State of fruit-based homegarden development, constraints and opportunities in western Amhara region, Ethiopia

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Abstract

Integration of fruits in homegardens could enormously enhance household food-security and hold a substantial potential for economic and ecological sustainability. A study was undertaken to assess the extant of use, constraints and opportunities of fruit-based homegardens in western Amhara region in 2006 and 2007. Data were collected by means of structured, semi-structured and key-informant interviews as well as through direct observation and species inventory. Results revealed that although fruit-based homegarden development is at its infancy, there is a greater tendency and surge of fruit tree planting in recent years. Of 104 annual and perennial crop species recorded, 15 species appear to be fruits, of which mango (Mangifera indica), guava (Psidium guajava), avocado (Persea americana), papaya (Carica papaya) and banana (Musa paradisiaca) had a higher abundance, density and frequency. Despite the great potential to contribute to food and nutritional security, however, fruits are generally found to be rare and play insignificant role in the diets of growers. Fruit tree management practices are sub-optimal, the quality of planting material used is mediocre and its supply is far from adequate. Lack of access to water, improved planting material, diseases incidence and wild animals attack represent some of the major challenges. Furthermore, a growing rivalry in land use between fruits and other cash generating crops adds to the problem. Technical backstopping of gardeners with respect to access to quality planting material, water, market and growing skill are suggested.

Key words: Fruit species, homegarden, species abundance, species density, species diversity

Introduction

Homegardening is presumably the oldest land use activity next only to shifting cultivation (Kumar and Nair, 2004). It is common in all ecological regions of the tropics and subtropics, especially in humid lowlands (Fernandes and Nair, 1986) and probably evolved over centuries of cultural and biological transformations and represent the accrued wisdom and insights of farmers who have interacted with environment, without access to exogenous inputs, capital or scientific skills (Kumar and Nair, 2004). In Ethiopia, the beginning of homegardening is believed to have been linked with the beginning of agriculture in the country dating back 5,000 - 7,000 years (Ehret, 1979).

Homegardening has been a way of life for centuries and is still critical to the local subsistence economy and food security. Homegardens play numerous roles as provision of nutrition, dietary supplements, food security in times of crisis, shade, fuel wood, cash income, experimentation, aesthetics, medicinal plants and small-animal raising (FAO, 1999). Moreover, since gardening may be done using locally available planting materials such as green manures, live fencing and indigenous methods of pest control, even the poor can easily enter to this type of production system (Marsh,1998).

Integration of fruits in homegardens as one component holds a substantial potential in terms of economic and ecological feasibility, as well as social acceptability, and could enormously enhance household food-security situations. Fruits are a major source of almost all known vitamins and many essential minerals and consequently are an important component of a healthy diet (WHO, 2005) that they improve the nutrition and health of children, the elderly and immune-compromised individuals such as HIV/AIDS patients (Barany *et al*., 2001). Fruits can also play an important part in poverty alleviation programs and food security initiatives, provide employment opportunities and also offer opportunities for trade and earning foreign currency (WHO, 2003).

In Amhara region, the land availability to the farming families has progressively declined to an average landholding per household of 0.75 ha (Nega *et al*., 2003) and 94 % of households have insufficient land to meet their food needs (USAID, 2000). As a result, most rural people can no longer afford to put aside land separately for perennial crops like fruits. These call for increased farm diversification to provide solutions that successfully combine increased food and nutritional security, cash generation and biodiversity conservation gains. One way of achieving this could be integration of fruits in homegardens. Unfortunately, however, while their multitude advantages warrant high recognition only very little has so far been done on fruit crops and homegardening in general in Amhara region. As a result, the potential contribution of homegardens in general and fruits in particular in peoples' welfare remains largely unrealized. Cognizant of this, this study was undertaken to assess the level of fruit-based homegarden development, its species composition and diversity and identify restraining factors and opportunities in selected areas of western Amhara region of Ethiopia.

Materials and Methods

Study area characteristics, site selection and sampling

The study was undertaken in Bahir Dar Zuria, Bure and Jabi Tehnan *Woredas* during 2006-2007. Bahir Dar Zuria and Jabi Tehnan *woredas* are predominantly characterized by tepid to cool moist climate while most part of Bure *Woreda* falls under hot to warm climate zone. The elevation, annual rainfall, mean monthly maximum and minimum temperatures on average are: 1300-1750m, 1507.1mm, 27.7°C and 13.2°C for Bahir Dar Zuria; 700-2350m, 1581.0mm, 25.0°C and 17.0°C for Bure and 1500-2300m, 1250.0mm, 29.0°C and 12.3 °C for Jabi Tehnan in the order indicated. The soil types are Luvisols, Nitisols and

Nitisols & Cambisols for Bahir Dar Zuria, Bure and Jabi Tehnan, respectively (BoPED, 1999)

Seven representative peasant associations (hereafter called sites) were chosen in the three woredas: Andassa, Wogelsa, Robit and Zeghe in Bahir Dar Zuria *woreda*, Wangedam in Bure *woreda* and Arbayitu and Woinma in Jabi Tehnan *woreda*. In each site depending on the perceived variability, 15-30 homegardens were randomly chosen and interviews were administered to a total of 150 informants using structured and semi-structured questionnaires. A complete fruit tree inventory was made on all fruit species of a year old and above. Moreover, other perennial and annual crops were recorded.

Data processing and analyses

Species diversity was assessed using Shannon diversity index (Magurran, 1988):

$$H = -\sum Pi * \ln Pi$$

where, H = Shannon diversity index; Pi = proportion of individuals found in the i^{th} species; *ln* = is the natural logarithm of this proportion.

Evenness (E) was calculated as the ratio of observed to maximum diversity (Pielou, 1969):

$$E = \frac{H'}{\ln S}$$

where, H′ = Shannon diversity index; S = species richness.

Relative abundance of fruit species was calculated as the abundance of a species as percentage of the total abundance of all fruit species while relative frequency of a species was calculated as the number of occurrences of a species as a percentage of the total occurrences of all species. Species or tree density was estimated by dividing the total numbers of species or trees to the garden area.

Rényi diversity profiles were employed to ordering sites in diversity following Kindt *et al*. (2006) as:

$$H\alpha = \frac{\ln\left(\sum Pi\alpha\right)}{1-\alpha}$$

where, Hα = Rényi diversity profile; Pi = proportional abundance of a species; α= scale parameter with values 0, 0.25, 0.5, 1, 2, 4, 8 and ∞.The values at α = 0, 1, 2 and ∞ in this order correspond to species richness, Shannon diversity index, reciprocal Simpson and Berger-Parker diversity indices.

Beta Diversity or species composition similarities of sites was assessed using ecological distances, i.e. Sorenson index proposed for qualitative data (Magurran, 1988):

$$D = \frac{2j}{a+b}$$

where, D = distance; j = the number of species found in both sites; a = the number of species in site A, and b = number of species in site B.

Data were analyzed using SPSS for windows version 15 and Biodiversity R. software (Kindt and Coe, 2005) built on the free R 2.1.1 statistical program and its contributing packages.

Results and Discussion

State of fruit-based homegarden development

Fruit-based homegardening was found to have a recent history in the study areas since close to half of the gardens (45.7%; n=150) are only 6 to 10 years old. This roughly coincides with the time when an aggressive agricultural extension service was embarked on. The extension program hooked up several farmers to improved fruit technologies and encouraged them to enter into fruit based garden development. However, probably because of high precedence to field crops, area allotted to homegardening is a mere fraction of the total landholding and varies from site to site. The average homestead landholding per household was only 0.44 hectare. This small land allotment to homegardening can be explained by the high land pressure that obligate farmers to allocate part of the homegardens to field crops since arable cropping cannot fully provide households with enough calories (Hoogerbrugge and Fresco,1993). This is instructive that the promotion of homegardens as fruit or vegetable gardens alone is likely to be unsuccessful for subsistence farmers.

Fruit species composition and diversity

Fruit species composition, abundance, frequency and density

In the 150 homegardens covering a total area of 64.5 hectares, 104 species of trees, annual and perennial crops were found inextricably assembled temporally and/or spatially. Of these, 15 species are fruits that are represented by 10 genera and 9 families. Citrus appears the most dominant genus comprising of 40% of the species. Likewise, 46.7 % of the species belonged to Rutaceae family (Table 1). This is presumably related to the long history of Citrus species, (as old as 16th Century), and their wide adaptation in the country (Westphal, 1975).

Fruit species richness ranged from 1-13 with a mean species richness and density of 5.1 and 0.2, respectively. There appeared also a statistically highly significant difference among sites ($P<0.01$) in both number and density of fruit species. Wangedam and Arbayitu recorded the highest total number of species. Gardens at Andassa recorded a significantly lower number of species and the lowest density. In terms of fruit tree abundance, the mean number of fruit trees per garden ranged between 26 at Zeghe and 246 at Woinma. The average fruit tree density was calculated at 4.1 and ranged from 0.09 to 90.5. At site level, fruit density ranged from 0.89 at Zeghe to 10.74 at Wangedam (Table 2). Generally, the study revealed that only a few species are recorded at higher relative abundances. These are banana, mango, guava, avocado and papaya which collectively make up 92.6% of the total number of fruit tree species. Banana appears to be the most abundant species at Wangedam, Woinma and Arbayitu. Likewise, guava, avocado and papaya in that order occur at higher abundances at Andassa, Robit and Wogelsa.

However, a mere abundance is not enough to judge the importance of a species as it might have limited distribution. For a species to be regarded important it should occur at higher abundance coupled with higher frequency. As is illustrated in Table 1,

Table 1. Relative abundance and density of fruit species recorded in homegardens in selected *woredas* of Amhara region.

Botanical name	Common name	Family name	Abundance (no.)	Proportion (%)	Mean number of fruit trees garden^{-1}	% Gardens growing (n=150)
Annona squamosa L.	Custard apple	Annonaceae	42	0.22	0.28	7.33
Carica papaya L.	Papaya	Caricaceae	1701	9.09	11.34	60.67
Casimiroa edulis LaLalave & Lex	White sapote	Rutaceae	3	0.02	0.02	0.67
Citrus aurantifolia (Christm)Swingle	Lime	Rutaceae	200	1.07	1.33	40.00
Citrus aurantium L.	Sour orange	Rutaceae	113	0.6	0.75	18.67
Citrus limon B.	Lemon	Rutaceae	158	0.84	1.05	28.00
Citrus reticulata L.	Mandarin	Rutaceae	41	0.22	0.27	11.33
Citrus sinensis (L) Osbeck	Sweet Orange	Rutaceae	615	3.29	4.1	38.00
Citrus medica (L.) Burm.f.	Citron	Rutaceae	96	0.51	0.64	18.67
Mangifera indica L.	Mango	Anacardiaceae	3166	16.93	21.11	84.67
Musa Xparadisiaca L.	Banana	Musaceae	7595	40.61	50.63	48.67
Persea americana Mill.	Avocado	Lauraceae	2055	10.99	13.7	65.33
Prunus persica (L.) Batsch	Peach	Rosaceae	117	0.63	0.78	17.33
Psidium guajava L.	Guava	Myrtaceae	2801	14.98	18.67	68.67
Punica granatum L.	Pomegranate	Punicaceae	1	0.01	0.01	0.67

five fruit species: mango, guava, avocado, papaya and banana appear to be highly frequent by occurring in 127 (84.7%), 103 (68.7%), 98 (65.3%), 91 (60.7%) and 73 (48.7%) of the 150 gardens in the order listed. As depicted in Figure 1, the relative frequency of these same species was also high.

Generally, species of high relative abundance and high density (Table 2) for most part match to high relative frequency (Figure 1) that provides insight into their importance and underscores the need for giving precedence to these species in fruit development interventions in homegardens. Zemede and Ayele (1995) suggest that crops of versatile utility and wide ecological plasticity are the most frequently grown crops in homegardens. In the present case, this exactly applies to mango which occurs both at the highest abundance and frequency in all locations but at Wangedam. The dominance of mango can generally be accounted, among others, for its good market value, storability, easy traditional propagation and water stress tolerance for its deep root system.

Fruit species diversity

Diversity refers to species richness and evenness. The Shannon diversity index of gardens of all sites (N=150) was calculated at 1.73 (63.8 % of the maximum possible diversity, 2.71) and ranged from 0.0 to 2.02 ($\overline{X}$ =1.05). It ranged from 0.92 at Andassa to 2.21 at Zeghe suggesting that the two sites had the lowest and highest species diversity (Table 2). Further evidence came from Rényi diversity profiles in Figure 2 whereby Andassa and Zeghe exhibited the lowest and highest species diversity, respectively.

Fruit species evenness statistics of gardens ranged from 0.18-1.00 ($\overline{X}$ = 0.69). When all gardens were taken as a unit, the evenness index was 0.38 (Table 2). A lower proportion of the most abundant species translates to a higher evenness that corresponds to profiles that their anti-logarithm of the reciprocal profile value at $\alpha = \infty$ was high. Accordingly, by recording the highest and lowest values at $\alpha = \infty$ Zeghe and Andassa correspond to high and low species evenness, respectively (Figure 2).

In general, the study indicated that fruit species diversity in the study areas was moderate suggesting that there is a clear need for enhancing diversity. Despite having the lowest mean planting size and fruit density, Zeghe site showed the most diverse species. This could possibly be attributed to its intermediate altitude and thus mild climate which permits the accommodation of a wide range of fruit species of low and high elevation range. On the other hand, the poor species richness, density and diversity at Andassa could be attributed, among other factors, to poor drainage condition and its warmer climate that restricts the growing of wider range of species.

Site similarity in fruit species

Table 3 demonstrates the level of fruit species similarity that exists among sites. Evidently, by registering a relatively lower dissimilarity value, Wangedam was very close to Arbayitu (0.16) and Woinma (0.26) sites. On the other hand, species composition of Zeghe was quite different from Andassa (0.51), Woinma (0.47), Arbayitu (0.45) and Robit (0.44).

Table 2. Fruit species richness, abundance, density and diversity in gardens by site (N=150), in Amhara region.

Parameters	Andassa	Robit	Wogelsa	Zeghe	Wangedam	Woinma	Arbayitu
Sample size (N)	29	19	19	20	25	20	18
Number of species site $^{-1}$	7	8	10	11	13	9	13
Mean number of species Garden^{-1}	2.4^{A}	4.6^{B}	3.8^{ABC}	6.1^{BD}	7.7^{DE}	6.0^{BDEFG}	5.5^{BCDF}
Mean number of species 100 m^{-2}	0.05±0.004^{A}	0.12±0.015^{A}	0.13±0.015^{A}	0.22±0.054^{A}	0.51±0.093^{B}	0.14±0.013^{A}	0.2±0.039^{A}
Mean number of fruit trees garden^{-1}	94.66^{AB}	133.79^{AB}	58.23^{AB}	26.05^{A}	154.84^{AB}	246.35^{B}	184.27^{AB}
Mean number of fruit trees 100 m^{-2}	2.16^{A}	2.46^{A}	1.90^{A}	0.89^{A}	10.74^{B}	5.61^{A}	4.02^{A}
Proportion of dominant species	0.67	0.44	0.56	0.22	0.64	0.57	0.63
Shannon diversity index	0.92	1.5	1.35	2.21	1.41	1.29	1.27
Evenness	0.36	0.56	0.39	0.83	0.31	0.41	0.28

*Numbers with the same letter are not significantly different from each other (Bonferroni, P<0.01).

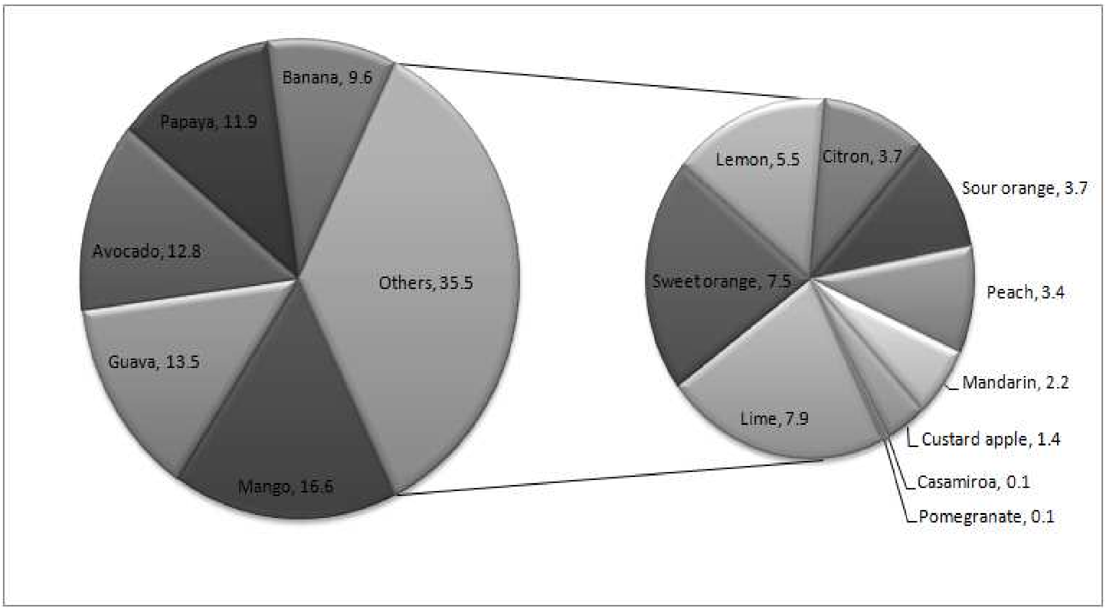

Figure 1. Relative frequency of fruit species in gardens (N=763) in slected *woredas* of Amhara region.

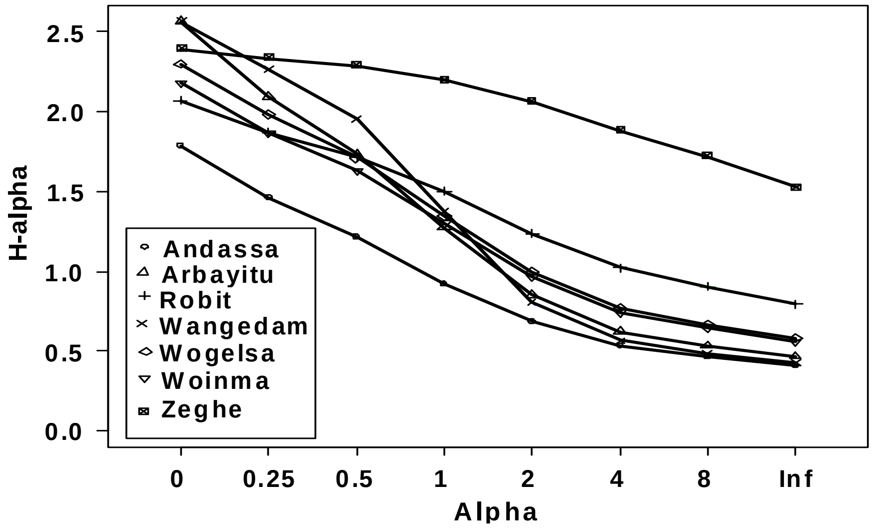

Figure 2. Rényi diversity profiles of fruits by site in Amhara region.

Several factors such as agro-ecological conditions, socio-cultural factors and availability of the crop and land (Zemede and Ayele, 1995) can play role in bringing such differences. Partly the similarity tends to follow a pattern of physical proximity of sites, i.e. the shorter the physical distance between sites the greater species similarity. This can be explained by similarities of sites in climatic conditions as well as shared culture of the people. On the other hand, while Andassa and Zeghe were relatively close to each other, their species compositions for the most part were dissimilar. This indicates that environmental factors are more important in species selection than the socio-economic-cultural determinants.

Based on results from ecological distance analysis and the dominant crop enterprise in homegardens of the seven sites were categorized into three groups: Andassa(I), Zeghe(II) and Wangedam, Woinma, Arbayitu, Wogelsa and Robit (III). This shows that similar species and management practices could be used for homegarden fruits in the majority of the study sites, wehereas Zeghe and Andassa might require special species choice and management practices.

Growers skill, agro-techniques and input utilization

In the study areas, garden and tree management practices were minimally practiced which is partly due to the gardeners' unfamiliarity with the fruit species and managemnt requirements. This is because the majority of fruits in Ethiopia are introductions from abroad and hence their managements are new to the people (Seifu, 2003). Moreover, growers received less support from expert knowledge. As a result, the homegarden agro-ecosystem was generally operated through the use of indigenous knowledge and skills. Hence, there is a need to augement farmers indigenous knowledge with up-to-date information for a better and improved fruit production.

Furthermore, effective homegarden development requires optimal use of important inputs like fertilization, insect pest and disease control and watering.

To all intents and purposes, growers were found not to apply synthetic fertilizers in homegardens. This is because homegardens are often considered more fertile than in the larger agro-ecosystem (Hoogerbrugge and Fresco, 1993). This was indeed the case in the study areas that compared to the outlying farms, most gardens have quite a good fertility status as growers practice application of different types of manures. The total nitrogen, available phosphorus, organic carbon of the different sites were found to be 0.18-0.38 % ($\overline{X}$ = 0.26%), 16.97-109.75ppm ($\overline{X}$ = 51.33 ppm) and 2.18-3.63% ($\overline{X}$ = 2.80%), respectively compared to the outlying fields that had a mean values of 0.19%, 6.79ppm, and 2.06% of these nutrients, respectively (data not shown). Likewise, despite the scourge of diseases and pests on several fruit species, chemical-based pest and disease control measures were absent, and neither were herbicides used for weed suppression. Growers were using any traditional managemnent methods they know. Of course, the capability to avoid dependency on imported inputs is the most distinct characteristics of traditional homegardens (Abdoellah *et al.*, 2002) and is a commendable practice. Generally, use of home generated inputs at no or low cost means that homegardens are economically efficient and sustainable. Moreover, the fruits from homegardens are clean and contribute to environmental protection as well as public health.

As there is a marked dry season nearly for half of the year in the study areas, fruit growing in most of the cases were inextricably linked to the availability of supplemental irrigation water; major sources being springs or rivers and hand-dug wells to a lessser extent. Neverthless, several potential water sources as ground water and rain water harvesting remain less exploited. In a nutshell, the study conveys the need for exploration of alternative sources of water and improved water management practices for effective fruit-based homegarden production.

Table 3: Dissimilarity among fruit growing sites in Amhara region based on Sorenson distance.

Site	Andassa	Robit	Wogelsa	Zeghe	Wangedam	Woinma
Robit	0.27					
Wogelsa	0.32	0.29				
Zeghe	0.51	0.44	0.36			
Wangedam	0.4	0.41	0.23	0.39		
Woinma	0.32	0.42	0.33	0.47	0.26	
Arbayitu	0.43	0.4	0.32	0.45	0.16	0.32

Access to the necessary planting material from a local, sustainable source is an important element for successful gardening. Except for the modest effort made by the Bureau of Agriculture (BoA), no other institution was known to supply fruit planting material in the study areas, indicating the need for private sector intervention. Other than government nurseries, planting material supply in a few cases sourced from own source, local purchases, barter or wildlings. Irrespective of its source, however, the quality of planting materials used were generally mediocre and the supply was far from adequate. Therefore, encouraging farmers to establish private and community nurseries and training them in related areas would help to solve the problem. In general, the majority of the fruit gardens in the study areas were not receiving the necessary inputs, cultural and tree management practices.

Fruit utilization and income generation

A great portion of the homegarden produced has been sold on market than consumed, indicating that the dietary role of fruits for growers is minimal which is contradictory to reports on role of homegarden products in several part of the world. The low consumption of fruits by growers could partly be attributed to ignorance of nutritional value and perhaps urgent need for cash and more importantly dietary custom. Therefore, there is a need to train farmers on nutritional aspects of fruit crops to achieve sustainable behavioral changes on fruit consumption.

Generally because of such factors as sub-optimal management, poor growing skill, low productivity of most fruits coupled with low prices, fruit production remains unrewarding. Nonetheless, few households with a well-developed fruit-based homegardens had in fact enjoyed a speedy wealth status change and have become well heeled out of fruit production. Some of them have become a role model for the community and received development patriotic prizes which might also motivate others to emulate. This is suggestive that promotion of fruit production and homegardening in general could have a substantial role in mitigating food insecurity and allievating poverty.

Production constraints, prospects and opportunities

The fruit-based homegarden production system in the study areas is constrained by as high as 21 bio-physical, socio-cultural and economic factors (data not shown). Among biotic factors, diseases, wild animals and parasitic plants were identified as the most formidable threats. *Phaermularia angolensis* was found to threaten orange production to the point of abandonment. As reported by 44% of the respondents, wild animals especially apes represented one of the most notorious and destructive fruit production problems. Mistletoes especially *Loranthus* spp. were reported by 4% of the interviewee to invade several fruits species and reportedly contributed to the disappearance of the local peach. In addition, access to improved planting material was a universal problem suggesting that provision of appropriate varieties needs to be kept more to the forefront. Water supply was another serious problem for fruit production which is further worsened by growers failure to explore available potential water sources.

Homegarden fruit production also suffered from the growing rivalry in land use between fruits and other cash generating crops mainly *chat*, *gesho* and coffee. Because these crops fetch a higher price they have got a high fervor among the gardeners compared to fruit crops, which have long gestation period and a relatively lower price. As a result, homegardens tend to eventually evolve towards a greater share of a few most profitable species which would lead to a decline in fruit production. Sooner or later, this will lead to a reduction in garden floristic diversity which is likely to affect the sustainability of the production system (Abdoellah *et al*., 2001). Hence, keeping fruit growing more remunerative is critical for sustainaing fruit production in homegardens.

Despite the above constraints, however, most of the gardeners expressed encouraging projections to expand fruit growing through taking various measures like establishment of own nurseries, using motor pump irrigation, digging hand wells, relocating gardens closer to water source, introducing improved fruit species and varieties, etc. Hence, given the increased curiosity of farmers to expand fruit production, it should be possible to harness these positive attitudes to a strategy that creates favorable environment to supporting and building upon their efforts. Another opportunity is that driven by the advent of synthetic fertilizers, hybrid varieties, improved cultural management practices and good market prices, once an obligate crop of homegardens, maize is becoming a field crop. This will undoubtedly leave a space for fruit production in homegardens. Furthermore, increased government focus on high value crops, increased access for improved fruit varieties, growing domestic and export markets, etc. would become incentives for fruit-based homegarden development in the study areas and beyond.

Conclusions

In the study areas, fruit-based homegardening is generally at its infancy but is in an active state of development where there is a greater tendency and surge of fruit tree planting in recent years. The existing fruit species diversity is moderate and is dominated by a few species. The current level of consumption is very low and fruits are rare and play insignificant role in the diets of growers. To ensure wider knowledge and acceptance of fruit production business and homegardening; and to achieve sustainable behavioral changes among the growers rigorous promotion and mainstreaming are required. Targeted and well-planned introduction of new economic species and varieties that are missing in homegardens would also be important to diversify the garden portfolio, attain system productivity and achieve a better economic return. Moreover, technical backstopping and assisting gardeners to have access to quality planting material, water, market and training are recommended. Further research is warranted on detail analysis of the homegardens for a better knowledge of the ecological and economic compatibility of different components.

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