



Horticulture Sector in Ethiopia-Achievements, Challenges and Future Prospects

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Abstract: Ethiopia is a country with great variety of climate and soil types that can grow diversity of horticultural crops for home consumption and foreign markets. Horticultural crops are rich in different nutrients that contribute to a major portion to an Ethiopian daily dish mix. The horticulture sectors play a significant role in developing country like Ethiopia both in income and social spheres for improving income and nutrition status. Horticultural crops help in maintaining ecological balance due to their high diversity, and also provide employment opportunities as their management being labor intensive. Therefore production of these commodities should be encouraged in labor abundant and capital scarce countries like Ethiopia. Ethiopia is blessed with a favorable climate and vast land, water and labor resources which together make it an incredible investment hub. Due to these facts, the horticulture sector has shown a very dramatic growth in the country. In recent decades, rapid growth in Fruits and Vegetables, Floriculture, Spice and Herb and in Aromatic, Medicinal and Biofuel Sector has been recorded. According to recent reports, one fifth of the foreign income is come from horticulture sector in Ethiopia. Basing the importance of the sector, significant amount of developmental and research efforts have been made to enhance the quantity and quality of horticultural products. Therefore this paper is intend to review, the development, and research efforts made so far, their achievements, challenges and opportunities of the horticulture sector in Ethiopia.

Keywords: Ethiopia, Floriculture, Fruits, Horticulture, Vegetables

1. Introduction

Horticulture is both an art and Science. It is originated from the medieval practices of growing intensively managed kitchen gardens that provided fruits, vegetables, herbs and ornamental plant materials. The English word horticulture is derived from the latin word hortus (garden) and colere (to cultivate). Today horticulture embraces the intensive culture of fruits, vegetables, ornamentals, herbs and other high-value, often perishable, specialty crops [94].

Also horticulture is defined by Webster's dictionary as "the science and art of growing fruits, vegetables, and flowers." It is the intensive commercial production of high-value and high-yielding plants. However, it also covers the growing of garden plants, landscaping ornaments, and the fusion of science and art. Horticulture contributes to the economy, provides good nutrition, beautifies and enhances the environment and is a valuable spiritual and psychological therapy [112]. As explained by these authors, areas of

horticulture include: fruit culture (Pomology), vegetable production, growing of cut flowers, potted plants, bedding plants, bulbs and floral design (Floriculture), nursery production of herbaceous and woody plants for landscape design and management (Environmental horticulture) and harvesting, handling and storage of horticultural crops (Postharvest physiology). Generally, horticultural crop provide essential food, minerals and vitamins that are critical to human nutrition. The production of horticultural crops can be characterized as an open and extremely complex system influenced by climate, soil, cropping system and interactions between these elements [92].

2. Horticultural Crops in Ethiopia

Ethiopia has a wide range of climatic conditions and soil types, making it possible to grow a variety of horticulture commodities for both domestic and international markets. Horticultural crops play a significant role in developing

country like Ethiopia, both in income and social spheres for improving income and nutrition status. Horticultural crops are abundant in vitamins, carbohydrates, and other nutrients, and they make up a sizable percentage of the daily meal mix in Ethiopia. Utilizing specific vegetable, root crops, and fruits can help rectify some nutritional deficiencies, such as vitamin A and C and iron.

In some areas of the country, root crops particularly potatoes and sweet potatoes are used as staple food for considerable portion of the population. Root crops in general and sweet potato in particular are drought resistant and serve as security food crops in drought prone areas. Furthermore, vegetables and root crops generate foreign currency earnings in the country [79]. In addition, horticultural crops help in maintaining ecological balance since horticultural crops species are so diverse. Further, it provides employment opportunities as their management being labour intensive. Therefore production of these commodities should be encouraged in labor abundant and capital scarce countries like Ethiopia.

Horticultural crop production in Ethiopia is scattered throughout the country on patches of land in peasant smallholder farm and the majority of the horticultural crops production comes from the peasant smallholder farms. Whereas Large scale production and processing of fruits and vegetables is carried out only by state organizations, predominantly by the Horticulture Development Corporation (HDC), which has been carrying out production and marketing development activities since 1980 [147]. This commercial production is concentrated in the eastern parts of the country, rift valley areas. Horticultural crops production in the peasant sector is under mixed crop-livestock farming system. Cultivation of land is made traditionally either by means of labour or draft animals. Horticultural crops production of individual peasant farm is mainly for self-sufficiency in food and income. Nevertheless, state organization and currently few private sectors get their land mechanized for commercial purposes [79].

Ethiopia has a variety of fruits, leafy vegetables, roots and tubers adaptable to specific locations and altitudes. The major producers of horticultural crops are small scale farmers, production being mainly rain fed and few under irrigation. Shallot, garlic, potatoes and chilies are mainly produced under rain fed conditions. Tomatoes, carrots, lettuce, beetroot, cabbage, spinach Swiss chard and other high-value perennial crops are usually restricted to areas where irrigation water is available [57]. Ethiopia has got an immense potential to develop intensive horticulture on small scale as well as on commercial scale. According to Semeret, [117], some of the favorable factors are as follows.

- 1) Proximity to profitable markets,
- 2) Suitability of the agro climate and abundant water resources for diverse irrigated crops,
- 3) Growth/increasing demand for horticultural crops, especially in urban areas,
- 4) Diversified agro-climatic conditions that facilitate the diversification of the crops,

- 5) The high productivity of horticultural crops as compared to cereals and
- 6) Encouraging conditions of export possibilities of these crops.

Despite its great potential and favorable environmental and socioeconomic benefits, horticulture is relatively underdeveloped. The range of current gains, in terms of area and output, is a small step up from what can be attained [117].

3. Status of Horticultural Crop Production in Ethiopia

Ethiopia's horticulture industry has grown dramatically, outpacing most other African countries that have an established operation long before Ethiopia start growing flowers.

This industry demonstrates in spades the enhanced and alluring environment that the investment regime offers to both foreign and domestic investors. [60]. Ethiopia is blessed with a favorable climate and vast land, water and labour resources which together make it an incredible investment hub. In essence, the sector is one of the top five foreign exchange earners to the nation. Land size is also expanding every year where new floriculture enterprises are opening (Ethiopian Trade and Investment). Ethiopia has a comparative advantage in a number of horticultural commodities due to its favorable climate, proximity to European and Middle Eastern markets and cheap labour [57].

The expansion of floriculture and other non-traditional, high-value agricultural exports in Ethiopia is a significant potential source of income growth. The agriculture development-led-industrialization strategy of the country envisages significant scope for achieving greater commercialization of smallholder agriculture. Ethiopia is considered to have the potential to achieve trade gains in these sub-sectors because of agro-climatic advantages [143].

3.1. Status of Fruits and Vegetables Sector

Over the past few decades, rapid growth in the international trade of high-value commodities has resulted in significant agricultural growth in many countries. Exports of traditional commodities like cereals, sugar, coffee, tea, and tobacco are increasingly being replaced by trade in high-value goods like fruits, vegetables, dairy products, poultry, and fish. Thus, during the 1980s, high-value exports increased by 8% annually while the total value of global trade in cereals, sugar, and tropical beverages decreased [138]. Fruits and vegetables are the largest component of high-value exports, with world-wide exports of US\$ 21 billion in 2001. Fruit and vegetable exports have grown 4.4 percent annually over the 1990s, and developing countries accounted for almost two-thirds of this growth [62]. Imports of fruits and vegetable products by the European Union exceed imports of all other categories of agricultural products [138]. Even though there is high production and market potential of fruit and vegetables in Ethiopia, it is much less developed than the production of food

grains in the country.

According to the information obtained from the Central Statistics Authority, the total area under fruits & vegetables is about 12,576 hectares in 2011. This shows that, of the total land area under cultivation in the country during the same year, the area under fruits and vegetables is less than one per cent (i.e. 0.11%), which is insignificant as compared to food crops [57].

This report also indicated that, the average vegetables and fruits produced by public and private commercial farms are 2,399,566 tons. This is estimated to be less than 2 percent of the total crop production.

Areas under production of fruit and vegetable crops from commercial private farms and private peasant holdings are indicated in the following table.

Table 1. Fruit & Vegetable Cultivation compared to other crops in Ethiopia for Private peasant Holdings (2010/11).

Crop Type	Area (ha)	%	Production (Quintals)	%	Productivity Qt/ha
Cereals	9,233,025.14	79.05	155,342,279.88	69.63	16.83
Oil seeds	780,915.89	6.69	6,436,143.98	2.89	8.24
Pulses	1,489,308.98	12.75	18,980,472.57	8.51	12.74
Cash Crops	159,287.98	12.75	39,226,177.5	17.58	246.26
Vegetables	7,309.16	1.36	1,403,234.19	0.63	192
Root crops	4,419.64	0.06	996,331.80	0.45	225.4
Fruit Crops	5,266.91	0.04	706,119.18	0.32	134.07
Total	11,679,533.17	0.05	223,090,759	-	-

Source: Statistical Abstract CSA 2011

Even though both state owned and private farms are operating in fruit and vegetable production, export and processing, the average yield of fruit and vegetable in the country is low as compared to other countries due to poor management.

Table 2. Productivity Status of Selected Fruits, Vegetables and Root Crops of Ethiopia as Compared to Other Countries.

S. No.	Crop type	Yield (qt/ha)		
		At peasant farm	At demonstration site	Other countries
1	Tomato	102	288	600-1000
2	Potato	62	294	600-700
3	Sweet potato	86	248	Above 700
4	Asparagus	-	400	1000
5	Banana	-	250	Up to 1000

Source: Ministry of Agriculture and Rural Development

3.2. Status of Floriculture Sector

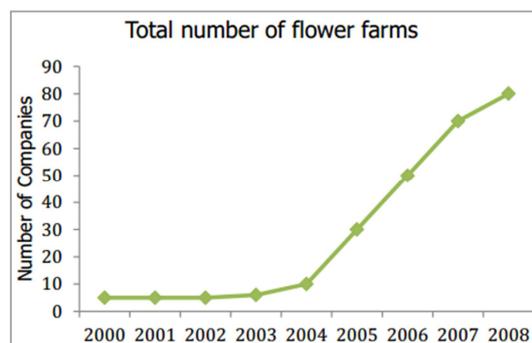
Floriculture is the “discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens and floristry” [76]. The Ethiopian Floriculture sector began in 1997 with just two flower farms, but has grown to more than 80 operational flower farms in the country until 2012 [84]. Ethiopia’s floriculture industry become one of the fastest growing export industries and surpassed most African nations historically engaged in floriculture [50].

Ethiopia is best known for the cultivation of numerous types of roses. In addition, Gypsophila, Hypericum, Limonium, Carnation, Statice, Chrysanthemum, Allium, Carhamus, Lilies, Freesia, and Geranium also cultivated in Ethiopia [70]. These flowers are produced in greenhouses around Addis Ababa and the Great Rift Valley for export to Holland, Germany, and the United Kingdom, as well as Russia, Japan, Scandinavia, Middle Eastern countries, and the United States to a lesser extent [50]. As stated by EHPEA, [70], the sector is one of the top five foreign exchange earners in Ethiopia, and will likely continue to bring in more income as usable land increases.

Today, the production and export of cut flowers has brought great economic development to Ethiopia and it is conceived to be an important means of diversifying the export regime, an additional source of export earnings and an employment

generation opportunity in the country [59]. According to the Ethiopian Horticulture Producers and Exporters Association [49], the number of horticultural products exporters had risen from 5 in 2002 to more than 100 in 2008. Foreign exchange earned also showed a substantial leap over from 1.5 million USD in 2002 to 125 million in 2008. According to [48], revenues are predicted to exceed \$200 million in 2012. Moreover, the sector created an employment opportunity for about 70,000 citizens; majority is held by women [127].

Floriculture quickly became a booming sector in Ethiopia and number of functioning flower farms between 1997 and 2008 is indicated by the figure below.



Source: Tamrat, 2011

Figure 1. Increment trends of flower farms in Ethiopia.

The cut flower industry in Ethiopia has emerged as one of the biggest sources of foreign exchange earnings in recent years, and the government predicted that in 2013 flower exports will overtake coffee exports at a value of one billion U.S. dollars [56]. As written by Tamrat, [127], in 2010, 80% of the \$250 million of horticultural exports were exports of cut-flowers.

Generally, floriculture has had a positive impact on employment in Ethiopia. About 70,000 new jobs have been generated by the sector, greatly contributed to enhancing livelihoods, ensuring food security, and reducing poverty.

The floriculture sector has created many skilled and unskilled jobs at the local level, reaching roughly 50 to 70 jobs per hectare [80]. The industry has taken steps to support workers by paying them well, and in 2010, the industry began paying wages that were equal to or above minimum wage [127].

3.3. Status of Aromatic, Medicinal, Spice and Biofuel Sector in Ethiopia

3.3.1. Status of Spice and Herb Sector in Ethiopia

Spice is referred to as a dried seed, flower, fruit, root, bark or vegetative substance primarily used for flavoring; coloring or preserving food. Whereas the term herbs refers to a type of plant whose leaves are used in cooking to give flavor to particular dishes, or which is used in making medicine. Also, herbs and spices can be defined as plants that have some medicinal, cooking, or other domestic use, such as dyes, insect repellents, or aroma [12]. Most of them are pleasingly fragrant or strongly aromatic. Their uses in Ethiopia can be dated back to the history of Queen of Sheba who visited king Solomon mentioned in the Holy Bible and remain as basic food items of the Ethiopian people. [52]. Spice, herbs and aromatic plants are now become a prime economic importance because of the continuous and increasing demand for their products by local and foreign markets [57].

The Spice and herbs subsector is one of the fastest growing subsectors in the world and in year 2012, the total amount of world production was estimated around 9.34 million of tones and over the past 16 years, the annual average growth was 5.8 %. India is the largest producer and consumer of spices and herbs and produced more than 4.1 million tons of spices or nearly 44% of the world production. China and Indonesia were the second and third largest producers with 1 million (10.7%) and 393,451 tons, respectively [64].

Due to the varied topography and climatic conditions, Ethiopia is homeland to different herbs and spices that grow at highlands and rift valley. Some of them includes: Korarima, long pepper, black cumin, Bishops weed, Ginger, Turmeric, Cardamom, Rosemary, Origano, Black pepper Sweet paprika pepper, Thyme, Cinnamon, fenugreek, sage, Black Cumin, Chilli peper, and coriander [125]. According to Fact sheet, [61], the average land covering by spices and herbs is approximately 222,700 ha and the production is 244,000 ton/annum. Cultivation of spices and herbs in Ethiopia has remained predominantly traditional over the centuries, being produced mainly by smallholder farmers

(more than 5 millions) operating on small plot land around homestead and in natural forests. In most cases, traders act as middlemen between farmers and extraction factories hiring trucks to collect the products from farm gate or intermediate markets.

Ethiopia has two plants for extracting spices and herbs, one of which is owned by the government and the other by a private company. The Ethiopian Spice Extraction Factory, a public spice extraction facility, has an annual processing capacity of 180 tons. The plant has the ability to process turmeric, capsicum oleoresin, and ginger from locally grown ginger root. Paprika accounts for more than 85% of its sales. Kassk Spices and Herbs Extraction P.Lc is the privately owned spice extraction facility in Ethiopia. This factory, which was established in Addis Abeba in 1997, has an annual processing capacity of 120 tons. All of the extracted spice is exported to Europe, primarily to Germany, Spain, and Italy, for use as food coloring and flavoring. [61]. As written by the Spice Sector Strategy Coordinating Committee, World production of spices is estimated at 2,000,000 Mts and the majority of this volume is consumed locally. Total volume of spices exported in the world is estimated at 600,000 Mts from this, Black and white pepper account for nearly one-third of the spices and of which 100,000 Mts is exported from Vietnam alone. The EU is a major importer of tropical spices with an annual volume of 220,000 Mts. When we see the African trend, most African spices are sold to the Middle East, India and China. Concerning Ethiopia, exports in 2009/10 is about 15,000 Mts. Ginger being a typical “cash crop” and is the largest exported spice. Black cumin and Turmeric comes second and third, respectively in contribution [125].

Table 3. Ethiopian Exports of Spice and Other Crops.

Ethiopian Agro-sector	Export (2008-2009)			
	Crops	Tons	USD 000	USD/ton
Coffee		134.000	\$376.000	\$2.806
Oilseeds & pulses		425.000	\$445.000	\$1.047
Sugar		27.000	\$15.549	\$576
Flowers		Na	\$130.697	Na
Fruits		37.161	\$11.912	\$321
Spice		15.000	\$11.100	\$740
Cotton		4.411	\$4.900	\$1.111
Other		40.000	\$18.000	\$450
Total		682.572	\$1,013.158	

Source: Spice Strategy Committee, 2010

3.3.2. Status of Aromatic, Medicinal and Biofuel Sector in Ethiopia

Ethiopia is remarkably rich in its biological, ecological and landscape diversity and is a home for many medicinal, aromatic and biofuel (MAPS) species. The potential of Ethiopia is estimated to be between 6,500 and 7,000 species, of which 10-12 % is considered to be endemic to Ethiopia; and around 1,000 species of MAPs have been identified in the Ethiopian flora; with still many more to be yet identified [52]. The greater concentration of MAPs is found in the South and South Western of Ethiopia following the

concentration of biological and cultural diversity [47]. As a study conducted on Bale mountain National Park in South east Ethiopia showed, the area is a biodiversity hot-spot with 337 identified species of which 24 are endemic [54, 81]. The study also revealed that, the identified species comprises of 283 species used as human medicine, 47 species used as livestock medicine and 76 species used by community healers, harvesters and traders for both human and livestock medicine.

The major biofuel plant that bear biodiesel in Ethiopia are castor and Physic nut that are found widely distributed in most part of the country in the wild as well as around homestead as fence and hedge in the farm lands. Currently castor and physic nut are considered as potentially important biofuel plants in Ethiopia. Ethiopia is ranked fourth in castor seed oil production following India, China and Brazil. [122]. Both castor and Physic nut have low water requirements; and thus can grow well in degraded and low fertility soils. This makes them good sources of income in most dried and degraded part of Ethiopia [63]. Due to this, the area and production has been increasing dramatically from year to year.

In Ethiopia, even if there are a large number aromatic, medicinal and biofuel plant species found in different natural ecosystems of the forests, grasslands, woodlands, wetlands, in field margins and garden fences, as weeds and in many other microhabitats, it is hardly possible to get the exact area of coverage due to lack of comprehensive assessment studies..

Except in few cases where MABPs are cultivated by Damascene Essential Oils PIC, tabor PLC and Ethio-Agri Ceft PLC, the majority of the essential oils processors are getting the raw materials from the existing plantation by collecting of raw materials from the farmers. Hence, it needs a comprehensive study on the available resource estimation.

Based on the available data from some parts of Oromia, Amahara and SNNPRS regions, the area covered by aromatic and medicinal plants is estimated to be 134,541.97 hectare. This is indicated by the table below.

Table 4. Production Area of Some Aromatic and Medicinal Plants.

Product	Total (ha)
Rosemary	312.73
Rue	340.67
Basil	6,104.88
Ariti	278.18
Thyme	119.76
Koseret	306.25
Globulus	127,000.00
Others (Citrodora, palmarosa, citronella, sweet marjoram, mints, geranium, stevia, hibiscus, chamomile, damask rose),	79.51
Total	134,541.98

Source: MOA, 2014

As Primary data collected by MOA from Oromia and SNNPRS regions in 2014 indicated, there is an increasing trend of some aromatic and medicinal plants (Rue, Basil, Rosemary, Koseret, Thyme and Ariti) cultivation.

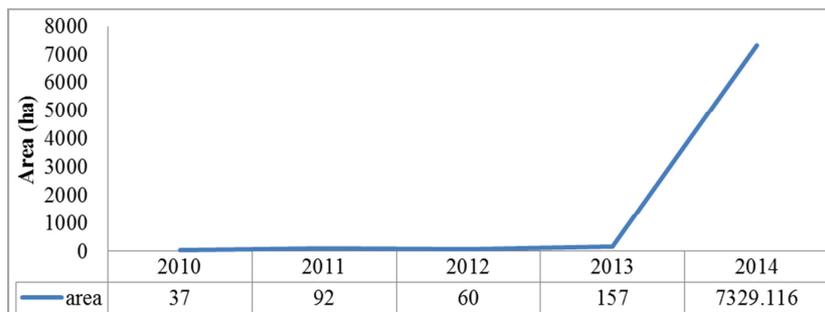


Figure 2. Cultivation trends of some aromatic and medicinal plants in Oromiya and SNNP regions of Ethiopia from 2010-2014.

Even though there is no exact production resource estimate and the sector is not at a desired level of development, there is an increasing trend of production and involvement of private

producers in the MABPs sector in Ethiopia. Currently, some private companies started production and essential oil extraction from aromatic and medicinal plant in Ethiopia (Table 5).

Table 5. Existing Ethiopian Essential Oil Processing Companies and Their Annual Production Capacities.

Name of the companies	Target Plants	Annual Processing capacity (kg in fresh form)	Annual essential oil production capacity (kg)
Damascene Essential Oils Plc	Globules, rosemary, rose scented geranium, lavender, mints, citrus	92,550.00	696
Abyssinia Essential Oils Plc	Peppermint, spearmint, lemon verbena, rose scented geranium, eucalyptus, palmarosa, citronella, lemongrass and chamomile	65,700.00	500
Cumin PLc	Globules, rosemary, lemongrass, palmarosa, citrus	41,500	600
Bale Forest Enterprise	Globules	-	3120
Arit Herbal	Lemongrass, mints, rose scented geranium	5000	1451
Tabor Essential oils PLC	Globules	-	1080
Ethio Agri Ceft	Citronella, palmarosa, mints, lemongrass, sweet marjoram	-	415
Total		204,750.00	7,862.00

Source: Primary data collected from the selected companies in 2014

Generally, the prospects of MABPs development in Ethiopia is promising due to different favorable factors such as: increasing demand for these plants worldwide, availability of suitable agro-ecologies for growing of MABPs, Existence of experiences in essential oil processing in the country, presence of different local companies that develop distillation machines, and government policy that encourages farmers and investors. Therefore the concerned bodies should collaborate in strengthening the research and development activities of aromatic, medicinal and biofuel plants.

4. Efforts Made So Far in Horticulture Sector

Ethiopian economy has long been dependent on Agriculture. More than 85% of the citizens depend on it. Around 90% of the foreign income is generated from agricultural products (MOA, 2004). According to JUCAVM, [89], one fifth is the share of horticulture from agricultural income. This shows that horticulture has a great contribution to the national economy. Basing the importance of the sector, significant amount of developmental and research efforts have been made to enhance the quantity and quality of horticultural products.

Concerning MABPs, the onset of research and commercial production of essential oil for local use and export market is started in the early 1950's by a foreigner owning a pilot essential oils distillation plant at Wondo genet [17]. Researches on biodiesel bearing plants such as castor started around 1970's at Werer and Hawassa. Research and development works on *Jatropha* is a recent history. Currently, Wondo genet Agricultural Research Center, Addis Ababa University, Ethiopian Health and Nutrition Research Institute and Ethiopian Institute of Biodiversity are the major governmental organizations involved in the research and development activities of MABPs in Ethiopia. Majority of the research and development work is coordinated at national case team level and handled by Wondo genet agricultural research center under crop research process of Ethiopian Institute of Agricultural Research. Below some of the researches and developmental activities on MABPs and other horticultural crops are presented.

4.1. Research Efforts Made on Horticultural Crops

Researches on agronomy and breeding, Plant protection, Biotechnology and postharvest and Socio-economics and Research Extension have been conducted on different horticultural crops by researchers from federal and regional research institutes, higher learning institutes, governmental and non-governmental organizations.

4.1.1. Agronomy and Breeding Researches on Horticultural Crops

Under agronomy and breeding there are different researches conducted in Ethiopia. Some of these are:-

Evaluation of garlic (*Allium sativum* L.) varieties [9],

Variety and fertilizer effect on growth yield of Onion (*Allium cepa* L.) and Hot Pepper (*Capsicum annum.*) [115, 135] Performance evaluation for agronomic and chemical traits under different agro ecologies of Ethiopia of Rose Scented Geranium (*Pelargonium graveolense* Herit), lemon grass (*Cymbopogon citratus*), Lemon Verbena (*Aloysia triphylla* L.) *Aloe Vera*, Oregano (*Origanum vulgare* L.), American and German Chamomiles, Stevia (*Stevia rebaudiana* Bertoni) and Coriander (*Coriandrum sativum* L.) [18, 21, 23, 26, 29, 31-33, 137]. Variability of genotypes for agronomic and chemical traits for Rosemary (*Rosemarinus officinalis*), Coriander Pyrethrm, Lemongrass, Spearmint (*Mentha spicata* L.) and ginger [15, 24, 25, 27, 69, 144]. Identification of suitable orange-fleshed sweet potato clones for production in wello zone [148], Oil content, fruit, seed, Fatty acid and biodiesel characteristics of Ethiopian *Jatropha* (*Jatropha curacas* L.) provenances [34, 35], Genetic divergence of Ethiopian Coriander accessions [20], Phenotypic Variability in Ethiopian Castor (*Ricinus communis* L.) Accessions [75], Correlation studies and path coefficient analysis of Ethiopian Coriander accessions by Beemnet et al [28].

Evaluation of Agronomic and chemical characteristics at different spacing and harvesting age for pepper mint (*Mentha piperiata*), Spear mint (*Mentha spicata* L.), rose-scented geranium (*Pelargonium graveolens* L. Herit), Japanis mint (*Mentha arvensis*), Artemisia (*Artemisia annua* L.), Palmarosa (*Symbopogon martini*) and Rosemary (*Rosemarinus officinalis* L.) [22, 82, 120, 121, 150, 151, 153]. Effect of population density on growth, yield and yield components of Castor (*Ricinus communis* L.) and cassava (*Manhot esculenta* Cranz) [41, 74].

Effect of lateral depth placement and number of emmitter per plant on yield and water use efficiency of Drip irrigated pepper [109], and effect of cutting position and rooting hormone on propagation ability of Stevia (*Stevia rebaudiana* Bortoni), [16]. Participatory development of quality seedling in Lemon verbena (*Aloysia tryphylla* L.) and Stevia (*Stevia rebaudiana Bertoni*); [24, 30], Effect of harvesting *Jatropha curcas* L. seeds at different fruit maturity levels on germination, oil content and seed weight [110], Determination of optimum transplanting time for *Salvia officinalis* L. [136], Effect of mulch type, mulching percentage and sucker management on growth and yield of pineapple (*Ananas comosus* L. Merrill) [43], effect of paricial root drying on the stomata of Rosa hybrid L. cv Prophyta Grown under high relative air humidity [96], Evaluation of propagation ability of Lavender (*Lavandula angostifolia* L.) and Sage (*Salvia officinalis* L.) using different cutting size and cutting position [154, 155], Effect of node number, part used and season of propagation on nursery establishment of Lemon Verbena and Effect of number of nodes on growth of vanilla cuttings [19, 78].

Irrigation Scheduling for onion seed production with and without fertilizer application [2], Spearmint Response to Deficit Irrigation [51], Response of pineapple varieties to organic and inorganic fertilizer rates by Daniel and Gobeze,

[40], Effect of male bud removal and bagging of the bunch on maturity time, yield and quality of Banana (*Musa Spp.*) [3], Yield and quality of statice (*Limonium sinuatum*) as affected by cultivar and planting density [39], Response of off-season Grown Potato (*Solanum tuberosum* L.) varieties to fertilizer rate and harvesting dates [42], Influence of plant density and nitrogen fertilization on yield and yield components of shallot (*Allium cepa* var *ascalonicum* Backer) [73], Growth stage effect on essential oil yield of Artemisia [152] and Effect of stage of maturity at harvest on quality of different Ginger cultivars [77].

4.1.2. Plant Protection Researches on Horticultural Crops

Some of plant protection researches conducted on horticultural crops in Ethiopia includes:-

Biting ant (*Tetramorium aculeatum*) and weaver ant (*Oecophylla longinoda*) problem at coffee plantation [129], Screening of Botanical Extracts for the Control of Spearmint, lemongrass, Japanese mint leaf rust and Artemisia rehan Aphid in Greenhouse and Field Conditions [98-101], Commercialization of Carmine Cochineal in Tigray [133], White mango scale assessment [104], Biology and economic importance of the sweet potato butterfly in Ethiopia [68]. Insecticide induced Oniun Thrip (*Thysanoptera: Thripidae*) population increment and its Effect on yield of shallot and Garlic [128].

Evaluation of Agrobacterium radiobacter strain K84 as potential Biocontrol agent against Crown gall (*Agrobacterium tumefaciens*) in Commercial flower farms under Greenhouse [55], Exploring allelopathic cover crop for ecological management of parthenium hysterophorus L. in Ethiopia [108], Occurrence and distribution of new species of Tomato fruit worm in Central rift valley of Ethiopia [71], Evaluation of contact fungicide spray regimes for control of late blight (*Phytophthora infestans*) in southern Ethiopia using potato cultivars with different levels of host resistance [119], Status of coffee wilt diseases (*Gibberella xylarioides*) in coffee development plantation Enterprise [130].

Evaluation of some botanicals to control Potato tuber Moth at bako [7], Evaluation of *Milletia ferruginea* for the control of the sweet potato butter fly in Ethiopia [67]. Integrated pest management of the sweet potato weevil [97], Adaptation of Citronella grass oil technologies as an alleternative method for cockroaches repellent [102] and Weed control method using *Artemisia annua* [124].

4.1.3. Biotechnology and Post-Harvest Researches on Horticultural Crops

On different crops conventional research approaches have tried to address the major research and development problems in Ethiopia. However, these approaches could not achieve the desired level of improvement unless they are supported by modern biotechnological tools. In recent years, biotechnology has been considered as an essential tool for increasing crop productivity and Ethiopia has started different activities of biotechnology in agriculture sector. Currently, Ethiopian Institute of Agricultural Research (EIAR), has developed a 20 years strategic agricultural

biotechnology plan and has recently established the Ethiopian biotechnology research center with the objectives of improving quality and productivity of food and industrial crops. Post-harvest loss of horticultural crops is also high and different efforts should be made to reduce post-harvest loss. Even if the biotechnology sector is infant in Ethiopia, and full solution is no obtained for post-harvest loss of horticultural crops, different research efforts were made in horticulture sector. Some of them includes:-

Solar Drying of Banana (*Musa spp.*) using solar cabinete drying [107], study on Beta Carotene Content and Storage Root quality of Orange flesh sweet potato (*Ipomoea batatas* (L.) Lam) clones consumed for daily Beta-carotene Requirement [132], Effect of off-shoot size and Indol-3-Butyric acid on Rooting of date Palm (*Phoenix dactylifera* L.) [134], In vitro micro-propagation of Banana genotypes ([13], in vitro multiplication of Pineapple (*Ananas comosus* (L) and Cardamom (*Elettaria cardamomum*) [149], In Vitro Antimicrobial and Antioxidant Activities of Anthrone and Chromone from the Latex of Aloe harlana Reynolds [72], Post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, [103] and Essential Oil Content Response of Lemongrass, Palmarosa and Citronella to Post Harvest Wilting and Chopping [123].

4.1.4. Socio-Economics and Extension Research on Horticultural Crops

Socio-economic and extension researches conducted on horticultural crops includes:-

Usage gap in components and rates of potato technology package among farmer in Welmera woreda [36], Retail marketing of horticultural products for economic development [85], Economic benefits of small-scale irrigation farming from farmers perspectives [1], Women farmers in practice: opportunities and challenges in accessing potato technology in welmera [37], Status of potato export from Ethiopia [10], cultural domina and potential contribution of wilde edible fruits for enhancing food and nutritional security in western Amhara region [65], Enhancing Onion Production and Productivity through Introduction of Seed Production Techniques in Central Zone of Tigray Region [145], Experience, challenge and future prospects in creating sustainable community-based informal potato seed scheme and associated technology in parts of western Amhara region [131], Trends of Avocado (*Persea Americana* M.) production and its constraints in Mana woreda, Jimma [140], Nutrient status of Nura-Era Citrus farm in the central rift valley of Ethiopia [45], Constraints and Opportunities of traditional horticultural crops production system in the lake tana [66], Prospects of cool season vegetables seed production in Ethiopia [116]. Analysis of Seed Potato Systems in Ethiopia [4], The Major problems and prospects of Tomato marketing [95], Cost-Benefit Analysis of Spear Mint Cultivation for Herbal Production [83], Profitability Study of Hibiscus sabdariffa L. Production around Wendo Genet District [126] and Production characteristics and Field management Practices of

Household Vegetables Crops Production System in the central Rift-valley of Ethiopia [46].

4.2. Development Efforts Made in Horticulture Sector

As it is known, Ethiopia has huge potential and possess favorable environmental conditions, cheap labor, rich water resource and government policy that creates good opportunities for the production of a wide range of horticultural crops such as fruit and vegetable, root and tuber crops, herbs and spices and flowers and ornamentals. The horticulture sector can serve as source of nutritious food, income generation and can create wide job opportunities for citizens. In different countries such as Kenya and India, horticulture sector has brought significant economic development.

The government of Ethiopia has considered the importance of horticulture sector in the country's economy and has given full support in policies and implementation. It has recognized the production, processing and export of horticultural crops where a number of important steps have been taken to improve the investment environment in linearization of foreign exchange, duty free importation, income tax holiday, customs ware-house facility and export guarantee scheme [13].

By understanding the importance and potential of the sector, various stakeholders are involved in the production and promotion, to a limited extent, in processing and export of horticultural crops in different part of the country. This includes farmers and farmer organizations, private investors, agro-processors, input suppliers, financial institutions, development partners, research institutes and extension service providers. Institutions like Ministry of Agriculture (MoA), Research institutes and higher learning institutes, Ethiopian Horticulture Development Agency (EHDA), Ethiopian Horticultural Crops Production and Export Association (EHPEA), Ethiopian Horticultural Science Society (EHSS) and non-governmental organization are widely involved in technical and resource support to insure fast and sustainable development of horticulture sector, mainly on export-oriented commodities [91]. Also, the Ethiopian Horticulture Development Corporation has been carrying out production and marketing activities of horticultural crops since its establishment in 1980 [5]. The Ethiopian Fruit and Vegetables Marketing Enterprise (ETFRUIT) established in April 1980 under the Horticulture Development Corporation is also dealing with domestic and export trade of fresh fruits, vegetables, flowers and processed horticultural products.

Even though the wide involvement of these bodies and availability of favorable conditions and high demand for food, export market and raw material for local industries of horticultural products in Ethiopia, the desired level of development is not achieved. The total area under horticultural crops cultivation added up to only 0.8 million ha which accounts for around 5% of the total land under cultivation [91, 142]. Due to absence of proper storage and marketing facilities, and seasonal surplus, farmers are forced to sell their products at thrown-away prices and at the earliest opportunity after harvest [139]. This also forces producers to

sell their horticultural crops at very low prices for their customers. Furthermore, the lack of ability in business planning, lack of marketing knowledge and the perishability of the horticultural products contribute to their weak influential position in the supply chain [139]. All of these contributed to insignificant development of the sector.

5. Challenges and Opportunities

5.1. Challenges

Even though considerable contribution of horticultural products to country economy, nutritional security and job opportunity, its production is challenged with different factors includes diseases and insect pests, unavailability of sufficient improved varieties, post-harvest loss, Climate change and marketing.

5.1.1. Diseases and Insect Pests Challenge

Horticultural crops produced in Ethiopia experiences different types of diseases and insect pests. Since the beginning of agricultural research in the country, a number of researches were made by different researchers in order to investigate and identify a number of diseases and insect pests associated with horticultural crops production. Some of the major diseases and insects pests reported on horticultural crops in Ethiopia includes: - *Cylas puncticollis*, *Acraea acerata*, potato hornworm, *Agrius convolvuli*, tortoise beetles, *Aspidomorpha* spp., *Lacoptera* spp. virus transmitters *Aphis gossypii* and *Bemisia tabaci* in Sweet potato [53]; *Helicoverpa armigera*, *phthorimaea operculella*, *Tuta absoluta* on Tomato [71], *Tetramorium aculeatum*, *Oecophylla longinoda*, Wlt disease in coffee [130], late blight (*Phytophthora infestance*), bacterial wilt, early blight Tubers moth in potato are the major ones.

As reported by [118], diseases such as Bacterial Canker, Bacterial Wilt, *Fusarium* Wilt, Early Blight, Late Blight, Powdery Mildew, Root-knot Nematodes and Yellow Leaf Curl Virus and insect pests such as Leaf miners, White flies, Tomato Bugs, Thrips, Fruitworms (American ball worm) and Spider Mites are the major diseases and insect pests that affects vegetables especially Tomato. Late blight, bacterial wilt and viral are most important potato diseases in Ethiopia [11]. The occurrence of white mango scale in western Ethiopia causes yield loss of 7-8qt per tree [105] and the occurrence of new tomato pests identified as *Tuta absoluta* in 2013 showed 100% infestation in the occurring field [71]. This shows that productivity of horticultural crops challenged by both the existing and the newly occurring pests. Generally, insect pests and diseases causes significant yield loss in horticultural crops [14, 87, 93, 105].

5.1.2. Unavailability of Sufficient Improved Varieties

Variety development is an essential tool for obtaining improved varieties that are resistant to diseases, insect pests, drought and high yielder. In horticultural crops, the numbers of released varieties are very small compared to cereals. This is one of the challenges for horticulture sector development.

List of released varieties of horticultural crops are indicated in the table below.

Table 6. Released Varieties of Horticultural Crops Until 2013.

No.	Crops	Number of released Varieties
	Tubers, Roots and Vegetable Crops	172
1	Irish Potato	32
2	Sweet potato	25
3	Taro	3
4	Cassava	2
5	Enset	6
6	Yam	3
7	Tomato	26
8	Garlic	4
9	Onion	14
10	Shallot	4
11	Chili pepper	4
12	Sweet/hot pepper	9
13	Cabbage	8
14	Water melon	4
15	Yello Courgette	1
16	Green Courgette	1
17	Broccoli	2
18	Cauliflower	1
19	Carrot	1
20	Red beet	1
21	Lettuce	10
22	Snap bean	1
23	Snap pea	2
24	Snow pea	2
25	Okra	1
26	Sweet corn	1
27	Fine bush bean	4
	Condiments and Medicinal Plants	27
1	Coriander	2
2	Black Pepper	2
3	Ginger	2
4	Turmeric	1
5	Cardamom	1
6	Sweet annie	1
7	Citronella grass	1
8	Pyrethrum	2
9	Black cumin	3
10	Lemmon grass	1
11	Pepper mint	1
12	Spear mint	1
13	Japanis mint	1
14	African marigold	3
15	Geranium	1
16	Chamomile	2
17	Lemon verbenia	1
18	Stevia	1
	Fruit Crops	36
1	Banana	12
2	Mango	4
3	Pineapple	1
4	Wine Grape	9
5	Avocado	6
6	ZIZIPHUS (kurkura)	2
7	Fig	2
	Stimulant Crops	36
1	Coffee	36
	Total	271

Source: MOA, Plant Variety Release, Protection and Seed Quality Control Directorate, 2013

5.1.3. Post-Harvest Loss

Most of horticultural crops are perishable and sensitive to post-harvest handling. According to Saxena et al., [113]; Alazar, [8], and Olayemi et al., [111], 50% of horticultural crops are lost due to post-harvest loss. Post-harvest losses and quality deterioration of horticultural crops are mostly caused by pests, microbial infection, natural ripening processes and environmental conditions such as heat, drought and improper post-harvest handling [88, 111]. Post-harvest loss is occurred due to post-harvest activities such as harvesting, handling, storing, processing, packaging, transporting and marketing [106]. The estimated post-harvest losses of fruits and vegetables range from 20% to 40% [141]. Even though only limited studies were conducted in Ethiopia, Post-harvest loss and quality deterioration of horticultural crops are estimated to be 25–40% [146].

As experiment conducted by [114] in Wollo, Ethiopia indicated, post-harvest-loss of banana, mango, papaya, carrot, onion, cabbage and tomato at different stages of handling (farmers level, transportation and storage) is 7.2%, 7.84%, 6.3%, 5.8%, 7.8%, 8.1%, 11.3%, 10.9%, respectively. According to a research conducted by Mohammed and [103] in Dire Dawa region, the highest post-harvest loss at the specified area was recorded for tomato (45.32%) followed by mango (43.53%), whereas the least post-harvest loss was recorded for coffee (15.75%). They also stated that, the severe post-harvest loss and quality deterioration of horticultural crops mainly occurred during harvesting followed by marketing, transporting and storage. According to them, post-harvest loss ranging from 20% to 50% was recorded in between marketing and consumption. Poor quality equipment and materials usage caused tremendous mechanical, physiological and pathological damages on horticultural crops.

The horticultural crops are inherently liable to deteriorate under different climatic and other circumstances due to their high moisture content [90]. Moreover, as they are biologically active and carry out transpiration, respiration, ripening and other biochemical activities, they tend to loss and deteriorate through time. This makes the post-harvest losses to occur in the field, packing areas, in storage, during transportation and marketing. Severe losses occur because of environmental conditions, poor facilities, lack of know-how, poor management, weak marketing processes or simply due to carelessness of farmers. Proper storage conditions, temperature and humidity are needed to lengthen the storage life and maintain quality of horticultural crops [90].

In general, the mishandling during harvesting, packaging, transportation and storage and unfavorable climatic condition and contamination are causing mechanical, pathological and physiological damage on horticultural crops. Therefore, support and research to improve post-harvest handling and reduce the post-harvest loss from concerned body is needed in order to get the required benefit from the sector.

5.1.4. Climate Change

Global warming and climate change is the greatest concern

of mankind in 21st century and climate change is already taking place now in Ethiopia. Although climate change is the global issue and affects all people of the world, its effect would be more pronounced particularly on poor people of the developing country, because of their weak adaptive capacities. Addressing problems of climate change is more challenging in horticulture crops compared to annual food crops. The issues of climate change and solution to the problems arising out of it requires thorough analysis, advance planning and improved management. The crop productivity is subjected to number of stresses and potential yields are seldom achieved with stress. Climate change is predicted to cause an increase in average air temperature increases in atmospheric CO₂ concentration, and significant changes in rainfall pattern [86].

The established commercial varieties of horticultural crops will perform poorly in an unpredictable manner due to aberration of climate. Commercial production of horticultural plants particularly grown under open field conditions will be severely affected. Due to high temperature physiological disorder of horticultural crops will be more pronounced. Air pollution also significantly decreased the yield of several horticultural crops and increases the intensity of certain physiological disorder like black tip of mango. In addition climate change affects horticultural crops production:- by changing suitability and adaptability of current cultivars; by changing the distribution of existing disease, pests, weeds and an increased threat of incursions; by increasing incidence of physiological disorders; and by increasing risk of spread and proliferation of soil born diseases as a result of more intense rainfall events coupled with warmer temperatures [6].

It can be understood that, climate change poses serious challenges to human and places unprecedented pressure on the horticulture industry. Therefore, in order to protect and sustain horticultural productivity against the climate change scenario, there has to be packages to manage stresses caused by climate change.

5.1.5. Marketing Challenges

The major marketing constraints in horticultural crops include high postharvest losses, poor marketing and value chain development, and weak linkages and integration among value chain actors. Postharvest losses of horticultural crops especially vegetables are high primarily because of poor postharvest handling, poor storage infrastructure and transportation facilities as well as poor market information and support systems in rural areas [38]. As the finding by the same author shows, smallholders in rural areas are often poorly linked to markets and do not adequately access functional market information. Often middlemen do make much higher marketing margins than the producers. This limits the motivation of farmers to expand production. Although there are many public, private, NGOs and development partners working across the entire value chain, including

seed systems, there are weak linkages and integration among the chain actors. As a result, there are no consistent and complementary synergistic efforts to develop the horticultural sector of Ethiopia [44]. Inadequate cooling chain and cargo handling, increase in the level of production of competing countries and their proximity to European market, increasing cargo freight cost for horticulture export products, poor quality of the packing material, Freight risk, Weather risk (unexpected rainfall) and price subsidy conditions are also challenges for export markets of horticultural crops in Ethiopia [143].

5.2. Opportunities

Ethiopia has a comparative advantage in a number of horticultural commodities due to different favorable conditions. Some of the opportunities for horticulture sector listed by Ethiopian Investment Agency, [58] are:-

- 1) *Favorable climate conditions*: Ethiopia has diverse climate and altitude conditions which are conducive to various agricultural activities. There are several lakes and perennial rivers that have great potentials for irrigated agriculture. Ethiopia has high groundwater potential of good quality and it is frequently used to supply homes and farmsteads. Most of the soil types in fruits and vegetables producing regions of the country range from light clay to loam and are well suited for horticultural production. Therefore, the potential to develop horticultural crops such as fruits, vegetables, root crops and cut flowers. is great in Ethiopia due to favorable weather, altitude, adequate water and availability of suitable soils,.
- 2) *Suitable government policy*: The Government emphasized the priority given to agricultural development through its policy document entitled Agricultural Development Led Industrialization (ADLI). This policy focuses on the development of agriculture both as a source of production for direct consumption and of raw materials for industrial processing. Thus production and processing of horticultural crops, vegetables and fruits have been placed by the Government in the list of high priority areas and various incentives have been provided for investors investing in this sub-sector.
- 3) *Cheap labor*: Horticultural farming is high labor-intensive and Ethiopia has abundant supply of unskilled labor at lower salary per day.
- 4) *Infrastructure*: access to road, electricity & airport.
- 5) *Investment incentives*, Investment guarantees, proximity to European and Middle Eastern markets, large domestic markets for the products and increased demand for horticultural products worldwide.

6. Recommended Research and Development Directions

Even though, there are a number of research and

development efforts made in horticulture sector, there are still many issues that should be addressed in the future in order to attain a promising growth in terms of production, processing and export of horticultural produces.

6.1. Future Research Directions

Research direction should focus on:-

- 1) Post-harvest handling
- 2) Variety improvement (in terms of productivity, quality, resistance to abiotic and biotic factors)
- 3) Investigate the genetic potential of locally available horticultural crops
- 4) Pest management researches other than pesticide application
- 5) Product formulations and quality analysis research especially for industrial crops
- 6) Chemotaxonomic characterization of aromatic, medicinal and spices crops
- 7) Physiochemical characteristics and nutritional value analysis of edible horticultural crops such as fruits
- 8) Characterization at molecular level
- 9) Development of High Yielding Varieties specially for aromatic, spice and medicinal plants

6.2. Future Development Directions

- 1) Upgrading the knowledge, skill and experience of key actors like producers, associations, supervisors and subject matter specialists to increase production and productivity
- 2) Improving marketing of horticultural products by arrangements of institutional, legal, educational and developing market facilities and by establishing and enforcing a legal system in the marketing management, defining quality parameters, standards, grades and putting in place regulatory frameworks that enforce pricing based on quality.
- 3) Upgrading the existing infrastructure
- 4) Improving packaging and handling materials of products
- 5) Encourage private companies and farmers union to involve in seed and planting material preparation.
- 6) Strengthening value addition of products
- 7) Strengthening collaboration with international organizations in experience and material exchange
- 8) Transforming the sector from stallholders to agro processing industry
- 9) Appropriate development strategic interventions for aromatic, spice and medicinal plant sector
- 10) Strengthening the participation of private commercial investors in aromatic, spice and medicinal plant production
- 11) Attention should be given to the development of horticultural crops such as aromatic, medicinal and spices since these crops will have great economic contribution for the country.

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