Multi-functional Environmental and Social-economic Benefits of Fruit Trees on Vulnerable Urban Steep Slopes and Informal Settlements: A case of Biryogo Primary School Kigali, Rwanda

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DECLARATION

I hereby confirm that I prepared this thesis independently and by exclusive reliance on literature or tools indicated herein.

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ABSTRACT

The purpose of this study is to develop strategies that could guide the implementation and management of fruit trees on vulnerable urban steep slopes and informal settlements. Policy documents, articles, observation, and interview were the major data collection sources. The study was conducted with a structured interview guide administered to fifteen experts namely, heads of farm groups, government agencies, departments, local government and NGOs. The results were analyzed using thematic analysis to establish the different fruit trees species suitable for urban farms and school gardens, benefits, policy and implementing challenges of fruit trees. Additionally, SWOT analysis was used to understand the strength, weaknesses, opportunity and threat for the implementation of fruit tree-based learning garden at Biryogo primary school. This study revealed that although most of the local people are aware of the social-economic benefits of fruit trees, the awareness on environmental benefits was very low. Moreover, the major fruit trees species that can thrive in Rwandan urban farms and school gardens are mango, avocado and oranges. Whereas few respondents mentioned that fruit trees can stabilize vulnerable steep slopes, all respondents agreed on the need to promote fruit tree planting for landscape management. The implementation of fruit trees is challenged due to lack of interest, information and inadequate stakeholders' participation. Therefore, this study recommended solution to address and promote fruit tree growing and school learning gardens at the national and local level - Biryogo primary school. The study will provide guidelines for a successful implementation and sustainability of a school gardening program to government, private and NGOs.

Key words

Environment, Fruit Trees, Informal Settlements, Multi-functional benefits, Rwanda.

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LIST OF ABBREVIATIONS AND ACRONYMS

FAO	Food and Agriculture Organization
FGD	Focused Group Discussion
GDP	Gross Domestic Product
IFT	Indigenous Fruit Tree
MIDIMAR	Ministry of Disaster Management and Refugees
MINAGRI	Ministry of Agriculture and Animal Resource
MINIRENA	Rwanda Ministry of National Resource Authority
MINIRWA	Ministry of Food and Agriculture
NAEB	National Agricultural Export Board
NARO	National Agricultural Research Organization
NGO	Non-Government Organization
PRA	Participatory Research Approach
RAB	Rwanda Agricultural Board
RECOR	Rwanda Environmental Conservation Organization
REDD	Reducing Emissions from Deforestation and Forest Degradation,
REMA	Rwanda Environmental Management Authority
SWOT	Strength Weakness Opportunities Threat
UN	United Nations
UR	University of Rwanda
WHO	World Health Organization
WRM	Water Resource Management

1 INTRODUCTION

1.1 Background

Globally, man has a great impact on slope stability due to different human activities such as forest roads or footpaths, housing constructions, farming, and deforestation among others. In Rwanda, hill slopes are mostly affected by mass movement, gully incision or both (Moeyersons, 2003). Rwanda has one of the African most population densities, slopes, and rainfall. It is commonly referred to as "land of 1,000 hills" (Kabeza et al., 2012). At the national level, tree planting campaigns and policies have been implemented. Therefore, afforestation and reforestation are used as landscape management to stabilize and enhance slopes for a sustainable land use.

In Africa, various tropical fruit trees have high root intensity and capacity to bind soil particles together (Awodoyin et al., 2015). Fruit tree-based agroforestry designs have the capacity to mitigate climate change, by considering food security and livelihood necessities for both small and large-scale farmers (Syampugani et al., 2010). However, fruit trees have been barely considered in the multiplicity of agroforestry systems and practical tool guidelines by different African governments and environmental management authorities. Fruit trees have great influence such as, direct environmental and social-economic benefits at household, regional and national level (Kassa, 2014). Furthermore, different development priority and policy settings in agroforestry indicate that fruit trees have little received attention (Bucagu et al., 2012). The economic gains and adaptation factors of fruit-based agroforestry systems have been modestly researched in Rwanda (Bucagu et al., 2012).

Rwanda has implicated various number of policies to govern environmental management which include the following: Rwanda environmental law; biodiversity policy; land policy; forestry policy; water and sanitation; geology and mine policy; environment and natural resources sector, 2013-2018 a five year strategy; water resource management national policy; environment and climate change sub-sector strategic plan 2013–2018; national strategy and policy for water supply and sanitation services and wildlife policy (REMA, 2015).

On the other hand, there laws that govern social-economic sectors for promotion of a sustainable and low-carbon development (REMA, 2015) they include: forestry law; land law; biodiversity law; water law; mining law; guidelines for strategic environmental assessment and environmental impact assessment (REMA, 2015). In addition, Rwanda is famously known world-wide for her law since 2008 on prohibition of plastic bags, manufacturing, importation,

use and sale of polythene bags thus a world leader in protecting the environment against the pollution of plastic bags (REMA, 2015).

The promotion of fruit tree planting for environmental and livelihood improvements in Rwanda has some limitation such as inadequate public participation, limited access to planting seedlings, limited access to agroforestry knowledge by small-scale farmers, low pH level in soil, soil erosion and inadequate research, among others (Mbow, 2014). Trees can stabilize slopes because of their deep root system and drought-resistant nature (Brunner et al., 2015). To address the environmental and social-economic challenges in Kigali, this study analyses the contribution of fruit trees towards landscape management and promotion of environmental education at both school and community level. This study will be significant in examining the environmental and social-economic benefits of fruit trees on urban vulnerable steep slopes and informal settlements. It will assess the different fruit tree types and varieties suitable for slope stabilisation, urban agriculture, and landscape design. Later, an output of guideline plans that will be useful at school level to promote and sustain school learning gardens for environmental knowledge transfer at school and community level.

1.2 The Problem Statement

School learning gardens, urban public space and landscape management designs are some of the current practical tree implementation projects for environmental management in Kigali. However, there are some challenges which have existed during the program implementation. For example:

1. in agriculture, some farmers at local level hardly realise the direct benefits from some tree species being recommended for agroforestry designs which impede adoption of agroforestry practices;
2. in landscape management, the frequently proposed and current designs consist of planting grass and flowers, yet fruit trees can also be used;
3. challenge to identify teachers who are passionate about environment and protest from some teachers and parents.

Therefore, the motivation of this study is based on two perspectives; a need to fill in theoretical and practical gaps that I identified during my participation in Rapid Planning entry project Nyarugenge upgrading workshop. (Business Improvement Strategy for Agricultural Practices and Multi-Level Waste Flow in Kigali, Rwanda, June 2016)[1]. The recent research experience

[1] The author participated in a two months internship supporting Rapid Planning fruit tree planting school entry project by researching about different fruit tree types and species suitable for school gardens in Rwanda (September-November 2016)

has put me in the critical and practical realization of the potential of fruit tree in closing the gap that exists in urban landscape management and promotion of practical environmental knowledge at school and community level.

The study aim is clearly outlined in the following subsections. It is aimed at providing a bottom-up approach of possible solutions, to some of the existing challenges in the implementation of tree planting activities that exist in urban agriculture, landscape management and school garden programs.

1.3 Study Aim, Objectives, and Research Questions

The aim of this study is to come up with strategies that can guide the implementation and management of fruit trees on vulnerable urban steep slopes and informal settlements.

The study objectives are:

1. To identify different fruit trees species suitable for urban farms and school gardens focus on slope stability
2. To assess the environmental and social-economic benefits of fruit trees on urban landscapes, farms, and school gardens
3. To identify areas for improvement in the promotion of fruit trees in East Africa

Study questions:

The questions that this study will seek to answer will include:

1. What are the different fruit trees species that can thrive in Rwandan urban farms and school gardens?
2. What are the environmental and social-economic benefits of fruit trees on urban landscapes, farms, and school gardens?
3. What are the policy and implementing challenges of fruit trees on school learning gardens?
4. What are the possible contributions of fruit trees in the promotion of environmental education in urban informal settlements and schools learning gardens?

1.4 Structure of the Thesis

The thesis is divided into six parts. Chapter one introduces the thesis, explains the problem, and states the aims of the study. Chapter two presents study methodology, the background information of the study area; this includes their physical and demographic characteristics,

socio-economic activities, and political organization. Chapter three presents literature such as major fruit tree species and their climatic favorable zones, agroforestry systems, environmental problems, and environmental social-economic benefits of fruit trees. Chapter four provides results and analyses of the current environmental and social-economic benefits of fruit trees. The chapter identifies the current and possible opportunities for fruit trees. It also analyses and interprets the result of the research (SWOT). Chapter five presents the discussion of the study results. Chapter six outlines the recommendations for future project response and for a better implementation and promotion of fruit trees urban informal settlements of Kigali Rwanda. Finally, it concludes the whole research results.

1.5 Significant of the Study

The findings of the study will equip the public, policymakers, urban planners, engineers and above all the East African governments with the facts on challenges that confront the promotion of tree planting activities, landscape management in urban informal settlement and school gardening programs. The study findings will also help to identify any lapses between the policy makers and implementers as well as support stakeholders to map out workable solutions and strategies to address the challenges. It can help strengthen the implementation of policies to promote environmental education at school and community level. The study findings will also contribute to the identification of different fruit trees that can be introduced in the country with a detailed plan of possible case project sites. Therefore, the needed assessments are eventually integrated into programme or project. Lastly, it will go a long way to promote fruit trees in environmental tree planting policies, plans and projects at East African level to ensure sustainable development.

2 LITERATURE REVIEW

This chapter presents some of the empirical findings from scholarly research. These findings were used to compare the results of the current study. Some of the literature reviewed included major fruit tree species, agroforestry systems, environmental problems, and the environmental and social-economic benefits of fruit trees in Rwanda.

2.1 Major Fruit Tree Species in Rwanda

In horticulture, the term 'fruit tree' only considers those that provide fruit for human and animals (Baugher & Sinhga, 2003). Therefore, a fruit tree bears fruit consumed by humans and some animals. Globally, fruit trees constitute important biological resources in various agro-ecological systems and forest ecosystems (Haq & Hughes, 2012). However, the tropics are endowed with great diversity of fruit tree species more than any other region in the world, that have provided humans with nourishment and basic food (Sthapit et al., 2012). Tropical Africa has four hundred seventy-seven edible fruit and nut species, consisting of both indigenous and exotic grown across the landscape (Awodoyin et al., 2015). Indigenous fruit trees (IFTs) play an important role in the livelihoods of various rural communities in Africa who rely on agriculture periodically (Awodoyin et al., 2015).

In Rwanda, fruit trees are a great source of income and nutrition for local communities. However, indigenous fruit trees are considered of a great value due to various benefits to the communities (Kristjanson et al., 2017). Even though most of them grow wild, they are considered as sustainable plant species with nutritive, medicinal, and economic values in rural communities of Rwanda. However, the country has no clear policy on raising communities' awareness about on-farm management and domestication of IFTs. Therefore, there is a strong need to widely spread the knowledge on the relevancy of IFTs. Advocating and promoting the management of IFTs can lead to broad knowledge on the benefits of the species (Cemansky, 2015).

In addition, similar to various tropical countries in Africa, scientifically planned selection and breeding programs have not been undertaken on a large scale. To select promising pomological traits such as, shape, fruit size, flavor, taste, suitability for processing into wine, juice and other beverages, resistance to abiotic and biotic stresses considering the numerous landraces of species. The production technologies such as high-density planting system, efficient rootstocks cultivars and plant protection, pruning, schedules are not standardized (Awodoyin et al., 2015). Due to the various challenges, there is a need to focus on tree improvement programmes. That will initially focus on important pomological needs of the country's IFT to intergrade with

similar commodity crops from tropical Asia and America. Therefore, encouraging the domestication and conservation of IFT species in the agroecosystem will provide highly sustainable production systems that conserve soil fertility, micronutrients, and biodiversity, as well as guarantee food security, climate change adaptation and mitigation (Kalaba et al., 20).

FAO (2010) stipulates that there is a great potential for growth of the fruit production in the international markets due to the increasing health consciousness about the consumption of more fresh fruits as well as vegetables in people's diets. Unlike the tropical fruit trees of Asia and American origin, indigenous fruit trees (IFT) of tropical Africa have scarcely achieved the status of international recognition in research arena and commodity markets outside Africa (Awodoyin et al.,2015). Current fruit production in Africa has been dominated by species introduced from tropical Asia and America, such as, banana, citrus, apple, mango, papaya, and pineapple (Ogate et al., 2016). Rwandese often snack on fruits between meals such as passion fruits, avocados, bananas, mangos, pineapple, and papaya are abundant.

2.2 Fruit Tree Species are Commonly Grown in Rwanda

This section contains an overview of the fruit tree production in Rwanda. This lay focus on the most widely produced fruits in the country such as avocado, citrus, tamarillo, papaya, mangoes, jackfruit, and guavas and their climatic zone. Table 1 shows fruit trees which are well adapted to Rwandese climatic conditions as described by the Belgian Development Agency (BTC).

Table 1: Trees production and their climatic zone in Rwanda

Agro-climatic zones	**Fruit trees**
Temperate zone	Apple, Plum, Pear, Cheries, Peaces
Subtropical zone	Guava, Tamarillo, Macademia, Pears, Litchi low chilling peaches
Tropical zone	Mango, Citrus, Avocado, Papaya

Source: (BTC, 2015)

Mango *(Mangifera indica)*

Mango (*Mangifera indica*) tree can range to a height of 10-30 m with a canopy of 30-38 m width, it grows under deep soils and the tap root can reach a depth of two meters. Mango (*Mangifera indica*) varieties that are grown in Rwanda are; boribo, dodo, sensation, tommy atkins, kent, apple mango and ngowe. The popular mango (*Mangifera indica*) varieties on the European market are; van dyke, tommy atkins, kent, heith and hade while the Middle East market prefer ngowe and apple. The annual mango (*Mangifera indica*) production is an

estimation of 2000 MT in a year dominated by local varieties, however new commercial orchards are being set in Rwanda mainly of kent and tommy atkins variety (NAEB, 2017).

Avocado *(Persea americana)*

Rwanda has inherent advantages in the production of avocado (*Persea americana*) which requires 750 – 1900 mm of rainfall per year (RDB, 2010). Avocado *(Persea americana)* trees could be expected to start yielding about 0.9 tons/ha after three years and 21 tons/ha from year seven onward (Austin, 2009; USAID, 2012). The local variety of avocado (*Persea americana*) is of a superior taste and consistency. However, the international market prefers the hass and fruete variety, which also has good taste. In addition, hass and fuete have a tougher rind, therefore, not perishable, and easier to ship long distances without damage. The international demand affects the prices of avocado (*Persea americana*) in Rwanda (NAEB, 2017).

Avocado (*Persea americana*) production is available year-round; however, the peak season is from March to August. Furthermore, Rwanda has thirty two avocado (*Persea americana)* availabilities such as hass, fuerte- wedon, fuerte- dougal, waldin, zutano, anahem, simpson, fuka, corona, simond, lula, booth 7, mesa, irving, jalina, dicson, fuerte -Kenya, bacon, collenson, No 841, booth 8, edranor, No 1005, puebla, zutano, donard, silliman, renco, ettinger, choquette, fuerte- althur, noella, No850). However, only three are grown for exports these include fuerte, hass and entinger, they can weigh from 1.5- 2.75 kg, the annual production is estimated at 10,000 MT in a year fuerte dominates the production. Avocado (*Persea americana*) are grown by small-scale and cooperative farmers at a country level however; the Eastern and Southern province are the most productive regions (NAEB, 2017). This is because the Eastern and Southern province rainfall ranges from 900mm to 1,500mm and experience more prolonged drought which are favorable for avocado (*Persea americana*) growth (REMA, 2007).

Oranges *(Citrus senesis)*

Rwanda is a net importer of oranges (*Citrus senesis*) from other countries in the region. Although oranges (*Citrus senesis*) can be grown, the country does not have a comparative advantage in any citrus product (Byanyima, 2009). Two varieties of oranges (*Citrus senesis*) varieties are mainly produced these are valencia and washington which are grown at country level, but mainly in Southern, Eastern and Western Provinces. It is possible to grow oranges (*Citrus senesis*) directly from seeds, but they may be infertile or produce fruit that may be different from its parent. Therefore, growing oranges (*Citrus senesis*) from tree seedlings is highly recommended (NAEB, 2017).

Tamarillo (Salanum betaceum)

Tamarillo (*Salanum betaceum*) is mostly in the northwestern and western parts of the country. This is because it is a sub-tropical climatic zone characterized with heavy rainfall thus some of the optimum conditions for the maximum growth of tamarillo *(Salanum betaceum*) (REMA, 2007). Tamarillo (*Salanum betaceum*) is a perennial bush with a woody trunk that grows to heights between two and five meters in favorable conditions. It requires a cool climate and optimal temperature range of 14°C to 20°C. It is susceptible to wind damage because of its shallow root system but adapts well to a variety of soil types. However, tamarillo (*Salanum betaceum*) is more suitable to medium texture with good drainage and considerable organic material. It does not require irrigation, but the availability of water can extend its productive period, which can typically last up to three years (for most of the plants) and improve yields and resistance to viruses" (Austin, 2009).

Furthermore, tamarillo (*Salanum betaceum*) is a relatively new product on international markets, with high demand in fresh form. Some of the international market demand for tamarillo are in United Kingdom Germany, Netherlands, and Spain. The Fair-Trade certification has helped to open markets for tamarillo (*Salanum betaceum*). After being imported, it is processed into juices, concentrates, jams, gelatins, and sweets. Rwanda lacks processing facilities and adequate transport to export tamarillo in form of fruit pulp. The annual production is estimated at 5,000 MT a year dominated by purple variety (NAEB, 2017).

Pawpaw (*Carica papaya)*

Pawpaw (*Carica papaya*), is a multi-purpose, early-bearing, space-conserving and herbaceous fruit. Pawpaw (*Carica papaya*) plants are grown by households on a small scale mainly for own consumption in its fresh form. At local level, the surplus fruits are normally sold to earn some cash. Pawpaw (*Carica papaya*) plants are mostly grown in the Western and Eastern province. Pawpaw (*Carica papaya*) grows at the rate of 1.8-3 meters in the first year and at a maximum of seven to nine meters in height at maturity. The pawpaw (*Carica papaya*) fruit is famous in most of tropical countries and has become naturalized in many countries including Rwanda (Medina et al., 2003). The above-mentioned fruits have also biophysical properties that are summarized in Table 2.

Table 2: The biophysical limits of different fruit tree species

	Fruit	**Scientific name**	**Mean annual rainfall (mm)**	**Mean annual temperature (°C)**	**Altitude (m)**	**Soils (p^H)**
1	Mango	*Mangifera indica*	300-2, 500	19-35	0-1,200	5.5 - 7.5
2	Avocado	*Persea americana*	300-2, 500	-4 – 40	0-2, 500	5-5.8
3	Orange	*Citrus Senesis*	900-2,500	5-40	0-2, 000	5-8
4	Papaya	*Carica papaya*	1, 000-2, 000	(15) 21-33	0-1, 600	6-7
5	Guava	*Psidium guajava*	1, 000-2, 000	23-28	0-2, 000	5.5
6	Jackfruit	*Artocarpus heterophyllus*	1,000-2,400	16-22	0-1,600	5-7.5

Source: (Orwa et al., 2009) and for guava (Loh & Rao, 1989)

2.3 Agroforestry Systems in Rwanda

Since 1930's, reforestation and cultivation of trees has been practiced. Farmers started to plant trees for different productivity. For example, fuel, fiber, fences fruits and medicine. The different agroforestry systems broke the chain of farmers' dependency on natural vegetation for productivity (Bigelaar, 1996). In addition, Balasubramanian & Egli (1986) found that the biggest percentage of farmers in Rwanda had at least nine fruit trees on their farms, such as, avocado (*Persea americana*), mangoes (*Mangifera indica*), oranges (*Citrus senesis*) and jack fruit (*Artocarpus heterophyllus*). The fruit trees were planted for various livelihood and ecological support (Balasubramanian & Egli, 1986). Four types of agroforestry are in existence, namely:

1. Agro silviculture; trees and crops are grown together through shifting cultivation (Holmström, 2013);
2. Enfomosilvicultural; trees and insects are mixed together. Under enfomosilviculture, there are two commonly designed systems apicultures (bee keeping, here trees are used for shade and foliage) and sericulture (silkworm feed on the leaves of the trees) (Holmström, 2013);
3. Aquasilviculture; trees and water animals are combined, trees provide leaves for fish feeds and manure for the ponds (Wekesa & Jönsson, 2014);
4. Silvopastoral; trees plantation mixed with animal production.

Therefore, different agroforestry systems are a practical example of economic diversity land use practice in favor of small-scale farmers, for example, to produce organic fertilizers from manure (Holmström, 2013).

2.4 Environmental Problems in Rwanda

Small scale and large-scale farming is an on-going activity in all parts of the country. Such agricultural activities have greatly deteriorated the environments. The population has been dependent on rain-fed agriculture from the 1959 massacres and 1994 genocide (REMA,2009). In addition, eighty percent of the homesteads have less than one hectare of land, smaller plots of land are continuously cultivated. In 2009, Rwanda Environment Management Authority (REMA) reported that vulnerable lands on the steep slopes from fifty five percent upwards are cultivated (REMA, 2009). The increase in the number of people farming on the hilly and mountainous terrain of Rwanda has resulted in significant environmental degradation because of overexploitation of the soil and continuous erosion. This leads to soil erosion down the hillside into the valley causing continuous sedimentation of the major rivers and other water sources. Therefore, an estimation of fifteen million tonnes of soil is lost in a year. The most vulnerable to erosion are the farmed northern and western uplands of Rwanda due to higher annual rainfall and steeper terrain (REMA, 2013). Rwanda has faced serious floods in the year; 1997, 2006, 2007, 2008, 2009 and 2012. The floods led to landslides occurrences, which led to negative impact on human, animals, crops and infrastructures, environmental degradation and soil erosion in the North-west region (REMA, 2013). Table 3 shows some examples of negative impact of landslides and flood on the environment.

Table 3: Damages and impacts of landslides and flooding's in Rwanda between 2001-2013

Period (year)	**Death of people**	**Death of livestock**	**Collapsed houses**	**Destructed houses**	**Damaged crops (ha)**	**Damaged infrastructure**	**Regions**
Sep-Dec 2001	42	159	1,244	4,605	1,645	50 bridges, 24 roads, 9 schools	North west
Sep 2007	15 people missing	-	456	-	100	-	North and West
2007	-	-	-	217	-	-	North west
2012	66	175	1,929	-	1,077.5	22 roads, 7 bridges, 16 small bridges, 2 water supply, 63 water sources, 6 schools	Kigali

Source: (REMA, 2013)

2.4.1 Types and influencing factors of landslide in Rwanda

The four main types and influencing factors of landslides in Rwanda are described in detail (Bizimana, 2015). The major landslides occur on the concave slopes, it is composed of debris flow of water concentration experienced in the down levels of clay. The concave slopes with an angle of fourteen to 55 degrees are always greatly affected by landslides. The slopes located in the north-west and west part of Rwanda are most vulnerable to Landslides. These areas are covered under topography and tropical climate conditions with soil types such as; aerosols, nitisols, gleysols, ferralsols and leptosols. In addition, these soils are identified to fall in the category of kaplinite. The primary factor for slope failure is prolonged rainfall rates on the topsoils which consist of a high infiltration rate (Bizimana, 2015).

Soil property influence

In Burera, there are two main types of residual soil that happen at cynanika carbonate. Sandy soil which is light grey and is normally five meters thick, they later break to red-brown soils which are more grained and finer. Largely consisting of A-horizon which later levels to an imperceptibly and extreme thicker and same B-horizon. Soil mass movement plays a very significant role in landslide occurrences. Soils in Rwanda are identified with greater clay content, clay particles are 0.002mm in diameter or lesser. Most of the clay soils have greater than twenty percent of these particles. This makes the clay to be more vulnerable to permeability (Bizimana, 2015).

Slope steepness influence

Relief determines the rate and type of landslides. The commonly significant relief factor is the slope steepness and this impact directly on the mechanism and the rate of the landslides (Bizimana, 2015). Slope stabilization against sliding is determined by the connection between the shear strength and the shear resistant. Landslides in Rwanda often happen on slopes with fourteen degrees being the lowest recorded, in the Northern province, higher than forty-five degrees of slopes gradient, west, thirty-five degrees, and south higher than twenty five degrees (Bizimana, 2015).

Slope undercutting

In the northern part of Rwanda, slope undercutting greatly influence landslides. Human activities like house construction, footpaths, roads, mines, and quarries have triggered landslides (Bizimana, 2015).

Prolonged rainfall as a landslide trigger

The rates of precipitation impact on soil infiltration and water run-off. In many parts of Rwanda, they experience torrential rains that contribute to a higher run-off which cause a lower amount of infiltration. The rate of rainfall has a measurable increase in specific mass rocks by twenty to thirty percent yet reducing the shear strength by fifty percent and impacting on the sheer pressure. Therefore, the shear strength is highly lowered and cause slope failure. Most parts of Rwanda get higher than 800 mm of rainfall annually and to some areas up to 300mm (Bizimana, 2015). In table 4 above, the destructive landslide events have led to damages such as, environmental degradation, loss of lives and collapse of farmlands in all the listed cases (Bizimana, 2015).

Table 4: Destructive landslide events and their prone areas in Rwanda

District	**Number of landslides**	**Triggering factors**
Kamanyi Ngororero Nyamagabe	7 cases in each district	Heavy rain Illegal mining Steep slopes
Rulindo Muhanga	5 cases	Heavy rainwater Steep slopes
Gicumbi	6 cases	Heavy rainwater Steep slopes

Source: (Bizimana, 2015).

2.5 Environmental Benefit of Fruit Trees

This section explains the environmental benefits of fruit trees which include slope stabilization and climate change mitigation.

Fruit trees as a tool for slope stabilization

Slope stability is the potential of soil covered slopes to withstand and undergo movement. Stability is determined by the balance of shear stress and shear strength (Coduto, 1998). Deep-rooting trees also help improve soil stability, while an increase organic matter from leaf litter can improve the soil's structure and reduce surface water run-off (Woodland Trust, 2017). Various tropical fruit trees found in Africa have high root intensity and root strength to have the capacity to bind soil particles together (Cemansky, 2015). The hilly nature of Rwandan topography is one of the main factors of soil vulnerability. The highland soils are particularly prone to erosion and landslides especially regions of the Congo-Nile ridge, valleys, and

lowlands (peat lands) as well as highland meadows (MINAGRI, 2005). It has been estimated that soil erosion results in a loss of 1.4 million tons of soil per year. Despite the growing awareness of the importance of soil conservation measures in the country, there is no corresponding implementation of anti-erosion measures (REMA, 2009).

Fruit trees as a tool for climate mitigation

Fruit tree-based agroforestry designs have the capacity to mitigate climate change by considering food security and livelihood necessities of both small and large-scale farmers (Syampugani et al., 2010). Fruit trees based-agroforestry systems have illustrated multiple benefits because of the higher social-economic and environmental ecosystem support (Kassa, 2014). Fruit tree planting campaigns have a direct benefit to the socio-economic needs at the household level as well as a way of mitigating climate change (Sthapit et al., 2012). Fruit trees mitigate climate change because even though households' focus on the economic benefits, the fruit trees help to remove excess carbon from the atmosphere (Kusolwa et al., 2012). Fruit trees are evergreen throughout the year, enabling carbon absorption from the atmosphere. This indicates that households can contribute to the overall mitigation of climate change negative impacts (Sthapit et al., 2012).

2.6 Socio-economic Benefits of Fruit Trees

This section introduces the social-economic benefits of fruit trees such as nutritional support, and income generation. It further explains the other additional benefits of fruits at local level and finally, the relevancy of fruit trees in school learning.

Nutritional support

Nutrients are the components in foods that the body needs to grow strong and health (US Department of Health Human Services, 1990). Fruits can add nutritional value and variety to daily human diet (Brat et al., 2006). In most African societies, fresh fruits are often taken as snacks (Oniang'o, 2003). Fruits can make a direct and immediate improvement in children's diet (Centers for Disease Control, 2013). Fruits deliver important nutrients for healthy and strong bodies such as vitamins A, C and B6, vitamin A is for healthy eyes and good vision, vitamin C provides general good health and reduces illness such as colds, vitamin B6 is good for pregnant women and young children for healthy development (Kehlenbeck, 2015). Pupils who eat more fruits as part of an overall healthy diet are likely to have a reduced risk of some chronic diseases. Fruits provide nutrients vital for health and maintenance of their body.

The combination of powerful flavonoids, antioxidants, minerals, vitamins, phytochemicals and the countless micro- and macronutrients make fruits very advantageous for school children's health. The daily consumption of fresh fruits lowers the risk of strokes, high blood pressure, indigestion, cancer, heart disease, diabetes, and other chronic diseases (Blanck et al., 2008).

Most fruits are naturally low in fat, sodium, and calories and none cholesterol (Craig, 1997). They are sources of many essential nutrients that are under consumed, including potassium, dietary fiber, vitamin C, and folate (folic acid) (Devasagayam et al., 2004). Diets rich in potassium may help to maintain healthy blood pressure (Whelton et al., 2002). Fruits resources of potassium include bananas, prunes and prune juice, dried peaches and apricots, cantaloupe, honeydew melon, and orange juice (Tucker et at., 1999). Vitamin C is important for growth and repair of all body tissues, helps heal cuts and wounds, and keeps teeth and gums healthy (Palmer, 2001; Puente et al., 2011). Folate (folic acid) helps the body form red blood cells (Fenech, 2001).

Dietary fiber from fruits helps reduce blood cholesterol levels and may lower risk of heart disease. Fiber also helps reduce constipation and diverticulosis. Fiber-containing foods such as fruits help provide a feeling of fullness with fewer calories. Whole or cut-up fruits are sources of dietary fiber; fruit juices contain little or no fiber (Kehlenbeck, 2015). Table 5 below shows the nutritional benefits derived from some fruit trees. The table gives the English name, scientific name, and the Swahili name of the fruit tree. It further gives the general scientific description of the tree, the nutritional values derived from eating the fruit and finally the benefits vitamins in the human body.

Table 5: The nutritional benefits of fruits

Fruit	Description	Nutritional value	Benefits
Pawpaw *Carica papaya)* *Mpapai* *(Swahili)*	Pawpaw is a tree-like herb with a branched stem and a small crown at the end of the stem, growing to a height of up to 10 m Pawpaw is easily grown from seeds. For commercial production, quality seeds of improved varieties should be used. The large sweet fruits can be eaten fresh or used to make fruit salads, or processed into juice, jam, jelly, sweets and dried fruits	Vitamin C Vitamin A	Vitamin C Strengthens the immune system and provides for good health Vitamin A is Important for good vision and a healthy immune system
Passionfruit *(Passiflora edulis)* *Mukundi* *(Swahili)*	Passion fruit is a perennial, shallow-rooted climber which can grow several meters in height Passion fruit can be grown from seed, but grafted plants are recommended for commercial cultivation. The fruit can be eaten fresh or processed into juice and jam and is in high demand both in domestic and export markets	Vitamin C Vitamin A Iron Fibre	Iron increases the quality of blood Fibre is an important part of a healthy diet. A diet high in fibre has many health benefits and can improve the digestive system
Orange *(Citrus sinensis)* *Mchungwa* *(Swahili)*	Orange is a small, spiny, and shallow-rooted tree or shrub with a round, dense crown, growing to a height of about 6 m Orange trees should be budded or grafted to obtain high-quality fruits. Several improved varieties are available. The sweet, juicy fruits can be eaten fresh or processed into juice, jelly or marmalade	Vitamin C	Vitamin C strengthens the immune system and provides for good health

Source: (Kehlenbeck, 2015)

Table 6 shows the possibility of having 10 tree species of fruit trees that can be planted on a piece of land for a year through harvest, nutritional and income support.

Table 6: Fruit tree species for year-round harvest for nutritional or income support at household level

Fruit	**Scientific name**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Pawpaw	*Carica papaya*												
Mango	*Magnifera indica*												
Water berry	*Syzygium spp.*												
Custard apple	*Annona reticulata*												
Guava	*Psidium guajava*												
Lemon	*Citrus limon*												
Orange	*Citrus sinensis*												
Chocolate Berry	*Vitex payos*												
Passion fruit	*Passiflora edulis*												
Desert date	*Balanites aegyptiaca*												

Source: (Kehlenbeck, 2015)

Additional support

Growing fruits has additional benefits to the society and community such as. Fruit gardens can foster a great sense of community through parent to parent connections, teacher to student or student to student (Blackmore & Hutchison, 2010). Schools and community may decide to build a community or school fruit garden which is a tremendous learning tool for all involved (Bouillion & Gomez, 2001). Fruit tree plantation fosters realization, acceptance, resolve to change and creates an enabling environment (Francis et al., 2015). In addition, fruit tree builds collaboration, networks and partnerships, fosters tree ownership and land tenure security for farmers through increased education and training (Birch et al., 2015). Furthermore, fruit tree planting increases enhances women's economic empowerment, creates community advocates, increases food security, health, and resilience, and improves the environmental comfort of rural communities (Okvat & Zautra, 2011).

The planting of fruit trees helps in making urban environment more pleasant to live, work and spend leisure time. Through provision significant outdoor, leisure or recreation opportunities for a natural city, thus enhancing quality of urban life (Ottosson & Grahn, 2005). Fruit tree planting promotes environmental responsibility and ethics. For example, building stronger sense of community social identity, self-esteem, significant emotional and spiritual experiences and providing opportunities for children to experience nature (Cloke & Jones, 2003). Planting of fruit trees is accompanied by more additional benefits which include; improve animal welfare by providing shelter or shade reducing exposure to extreme weather, through fruit tree hedges and providing fodder for animal health and welfare (Andrewartha et al., 1986). Furthermore, fruit trees can also provide wood fuel because fruit tree branches are regular source of firewood at local level and if managed correctly, valuable timber can be obtained from fruit trees (Gokcol et al., 2006; REMA, 2009). Fruit trees provide a great environment for "tourist" activities such as cycling and running if planted a long side urban open spaces because tourists get to know of the different fruit found in an area (Chen & Weng, 2012).

2.7 Environmental Education

UNESCO-UNEP Congress on Environmental Education and Training program (1987) agreed that environmental education should simultaneous attempt to create awareness, transmit information, teach knowledge, develop habits and skills, promote values, provide criteria and standards and present guidelines for problem solving and decision making. The later necessities are both class room and field activities.

A school learning garden is a tool for the promotion of environmental education. A school garden is an innovative teaching tool and strategy that lets educators incorporate hands-on activities in a diversity of interdisciplinary, standards-based lessons (Deichler, 2017). The garden engages students by providing a dynamic environment in which to observe, discover, experiment, nurture, and learn (Railsback, 2002). It is a living laboratory where lessons are drawn from real-life experiences rather than textbook examples, allowing students to become active participants in the learning process (Chinn, 2006). Through the garden, students gain an understanding of ecosystems, an appreciation for food origins and nutrition, and knowledge of plant and animal life cycles. At the same time, they learn practical horticultural skills that last a lifetime (Bowker & Tearle, 2007).

In Kigali fruit trees are a logical, and sweet, extension of school gardens. Not only can they provide an abundant source of nutrient-rich food for students and cafeterias, but they can also stand for years as the centerpiece of a living ecology classroom, explained by Wisconsin School

Garden Initiative Brief (2017). Experience and research have shown numerous benefits of school gardens and natural landscaping. Students learn to focus and be patient, cooperation, teamwork, and social skills (Dyment & Bell, 2008). They gain self-confidence and a sense of "capableness" along with new skills and knowledge in food growing. Garden based teaching addresses different learning styles and intelligence, non-readers can blossom in the garden, achievement scores improve because learning is more relevant. Hands-on, students become more fit and healthy as they spend more time active in the outdoors and start choosing healthy foods over junk food, the schoolyard is diversified and beautified because students respect what they feel and some sense of ownership (Green Hearted Education, 2017).

Kiefer et al. (1999) added that many schools have become aware of the multiple benefits of school gardening for students, teachers, schools, and communities. Benefits of school gardening for students include; educational benefits, gardening offers hands-on, experiential learning opportunities in a wide array of disciplines (Williams & Dixon, 2013). For example, the natural and social sciences, math, language arts (through garden journaling), visual arts (through garden design and decoration), and nutrition (Swank & Swank, 2013). It is evidenced that students who participate in school gardening score significantly higher in standardized science achievement tests (Glenn, 2000).

Teachers develop useful concepts, such as "invisible walls," to create a sense of boundaries when learning in the garden (Howes et al., 2009). Teachers as gardeners themselves also learn useful gardening skills when they incorporate gardening into their lesson plans. These skills can be transferred into their own homes and social networks, thereby benefiting their own health and the health of their families. In addition, connection to history and the community gardening ties students to the social and material history of the land (Tharp & Gallimore, 1991).

Furthermore, gardening offers many opportunities for connecting with local history by incorporating native plants and plants grown during specific historical eras. Garden themes bring school pride and sustainability education thus bringing life to schools and schools to life (Williams & Brown, 2013). Gardening offers schools a way of helping children to identify with their school and to feel proud of their own individual contribution. Children know which plants they helped to grow, and they feel proud of themselves. This can improve school spirit and children's attitudes toward the school (Blair, 2009).

The planting of fruit trees and school gardens contributes to environmental stewardship and connection with nature. By deepening children's sense of connection with nature, school gardening can inspire environmental stewardship (Bell & Dyment, 2008). When children learn about (water and energy cycles, the food chain, and the peculiar) needs of individual species

they have a reason to care about all the forces that impact that plant's future. A garden offers many occasions for achieving insight into the long-term human impact on the natural environment. From the water shortage to the over-use of pesticides, children who engage in gardening have first-hand opportunities to observe the importance of conservation. They have intelligent allocation of resources, lifestyle and nutrition. This is because school gardening offers children opportunities for outdoor exercise while teaching them a useful skill (Blair, 2009). In addition, gardens containing fruit and vegetables can also help to revise attitudes about foods. There is mounting evidence that active learning in less structured, participatory spaces like gardens is more likely to transform children's food attitudes and habits. Therefore, school gardening especially when combined with a healthy lunch program or nutritional education, encourages more healthful food choices (Dobbs et al., 1998).

3 STUDY METHODOLOGY

This section describes a brief overview of the study area (Rwanda), background and historical formation of Kigali City – Gegraphical location, climatology, soil formation, land use, topography, hydrology, Nyarungenge District and Biryogo primary school. The research further describes the research approach and design.

3.1 The Study Area

Rwanda is in the central east part of Africa, surrounded by Democratic Republic of Congo, Uganda, Tanzania, and Burundi. Steep mountains and deep valleys cover the largest part of the country (Figure 1). In the northern part lies lake Kivu, at an altitude of 4,829 feet the highest lake in Africa. Further, in the north the Virunga mountains, which consists of Kalimba volcano (14,187 ft, 4,324m) the highest point of Rwanda. Kigali is the capital and largest city with an estimated population of one million people (2011, est.). Seventy to eighty percent of the population live in the rural areas and ninety percent of the population depends on their own agriculture (Kabeza et al., 2012). The total population of Rwanda is projected to be 16 million people by 2020 (Kabeza et al., 2012).

Figure 1: Map of Africa showing the location of Rwanda
Source: (Lawson, 2012)

Background and historical formation of Kigali City

Kigali city was named after mountain Kigali, Ki' is derived from Bantu diminutive prefix, and 'gali' in Rwanda means broad (REMA, 2013). The foundation of Kigali was in 1907 as a Germany colonial out post and trade centre, Kigali was a favourable commercial transportation route connecting Bujumbura (Burundi) and between Bukoba, Kigoma (Tanzania) and, Kisangani (Democratic Republic of Congo) and, Kampala, (Uganda) (REMA, 2013). During that time Nyanza (the city of king Umwami) was the traditional capital while Butare the colonial city of power (REMA, 2014). In the year 1916 the Beligian troops defeated the Germans and colonised Rwanda until her independency in 1962. Kigali strategic central location won the final decision of the capital city for Butare was the preferred option during that time (REMA, 2013). At independency Kigali occupied an estimated area of 3sq km. covering the hills of Nyarugenge and Nyamirambo with an approximately population of 6,000 people. Later, the city grew very quickly to become the countries' economic, political and cultural centre. In 1979, the city area was expanded to 112 sq. km by law and later in 1990 to 349sq.km through presidential order. Finally, in 2005 the limits of Kigali where expanded through law from 314 sq.km to 730 sq.km, the current total area (REMA, 2013). In addition, Kigali city is made up of three districts namely; Gasabo on 429.3 km2; Kicukiro on 166.7 Km2 and Nyarugenge on 134 km 2 Kigali city continued to grow until the 1994 genocide against the Tusti and it is estimated by the government of Rwanda that over one million people were killed having 250,000 victims buried at Kigali memorial site. However, it was reported by World Bank 2009 that between the years 1994 to 2002 the population of Kigali resumed threefold. Kigali city is one of the African fastest growing cities with a population of more than one million people representing about 10% of the national population. Rwanda famously known as a land of 1,000 hills and the city rapid growth surrounds the hilly terrain. The population directly and indirectly depend on the natural ecosystem services for example growing food, forest for timber, water from lakes and rivers, climate regulation and clean air (REMA, 2013)

Geographical location of Kigali city

Kigali is found in the middle of Rwanda and closest to the equator spending at the east of African centre at a longitude of 30°07'E and latitude of 1°58'S. At country level the city is based in the natural region known as Bwanacyambwe near river Nyabugogo basin and between mountain Jali and mountain Kigali (REMA, 2013). From the city centre the urban areas spread north ward covering the slopes of mountain Jali, the hills of Kibagabaga, Gisozi, Gaculiro and Kagugu; east wards around the hills of Kacyiru, Kimihurura, Mburabuturo, Nyarutarama,

Remera and kanombe; west around mountain Kigali and the hills of Kabusunzu and Kimisagara; south wards occupying the slopes of mountain Nyarutarama (REMA, 2013). Therefore, the city is built on the hills, with mountain Kigali has the highest hill at 1,850 m, the highest ridge is on an elevation of 1,600 m and the valleys are at 1,300 m above the sea level. The city is partly surrounded by lake Muhazi ate the north eastern edge and surrounded by river Nyabugogo. The city has Nyarugenge ridge has the Central business district while Kacyiru ridge located with most of the administrative and judiciary institutions of the city (REMA, 2013).

Climatology

The Kigali has temperate climatic conditions (Table 7). It is vital to note that various natural resources influenced urban development namely, land, water, vegetation, climate, and wild life, but currently affected by the city expansion (REMA, 2013). The city has two rainy seasons in the year, first season from February to May and from November January, June and July are the coldest months of the year while February and March the hottest, the rainiest season of the year is from March through May (REMA, 2013). During extreme daily weather condition, the city can be vulnerable to flooding due to changes of hydrological conditions of the river as a result to city development.

Table 7: Average daily temperature and rainfall of Kigali

Month	**Average Temperature ^{0}C Daily minimum**	**Daily maxium**	**Average total rainfall (cm)**	**Average number of rainy days**
Jan	15.6	26.9	7.7	11
Feb	15.8	27.4	9.1	11
Mar	15.7	26.9	11.4	15
Apr	16.1	26.2	15.4	18
May	16.2	25.9	8.8	13
Jun	15.3	26.4	1.9	2
Jul	15.0	27.1	1.1	1
Aug	16.0	28.0	3.1	4
Sep	16.0	28.2	7.0	10
Oct	15.9	27.2	10.6	17
Nov	15.5	26.1	11.3	17
Dec	15.6	26.4	7.7	14

Source; (REMA, 2013)

Soil composition

Kigali city is composed of meta -sedimentary and granitic rocks, sandstones, and schists (REMA, 2013). Lateritic soils dominate the city hill surface, rich in aluminium and iron while the river valleys comprise of fertile alluvial soils and the lowlands and wetlands are dominated

by organic soils. The city slopes are highly strained due to the informal settlement and improper developed hence highly subjected to soil erosion. Kigali city is in arrange between medium and high risk to heavy soil erosion hence loss in soil fertility and wetland habit performances down the valleys (REMA, 2013). In addition, the soil fertility and stability on the slopes of Kicukiro, Remera and kisozi is on a high risk due to human development (REMA, 2013).

Land use

Kigali city land area was once heavily forested, currently the forest cover 77sq. km at a percentage of 10.6. Forestry degradation was a result of urban development and other land use practices including sub-substance farming system, zero grazing and commercial diary hence little natural vegetation left. Reforestation schemes are currently dominated by Eucalyptus plantations for agroforestry purposes (REMA, 2013).

Topography

Kigali city is on the sloping landscape of valleys, ridges, and hills. It is in the middle of Iburanga volcanoes (Northen province) to the north west and the low –lying wetlands at the peak of lake Mugesera (Eastern province) to the south east. Kigali has a lower mid-altitudinal range of 1,300 m in the wetlands, to the top of mount Kigali at 1,850 m while the surrounding regions ranges in altitude between 787 m to over 4,000 m (REMA, 2013). The city slopes differ steepness from incline of up to 45 or 50 per cent, compared to those in valley wetland regions with slopes lower than 2 per cent (REMA, 2013).

Hydrology

Kigali is comprised of 25 water shades part of the Lake Victoria basin. In the central and northern part of the city is relatively steep and waters drained in river Nyabugogo is the main water course in the; north west quadrant, (flowing south wards into river Nyabugogo); western and southern (edges of the city limits). Various rivers flow into river Nyabugogo which include, Ruganwa, Rwazangoro, Kibumba and Yanze. The Nyabugogo river is combine with Akanyaru river tributary to become Kagera river that flows into and through lakes (Mweru, Mugesera and Victoria) and finally into river Nile. The largest natural lake in Kigali is lake Muhazi boarding the north eastern slopes of Gasambo district. Furthermore, wetlands are other major hydrological sources of Kigali with a total coverage of 12.5 percent of the city total land area. Though these wetlands are of high environmental services, are under threat due to human

developmental activities for example; farming; settlement; industrial use and live stoke farming (REMA, 2013).

Nyarungenge District

The population of Nyarugenge district is estimated at 282,000 and an estimation of 49% aged 19 years and below. An estimation of 52% of the population to be female and about 87% under 40 years. People aged 65 years and above make up to 2 % of the population. The average size of household is with 5 persons per household. About 90% of the population is identified as non-poor with 6.5% as poor and 3.6% as extremely poor. Most people aged 16 years and above are wage non-farmers at an estimation of 53%. Trade is the main industry with 26% of the population aged 16 years and above, followed by other services with 20% in agriculture and 17% in government institutions. The level of literacy rate is at 86.7% among the population aged 15 and above and the district is ranked as the second after Kicukiro 89.5% other districts range from 56.5% to 72.9% (NISR, 2011).

Biryogo primary school

The school is in Agatare cell in Nyarungenge sector it was started by national government in 1982 on a total land area of 104.7 acres. The current number of pupils and teachers is 1,680 and 29 respectively and 2 non-teaching staff members. Biryogo primary school as located in Figure 2 has 23 classrooms. The pupils are aged between 6 to 14 years.

Figure 2: Location of Biryogo primary school in Agatare cell, Nyarugenge sector
Source: (Brandt et al., 2017)

The school is an entry showcase school for Rapid Planning project- Sustainable Infrastructure, Environmental Resource Management for a highly dynamic Metropolises (Brandt et. al, 2017). Rwanda Housing Authority (RHA, 2014) 78% of Kigali settlements are informal. The city policy is to upgrade the entire neighbourhood without demolishing (RHA, 2014). The upgrading activities include Nyarugenge sector, which comprises of city cells of Biryogo, Kiyovu, Agatare and Rwampara. Therefore, the case school Birygo is in Agatare cell in Nyarugenge sector. Planting of fruit trees around the school playground (Figure 3) is among the Rapid planning element for a sponge school concept (Zeitz et al., 2017).

School playground **School classrooms**

Figure 3: Biryogo primary playground and classrooms

3.2 Study Approach and Design

This section deals with the study approach and design. This study used basically qualitative. The use of qualitative studies is a well-established approach in anthropology, sociology, economics, and humanity and among others. The study employed a qualitative method in the first objective to understand the available and the commonly preferred fruit tree species at the local level. The reasons for their preferences were examined by using stakeholder perceptive survey and key informant interview. The rest of the study objectives were examined through SWOT analyses for promoting fruit tree-based learning garden at Biryogo primary school, through conducting school perceptive survey. It is an approach that has been used successfully by various researchers in this field (Dyson, 2002)**.** Figure 4 summarizes the methodological approach used in the study.

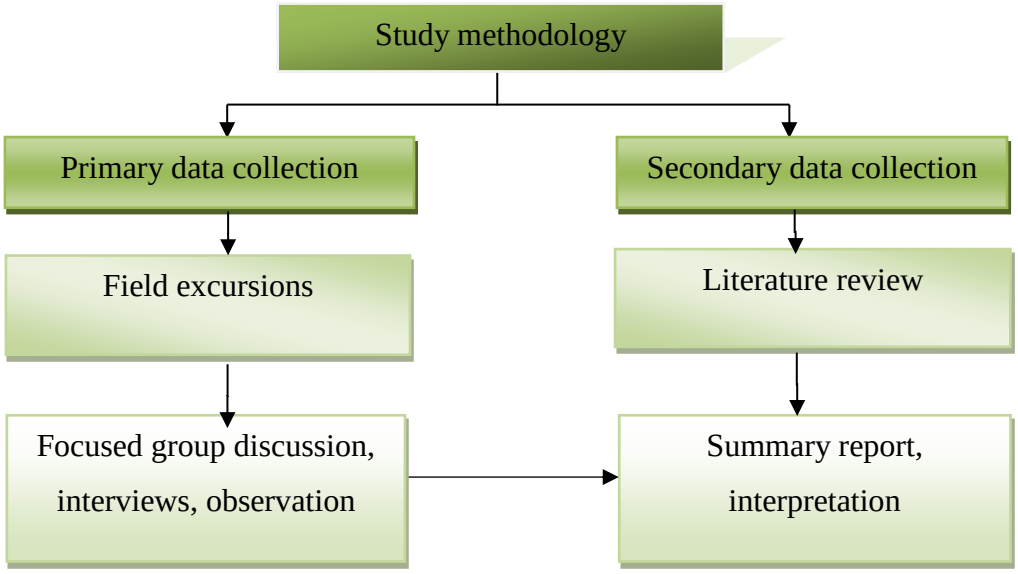

Figure 4: Method of data collection

The study applied data 'triangulation' because the researcher used different sources of data, more than one study method or data collection technique was applied. The environmental benefits of fruit trees and their multi-function nature, called for attention on how the study was carried out. Therefore, informant interviews were used to have a better insight of the environmental benefits of fruit trees. This study explores how relevant stakeholders engaged with one another toward the attainment of the overall goal of promoting fruit trees in Rwanda. The above approaches were complemented with one focus group discussion. The focus group comprised of the City authorities, international and local stakeholders, Rwanda agricultural Board and community representative. To examine the environmental and social-economic benefits of fruit trees on vulnerable steep slopes and urban informal settlements, specifically on school learning gardens, household, and small-scale farmers the study borrowed the definition of Innes & Booher (2010) as ‘‘results on the ground.’’

The study design constitutes the case study method. A case study method was used to investigate a contemporary phenomenon within its real-life context when the boundaries between the phenomenon and context are not clear evidence; when multiple sources of evidence are used to guide data collection and analyses (Yin, 1989). These were the choices of the case study, the selection of location such as community, town or city and respondents, the sources of data, methods of data collection and the analyses to be done. Case studies are widely used in several studies and research which has maintained its credibility and integrity. Case study

application are seen in the areas such as sociological studies, political studies, education studies, organisational studies, public management studies, environmental studies **(**Zaida, 2007**).** Furthermore, Yin (2003) points out that "the distinctive need for case studies arises out of the desire to understand complex social phenomena" because "the case study method allows investigators to retain the holistic and meaningful characteristics of real-life events", typically, in organizational and managerial processes. Yin (1994) identified six sources of evidence for data collections in the case study protocol and among them are: documentation, archival records, interviews, direct observation, participant observation, and physical art facts.

The study was primarily a survey, exploratory and descriptive design. They were applied to explore those situations in which the issue being evaluated has no clear, single set of outcomes, while descriptive case study describes a phenomenon and the real-life context in which it occurred (Yin, 2003). Case studies have become "one of the most common ways to do qualitative inquiry but also they are neither new nor essentially qualitative (Stake, 2000).

3.3 The Study Population and Sample Units of Enquiry

In this section, the population of the study is described. The population included the characteristics of the respondents and the sample which will be the representative of the population. Additionally, a unit of inquiry for the study is described.

Population

In this study, the population included the teachers and pupils at Biryogo primary school and NGOs dealing in the promotion and supporting of school gardening program for environmental education and urban small-scale farming in Kigali.

Units of enquiry for the key informant interviews

The key informants included; Rwanda Agricultural Board (RAB), urban wetland farmers' cooperatives, University of Rwanda, Rhineland Palatinate, Africa evangelic enterprise. Makerere University, Uganda National Agricultural Research Organization (NARO), NGOs, management, and development partners. Other informants included administrators Biryogo primary school and community representative.

The study focused on environmental benefits of fruit trees to stabilize slopes because various steep slopes characterize the country's geography. Several human developments have occurred on the city slope, yet a challenge to implement stabilization techniques' in the informal settlements. Therefore, when the slope failure occurs without massive support, both

environmental and social-economic systems take a while to recover from the event. Promotion of fruit tree growing involves several stakeholders or organizations and multiple interactions among relevant stakeholders at the national, regional, and local level. These stakeholders are concerned in various ways in the promotion of fruit tree growing and management. The major implementation units for fruit tree growing could include; school learning gardens, public spaces, urban small-scale farmers, households, and institutional landscape management. The various stakeholder for promotion of fruit trees may include: ministry of agriculture, ministry of education, ministry of health, ministry of infrastructure, ministry of forestry and mines, ministry of environment and lands; local government and urban development; city planners; cooperatives, academia, research institutes, media, non-government organization and development partners. To obtain a balanced and representative data, the study at this point divided the target stakeholders into three groups. Below is the list of stakeholders that were consulted.

Government

1. Ministry of Food and Agriculture /Rwanda Agricultural Board (RAB)
2. University of Rwanda (UR) School of Agriculture and Environmental Engineering
3. Health and Sanitation Officer Nyarugenge Sector, Kigali
4. Urban planner Nyarugenge Kigali
5. Engineer City of Kigali
6. Uganda National Agricultural Research Institute (NARO)

Farmers' stakeholder

1. Agako Farming Training Centre
2. African Evangelistic Enterprise
3. Urban Wetland Farmers Cooperative Nyarugenge

School gardening stakeholders

1. Headmistress Biryogo Primary School
2. Rhineland-Palatinate, Kivu, Kigali
3. Rwanda Environmental Conservation Organization (RECOR)
4. Rapid Planning Project.

Group one: organizations which have direct responsibility for planning, designing, operating and supporting of fruit tree growing for environmental and social-economic benefits.
Group two: stakeholders that are direct beneficiaries of the fruit tree promotion.
Group three: stakeholders comprise of the organizations, especially with established interests and activities in fruit tree planting or in environmental education programs.
Furthermore, expert interviews were conducted with at least one representative from each organization involved in implementation work such as policy makers, institutions, NGOs, farmers (Table 8). If the performance of the physical environment is a threat at local level, the negative perception will increase negative attitude and intentions. It is, therefore, important to understand the perception of stakeholders, especially in informal settlements such as schools, urban farmers, households, and NGOs to inform decision-makers about local people perception and needs. Stakeholders perception is crucial in measuring the environmental and social-economic benefits of fruit trees to school learning gardens, urban farmers, and residents (Hu et al., 2014). Since stakeholders' perceptions are different and complex, literature recommends different assessment tools for comparing the perceptions of respondents in groups (Nowata et al., 2014; Owusu et al., 2012). However, one major challenge that can lead to bias during stakeholders' perceptions survey is a failure to answer questions correctly by the respondents. Grawford (1997) reported that it could be that, respondent did not understand the question properly or the interviewer could not build sufficient rapport. Therefore, this challenge could be minimised by using Participatory Research Approaches (PRAs) such as focus group discussion, semi-structured interviews and observation-transect walk (Guijt & Veldhuizen, 1998) to make up for the gaps in the study findings.

Table 8: List of key informants and their organizations

Name	Organisation
1. Prof. Dr. M. Sankaranarayanan	University of Rwanda
2. Mr. Nsigaye Alfred,	Rwanda Agricultural Board
3. Mr. Maniriho Festus	University of Rwanda
4. Mr.Munyerango Richard	Agako Farming Training Center
5. Magezi Charles	African Evangelistic Enterprise
6. Mr. Bambe Jean	Rwanda Agricultural Board
7. Mr. Nkuba Epaphrodite	Rwanda Agricultural Board
8. Mr. Ssekasamba Ronald	Uganda National Agriculture Research Centre
9. Ms. Monique Mukaruliza	Biryogo Primary School
10. Mr. Butoto Patrick	Biryogo Primary School
11. Ms. Anuschka Häußler,	Rhineland-Palatinate
12. Ms. Nyaranshuti Felicite	Rhineland-Palatinate
13. Mr. Christopher	RECOR
14. Mr. Duhirwe Chaste	Nyarugenge Sector
15. Mr. Mumuhire Abias	Engneer city of Kigali
16. Mr. Emanuel Ingabire	Urban planner Nyarugenge, Kigali
17. Ms. Kanimba Sylvie	Rapid Planning
18. Mr. Gatwaya Canisius	Community Representative

Units of enquiry for the focus group discussions

Focus Group Discussions have been applied in many fields. For example, marketing, health, and social science as well as in homogeneous groups of populations to determine the needs, opinions, and preference of the groups (Ekblad & Baarnhielm, 2002). Another advantage of FGDs is that it provides interaction between participants and highlights their views, the language they use about an issue and their values and beliefs about a situation (Kitzinger, 1994). Kitzinger, (1994) further argues that participants ask questions among themselves, as well as to re-evaluate and reconsider their own understanding of their specific experiences. During the exploration stage of the study, FGDs were used as a complementary method especially for triangulation method and to check the validity of the data collected.

3.4 Sources of Data and Methods Used for their Collection

In every study, the use of multiple data source is necessary. However, users require the skills and knowledge to apply them and it will also depend on what is available and relevant to the study. The study relied on sources which include: (1) Documentation (2) Archival records (3)

Interviews (4) Direct observation and (5) Participant observation. The importance of multiple sources of data is a strategy to enhance the credibility of the data (Stake, 1995; Yin, 1994).

Primary data collection methods

The primary data collection used Participatory Research Approaches (PRAs) such as field observation, interviews of farmers and school organizations, agencies or departmental heads, extension officers, and administering of interviews and observation. The data collection exercise took off from first September to fourth Novembers 2016. The goal was to have an insight about stakeholder perception about the promotion of fruit trees in urban informal settlements, management and environmental and social-economic benefits in school learning gardens, urban farms and at house level. The period was chosen because Rapid Planning Project needed research on the possible fruit tree species and varieties that can be planted at Biryogo primary school playground. The fruit tree survey was carried out with the support of the Rwanda Agricultural Board's Department of Horticulture at Rubona Station.

Secondary data collection methods

Secondary data from institutions such as UR, Rhineland Palatinate, FAO, WHO, NARO, RECOR, GAKO and Makerere University, was an important source of information. The reports were assessed to determine what kind of information was available, the problems and how the system had been managed. The information collected was compared to the prevailing conditions at the site. However, the information was not enough and detailed. Therefore, it was imperative to go an extra mile to conduct field study and in this regard stakeholder in gardening programs had an important role to play. Review of relevant literature was used, including information from a wide range of files, online publications, published and unpublished reports on relevant works on the environmental benefits of fruit trees and slope stabilization theories, management, and benefits in Rwanda. The researcher made use of the internet as a source of data collection. Basically, it consisted of a literature search on environmental benefits of fruit trees which was compared to the actual practice to determine the gap in the research.

Field observation

The primary data began with field observation to obtain first-hand information. It involved paying attention, watching, and listening carefully in the field where the researcher used all the senses, noticing what is seen, heard, smelled, tasted, or touched to collect relevant information

(Kreuger & Neuman, 2006). The observation was done before the school survey to pre-inform the interview process. It was observed that the school gardens and urban landscapes are mostly managed by planting non- fruit trees, grass, and flowers. During the sessions the fruit trees were observed as well. Two extension officers were useful in discussing observation findings. The results were used to validate the responses obtained from the semi-structured interviews. During such observations, it was found that a few fruit trees were seen on school compounds. To establish fruit tree on the school compound will require a lot of resources, such as fertile soil, water for irrigation during the dry season, protecting fences among others.

Interviews

Interview appointment was made with key informants through a telephone conversation and emails. The date and time of the interview were scheduled before any interview was conducted, there was an in-depth background check of each stakeholder through their website. This was to get the overview of operational activities and administrative structure of the organization. The informant's interview was done in the office and an average of twenty minutes was spent. To make the primary information reliable and useful, telephone or email communication interviews were done to clarify issues pertaining to the research. Additionally, the interviews with urban farmers were conducted in the local language Kinyarwanda by the help of a translator.

The interview guide was developed to ascertain stakeholder perceptions on the various sections see Appendix A (interview question guide). The guide consisted of seven questions guide which examined the type and varieties used, reason for preference and environmental and social-economic benefits. Limitations and possible challenges to the promotion of fruit tree-based planting designs, examine the extent fruit tree are used for slope stabilization. The following problems were encountered during the interview sessions:

1. Difficulties in accessing proper records on projects and research;
2. The Kinyarwanda language is a more preferred language for communication across the country. However, some of the farmers interviewed were fluent in French than English (the researcher had very little knowledge of Kinyarwanda and no French). The language difference resulted in the extension of the time for interviews since more explanation was needed for the respondents to express themselves in English;
3. Visit to some farms was not possible because the research was conducted during the dry seasons and most organizations were not comfortable with it.

3.5 Methods of Data Analysis

It was imperative to employ qualitative study to explain the factors underlying the broad relationships. The result from qualitative data methods serves as a check on each other which give a high confidence in the overall result. The mixed method of data analysis is described below.

Qualitative data analyses

Regarding the qualitative data analyses, the identified issues, concepts, or themes were compared to existing literature. Thematic analysis was used to identify emerging issues from the interview's transcripts to have meaning with the research goal. Transcribed data were analyzed to identify similar themes, emerging ideas, concepts from the interviewees. This analysis was aimed at understanding stakeholder perspectives on the promotion of fruit trees. Furthermore, the processes, effects, and implications on of fruit trees on urban vulnerable slopes and informal settlements at the household level. For example, the respondents were asked about what kind of fruit tree types commonly preferred at the local level and the main reasons for their preference challenges and opportunities. The study provided the roles they played in relation to the management areas such as environmental and social-economic support services among others.

A desktop analyses and literature research were also carried out to analyses the data. Tables, and SWOT analyses were applied. The SWOT comprises of the Strength, Weakness, Opportunity, and Threat for the implementation of fruit garden at Biryogo primary school. The techniques depicted the nature, the magnitude and the inter-relationships between the challenges faced by the community.

3.6 Methodological limitation

The study had some methodological limitations that needed to be considered for future research work. Findings from the current study cannot be generalized because the current study information was case-specific. Further research can replicate this study to assess and compare the findings with other urban informal settlement.

3.7 Ethical Considerations and Integrity of the Study

The study first sought permission from the relevant stakeholders before any data collection. It was ensured that the respondents understood that the exercise was voluntary and assured any information given was treated with utmost confidentiality. An opportunity was provided for

each participant to ask questions and to air their views. Addressing the respondents' right to full disclosure, the researcher described the nature of the study, the participants retained the right to refuse to participate in the interview.

Furthermore, it is important to provide quality and trustworthiness during the study. Therefore, it is very necessary to incorporate mechanisms that guarantee the researcher and the reader about the integrity of the study. A quality case study research avoids criticisms due to lack of methodological rigor and bias and (Smith, 1988; Yin, 1989). This study took into accounts to deal with integrity in relation to the following criteria: construct validity; conformability; internal validity; external validity and finally dependability (Miles & Huberman, 1994; Yin, 1989).

To start with, in the case of construct validity, the study worked with grounded theories approaches and the theories fit the outcome of the study **(**Glaser & Strauss, 2004**).** Prudently, respondents and organizations were chosen, structured interview process, transcribing and interpreting the data to reduce bias or subjectivity (Dick, 1990).

Secondly, confirmability of the study is manifested in the transcriptions, interview notes and secondary sources. That is, another researcher can also observe and use it for further study. Furthermore, credibility in the study can be ensured by preventing bias at all levels. Feedbacks to the respondents were used to fill the gap in the study. Transferability suggests the applicability of the study results but takes into accounts the study focuses on idiographic (case) rather than the nomothetic (generalization) (Guba, 1981).

Lastly, to improve the reliability of the study, it followed the case study method and procedures in the data collection exercise, interview processes and data analyses. Presentation of the study results to different stakeholder for a focused group discussion. The integrity of this study is dependable because it satisfies the criteria by Yin, (1989) and Miles & Huberman, (1994).

4 RESULTS PRESENTATION

This chapter presents the results of the study. The results are grouped into three sections. The first section deals with the available and the major fruit trees at the local level. The second section presents the fruit tree species suitable for Biryogo primary school, the fruit trees species that can be introduced in Rwanda and other multi-functional trees that can be grown in school gardens and compounds. The third is the presentation of the Strength, Weakness, Opportunity, and Threat (SWOT) for promoting fruit tree- based learning garden at Biryogo primary school.

4.1 The Available and the Major Fruit Trees at the Local Level

Table 9 shows the commonly grown fruit tree species in Kigali, Rwanda. The table further shows the scientific name for each fruit tree identified and their corresponding varieties at Rwanda Agricultural Board (RAB). These fruit trees are commonly seen throughout Rwanda on small-scale farm fields and at the household level, particularly the local varieties.

Table 9: Available fruit tree species in Kigali, Rwanda

	Fruit	**Scientific name**	**Variety at RAB**
1	Mango	*Mangifera indica*	Tommy Atkins Apple mango Kent Haden Sensation Atualfo Ngowe Borimbo Dodo
2	Avocado	*Persea americana*	Hass Fuerte Ettinger Nab
3	Oranges	*Citrus senesis*	Valencia Washington
4	Papaya	*Carica papaya*	Female Flower Male Flower
5	Guava	*Psidium guajava*	Tropical white Tropical Pink
6	Jackfruit	*Artocarpus heterophyllus*	Several varieties of local names

Table 10: Supply market and prices of fruits at Kimironko market

Fruit	Supply market	Price	Quantity
Mango	Uganda	1,000 RwF (€1.00)	1 kg
Orange	South Africa	400 RwF (€ 0.40)	1 piece
Avocado	Rwanda	400 RwF (€ 0.40)	1 piece
Apple	South Africa	250 RwF (€ 0.25)	1 piece
Tamarillo	Rwanda	1,200 RwF (€ 1.21)	1kg
Pawpaw	Rwanda	1,000 RwF (€1.00)	1 piece
Madrines	Rwanda	1,000 RwF (€1.00)	1kg
Passion fruit	Rwanda	1,000 RwF (€1.00)	1 kg

Table 11 shows the top three common fruit tree species and their corresponding varieties, namely; mango, (*Mangifera indica*) avocado (*Persea americana*) and oranges (*Citrus sinensis*). It also presents the various fruits that can be harvested per tree in a year.

Table 11: The common fruit tree species and variety

	Fruit	Scientific name	Variety	Harvest quantity kg/ yr	Major reasons for preferences
1	Mango	*Mangifera indica*	(a) Local variety	170	(a) Weather and climatic suitability (b) Soil suitability (c) Climate change mitigation (d) Slope stabilisation (e) Shade (f) Evaporation / canopy (g) Large quantities and quality harvest (h) Nutritional support (i) Agroforestry urban crop farming (j) Environmental education
			(b) Kent	250	
			(c) Tommy	200	
			(d) Zilate	250	
2	Avocado	*Persea americana*	(a) Local variety	80	
			(b) Fuerte	180	
			(c) Hass	100	
3	Oranges	*Citrus sinensis*	(a) Valencia	75	
			(b) Washington	80	

4.2 The Fruit Tree Species Suitable for Biryogo Primary school

Table 12 shows the fruit tree species and varieties that were identified for Biryogo primary school. The table also indicates the scientific and Kiryarwanda[2] names for the fruit trees. The

[2] Official language spoken in Rwanda

relevance of this table is to show that a fruit-tree based learning garden can be designed to show the possibility of using a school garden for practical nutritional and environmental knowledge transfer at school and local level such as harvesting fruit throughout the year. The table further gives a physical general description for each tree particularly the planting availability at RAB, height, size of canopy, spacing to the next tree, root type, period for the first fruiting and harvesting months, main reasons for the recommendation and other additional purposes.

Table 12: The identification of fruit tree species for Biryogo primary school

	Fruit	**Scientific name**	**Kinyarwanda name**	**Variety**	**Availability at RAB**	**Height (m)**	**Size of canopy**	**Spacing to the next tree (m)**	**Root type**	**Period for first fruiting/ harvesting months**	**Main reason for recommendation**	**Additional advantage**
1	Mango	*Mangifera indica*	Imyembe	Kent, Tommy, Zilate	Tree seedlings	3	Medium	6x6	Deep	2-3 years/ Dec-Feb	Drought resistant Shade tree Survive in the soils Education	Timber, leaves and stem herb to a cough
2	Oranges	*Citrus sinensis*	Amacunga	Valencia, Washington	Tree seedlings	3	Medium	6x6	Deep	2-3 years/ May-Jul	Educational purposes	Leaves a cure cough
3	Avacado	*Persea americana*	Amavoka	Hass, Fuerte	Tree seedlings	5	Medium	6x6	Deep	2-3 Years/ Oct-Nov	Provide shade, Drought resistant, Roots can bind soils	Timber, leaves and branches are medicinal
4	Mulberry	*Morud*	Iboberi	RsC3	Stem cuttings	6	Medium	0.9x0.4	Shallow	3 months	Quick to grow, a lot of fruits, drought resistant	Fodder, leaves used for green tea,
5	Guava	*Psidium guajava*	Amapera	Tropical white Tropical pink	Seeds	3	Medium	4x4	Deep	2-3 Years	Ecosystem interaction (birds feed on guava has well)	Fodder for pigs, leaves feeds for Fish and Chicken
6	Papaya	*Carica papaya*	Amapapayi	Female flower Male flower	Seeds	4	Small	4x4	Shallow	8 months	Quick growing, Drought resistant	Papaya leaves are medicinal, Shade
7	Tamarillos	*Salanum betaceum*	Ibinyomoro	Local names Insongore and Imbundi	Seeds	2	Very small	2x2	Shallow	8 months/ Aug-Oct	Good for a school garden not in playground shrub	Leaves are herb on small cutes
8	Jackfruit	*Artocarpus heterophyllus*	Ibifenesi		Seeds	6	Large	6x6	Deep	3-4 years	Shade, Drought resistant	Timber, Fodder

Table 13 shows a list of other multi-purpose trees suitable for Biryogo primary school garden and compound. The relevance of the assessment was to identify different ornamental multi-purpose trees that can meet many environmental and social needs at the school level.

Table 13: The multi-purpose trees identified by RAB for school gardens, compounds and urban

	Common name	**Scientific name**	**Height (m)**	**Size of canopy**	**Reason for recommendation**
1	Croton	*Croton megalocarpus*	6-30	Large	Ornamental, Bio-fuel, Medicinal, Poultry Feeds Drought resistant Fast growing Not browsed by animals
2	Spectacular cassia	*Senna spectabilis*	6-10	Medium	Ornamental, Shade,Fast growing Drought resistant Leaves provide mulch Boundary and supportive
3	Red calliandra	*Calliandra calothyrus*	2-12	Medium	Fodder, Erosion control, Nitrogen fixation Green Manure Pollen source of honey production Land rehabilitation Stake in climbing beans
4	Coast she oak	*Casualina equisefoliora*	6-35	Dense	Erosion control, Shade, Nitrogen fixing Fast growing Soil Improver Drought resistant
5	Markhamia	*Markhamia lutea*	6-15	Large	Erosion control, Bee forage, Mulch Termite resistant Ornamental Medicinal
6	Entada	*Entada abyssinica*	6-10	Medium	Medicinal, Ornamental, Fast growing Drought resistant
7	Parasol	*Polyscias fulva*	6-35	Medium	Fast growing, Handcrafting, Drum making Ornamental Soil rehabilitation
8	Outeniqua yellowwood	*Podocarpus falcatus*	6-45	Large	Ornamental, Medicinal, Fruits eaten by birds Fast growing Drought resistant

Note: They all have a deep root system

4.3 Swot Analysis for Promoting Fruit Tree-based Garden Biryogo Primary School

Table 14 shows the swot analysis for the promotion of fruit tree- based learning garden at Biryogo primary school. The analysis of promoting and managing fruit tree- based learning garden provides important insight into the strength, weakness, opportunities, and threats at the school level. The relevance of the assessment is to address the weaknesses and strengthen the management capacity at the school level. Therefore, the decision makers should balance these aspects.

Table 14: The swot analyses for promotion of fruit tree-based learning garden at Biryogo primary school

Strengths	**Weakness**
1. Cordial relationship among staff members, members of the community and other NGOs 2. Community participation and support 3. Enabling policy	1. Inadequate of motivation 2. Poor coordination 3. Insufficient resources at school level
Opportunities	**Threats**
1. The presence of NGOs 2. Scale up of school gardening projects 3. Environmental education	1. Illegal Certification 2. Animal encroachment 3. Discontinuity of monitoring activities and motivation

5 DISCUSSION OF RESULTS

This chapter provides the discussion of the results under various sections namely, the major fruit trees, the environmental conditions for growing fruit trees, environmental and social economic benefits of fruit trees. The section also discusses the swot discussion for Biryogo primary school.

5.1 Major Fruit Trees

Six fruit tree species were identified as illustrated in Table 9 of chapter four, however, the available and major used fruit tree species in Kigali Rwanda include, mango *(Mangifera indica*), avocado (*Persea america*) and oranges (*Citrus senesis*) in Table 11 of chapter four. These results match those observed in earlier studies (MINAGRI, 2014). The top three fruit species are also commonly preferred in all East African countries (Sonko et al., 2005). There are many reasons as to why they are common and preferred at the local level which includes; large harvest, consumed as snacks and for substance household income among others (Schreckenberg et al., 2006).

5.2 Environmental Benefits of Fruit Trees

Slope stabilisation

This finding cannot be attributed to all respondents; it was a common response from focused group discussion, who pointed out that most fruit trees have a deep root system that can stabilize the slopes and mitigate any possible slope failure. Fruit tree planting can be a productive landscape management implementation plan at household and institutional level particularly in the informal settlement. A possible explanation could be that surface tree roots have the potential to resist tension by increasing the shear strength of shallow soils (Roering et al., 2001). The identified fruit tree species in Table 12 of chapter four are classified in medium class ability to increase shear strength as reported by a previous practical study on root shear strength (Budidarsono & Wijava, 2004). A previous research study in Tajikistan, Asia indicated that native fruit tree species can stabilize vulnerable steep mountain slopes (Nekushoeva, 2011). On the other side, a possible explanation as to why the stakeholders involved in agriculture and high institution of learning are the only respondents who considered fruit trees for slope stabilization could be due to their higher educational status. The respondents who have higher educational level tend to get easy access to information. The educated respondents are well informed about the future possible natural risks at both regional and national level. Therefore, the result implies that the consideration of fruit trees for slope stabilization by

stakeholders can be promoted in land use and environmental plans through afforestation as key landslide prevention.

Climate change mitigation

Climate change is one of the major environmental problems that have affected not only human livelihood but also ecosystem and biodiversity. It is also important to realize that planting fruit trees can be one of the ways of mitigating the menace of climate change as previous reported by Akinnifesi et al. (2007). In recent times, the attempt to mitigate climate change has been focusing on merely planting of trees without taking into accounts additional direct social-economic benefit like fruits for the nutritional and economic benefit. In addition, some local organizations have not been successful in tree planting campaigns this is because the tree supply does not have direct benefits to the household. Strategies such as Reducing Emissions from Deforestation and Forest Degradation (REDD) national tree plantation program help in addressing the problem of climate change. The fruit tree planting at local level will not only improve food but also contribute to some extent in reducing increasing global temperature.

Previous studies have shown that fruit tree planting campaign has a direct benefit to the socio-economic needs at the household level as well as a way of mitigating climate change (Sthapit et al., 2012). It mitigates climate change because even though households focused on the economic benefits, the fruit trees help to remove excess carbon from the atmosphere at the regional level, thus contributing to the reduction of climate change (Kusolwa et al., 2012). Fruit trees are evergreen throughout the year, enabling carbon absorption from the atmosphere. This implies that climate change could be carbons will be mitigated right at the household level.

Evaporation

Evaporation is one of the direct environmental processes that can reduce the amount of fresh water, especially during the drought seasons. Planting fruit trees can collect liquid water inform of fog and drops down to the ground. This will help to improve the macroweather and climatic conditions at local levels. Fruit trees like any other trees contribute to evapotranspiration but they are in position to collect more water than they evaporate because of their deep root system, wider canopy, and the fact that they bear leaves year through (Williams, 1997). This implies that they can be used for evapotranspiration particularly in the dry seasons for water balance. This finding agrees with Sandu, et al. (2010). Therefore, evaporation and evapotranspiration processes can be achieved in different forms such as planting fruit tree: on small-scale farms as buffers, urban landscapes, school gardens, urban agroforestry.

5.3 Social-economic Benefits of Fruit Trees

Large harvest

Large harvest or quantity per season was, identified to be among the main reasons as to why some fruit trees are preferred at both household and community level has previously shown in Table 11 of chapter four. For example, 250 kg of mango and 180 kg of avocado are harvested per year on every single tree. Therefore, such large amounts of harvested fruits are normally consumed excessively at the household level in their fresh form. However, the surplus fruits are not left to rot, rather given out, batter traded, or sold to neighbours. This is consistent with the findings of Miller et al. (2016). Furthermore, at the peak season fruits are sold at a very low price and most of the fruits produced are local varieties. The reason for low prices is that everyone has similar fruits, thereby increasing the surplus at local markets. On the other hand, most of the fruits that are preferred and sold on the local market such as mangoes and oranges are mostly got Burundi, Kenya, Uganda, and South Africa. The reason for preference of fruits got from outside countries is because they ar of a higher quality. They are normally sold at a higher price (Table 10). Therefore, most local people with a low income cannot afford to include fruits on their daily diet after the local fruiting season. The above finding implies that during the fruiting season extra fruits are put to waste, while after the fruiting season individuals particularly from low and middle-class income lack nutritional benefits from fruits. Therefore, there is a need to promote the post-harvest small-scale technology. For example, machines to dry fruit into chips and to produce fruit jam and wine at household level or through local industries. The finding corresponds with Affognon, et al. (2015). Another relevance of this finding is the fact that improved fruit tree species should be introduced at the country level to reduce the number of fruit trees imported in the country. This will not only reduce the future market price of fruits but also for local employment opportunities.

Nutritional support

Fruit can boost the immune system of the human body system (Brat et al., 2006). One of the common responses from this study was that mango fruits (*Mangifera indica*) are healthy for children and pregnant women. This result is consistent with other studies that identified that women consume more fruits than men (Nicklett & Kadell, 2013). Primary pupils and secondary students preferred mangoes (*Mangifera indica*) and oranges (*Citrus senesis*) trees because they believed they are healthy for their growth. The reason for this response could be that they are readily available, and they can harvest themselves.

Additionally, stakeholders were greatly concerned about the need of planting more fruit trees to support a healthy living in young children. The explanation for these results is that they are senior citizens and have been able to identify a continuous decrease in fruit trees. This has resulted in the increase of malnourished and anemic urban-rural children (Giskes et al., 2002). On the other hand, some elderly individuals believe that the consumption of fruits is unnecessary because they believe they are healthy enough and that they consumed more than enough when still young. This result can be related to their low income, thereby lowering their desire to increase their expenditure by adding fruits on their daily diet as found by Giskes et al. (2002). In addition, it could be that, due to lack of education, the elderly people are unaware of the benefits of fruit at their old age as compared to the developed countries where nutritional information is highly accessible (Sarafino & Smith, 2014).

Provision of shade

The most preferred fruit trees have a large and wide canopy. For example, most of the trees found in the household were planted in the centers of some home and school compounds with a purpose to the provide shade during the hot weather conditions. However, there are various reasons for positioning and preference of fruit trees. This depends on people specific needs as earlier observed by Shackleton et al. (2008).

The relevant of trees shade is to protect the people against the early sunrise in household, industrial and institutional level. The sunrise[3] sets early, for example, in September the sunrise starts at 05:47 am and in October and November 06:30 am which exposes individuals to suffer from direct sunlight. While compared to the neighbor country Uganda, the direct sunrise[4] start at around 8:30 almost throughout the year. The direct sun can lead to the loss of concentration while working outside and health implications such as dry skin, headche, noise breeding among others.

Additionally, the most encouraging implication of this finding is that the most preferred fruit trees are evergreen, and drought resistant thus in position to provide shade throughout the year. The trees can be planted in the spacing of six by six meters apart thus providing a dense and enough shade at household, institutional and industrial level during hot weather conditions.

[3]Kigali, Rwanda — Sunrise, Sunset, and Daylength https://www.timeanddate.com/sun/rwanda/kigali (accessed on 29th of November 2017)

[4]Kampala, Uganda — Sunrise, Sunset, and Daylength https://www.timeanddate.com/sun/uganda/kampala (accessed on 29th of November 2017)

The wider canopy can be of various functions such as absorb dust, windbreakers and improve the macro environment among others as earlier observed by Cameron & Hitchmough (2016).

Additional uses

This study found out that fruit trees are preferred or used for several social-economic uses, different parts of a tree are used for various benefits at both house and local community level. For example; fruit leaves are used as fodder commonly for cows and goats, traditional herbs, (leaves and barks for avocado, mango and oranges are cooked and used to traditionally cure a cough and several diseases) at local level (Orwa et al., 2009). It is also a common practice to cut off excess branches on fruit trees and use them for; construction of temporary chicken houses (it is a common practice for households to have 3-5 chicken); energy; wood fuel; planting of hedges; mulches and manure; ornamental and food security.

A positive implication for the additional uses and purposes for fruit trees is that they can be derived for a longer lifespan. This implies that goals of sustainable development can be promoted and achieved at the local level through fruit trees planting campaigns. This is because everyone in the household will be able to relate to a fruit tree and have a collective responsibility towards the fruit tree growth since the existence of fruit trees serves several direct social economic needs at house level.

The study also focused on environmental education regarding primary and secondary school learning gardens. There are two important aspects in creating and promoting environmental education at school and community level. The first important aspect is that, at the school level, it was found that fruit trees can be used for practical lessons, for example in science, mathematics, biology, agriculture, ecology, fine art, among others (Deichler, 2017). This is because different fruit trees have different scientific descriptions and physical appearance. That is when considering the physical, biological, ecological description for a fruit tree species, for example, they have different leaflets, fruits, seeds, stems, flowers among others.

Varieties of fruit trees in school learning gardens contribute to practical education to different age groups and class level. Having practical education outside classrooms can broaden children knowledge and attitudes towards the natural environment. This is because several pupils and students in the city live in fenced houses or informal settlement thus detaching them from the natural environment. Therefore, the aesthetic nature of fruit trees can be used to attractive pupils and students to nature by fostering positive environmental attitudes through school learning gardens.

Additionally, having fruit trees can keep the school learning gardens green throughout the year. Currently, the commonly used crops are vegetables such as spinach, cabbage, carrot, tomatoes, and onions among others in school learning gardens which are seasonal crops. Therefore, fruit trees can be used as permanent crops hence promoting urban agroforestry at an early age. Therefore, improved fruit tree species are suggested in the school learning gardens because of their early fruiting, quality fruits and manageable canopies that are suitable for intercropping.

Furthermore, having the proper selection or combination of fruit trees is highly recommended for the school. This is because some fruit tree species and varieties can affect the undergrowth of other crops thereby retarding their growth. The second important aspect is that school learning gardens target a wider audience. For example, teaching staff, non-teaching staff, parents, and community members. It communicates and promotes practical environmental education in the management areas such as urban agroforestry, organic waste management (reduce, reuse, and recycle), material management (designing compost manure) this finding relates with Williams & Brown (2013). Additionally, a model case site for introducing new fruit tree species in the country will promote professional network between local and national level since experts from different sectors can meet and offer advisory role to the school and community members' in making fruit gardens a success.

5.4 Favourable Conditions for the Growth of Fruit Trees

This section describes the major favorable conditions required for the optimum growth of fruit trees. Two major conditions were identified which include; soil suitability and rainfall availability to support the optimum growth of all the fruit trees previously identified in Tables 11 and Table 12 of chapter four.

Soil suitability

The most interesting finding was that soils in the study area can support the growth of fruit in the city as elsewhere in the country. There are several possible explanations for this result. First, it could be due to the natural soil characteristics in Rwanda. The average soil pH value for Rwandan soil is 5.1 with 67% acidic pH < 5.5 (Ngendo, 2013) while the optimal pH range of soil to support plant growth is 5.5-7.5 (Kangit et al., 2006). This is encouraging to compare the pH soil tolerates for different fruit tree species as earlier described in Table 4 which is in range with the average soil pH of Rwanda.

Furthermore, it is necessary to clarify that the soil types in the study area can support fruit tree growing. The soil is composed of a large component of mainly of sandy clay loam physical

soils properties. Previous literature has pointed out that Kigali is dominated by ferric, haplic and humic crisols soils type (Stoorvogel et al., 2016;) Therefore, fruit tree growing in cresol soil type can be managed with basic or minimal soil management practices.

For example, FAO describes cresol soil type to be used in rainfed and irrigated crop agricultural and can be managed through careful fertilization. Most fruit tree roots can grow in the humus surface horizon with a few tap roots growing deeper to the subsoils (FAO, 2015). Additionally, planting of fruit trees can lead to soil formation due to higher soil microbial populations (Ranjith, 2008). In the same line, the establishments of fruit tree-based agroforestry crop systems contribute to a higher carbon sequestration and landscape diversity hence improving soil formation as observed by Ranjith (2007).

Rainfall availability

Rainfall is one of the important factors for plant growth thus knowing the best month for fruit tree planting is very crucial. In the case study, a suitable month for the planting of fruit tree seedlings was identified and recommended. It was observed that the plants die out due to wrong planting season. October or end of August is mistakenly considered to be the best month for fruit tree planting. This is because it is the beginning of the rainy season. However, November was identified as the most suitable month because it consists of the highest number of rainy days in the year as indicated in Table 7 of chapter 3. This implies that, once fruit trees are planted in November, irrigation may not be necessarily required once the fruit tree seedlings are planted. This will save water, labour and time spent in school garden. This finding relates to that of Ndahiro (2006).

On the other hand, Rwanda Ministry of Natural Resource Authority (MINIRENA) identified that Water Resource Management (WRM) as a major challenge for the future. Due to increasing multiple water demands for internal use (MINIRENA, 2011). This is because, 4.3km3 of rainfall per year is lost to runoff and most of the irrigation schemes are inefficient (MINIRENA, 2011). Therefore, this implies that a right planting month for fruit trees should be observed and communicated to the relevant stakeholders to mitigate on the future challenges and extra costs that arise from planting in the improper season.

5.5 Fruit Tree Implementing Challenges on School Learning Gardens

The fruit tree seedlings that are available for planting are too short and delicate to handle at school level. Some teachers loose interest in planting of these seedlings because most them are too sensitive to harsh weather conditions and to pests and diseases. This finding corresponds

with that of Iizumi &Ramankutty (2014). The reason as to why some teachers find the harsh weather conditions a threat, could be that they lack information on the proper planting season or month for fruit tree as discussed in the above paragraph. Another implementation challenge is that some students and pupils in urban school lack enough motivation from their teachers and parents to participate in school learning gardens or environmental clubs. Some non-government organisations have a big challenge to find teachers and students that are passionate about the environment. The possible explanation to this challenge could be that less environmental awareness programs are done at local level. Therefore, if people lack enough information or have not been in any environmental programme campaign, they are more likely to have less interest in any on growing environmental protection activities. This finding is in collaboration with Rao (2010) finding. Furthermore, another implementation is that fruit tree seedlings are costlier compared to non- fruit tree seedlings. The price for one fruit tree seedling is at 1000Rw (€1.00) while the price for non-fruit tree seedlings is at 300Rw (€0.30). Therefore, fruit trees are affected by opportunity cost, schools prefer to plant non-fruit tree compared to fruit tree to maximise costs. This finding is in relation with Hagura (2017) that costs can influence decision.

5.6 SWOT Analysis

Table 14 presents in the section of findings shows the swot analyses. The major strengths that were identified include cordial relationship among staff members, community participation, and support, presence of NGOs, enabling policy and institutions to promote and support the successful implementation of fruit tree-based garden at Biryogo primary school. The strength lies in the fact that Rwanda has a national policy and programs that support school gardening programs. Additionally, the school is also a case study area for the Rapid Planning project entry implementation program for the promotion of fruit tree planting in school compounds. Therefore, Rapid Planning project willingness to support will empower the school gardening activities with professional advice from international, national, and local stakeholders in different areas. For example, setting up, maintenance and upgrading of fruit tree-based school learning garden.

The implication is that gardens do integrate several professionals thus providing room for practical knowledge transfer as previously reported by Buch, (2016). In addition, the school has a strong connection with the community members. For example, the school receives supports from urban wetland farmers' cooperative who cultivate vegetables and rear livestock around the wetland (10 minutes' walk from the school). Therefore, the school will have access

to compost manure and later in exchange, the farmers' cooperative will have fodder for live stocks.

However, apart from rapid planning project, inadequate motivation remains a major weakness for the promotion of fruit trees school due to inadequate coordination at the school level. This can be attributed to the fact that there are insufficient resources and fruit tree planting involves high cost input (materials and equipments). For example, at Rwanda Agricultural Board (RAB) the price for one fruit tree seedling is at 1000Rw (€1.00) while the price for non-fruit tree seedlings is at 300Rw (€0.30). The school is challenged with several challenges such as flooding, storm water, and inadequate learning materials. Therefore, establishment of a fruit tree garden might not be one of the immediate development projects at school level.

Among the key opportunities, there are existing NGOs such as Rhineland Palatinate. That can support the school with some of the gardening equipment materials and professional advice. This will reduce the expenditure in setting up the school garden. The involvement of fruit trees can scale up school gardening programs and promotion of environmental education at both school and community.

Illegal certification for some nursery bed owners in the city is a great threat to the promotion of fruit trees. This is because different buyers are biased about the quality and the type of fruit tree seedlings they sell. For example, one can buy an orange seedling but upon maturity, the fruits are for lemon. This make individuals to lose interests in buying improved fruit tree seedlings from the city nurseries. Animal encroachment is another serious threat to the fruit trees in the school compound. There have been some cases where goats enter the school compound and feed on plants, resulting in conflicts between the school and the animal owners.

Finally, the discontinuities of monitoring and motivation activities are potential future threats. Some of the study findings indicated that it is hard to promote school gardening programs because it is a challenge to identify teachers and students who are passionate about the environment or interested in gardening activities. Some city students and parents those in informal settlements find school gardening activities degrading. Most of the above-mentioned challenges are comparable to the research results of Yu (2012). Therefore, there is need to for the continuous education and promotion of gardening activities to mitigate future threats for the above-mentioned challenges.

6 CONCLUSIONS AND RECOMMENDATIONS

This chapter brings the study conclusion and recommendations. The recommendations are divided into general and specific recommendation.

6.1 Conclusion

Fruit tree growing contributes significantly to the livelihood of the communities through the provision of environmental and social economic benefits. There are also a source of income and employment for the residents working in agriculture.

The study found out twelve fruit tree species that can be grown at household, city urban farms and school gardens. The identified fruit tree species can stabilise slopes because of their deep root systems and the drought resistant nature. Out of the twelve fruit tree species seven are locally available while the five are locally available in neighbouring country Uganda. It can be concluded that fruit trees have been less utilised because out of the seven only three fruit tree species are commonly available at local level these are, mango (*Mangifera indica*), avocado (*Pesea americana*) and oranges (*Citrus senesis*).

One of the objectives was to assess the environmental and social-economic benefits of fruit trees. The benefits that the study identified include, slope stabilisation, climate change mitigation, evaporation, household income, nutritional support, provision of shade and other additional benefits such fodder, traditional herbs, source of wood fuel and timber. Therefore, at local level, the communities are aware of benefits that can be delivered from planting fruit trees; however, the environmental benefits are less known.

One of the study questions was to find out the policy and implementation challenges of fruit trees in school gardens. Some of the implementation challenges the study found include; limited access to fruit tree planting seedlings, low pH value in the school soils, limited access to manure, low student participation and hard to find teachers who are passionate about the environment or school learning gardens. This has influenced negatively the rate at which fruit trees are planted.

Soil and climatic suitability were major natural factors that the study found that can support the growth of fruit trees in Kigali. The study found out that the soil in Kigali are dominated by ferric, haplic and humic crisols soil type which can support the growth of fruit trees either through rain fed agriculture or irrigation. Rainfall is one of the most important factors for fruit tree growing. Rwanda is made of three agro-climatic zones which include; temperate, sub-tropical and tropical zone but Kigali city is under the tropical zone that can support the growth of various tropical fruit trees.

The study found out that several local people were biased about the climatic conditions of Kigali that it cannot support fruit tree growing. The people have often observed wrong planting month. The best planting month for fruit trees was November. It can be concluded that the local people need more awareness and continuous update about the best planting seasons and months amidst the changing climatic conditions.

The study found out that at local level, community members are willing and prefer planting fruit trees compared to other non-fruit trees. However, they are limited due to many factors such as illegal certification, pests and diseases, vulnerability of tree seedling (maximum height of 0.4 cm), lack of fencing against animal bruises, higher costs of fruit tree seedlings compared to non- fruit tree seedlings, limited knowledge on management of fruit tree seedlings.

The limitation of the study is that, the case study data made it difficult to generalize the findings. Geographically, only one primary school in Agatare cell, Nyarugenge district of Kigali City was considered. However, it is recommended that future work on the promotion of fruit trees and gardening programs should cover more schools in the different sectors of Kigali city.

6.2 Recommendation

This section consists of specific and general recommendation. The general recommendations are about how to promote fruit tree growing and school learning gardens at a national level and specific recommendation for fruit tree garden for Biryogo primary school.

6.2.1 General recommendations

The results indicated that the maximum height of fruit tree seedlings which is at four cent metres is still delicate to be properly managed and vulnerable to several damages. The agricultural board could provide a second option for farmers, households or institutions that find a big challenge to handle small seedlings. Tree seedlings of hundred cent metres height could be another option to promote fruit tree planting. This would reduce on the bias towards very short fruit tree seedlings' that they are highly vulnerable to harsh weather conditions and pests and diseases.

As proven by the results that several fruits can be grown in urban informal settlement for slope stabilisation and nutritional slopes in the urban informal settlements. Therefore, the government through the agricultural board could set up fruit tree community nurseries that local people could afford to buy the fruit tree seedlings. The possible suitable sites for nurseries could be public spaces or schools. University students and secondary students could be a source

of labour. This will help the students to gain practical knowledge and at the same time the government to save on the implementation costs.

The results indicated that inadequate resources at school level is a major hindrance towards the promotion of school learning gardens. Therefore, the government and non-government organisation should come up with a policy of providing the basic gardening tools and equipment's at school level identified in Table 15.

Table 15: A list of some recommended basic essential tools and materials in a school garden

Tools	**Uses**
Hoe	For establishing farms and weeding
Shovel	For building beds, digging plants holes, and turning soils
Garden rake	For smoothing soil
Hand trowel	For removing deep-rooted weed and digging plant holes
Three- prolonged	For weeding and cultivating soil in small areas
Watering can	For irrigation
Wheelbarrow	For carrying plant, mulch, and compost
Materials	
Garden stakes and row maker	To keep track of what and where to plant
String and tape measure	For spacing between beds, seeds, rows
Mulch material	To cover pathways and beds
Fertilizer	To maintain crop yields and plant health

In addition, the presence of community fruit tree nurseries could solve the challenge of illegal certification of some city nurseries. The results showed that most people are biased about buying fruit tree seedlings. Therefore, community nurseries supervised and monitored by agricultural expertise and maintained by different university and secondary students would help to promote fruit trees planting at the local level. The extension agents could use that opportunity to raise the awareness of the population on the role of fruit trees on landscape management such as slope stabilisation.

The results indicated that non-government organisations involved in the promotion and implementation of school gardening programs still face serious challenges in urban schools. For example, students do not want to involve in the gardening programs for they find them degrading, hard to identify teachers who are passionate about the environment. Therefore, the government and other non- government organisations should put more focus on organisation

of special community environmental education and awareness programs, particularly parents, teachers' pupils, and students at local level. This could be done by showing video films of challenges and successful stories within in and outside the country.

Table 16: Steps to promote school gardening

	Step	**Why**	**How**	**So, what**
1	Gathering information	To get support from administrators, educators, teaching and non-teaching staff, parents, community members	-Through effective communication -Through brain storming meetings	The garden will have a strong background to implement and sustain
2	Forming a gardening committee	To represent the different stake holders to plan, plant and maintain	- 6-12 members can be selected -Committee chair can be selected to communicate with committee and non-committee members	The garden has a team of dedicated individuals
3	Determine garden programs	To have different ideas organized into a garden design	-Garden committee can bring together all ideas from different members to form garden goals and objectives	The goals guide the and act as a measure of success
4	Design a garden	To have all learners of different age, height, and abilities in cooperated in the design	-To consider pupils or students from both lower and upper primary, or from lower and upper secondary	Different classes can have a connection during classroom activities
5	Identifying the need and obtaining resources	To have the basic tools and the right planting seedlings	-A nursery bed or compost manure can be designed at school	Investment in high quality soil and durable tools can led to sustainability

There is also a need to inform farmers' fruit tree cooperatives on how to get information on available markets for their products. This will create income diversity and increase the household income of cooperative members. An increase in cooperative income would raise the rate at which new fruit trees species are demanded for planting.

Some fruit tree species are commonly available in Uganda at the local level and can be introduced in Kigali. This can be replicated in Rwanda through pilot garden that can be used to introduce new fruit tree species with the support of city urban planners, agriculturalists, agronomists, and other relevant stakeholders.

6.2.2 Specific guidelines for Biryogo primary school

The results for Biryogo primary school indicated that inadequate motivation remains a major weakness for the promotion of fruit trees. Therefore, at school level private seminars or workshops on the basic principles of environmental education and the relevancy of school learning gardens should be first administered to teachers, parents, and pupils of Biryogo primary school before setting up a fruit tree garden.

The results also identified insufficient resources, animal encroachment to be a mong the weakness and threat of fruit tree growing at the school level. Therefore, the agricultural board could grow taller and stronger fruit tree seedlings in the nursery before supplying them to the primary school. Fruit tree seedlings of a height at least one and a half metre could be supplied to the school to save maintenance and protection costs of building a fence.

A rectangular space with lengths of eighteen metres and widths of eight metres could be used to design a modern fruit tree-based school learning garden, to promote practical education at school level. A selection of preferred food crops and vegetables that can be grown in a fruit garden should be made by teachers, parents, and pupils such that the different choices are included in the school garden. Teachers, parents, and pupils should be put in separate groups to come up with a theme for the school garden and a possible garden design. Later, the different themes and designs should be integrated into one theme and come with a final garden theme and design. This would create a sense of ownership for different stake holders once a fruit tree-based school learning garden is established.

LIST OF APPENDICES

Appendix A: Interview guide

1. Which fruit tree species and varieties that can be planted in Kigali?
2. What are some of the fruit tree that can be introduced in Kigali?
3. What are possible challenges faced during the promotion of fruit tree planting at the local level?
4. What are possible solutions to the fruit tree implementation challenges?
5. What are the primary benefits of fruit trees on small-scale farms and school compounds?
6. What have commonly grown fruit tree species and varieties at the local level?
7. What are the challenges faced during school gardening implementation programmes?
8. What are the possible solutions to the challenges faced during implementation programme?
9. What are the parents and teacher's perspective about school gardening activities?

Appendix B: Invitation letter

Rapid Planning
Project Office
KG 515
Kigali, Nyarutama
Rwanda

27th July 2016

Ms. Dorothy Julian Nalumu
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Email: dorothynalumu@gmail.com

INTERNSHIP ACCEPTANCE FOR MS. NALUMU DOROTHY JULIAN

Dear Dorothy,

UN Habitat is one of the main partners in the research project 'Rapid Planning - Sustainable Infrastructure, Environmental and Resource Management for Highly Dynamic Metropolises', funded by the German Federal Ministry of Education and Research (BMBF) under the umbrella of the Future Megacities Research Programme. 'Rapid Planning' targets urban development and infrastructure supply in four case cities in different geographical contexts, namely Assiut (Egypt), Kigali (Rwanda), Frankfurt (Germany) and Da Nang (Viet Nam).

I am pleased to inform you on behalf of the Rapid Planning project in Kigali, Rwanda, that your proposal for internship as a student researcher position as been accepted.

This was based on your presentation about "School gardening for environmental education and nutritional support focused on fruit trees" during your participation at the Rapid Planning project mission from June 27th to July 1st 2016 in Kigali.

As you will be preparing your master thesis related to above mentioned topic, you will not be paid. Additionally, students do not receive any benefits as part of their internship program.

The proposed schedule for your internship will be an 8 weeks period during September and October 2016. I am sure that you will be able to contribute to the implementation of the Entry Project of the Rapid Planning Project in Agatare Sector, Kigali related to the trans-sectoral improvement of the playground and open space of the primary school in this sector.

Yours sincerely

(Sylvie Kanimba – Local Project Manager, UN Habitat - Rapid Planning Office – Kigali)

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