



# Home garden system dynamics in Southern Ethiopia

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**Abstract** Home gardens in southern Ethiopia are regarded as efficient farming systems, allowing interactions and synergies between crop, tree and livestock components. However, these age-old traditional home gardens are evolving rapidly in response to changes in both the socio-economic and biophysical environment. Altered cropping patterns, farm size and component interactions may affect the systems' sustainability. Home gardens exhibit a huge diversity in farms and farming systems, which needs to be understood in order to design interventions for improvement. Dynamics of home gardens were studied over two-decades (1991–2013) based on a survey of 240 farm households and focus group discussions. Farms were grouped into five types: Khat-based, Enset-cereal-vegetable, Enset-based, Enset-coffee and Enset-livestock. Farm trajectories revealed a shift from food-oriented Enset-based and Enset-livestock systems to (1) cash crop oriented khat-based systems, and (2) combined food and cash crop oriented Enset-

cereal-vegetable systems. In densely populated, market proximate areas a major trend was expansion of khat, from 6 to 35% of the area share per farm, while the combined area share of enset and coffee decreased from 45 to 25%. Concurrently, the cattle herd size fell from 5.8 TLU to 3.9 TLU per household. In medium populated, less accessible areas the trend was consolidation of combined production of food and cash crops. Enset and coffee together maintained a share of over 45%. Easy transport and marketing of the perishable cash-generating khat compared with traditional crops favoured its cultivation among smallholders located close to markets. The insights in home garden change in response to increasing population pressure, decreasing farm size and market development may help to design interventions to increase system sustainability.

**Keywords** Home garden types · Cropping patterns · Cash crops · Commercialization · Diversification · *Catha edulis*

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## Introduction

Home gardens are characterized by multipurpose trees and shrubs in intimate association with annual and perennial crops and livestock around the homestead (Kumar and Nair 2006). Home gardens ensure a sustained availability of multiple products and

generate income (Kumar and Nair 2004). Despite their small size (Kumar and Nair 2006), home gardens fulfil most of the basic food and nutritional needs of the households, while the multi-storied configuration and high species diversity maintain their structure and function in the face of external stress (Kumar and Nair 2004).

In the Southern Nations Nationalities and Peoples' Regional State (SNNPRS) of Ethiopia, home gardens are the prevalent land use system covering about 576,000 ha, which is 31% of the region's cultivable land (Abebe 2005). The traditional 'enset-coffee' home gardens are characterised by the combination of two perennial crops: enset (*Enset ventricosum* (Welw.) Cheesman) and coffee (*Coffea arabica* L.). Enset is a herbaceous, multipurpose crop and a staple food for more than 15 million people (Abebe et al. 2010). Enset leaves are a key livestock feed and used as mulch to reduce soil erosion and runoff (Amede and Diro 2005). Hence, enset fulfils both productive and protective functions (Kippie 2002). Coffee is mainly a cash crop, but is also consumed (Kippie 2002; Abebe 2005).

Increasing population pressure and subdivision of farms have led to fragmentation of land, a decline in the area under coffee and enset (Tsegaye and Struik 2001; Abebe 2005) and gradual replacement of the age-old diverse system. A major change is the expansion of a mono-cropping system of khat (*Catha edulis* Forsk) at the expense of enset-coffee home gardens (Tsegaye and Struik 2001; Abebe et al. 2010). Khat is grown for its economically important leaves and tender twigs, which are chewed for their stimulating effect. Due to the decline in enset cultivation, many households have become more dependent on the food market (Amede and Diro 2005). Market dependency for family food is further exacerbated by decreasing farm area and productivity of food crops (Amede et al. 2001). In countries like Ethiopia, where smallholder farmers have no access to insurance, the market dependency increases the vulnerability to economic or environmental shocks. The replacement of enset has also induced a shortage of livestock feed with direct repercussions on herd size, herd composition, livestock production and hence, nutritional quality of human diets (Tsegaye and Struik 2001). Most studies on the home gardens of southern Ethiopia claimed that expansion of khat has resulted in homogenization of the structure and composition of

the traditional land use systems (Abebe et al. 2010; Dessie and Kinlund 2008). Yet, little is known about the rate at which those systems have shifted to mono-cropping systems, how that differs across the region, and which factors could explain it. Other studies (Herrero et al. 2009; Ebanyat et al. 2010) suggest trends in institutional support, resource endowment, prices, social conditions and technology as drivers of farming system change, but these have not yet been investigated for the particular case of home gardens in southern Ethiopia.

Similar to many other areas in sub-Saharan Africa, SNNPRS is characterized by a huge diversity in farms and farming systems, even though they are grouped under the common term home gardens. Recognizing this variability within and among farming systems and localities is the first step in the design of new technologies to improve agricultural production (Giller et al. 2011; Descheemaeker et al. 2016).

With the wider aim to contribute to the development of tailored interventions to improve agricultural production and productivity, this paper aims to: (1) understand the diversity in home garden systems of southern Ethiopia; (2) analyse trends in farm size, cropping pattern and livestock population over the past two decades; (3) explain the spatial patterns of change in home gardens in relation to market access, agro-ecological conditions and population density. We combined quantitative and qualitative methods, including secondary data collection on demography and farm size, a farm typology based on the area share of crops and grazing land, and constructed a 20-year timeline of farming system change based on detailed household interviews concerning current and past farm assets and practices.

## Materials and methods

### The study area

Sidama and Gedeo are representative zones of the SNNPRS region with a prevalence of enset-coffee home gardens. These home gardens are characterised by the production of enset, coffee and multi-purpose trees, accompanied by root and tuber crops, vegetables, annual cereal crops and livestock keeping (Kippie 2002; Abebe et al. 2010). Sidama is located within 5°45'–6°45'N and 38°5'–39°41'E, covering a

total area of 7672 km<sup>2</sup> (Abebe 2005) with 3.50 million inhabitants (CSA 2007). Gedeo is located within 5°50′–6°12′N, 38°03′–38°18′E, covering a total area of 1347 km<sup>2</sup> (Kippie 2002) with 0.84 million inhabitants (CSA 2007). Most *kebeles* (smallest Ethiopian administrative unit, also called peasant association or PA) in both zones are classified as ‘rural’ (CSA 2007). The rainfall distribution is bimodal with a long (June to September) and short (March to 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 moist mid-altitude zone ranges in elevation from 1500 to 2300 m a.s.l. and receives 1200–1600 mm rainfall annually; the average annual temperature ranges from 16 to 22 °C. The moist highland zone comprises an elevation range of 2300–3200 m a.s.l.; mean annual rainfall amounts to 1600–2000 mm and the average annual temperature ranges from 15 to 19 °C. The soils in the mid-altitude and highland agro-ecologies are mainly characterized by clay-loam to silt-loam and sandy-loam to sandy-clay textural classes respectively.

#### Selection of study sites and farm households

Within Sidama and Gedeo zones, four districts (In Amharic: *woreda*) were selected (Wondo Genet, Melga, Dale and Bule) and within each district, 6 PAs, giving 24 PAs in total (Fig. 1). The multistage sampling approach for districts and PAs was designed to encompass differences in distance to markets, agro-ecological conditions and population density (Table 1). These factors were hypothesised to affect farmers’ crop allocation decisions through their influence on the ease of transportation of agricultural products, crop suitability and farm size, respectively. Distance from a major market and altitude were measured using a global positioning system (GPS) following roads and foot paths. The population density of each PA was collected from the Ethiopian Central Statistics Agency (CSA 1991–2013). The PAs were categorized into (1) three classes of distance to market, i.e. near (<36 km), medium (36–70 km) and far (>70 km), roughly corresponding to travelling times of 1.5, 3 and more than 3 h by car, respectively, (2) two elevation classes, based on agro-ecological zoning, i.e. high (>2300 m a.s.l.) and medium (1500–2300 m a.s.l.) (Kippie 2002; Abebe et al.

2010) and (3) three classes of population density, i.e. high (>800 person/km<sup>2</sup>), medium (500–800 person/km<sup>2</sup>) and low (<500 person/km<sup>2</sup>).

On average 10 households per PA, 240 households in total, were selected for the household survey. The districts’ Bureau of Agriculture categorized farms as small, medium and large based on the area of their land holding and the number of livestock. Farms with >1.25 ha of land and >5 TLU were categorized as large, 0.5–1.25 ha and 1–5 TLU as medium, and <0.5 ha and 0–1 TLU as small. Stratified random sampling ensured that the number of selected households in each group was in line with their share in each of the PAs.

#### Data collection

We combined qualitative and quantitative data collection approaches to triangulate the relevance and accuracy of the information gathered (Ebanyat et al. 2010). Eight focus group discussions (FGDs) were organized, four in midland PAs (Ywo, Kochow, Soyama and Dero) and four in highland PAs (Gikeatoye, Guguma, Duba and Elalcha). In each FGD eight to ten farmers participated representing different age groups, both sexes and each farm size category. The discussion focused on positive and negative aspects of khat expansion, constraints to maintain enset and coffee, population growth and its impact on resource availability (land), change in income sources, emergence of new activities, economic infrastructure (roads and transport service), market development and price trends.

A detailed household survey was administered between August and November 2013 with 240 farm households. We used a semi-structured questionnaire to collect data on changes, trends and events in the past two decades with the aim to construct a timeline. To capture the changes in cropping and livestock systems, household heads were asked to recall the year of khat introduction, land allocation to various annual and perennial crops (food crops, cash crops), total land holding and herd size from 1991 to 2013 in a stepwise fashion. The year of the regime change in Ethiopia, 1991, and the following national election years (1994, 2000, 2005 and 2010) were used as benchmarks to help respondents’ recall. Household heads were further asked about demographic characteristics (family size, level of education), production objectives,

**Table 1** Peasant associations (PA), numbers of surveyed households in each of the three farm size categories, distance to market, elevation and population density. *Source:* Ethiopian Central Statistical Authority (CSA 1991–2013)

| No.   | Site (PA)     | District (Woreda) | Sample size | Sampled farms by farm size |          |           | Distance to major market place (km) | Elevation (m a.s.l.) | Population density (person/km <sup>2</sup> ) |   |      |
|---|---------------|-------------------|-------------|----------------------------|----------|-----------|-------------------------------------|----------------------|--|---|------|
|   |               |                   |             | Large                      | Medium   | Small     |                                     |                      |  |   |      |
| <i>Mid-land agro-ecology (1500–2300 m a.s.l.)</i> |               |                   |             |                            |          |           |                                     |                      |  |   |      |
| 1   | Ywo           | Wondo Genet       | 11          | 1                          | 4        | 6         | N                                   | 12.4                 | 1679   | H | 958  |
| 2   | Chuko         | Wondo Genet       | 12          | 1                          | 3        | 8         | N                                   | 26.4                 | 1756   | H | 1551 |
| 3   | Weterakechema | Wondo Genet       | 7           | 1                          | 2        | 4         | M                                   | 36.4                 | 1755   | M | 714  |
| 4   | Kochow        | Melga             | 10          | 2                          | 4        | 4         | N                                   | 24.4                 | 2145   | H | 834  |
| 5   | Manicho       | Melga             | 11          | 1                          | 8        | 2         | N                                   | 25.4                 | 2190   | H | 858  |
| 6   | Berana        | Melga             | 9           | 1                          | 6        | 2         | N                                   | 30.9                 | 2216   | H | 915  |
| 7   | Soyama        | Dale              | 9           | 1                          | 6        | 2         | M                                   | 36.3                 | 1787   | H | 852  |
| 8   | Megera        | Dale              | 10          | 1                          | 4        | 5         | M                                   | 47.8                 | 1746   | M | 566  |
| 9   | Awada         | Dale              | 11          | 2                          | 2        | 7         | M                                   | 44.7                 | 1753   | L | 433  |
| 10  | Dero          | Bule              | 11          | 1                          | 4        | 6         | F                                   | 126.8                | 2245   | M | 792  |
| 11  | Bassura       | Bule              | 11          | 3                          | 3        | 5         | F                                   | 114.8                | 2253   | M | 773  |
| 12  | Osselemajo    | Bule              | 8           | 2                          | 2        | 4         | F                                   | 118.5                | 2250   | M | 737  |
|   | Sub total     |                   | 120         | 17 (14%)                   | 48 (40%) | 55 (46%)  |                                     |                      |  |   |      |
| <i>Highland agro-ecology (2300–3200 m a.s.l.)</i> |               |                   |             |                            |          |           |                                     |                      |  |   |      |
| 13  | Weteragedo    | Wondo Genet       | 8           | 3                          | 3        | 2         | M                                   | 38.1                 | 2597   | H | 945  |
| 14  | BaboChorora   | Wondo Genet       | 9           | 2                          | 4        | 3         | M                                   | 40.5                 | 2624   | M | 646  |
| 15  | Gikeatoye     | Wondo Genet       | 13          | 3                          | 5        | 5         | M                                   | 44.9                 | 2599   | H | 1565 |
| 16  | Fitoketemuna  | Melga             | 12          | 4                          | 4        | 4         | M                                   | 41.1                 | 2561   | H | 950  |
| 17  | Gerewe        | Melga             | 9           | 3                          | 4        | 2         | N                                   | 34.6                 | 2634   | M | 508  |
| 18  | Guguma        | Melga             | 9           | 3                          | 2        | 4         | M                                   | 47.1                 | 2677   | M | 583  |
| 19  | Hayello       | Dale              | 8           | 2                          | 2        | 4         | F                                   | 70.2                 | 2328   | H | 1023 |
| 20  | Duba          | Dale              | 10          | 1                          | 2        | 7         | M                                   | 47.4                 | 2338   | H | 1153 |
| 21  | Gedamo        | Dale              | 12          | 1                          | 3        | 8         | M                                   | 64.7                 | 2339   | L | 102  |
| 22  | Elalcha       | Bule              | 11          | 3                          | 4        | 4         | F                                   | 126.9                | 2902   | L | 469  |
| 23  | Akollo 1st    | Bule              | 11          | 2                          | 4        | 5         | F                                   | 142.9                | 2787   | L | 272  |
| 24  | Suko          | Bule              | 8           | 2                          | 2        | 4         | F                                   | 135.1                | 2709   | L | 43   |
|   | Sub-total     |                   | 120         | 29 (24%)                   | 39 (33%) | 52 (43%)  |                                     |                      |  |   |      |
|   | Total         |                   | 240         | 46 (19%)                   | 87 (36%) | 107 (45%) |                                     |                      |  |   |      |

*N* near, *M* medium, *F* far, *H* high, *M* medium, *L* low

sources of income, constraints to crop production and livestock rearing and dependency on the market for food (number of months per year). Farmers also listed and ranked political, cultural, environmental and economic factors triggering the changes in land allocation and farming practices based on a score of one (low importance), two (average importance) or three (high importance). The mean score of each factor was calculated using the formula

$$M_i = \frac{\sum_{j=1}^3 f_{ij} \times j}{n}$$

where  $M_i$  = mean score of factor  $i$ ;  $f_{ij}$  = the percentage of respondents that gave a score of  $j$  for factor  $i$  and  $n$  = the total number of respondents that listed factor  $i$ .

Enumerators with a certificate in agriculture and speaking the local language were recruited from the

localities and trained in data collection. Retail prices of coffee, khat, kocho (the processed edible part of enset), tef (*Eragrostis tef* (Zucc.) Trotter) and maize (*Zea mays* L.) were collected from CSA. The price in Ethiopian birr was converted to US\$ at a rate of 2.5, 6.3, 8.6, 17.5 and 19.1 Eth. birr to one US\$, the average exchange rate in 1991–1994, 1995–1999, 2000–2008 and 2009–2012 and 2013–2014 respectively (NBE 1991–2014). The revenue per hectare was calculated by multiplying the price of each crop with the average yield (assumed to be constant over the study period).

### Farm typology

We constructed a farm typology based on crop allocation data from the household survey after exploring the data using Ward's minimum variance method (Joe and Ward 1963), followed by a K-means clustering (Blazy et al. 2009). The area shares of nine crops (enset, coffee, khat, maize, other annual cereals, beans, root and tuber crops, vegetables and sugarcane) and grazing land were considered. Each of the identified farm types was named after the crops with the major area shares in 2013. In order to classify farms based on the same criteria over time, thresholds of area shares were derived based on the variation within each farm type, following Falconnier et al. (2015). Considering these thresholds, we developed a decision tree to classify each farm into a distinct farm type for the six benchmarks in the timeline 1991–2013.

### Data analysis

A one way analysis of variance (ANOVA) was used to test the difference between the means of five home garden types in family size, farm size, land to person ratio, herd size, income and market dependency. Differences were deemed significant at  $P < 0.05$ . Analyses were performed using the Statistical Package for Social Sciences (SPSS) version 20. Qualitative data was used to support the discussion of results.

## Results

### Characteristics of the home garden types

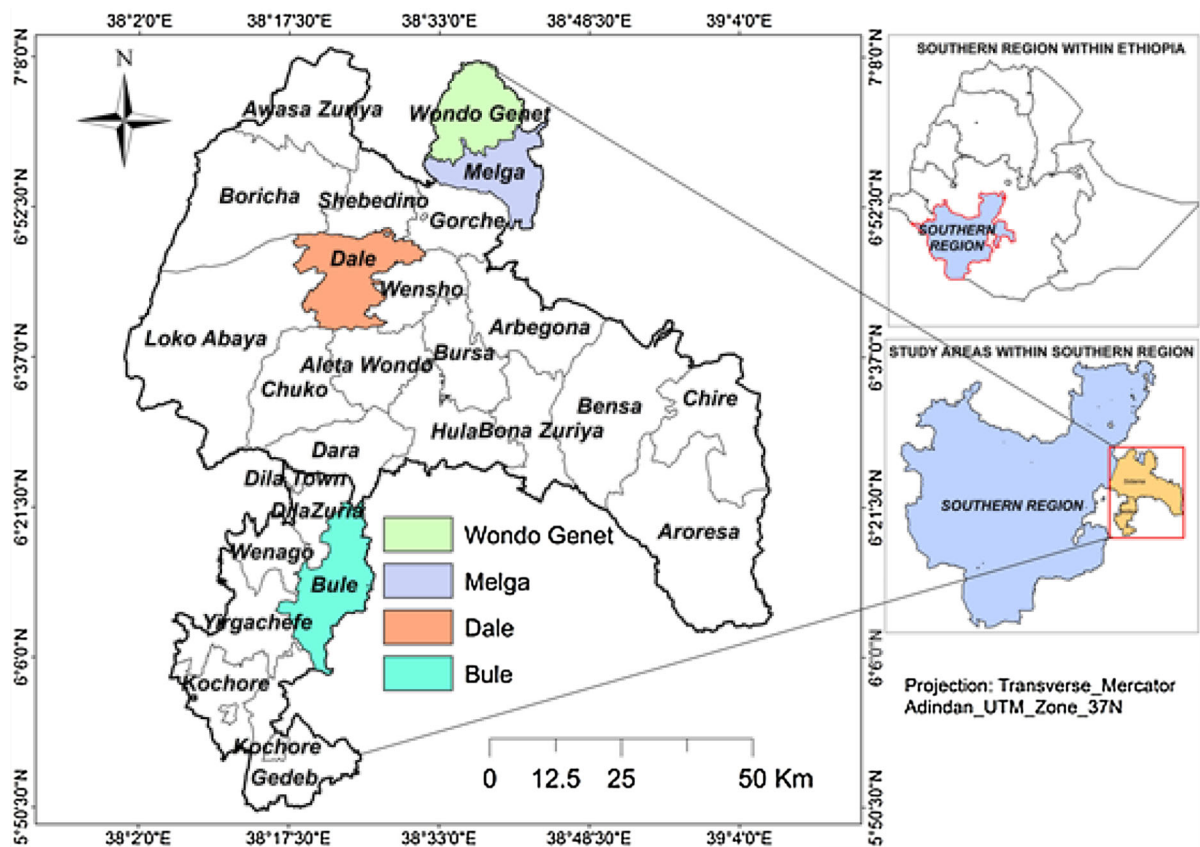
The variability in land use indicated a large diversity in farming systems in Sidama and Gedeo zones of

southern Ethiopia. Five different home garden types were identified and characterized by the area share of the dominant crops and grazing land (Table 2; Fig. 2). Our decision tree (Fig. 2) dictated that throughout the study period, farms with an area share of khat over 30% were classified as Khat-based systems. With less than 30% khat, home gardens were described as Enset-coffee if at least 35% of their area was covered with coffee. Subsequently, Enset-livestock systems were identified if grazing land covered more than 20%. Of the remaining two types, Enset-based and Enset-cereal-vegetable systems were distinguished based on an enset area share of at least and less than 35% enset, respectively.

In Khat-based and Enset-based home gardens khat and enset covered 51 and 58% of the farm land respectively (Table 2). The combined area of enset, cereals and vegetables covered more than 60% of the area in the Enset-cereal-vegetable system, while 89% of the area in Enset-coffee home gardens was covered by enset and coffee. In Enset-livestock home gardens the combined area of enset and grazing land covered more than 50% of the farm area. The highest proportion of cash crops was observed in Khat-based home gardens (60%) while the highest proportion of food crops was observed in Enset-based home gardens (74%). The largest proportion of grazing land was documented in Enset-livestock systems (34%). The average family size in Khat-based home gardens was significantly larger than that in Enset-based and Enset-livestock home gardens (Table 2). The average farm size showed no significant difference between home garden types, and the Khat-based home gardens had the smallest land to labour ratio.

### Distribution of home garden types across districts and socio-economic and biophysical environments

The four districts of the study area showed a different prevalence of the five home garden types. Wondo Genet and Melga were characterized by the dominance of two home garden types, namely Khat-based and Enset-cereal-vegetable in Wondo Genet and Khat-based and Enset-livestock in Melga. In both districts Enset-coffee systems were absent. Dale and Bule showed a more even representation of four home garden types. The Khat-based home garden type was not present in Bule and nearly absent in Dale.



**Fig. 1** Map of the study districts (*woredas*) within Sidama and Gedeo zones, SNNPRS, Ethiopia

The presence of the home garden types differed in relation to market access, population density and agro-ecology (Fig. 3). Close to markets, 56% of the farms were Khat-based (Fig. 3a). At medium and far distance their share was 17 and 0% respectively. The shares of Enset-cereal-vegetable, Enset-based and Enset-coffee home garden types all decreased with proximity to the market. The distribution of home garden types in relation to population density showed a similar pattern (Fig. 3b), with Khat-based systems gaining importance with increasing population density and an opposite trend for Enset-cereal-vegetable, Enset-based and Enset-coffee home garden types. Population density had no clear effect on the presence of Enset-livestock home gardens. In the mid-altitude zone Khat-based and Enset-coffee home gardens were more prevalent, while in the high-altitude zone Enset-based and Enset-livestock systems were more common (Fig. 3c).

Dynamics in cropping pattern and livestock holding in the four districts

The overall trend in cropping patterns in Wondo Genet and Melga indicated a shift from food to cash crop production over time, while in Dale farmers continued to produce a combination of food and cash crops and in Bule they remained food crop oriented (Fig. 4). In 1991 the combined area share of enset and coffee amounted to more than 45% in all districts of the study area. In 2013 it had fallen below 25% in Wondo Genet and Melga, whereas the area share of khat increased from about 5% in 1991 to about 35% in 2013 (Fig. 4). Even though khat cultivation was observed in 1991 also in Dale, it expanded less there from 0.9% in 1991 to 8% in 2013. In Bule, khat has not played any role worth mentioning in the past two decades (Fig. 4). Unlike the cropping pattern, the grazing land area was not noticeably influenced by the expansion of khat and was maintained at 8–12% in Wondo Genet and

**Table 2** Average ( $\pm$ standard error of the mean) crop allocation and household characteristics for the five home garden types; significant differences in household characteristics at

P &lt; 0.05 are indicated with different letters within a row; dominant crops and grazing land that lend their name to the type are indicated in bold

|                            | Description  | Home garden types             |                                  |                                  |                                  |                                  |                |
|----------------------------|--|-------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------|
|                            |  | Khat-based (K-b)              | Enset-cereal-vegetable (E-c-v)   | Enset-based (E-b)                | Enset-coffee (E-c)               | Enset-livestock (E-l)            |                |
|                            | Number of farms  | 58                            | 51                               | 43                               | 30                               | 58                               |                |
| Share in the farm area (%) |  |                               |                                  |                                  |                                  |                                  |                |
| Food crops                 | Enset  | 26.9 $\pm$ 1.7                | <b>18.8 <math>\pm</math> 1.3</b> | <b>57.6 <math>\pm</math> 2.2</b> | <b>39.9 <math>\pm</math> 2.2</b> | <b>21.7 <math>\pm</math> 1.4</b> |                |
|                            | Annual cereals   | 5.9 $\pm$ 1.4                 | <b>24.3 <math>\pm</math> 1.9</b> | 11.6 $\pm$ 2.2                   | 1.8 $\pm$ 1.0                    | 13.5 $\pm$ 1.5                   |                |
|                            | Other food crops <sup>a</sup>                            | 0.4 $\pm$ 0.2                 | 11.8 $\pm$ 1.3                   | 4.8 $\pm$ 1.6                    | 2.3 $\pm$ 1.1                    | 7.1 $\pm$ 1.5                    |                |
|                            | Total food crops   | 33.2 $\pm$ 2.1                | 54.9 $\pm$ 2.5                   | 74.0 $\pm$ 2.6                   | 44.0 $\pm$ 2.4                   | 42.3 $\pm$ 2.2                   |                |
|                            | Cash crops   | Coffee                        | 3.0 $\pm$ 0.6                    | 5.6 $\pm$ 1.3                    | 10.8 $\pm$ 1.8                   | <b>49.4 <math>\pm</math> 2.0</b> | 3.4 $\pm$ 1.0  |
|                            |  | Khat                          | <b>51.2 <math>\pm</math> 2.0</b> | 11.0 $\pm$ 1.7                   | 4.1 $\pm$ 1.4                    | 2.0 $\pm$ 1.3                    | 14.7 $\pm$ 1.6 |
|                            |  | Vegetables                    | 3.8 $\pm$ 1.0                    | <b>18.7 <math>\pm</math> 2.2</b> | 5.8 $\pm$ 1.8                    | 1.4 $\pm$ 0.8                    | 4.8 $\pm$ 1.0  |
|                            |  | Other cash crops <sup>b</sup> | 1.7 $\pm$ 0.8                    | 3.4 $\pm$ 1.1                    | 1.8 $\pm$ 0.9                    | 2.1 $\pm$ 0.8                    | 0.8 $\pm$ 0.2  |
| Total cash crops           |  | 59.7 $\pm$ 2.2                | 37.8 $\pm$ 2.6                   | 21.8 $\pm$ 2.6                   | 54.9 $\pm$ 2.5                   | 23.7 $\pm$ 1.8                   |                |
|                            | Grazing land   | 7.1 $\pm$ 1.2                 | 7.3 $\pm$ 1.1                    | 4.2 $\pm$ 1.3                    | 1.1 $\pm$ 0.5                    | <b>34.0 <math>\pm</math> 1.7</b> |                |
| Household characteristics  | Family size (#)  | 9.0 $\pm$ 0.5a                | 8.8 $\pm$ 0.4a                   | 7.0 $\pm$ 0.5b                   | 8.8 $\pm$ 0.8ab                  | 7.3 $\pm$ 0.5b                   |                |
|                            | Farm size (ha)   | 0.8 $\pm$ 0.1a                | 0.8 $\pm$ 0.1a                   | 1.0 $\pm$ 0.1a                   | 0.80 $\pm$ 0.2a                  | 1.0 $\pm$ 0.1a                   |                |
|                            | Land: labour ratio                                       | 0.13 $\pm$ 0.0b               | 0.18 $\pm$ 0.0ab                 | 0.27 $\pm$ 0.1a                  | 0.25 $\pm$ 0.0a                  | 0.25 $\pm$ 0.0a                  |                |
|                            | Cattle (TLU)   | 3.8 $\pm$ 0.4a                | 3.8 $\pm$ 0.4a                   | 2.8 $\pm$ 0.5b                   | 1.6 $\pm$ 0.2b                   | 4.5 $\pm$ 0.4a                   |                |
|                            | Small ruminant (TLU)                                     | 0.4 $\pm$ 0.0b                | 0.7 $\pm$ 0.1a                   | 1.0 $\pm$ 0.2a                   | 1.5 $\pm$ 0.3a                   | 1.0 $\pm$ 0.1a                   |                |
|                            | Income (10 <sup>3</sup> Eth. Birr)                       | 28.0 $\pm$ 8.0a               | 18.0 $\pm$ 2.0ab                 | 7.0 $\pm$ 1.0c                   | 12.0 $\pm$ 3.0b                  | 16.0 $\pm$ 3.0b                  |                |
|                            | Market dependency for food (months)                      | 5.3 $\pm$ 0.4a                | 2.9 $\pm$ 0.4b                   | 3.9 $\pm$ 0.5a                   | 3.1 $\pm$ 0.6ab                  | 3.2 $\pm$ 0.4b                   |                |
|                            | Number of household heads according to educational level | Illiterate                    | 10 (17%)                         | 7 (14%)                          | 13 (30%)                         | 2 (7%)                           | 21 (36%)       |
| Write and read             |  | 7 (12%)                       | 3 (6%)                           | 7 (16%)                          | 5 (16%)                          | 14 (24%)                         |                |
| Elementary                 |  | 33 (57%)                      | 27 (53%)                         | 17 (40%)                         | 17 (57%)                         | 20 (34%)                         |                |
| Secondary                  |  | 8 (14%)                       | 14 (27%)                         | 6 (14%)                          | 6 (20%)                          | 3 (5%)                           |                |

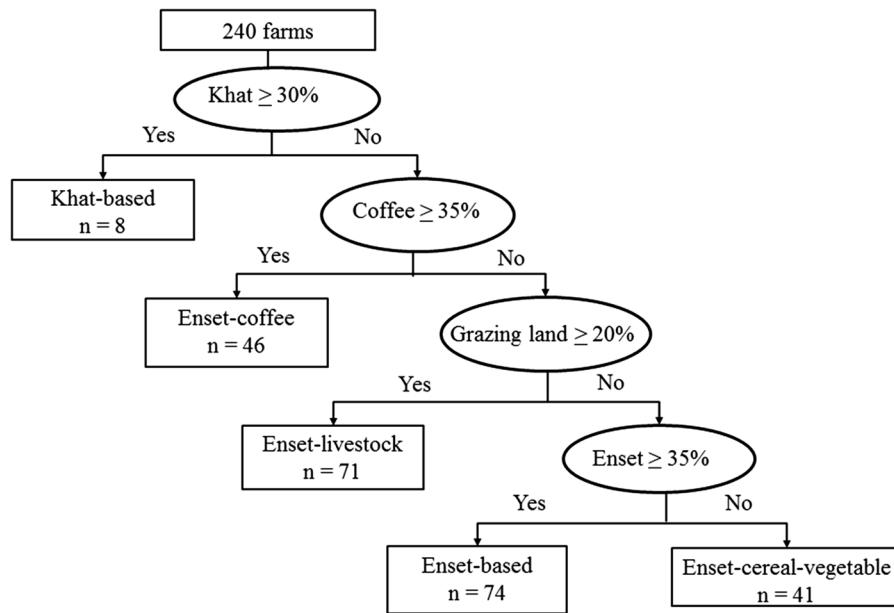
TLU tropical livestock unit

<sup>a</sup> Other food crops include: beans, root and tuber crops<sup>b</sup> Other cash crops include: sugarcane

20–23% in Melga for the last two decades. Grazing land area remained below 10% in Dale, and in Bule it varied between 8 and 17%, with a share of 13% in 2013.

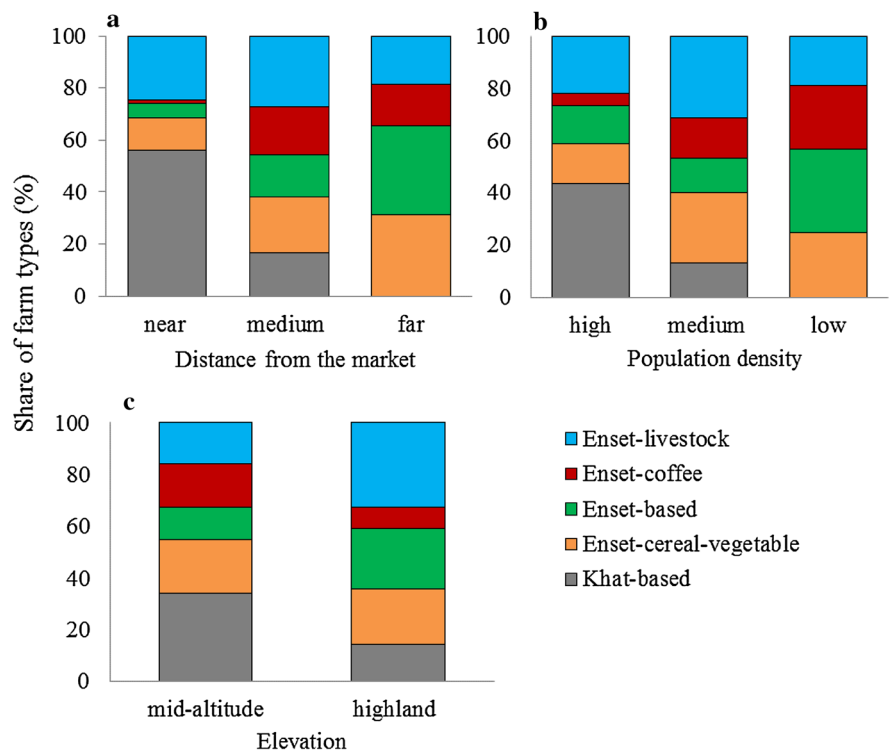
In the period 1991–2013 the cattle and small ruminant population dynamics varied among the four districts. In three districts the cattle holding decreased and only in Melga it increased from 5.1 TLU in 1994–2000 to 5.9 TLU in 2005–2013. In Dale the cattle holding decreased from 2.7 to 2.1 TLU and in

Bule from 4.8 to 3.4 TLU over the same time. In Wondo Genet the cattle holding steadily decreased from 5.8 TLU in 1991 to 3.9 TLU in 2013. The number of small ruminants varied between districts, but changed little over time. Only in Wondo Genet it tended to decline from 0.9 TLU in 1991 to 0.5 TLU in 2013, but also here it varied between years. In Melga the number of small ruminants per farm represented 0.5 TLU, in Dale it varied between 0.1 and 0.3 and in Bule between 1.0 and 1.3 TLU.

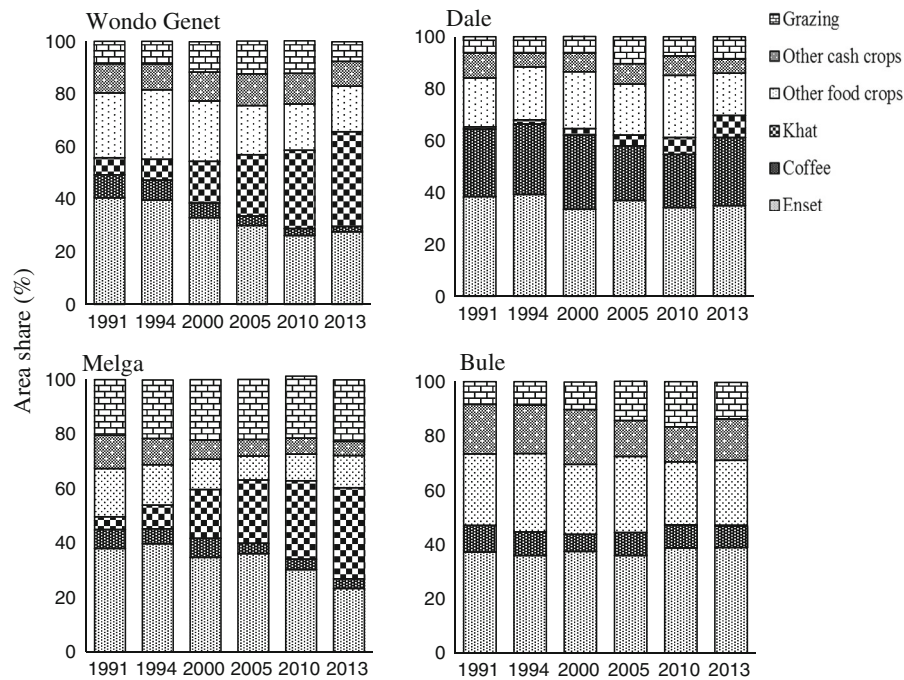


**Fig. 2** Decision tree and threshold values for area share used for farm classification in five home garden types. Number of farms (*n*) refers to the year 1991

**Fig. 3** Share of home garden types in 2013 classified according to **a** market access, **b** population density and **c** elevation







**Fig. 4** Land use dynamics in the four districts of the study area in the period 1991–2013

Dynamics in the prevalence of home garden types in the period 1991–2013

In 1991, about 30% of the sampled farms were engaged in Enset-based and 30% in Enset-livestock farming, while only 3% was engaged in Khat-based farming (Fig. 5). The proportion of Enset-livestock and Enset-based home gardens decreased to 24% and less than 20% of the farms respectively in 2013 (Fig. 5). The share of Enset-coffee home gardens declined from 19% in 1991 to 13% in 2013. In contrast, the share of khat-based farms increased from 3% in 1991 to 24% in 2013. The percentage of farms in the Enset-cereal-vegetable system slightly increased from 17% in 1991 to 21% in 2013 (Fig. 5).

The transitions in home garden systems varied across the four districts of the study area (Fig. 6). In Wondo Genet most Enset-based home gardens in 1991 transitioned to Khat-based or Enset-cereal-vegetable home gardens in 2013, and the proportion of Enset-based farms dropped from 44% in 1991 to 7% in 2013. The farms practicing Enset-coffee farming in 1991 have all transitioned to either Khat-based or Enset-cereal-vegetable home gardens in 2013, as have

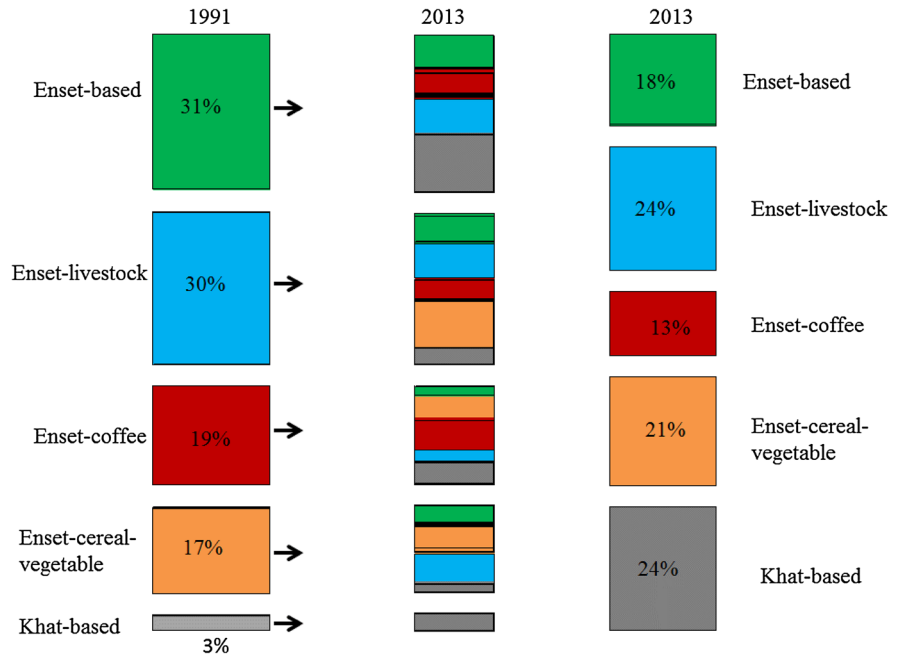
half of the Enset-livestock home gardens. Also in Melga the major emerging type was the Khat-based home garden, increasing from 3 to 39% of the farms at the expense of Enset-based and Enset-coffee home gardens, which fully disappeared by 2013.

The farm transitions were different in Dale and Bule districts. In Dale the emergence of the Khat-based home garden type was restricted to only 3% of the farms, but an increase in the proportion of the Enset-coffee system was noticed (Fig. 6). In Bule the Enset-based and Enset-cereal-vegetable home gardens gained some importance at the expense of the Enset-livestock and Enset-coffee home gardens (Fig. 6).

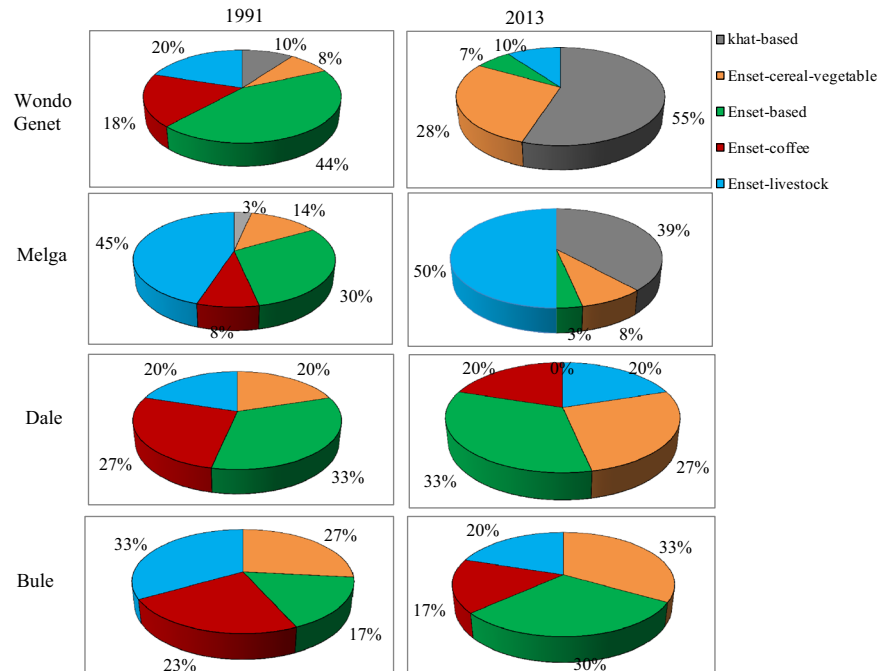
Determinants of farming system dynamics

Respondents identified population pressure, policy, infrastructure, profitability, decline in soil fertility, cultural change, lack of input, labour availability and harvesting frequency of khat as major determinants of land use change in the area. Among these nine factors, population pressure was ranked as the major driver of land use change. In all four districts population pressure increased (Fig. 7a) and contributed to the

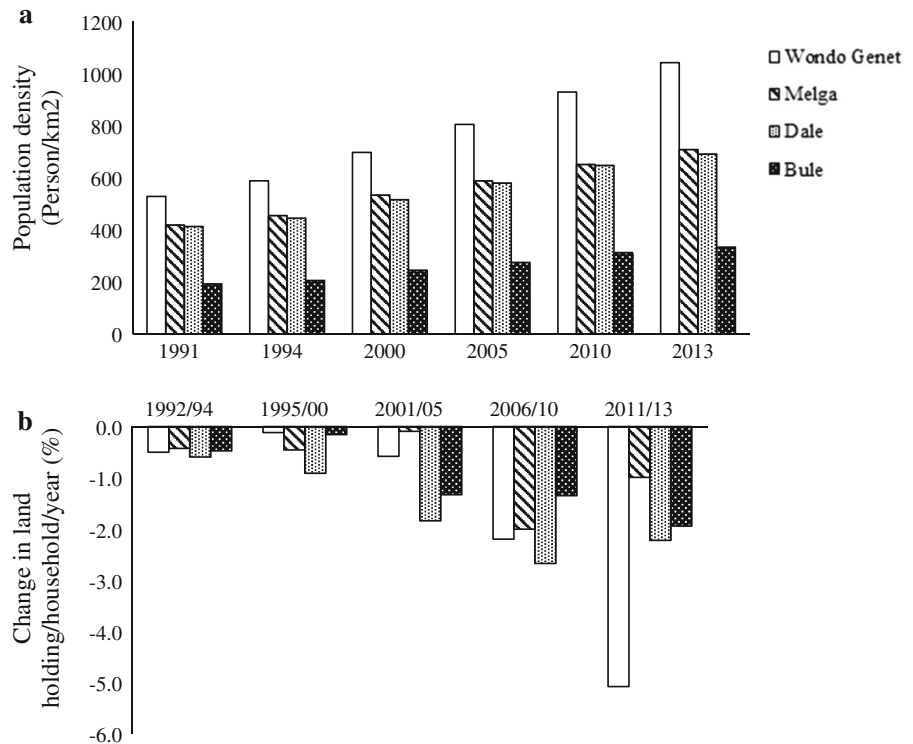
**Fig. 5** Proportion of each farm type in 1991 and 2013 and their transition during this period in Sidama and Gedeo zones ( $n = 240$  farms). The *stacked bar* in the *middle* represents the transition of farms from a given type in 1991 to the types in 2013; the height of each stacked cell and *bar* is representative of the number of farms



**Fig. 6** Changes in the prevalence of home garden types in the four districts of the study area over the period 1991–2013



**Fig. 7** Population density (a) and change in land holding per household (b) in the four districts between 1991 and 2013



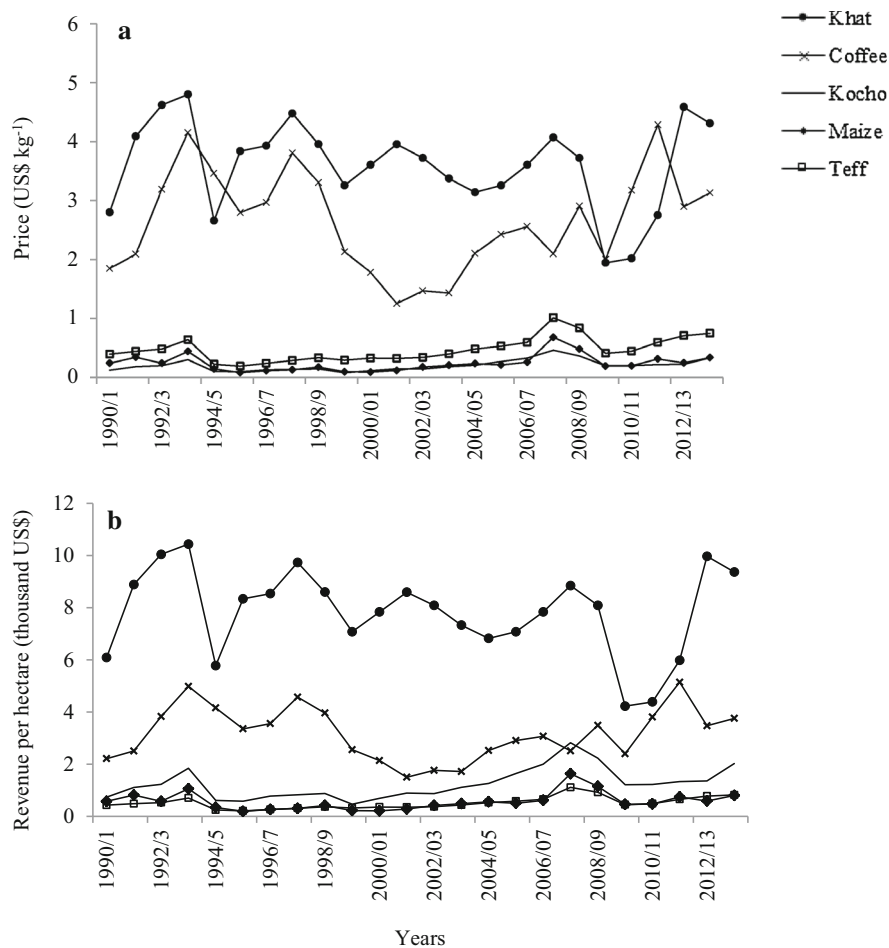
decline in farm size and land fragmentation. In Wondo Genet where population density doubled between 1991 and 2013 the rate of decline in land holding per household increased from 0.5% per year in the period 1992/94 to 5.1% per year in the period 2011/13 (Fig. 7). In Melga, Dale and Bule districts, where the increase in population density was less pronounced, the rate of decline in land holding did not exceed 3%.

A market liberalization policy implemented in 1991 and constitutionalized in 1995, which eliminated crop and livestock sale quota and price controls, was ranked as a second determinant. As a third factor farmers mentioned the cultivation of khat, which became popular thanks to its frequent harvesting and high return per unit area. According to the respondents, the shift to khat cultivation was further fuelled by the development of infrastructure (road, mobile phone) and urban expansion.

Declining soil fertility coupled with a lack of farm inputs (seed, fertilizer and manure) also influenced the land use dynamics of the study area. Farmers further referred to cultural change, and in particular to changing diets. Labour availability was ranked last in terms of its influence on land use change.

The price of staple foods (maize, kocho and teff) rose gradually over the two decades (Fig. 8a). Among the food crops, the teff price showed the largest increase, from 0.4 US\$ per kg in 1990/1 to 0.8 US\$ in 2013/14. The price of maize was very close to that of kocho, increasing from about 0.2 to 0.3 US\$ per kg over the whole period. The price of khat fluctuated around 3.5 US\$ per kg of fresh weight in 1990/1 to 2013/14, and for coffee, it fluctuated between 1.3 and 4.3 US\$ per kg in the same period (Fig. 8a).

Besides the price fluctuation, the greater income per hectare from khat may have further discouraged production of coffee. The average revenue per hectare from khat by far exceeded the average revenues from food crops (maize, teff and kocho) (Fig. 8b). As a result of the continuous fragmentation of land, the inability to produce sufficient amount of family food also discouraged smallholders to allocate land to food crops. Based on the assumption that 50% of the energy demand is provided by enset and 50% by maize, the area required to produce year-round food for an average household of three adults and five children was 0.46 ha. A yield of 6.2 ton per ha for enset and



**Fig. 8** Annual retail prices of food and cash crops (a) and revenue per hectare (b) over the period 1991–2014. (Source: Retailer prices calculated and summarized from price lists for the period 1991–2014 from CSA and Regional Custom Offices;

the average maize, teff and coffee yield per ha summarized from the CSA statistical bulletin (2000–2013); average yield for kocho and khat per ha from ATA (2012)

2.3 ton per ha for maize were considered (ATA 2012). If these households shift to khat and buy all their food, they need only 0.05 ha, assuming a khat revenue of 9368 US\$ per ha (Fig. 8b) and a price 0.3 US\$ per kg for enset (kocho) and maize (Fig. 8a).

## Discussion

### Expansion of khat cultivation

Cropping patterns in Sidama and Gedeo zones of southern Ethiopia changed most strongly in areas

where khat was introduced and expanded over the last two decades (1991–2013). This trend was observed in particular in Wondo Genet and Melga (Fig. 4) and simplified the cropping pattern with khat monoculture now occupying more than one-third of the farm area. A similar expansion of khat was observed in the eastern highlands of Ethiopia, where it replaced sorghum (Feyisa and Aune 2003; Mekbib 2009) and in the Jima zone of southern Ethiopia where it replaced coffee (Dube et al. 2014).

Khat's popularity with smallholders is related to its profitability, its regular harvesting (two to three times per year) and its quick establishment (one to two years). On the one hand, the process of

commercialization and specialization in cash crop monoculture may expose smallholder farmers to unpredictable market fluctuations, disease outbreaks and other adverse shocks, with a risk to become food aid dependent (Amede and Diro 2005). Farmers are particularly vulnerable if institutions, policies, and markets are non-supportive (Von Braun 1995), as in the case of the study area, where e.g. crop insurance schemes are non-existent. Similarly, other studies reported the incapability of small commercialized farms to continue cash crop cultivation following a decline in output prices, after which they reverted back to subsistence cropping (Wiggins et al. 2011). On the other hand, the increased income from cash crops may enable smallholders to buy food crops rather than having to produce everything themselves (Timmer 1997).

Khat's popularity with smallholders is further driven by disadvantages of the traditional crops, such as the long time before enset plants can be harvested (3–4 years after transplanting) and the unreliable price and long establishment period of coffee. Thus, in the context of the study area, the incorporation of khat in the production system may be viewed as an innovation to take advantage of market opportunities towards achieving food security and improving household income (Rehima et al. 2013).

#### Farming system transitions

The historical analysis of farming system transitions indicated a shift away from the traditional home gardens based on enset, coffee and livestock (Fig. 5), illustrating the inability of these systems to accommodate the increasing population. Whereas the traditional systems are known to support very dense populations of up to 500 persons km<sup>-2</sup> (Kippie 2002; Abebe 2005), the population density of all study districts, except Bule, has surpassed this density since 2000 (Fig. 7).

In areas far away from major roads and markets farmers were less inclined to shift to khat, because of less stringent land constraints on the one hand and difficulties related to the marketing of the perishable khat twigs on the other hand. Hence, farms transitioned to Enset-based systems or modified the traditional systems by incorporating annual crops like cereals and vegetables, leading to the expansion of Enset-cereal-vegetable systems in Bule (Fig. 6).

Similar diversification with French beans or tomatoes was reported among smallholder coffee growers in central Kenya (Dorsey 2015). The degree of crop-livestock integration varied between farming systems, and the prevalence of competitive versus complementary roles of crops and livestock partly explains dynamics in livestock herd sizes. The advantage of combining crop and livestock activities in the traditional systems was related to the availability of cheap fodder for livestock, such as enset leaves, and of animal manure, contributing to enset and coffee growth. In the traditional home gardens, livestock also played a critical role in providing a protein and nutrient rich diet to the household, given the low nutritious value of enset (Brandt et al. 1997; Tsegaye and Struik 2001). The transition towards khat cultivation reduced herd sizes due to decreased fodder availability, especially from enset, and also lowered the interest in livestock rearing as a source of cash and manure. For example, in Wondo Genet the khat expansion went hand in hand with a decline in small ruminant numbers. If the demand for cash is met by khat, the need for keeping small ruminants recedes. Moreover, khat is typically fertilized with mineral fertilizer, reducing the need for animal manure. In addition, the feeding behaviour of small ruminants, browsing leaves and twigs, is incompatible with khat, as leaves and twigs are the economic product. Similarly, less interest in keeping draught animals was reported where khat, which does not require ploughing, replaced annual cropping systems in eastern Ethiopia (Kandari et al. 2014). Contrastingly, small ruminant herd sizes did not decrease in Dale and Bule, where the share of enset and coffee remained fairly constant (Fig. 4). This could be related to the availability of browse tree species for goats and understory grazing for sheep in coffee fields.

The decrease in cattle holding per household in the khat-dominated district of Wondo Genet occurred together with the replacement of enset (Fig. 4). Enset leaves have a high protein content (Brandt et al. 1997; Tsegaye and Struik 2001; Solomon et al. 2008) and a feeding value that is comparable to a good quality grass (Fekadu and Ledin 1997). Similarly, Kandari et al. (2014) reported a decline in per capita herd size following complete replacement of major fodder crops by khat in Harar region of eastern Ethiopia. In Melga we observed the opposite trend of a slight increase in cattle ownership, which could be related to the

absence of feed shortage in this district, allowing farmers to expand their herd size. This hypothesis is supported by the relatively large grazing land area per household and the fact that smallholders move their cattle to nearby lowland areas during the rainy season and conserve their own pasture land for dry season grazing (focus group discussion). The smallest herd sizes were observed in Dale, where the area of grazing land was particularly small. Indeed, livestock feed scarcity due to lack of grazing land is often reported as the major constraint of livestock production also in other districts of Sidama zone (Samuel 2014).

#### The main drivers of changes in land use and farm type transition

The main land use change, the replacement of Enset-oriented systems by Khat-based systems, was observed in areas close to markets (Fig. 3). The improved road networks and the proximity to the regional capital city, Hawassa, opened up market opportunities for the farmers, especially in Wondo Genet. The importance of a nearby market is related to khat's perishable nature, with a maximum shelf-life of four days after picking (Distefano 1983). Also in the Hararghe highlands of eastern Ethiopia, the proximity of a market and easy transportation were determinants of khat expansion (Woldu et al. 2015). In addition, the high income potential motivated smallholders to allocate more land to khat cultivation. The revenue per ha from khat exceeded that of maize and teff 16 times and of coffee three times (Fig. 8b). Dessie (2013) reported similar values, fifteen times for cereals and four times for coffee. In Wondo Genet, the expansion of khat was further stimulated by the growing population density (Fig. 7). The resulting land fragmentation, particularly after 2005 when population density exceeded 800 persons  $\text{km}^{-2}$  (Figs. 4, 7), left khat cultivation as one of the few alternatives to make a living from the tiny farm areas. The strong positive relationship between area share of khat and population density was also confirmed in eastern Ethiopia (Tefera 2009). In Wondo Genet the total area allocated to cash crops increased over time to almost 50% (Fig. 4). The inclination of smallholders towards cultivating cash crops when smaller farm sizes impair food self-sufficiency was also described by Woldu et al. (2015).

In contrast to Wondo Genet, in Bule none of the identified drivers for khat introduction and expansion

was present. The district is far from the market ( $>100$  km), population density in 2013 was medium (750 people  $\text{km}^{-2}$ ) in the mid-altitude zone and low in the highlands (250 people  $\text{km}^{-2}$ ). Furthermore, the highland altitude of 2700–2900 m a.s.l. is above the suitable range for khat (Lemessa 2001). Melga closely resembled the situation in Wondo Genet, with the difference that population growth and also land fragmentation were somewhat lower. As a result, the area share of khat-based systems and the area under cash crops were smaller than in Wondo Genet in 2013. Dale also took an intermediate position. It is at medium distance from the market, leading to a risk of quality loss for khat during transport (Distefano 1983). It had a medium population density, similar to Melga, and the altitude did not exceed 2350 m a.s.l., posing no agro-ecological constraint to khat. The improved road networks around Hawassa also benefitted the districts further from the market, such as Dale.

An increase in population also results in a growing labour force. Khat requires about three times more labour than cereal crops on a per hectare basis (Getahun and Krikorian 1973). However, in the densely populated study area there are no labour shortages that could have constrained khat expansion. Some authors argue that khat may expand even further (Dessie 2013). On the other hand, the controversy and uncertainty about a possible prohibition of its cultivation seem to restrain smallholders from allocating all of their land to khat (Dessie and Kinlund 2008).

#### Implication and options for future developments

The traditional home garden systems in the SNNPRS can no longer absorb the increasing population. Part of them have transitioned to intensive khat-based systems, replacing the cultivation of enset and coffee by khat and hence producing less food. This development is associated with various risks such as an increased dependency on one crop, khat, and hence vulnerability to harvest failure, price fluctuations, and pests and diseases. This study has shown that the trends in land use and farm types differed between districts depending on market access, local population density and elevation. Taking into account this observed heterogeneity is crucial in order to identify adapted interventions to achieve social and economic development of smallholder farmers. We have identified several

options for locally adapted interventions. For the khat-based home gardens, diversifying agricultural produce by intercropping khat with annual crops such as cereals and legumes could reduce the risk of depending primarily on one crop. Khat is the main crop receiving artificial fertilizer, which in intercropping systems will also benefit the food crops, contributing to food security. Crop residues can be left in the field to improve soil fertility. The integration with livestock is difficult as not much feed becomes available from this intercropping system.

Enset-oriented home gardens offer scope in areas with lower population densities as enset takes several years to yield. A more intense coupling of enset with crossbred (i.e. Boran-Holstein-Friesian) milking cows or small ruminants could be of mutual benefit, as the enset leaves can be used as animal feed and enset needs manure for a good production. The time required for enset to reach maturity is up to eight years without manure application, compared to three to four years with manure application (Shumbulo et al. 2012). Milk and meat could improve the nutritional quality of family diets, whereas other livestock functions like banking functions also contribute to rural livelihoods (Moll 2005; Thornton et al. 2007). In areas where grazing land is scarce the integration with livestock is not feasible. Here, introducing locally adapted improved coffee and enset varieties could contribute to enhance the income and food security of smallholder farmers through improving the productivity. The shortage of manure to maintain soil fertility can be addressed by the use of compost, prepared from coffee husk waste (Abebe 2013) and the inedible portions of enset leaves and, pseudostem sheath and corm (Tamire and Argaw 2015). There is also scope to integrate high value and productive fruit trees with the aim to maintain the diversified nature of the system and smallholders' sources of income. A continuous soil cover with diversified living plants facilitates the capture and infiltration of rainwater and protects the soil, besides being a source of organic matter through litter accumulation (Mollison and Slay 1991). However, in-depth research is required to quantify the effects of intercropping of the khat-based systems on productivity and of further integration of enset and crossbred animals.

## Conclusion

We found a huge diversity of home garden systems in southern Ethiopia and their dynamics over the last two decades. Five home garden types were distinguished based on cropping patterns. Smallholders specialized in khat production typically allocate about half of their farm land to khat, as such depending on the market for about half of the year for family food requirements, but earning a good income. Contrastingly, farmers specialized in food production allocated about 75% of their farm to food crops, thus generating significantly less income. Over the past two decades cropping patterns had changed considerably, showing: (1) a shift from food crop to cash crop production in densely populated areas close to markets; (2) a continuation of combined food and cash crops in medium populated, less accessible areas. In line with changes in land use and livestock populations, two main trends in home garden systems were observed: (1) a transition to cash crop oriented home gardens, and (2) development of combined food and cash crop oriented home gardens. These dynamic changes were influenced by changes in population density and market access, changes in prices, a decline in soil fertility and a policy of market liberalization. Our insights on how enset and coffee based home gardens of southern Ethiopia have responded to increasing population pressure and commercialization provide insights that can inform the design of alternative options for sustainable development.

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