

Research Article

Assessment of Urban Farming Production, and Contribution to the Households' Livelihood: A Case of Kigali City and Musanze District

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Abstract

Agriculture plays an important role in the economic growth and food security control in developing countries including Rwanda. This research study was carried out in Kigali and Musanze. Urban farming is one way to best use useless places closed inside household fences, resulting in high yields. Due to their short production cycle, Horticultural crops provide a quick response to emergency food needs, particularly in cities. These species have considerable yields that generate more income for farmers when used appropriately. The main objective of this study was to analyze the factors influencing urban farming production, profitability, and contribution to the households' livelihoods in Rwanda. The population of interest for this research study constituted smallholder farmers of vegetables and fruits in Kigali and Musanze cities. The sampling unit was the garden household. A multistage sampling technique was employed involving purposive sampling of four districts Gasabo, Kicukiro, Nyarugenge, and Musanze. The study used a sample frame of 1085 population and a sample size of 112 respondents. The results from the study indicated that ten factors over fourteen have a positive influence on urban farming production while four have a negative influence in the study area. The results also showed that the productive fruits grown are classified into five classes indicated in [Figure 1](#). The results of the study revealed different places/methods used to grow vegetables/species and fruits such as bags, baskets and basins, hanging baskets, old wheels, pallet gardens, open ground, trellises, arches, shelves, fences window box walls. The results displayed that the crops do well in small areas/places closed inside the household's fences. The results proved that urban farming contributed to the social economy through different parts example malnutrition control, money saving, and food security. The results pointed out that urban farming production is constrained by some challenges such as small owned parcels, lack of urban farming knowledge, lack of technologies, period of crop maturity, lack of capital, lack of awareness, habitation system, and infrastructures. However, urban farming development should be enhanced to maintain national food security and improve income for farmers.

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Keywords

Assessment, Urban Farming, Production, Profitability, Households' Livelihoods

1. Introduction

Currently, the main challenge in the developing countries of Sub-Saharan African countries including Rwanda is the highest population growth with the reduction of arable land and lower production from the agriculture sector due to an improper use of available spaces. Most cities in developing countries have great difficulties coping with this development and are unable to create sufficient formal employment opportunities for the poor. They also have increasing problems with the disposal of urban wastes and wastewater and maintaining air and river water quality [8].

It is expected that by 2020, 85% of the poor in Latin America, and about 40-45% of the poor in Africa and Asia will be concentrated in towns and cities [10]. The rapid urbanization goes together with a rapid increase in urban poverty and urban food insecurity. Poverty, hunger, and food insecurity have human rights implications. Sub-Saharan Africa, where the average income is low and the average income of those below the poverty line is even lower, will face great difficulties in bringing the poorest people to an adequate standard of living [32].

Indeed, it is now widely accepted that poverty should not be seen only as a lack of income, but also as a deprivation of human rights and that hunger constitutes a violation of the human right. However, food and nutrition insecurity has been a major challenge in Sub-Saharan Africa (SSA) [7].

Most of these people will be living in slums, without access to adequate food, water, or sanitation. Urban poverty in SSA has a broader meaning of cumulative deprivation, characterized by squalid living conditions, risk to health and life from poor sanitation, air pollution, natural disasters, and the breakdown of traditional family and community safety networks [10].

In 2012, Rwanda had a physical population density of 415 persons per sq. km. Compared to neighboring countries such as Burundi (333), Uganda (173), and Kenya (73), Rwanda has the highest density in the region [16]. Population density is high in all Districts but varies tremendously from one District to another. The least densely populated Districts are found in the Eastern Province (178 in Kayanza, 280 in Bugesera). The most densely populated Districts are Kigali City: Nyarugenge (2,124), Kicukiro (1,911) and Gasabo (1,234). Rubavu in the Western Province has the highest population density outside Kigali City with 1,039 inhabitants per square kilometer [19]. To achieve global food security and environmental sustainability, agricultural systems must be transformed to address the challenges of food production and environmental protection.

Urban agriculture may be one affordable alternative for the maintenance of public green spaces [23].

Urban agriculture is defined as the production of fruits and vegetables within or in proximity of an urban area. Generally, urban agriculture is an intensive, high-input like organic pesticides and organic manure use, high-output system favoring the production of a diversity of crops and animals throughout the year. Urban farming is a common practice and extremely heterogeneous. It involves efficient use of water; careful management of soil fertility, crops, and animals; and close attention to environmental protection [2].

Urban agriculture can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping, and horticulture. These activities occur in peri-urban areas as well, and peri-urban agriculture may have different characteristics. For others, food security, nutrition, and income generation are key motivations for the practice. In either case, more direct access to fresh vegetables, fruits, and meat products through urban agriculture can improve food security and food safety. The food grown in an urban farm can be sold for profit besides being used for personal consumption. This type of farming is a more practical way of growing your food than community gardening [13].

The production and productivity of urban farming depend mainly on methods or systems used for the available space. With these factors above, the farmer also needs to plan and think carefully about the plants he/she wants to grow and the amount of sunlight that each plant will receive in the place you dedicated for them. For urban areas, a vertical garden is an inventive way to make more of your growing space while also reducing disease and insect problems. Growing plants vertically adds beauty to your decks or patio. When you grow vegetables vertically, supportive structures like trellises, stakes, and obelisks become part of the decor while still being functional [13].

Any vegetable that can be grown in a garden works well for a container garden. You can find many different-sized containers that can be used to grow vegetable plants, and sometimes that means getting creative. Shelves, hanging gardens, arches, fences, pallet gardens, window box walls old wash tubs, wooden crates, old wheelbarrows without wheels, five-gallon buckets, and more are all possible containers for growing veggies and small fruits [14]. In urban farming one of the first things, you might not forget to use our shelves. Shelves have several benefits for growing different vegetables. You can pick which shelf the vegetable is set on by how much

sunlight they need. The best type of shelves for vegetable gardening is the kind with slats because it allows air to circulate and some sunlight to make it down to the other plants. Urban household farmers use leafy vegetables collected from the wild less than rural households because they lack access to sites where these vegetables grow naturally [14].

In urban farming, horticultural species have considerable yield potential and can provide up to 50 kg of fresh produce per square meter per year, depending upon the technology applied. In addition, due to their short production cycle, they provide a quick response to emergency food needs (several species can be harvested 60 to 90 days after planting). Leafy vegetables, tubers, and herbs grown in simple containers help low-income families meet their daily needs for fresh, nutritious produce. Urban farming plays different roles in food security in developed and developing countries [21]. In developed countries, urban farming improves nutrient intake in food deserts for underserved populations and serves as a general source of healthy, locally sourced food, closing the loop of the circular economy [17].

Micro-gardens are highly productive and can be easily managed by anyone women, men, children, the elderly, and the disabled. Where no land is available, vegetables can be planted in a container filled with garden soil or a "substrate" made from local materials, such as peanut shells, coconut fiber, rice husks, coarse sand, or laterite. If substrates are unavailable, there is another option: growing the vegetables in water enriched with a soluble fertilizer [10].

A micro-garden can be grown in an area of just one square meter. Water requirements are modest, an important consideration in developing cities, where good quality water is often scarce and expensive. In a year, a one-square-meter micro-garden consumes about 1,000 liters of water, or less than 3 liters per day [9]. To ensure a regular water supply, micro-gardeners can channel rainwater into storage via a system of gutters and pipes. Rainwater is virtually free (after the investment in harvesting equipment) and usually. Generally, in developing countries, vegetable production stimulates rural and urban economies and generates employment and income [12].

Growing poverty, hunger, and lack of formal employment opportunities, as well as the special opportunities provided by the city including the growing demand for food, proximity to markets, and availability of cheap resources such as urban organic wastes and wastewater have stimulated the development of diverse agricultural production systems in and around Cities. However, urban agriculture has the potential of making use of wastewater and urban solid waste as key inputs to production thus ensuring environmental sustainability [22].

For a long time, most of the empirical work in Rwanda has significantly focused on traditional and staple crops such as tea, coffee, pyrethrum, maize, potato, bean, rice, wheat, sorghum banana, and cassava. However, vegetables and fruits are increasingly produced in both rural and urban zones [15]. Horticulture crops are cultivated in every region of Rwanda in

the uplands, lowlands, and valleys. Horticulture production in Rwanda is an intensive system due to the high good climate and use of external agricultural inputs (improved varieties/seeds or seedlings, fertilizer, and pesticide). Horticulture crop production especially vegetables is twice as labor-intensive as cereal production and yields ten times more revenue from land than cereals [31].

Consequently, ignoring the urban farming system should increase vegetable and fruit demand in this area at a high level compared to the rural area. This is due to the urban farming system that was not taken into consideration and much attention in the past research period. The global objective of this study was to analyze the factors influencing urban farming production, profitability, and contribution to the households' livelihoods. A case of Kigali city and Musanze district. While specific objectives were to assess the social economic factors influencing urban farming production in the study area; to identify the productive crops/vegetables/Spices and fruits grown in the study area; to identify the places/methods used to grow vegetables/species and fruits in the study area; to determine the profitability of using useless places inside fences for vegetables/fruits production; To determine the social-economic contribution of urban farming to household livelihood; to assess the constraints facing farmers in the development of urban farming in the study areas.

2. Materials and Methods

This research study was carried out in two urban cities namely Kigali and Musanze. Kigali is the capital and largest city of Rwanda. It is near the nation's geographic center. The city has been Rwanda's economic, cultural, and transport hub since it became its capital at independence in 1962. The city hosts the main residence and offices of the President of Rwanda and government ministries. The city is within the province of Kigali City, which was enlarged in January 2006, as part of local government reorganization in the country. Kigali's city limits cover the whole province; it is consolidated. The city's urban area covers about 70% of the municipal boundaries [18]. Kigali is located in the center of Rwanda, at 1°57'S 30°4'E at 1567m of elevation. The city is coterminous with the province of Kigali, one of the five provinces of Rwanda introduced in 2006 as part of a restructuring of local government in the country. The city has boundaries with the Northern, Eastern, and Southern provinces. The city is divided into three administrative districts Nyarugenge, which lies in the southwest, Kicukiro in the southeast, and Gasabo, which occupies the northern half of the city's territory. The total area of Kigali is 730 km² with a population density of 1,600/km². Kigali lies in a region of rolling hills with a series of valleys and ridges joined by steep slopes [33].

According to the 2012 Rwandan census, the population of Kigali was 1,132,686 with an urban population of 859,332. At the time of independence in 1962, Kigali had a population of 6,000, consisting primarily of those associated with the Bel-

gian colonial residency. The population exceeded 600,000 in 2002, and in the 2012 census had reached 1.13 million, with the boundaries of the city expanded. As of the 2012 census, 51.7 percent of residents were male and 48.3 percent were female [19].

Musanze is a city found in the Northern Province, of Rwanda. It is located at 1.50 latitude and 29.63 longitude and it is situated at elevation 1849 meters above sea level. Musanze is Rwanda's most mountainous district, containing the largest part of the Volcanoes National Park, and its head office at Kinigi. It is also in this district that most of Rwanda's mountain gorillas are found, making it the most popular tourist destination in the country. The district has two distinct zones and consequently related types of soils; one being a volcanic area with moderate slopes and volcanic ash soils with lava-predominant stones, the average altitude is 1860 m.

The other part comprises steep hills where erosion is active. Musanze District has a tropical climate of high altitude with an average temperature of 20 °C and rain that varies between 1400 mm and 1800 mm. The total area of the district is 530, 4 km² and it is divided into 15 sectors 68 cells, and 432 villages. In 2012, the total population was 368,563, and a gross density of 695 inhabitants per km². It has an average annual growth rate of 1.8% where Males stand at 174,760 and Females at 193,803 [18].

The population of interest for this research study constituted smallholder farmers of vegetables and fruits in Kigali and Musanze. The sampling unit was the garden household. A multistage sampling technique was employed involving purposive sampling of four districts namely Gasabo, Kicukiro, Nyarugenge, and Musanze. A purposive sampling of two sectors in each district making eight sectors was done. A sample frame of 1085 population and a sample size of 112 respondents were considered. The sample size was then proportionately scattered from eight sectors based on the proportion of population density of urban farming growers in the area.

Data collection was conducted during the period of December 2019 to March 2020. The study adopted a survey design for collecting primary data concerning farmers' socio-economic characteristics of urban producers in Kigali and Musanze cities using personally administered structured questionnaires and observation methods. The data included information on urban farming operations such as methods of farming, farming tools, type of vegetables and fruits grown, the impact of urban farming, quantities of seeds/seedlings, planting and topdressing fertilizer, manure, pesticides, fungicides, land area, and labor person-days and constraints of urban farming development in the study area. Additional data focused on household socio-economic and institutional characteristics such as gender, age, education level, farming experience, main occupation, household size, off-farm income, parcel size, land tenure (land owned, land rented), distance to the market, and price of produce at the market.

Descriptive analysis was done using SPSS version 20 and

regression using STATA version 13. The results were presented as descriptive statistics and an econometric model. The functional form of the production model employed for this study is the Cobb-Douglas functional form because the C-D form is usually fitted and highly restrictive for returns to scale and elasticities.

Econometric analysis was used to determine the factors influencing urban farming production and profitability in the study area. The regression results indicate the degree to which specific farm and household characteristics variables influence Kigali and Musanze city's urban farming. This study used tobit model for both the farm and household-specific factors regressed here include gender, age, education level, main occupation, and farming experience of the farmer; as well as farm size, off-farm income, distance to the market, household size, parcel size, and land tenure. The structural equation of the Tobit model is given as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_n X_n + \varepsilon \quad (1)$$

Where:

Y: Urban farming production

X₁-X_n: are the explanatory or independent variables

β₁-β_n: are parameters associated with the independent variables to be estimated

ε: is the independently distributed error term assumed to be normally distributed with a mean of zero and a constant variance.

3. Results and Discussions

3.1. Socio-Economic Characteristics of Surveyed Respondents

The demographic characteristics of the study area were considered in this section such as gender, age, education level, farm size, household size, and experience. This gave a detailed view of understanding the relationship between the variables in the study area.

Table 1. Socio-Economic Characteristics of Surveyed Respondents.

Variable	Frequency	Percentage (%)
Gender		
Male	58	51.78
Female	54	48.22
Total	112	100
Age		
Less than 35	11	9.82
36-45	33	29.46

Variable	Frequency	Percentage (%)
46-55	45	40.18
56-65	18	16.07
66 and above	5	4.47
Total	112	100
Education level		
No education	15	13.39
Primary	30	26.79
Secondary	42	37.5
University	25	22.32
Total	112	100
Family size		
4 and less	34	30.36
5 to 8	59	52.68
9 and above	19	16.96
Total	112	100
Marital status		
Single	21	18.64
Married	57	51
Widower	22	19.64
Divorced	12	10.72
Total	112	100

The majority of the farmers interviewed were male with 51.78% while females were 48.22%. The respondents interviewed 40.18% were in the range between 46-55 followed by 29.46% in the range between 36-45, followed by 16.07% in the range between 56-65 while the last class is in the range of 66, and above with 4.47%. Thus, findings revealed that a majority of the respondents interviewed were in the maturity ages.

The results indicated that out of the 112 respondents 52.68% had between 8-7 members of the household, followed by 30.36% with four or fewer members of the household and the last class is between nine and above members of the household with 16.96%. This shows that a vast majority of the respondents of more members of their family enabled farmers to engage more in agricultural production because of the labor force available in the household and the higher the members the higher consumption of vegetables and fruits, especially children and women who are more vulnerable to diseases.

Findings indicated that 37.5% of the respondents had attained secondary school, and 26.79% had attained primary school. While 22.32% of the respondents had achieved a university. These results indicate that the majority of 86.6% of

respondents attained formal education. While The no education, respondents were represented by 13.39%. Which may contribute to the poor application of urban areas farming. However, education is a significant factor in facilitating awareness and adoption of new or improved systems. A high level of education enhances understanding of instructions given and improves a farmer's level of participation in farming activities.

The findings indicated that 51% of respondents are married, followed by 19.64% representing the widower class, the third class is single with 18.64% while the last class is Divorced with 10.72%. Generally, the results from marital status indicated that the households that have children use urban farming more than those not have them.

3.2. Factors Influencing Urban Farming Production in Study Area

The results in table 2 indicate that ten factors over fourteen have a positive relation influence on urban farming production while four have a negative influence on urban farming production in study area. All variables were tested at three different levels of significance, which are 1%, 5%, and 10%. As a result, the overall model was significant and all the explanatory variables used in the model were collectively able to explain the urban farming production in the study area. According to the significance of variables, education level, parcel size, parcel, and ownership statistically significantly influenced urban farming production at 0.001%. The second class of variables such as gender, farming experience, and off farm, income significantly influenced urban farming production at 1%. While household size and type of crop grown significantly influenced urban farming production at 5% and 10% respectively.

Table 2. Tobit Regression of the Factors Influencing Urban Farming Production.

Variables	Coefficient	Standard Error	P-value
Age	0.026	0.040	0.473
Gender	0.041	0.025	0.007
Marital status	0.183	0.07	0.009
Household size	0.024	0.005	0.021
Parcel size	0.620	0.011	0.000
Parcel ownership	0.444	0.047	0.003
Parcel rented	-0.821	0.053	0.000
Type of crop grown	0.041	0.162	0.072
Period of crop maturity	-0.140	0.025	0.013
Farming experience	0.228	0.025	0.021

Variables	Coefficient	Standard Error	P-value
Education level	0.085	0.010	0.000
Off-farm income	0.043	0.019	0.017
Main occupation	-0.367	0.026	0.000
Proximity to the rural market	-0.066	0.045	0.000
Constant	0,748	0.145	0.1605
Number of observations = 112, Prob > F = 0.0000			
Log pseudo-likelihood = -41.77, Pseudo R ² = 0.8160			

As the results in Table 2 indicate ten factors over fourteen have a positive relation influence on urban farming production while four have a negative influence on urban farming production in the study area.

A large parcel holding led to an increase in urban farming production. This facilitates farmers to increase production for family consumption and market supply. This means that an increase of 1% in parcel size should increase urban farming production by 0.6%. The higher the parcel size the higher the different crops grown and the high production harvested.

An increase in the number of household members who provide farm labor by one person would increase urban farming production by 2.4%. Households with a high number of members working on the farm are more effective, given that household labor is the key source of labor supply and food consumption among smallholder households. Parcel ownership influenced urban farming production of vegetables and fruit crops. An increase in parcel ownership by 1% would increase the urban production by 0.4%. This means that the owner should grow different crops in different designs and technology both fixed and mobile more than parcel rented where the only accepted method is to use mobile technology and crops of the short-run period for maturity.

The vast majority of market gardeners, in most of the countries reviewed, operate on land they do not own, under a variety of temporary tenure arrangements or without title of any kind. They make their livelihoods within notoriously “fuzzy” systems of land ownership, with overlapping formal and traditional tenure rights, and rapidly changing land uses and values [11].

A reduction of distance by one kilometer to the proximity of the local market would reduce the urban production by 7%. This is because people to the nearest market always prefer to buy than to have other options reducing costs like urban farming production. The increase in education level by one year increases urban farming production by 8.5%. Normally educated household heads are expected to understand new technologies in a shorter period and implement the technology than those with poor education. It was supported by Veenhuizen [27] showed that Urban farming is, with exceptions,

oriented to close-by urban markets rather than national or global markets. Proximity to the market predisposes crop selection to perishable products for which urban farmers have a competitive edge over rural farmers by being able to deliver fresh products to consumers. Urban farming also normally involves fewer middlemen between farmer and consumer than rural agriculture, and the transportation and storage needs of urban produce are much lower. Purchasing food that is locally grown decreases energy needs and costs associated with long-distance travel and refrigeration. Fruits and vegetables shipped between states can spend 7-14 days in transit. Nearly 50% of food is lost before it ever hits the shelves [29]. Because of this, most varieties of produce sold in stores are selected based on their ability to handle extended travel. Growing locally would allow for greater varieties of crops that are selected for their taste and nutritional qualities rather than their shelf lives [29].

Growing poverty, hunger, and lack of formal employment opportunities, as well as the special opportunities provided by the city including the growing demand for food, proximity to markets, and availability of cheap resources such as urban organic wastes and wastewater have stimulated the development of diverse agricultural production systems in and around Cities [4].

Off-farm income has a positive and significant influence on urban farming production at a 1% level. In the study for example income from other activities increases capital for the farmer to purchase agricultural inputs such seeds/seedlings, fertilizer, pesticides, and other materials used in urban farming like containers, pallets, baskets, boxes, and poles as well as hiring labor for construction and technology installation. This was supported by A study conducted in Ghana that found that production loans had a greater positive impact on gardeners' earnings than age, years of schooling, gender, household size, or number of agricultural extension visits. However, insecure land tenure not only stifles vegetable growers' capacity to build up working capital; without land title, they have virtually nothing to offer financial institutions as collateral. Women, who face higher legal barriers to land ownership, are particularly disadvantaged [11].

The marital status of the household head positively and significantly influenced urban farming production in the study area. Married people are more willing to understand and adopt urban farming than singles because married people are more likely to have more family members and children who require more care of food containing vegetables and fruits than singles. This task obliges married people to be interested in urban farming to reduce food security and control malnutrition. Farming experience has a positive influence on urban farming production. This is because more experienced household heads are expected to understand new technologies in a shorter period and implement the technology than inexperienced farmers. One study in the Netherlands showed that participants of all age categories experienced health benefits and that older participants experienced the greatest benefits

[25].

The period of crop maturity was significantly at 1% and negatively influenced urban farming production in the study area. This implies that an increase in the period of crop maturity reduces the production of urban farming. The lower the period of maturity and harvesting, the more adoption and production of crops grown in urban areas, especially vegetables and fruits. The results were supported by FAO [9] that horticultural species have considerable yield potential and can provide up to 50 kg of fresh produce per square meter per year, depending upon the technology applied. In addition, due to their short production cycle, they provide a quick response to emergency food needs several species can be harvested 60 to 90 days after planting. The physical and mental health of residents would improve with access to more nutritious food and opportunities for exercise associated with gardening. Gardening 3-4 times per week has the same health benefits as moderate walking or moderate bi-cycling [29].

This was supported by FAO [13] showed that very short intervals between crop cycles and the repeated sowing of solanaceous crops, such as tomatoes, peppers, and eggplants, lead to higher adoption of urban farming but also incidence of pest infestations and soil-borne diseases. High planting densities also encourage pest upsurges and fungal diseases.

3.3. Productive Fruits Grown in the Urban Gardens in the Study Area

Fruits are trees, which bear fruit that is consumed or used by humans and some animals. All trees that are flowering plants produce fruit, which are the ripened ovaries of flowers con-

taining one or more seeds. Botanically speaking, a fruit is a seed-bearing structure that develops from the ovary of a flowering plant, whereas vegetables are all other plant parts, such as roots, leaves, and stems. In horticultural usage, the term 'fruit tree' is limited to those that provide fruit for human food. In common language usage, "fruit" normally means the fleshy seed-associated structures of a plant that are sweet or sour, and edible in the raw state, such as apples, bananas, grapes, lemons, oranges, and strawberries. Fruits can be eaten raw, frozen, stewed, cooked, or dried. All fruits may be classified into three major groups: simple, aggregate, or multiple. The figure below indicates the fruits grown in the study area.

In study areas, different productive fruits grown are classified into five classes. The first class is occupied by avocados and bananas followed by orange, citrus, and guava in second class. The third class is occupied by mango, papaya, and Tamarillo (Cythomandra betacea/Solanum betaceum) while apple, strawberry, and gooseberry occupy the fourth class. Both two types of passion fruit (yellow and brown) occupy the fourth class. The results showed that avocados and bananas are preferable and best grown in the study area due to their productivity and income in the long run. The respondents indicated that they prefer these two crops because they require lower inputs and labor force for maintenance than other crops. They indicated that a grafted avocado tree requires a small space and a short time to attain the maturity and harvesting stage. Its production does not require even the regional or international market for income generation. These fruits are mainly grown for food security, malnutrition control, income generation, and other roles provided to the household.

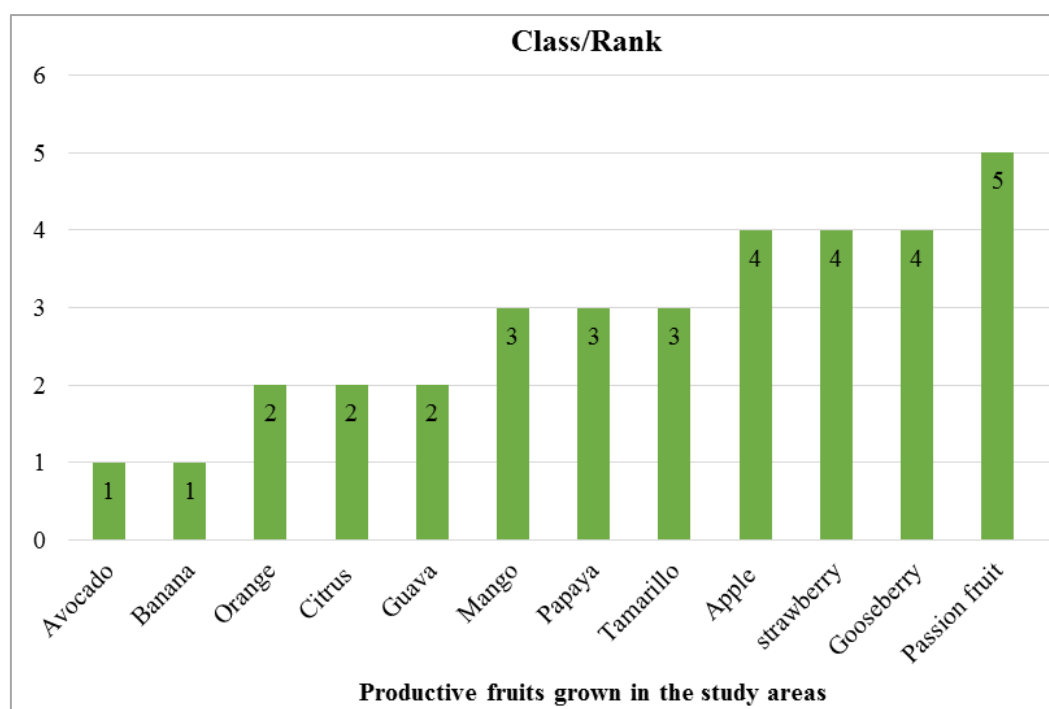


Figure 1. The productive fruits are grown in the study areas.

3.4. Productive Vegetables/Spices Grown in the Study Areas

Vegetables are parts of plants that are consumed by humans or other animals as food. In common, narrow usage, the term vegetables usually refers to the fresh edible portions of certain herbaceous plants' roots, stems, leaves, flowers, fruit, or seeds. Vegetables can be eaten either raw or cooked and play an important role in human nutrition, being mostly low in fat and carbohydrates, but high in vitamins, minerals, and dietary fiber. Many nutritionists encourage people to consume plenty of fruit and vegetables, five or more portions a day often being recommended rather than a sweet, dish. The scale of production varies from subsistence farmers supplying the needs of their families for food to agribusinesses with vast acreages of single-product crops.

In study areas, different productive vegetables/spices grown are classified into six classes. The first class is occupied by amaranths, cabbage, onion, and spinach followed by cucumber pepper, tomato, and carrot in second class. Beetroot, lettuce, rosemary, lemon grass, and celery occupy the third class while eggplant and French beans and eggplant occupy the fourth class. The fifth class is occupied by black nightshade and cau-

liflower. The results indicated that the vegetables of the first class are 100% more preferable and the best vegetables grown by all surveyed households in the study area due to their main daily home food consumption, short time to attain maturity stage, and harvesting period. The surveyed respondents indicated that they prefer to grow vegetables and spices because those require small spaces/places even containers for example baskets, bags, pallets, shelves, arches, fences, boxes, old car wheels, and so on. Its production also does not require even the regional or international market for income generation because the local market is enough for the produced quantity. Those vegetables and spices like fruits are mainly grown for food security, malnutrition control, sometimes for income generation, and other roles provided to the household. Leafy vegetables provide a quick return that helps families meet their daily cash requirements for purchasing food. Urban production has another advantage for household livelihood. Leafy vegetables are particularly perishable and post-harvest losses can be reduced significantly when production is located close to consumers. Urban producers also achieve real efficiencies by making productive use of under-utilized resources, such as vacant land, treated wastewater and recycled waste, and unemployed labor [9].

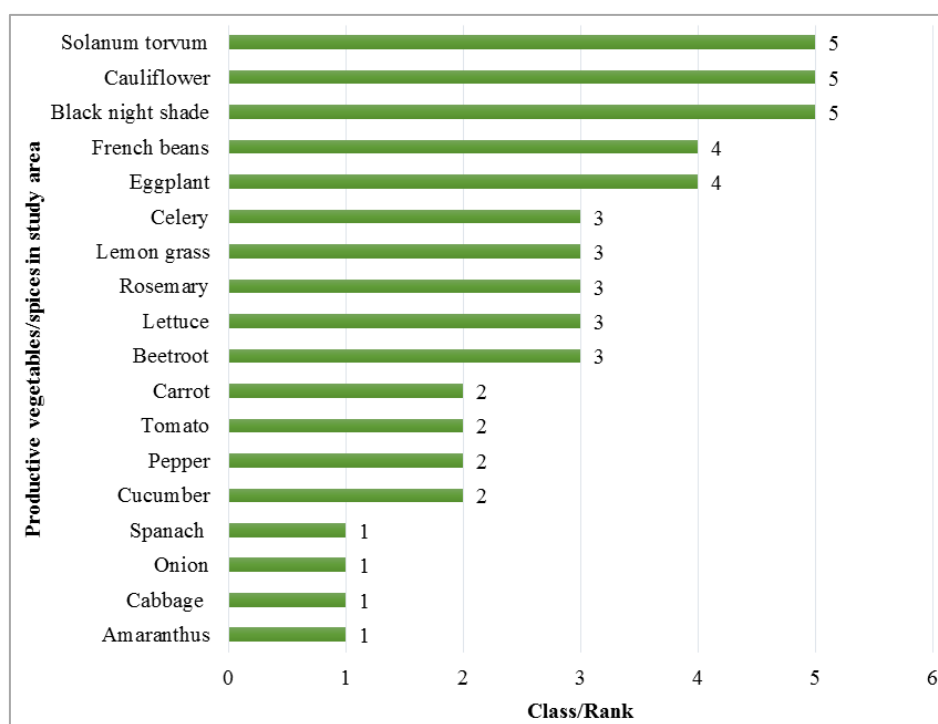


Figure 2. The productive vegetables/spices grown in the study areas.

3.5. Best Methods and Places to Grow Vegetables and Fruits in the Urban Farming

Urban agriculture, urban farming, or urban gardening is the

practice of cultivating, processing in addition, and distributing food in or around urban areas. Horticultural species have considerable yield potential and can provide up to 50 kg of fresh produce per square meter per year, depending upon the technology applied. In addition, due to their short production

cycle, they provide a quick response to emergency food needs. Leafy vegetables provide a quick return that helps families meet their daily cash requirements for purchasing food and other daily needs. Various cultural practices are more important for achieving the highest possible yields. Measures taken to increase stands include improvements of soil, cultural

practices, methods of farming, materials/tools, proper places for farming, and use of chemical and biological fertilizers and certified seed/seedlings. Those factors can be taken into consideration to maximize yields both in quality and quantity of fruits and vegetable crops grown in urban farming.

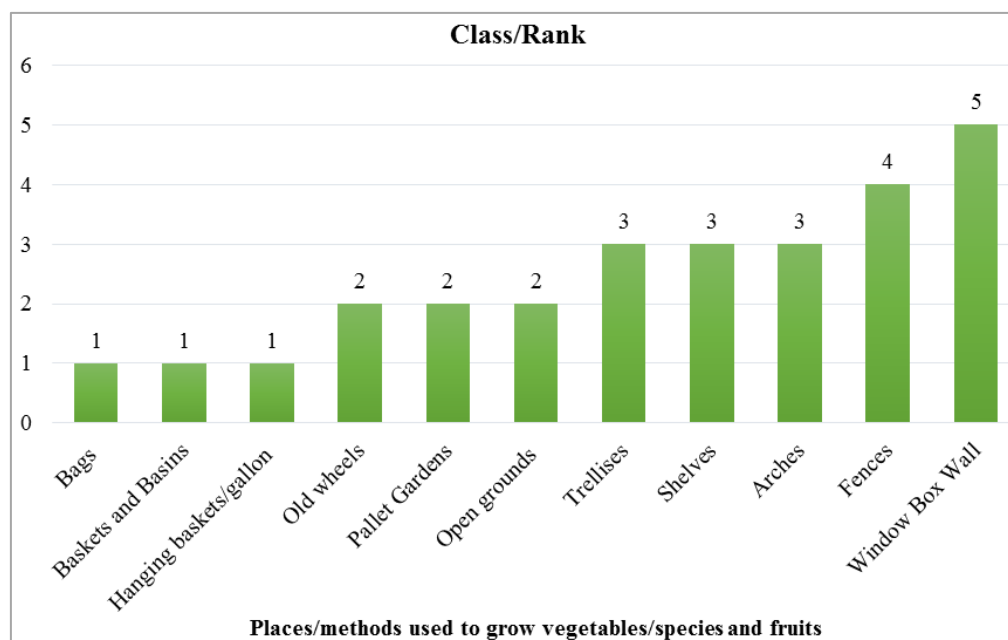


Figure 3. Best methods and places/tools to grow vegetables and fruits in study areas.

In study areas, different places/methods used to grow vegetables/species and fruits are classified or ranked in fourth classes. The first class is occupied by the respondents who grew those crops in bags; baskets basins; and hanging baskets where amaranths, onions species, cabbages, spinach, pepper, tomato, carrot, beetroots, some spices, and straw belly were the best crops grown in those spaces or those methods. Farmers cultivating those crops in old wheels, pallet gardens, and open ground occupy the second class where most of all vegetables/spices and fruits should be ground there, especially in the open ground place. Trellises, arches, and shelves occupy the third class of places or methods used by farmers in urban farming in the study area. Trellises, arches methods, or places are more suitable for climbing crops such as beans, peas, tomatoes, cucurbitaceous species, and passion fruits. The shelf is also in the third class and it is suitable mainly for spinach, cabbage, onions, and some spices. Fence wall places/methods occupy the fourth class followed by window boxes occupying the fifth class. For these two last places or methods, the results indicated that the climbing crops example beans and passion fruits are the most suitable crops for fence place methods while the straw belly crop is the most suitable crop for window box walls. This study was supported by Mogk, J. E *et al.*, [16] said that urban farming could be practiced on land of any size or shape making it a land use type that can easily be adapted on underutilized lands, such as vacant

lands that are often unsuitable for other purposes because they are small and irregular in shape. Furthermore, urban farming can be practiced on floodplains and land with earthquake risks [3].

It was also supported by FAO [10] indicated that micro-gardens are highly productive and can be easily managed by anyone women, men, children, the elderly, and the disabled. Where no land is available, vegetables can be planted in a container filled with garden soil or a “substrate” made from local materials, such as peanut shells, coconut fiber, rice husks, coarse sand, or laterite. If substrates are unavailable, there is another option: growing the vegetables on water enriched with a soluble fertilizer. The findings were supported by the study of Veenhuizen [27] revealed that urban farming is intensive and makes the best use of space, with a predominance of shorter-cycle, higher-value market commodities. It employs multi-cropping and integrated farming techniques and makes judicious use of both horizontal and vertical space through such techniques as chicken coops on shelves, multi-species fishponds, and container farming.

3.6. Economic Analysis of Profitability of Five Vegetables and One Fruit Tree

Profit is one of the many factors influencing farmers to decide to invest in any business including agribusiness especially opti-

imum yield and high get price. The yield of any crop farming or cultivation depends on several key factors such as the variety, plant age, soil type, and climate conditions along with the farm management skills Practiced for the cultivation. However, on average, it is possible to obtain optimum production per unit area

of the plantation on the main field used. Table 3 indicates the profitability of urban farming production of five vegetables and one fruit tree in nineteen (18) basins/bags/sacks of the same measures of diameter disposed to 2,88m².

Table 3. Profitability Analysis of Five Vegetables and One Fruit Tree Production/Year.

Name of crop	Area (m ²)	Number/area	Production/Kg/bundle/fruit	Farm get price	Gross margin/Year
Grafted avocado	2.26	1	450	75	33,750
Tomato	2.26	16	96	250	24,000
Amaranths	2.26	54	216	100	21,600
Peppers	2.26	16	32	600	19,200
Peas	2.26	56	1.2	1500	1,800
Solanum torvum	2.26	2	4	750	3,000

The results in Table 3 above showed that different crops should be grown at one site at different times or at the same time each crop in its basin/bag or sack of 0.1256m². The results revealed that the crops do well in small areas/places closed inside the household's fences. For example, at 2,26 m² a farmer should gain 33,750 Rwf from a grafted avocado tree while 16 indeterminate tomatoes give 24,000 Rwf compared with 21600 Rwf from 54 amaranths. With this method of farming, a farmer should gain 19,200Rwf from 16 peppers compared with 1,800Rwf from peas (*Pisum sativum*). The results were supported by studies carried out in Senegal found that around 35% of produce is kept for home consumption, while the rest is sold. Typical income from a family micro garden of 10m² ranges from US\$15 to US\$30 a month [10]. Leafy vegetables, tubers, and herbs grown in simple containers help low-income families meet their daily needs for fresh, nutritious produce.

By comparing crops gross margin, it has been found that avocado, tomato, amaranths, peppers, Solanum torvum and peas, and do well in small areas/places closed inside the household's fences respectively. This means that horticulture crops are more profitable than other crops example maize. This implies that the best use of small areas/places closed inside the household's fences is the best way of improving and increasing the quality and quantity of urban farming production of fruits and vegetables/spices in study areas. Economically speaking this will significantly contribute to household food security, malnutrition control, and hunger eradication in the study area. Maintaining regional and local farm-to-consumer enterprises helps keep the entire industry

accountable for the food system, increasing the likelihood that food is produced and consumed in sustainable ways and helps support the local economy.

It was also supported by the study Horticulture provides livelihoods that are resilient to economic downturns, and it contributes to cities' economic development. Being labor intensive, market gardening creates employment directly in production by one calculation, one job for every 110 m² as well as in input supply, marketing, and value-addition. Horticulture employs around 150,000 people in Hanoi [11].

3.7. Social Economic Contribution of Urban Farming Production on Household Livelihood

Urban farming production particularly horticulture crops contributes more to food security, nutrition, and livelihoods in a combination of ways providing for family self-consumption, thus contributing to a healthy diet and allowing for saving on food expenditures. Providing a source of income, through the sale of surplus or specialized and intensified commercial-oriented production systems. Improving the supply of local markets with fresh and micronutrient-rich foods at competitive prices, ensuring a continuum of tree cover through landscape management and use of agroforestry systems, hedgerows, and woodlots. The social economic contribution of urban farming production is indicated in Figure 4 below.

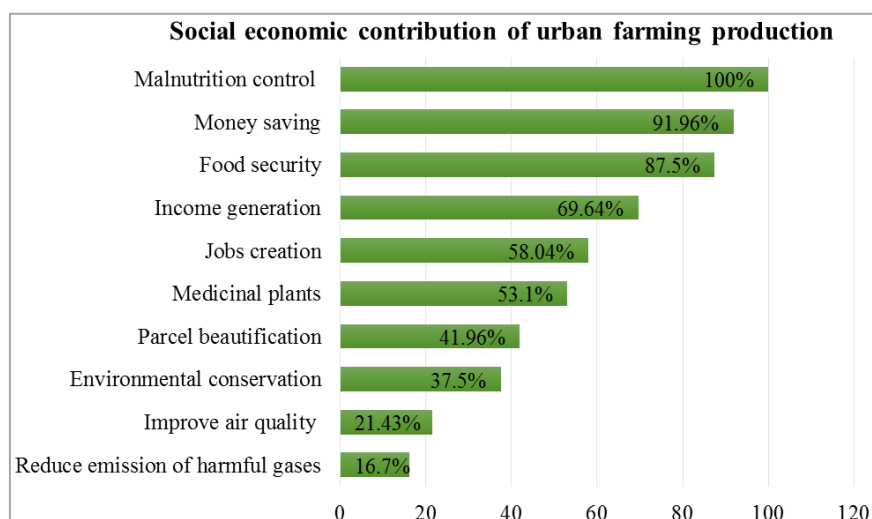


Figure 4. The social-economic contribution of urban farming production in the study area.

Urban farming is a very important resource for household income generation and socio-cultural and nutritional requirements. The most crucial role of this activity is the provision of edible parts, as a source of daily consumption, good nutrition, and money. This is because urban farming production and products are the easiest to convert into cash used to settle basic needs at the household level, such as salt, sugar, soap, paraffin, cooking oil, and sometimes house utensils, as well as other personal expenses. The results from surveyed respondents indicated that urban farming production mostly contributed socially and economically to different sectors such as malnutrition control, money saving, food security, income generation, job creation, parcel beautification, environmental conservation, improved air quality, and reduced emission of harmful gases. The results were supported by Dickson Kibata Githugunyi [4] showed that Agriculture is only a part of diverse livelihoods in the study area, while still providing a significant contribution to food security, income, and employment. Otherwise formal employment, business, and casual employment tend to dominate. For most of the households interviewed, agriculture contributes to food security and income generation. This illustrates the importance of local food production not only as a direct food source for enhancing food security but also as a means of saving income for other purposes.

The current study contrasted with the study of Dickson Kibata Githugunyi [4] indicated that Urban farming may pollute the environment through the use of agrochemicals and leaching of animal excreta, as well as increase the habitat for certain disease-carrying vectors. Heavy metals and pathogens can be harmful if consumed by humans because plants grown in cities may pick them up from the soil, air, or water and transmit them to consumers. His study showed that livestock can introduce vital micronutrients into local food systems; they also can be the source of disease affecting humans. As well as being pathways for micronutrients, horticultural crops are also potential pathways for biological and chemical contaminants, negatively affecting the health of the urban eco-

system, including human health [4].

The results of the current study showed that 100% of respondents reported that the production of urban farming controlled malnutrition in the study area. This showed that these farmers would easily compare the benefits of using available areas or spaces in urban farming rather than planting palm trees or having cemented grounds. This was supported by FAO [10] said that low-income families master micro-garden technology very quickly. Micro-gardens allow low-income families to meet their needs for vitamins, minerals, and plant protein by providing direct access to fresh, nutritious vegetables every day.

It was also supported by FAO [10] reported that eating at least 400 g of fresh fruit and vegetables a day helps to alleviate micronutrient deficiencies and prevent chronic diseases associated with unhealthy urban diets and lifestyles. FAO also supports action to help low-income urban households to “grow their own”, as a way of improving the quality of their diet, saving cash to spend on other needs, and earning income from the sale of surpluses.

About 91.96% of respondents revealed that urban farming contributed to money saving and 87.8% to food security. This showed that farmers practicing urban farming in the study area save money that should be used to buy vegetables or fruits as well as spices. Urban farming contributed to the livelihoods of the respondents in several ways. These were economic, social as well as ecological [24]. The implementation of urban farming showed the economic improvement in the livelihood of different households. Urban farming has already been proven to address many urban challenges (such as food security, access to fresh food, resilience, dietary diversity, nutrition intake, social inclusion, heat island effect, and a source of income for urban poor [28].

This was confirmed by the majority of respondents indicating that about 69.64% and 58.04% of urban farming production economically contributed to income generation and job creation respectively. The findings were supported by

Anastasia Calhoun [1] showed that urban farming can provide numerous economic benefits to a community. In addition to the obvious reduction in food costs, it can provide opportunities for entrepreneurship and create local jobs. The full economic potential of urban agriculture becomes apparent when considering the possibilities for regional food connections.

About 53.1% of respondents indicated that they cultivate some vegetables and fruits in their home garden as medicinal plants like *solanum torvum* (Inkarishya/inyinya) to control different diseases and the improvement of digestion as a social economic contribution to the household's livelihood. This was in the same agreement of Van Veenhuizen, R.; Danso, G. [26] showed that an increased intake of fresh fruits and vegetables from urban farming has been linked to the prevention of cardiovascular diseases, cancer, and other dietary-related health problems.

The results from respondents showed that urban farming improved the nature of the study area where about 41.96% and 37.5% respectively contributed to parcel beautification and environmental conservation. This was supported by one study in New York City found that participation in community-supported agriculture increased people's vegetable consumption, induced positive changes in dietary patterns, and increased consumption of seasonal, local foods [30]. One study in the Netherlands showed that participants of all age categories experienced health benefits and that older participants experienced the greatest benefits [25]. Urban food planning can help to secure food on a local scale and to create greener cities [20].

The results from surveyed respondents indicated that urban farming contributed to the atmosphere control. This was supported by Anastasia Calhoun. [1] indicated that the benefits to the environment and society offered by urban agriculture are just as numerous as the many physical forms it can take. An increase in green spaces results in cleaner air, lower summer temperatures, humidity regulation, and the reduction of greenhouse gases. It also provides noise filtering and promotes biodiversity. Urban agriculture can use its waste and that of its community to create more food through the composting of organic matter and processing of grey water. The ability to

influence their immediate environments creates a sense of empowerment in individuals, which can also help to reduce stress and anger. Green spaces create a sense of community by providing a place for social gatherings. In general, when the food security of a community increases, crime, health care costs, and requirements for city services decrease [29].

This is because 21.43% and 16.7% of respondents said that urban farming contributed to the improvement of air quality and reduction of emission of harmful gases mainly increased by human activities example cars, industries, factories, and so on. By purification or the creation of oxygen from vegetables and fruit trees cultivated, these two last parts of urban farming contribution are significantly possible. This was supported by Drescher [6] revealed that urban farming may help to solve some of the problems of city authorities through integrated programs of wastewater reuse and organic waste recycling, as well as through the integration of market wastes with urban fodder consumption.

In this context, urban farming has been discussed as one source of disaster and pandemic diseases like COVID-19 preparation food. Although current emergency food fulfills its purpose of providing sufficient energy, urban farming can help to provide nutrients lacking in post-disaster and pandemic disease situations.

3.8. Constraints of Urban Farming Development in the Study Areas

Small-scale farm producers dominate agriculture in Rwanda as in most other developing countries. However, agricultural technology for the small-scale farmer must be enhanced to improve and increase agricultural productivity through the important use of all possible areas that are currently unproductive and closed inside the household's fences. Despite the key role horticulture crops play in food security and income generation in the study area throughout the whole country, the development of urban farming production fluctuates and its yields decline significantly. The main constraints of urban farming development are indicated in the figure below:

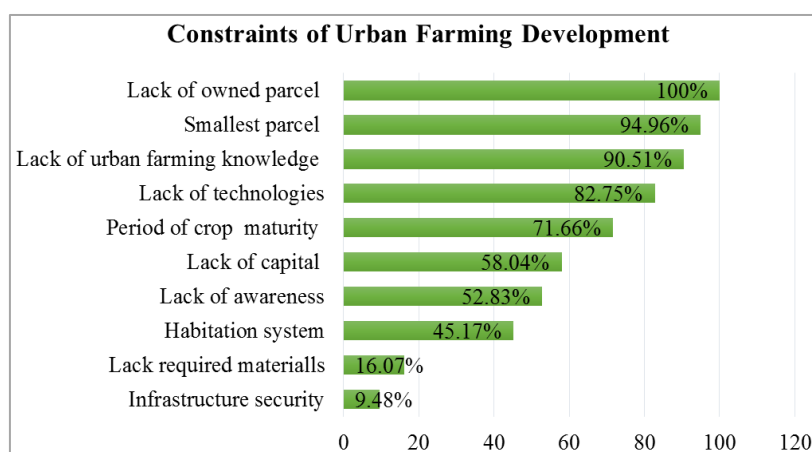


Figure 5. Constraints of urban farming development in the study areas.

About 100% of respondents indicated the lack of owned parcels as the main challenge of urban farming development in the study area. Most respondents 94.96% indicated that they did not practice urban farming due to the smallest parcel owned. The results were supported by the study of Anastasia Calhoun [1] reported the many obstacles and potential criticisms involved in urban farming do not own the land they use to grow food. He indicated that without title or long-term leases, they run the risk of losing their investments and Start-up costs could be prohibitive for people on limited incomes. Often community gardens are directed at these same people.

The findings are supported by Drechsel [5] reported that a major challenge to the viability of urban farming is land availability coupled with water access. Urban farming is influenced by rapidly changing land rights, uses, and values. To urban, and even some peri-urban farmers steady access to land, at affordable prices, is almost unknown. Looming over many urban farmers, both men and women is the constant threat of losing access to their plots and being forced to stop production activities. In many areas, non-farming households' inability to access land in the city is the major reason given for not farming.

More than 90.51% of the respondents reported that they have problems with a lack of urban farming knowledge to achieve the optimum yield per area cultivated. Extension agents play vital roles in disseminating information on new technologies and good agronomic practices for capacity enhancement to the farmers. In this study area, 82.75% of respondents showed that lack of technologies is one of the main challenges of urban farming development due to the high cost of materials used for construction or installation. This was supported by Anastasia Calhoun [1] revealed that in many climates, food production is not always viable as a year-round source of food security. Small-scale and sustainable farming techniques are too expensive.

The increasing use of synthetic pesticides in African market gardens is linked to poor cultivation practices. However, public extension systems in most African countries have long been in decline. In many, NGOs employ more extensionists than the Ministry of Agriculture [11]. About 71.66% of respondents identified the period of crop maturity as one of the constraints of urban farming in the study area. This means that, the longer the period of crop maturity, the lower the choice of farmer of that crop in urban farming, particularly fruit tree crops.

Lack of capital was also indicated among the constraints identified by the respondents in the study area (Figure 5). About 58.04% of surveyed respondents reported a lack of capital in households among other challenges met by farmers in the study area. This could be the limiting factor for producers to afford inputs such as fertilizers, improved seeds, and agrochemicals to achieve maximum production and productivity. The study by Dickson Kibata Githugunyi [4] reported

that the majority of the respondents that lack of Government support, inadequate land inadequate rainfall, lack of farming technology, environmental pollution, food safety, conflict with neighbors, high costs of farm inputs and animal diseases.

Lack of awareness and habitation systems were identified among the challenges by 52.83% and 47.17% respectively in the study area. Lack of awareness is a more critical challenge of urban farming development because, in the study area, the results showed that 100% of respondents should use one of the identified methods/places to grow vegetables/spices (figure 3). Lack of awareness is the constraint where some people choose to make their grounds with cement or plant inedible trees like palms or others rather than plant fruit trees that help to reduce household consumption costs.

Lack of required materials and inputs was identified among the challenges. Around 16.07% of respondents revealed that the lack of required materials limits urban farming development in the study area. FAO [11] showed that the productivity of market gardening is held back by the general unavailability of certified seeds of improved crop varieties. In sub-Saharan Africa, government programs for breeding improved vegetable and fruit varieties are practically non-existent.

Infrastructure security was also identified as a constraint to the development of urban farming in the study area. It was supported by [11] reported that providing city-dwellers with fresh food is difficult, especially in sub-Saharan countries: popular vegetables, such as amaranth, sorrel, lettuce, and tomato, start to spoil within a few days of harvesting. The poor state of roads leads to heavy losses of produce in transit from rural areas.

About 9.48% of respondents indicated that poles of electricity and wires are the main challenges to growing some fruit trees like avocado, mango, and papaya that can cause an accident during heavy rain and wind when they are damaged by those.

4. Conclusion and Recommendations

The majority of the respondents interviewed were male compared to female. The majority of respondents interviewed were in the range between 46-55 ages. The results from the study indicated that ten factors over fourteen have a positive relation influence on urban farming production while four have a negative influence on urban farming production in study area. The results also showed that the best productive fruits grown are classified into five classes shown in Figure 1. These fruits are avocado, banana, orange, citrus, guava, mango, papaya, Tamarillo (*Cyhomandra betacea/Solanum betaceum*) apple, strawberry, gooseberry, and passion fruits. The best productive vegetables/spices grown are amaranths, cabbage, onion, spinach cucumber pepper, tomato, carrot, beetroot, lettuce, rosemary, lemon grass, celery eggplant, French beans, eggplant, black nightshade, and cauliflower.

The results of the study revealed different places/methods

used to grow vegetables/species and fruits such as bags, baskets and basins, hanging baskets, old wheels, pallet gardens, open ground, trellises, arches, shelves, fences window box walls. The results displayed that the crops do well in small areas/places closed inside the household's fences where a farmer should gain 25000 Rwf from one grafted avocado tree or 23400Rwf from 18 tomatoes at 2,26 m² area or in containers like bags/sacks/basins in six months.

The results proved that urban farming contributed to the social economy through different parts, particularly malnutrition control, money saving, food security, income generation, jobs creation, medicine production, parcel beautification, environmental conservation, improvement of air quality, and reduction of emission of harmful gases. The results pointed out that different constraints such as lack of owned parcel, small owned parcel, lack of urban farming knowledge, lack of technologies, period of crop maturity, lack of capital, lack of awareness, habitation system, and infrastructures like poles of electricity and wires.

Based on the conclusion, the following recommendations are suggested to increase urban farming production and sustainability in the study area.

The results showed that many areas/spaces inside closed household fences are not used in agriculture production because of lack of awareness while some crops do well and give profitability if used appropriately. People should be encouraged to grow fruits and vegetables, especially indeterminants example amaranths, tomatoes, peppers, limom grass, and avocado fruit in unusable places rather than to grow palm trees or make big grounds with cement.

Urban farming production contributed socially and economically to malnutrition control, money saving, food security, income generation, and job creation. The government should develop a system that should be more efficient in building skills and capacity of farmers resulting in high yield both in agricultural and economic models.

As the results indicated, urban farming production and development were constrained by small parcels, lack of technologies, period of crop maturity, and lack of capital, habitation system, and infrastructures in study areas. Government through local government leaders and agronomists should enhance/encourage urban farming production by use of different methods example bags, basins, baskets, old wheels, pallet gardens, small open grounds, trellises, arches, shelves, fences window box walls, because they don't require big parcels and high technologies to give good production.

Urban farming production provides livelihoods that are resilient to economic downturns, and it contributes to cities' economic development. Being labor intensive, market gardening creates employment directly in production through input supply, marketing, and value-addition. However, the policy makers for city and town planning should enhance and consider this sector for sustainable livelihoods.

Urban farming uses recycled urban waste as a productive resource. In cities, treated wastewater from households pro-

vides over 75% of the irrigation water for urban vegetables. Urban farming creates green belts, which build resilience to climate change; by reducing the need to transport produce from rural areas, it generates fuel savings and less air pollution; it can even lower city temperatures. Therefore, people should be encouraged to do that as a professional activity to have a safe, clean environment.

Developing a sustainable urban farming horticulture sector calls for innovative approaches to urban development. All city habitants should be encouraged and supported to incorporate horticulture crops into their urban planning as well as have enough quantity fruits and vegetables that should be supplied from the cities and towns rather than depending on that from rural areas and or rural markets.

Fruits and vegetable gardens provide low-income groups with food, income, and a focus for shared enterprise, which helps to build healthier, more stable communities. Gardening offers a constructive channel for young people's energy. Many types of urban agriculture can be mobile or require little investment. These types are well suited for short-term or more uncertain leases as well as healthy communities.

The price tag on industrially processed foods does not reflect the added costs of environmental cleanup and healthcare. Growing own food organically from urban gardens is less expensive than buying individually produced foods at retail prices. Therefore, growing food in a sustainable space found inside the household fences should be the best way to decrease the overall cost of living in cities and towns.

Keeping home gardens productive is also simple. They can be fertilized regularly, at no cost, with compost produced from household organic waste. Pests are controlled by non-chemical means, including small modern traps, insect-proof nets, and intercropping with aromatic herbs that naturally repel insects, such as basil, garlic, onion, parsley, and mint.

To be successful, home gardening programs should establish, at the outset, a training and demonstration center, and identify local sources of inputs, such as containers, seeds, substrates, and fertilizer to facilitate urban farming more understandable, productively, and profitably.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Some Pictures of Urban Farming in Different Containers



Figure A1. Bags.



Figure A2. Basins.



Figure A3. Baskets and old wheels.



Figure A4. Hanging baskets.



Figure A5. Trellises.



Figure A6. Shelves.



Figure A7. Arches.



Figure A8. Fences.



Figure A9. Pallet Gardens.



Figure A10. Window Box Wall.



Figure A11. Open ground garden.

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