Smallholder-based fruit seedling supply system for sustainable fruit production in Ethiopia: Lessons from the IPMS experience

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ABSTRACT

Ethiopia has a diverse agroecology and many areas are suitable for growing temperate, sub-tropical or tropical fruits. Substantial areas receive sufficient rainfall and many lakes, rivers and streams could also be used to support fruit production. Despite this potential, the total land area under fruits is very small and mainly smallholder-based. According to the Ministry of Agriculture and Rural Development (MoARD), the area under fruits is about 43,500 ha with a total annual production of about 261,000 metric tonnes of which less than 2% is exported. Many supply and demand reasons are associated with the poor performance of the sub-sector including technical, organisational and institutional factors. The lack of sufficient supply of planting materials of improved fruit varieties/cultivars and accompanying knowledge were identified as key constraints during a participatory rural appraisal (PRA) study conducted by the IPMS project in 2005. This is because the source of planting materials for tropical, sub-tropical improved and temperate fruits are limited to a few mostly government operated sites, which are located far away from potential planting places. To alleviate this problem, IPMS in collaboration with district Offices of Agriculture and Rural Development (OoARD) initiated smallholder farmer-based improved fruit seedling supply system in many of its project districts. This initially required the establishment of improved mother trees and farmer capacity building on nursery and fruit tree management, among others. The objective of this paper is, to share the IPMS experiences in the establishment of sustainable farmer-based improved fruit seedling supply system which contributed to the improvement of livelihoods of many farmers. Nursery operators earned between 100 and 11,000 USD equivalent from sale of seedlings/suckers or fruits in a season. The lessons learnt indicate that farmer-based fruit nurseries a) can be established by linking the right public and private sector actors for knowledge, skills development and input supply b) are cost effective compared to the current suppliers, in most cases c) convinced all actors that farmers can handle the seemingly difficult grafting/budding techniques d) created employment opportunities for the landless youth, individual male and female farmers, e) generates a significant income for nursery operators, f) reduce transport cost of the seedlings significantly. This paper also uses a spatial analysis tool, DIVA-GIS software, to analyse likelihood of adaptability of four fruit species to a wider area within the study districts and the likely production potential and value.

Key words: DIVA-GIS, Fruit nursery, IPMS, PRA, Smallholder farmer, Sustainable

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BACKGROUND

Ethiopia is agro-ecologically diverse and has a total area of 1.13 million km^2. Many parts of the country are suitable for growing temperate, sub-tropical or tropical fruits. For example, substantial areas in the southern and south-western parts of the country receive sufficient rainfall to support fruits adapted to the respective climatic conditions. In addition, there are also many rivers and streams which could be used to grow various fruits. Ethiopia has a potential irrigable area of 3.5 million ha with net irrigation area of about 1.61 million ha, of which currently only 4.6 % is utilized (Amer, 2002).

Despite this potential however, the area under fruits is very small and mainly smallholder based. According to the Ministry of Agriculture and Rural development (MoARD, 2005), there are about 3 million farmers involved in fruit production with a total area of about 43,500 ha and producing about 261,000 t annually. However, less than 2 % of all the produce is exported (Joosten, 2007). Although the number of farmers seems high, each farmer grows very few trees of unimproved varieties/cultivars which are also poorly managed and are mainly for home consumption, except banana production in the south. These fruits are typically cultivated to supplement household income from their main crops. The few state farms with about 3,000 ha mainly grow tropical fruits (banana, avocado, mango, orange, and papaya) and are mainly located in the eastern Rift Valley (Siefu, 2003). Apples are mainly grown in the highlands of Chencha, in the south, and are expected to expand to other highland areas in the country (Joosten, 2007).

The policy of the government until recently was also focussed mostly on increased grain production while fruit development was marginalised. Although the number of trained manpower in the area of horticulture was also very small, efforts are underway to increase the number of graduates. The government realised this gap and has created a more enabling environment for the private sector by developing the PASDEP (Plan for Accelerated and Sustained Development to End Poverty). This policy encourages privatization of state enterprises, promotion of commercial production and exports, in which the horticulture sector is a major component. Recently again the horticulture sub-sector has been receiving more attention within the Ministry of Agriculture and Rural Development and is now elevated from a small unit/section to a level of agency.

The major limiting factors for the poor performance of the fruit sub-sector technically are many, including an inefficiently organised system for the production and supply of improved fruit varieties/cultivars. Seedlings are mainly supplied from a few centralised government or NGO supported nurseries, which supply mostly subsidised seedlings to government/donor funded development programs. For example, Upper Awash Agro-industry state farms (UAAI), which are the major sources of mango and avocado seedlings, supply slightly over 600,000 annually. To close the gap in supply the government and NGOs are also importing seedlings from Spain (Joosten, 2007). This therefore calls for a complementary approach including the development of village level smallholder farmer-based fruit nurseries. This follows the experiences gained with coffee seedling production by small holders, which has seen 80% of the seedlings in a District being supplied by small scale nursery operators (IPMS, 2007). Not only will this complementary system contribute to the supply of seedlings but also a) reduce transport distance between seedling suppliers and users, b) reduce mortality of the scion[2] or seedling during transportation, c) reduce the high transport cost and d) create

[2] Branch from another fruit tree with desired qualities, grafted onto the rootstock to get true to type fruit.

employment and income for farmer operated nursery operators. The objective of this paper is therefore, to share IPMS experiences in establishing farmer-based improved fruit seedling supply system, which is also expected to contribute to the creation of sustainable fruit production in Ethiopia and hence to improved livelihoods of farm households.

METHODOLOGY AND APPROACH

The study sites

This paper is based on data and experience from seven IPMS project districts in Ethiopia (Fig. 1) which have variable environmental conditions (Table 1) and farming systems. All the districts have bi-modal rainfall which usually extends from June to September (main rains) and March to April (small rains) except Metema district which has a uni-modal rainfall only during the main rains. As shown on Table 1, the three high rainfall receiving districts (Bure, Dale and Goma) have lower soil pH values of about 5.5 compared to the others.

Please insert Figure 1 here

Please insert Table 1 here

Participatory diagnosis of the problem and selection of nursery operators

A participatory rural appraisal (PRA) was conducted in a value chain framework to identify, marketable priority commodities, the resource base and also technical, organisational and institutional constraints in the 10 IPMS project districts (Fig. 1). During the PRA, relevant tools like group discussion, key informant and observant interviews, personal observations, transect walks and community resource mapping were applied. During this process, fruits were identified as marketable commodities in seven districts. After this exercise, in a subsequent stakeholder meeting, constraints in the fruit value chain (input, production and marketing) were listed out for possible solutions and the potential stakeholder organisations who will contribute towards solving these constraints were also identified. The stakeholders in these meetings included farmers, Office of Agriculture and Rural Development (OoARD) staff, researchers, traders, farmers' association (FA) and administrators. In addition to the PRA, the project also conducted rapid fruit market assessment in some of the districts (Aithal and Wangila, 2006).

During the PRA, suitability of particular fruit specie was determined with the stakeholders (farmers, researchers, OoARD, IPMS, traders) and GIS analysis was also used to determine the extent of suitability of each fruit specie in each district. Supply of seedlings of improved and suitable species at village or even district level was identified as a major bottleneck for fruit development, among others. To tackle the shortage of improved fruit seedling supply, 46 business-oriented farmers from the seven districts were selected.

Selection criteria, distribution of nursery operators and gender diversity

Agro-ecological suitability of peasant associations (PAs) within each district was considered during farmer selection. After identifying suitable PAs, the project personnel along with the Development Agents (DAs) from each district, approached some men and women farmers and youth to enter into this business and serve as fruit seedling suppliers for a cluster of PAs. Many of them showed interest, however, prior to selection, the project and the OoARD prepared a set of criteria among which interest and entrepreneurship, capability, easy access to road and a water resource, experience in nursery operation (whenever possible), gender

and suitability of the PA where the operators are located were among the major criteria that led to the selection of a farmer to be involved or not.

Even though gender was considered as criteria for selecting nursery operators, most of them were men. However, the number of women operators was equal to the number of men in some districts like Goma. In some districts, women were not involved as operators.

Training, study tour and establishment of mother trees[3]

Following the selection, farmers along with their respective DAs were trained on fruit production practices in general and nursery management in particular by experienced staff from the project, research centres (Melkasa Agricultural Research Centre, (MARC), Adet Agricultural Research Centre) and OoARD. In some districts, couples were trained together in order to enhance gender balanced development which may also contribute to minimising exposure to HIV/AIDS. Trainings focused on fruits that they will be raising. Farmers were also taken on study tours to major fruit growing areas. For instance, farmers who were to be engaged in avocado and mango seedling production were taken to MARC and the UAAI, while those to be engaged in apples were taken to Chencha and Injibara. Similarly, those farmers to be involved in banana sucker supply were taken to Arba Minch, which is the major banana producing area but also to MARC and UAAI. During the initial intervention period, each selected farmer then planted improved and agro-ecologically suitable fruit species as mother trees. Varieties/cultivar introduced include Hass, Ettinger, Fuerte, Pinkerton, Bacon (avocado); Tommy Atkins, Apple mango, Kent, Keitt (Mango), dwarf Cavendish, giant Cavendish, Poyo, William 1 (Banana); and Crispin, Bond Red, Anna, Jonagored (Apple). These were among the best released varieties/cultivars by the national agricultural research system but are also internationally well known. This is because in the event of the industry's development, fruits harvested will fetch good prices both in the local and international markets. These mother trees will be the future source of scions and were obtained from MARC and UAAI (avocado and mango); farms around Zwai and Arba Minch towns (banana); and Chencha and Enjibara (apples). As these mother trees were to be mainly used for scion production, farmers were also trained on the appropriate management to maximise number of scions.

Technical considerations during establishment of mother trees

Management of mother trees for scion production requires increasing the number of branches which could bear sufficient number of grafting sticks. In this regard, spacing of these plants was important. On the other hand, some of the fruit species required special planting arrangements to encourage effective cross pollination. This is especially so with apples and avocados. For example, there are known pollinator apple varieties which were placed in a special arrangement. Similarly, avocado flowering has special features because flowers of varieties open on a specific time of the day. Therefore, for effective pollination, characteristics of each variety were also studied before deciding the variety to be planted and planting arrangement to be followed. Avocado, mango and apple require about 3-4 years for production of sufficient scions. Therefore, the project continued to facilitate supply of scions during this time. This will also help farmer seedling producers practice and refine their grafting skills. A well managed mother tree trained for scion production could give a minimum of about 300-400 (apple) and 200 (mango and avocado) scions/year under farmer management. Therefore, farmers can adequately supply grafted seedlings to farmers in their districts and beyond using their own planting materials. In some of the districts, the mother

[3] Fruit trees with desired qualities from which scions are produced.

trees have already attained the level of maturity for supplying scions. In addition to the money earned, this system is already creating sustainability in fruit seedling supply at village level.

Nursery establishment and ownership

Immediately after training and establishment of the mother trees, farmers were advised to grow rootstocks[4] of avocado, mango, apples and banana suckers. Most farmers established the nurseries themselves with technical advice from the project and OoARD. In few cases, mother trees and rootstock in apple and some cases with avocado and mango scions were supplied by the project and OoARD. Seeds for avocado and mango were obtained from locally grown fruits and were farmer managed. However, an internationally recognised rootstock variety (MM106) was used for apple, which was bought and transported to 2 sites (Bure and Atsbi districts) by the project. There were 365 mother plants and 275 rootstocks distributed to seven nursery operators in these districts. Since the seedlings were introduced recently, this paper does not report on this fruit, except testing their wider likely adaptability in these districts. Dwarf Cavendish banana was the major cultivar widely distributed. Farmers engaged were de-suckering to reduce competition but these removed plantlets were sold as planting materials to others. In this case, farmers benefited from sale of both suckers and fruits. Number of seedlings/suckers raised by each nursery operator was dependent on viability of the seed used (avocado, mango), anticipated demand for the grafted seedlings and availability of scions from MARC (avocado, mango) and management of the banana plantations.

Analyse of adaptation likelihoods of 4 fruits in 7 districts

This paper uses, DIVA_GIS software (Hijmans et al., 2001) and other spatial analysis tools, to analyse likelihood of adaptability of these fruit species to wider areas within the study districts. Environmental requirements of these species were collected from literature and from practical experience within Ethiopia (Table 2). Data in this software were modified to suit the environmental requirement as shown on Table 2.

Please insert Table 2 here

RESULTS

Nurseries are mostly operated on individual basis but with support from family labour while only one was operated by a group. Number of seedlings sold is still small (Table 3), mainly because of shortage of scions, but with the scions now becoming available from the earlier planted mother trees, production/sale of fruit seedlings is expected to grow exponentially. Prices of mango and avocado seedlings ranged from 13-25 Birr[5] while that of banana from 2-10 Birr, depending on the farmer and the district. Most seedlings were sold to individual commercially oriented farmers, however in two districts, part of the seedlings were sold to government/donor sponsored programs which in turn sold/supplied them at subsidised prices to less well endowed farmers. Results also show that farmers involved in this business earned from 200 to 34,375 Birr/year on individual basis. As a result of the benefits from the business, many of the farmers involved expanded their business and used the money as a start up for other farming activities and businesses, and a few also bought houses. The benefit will not only be limited to these nursery operators but also to the many farmers who bought these seedlings. Most of these seedlings from the improved fruits will bear fruits in short period of

[4] Plant with established root system where a twig/cutting from another plant will be grafted/budded on to.
[5] 1 USD is equivalent to 12.50 Birr

time. For example, banana would need less than one year while avocado and mango need 3-4 years. During the short project life, farmers producing bananas already benefited from selling fruits. For example, a farmer in Metema district sold 500, 7,500 and 27,500 kg of banana fruits from 2007-09 and earned 2,500, 37,500 and 137,500 Birr during these years, respectively. There are other farmers with more acreage who also sold banana fruits worth more than 150,000 Birr. Prior to 2005, there was no single tree of dwarf Cavendish banana in Metema district (Kahsay *et al*, 2008). Currently, there are more than 1000 farmers growing banana and it is being scaled out to similar neighbouring districts. The establishment of private fruit seedling supply system will also benefit the country through increased export or import substitution of fruits. For example, Ethiopia imported around USD 2.5 million worth of fruit products (fruits, nuts and juices) in 2003 (http://www.intracen.org/tradstat/sitc3-3d/ir231.htm

Please insert Table 3 here

The following cases of 2 nursery operators will demonstrate the impact of this activity in the livelihoods of the farmers involved, even though these are among the least benefited.

Case 1.

Kedija is a 36 years old housewife and a mother of 4 children who lives in a small village in Goma district, Oromiya region of Ethiopia. Kedija and her family are landless and live in a small hut with of 500 m^2 plot rented from the village administration. She has a few coffee, avocado and enset plants in her backyard. In a good year, she earns about 300 Birr from sale of enset products, while coffee beans are only sufficient for home consumption. The family's other source of income was limited to the income they get from the sale of injera (traditional Ethiopian bread) and small amount of cash from sale of an assortment of small items in their petty trade. Two years ago, Kedija was selected to take part in an intervention supported by the IPMS project in which a participatory commodity development scheme including the development of "farmer-based fruit seedling supply system" was being tried. Kedija was trained on fruit grafting techniques and nursery management and participated in an experience-sharing tour to a state-owned fruit farm, which also happened to be the major supplier of grafted mango and avocado in the country. IPMS brought Kedija 15 improved avocado seedlings. The seedlings consisted of three popular varieties (Fuerette, Hass and Ettinger) and were targeted to serve as future mother plants. In 2008, Kedija grafted 300 avocado seedlings in a 10 m^2 area and sold 70 grafted avocado seedlings for Birr 1750. Using this money, she bought a local breed heifer for 600 Birr and purchased nursery materials (polythene bags and plastic sheet) for raising grafted avocado seedlings and a hybrid coffee variety. The rest of her "new found wealth" was spent to cover her household expenses. Currently, she has about 45 grafted seedlings which can generate an additional 1125 Birr. Apart from selling grafted seedling, she is also hoping to earn an income from selling scions to other farmers. She has prepared 500 avocado rootstocks and 200 hybrid coffee seedlings. From these activities she is expecting to earn 14500 Birr. Her family members play integral roles in executing these activities. Money from the sale of seedlings is now their main source of income. Kedija had never been engaged in agriculture herself and has never earned so much cash from her very small plot of land or from any other business throughout her life. She now has a strong and positive vision about the potential rewards of even small-scale agriculture and wants to expand this business. She has applied to her PA administration for additional land along the roadside.

Case 2:

Ashebir Alemu is a 20 year old young man who lives in Bure district of Amhara Regional State in Ethiopia. He has 8th grade education and lives with his mother. Ashebir's father died when he was 10 years old and he has since shouldered the responsibility to generate money for food and other essential needs of his mother, nephew, niece and himself by working after his school hours. The family farm is just a quarter of a hectare of land and this makes it very difficult to produce adequate food even for subsistence. As a result, he was forced to look for other income generating activities. Since their home is in front of the highway between Bahir Dar and Addis Ababa, Ashebir started generating money by selling charcoal. He also farms rented land in order to produce supplementary grain for their consumption. A government fruit nursery for the district is situated in front of his house and Ashebir has watched the annual fruit multiplication activities since his childhood. However, he had never thought of its potential importance for generating good income from a small plot of land. He also did not know anything about grafting. In July 2007, the IPMS project was introducing grafted avocado seedlings to some farmers around Ashebir's village and he and his friends happened to be assisting the project staff unloading of these seedlings. Ashebir asked the project's Research & Development Officer (RDO) how grafting is done. The RDO explained to him some grafting techniques and the importance of grafting to farmers with small holdings. After two months, Ashebir invited the RDO to his house and showed him the success of his first grafting attempt. The RDO encouraged him to get a one-week training on theoretical and practical orchard management and grafting techniques. Following this, he started raising rootstocks and grafting at the end of 2007. Considering his commitment, the project provided him with a few scions of avocado from Melkassa Agricultural Research Center to expand his activity. In 2008 he sold 10 grafted avocado seedlings for 200 Birr. The following year he sold 258 grafted avocados and earned 5,160 Birr and invested this money to expand his fruit nursery business and to start grain trading. Currently, he has over 1500 grafted avocados for sale in the 2010 planting season and is expecting to earn more than 30,000 Birr. Moreover, he is currently diversifying his nursery activity by including apple mother trees and 30 rootstocks and is soon expected to graft and sell apple to the neighbourhoods which is the first of its kind in the district. His full engagement in fruits business makes him work for environment-friendly activity taking him away from selling charcoal which enhances deforestation.

Likely suitable areas

In order to assess long term potential impact of this intervention, these fruits were analysed for their likely adaptability to the study districts, using DIVA-GIS. This analysis showed that there is a high potential for wide adaptability implying that livelihoods of many farmers could be improved. Figures 2 to 5 show the likely suitable areas, while Table 4 shows the potential area (ha), production and expected value (Birr) for the four fruits in the study districts. Assuming that only 5% of the area considered suitable becomes under production, the income that could be generated by both selling seedlings and fruits (in the long run) is going to be enormous. The PAs identified as suitable for growing these fruits inhabit many farm households and these are expected to be the initial clients for seedlings raised by the operators. This indicates that, more nursery operators will be required to supply sufficient fruit seedlings in the future, but with experience and availability of own mother plants, number of seedling raised and sold is expected to increase.

Please insert Figures 2-5 here

Please insert Table 4 here

Factors influencing adoption of the intervention

*Encouraging policy***:** The economic development policy and strategy document of the government has stressed the need to accelerate the transformation of the agricultural sector from subsistence to a more business/market-oriented agriculture (MoFED, 2005). This contributed to a changing mentality of the OoARD staff and farmers towards market orientation. It also resulted in the government promoting horticultural development and rewarding of successful farmers.

*Use of value chain approach/innovation system concepts with the participation of relevant stakeholders***:** This led to the identification of fruits as a marketable commodity, the use of demonstrations and study tours to create interest in the commodity, the current supply system of seedlings as a bottleneck to expansion of fruit production, and the identification of an alternative (farmer based) seedling supply system including selection of farmers, suitable varieties/cultivars and knowledge/skills needs. The study on fruit marketing (Aithal and Wangila, 2006) showed that there is high demand for fruits in the study areas, including some of the districts in this paper. This study also revealed that demand for exotic species is higher than the demand for local species. The fruit varieties which are being promoted are also internationally recognised.

Partnership/linkage roles: IPMS forged linkages with various actors to bring knowledge skills and supply of inputs including the research system, NGOs, state farms and the OoARD and nursery operators. The project staff played a leading role at the beginning and continued until the OoARD and farmers were able to takeover. For sustaining the innovation processes, the project tried to develop capacities of the public and private sector to take over this role to ensure sustainability after the project terminates and ownership by local organizations.

What is working well and why?

These nursery operators now are selling improved fruit seedlings to fellow farmers in their neighbourhood and beyond with scions brought from the MARC, but some have already started using their own mother trees as the source of scions. As a result, supply of improved fruit is becoming an important source of livelihoods to the farmers operating the nurseries.

The main reason for the success is economic viability of the nursery operation, based on the demand for seedlings in the study areas. For example, in 2008, farmers in Bure district requested their respective DAs for buying 14,280 mango, 8,964 avocado and 2,995 banana suckers. However, the operators could not avail the quantity needed because of limited capacity. As can be seen from Table 3, number of seedlings sold was very low compared to the demand in 2008. However, many farmers will establish their own mother trees and demand will be reduced, in the near future. Field days, focusing on the project activities, including fruit nurseries, have been conducted for zonal and regional levels which are expected to contribute to the sale of seedling beyond the district boundaries. In the future, more benefits are expected come from the sale of fruits than from seedlings.

The role of the OoARD is changing from input supplier to knowledge provider on fruit (seedling) production, which should result in improved livelihoods of the rural poor. If fruit seedling supply, as is common with other input supply services, is handled by the private sector, it is expected to be more efficient than the public sector and this efficiency is expected to lead to increased sale of fruit seedlings and hence many farmers will be able to grow and sell fruits which will contribute to improved livelihoods.

What is not working well and why?

Shortage of scions: At present scion is brought from MARC and is in short supply because all our sites get scions from this research centre. As a result, some farmers who started raising seedlings for rootstock have stopped because they were frustrated by the shortage of scions. In some of or districts nursery operators have already started using scions from own mother trees. Other districts will follow next year.

Low success rate of grafted seedlings: Some nursery operators reported lower survival rates of grafted seedlings, especially with mangos. This is attributed to lack of experience and the fact that the scions currently used are also transported from long distances. However, with increased practicing in grafting by the operators and use of own scions, it is believed that this problem will be reduced substantially in the future.

Lack of nursery tools: Hand tools, polythene bags, grafting knife, rapping plastics and other, necessary for nursery activities are unavailable in the districts. Use of this may also contribute to low lower success rate of grafted seedling in the nurseries. Existing credit schemes could be used to encourage and establish village level farm tool shops, including nursery tools, by farmers. The project has implemented similar activities in developing input supply services for other commodities like coffee, forage seed, supplementary feed and honey producers in some districts.

Lack of seeds for rootstock: Seeds from locally grown mango and avocado are raised as rootstock, but the fruits are not widely grown in most of the districts. Therefore, nursery operators have to collect these seeds from juice selling houses and market places. However, seeds collected are not sufficient and have poor viability. Government and other farmer nurseries also collect these seeds for raising seedlings. Fruit development is at its infant stage in the study districts, but is expanding which is expected to solve problems related to seed shortage in the future.

Limitations of the spatial analysis

The overall accuracy of the digital outputs depends on the spatial resolution of the digital layers used. Detailed socio-economic characteristics of the areas considered suitable will also

be important before finally recommending these fruits, based on their environmental requirements, so that factors that negatively influence adoption will be avoided.

Lessons learned and Recommendations

The IPMS approach focussed on a system that requires a market-oriented approach to agricultural development with the involvement of many but relevant stakeholders. This intervention proved that multi-stakeholder-participatory identification of commodities, their constraints and solutions and relevant stakeholders in a value chain approach is key to creating a sustainable system. The various stakeholders contributed at the different stages of the value chain. The involvement of the various stakeholders from the initial stage also helped to target the right intervention areas, farmers, sites and others. This further facilitated the buy-in by and ownership by the key stakeholders because projects such as this only last for few years and there is a need for sustained ownership. On the other hand, the proper targeting and identification of bottlenecks in the area of capacity building of the participating farmers and starting to build the capacity of the participant farmers at the initial stage was also key to the success. This is because activities which seemed difficult and requiring special skills (grafting) were easily managed by farmers.

There was no thorough study on cost of seedling production but rough calculations show that each avocado and mango seedling would cost about 5 Birr. The operators sold these seedlings between 11 and 25 Birr each (Table 3), while between 2 and 10 for banana suckers. However, in the existing supply system, sales price of 1 avocado or mango seedling is 15 Birr. However, by the time the seedling reaches Metema, for example, it will be about 45 Birr, where cost of transport is a major expense.

Looking at the size of the areas suitable for growing the fruits (Fig. 2-5), many more nursery operators will be required to supply sufficient fruit seedlings in the future. On the other hand, with experience, benefits earned and availability of own mother trees, the current operators are also expected to increase number of seedlings sold, while the number of nursery operators will remain small, relative to the number of farm households, in the future. However, nursery operation is not an end by itself, rather it is a way to support the fruit industry in the districts and ultimately in the country, so that benefits will not only be limited to the nursery operators but also to the broader fruit growers as well. The experience gained by both farmers and DAs and the link created among these stakeholders and the researchers is expected to create a sustainable fruit seedling supply system for newly emerging varieties/suckers in the long run, in support of the likely fruit expansion in the districts. The fruit supply system has already started to scale up and out beyond the study sites, calling for strong support of the intervention. It is therefore believed that, in addition to district, zonal and regional level offices, the newly established Horticulture Development Agency (HDA) will be strongly involved in regulating these efforts so that quality is not compromised. With further development of the sub-sector, HDA will also be a key player in market information delivery and advisory services to the sub-sector.

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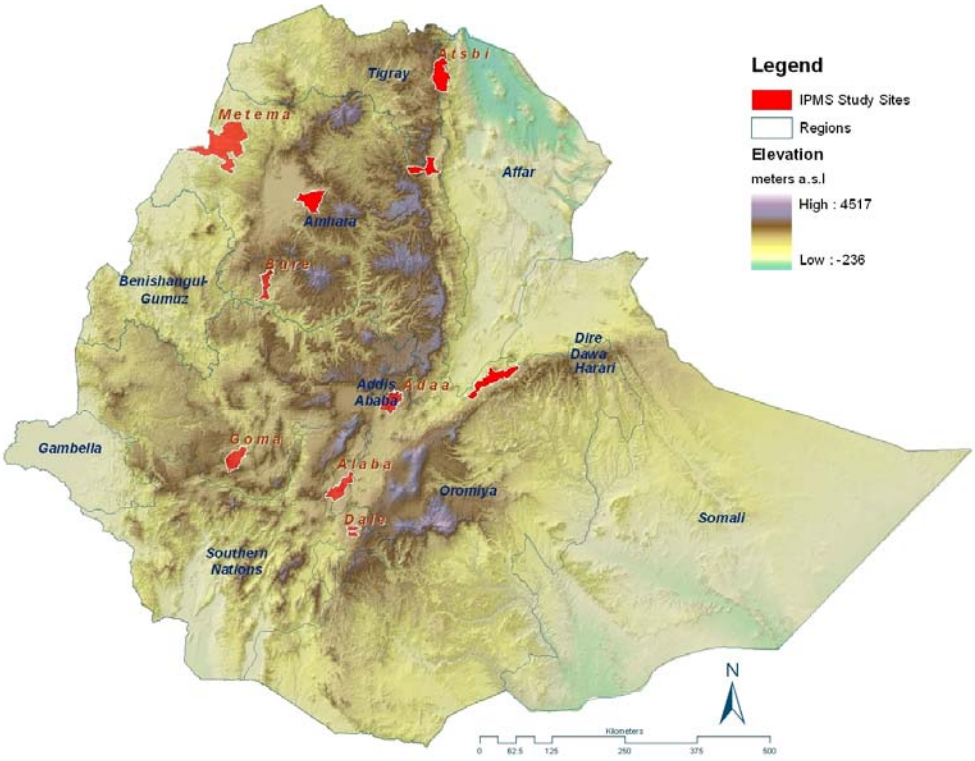

Figure 1. Map of Ethiopia depicting the study sites

Table 1. Some social and environmental conditions of the study sites

District	Agricultural population[1]	Altitude range (m asl)	Annual temperature range (ºC)	Annual rainfall range (mm)	Major soils
Ada	194,664	1800-3100	8–28	871-1070	Vertisols
Alaba	214,309	1555-2261	17-20	857-1085	Andosol (Orthic)
Atsbi	100,635	918-3069	13-25	365-678	Lithic Leptosols
Bure	143,854	713-2604	14-24	1386-1757	Humic Nitosols
Dale	196,758	1170-3200	15-19	1162-1353	Nitosols
Goma	247,326*	1387-2870	13-29	1779-2005	Nitosols
Metema	48,012	550-1680	22-28	850-1100	Haplic Luvisols and Vertisols

[1]Source: CSA (2003)
*Includes urban population

Table 2. Soil and climatic requirements of some fruit crops

Fruit	Climatic and soil conditions	Source of information
	Annual rainfall (mm)	
Mango	500-1250	Griesbach**,** J. 2003; Singh A. (1996)
Avocado	665-1475	Gaillard J.P. & J. Godefroy (1995);
Banana	1500-2000	van Ee, S. 1992
Apple	1300-1600	Personal observation
	Temperature (^{0}C)	
Mango	20–27	Griesbach**,** J. 2003; Singh A. (1996); van Ee, S. 1992;
Avocado	12-30	Saurindra P. Ghosh (2000); Gaillard J.P. & J. Godefroy (1995)
Banana	25-38	
Apple	15-21	Singh A. (1996)
	Altitude (m asl)	
Mango	0-1200	Griesbach**,** J. 2003
Avocado	1000-1800	HDD, 1980
Banana	0- 1200	Singh A. (1996)
Apple	2000-2800	EARO (1998); Singh A. (1996)
	Soil reaction (pH)	
Mango	5.5-7.5	Griesbach**,** J. 2003
Avocado	5 -7	Saurindra P. Ghosh (2000); Gaillard J.P. & J. Godefroy (1995)
Banana	4.5 -7.5	Singh A. (1996)
Apple	6-7	EARO (1998)
	Other characteristics	
Mango	Drought tolerant, 3 m deep and well drained soils	Griesbach**,** J. 2003
Avocado	Intolerant to saline conditions, require 1 m deep, very well-drained soils; frost-free areas and cool night temperatures of 5 to 10°C; irrigation water with <100 ppm chloride content; plenty of sunshine (2300 to 2500 hours per year)	Saurindra P. Ghosh (2000); http://www2.dpi.qld.gov.au/horticulture/4736.html; Gaillard J.P. & J. Godefroy (1995) van Ee, S. 1992
Banana	Well drained soils; water table < 1 m; warm humid and rainy areas near the tropics suit banana	Singh A. (1996); van Ee, S. 1992
Apple	Some cultivars require chilling below 4-5^{0}C for about 40-60 days to break rest period. Temperature below 3^{o}C inactivates normal metabolic activity of the tree.	Singh A. (1996)

Table 3. Fruit seedlings raised and sold by nursery operators by district

District	PA	Nursery operators		2008		2009	
		M	F	Seedlings/suckers sold	Value (Birr)	Seedlings/suckers sold	Value (Birr)
				Avocado			
Ada	2	2	0	1700	25500	1675	29949
Alaba	2	2	0	1394	34850	1800[6]	18300
Bure[7]	2	5	1	110	2200	379	7580
Dale	2	5[8]	0	1194	29850	1683	22209
Goma	4	3	3	0	0	1714	42875
Total	**12**	**17**	**4**	**4398**	**92400**	**7251**	**120913**
				Mango			
Ada	2	2	0	1000	15000	842	15156
Alaba	2	2	0	1756	39900	2160	45900
Dale	2	5	0	700	17500	946	12427
Total	**6**	**9**		**3456**	**72400**	**3948**	**73483**
				Banana			
Bure	3	9	3	538	1214	1293	3851
Metema[9]	3	6	0	4756	43848	6311	54149
Total	**6**	**15**	**3**	**5294**	**45062**	**7604**	**58000**

Table 4. Likely adaptability of 4 fruit species to 7 districts

Fruit	District	Likely suitable area (ha)	Potential		
			No. of farmers	Production (t)	Value (Birr)
Avocado	Ada	8,490	17,910	33,960	33,960,000
	Alaba	59,000	127,362	236,000	236,000,000
	Bure	23,800	48,610	95,200	95,200,000
	Dale	23,100	160,528	92,400	92,400,000
	Goma	18,300	49,250	73,200	73,200,000
Mango	Ada	11,050	2,331	44,200	44,200,000
	Alaba	4,430	956	17,720	17,720,000
	Dale	6,920	4,808	27,680	27,680,000
Banana	Bure	2,068	4,223	51,700	51,700,000
	Metema	5,087	626	127,175	127,175,000
Apple	Atsbi	14,800	12,214	59,200	473,600,000
	Bure	52,840	107,911	211,360	1,690,880,000

Assumptions:

Production: Avocado, mango and apple 4 t/ha after about 4 years, while banana 25 t/ha in less than one year period.

Farm gate prices: Avocado, mango and banana @1 Birr/kg and apple 8 Birr/kg

[6] Data from only 1 farmer

[7] There are 3100 avocado seedling ready for 2010 by 3 operators but 1 farmer alone grafted and prepared 1500 seedlings of these and is expecting to make 30,000 Birr.

[8] In this district couples are trained and are managing together.

[9] In 2007, these nursery operators sold 3099 banana suckers for 28,240 Birr in addition to sales from banana fruits.

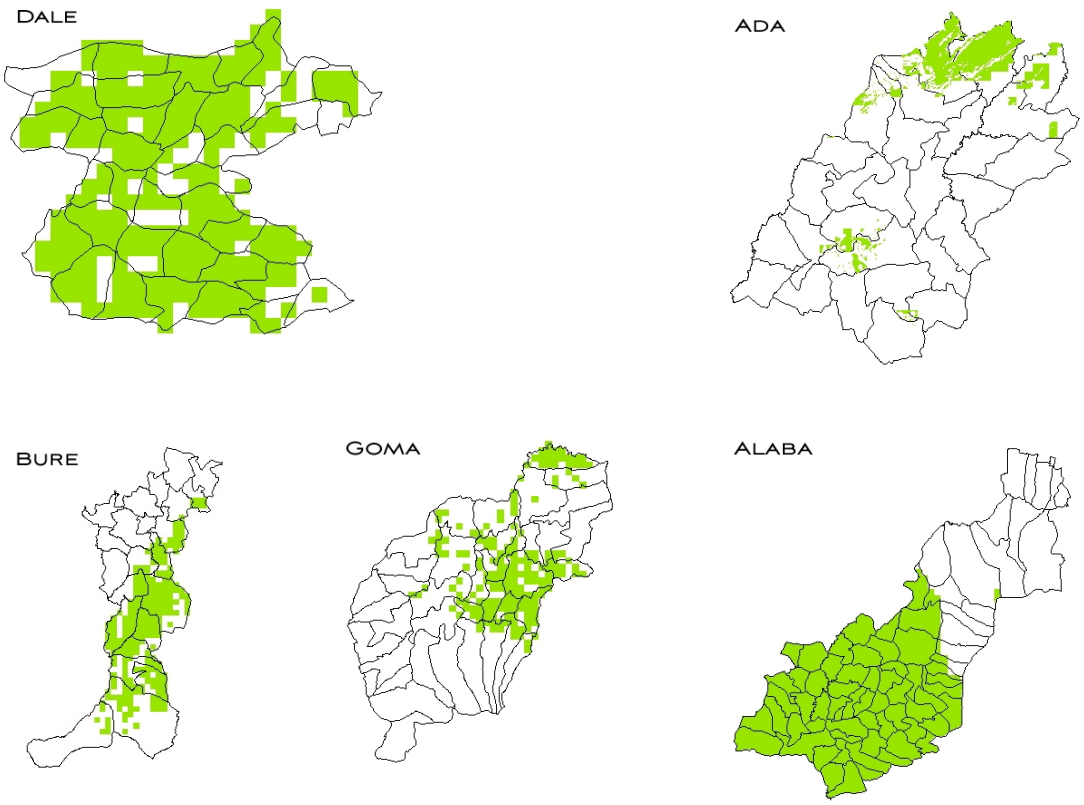

Figure 2. Likely adaptability of avocado to five of the study districts

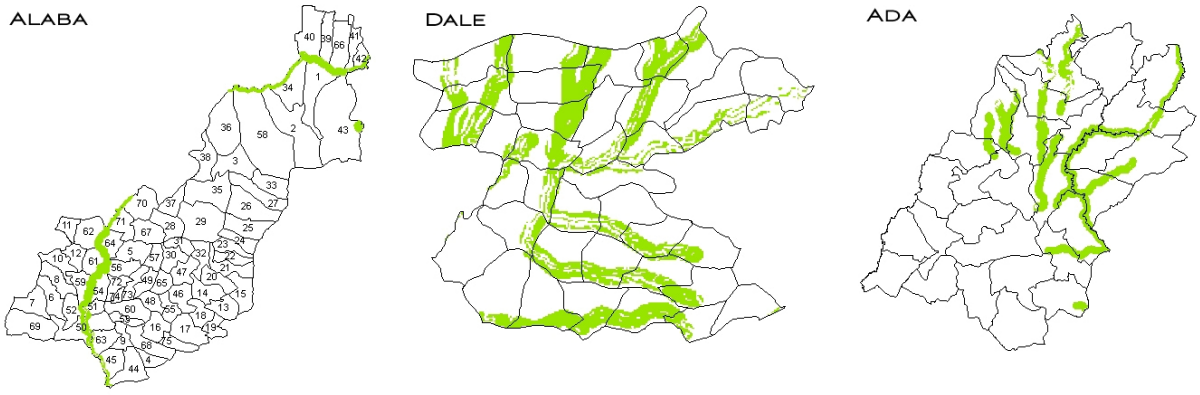

Figure 3. Likely adaptability of mango to Alaba, Dale and Ada districts

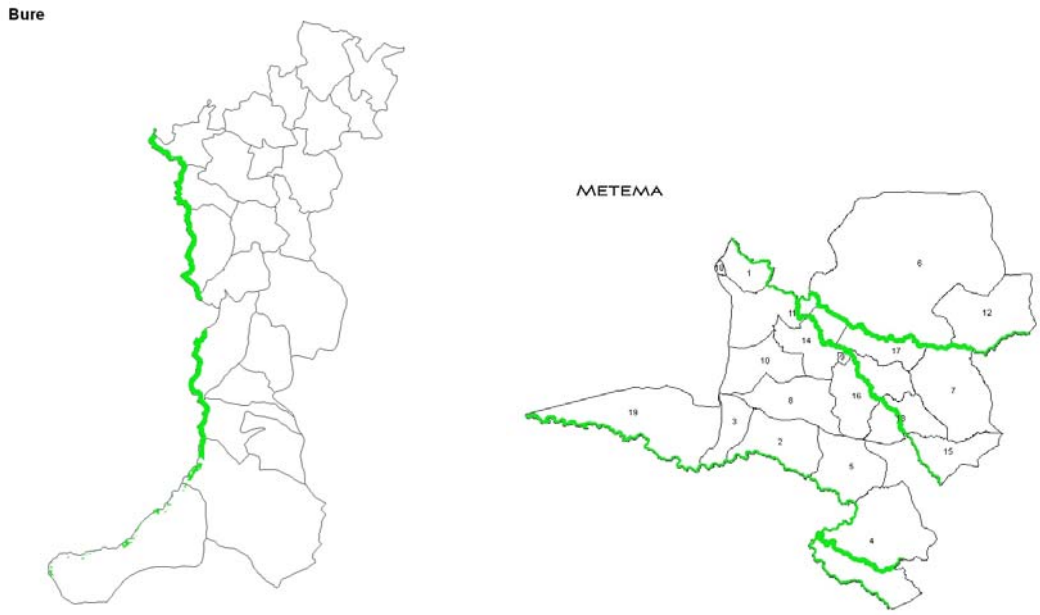

Figure 4. Likely adaptability of banana in Bure and Metema districts

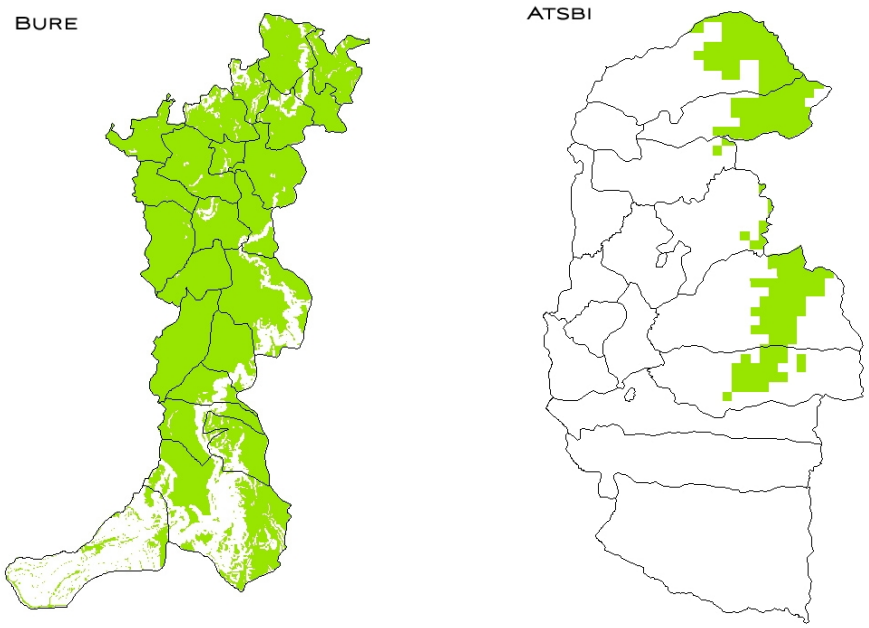

Figure 5. Likely adaptability of apple to Bure and Atsbi districts