Agriculture, Ecosystems and Environment 252 (2018) 1–13

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Research Paper

Are traditional home gardens in southern Ethiopia heading for extinction? Implications for productivity, plant species richness and food security

Beyene Teklu Mellisse[a,b,*], Katrien Descheemaeker[a], Ken E. Giller[a], Tesfaye Abebe[c], Gerrie W.J. van de Ven[a]

[a] Plant Production Systems, Wageningen University and Research (WUR), PO Box 430, Wageningen, The Netherlands
[b] Wondo Genet College of Forestry and Natural Resources, Hawassa University, P.O. Box 128, Shashemene, Ethiopia
[c] Department of Plant and Horticultural Sciences, College of Agriculture, Hawassa University, Hawassa, Ethiopia

ARTICLE INFO

Keywords:
Cash crop
Dietary diversity
Energy availability
Food self-sufficiency
Home garden systems

ABSTRACT

While home garden systems are acknowledged for their capacity of supporting a very dense population, the productivity of these systems and their contribution to food security and dietary diversity are poorly quantified. Although several articles document the decrease in species richness in home gardens due to processes of modernization, relatively little attention has been given to how the change in diversity impacted productivity. Five predominant home garden systems identified in a previous study were intensively monitored during 12 months within four districts of Sidama and Gedeo zones of southern Ethiopia. Data from 24 farms were collected on plant species, soil characteristics, crop inputs, field sizes and crop yields and livestock production. The productivity of enset for both food and feed was lowest in Enset-coffee home gardens. Barley and khat yielded significantly more per ha in Khat-based systems than in other ones. Maize and coffee productivity did not differ significantly between home garden types. Overall crop productivity was lowest in the traditional Enset-coffee systems (1820 kg DM ha^{-1}) and highest in the newly evolved Enset-cereal-vegetable systems (3020 DM kg ha^{-1}). Energy productivity from food crops was higher in Enset-based systems (43 GJ ha^{-1}) than in other systems whereas revenue was lowest in Enset-based systems (719 US$ ha^{-1}) and highest in newly evolved Khat-based systems (6817 US$ ha^{-1}). The rate of N application through compost explained 30% of the variability in kocho standing biomass. The rate of N application in inorganic fertilizer explained 43% and 25% of the variability in khat and barley yield respectively. There was no positive effect of plant species richness on total crop and energy productivity except for the revenue in enset-oriented systems. Khat-based and Enset-cereal-vegetable systems were more food secure than the traditional home gardens, and these newly evolved systems also did not lead to a loss in plant species richness. The modification of traditional home garden systems by introducing the high value cash crop khat and annual cereals in response to farmland constraints and market opportunities enabled smallholders to maintain food security and dietary diversity without jeopardizing plant species richness. With population density expected to continually increase in the region, improvement options tailored to the specific systems are required for sustainable development.

1. Introduction

Home gardens are characterized by combined production of multipurpose trees together with crops and livestock around the homestead (Kumar and Nair, 2006). In southern Ethiopia, home gardens are fields around the houses that form the principal means of living for more than 15 million people without extra land elsewhere (Abebe, 2005). They are characterized by the combined production of the staple crop enset (*Enset ventricosum* (Welw.) Cheesman) and cash crop coffee (*Coffea arabica* L.) together with annual crops, livestock and multipurpose trees on a small plot of land. Growing enset and coffee in an intimate association with annual crops, trees and livestock is claimed to reduce risk, sustain productivity and enable food security of smallholders (Kippie, 2002; Kumar and Nair, 2006; Abebe, 2013). The presence of several plant species with diverse canopy structure, in this case annual crops and enset, is acknowledged for better utilization of light, water and nutrient resources (Niñez, 1987; Soemarwoto, 1987). The advantage of combining crop and livestock activities in the traditional systems is related to the availability of cheap fodder for livestock in the form of enset leaves, and of animal manure, recycling nutrients to support enset

* Corresponding author at: Wondo Genet College of Forestry and Natural Resources, Hawassa University, P.O. Box 128, Shashemene, Ethiopia
E-mail addresses: beyene.mellisse@wur.nl, beyteklu@gmail.com (B.T. Mellisse).

http://dx.doi.org/10.1016/j.agee.2017.09.026
Received 24 April 2017; Received in revised form 25 August 2017; Accepted 24 September 2017

and coffee growth (Mellisse et al., 2017b). Livestock also play a critical role in providing protein and nutrient rich products that complement the nutrition-poor enset diet (Brandt et al., 1997; Tsegaye and Struik, 2001). These features of traditional home garden systems are claimed to contribute to the capacity of home gardens to support dense populations of up to 500 persons km^{-2} (Kippie, 2002; Abebe, 2005). In addition home gardens are acknowledged for their biodiversity maintenance and avoidance of environmental deterioration (Kumar and Nair, 2004). However, recently there is a rapid shift away from the traditional home gardens to cash crop Khat-based systems, particularly in areas close to markets (Mellisse et al., 2017b). In such areas, khat (*Catha edulis* Forsk) expanded from 6% to 35% of the farm area in the period from 1991 to 2013. In response, the share of farm area devoted to both enset and coffee decreased from 45% to 25%, which was interpreted as a simplification of the traditional land use systems (Dessie and Kinlund, 2008; Abebe et al., 2010). On the one hand, uniformization of the landscape is believed to threaten food security and ecological services that the traditional home gardens provide. On the other hand, it is recognized that the changes in the structure and composition of home gardens have enabled the systems to respond to socio-economic changes through so-called productive bricolage processes at micro scale (Abebe and Bongers, 2012). The latter is defined as the flexible and dynamic crafting of various livelihood options and its associated impacts on the landscape (Ros-Tonen, 2012). However, the question whether or not the recent changes impaired the sustainability of the home gardens remains unresolved as hardly any quantitative information on the productivity of the traditional and the newly evolved systems is available. Also, the relation between productivity and plant species diversity has rarely been assessed. Furthermore, the inductive nature of earlier studies about home gardens, that either describe the system or assess species composition and diversity (Kumar and Nair, 2004) overlooked the contribution of the diverse system components to productivity, food security and dietary diversity, which are important sustainability indicators in areas characterized by severe land pressure.

Given the rapid transitions of the traditional home garden systems to cash crop oriented systems, we test the hypothesis that the system transitions enhance productivity and food security at the expense of agrobiodiversity. Our objectives were: i) to analyse and explain crop productivity of different home garden systems; ii) to assess plant species richness of different home garden systems and analyse its relation with crop productivity; iii) to assess and explain food self-sufficiency, food security and dietary diversity of different home garden systems.

2. Materials and methods

2.1. Analytical framework and scope of the study

The complex interactions between the various components of a home garden system (crops, trees, livestock and farm household) require a systems approach to understand how these components operate together and interact with the larger-scale context. As the latter is characterized by land and food scarcity and the need to sustain ecosystem services, including agrobiodiversity, we chose to evaluate the sustainability of the system based on productivity, species richness and food security, including dietary diversity. An earlier study characterized five distinct home garden systems in the region (Mellisse et al., 2017b) based on the area share of the dominant crops and grazing land (Fig. 1). Farms with more than 30% of the area under khat were classified as Khat-based systems. With less than 30% khat, home gardens were classified as Enset-coffee if at least 35% of their area was covered with coffee. Grazing land and enset covered at least 20% and 35% of Enset-livestock and Enset-based systems respectively. In Enset-cereal-vegetable systems less than 35% of the land was cultivated with enset and annual cereals and vegetables were present. Khat-based and Enset-coffee home gardens were present in both mid-altitude (< 2300 m.a.s.l.) and high-altitude zones (> 2300 m.a.s.l). The other three home garden systems were prevalent in the high-altitude area (Mellisse et al., 2017b). As all systems had at least one crop (enset) in common and the new Khat-based and Enset-cereal-vegetable systems evolved from the traditional home gardens, a system comparison was deemed appropriate. As the home gardens comprise several crops with distinct advantages (e.g. biomass production, cash generation), integrating the productivity of all crops into one indicator of productivity is challenging. We therefore expressed productivity in three ways, based on annually harvested biomass, annual energy and annual revenue. For the land constrained smallholders of southern Ethiopia, the portions that are harvested annually as food or cash sources are more meaningful than standing biomass. However, for enset the standing biomass was considered as it indicates the readily available food reserve, which could be harvested any time whenever the need for food arises. As the home garden systems differ in management related to input use and recycling of organic matter (including manure, added to compost) we used soil fertility and input use as explaining factors for yield differences.

2.2. The study area

Sidama and Gedeo are representative zones of the Southern Nations Nationalities and Peoples' Regional State (SNNPRS) of Ethiopia with a prevalence of enset-oriented and Khat-based home gardens (Mellisse et al., 2017b). Sidama is located between 5°45′–6°45′ N and 38°5′–39°41′ E, covering a total area of 7672 km^2 (Abebe, 2005) with 3.50 million inhabitants (CSA, 2007). Gedeo is located between 5°50′–6°12′ N and 38°03′–38°18′ E, covering a total area of 1347 km^2 (Kippie, 2002) with 0.84 million inhabitants (CSA, 2007). Some 94% of the *kebeles* (smallest Ethiopian administrative district, also called peasant association or PA) in both zones are classified as 'rural'(CSA, 2007). Sidama and Gedeo are home to two ethnic groups bearing the same name as the zones. The rainfall distribution is bimodal with a long (June–September) and short (March–May) rainy season. Both Sidama and Gedeo straddle two agro-ecological zones, the moist mid-altitude (In Amharic: *woinadega*) and the moist highland (In Amharic: *dega*). The mid-altitude zone ranges in elevation from 1500 to 2300 m above sea level (a.s.l.) and receives 1200–1600 mm rainfall annually; the average annual temperature ranges from 16 to 22 °C. The highland lies between 2300 and 3200 m a.s.l.; annual rainfall is 1600–2000 mm and the average annual temperature ranges from 15 to 19 °C (Kippie, 2002; Abebe, 2005).

2.3. Description of crops grown in home gardens of southern Ethiopia

Enset and coffee are the main crops of traditional home garden systems (Fig. 1a and b). Enset is an evergreen perennial crop, domesticated as a staple food crop only in Ethiopia (Brandt et al., 1997; Negash and Niehof, 2004). Enset is propagated by suckers and transplanted several times. After growing at least three years at its final place, it can be harvested for food. The starch accumulated in the leaf sheaths and the corm is the main edible product of enset. During harvesting, the corm together with pseudostem is dug out, the leaf sheaths are peeled off and scrapped with a knife to separate pulp from fiber. Finally, the pulp mixed with decorticated corm is collected in a pit lined with fresh enset leaves and is ready for consumption after two to three weeks of fermentation. This product is known as *kocho* and the fine starchy liquid drained from the mixture is called *bula*. Only plants older than 4 years yield bula. Coffee is a perennial cash crop and usually intercropped with trees and food crops. Khat (Fig. 1d) is a woody perennial plant, commonly grown in monoculture for its economically important leaves and tender twigs, which are chewed for their stimulating effect (Megerssa et al., 2013). Depending on the pruning management, khat plants can be up to 4 m high or maintained at 1 m (Mellisse et al., 2017a). The leaves and twigs of khat are rapidly