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Review of Options for Horticultural Research and Development: A Case of Zambia

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Abstract

This review focused on horticultural development as a key economic subsector sector. Although practiced by more than 60 % of the population, agriculture and horticulture largely remain small scale in Zambia. Partly due to the relatively high income generation potential of commodities, the horticultural sector holds immense potential to make significant contribution to the poverty reduction. It has been estimated that since 1960, worldwide demand for fresh produce has more than doubled compared to a 20 % increase in demand for cereals. However, in Africa per capita supply of fresh produce has been declining since 1970. The key challenge therefore remains how to expand horticultural production in a manner that is sustainable and beneficial to all players throughout the food system. A vision of '*An efficient and dynamic horticulture sector responsive to changing needs of society*' is advanced. This article reviews the emergence of horticulture sub sector contributing significantly to the agricultural GDP and poverty reduction, outlines its limitations and explores options for improving the sector. While the traditional biotic and abiotic approaches are the primary focus (improved research and development to drive production, and reduce postharvest losses), emerging challenges such as globalization, and climate change are considered. The findings suggest poor production technologies, limited crop varietal choices, high postharvest loses and inadequate marketing infrastructure and low smallholder participation horticultural markets contributing to overall poor sector performance. To achieve sustained and environmentally safe horticultural performance there is need to establish effective linkages, networks and partnerships among different players throughout the horticulture value and supply chains, both from private and public sectors.

Keywords: consumption, fruits, food security, flowers, marketing, vegetables

1. Introduction

This paper is grounded on a generic vision of '*An efficient and dynamic horticulture sector responsive to changing needs of society*'. Additionally it is postulated that the triple agenda of agriculture- promoting food security, poverty reduction and environmental stewardship can be achieved more efficiently by expanded horticultural production. Agricultural statistical digests (CSO, 2014; Chapoto and Chisanga, 2016; Mulenga *et al.,* 2020) show Zambia's agriculture sector is the mainstay of the rural economy with about 49 % of the Zambian population depending on agriculture, primarily through smallholder production for their livelihoods. In 2015 the sector contributed 8.5 % to the GDP and approximately 9.6 % of national export earnings (CSO, 2015; World Bank, 2016). Horticultural production has been part of the general agro pastoral activities of most societies including Zambia. In a time of increasingly serious environmental constraints and inequitable wealth distribution, progress towards nurturing and nourishing the world's' poor requires paying serious attention to the needs and potential of smallholder farmers in developing countries (Serageldin, 2004; Simon *et al*., 2020). The last couple of years have seen increasing poverty levels, recently estimated at about 65 % in the urban areas and much higher in the rural areas of Zambia (Mulenga *et al*., 2020; Hichaambwa *et al.,* 2015; Chileshe, 2013). A 2020 UNICEF report noted that there were an estimated 15 million cases of acute malnutrition in Western and Central Africa in 2020 (Balde and Sidhu, 2020). The horticulture industry can contribute to reduced malnutrition by among other ways providing vitamin and mineral rich foods, and reduced poverty through high income generation. Additionally, a variety of high value non- food products ranging from aesthetics (flowers) to environmental protection are also produced.

Zambian agriculture is predominantly maize based and this sector receives on average 60 % of annual government agriculture expenditure through input and output subsidies (Hichaambwa et al., 2015; Mulenga *et al*., 2020). Of concern is that despite substantial growth in agricultural GDP, since the year 2000, rural poverty levels have remained unchanged at around 80 %. There is therefore, need to identify agricultural subsectors or commodities that can assure producers of higher incomes within the existing resource base. One key characteristic of smallholder farming in Zambia is that although there are in excess of 1.6 million farm- families, over 70 % of these growers cultivate less than 2 hectares of land (Hichaambwa *et al.*, 2015). Additionally, only about 21 % of the smallholder households participate in horticultural markets and a significant proportion of these households are female headed. So the choice of enterprises to be used in ensuring that increased agricultural GDP results in poverty reduction have to be capable of generating high incomes within this resource envelope. Hichaambwa *et al* (2015) showed that increased horticultural production and participation in horticultural markets can increase incomes by over 150 % compared to 22 % in maize production. The same authors showed that low smallholder participation in horticultural markets is due to a variety of reasons including, lack of cold chain facilities (accentuating postharvest losses), long distances to markets, and lack of developed wholesale market infrastructure that exposes sellers to unscrupulous middlemen masquerading as brokers who have exclusive rights to fixing prices at exorbitant fees.

Demand for horticultural products has been observed to grow rapidly with urbanization and increased incomes. Between the years 2000 and 2010 the population of Zambia grew at the rate of about at about 2.8 % but in large cities the growth was much higher for example Lusaka has been growing at 4.9 % (Chileshe, 2013. In Africa, studies have shown that per capita supply of fresh produce has been declining annually by 0.3 % since 1970 (Hichaambwa and Tschirley, 2006; USAID, 2005, Hampwaye et al., 2016). Since 2000 there has been rapid expansion of huge retail outlets commonly called malls. Additionally, there has been an increase in the ratio of horticultural imports to exports due to South African mall operators importing horticultural products from their home country (Chapoto and Chisanga, 2016). The key challenge therefore remains how to increase horticultural production and productivity to utilize the sector's capacity to contribute to food security, nutrition, poverty alleviation and environmental protection.

1.1 Rationale of Review

Just as with other disciplines, reviews in horticulture are a regular feature - Horticultural Reviews annual series by Jules Janick are an example. However, most of these reviews have focused on situations prevailing in developed countries and rarely deal with issues that bedevil developing countries. Additionally, most of these reviews have tended to deal with narrow physiological or production related problems and rarely have a sector- wide approach. The resource endowment, production systems and product mix in developed countries are different from developing countries and therefore such works have low utility for developing countries.

This review on the other hand focused on developing country horticulture- Zambia- the findings can thus be applied to countries at a similar stage of development. The review is divided into two parts: the first one assembled and reviewed critical work on the state of knowledge regarding horticultural development in Zambia. The second part used this information to develop optional strategies for enhancing horticultural development. It is anticipated that the paper will contribute to discussions on how to develop a more robust horticulture sector that contributes effectively and efficiently to addressing nutritional and socio- economic problems that affect many developing countries such as Zambia.

1.2 State of the Zambian Horticulture Sector

One key challenge with analyzing the horticulture in Zambia is a dearth of up-to-date data. The lack of information is partly a reflection of the low priority afforded to the sector - this is despite the sector having a higher income generation potential. One important data source was from local think tank Indaba Agricultural Policy Research Institute (IAPRI) (Chapoto and Chisanga, 2016; Mulenga *et al.,* 2020; Hichaambwa, *et al*., 2015; Sitko *et al.,* 2011).There is need to improve sector in formation collection and retrieval systems to ensure that planning is based on robust up to date and reliable data.

One attractive feature of horticulture is that incomes from this sector are about 8 to 10 times higher than compared to other sectors of agriculture such as cereals like maize (Hichaambwa, *et al*., 2015). The horticulture sector particularly fruits and vegetables has shown great growth everywhere in the world except sub Saharan Africa (SSA), excluding South Africa (Hichaambwa and Tschirley, 2006, 2010; Simon *et al.,* 2020). The reasons for the stagnation of horticulture in Africa and Zambia in particular are varied ranging from production constraints, to marketing, lack of processing/ value- addition and all these factors being driven by ineffective policy framework (Sitko *et al.* 2011). Surveys conducted by the Zambia Central Statistical Office (CSO), the Food Security Research Project (FSRP) and the Ministry of Agriculture and Cooperatives (MACO), showed that in the year 2000 there were about 650,000 small scale horticulture farmers or households (Hichaambwa and Tschirley, 2006). Of this number, only 21 % were involved in commercial horticulture production, underscoring the fact that local horticulture remains a subsistence activity. Each household sold an average of US $ 100 of fresh produce in per year, nearly all of it into the domestic market (Hichaambwa and Tschirley, 2006). Ten years later, the number of smallholder farm- families grew to about 1,700,000 but the proportion of growers selling fresh fruits and vegetables remained between 18 and 20 % (Hichaambwa *et al.,* 2009). Between 2015 and 2020 Annual consumption (fruits and fresh vegetables) was estimated at 1 million MT, worth over USD 330 million, in 2015 and this is estimated to increase to 1.4 million MT worth USD 500 million by 2020. Total horticultural production was estimated at 1.4 million MT, worth USD 235 million, and is projected to increase to 2.2 million MT by 2020 (Mulenga *et al.,* 2020).

The above named surveys have provided valuable information on horticultural production and consumption. With reference to specific crop combinations, for instance in the years 1997/98 among the households growing vegetables, about 22 % grew cabbage, 33 % grew rape, 23 % grew tomato and 5 % grew bulb onion. Green maize was another relatively popular crop (5 %). Other vegetable crops- mostly indigenous species- were grown but these were low (at less than 5 %) and were grown by a small number of farmers (Hichaambwa *et al*., 2007; Hichaambwa et al., 2015). The largest income from sales of vegetables was from cabbage (31.8 % of the total value of vegetable sales), followed by tomato (27.7 %), and rape (25.0 %). Important fruits include banana, mango, citrus (oranges, lemons), pineapples, guavas and a few indigenous species.

The number of commercial horticulture farmers, is much lower with most producers clustered around the main cities and towns. Commercial horticulture in Zambia developed rapidly in the 1980s, spearheaded by large commercial farms that grew horticultural commodities to raise foreign currency to import equipment for their main activities (cattle and cereal farming). In the late to 1990s to mid- 2000s, export horticulture flourished and the main commodities were initially summer flowers such as roses, hypericum, solidago, rudbekkia and later high value vegetables like baby corn, fine beans, runners beans, sugar snaps, mangetout . Nationally, the major horticultural commodities include vegetables- tomato, cabbage, rape; fruits- citrus, mango, bananas, avocado. Another addition to horticulture sector activities has been the establishment of commercial retail and wholesale nurseries near major cities and towns producing a variety of planting materials.

Over the coming decades as population increases mankind will demand more food from less land and water resources. While projected income changes have the highest partial impact on per capita food consumption, population growth generally leads to the highest increase in total food production (Schneider *et al.* 2011). Zambia is undergoing a phase of rapid population growth, urbanization and in some population sectors rising per capita income (Hampwaye *et al.*, 2016; Chileshe, 2013; Central Statistical Office, 2015). These demographic changes are transforming food systems and food consumption patterns but it is not clear that related food policies and legislation are being aligned to evolving demographic and economic changes (Local Government Act, Chapter 281 of The Laws of Zambia (With amendments of 1995 (GRZ, 2020a); The Markets Act, the Laws of Zambia Chapter 290; The Competition and Consumer Protection Act, of 2010, INIBAP, 2020b; The Public Health Act, Chapter 295 of the Laws of Zambia (GRZ, 2020c).

Although in the past, societies depended on a wider range of species for food, fibre and other needs, in today's contemporary agriculture, a small number of crops account for the majority of the food used in human diets, (Williams and Huq, 2002). About 30 crop species provide 95 % of the world's food energy whereas 7,000 species have been known to have been used for food and are either partly, or fully domesticated (Williams and Huq, 2002). This large array of plant species that no longer contribute significantly globally and over the decades have been largely ignored can be considered as under- utilized minor crops (Mataa *et al.,* 2020). Underutilized leafy vegetables such as cassava (*Manihot esculentum*) roselle (*Hibiscus sabdariffa*), sweetpotato (*Ipomoea batatus*), and pumpkin (*Cucurbita* spp) are important particularly among low income brackets of the population and in the rural regions (Mataa *et al.* 2018; Mataa *et al.,* 2020).

Chisanga and Zulu- Mbata, (2017) showed transformation of food expenditure patterns particularly among the urban high income households, but also among the lower income strata. Household food expenditure for fresh fruit and leafy vegetables have increased with cabbage, rape, tomato, onion and local leaves being the most consumed vegetables in the sample urban areas. The average per capita consumption of vegetables in Zambia in 2004 was 39 kg per capita which was higher than the FAOSTAT estimate of about 22 kg per capita (Farrington and Saasa, 2002). According to these authors, consumption was high in Southern (68 kg) and Eastern provinces (66 kg), and comparatively low in Luapula (11 kg) and Western (11 kg) provinces. Compared to vegetables, the consumption of fruits is even much lower. Whereas it has been estimated that consumption of citrus fruits in the USA is 60 kg per year in third world it has been estimated at 6 kg (Saunt, 1995). Other fruits of importance albeit of a seasonal nature include mango, guava. Indigenous species such as masuku (*Uapaca kirkiana*), busika (*Tamarind* *tamarindus*), masau (*Zizyphus mauritana*) are popular among in the low income households (Fanshawe, 1962, Storrs, 1995).

Horticulture appears to be the single most important or lucrative source of cash income from agriculture, surpassing maize, cash crops such as cotton and tobacco, and livestock (Chisanga and Zulu- Mbata, 2017). However, the number of small scale producers producing for the market remains small. It has been shown that in Zambia only about 20 % of all smallholder households reported sales of any fresh produce compared to 70 % in Kenya and 25 % in Mozambique (Jayne *et al.,* 2009). This very low figure suggests the possibility that new demand points – if linked to rural areas with information and reliable purchases – could generate an impressive supply response. With regard to regional differentiation, the proportion of smallholder farmers selling FFV is higher in the more urbanized regions and least in more rural provinces.

Horticultural marketing remains largely informal (Shah, 2012). The dominance of the traditional/informal system in the marketing of fruits and vegetables was overwhelming at over 95 % (Chileshe, 2013; Shah, 2012; Hichaambwa and Tschirley, 2006). Although the share of population using formal system retail outlets (grocers, mini-marts and supermarkets) is higher in the high income bracket than low expenditure bracket, the traditional/informal system still predominates. Informal marketing channels though convenient especially for the low income population have attendant problems of high food losses and inability to maintain quality and food safety (Davies, 2015).

According to Mulenga *et al.,* (2020), there has been steady growth in the production, sales and consumption of horticultural products in Zambia over the years and this trend is projected to continue in the medium term. One major push factor is the move towards healthy eating, with fruits and vegetables forming the bulk of the ingredients for healthy foods. Annual consumption was estimated at 1 million MT, worth over USD 330 million, and this is projected to increase to 1.4 million MT worth USD 500 million by 2020. Production is estimated at 1.4 million MT, worth USD 235 million, and is projected to increase to 2.2 million MT by 2020 (Mulenga *et al*., 2020). Urban and peri-urban market oriented horticultural production is significant around urban areas, or within 50- 100 km radius of main urban centers. This pattern suggests the possibility that new demand points could enjoy a quite substantial supply response from the smallholder sector if they linked effectively to them. This is especially true for fruits such as mango, much of which now goes to waste for lack of storage and processing capacity.

Despite government interventions to reduce poverty and food insecurity through programmes such as Farmer Input Support Programme, malnutrition manifested through problems such as stunting still plagues the population (National Nutritional Surveillance Report, 2009; CSO *et al* 2015). Growth stunting is a gradual process that occurs in response to chronic biological assault, including malnutrition and infectious diseases, during periods of linear bone growth. Up to date consumption data on fruit and vegetables is difficult to find but generally it is recommended that two servings of fruits and three servings of vegetables per day are required daily (Casagrande *et al.,* 2007). The National Food and Nutrition Commission survey of 2009 showed the following; the overall stunting in Zambia was 49.7 % with subsequent surveys showing only minor decline. Hence increased horticultural production can help deal with these nutritional problems.

Among the factors that limit crop productivity include sub optimal management, over generalized production recommendations not related to area specific agro ecological conditions and soils; lack of adapted cultivars and high quality disease free planting materials (Mataa and Nalumino, 2001). Additionally, marketing bottlenecks and absence of appropriate postharvest processing facilities are a further draw back. The next part of the work focuses on strategies that can be used to deal with the observed limitations.

2. Suggested Sub-sector Interventions

2.1 Theme 1. Horticultural Production

Land and water are essential resources for the production of food and constitute two of the most fundamental resources for mankind (Schneider *et al.,* 2011). However, these resources are under pressure from population growth, economic development and environmental change. In future, farmers will need to adopt strategies that will produce more food using fewer resources. The open field is by far the common production system but due to little environmental control, yields and quality of produce are low. The mid 1990s to mid- 2000s Zambia saw an increase in semi- controlled greenhouse production mostly for high value export commodities such as rose flowers. Outgrower schemes were also emerging in the horticultural sector. Farrington and Saasa (2002) suggested that the horticulture industry alone in the early 2000 employed 10,000 persons directly and engaged about 10,000 more as out-growers. Over the next twenty years, these numbers have continued to decline (Mataa and Hichaambwa, 2010; Mulenga *et al.,* 2020). Although horticulture generates higher incomes than conventional agriculture, the sector presents higher risk of environmental damage due to its intensive production nature. Therefore it is critical that safe and sustainable production practices are practiced.

2.1.1 Sustainable Horticultural Practices

The negative impact of agriculture on the environment and the attendant effects of climate change are well recognised and have caused a change in agricultural production systems. For field crops sustainable practices such as Conservation farming and Climate smart agriculture are the emerging trends. In horticulture, on the other hand despite the increasing awareness of harmful impacts of modern intensive production systems on the environment there has been little effort to introduce environmentally compatible horticultural production systems. Due to the intensive horticulture exemplified for instance higher use of inputs (for example in vegetable production 600 to 800 kg of 10- 20- 10 analysis fertilizer compound or urea are applied per hectare compared to 200 kg in maize) it has higher risks of environmental degradation. Key interventions include evaluation and adoption of practices such as Integrated Fruit Production (Sansavini, 1996) that recognize the impact of production technologies on the environment (chemical pesticides, fertilizers in groundwater etc.). Additionally the use of mycorrhizae in tree nutrition and as 'bio- pesticides' can help in ameliorating environmental damage.

2.1.2 Development of Horticultural Production Belts Based on Niche Climatic Conditions

Strategies for increased production should take into consideration climatic and soil suitability for economic exploitation of any species (Singogo *et al.,* 2021; Mataa et al., 2020; Karim and Mad, 1990; Uppal, 1987). There is need to grow commodities where the soils and climate are most suitable. Key activities in this theme will include validation of Soil Survey Correlation work relating to crop suitability maps to delineate the country into specific commodity production belts based on regional soil-climatic conditions. This approach will be most profitable for perennial commodities such as fruits. Unlike other countries in the region such as Zimbabwe (Marondela) or Tanzania in the Tanzanian highlands Zambia has not taken advantage of mild climates in the highlands. The high elevation Muchinga escarpment areas of Serenje, Mpika, Nyika plateau, cool, northern regions such as Mbala would be ideal areas for evaluating temperate climate fruit crops such as - peaches, apples, grapes and growing of temperate vegetables like Irish potatoes. For fruits, of immediate importance is determination of yield potentials and factors responsible for low yield; tree phenological/physiological development patterns; carbohydrate/nitrogen cycles; and flowering and fruit set rates.

2.1.3 Integration of Indigenous and Under-utilized Species into Conventional Agro Systems

Although the Zambian commercial horticulture sector is dominated by exotic commodities such as cabbage, rape, banana, citrus (oranges and lemons), mango the bulk of the rural population and low income population consume more indigenous fruits and vegetables. Based on work done by International Centre for Research in Agro- forestry (ICRAF), National Institute of Scientific and Industrial Research (NISIR) and the Forestry Department surveys on species distribution of major fruit and timber trees that have potential for commercial exploitation, showed there were over 50 promising indigenous fruit (Fanshawe, 1962; Storrs, 1995). In the late 1980s to mid-2000s the ICRAF Indigenous fruit tree programme initiated domestication work on five fruit species that included Masuku (*Uapaca kirkiana*), Marula (*Sclerocarya birrea*), Mpundu (*Parinari curatellifolia*), The project came to an end and as is common with projects all the work has come to a close without any continuity. Close collaboration of the ICRAF with Forestry Department and NISIR participation in the domestication work, particularly after the end of the ICRAF donor support phase would have ensured continuation of the work. Among other successes, the ICRAF project was able to develop propagation methods, outline low cost processing protocols for making jams, jellies. Other species that are widely consumed and can benefit for more attention include makole (*Azanza garkeana*), nthunza (*Flacortia indica*), masau (*Zizyphus mauritana*), busika (*Tamarindus indica*), mumosomoso (*Vangueriopsis lancifolia*) and muchenje (*Diospyrosis kirkii*). The main thrust of work is domestication and commercialization therefore, collection, characterization, evaluation, utilization and conservation will be critical.

2.1.4 Increasing Access to Low-cost Irrigation

Wahid *et al.,* (2007) outlined the physiological and morphological effects of water stress and the impact on plant performance. The amount of fresh water is finite and water has multiple and competing uses including direct human, industrial and agriculture uses. The advent of climate change has increased the frequency and extent of extreme weather patterns including drought (Godfray *et al.,* 2010). Profitable horticultural production cannot rely on rain fed water, irrigation is an important prerequisite. Zambia has a unimodal rain season with rains falling between November and March (Bunyolo *et al.,* 1995). As is the case with other crops, productivity of horticultural crops is enhanced by irrigation particularly during dry season and drought (Mataa *et al.,* 1998; Mwenda *et al,* 2005; Mataa *et al.,* 2019). Horticultural farming among the small-scale farmers has not been very successful partly because of the lack of water in the dry season. The seasonal nature of water availability from rain severely impacts perennial crops such as fruit trees and, commonly, early tree death is the consequence. Even where the trees survive, long-term fruit productivity and quality are permanently reduced because growth and development are impaired seasonally. Lack of access to affordable and appropriate irrigation equipment is accentuated by lack of local manufacturing capacity (Mwenda *et al,* 2005). The government has concentrated on large scale irrigation infrastructure such as dams with less emphasis on 'soft' skills such as farmer training, enhancing related value and supply chains that would ensure effective and efficient use of the harnessed water.

Affordable and efficient irrigation technologies like pedal pumps, low-cost drip and micro- sprinkler irrigation need to be evaluated and promoted. Although these water efficient systems can induce growth restriction effects due to the partial wetting of the rhizosphere ('drip root systems') these effects can be exploited to control excessive vegetative growth and increase yield (Bravdo *et al,* 1992; Mataa *et al.,* 1998). Similarly work on deficit irrigation to improve fruit quality and conserve can be initiated water (Mataa *et al.,* 1998, Mills *et al.,* 1996 Yelonsky, 1991). Women are heavily involved in small-scale horticulture. One of the key activity that takes a lot of time of the womenfolk is watering and therefore efficient and low cost irrigation technologies and other gender sensitive technologies would be most helpful.

2.2 Theme 2: Horticultural Research

Except for a few exotic vegetables and temperate fruits species there has been very little systematic and sustained horticultural research in Zambia. Most of this work has consisted of evaluation of imported germplasm for potential local introduction. Consequently most of horticultural seeds and other planting materials are imported and thereby making them expensive and beyond reach of small farmers (Sitko *et al.,* 2011).

Biotechnology holds immense potential in horticulture such as in fruit improvement because of reduction in generation time needed to develop new varieties and ease in transfer and storage of germplasm. For fruit research, cell and tissue culture, micropropagation and gene transfer are important (Jones and Montcel, 1993; Sansavini, 1996). Although Biotechnology is expensive, low cost alternatives can be incorporated (Read and Chishimba, 1997). The potential for commercialization is immense. Zambia has the capacity to conduct biotechnology research safely and thus keep up with scientific developments (Mataa *et al.,* 2009). Additionally the country has established legal framework to determine and manage risks associated with products of genetically modified products.

2.2.1 Determination of Priority Commodities for Improvement

Given the scarcity of resources it is important that the list of research commodities to be researched on should commensurate with available financial/human resources. Particularly in the fruit sub sector there was an attempt to research on any and all fruit species without any prioritization. Emphasis on tropical/subtropical fruits like citrus, banana, mango, pineapple and avocado that are more adapted to local climate and soils will be appropriate (Mataa and Nalumino, 2001; GRZ, 1990a). Although basic research on flowering and dormancy, and applied research on timing and dormancy breaking can be attempted in temperate fruits (Dennis, 1992), it may not be economical because of availability of cheap imports from South Africa. The research system and priorities should, be flexible to include other commodities that may become important (either as exports, nutritional or industrial inputs) in the future (GRZ, 1991; GRZ, 1993b).

2.2.2 Development and/or Introduction of New Varieties

Introducing new crops and cultivars is an integral part of agricultural development but the performance of the new crops in the new environment has to be determined to avoid producers incurring losses due to poor crop adaptability (Mataa and Chilembo, 2009). Since the early 1970s, little systematic introduction of new fruit varieties and/ or selection and evaluation among local germplasm has been done. Meanwhile new challenges such as emergence of new diseases, pests and changing consumer preferences have emerged. Locally there are chances of finding highly productive and adapted types particularly in oranges, guava and even bananas. Washington navel and Valencia late still remain the principal commercial orange cultivars despite the problems of low fruit set and high acidity of the juice associated with the two cultivars. There is also a lack of 'very-early' and 'mid-season' cultivars, thus shortening the available season for most fruits. As is the case with other crops continuous evaluation of new horticultural species and varieties would benefit the sector (Aubert and Vullin, 1998).

2.3 Enhanced Plant Propagation

For perennial commodities such as fruit trees some of the key activities that need to be considered include;

1) Adoption of new, rapid and low cost vegetative propagation methods to produce large quantities of cheap, standardised, uniform and disease free planting materials. Tissue culture and other rapid propagation techniques.

2) Introduction and evaluation of new high productivity varieties. There has been very little systematic introduction of new fruit tree varieties. In the early stages of fruit tree research a number of temperate species were imported for evaluation but all these materials were lost. Due to failure to maintain all research species in Mother Tree orchards there is no material to be used as bud wood sources (Aubert & and Vullin, 1998).

3) Introduction of a Bud-wood Certification Programme. To date no disease indexing of foundation budwood source trees (for virus and virus-like diseases like Psorosis, Triesteza-Disease complex, Exocortis) and evaluation of their production potential has been done (Roistacher, 1991). Thus all materials produced locally may be contaminated and spreading graft transmissible diseases.

4) There are very few rootstock varieties, for example, almost all citrus trees in the country are budded on rough lemon rootstock despite the noted inferior performance of this specie in the rootstock evaluation trials (GRZ, 1990a). To avoid risks associated with monocultures, new rootstocks selected from the old Citrus rootstock study could have been released to farmers. Possible candidates include Cleopatra mandarin which has shown satisfactory quality and yield capacity (GRZ, 1990a). Efficient vegetative propagation methods for mango, guava, and indigenous fruits need to be explored.

5) Government support to fruit nurseries has not been adequate to maintain irrigation facilities, purchase pesticides, fertiliser etc. One alternative is the privatisation of public fruit nurseries so that the government is involved only in monitoring quality of propagated materials (Aubert and Vullin, 1998).

2.4 Germplasm Conservation

Much progress has been achieved in conserving cereals and grain plant genetic resources in Zambia as attested by the existence of the National Plant Genetic Resource Centre (NPGRC) at Mt. Makulu in Chilanga and the Southern African Development Council (SADC) PGRC in Chongwe, Lusaka. However similar effort has not been applied to fruit tree and other vegetatively propagated plant species. Therefore the country lacks a center to conserve its fruit tree and related perennial plant genetic resources. One of the key germplasm introductions was the Citrus collection at the Natural Resources Development College in Lusaka but it was neglected and can no longer be used for the intended purposes. The temperate fruit collection at the Zambia Agricultural Research Institute in Chilanga has been lost but some useful information that was collected (Mataa, 2000).

2.5 Plant Protection

One of the serious limitations to expanded horticulture is the prevalence of diseases and pests. The changing climate has further exacerbated the situation by emergence of new pests and diseases. New pests such as *Tuta absoluta* in tomato and multi host pests such Army worm presents an added burden to growers. Traditional chemical control methods are no longer feasible due to challenges of pollution and affordability. Work done in the USA on agrochemicals usage has shown a shift from predominantly organophosphates and N- methyl carbamates to a mix dominated by neonicotinoids and pyrethroids (DiBartolomeis *et al.,* 2019). These new chemicals although applied at lower dosages are considerable more toxic to beneficial insects, impairing their ecological functions and persisting longer in the environment (DiBartolomeis *et al.,* 2019). Innovative ways of managing these biological stresses are needed (Furlan & Kreutzweiser, 2015).

2.5.1 Vegetable Grafting

Grafting of herbaceous vegetable grafting goes back to the early 20th century. Early attempts involved grafting water melon (*Citrullus lanatus*) grafted on squash (*Cucurbita moschata*) rootstocks to overcome Fusarium wilt. Vegetable grafting is used to manage soil borne diseases and root knot nematodes mostly in the *Solonaceae* and *Cucurbitaceae* vegetables. Interest in vegetable grafting has grown as alternative to soil fumigants (methyl bromide) and as an IPM practice.

Table 1. Diseases reported to be controlled by grafting in vegetables

Disease and pest	**Pathogen**	**Commodity**
Fungal and oomycete diseases	*Fusarium oxysporum*	Tomato, watermelon, melon, cucumber
Fusarium crown and root rot	*Fusarium oxysporum Fusarium solani*	Tomato, watermelon, peppers
Verticilium wilt	*Verticilium dahlia*	Tomato, watermelon, eggplant, melon, cucumber
Monosporascus sudden wilt Phytopthora blight	*Monosporascus cannonballus Phytopthora capsci*	Watermelon. Melon Tomato, pepper, watermelon, Cucumber
Corky root	*Pyranochaeta lycopersci*	Tomato, eggplant
Target leaf spot	*Corynespora cassicola*	Cucumber
Black root rot	*Phomopsis sclerotinoides*	Cucumber, melon
Gummy stem blight	*Didymella bryoniae*	Melon
Brown root rot	*Colletotrichum coccodes*	Tomato, egg plant
Rhizoctonia damping off	*Rhizoctonia solani*	Tomato
Powdery mildew	*Podosphaera xanthi*	Cucumber
Downey mildew	*Pseudoperonospora cubensis*	Cucumber
Bacterial diseases		
Bacterial wilt	*Ralstonia solanacaerum*	Tomato, pepper, eggplant
Nematodes	*Meloidogyne* spp	Cucumber, melon, watermelon
Viral diseases		Tomato, eggplant, pepper
Melon necrotic spot virus	Melon necrotic spot virus (MNSV)	Watermelon
Tomato yellow leaf curl	Tomato yellow leaf curl virus (TYLCV)	Tomato
Tomato spotted wilt	Tomato spotted wilt virus (TSWV)	Tomato
Peppino mosaic	Peppino mosaic virus (PepMV)	Tomato

Source: King *et al.,* 2008 and Louws *et al.,* 2010

Fruit trees, (with the exception of high-density orchards), are planted with a view that they will last many years (30 years or more). The threat of new diseases and pests in fruit production is particularly serious because of the high cost of orchard establishment and the longer time taken for the trees to start economic production (about 5 years for citrus but shorter in other fruits). The threat of black Sigatoka (*Mycosphraella fijiensis*); Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*); Banana Bunchy Top Disease and pests such as burrowing nematodes (*Radolphus similis*); banana weevil (*Cosmopolitus sordidus*) in bananas need early attention (Raemaekers & Patel, 1973; Jones & Montcel, 1993). The lack of effective plant-quarantine facilities in some border areas increase the risk of their introduction into the country (Ndungu, 1986). Black Sigatoka can cause crop losses in susceptible cultivars of up to 50 % (Mobambo *et al.,* 1993). One of the real threats to banana production is Banana Bunchy Top Virus, this disease has been reported in Zambia but the extent of infestation is yet to be determined. Active participation in regional programmes like International Network for Improvement in Banana and Plantains (INIBAP) will reduce research costs (GRZ, 1990b).

For Citrus, Cercospora leaf spot, scale insects (*Aonidiella auranti, Coccus* spp) and False codling moth (*Argroplace leucotreta*) need attention. With the growing environmental and health awareness the focus should be on environmentally safe and low cost alternatives such as Integrated Pest Management technology.

2.6 Theme 4: Marketing

No amount of research or extension to increase production will be really meaningful without determining markets for the produce and working out marketing methods. Marketing is indeed a neglected area of research (Mahadeva, 1988). More work in the whole value chain is needed if growers are to realize meaningful economic returns to their investment.

According to Jayne *et al.,* (1999) the major challenges facing policymakers in the region are how to:

1) Design agricultural marketing systems to better serve as catalysts for farm productivity growth, particularly for smallholders.

2) Cost- effectively deal with price instability for both consumers and producers in a liberalized marketing system.

3) Develop the commitment to a consistent and stable policy environment to support long run private investment and insulate the new systems from disruptive policy lurches in response to short-term political crises.

4) Design a process of collaboration between policymakers, donors, researchers, and the private sector to maximize the probability of achieving improved agricultural policy and performance over time.

A key feature of each of these challenges is the need for a better understanding of how to stimulate private investment in the food system.

2.7 Theme 5: Post Harvest Processing and Preservation

Food preservation and processing facilities whether at small subsistence or commercial level are inadequate and almost non- existent. One implication is that high supply is accompanied by low prices and high losses and wastage. For highly perishable commodities losses can exceed 30 % (Sansavini, 1996). High postharvest losses and wastage have both economic and ecological impacts and therefore it is important that strategies are put in place to increase food preservation and processing. The highly perishable nature of most fruit and the seasonal production, demands that processing into products like jams, canned fruits and juices go hand in hand with attempts to increase production. The situation of pineapples in Northwestern province and mango in Western province are some examples where such support is necessary.

One avenue to redress the situation is the development of small cottage industries organized within farmer co-operatives in main producing areas. With the liberalization of the economy there has been an increase in imports of fruit juices and jams from neighboring countries especially South Africa and yet most of these products can be produced locally.

2.8 Quality Control

Other related areas in need of attention include the development and integration of Quality Control, a key output would be establishment Standards and Grades both for the local and export markets.

2.9 Theme 6: Amenity/ Environmental Horticulture

Until the mid-1990s, focus of the Zambian horticulture industry was on food commodities – vegetables and fruits- almost to the total exclusion of environmental horticulture activities such as floriculture, landscape design. Such a situation is to be expected because in a society still grappling with under- nutrition it is inconceivable that resources will be expended on aesthetics such as beautifying environment or growing of flowers. However, with rising incomes and the problems of climate change, the importance of environmental horticulture is expected to grow. The last few years have seen an increase in flower and ornamental production both for the local and export market (Anon, 2006; Saasa *et al* 1999). Systematic support to this sector would be beneficial particularly that the sector has demonstrated high employment generation capacity.

Furthermore, it has been proven that flowers and ornamental plants have a therapeutic benefits on humans and this is critical particularly with the stress associated with urban lifestyles (Skelly, 2016; Starling, 2016). Some of the benefits of landscape discipline include, carbon sequestration, through planting of ornamental trees (Green cities), enhancing the mental wellbeing/ therapeutic effects whether in door or outside landscape design. The concept of Green cities is becoming popular although it unclear what it really means to the average citizen. Urbanization is estimated at 60 %, agricultural sector has to develop strategies to bring this sector of the population in agriculture through the promotion of ecologically sound urban horticulture.

2.9.1 Theme 7: Sustained Strategic Staff Training

Human resource training and financial support. The quality of research depends mainly on the training that young scientists receive (Sansavini, 1996). There has been little specialized human resource training (long and short medium term) which has contributed to generally very little impactful research.

There is a lack of formal institutions providing training in landscape design and landscape architecture. As a result most of the landscaping is done by individuals lacking formal training. The University of Zambia is in the process of offering a BSc. in Horticulture which will have equal focus on Vegetable, Fruit Science and Landscape design (including floriculture) and it is anticipated that the programme will assist in strengthening the landscape design and floriculture industry.

2.9.2 Theme 8: Research Infrastructure

In order to conduct research there is among other things need to have well equipped laboratories and related infrastructure. Over the years the investment in infrastructure has been insignificant. There is need to re-capitalize, modernize and rationalize the use of research equipment on a regular basis; Maintain and expand office and laboratories spaces; provide adequate transportation; provide adequate field; and provide adequate ICT services and library facilities for research.

3. Conclusion and Recommendations

This paper was an attempt to outline some of the key challenges facing horticulture industry in Zambia and possible interventions. The horticulture sub- sector has immense potential to contribute to improved nutrition and poverty reduction. However it is constrained by a myriad of limitations ranging from biological to socio economic. The range of horticultural products is wide ranging from exotic to indigenous species. There is therefore, need to prioritize key products and develop appropriate and effective plans ranging from short, medium and long term that take into consideration the wide climatic and geographical characteristics of the whole country.

Previous studies have shown that smallholder participation in horticultural markets is impeded by factors such as long distances to markets, price volatility, lack of market information, involvement of predatory marketing brokers and undeveloped standards and quality control. On the production side improvements are needed in extension support to ensure effective production and postharvest practices. Unlike other specialized agricultural sub sectors such as poultry and Dairy sub sectors, the horticultural industry lacks a common platform or association that would bring together key players in the industry. Such an organization would assist in promoting interests of the industry, act as lobby group and also facilitate sharing of information among members.

More innovative approaches can address most of these short comings and hence the need for systematic horticultural and allied research. Horticultural research has to move to the fore front of agricultural research particularly if the dream of using agriculture to drive the economy and reduce poverty is to be realized. For sustained and safe horticultural development there is need to establish linkages, networks and partnerships among different research and development institutions, both from private and public sectors, national and international. The aim is to take advantage of synergies, promote competitiveness in a global environment and avoid system redundancy (duplication). Only when these interventions are implemented will the sector achieve its full potential and contribute to poverty reduction especially for the most vulnerable sectors of the population.

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