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ENVIRONMENTAL AND SOCIO–ECONOMIC IMPACTS ANALYSIS OF RAINWATER HARVESTING IN RWANDA. A CASE OF KAGARAMA SECTOR, KICUKIRO DISTRICT

***Eric Izerimana**

Faculty of Environmental studies, University of Lay Adventists of Kigali (UNILAK), Kigali, Rwanda

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Corresponding author: **Eric Izerimana,**

ABSTRACT

Learning to manage rain water means succeeding in mastering not only water scarcity but also excess and supplying water for agriculture, hygiene thus maintaining the quality of environment and improving socio-economic conditions. However, even if Kagarama sector located in Kicukiro districts in Rwanda has two rainfall seasons which serves as the ample water resources. Kagarama sector is still affected by low per capita water availability in summer days and water excess in rain season both leading to problems related to socio-economic activities and environment. Therefore, the present study was intended to evaluate the environmental and socio-economic impacts of rain water harvesting in Kagarama sector during the year of 2017. To achieve that objective, I used a quantitative research design with a descriptive correlation study and cross tabulation method to investigate associations between variables. Using Yamane formula at 90% of confidence interval, a sample of 96 households in Kagarama sector was taken and using a simple random method, 2 villages represented by 16 households each were selected within 3 cells of Kagarama sector. A questionnaire was used as a data collection instrument. After data collection, SPSS 16th edition was used as a statistical tool to analyze variables. The study found that there is a positive impact on environment and socio-economic life. But some respondents agreed that rain water may also be a source of major disease namely intestinal parasites to those who used rain water as drinkable water and rain water harvesting (RWH) can also be a source of vectors like malaria or death for those who used or neighboring dams or pits. Finally, RWH can be used to resolve problems related to water scarcity thus improving socio-economic life and protect the environment.

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INTRODUCTION

Water is globally known as capital product (Bizoza A. R.and G. Umutoni, 2012) . This is because the consumption of water is essential for humans, plants and animals hence improving life in terms of environment and socio-economical development (McReynolds, 2005). For instance, in a year, Kicukiro District in Rwanda where Kagarama sector is located has the average rainfall of 964 mm but Kagarama sector is still affected by low per capita water availability leading to problems related to socio-economic activities and environment (MINIRENA, 2013). Therefore, Rainfall harvesting can change the distribution pattern of rainfall runoff in time and space, which would supply humankind with steady water sources to some extent and reduce damages cause by runoff (Li Xiaoyan, *et al*, 2002). Water harvesting implies collection and storage the precipitation runoff for a variety of purposes where water shortage is common because of scanty rainfall and its distribution. The implementation of rainwater harvesting has a profound impact on the development and resolves the problems of water shortage (Li Xiaoyan, et al, 2002). According to Amha (2006), the Impact of rainwater harvesting has been observed across Africa, both Kenya and Egypt harvesting runoff water using underground spherical tanks provide water for irrigation and now not only farmers are producing high value cash crop and improving households' income but also the environment is safe from runoff and floods. In Rwanda, rainwater harvesting (RWH) has been introduced to be a complementary source of water which will help to meet the ever increasing and conflicting demands of water for human needs, socio-economic development and environmental protection (MINIRENA, 2013). Furthermore, Rwandan government has also established the rainwater harvesting loan scheme which is a public private

partnership operation initiated by the Ministry of Natural Resources in order to facilitate local communities to get financial support in the use of rain water harvesting systems started in Kicukiro district and in other district with high rainfall (NTIRENGANYA, 2016). All these measures will contribute significantly to the reduction of flood and drought risks building resilience to climate change (Kanyesigye, 2017). In addition, Rainwater harvesting has been included in District Development Plans to address issues of water and sanitation, environmental protection and disaster prevention thus improving socio- economic conditions. For instance the District of Kicukiro has a target to equip 100% of new buildings and 80% of existing buildings with RWH facilities by 2018(Fonerwa, 2015). In addition, Rwanda is facing major water related challenges due to heavy and intense rainfall and surface runoff during the rainy and drought during dry season. Among those challenges they are the loss of runoff and inadequate storage facilities, inappropriate farming methods, inadequate skills and knowledge about Rain Water Harvesting (RWH), environmental degradation.

During rainy seasons, urban areas of Rwanda suffer from soil erosion and floods caused by runoff of water; while in dry period other areas face serious problem of dryness which, affect residents in terms of environmental and socio-economical terms not only that but also during dry season there is scarcity of water especially in urban areas including Kagarama sector and this impede the socio-economical development and the environment. In contrast, since the implementation of rain water harvesting strategy in Rwanda, little is known about their environmental and socio-economic impacts where the overall objective of this study is to assess if the installed RWH are being beneficial in terms of environment, social and economic.

MATERIALS AND METHODS

Case study profile: Kagarama sector is among 10 sectors of Kicukiro district, Kigali Province, Rwanda. It is located at Latitude: -1°59'18.96" and Longitude: 30°6'2.16" (rw.geoview, 2017). It has 3 cells namely Rukatsa, Muyange and Kanserege with in total 15 villages. It has 14,385 inhabitants in 2,330 households. Furthermore, Kagarama has a tropical climate. According to Köppen and Geiger, this climate is classified as Aw. In Kagarama, the average annual temperature is 20.2 °C. In a year, the average rainfall is 964 mm. The driest month is July, with 7 mm of rainfall. In April, the precipitation reaches its peak, with an average of 163 mm. The difference in precipitation between the driest month and the wettest month is 156 mm while the variation in annual temperature is around 1.3 °C. The warmest month of the year is September, with an average temperature of 20.9 °C. At 19.6 °C on average, June is the coldest month of the year. (Climate-data.org, 2017).

Research Design: This research used a quantitative design with a descriptive correlation study. In addition, cross tabulation method also has been used to investigate associations between dependent and independent variables. The quantitative approach of data collection such as questionnaire, observation and pre-existing data has been used to gather all information. The quantitative approach allowed the variables to be analyzed simultaneously; these approaches were more useful in analyzing variables and make a relationship between factors.

Households and sampling techniques

Target population: The target population are households from all cells of Kagarama sector namely Muyange, Kanserege and Rukatsa cell and each cell is represented by 32 households equally divided in two villages namely Muyange and Rugunga villages in Muyange cell, Bwiza and Byimana villages in Kanserege cell, Rukatsa and Inshuti villages in Rukatsa cells. All those villages have been selected basing on probability.

Sample Design: The probability sampling was used in this study. To select respon, a simple random sampling technique was used which means that every participant of this study had an equal probability of being selected for the sample. The self-administered questionnaire was distributed among the selected respondents.

Sample Size: In any study to study the whole population is neither practical nor feasible, therefore a set of participants is selected from the population, which is less in number (size) but adequately represents the population from which it is drawn so that true inferences about the population can be made from the results obtained. This set of individuals is known as the "sample." (Bhalerao, 2010). The sample size for this study is illustrated by the use of Yamane (1967:886) simplified formula to calculate sample sizes:

With: n is the sample size, N is the population size, and e is the level of precision or the standard error at 90% confidence level and P = 0.1 are assumed for equation.

Inclusion Criteria: any population within Kagarama sector.

Exclusion Criteria: Any person who is not a habitant of Kagarama sector.

$$n = \frac{N}{1 + N(e)^2} \quad \text{then} \quad = \frac{2330}{1 + 2330 \times 0.1^2}$$

$$= 95.885 \approx 96 \text{ households}$$

Sampling Technique: The selection for filling the questionnaire was based on probability method through a simple random sampling technique which means that every habitant of selected villages had an equal probability of being selected for the sample.

Research instruments and data gathering procedures

Data collection instruments: The self- administered questionnaire was distributed among respondents with the consent form. The questionnaire has been filled with every participant with the assistance of a data collector. A structured questionnaire has been administrated to collect data on the concepts that are relevant for answering the research questions in this study. This research instrument was based on the standardized, validated questionnaire. It contains three parts: part (A) contains household characteristics (B) contains independent factors as Rain water harvesting; (C) which contains dependent variables: environmental and socio-economic factors. To check its consistency an extensive evaluation of final version of the questionnaire has been developed.

Administration of data collection instruments: A letter of permission was requested from University of Lay Adventists

of Kigali and was presented to Sector officials of Kagarama sector informing them on the topic of the study and its importance thus, requesting for permission to interact with the population. The data collector also explained the objectives of the study to the authorities concerned and respondents assuring their confidentiality.

Validity and Reliability of the instrument

Validity: The validity is the extent to which a test measures what it is supposed to measure is relevant with the topic. Content validity was ensured by taking suggestions from experts, advisers and lecturers that looked at its relevancy, clarity and consistence to the study. After, the questionnaire has been amended according to the suggestions. According to Cronbach, to the question "what is a good validity coefficient?" the only sensible answer is "the best you can get", and it is unusual for a validity coefficient to rise above 0.60, though that is far from perfect prediction. Therefore, Cronbach coefficient was used to see the strength of any question.

Reliability: Reliability is the degree to which a test consistently measures whatever it measures. Errors of measurement that affect reliability are random errors and errors of measurement that affect validity are systematic or constant errors. For the reliability of the instrument a pilot study will be done together with pre-test to test its reliability.

Data analysis procedure: After the collection of the data, I processed and analyzed them. I examined the raw collected data to detect errors and omissions, and correct them when necessary and possible. Once examination of the raw data was finished, the step of encoding was followed in order to clean and classify the raw data into the usable. I put data in a logical order after having assembled the data which has been summarized into the raw data and displayed in the compact form; that is showing data in language of statistical tables for further analysis. The data were arranged orderly in columns and rows and were analyzed. The analysis of quantitative approach was done by the use of statistical technique, tables and percentages. Statistical Package for Social Sciences (SPSS) 16th edition was used as a statistical tool to compare variables.

Ethical consideration: Purpose and nature of the present study was explained to the study participants. Also, the target households were announced that participation of the study were not receive prior training and/or previous exposure to many of these activities and the goal of this study is to assess impact and training needs, and identify any and all areas that need to be addressed. Every single study unit was informed that participating in the research was voluntary. Oral consent was obtained from participants. The questionnaires completed were coded and no names were not on the questionnaires. Name links to the codes were kept in a coded drawer. Information was kept confidential.

RESULTS AND DISCUSSION

Types of rain water harvesting found in Kagarama sector: One of the objective of this study was to identify types of rain water harvesting used at household level, UNEP (2009) classifies rainwater harvest system into in situ and ex situ technologies, even in manmade or impermeable surfaces. Therefore based on the findings, the majority of sample of 96 households, 82 households which is equivalent to 85.4% had rainwater harvesting technologies, while 14.6% didn't had any rainwater harvesting technology. Moreover, based on the general observation in the field and in data obtain from the sample, among 82 of households which is equivalent to 84.5% who had rainwater harvesting technology, the majority (81.7%) had domestic rainwater harvesting including plastic tanks, jerry cans, baskets, etc…, 9.8% had surface catchments including rocks, concrete, plastic sheet, 4.9% had small scale dams namely sub-surface ponds or pits, 3.7% had micro catchment namely contour bunds and terraces.

Impacts of rain water harvesting on environment: According to the responses to the questionnaires, 64% and 21.9% were agreed and strongly agreed respectively that RWH installation should be compulsory as a solution to flood and runoff while 10.4% and 3.1% were disagreed and strongly disagreed respectively. Concerning RWH as one of solutions for environmental management, 56.2% and 37.5% were strongly agreed and agreed respectively, 4.2% and 1% were disagreed and strongly disagreed while 1% was uncertain. To emphasize the above discussion, the evidence from the respondents was revealed that based on N= 96 households, the majority (74%) of respondents have been affected by excess water causing flood or runoff while 26% didn't been affected before using a rain water harvesting techniques in their households. Moreover, among those 71 respondents who have confirmed that they have been affected by flood or runoff, most of them (62%) were affected by water coming from their own houses, 31 % by that water coming from neighborhood while 7% were affected by water coming from ravine. However, after using a rainwater harvesting techniques, 85.4% of 96 households which is 82 households who had a RWH system, 84.1% were no longer been affected by flood or runoff, while 15.9% were still affected, this because those 15.9% was using a RWH technique which is not appropriate to the provided quantity of water for instance baskets while their rooftop was providing more than 5,000 liters and also some of their neighbors may not have any RWH technique which increased the runoff.

Furthermore, based on the sample of 96 households, the majority (78.1%) have been experienced water shortages while 21.9% didn't been affected. But after using RWH techniques, among 85.4% of 96 households who had a RWH technique, 70.7% were no longer experiencing water shortages, while 29.3% were still experiencing water shortages, this because those 29.3% may have a RWH technique which is not able to collect high quantity of water comparing to its demand. In addition, water is available for those households with RWH techniques for a period at least 15 days. Among 85.4% of 96 households who had a RWH technique, 74% confirmed that the collected water last from 1 to 15 days, for 8.3% the collected water last between 15 – 30 days, while for 3.1% the collected water last less than 1 day. Therefore, this is evidence that RWH techniques have a positive impact on environment by controlling flood and runoff and making water available for use.

Socio- economic impacts of rain water harvesting: Economic benefit of RWH is money and time saving because the more water saved, the more money saved (Caleb C. A; Rahman A and Gathenya J, 2016). According to the responses

to the questionnaires, 39.6% and 52.1% were agreed and strongly agreed respectively that once RWH system is installed, the money spent on water decreases, 5.2% and 2.1% were disagreed and strongly disagreed respectively. Moreover, regarding money spent on a RWH technique would be better spent elsewhere, 4.2% and 10.4% were strongly agreed and agreed respectively, and 62.5% and 21.9% were disagreed and strongly disagreed respectively while 1% was uncertain. In addition, concerning the statement on balance, the cost of a RWH system is worth the investment, 3.1% and 46.9% were strongly agreed and agreed respectively, 42.7% and 5.2% were disagreed and strongly disagreed respectively while 2.1% were uncertain. While on the statement is easy to operate and to maintain, 12.5% and 64.6% were strongly agreed and agreed respectively while 19.8% and 3.1% were disagreed and strongly disagreed respectively. This study found that in Kagarama sector the main source of water is taps water, the majority (90.6%) had taps at their households as a main source of water which is good as it meets the SDGs plan concerning water sanitation, 8.3% used common source/ public taps as a main source of water while 1% used rainwater. Regarding the time spent fetching water, the majority (90.6%) spent less than 5minutes to get to a water source, 3.1% spent 5-30 minutes while 6.2% spent 30 – 60 minutes to get to a water source. Concerning the average daily quantity of water in liters needed by households, the majority (74%) needed 80 liters daily, 22.9% needed 80 – 100 liters daily, and 2.1% needed more than 100 liters daily while 1% needed 20 liters. This is a clear indication that the rain water is an additional or complementary source of water needed at household level and it is very helpful because based on the quantity of water needed and monthly average rainfall, a household may choice the best RWH techniques which will resolve problem related to water scarcity.

Rain water is high used to resolve hygienic problem and help to save money by using rain water for those hygienic activities consuming high quantity of water. The majority (80.5%) of those who had RWH systems used the collected water for laundry and cleaning, 12.2% used the harvested water for toilette, 3.7% didn't use that water they wait for its infiltration, 2.4% used the collected water for agriculture/ irrigation purpose 1.2% used the collected water for livestock feeding
Furthermore, according to the responses to the questionnaires, 24% and 7.3% were agreed and strongly agreed respectively that RWH system is not the answer to water shortage. Regarding Water shortages affect your children by making them late to school and tired, 36.5% and 22.9% were strongly agreed and agreed respectively, and 40.6% were disagreed. For our household, we continue to use the main water source even if we have a RWH system, 2.1% and 61.5% were strongly agreed and agreed respectively, and 35.4% and 1% were disagreed and strongly disagreed respectively. In contrast RWH may be a source of health problem (Bizoza A. R.and G. Umutoni, 2012) and this also had been stressed by households from Kagarama sector that RWH system has negative impacts like source of water borne diseases, vector sources and death, 60.4% and 32.4% were strongly agreed and agreed respectively while 7.3% were disagreed.

Relationship between RWH and environment and socio-economic factors: The relation between rain water harvesting and environment was positive as among 82 households which had RWH techniques 69 were no longer been affected by rain water causing flood and runoff comparing to 13 which were still affected this is because they are using inappropriate techniques of rain water harvesting and storage. In addition, among 82 households which had RWH techniques 59 were no longer been affected by water shortages comparing to 24 which were still affected this is because they are using inappropriate techniques of rain water harvesting and storage.
Concerning the relation between rain water harvesting and socio- economic factor was positive at extent that 46 households which had a RWH system were strongly agreed and 33 agreed that since installing RWH system, the money spent on water has decreased compared to 3 households which were disagreed that since installing RWH system, the money spent on water has decreased. From the responses, 92.8% which is the equivalence of 13 households among 14 which didn't have any rain water harvesting method spent more than $5 for water bill per month and a half of them spent more than $9 compared to 13.4% of those which had a rainwater harvesting method. For those which had a rainwater harvesting method 85.3% of them monthly spent less than $5 compared to 7.2% of those which didn't have any rainwater harvesting method. Furthermore, it is statistically significant as p value < 10% (0.001<0.1).

Conclusion

The study found that the most common RWH type in Kagarama sector is ex situ method namely domestically rain water harvesting from observation in field rooftop rain water harvesting is the most used techniques, but also little number of households was using in situ method contour bunds. Rain water harvesting had a positive impact on environment as it reduces the number of households affected by rain water causing flood or runoff. But even if RWH has a positive impact on socio-economic life like helping to save and gain money which would be paid to complete households activities consuming high quantity of water, hence providing a sustainable source of water, rain water may also a source of major disease namely intestinal parasites to those who used rain water as drinkable water and RWH can also be a source of vectors like malaria or death for those who used or neighboring dams or pits. There is significant relationship between rain water harvesting and environment and socio-economic in Kagarama sector.

Recommendations

To ensure the safety of rain water harvested. After noticing that rain water harvested was highly used in daily households' activities, it recommendable to provide filtrating methods. It is also recommended to increase the mobilization about the importance of rain water harvesting method as some people don't much about it. To mitigate those risks, people should be informed on this potential health impact if the collected ponds water is used properly, also insecticide impregnated bed-nets have to be distributed to near runoff ponds village (Minela, 2011). Due to the scope and limitations of the study, the researcher recommends that further research on impact of rain water harvesting. Finally given that this study was done in small scale area with limited time, a broader analysis on impacts of rain water harvesting is required to provide more findings by enlarging the sample size and using different statistical tool.

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