatu *et al.*, 2015b). In the households studied by Abebe (2005), a higher diversity of crops and trees was seen in farms without easy access to roads, whereas farms located closer to roads put more land to annual staples, such as maize and sweet potato, and cash crops, like khat and pineapple (Abebe, 2005; Table 3). In this light, assets gained through the sale of cash crops (*e.g.*, coffee, khat, pineapple) or livestock (products) from enset-based farms, play a key role for the provision of additional food sources.

Cash crops are integral to enset-based production systems (*e.g.*, coffee, khat). Livestock too provides not only manure for soil improvement, but also cash to contribute to dietary needs (Tsegay, 2002). Coffee remains a key player in regional and national economies, and contributes to household income. However, khat is increasing its importance as a cash crop for enset farmers, it is cultivated on almost 95,000 ha of land (roughly ⅓ of the surface area devoted to coffee) and is currently the fastest-growing export commodity, currently ranking second after coffee, as a source of foreign exchange (Abebe, 2005; Kandari *et al.*, 2014). Compared to coffee, the interest of cultivating khat is that it is not reliant on external inputs and it can be harvested 2–3 times a year, and thus distributes the annual family income more evenly. Khat is dependent on easy road access, and its bushy nature may hinder cultivation of other crops, due to its continuous ground cover (Abebe, 2005).

Finally, enset itself is also an important asset for the farming household. It provides financial security against crop failures. It is used as a buffer in the case of illness or any unexpected expenses, or to pay annual land taxes. Larger enset plants can be sold as a standing plant before being processed or a portion of fermented *kocho* or *bulla* may be taken from the storage pit for sale at any time (Negash, 2001). Assets may also be generated through the sale of wood from khat and eucalyptus trees, khat, coffee, tobacco, hops, *kocho* and banana (Spring, 1996). From richer to poorer households, the percentage land allocated to various crops differs, with enset and grazing increasing and khat, coffee and eucalyptus decreasing. Poorer households will sell their labour, harvest few enset plants and try to sell hay or crafts to gain income (Spring, 1996). Rich farmers have more land and manure-producing livestock, and they plant more enset landraces than poor farmers (Tsegaye and Struik, 2002). In total, about 76% of the land belongs to the rich, 16% to middle-income and 8% to the poor (Spring, 1996).

Conclusion

Enset is uniquely adapted to highly populated regions in Ethiopia where rainfall and temperatures are adequate. It provides food security, it is drought tolerant, it can be stored over the long-term, and it is more efficient in terms of energy per unit space and time than any other staple crop in Ethiopia. The ability of farming households to grow sufficient enset depends in some extent on the wealth status of the household, and market access will strongly influence decisions to plant annual staple crops or invest in cash crops other than coffee. Although annual crops may not provide as much food and income security in the long-term, they may allow easier access to household income.

In general, most enset-based households have a balanced diet, if they are able to supplement enset with protein from legumes and/or animal products, as well as other essential nutrients (minerals and vitamins). However, the very poor households tend to fall back on *kocho*, bean sauce, cabbage and taro, with little daily variation and low dietary diversity throughout the year.

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