Promoting Multi-Functional Fruit Trees in Vulnerable Urban Steep Slopes and Informal Settlements: A case of Biryogo Primary School Kigali, Rwanda

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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 analysed using SWOT and thematic analysis to establish the different fruit trees species suitable for urban farms and school gardens. 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. Whereas few respondents mentioned that fruit trees could stabilise 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 a solution to address and promote fruit tree growing and school learning gardens at the national and local level - Biryogo primary school.

Keywords *— Fruit Trees, Informal Settlements, Multi-functional benefits, Rwanda*

I. INTRODUCTION

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, rainfall, and commonly referred to as "land of 1,000 hills" (Kabeza et al., 2012). 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 can mitigate climate change, by considering food security and livelihood necessities for both small and large-scale farmers (Syampugani et al., 2010). 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 received little 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). 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 the soil, soil erosion and insufficient research, among others (Mbow, 2014). 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: in agriculture, some farmers at the local level hardly realise the direct benefits from some tree species thus leading to the low adoption of agroforestry practices. Additionally, to identify teachers who are passionate about the environment to promote environmental education is a challenge. It is against this background that the study tends to identify the different fruit tree species that can thrive in urban farms and school gardens; the benefits and policy implementation challenges in Kigali.

II.MATERIALS AND METHODS

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. Kigali is the capital and largest city with an estimated population of one million people (2011, est.). The total population of Rwanda is projected to be 16 million people by 2020 (Kabeza et al., 2012). The case school is Biryogo primary school**.** The school is in Agatare cell in Nyarungenge sector, the national government started it 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 has 23 classrooms. The pupils are aged between 6 to 14 years. The primary data began with field observation to obtain first-hand information and followed by an interview. We interview informants or experts from 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, development partners, administrators from Biryogo primary school and a community representative. 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 a community representative. Secondary data from institutions such as UR, Rhineland Palatinate, FAO, WHO, NARO, RECOR, GAKO and Makerere University. Relevant literature was used, including information from a wide range of files, online publications, published and unpublished reports on relevant works on the socio-economic and environmental benefits of fruit trees in Rwanda. Thematic analysis was used to identify emerging issues from the interview's transcripts to have meaning with the research goal. This study utilised SWOT analysis to derive the internal and external factors found in the process of planning and promoting of fruit tree-based learning garden at Biryogo primary school.

III. RESULTS AND DISCUSSION

A. The Fruit Tree Species Suitable for Biryogo Primary school

Shows the fruit tree species and varieties that were identified for Biryogo primary school (Table 1). It describes each fruit tree, particularly the planting availability, 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. The top three fruits are the common fruit trees in Kigali. Table 3 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.

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

The relevance of the assessment is to address the weaknesses and strengthen the management capacity, therefore, decision makers should balance these aspects.

Strengths

1. The cordial relationship among staff members, members of the community and other NGOs
2. Community participation and support
3. Enabling policy

Weakness

1. Inadequate motivation
2. Poor coordination
3. Insufficient resources at the school level

Opportunities

1. The presence of NGOs
2. Scale up of school gardening projects
3. Environmental education

Threats

1. Illegal Certification
2. Animal encroachment
3. Discontinuity of monitoring activities and motivation

C. Major Fruit Trees

Six fruit tree species were available as illustrated in Table 1, however, the dominant used fruit tree species in Kigali include, mango *(Mangifera indica*), avocado (*Persea America*) and oranges (*Citrus senesis*). These results match those observed in earlier studies (MINAGRI, 2014). The top three fruit species are also commonly preferred in all East African countries. The reasons as to why they are common and preferred at the local level include; large harvest, consumed as snacks and for substance household income, among others similar to Schreckenberg et al. (2006).

D. 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 stabilise slopes. Fruit tree planting can be a productive landscape management implementation plan at household and institutional level, particularly in the informal settlement. It is because 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 1 are classified in medium class ability to increase shear strength as reported by a previous practical study on root shear strength (Budidarsono & Wijava, 2004). The result implies that fruit trees for slope stabilisation can promote land use and environmental plans in preventing a landslide.

Climate change mitigation: Climate change is one of the significant environmental problems that have affected not only human livelihood but also the ecosystem and biodiversity. It is also important to realise that planting fruit trees can be one of the ways of mitigating the menace of climate change as previously reported by Sileshi 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. Some local organisations have not been successful in tree planting campaigns this is because the tree supply does not have direct benefits to the household. 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).

Evaporation: Evaporation is one of the direct environmental processes that can reduce the amount of fresh water, especially during the drought seasons. Fruit trees like any other trees contribute to evapotranspiration, but they are in a 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.

E. 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 because of the amount harvested. Therefore, such large amounts are typically consumed excessively at the household level in their fresh form. However, the surplus fruits are not left to rot, instead given out, batter traded, or sold to neighbours. This is consistent with the findings of Miller et al. (2016).

Nutritional support: Fruit can boost the immune system of the human body system (Brat et al., 2006). One of the common responses 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 much concerned about the need for planting more fruit trees to support healthy living in young children.

Provision of shade: The most preferred fruit trees have a large and wide canopy. Most of the trees found in the household were planted in the centres of homes, and school compounds with a purpose to provide shade during the hot weather conditions. The relevant of trees shade is to protect the people against the early direct sunrise. The sunrise[1] sets early which exposes individuals to suffer from direct sunlight. The direct sun can lead to the loss of concentration while working outside and health implications such as dry skin, headache, noise breeding among others. 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). Different parts of a tree are used for various benefits at the local level. For example; leaves are used as fodder 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.

F. 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 the school level. Some teachers loose interest because they are too sensitive to harsh weather conditions, pests and diseases. 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. Some students and pupils in urban school lack enough motivation from their teachers and parents to participate in school gardens or environmental clubs. Some non-government organisations have a significant challenge to find teachers and students that are passionate about the

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

environment. The possible explanation could be that less environmental awareness programs are done at the 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 environmental protection activities.

G. SWOT Analysis

The major strengths that were identified include cordial relationship among staff members, community participation and support, the presence of NGOs, enabling policy and institutions to 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. However, apart from the rapid planning project, inadequate motivation remains a major weakness for the promotion of fruit trees school due to insufficient coordination at the school level. This can be attributed to the fact that there are inadequate resources and planting of fruit tree involves high-cost input. Among the key opportunities, there are existing NGOs such as Rhineland Palatinate who can support the school with some gardening equipment and professional advice. This will reduce the expenditure in setting up the school garden. The planting of fruit trees can scale-up school gardening programs and promote environmental education in both school and community. Illegal certification for some nursery bed owners in the city is a significant 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. 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. Finally, the discontinuities of monitoring and motivation activities are potential future threats. Some students and parents in informal settlements find school gardening activities degrading. Therefore, there is a need to for the continuous education and promotion of gardening activities to mitigate future threats for the challenges mentioned above.

IV. CONCLUSION

It can be concluded that fruit trees have been less utilised because out of the seven only three fruit tree species are commonly used at local level these are, mango (*Mangifera indica*), avocado (*Pesea americana*) and oranges (*Citrus senesis*). The environmental benefits are less known due to implementation challenges. Therefore, 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 before setting up a fruit tree garden. The results also identified insufficient resources and animal encroachment. Therefore, the agricultural board could grow taller and stronger fruit tree seedlings in the nursery before supplying them to the primary school. Policy makers and development organisations can provide financially or play an advisory role in the planning and implementation of school learning gardens.

ACKNOWLEDGEMENT

We would like to thank the environmental experts and Biryogo Primary School, Kigali for their immense contribution and support toward this research.

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Table 1: 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 Haden Sensation Atualfo Ngowe Borimbo Dodo	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 Ettinger Nab	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

*Available fruit tree species in Kigali, Rwanda

Table 2: 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 have a deep root system