Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/7576
DOI URL: http://dx.doi.org/10.21474/IJAR01/7576

RESEARCH ARTICLE

CHALLENGES AND MANAGEMENT OF ECOLOGICAL SANITATION IN RWANDA: NORTHERN AND SOUTHERN PROVINCE.

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Manuscript Info

Manuscript History

Received: 16 June 2018
Final Accepted: 18 July 2018
Published: August 2018

Keywords:-
Sanitation; Closed Loop System; Social Challenges; Management Strategy; Rwanda.

Abstract

Ecological sanitation, is an approach which is characterized by a desire to safely "close the loop" (mainly for the nutrients and organic matter) between sanitation and agriculture. Ecological sanitation systems aim at providing a hygienically closed loop system that is safe and economical. Human excreta is converted into nutrients and returned to the soil for agricultural purposes and water to land. Sustainable development goal number 6 focuses on the need to ensure availability and sustainable management of water and sanitation for all. The aim of this study was to assess the effectiveness of ecological sanitation toilets in Huye and Musanze districts, of Rwanda .This research was conducted to understand properly the challenges faced by the residents of the two districts. Out of the 400 residents with ecological sanitation toilets from the two districts, 150 were sampled randomly and questionnaires administered. 10 key informants were selected for an in-depth interview. During the study, respondents acknowledged that sanitation and hygiene was a key to human health. Despite the presence of the ecological sanitation toilets, some of the residents did not utilize them properly. This was evidenced by the presence of human excreta in and around the toilets, foul smell, and presence of big blue and green flies. In the study, culture and religion were some of the key factors that hindered the residents from properly utilization and sharing of ecological sanitation toilets. Lack of knowledge, poor attitude and large family sizes also largely contributed to improper utilization of ecological toilets. Intensive labor involved in emptying of the toilets was another challenge. The main challenge seen on terrain was cultural factors which were faecophilia and faecophobic continuum. Some of the responses were classifying all the human excreta as clean and clean meaning those who touches human excreta like feacal matter would be referred to as untouchable.. Government and senior officials and Policy makers are very crucial in the sanitation campaigns to bring all the projects to the owners. The research illustrates how government should address the sanitation concern. The study recommends intensive awareness campaigns and advocacy to remove negative attitudes towards ecological sanitation toilets; training in ecological sanitation toilets operation; regular reviews and check-ups by authorities.

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Background:-

Currently, global trends on the problems of water crisis and sanitation continue to surface for many years in many African countries (Cross and Coombes 2013, Cross and Coombes 2015). As African countries are in the final push towards attaining SDG's and MDG's that were initially adopted in the early 1990's by the world's governments as a blue print for building a better world in the 21st c, the issue of sanitation has consistently become real and problematic regardless of MDG 7 that was specifically set to deal with improved accessibility to suitable safe water and sanitation (Sano 2007). The situation in Africa demonstrates the biggest challenge ahead in meeting MDG.

The continent has the lowest water supply and sanitation coverage of any region in the world. "Access to sanitation is deeply connected to virtually all the Millennium Development Goals, in particular those involving the environment, education, gender equality and the reduction of child mortality and poverty," UN Secretary-General Ban Ki-moon said. "An estimated 42,000 people die every week from diseases related to low water quality and an absence of adequate sanitation. This situation is unacceptable."Developing countries are setting up high development standard measures that in one way or the other, compete unfavorably with the ever and over growing populations. And to this effect, sanitation health concerns gradually become an automatic spillover to this mix up, thus severely affecting the environment as well. As cities expand with the increasing population, the situation will grow worse and the need for safe, sustainable and affordable sanitation systems will become even more critical (Winblad and Simpson-Hebert 2004). In essence, inadequate sanitation systems greatly impacts man as well as nature in one way or the other. An estimate of 2.6 billion people worldwide lack access to improved sanitation. That is, they lack facilities that hygienically separate human excreta from human contact (Rosemarin 2003, Supply, Programme et al. 2005)).

In Rwanda, over 80% of the population has got access to latrines, but only 8% of these meet hygienic standards. A great number of the country's house hold population is prone to sanitation related disease threats (Kayitesi 2008). Sanitation and hygiene are part of local community concerns and deservedly will require a ground plan of action. Rwanda being African Ministers' Council On Water (AMCOW) member, greater efforts to lead are required in sanitation improvement by engaging the private sector and civil society. There is need to vitally reverse this hazardous situation through a deeper analysis with contestations of what would best be implored to rectify sanitation spillovers. In other words, look for affordable and applicable technology both in design and implementation.

Africa and south Asia regions in the world rank with the greatest sanitation challenges. In 19 countries in sub-Saharan Africa, less than a quarter of the population uses an improved sanitation facility (Leibowitz, Antonovsky et al. 1966, Small and Bunce 2003). Asia and Africa have continued struggling with contaminated drinking water that is in the end is accompanied with illness. Every year, under the Millenium Development Goals (MDG's), unsafe water and lack of basic sanitation kills at least 1.6 million children under age of five years (Organization 2000, Rosemarin 2003, Supply, Programme et al. 2005). Key facts about sanitation by world health organization (WHO) reviewed 2016 shows - In 2015, 68% of the world's population had access to improved sanitation facilities including flush toilets and covered latrines, compared with 54% in 1990. Nearly one third of the current global population has gained access to an improved health care system.

Currently, 2.6 billion people; that is, more than 40% of the world population, do not use toilets and open air defecation becomes the order of the day. And nearly 2.4 billion People still do not have basic sanitation facilities such as toilets or latrines. Of these, 946 million still defecate in the open, for example in street gutters, behind bushes or into open bodies of water. The proportion of people practicing open defecation globally has fallen almost by half, from 24%to 13%.

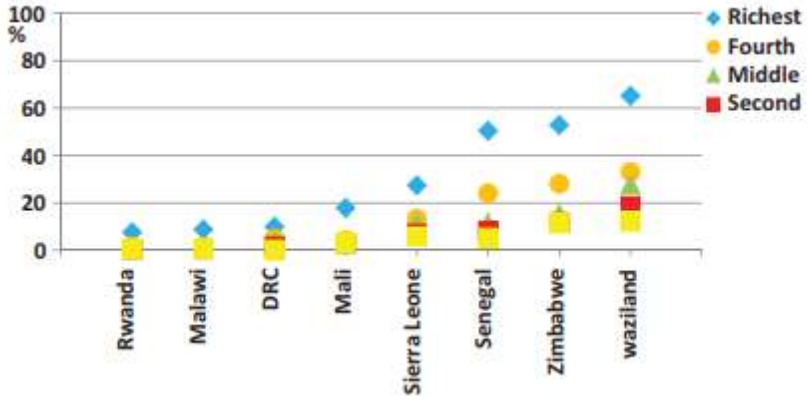

Figure 1:- Hand washing situation in Africa

Hand washing is lowest done and practiced in poorest households and below 20% in richest households as seen in the Figure 1. (Cross and Coombes 2015)

Open defecation much as it is declining in every sub-Saharan region; it clearly emerges as the most costly form of unimproved sanitation. This clearly indicates a demand move onto the sanitation ladder. However, access to improved sanitation has not kept pace, hence the comparative increase in population using shared or unimproved sanitation (Sanitation Drive 2015, 2013).

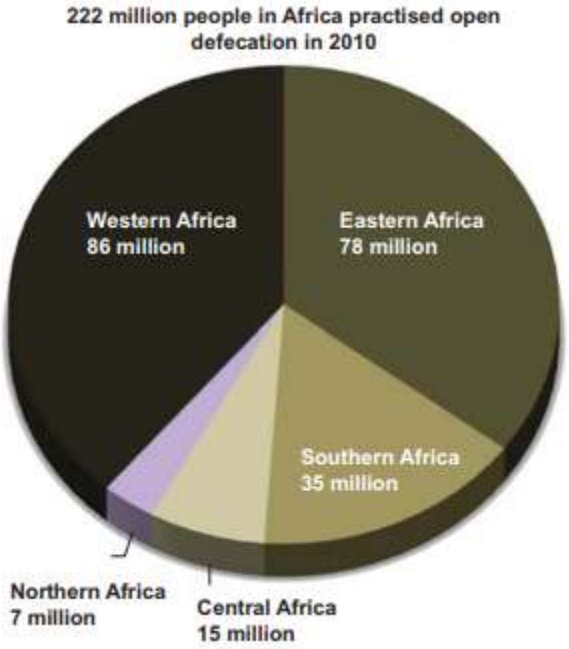

Figure 2:- Open defecation by region

At least 10% of the world's population is thought to consume food irrigated by waste water. Inadequate sanitation is a major cause of diseases world-wide and the improvement of such (sanitation) is known to have a very significant health impact both to households and across communities. (Cross and Coombes 2013). Today, many people are living in polluted environments whereby the children growth is cut short by premature deaths and this, in developing countries is registered as the worst scenic area (Organization 2000). About 2.4 billion people do not have sustainable sanitation and this is more evident in developing countries. Poor sanitation in developing countries is at a worrying state, putting her citizens to health risks. In every one out of five persons have no access to safe and sufficient sanitation (Langergraber and Muellegger 2005), (McGranahan 2010). All this is caused by lack of toilets or toilets'

mismanagement and because of the latter; it leads to diseases like cholera, diarrhea and others due to Pathogens. The question still remains; what can be done to rectify this global health concern? Is there an affordable and managed design system that can come as a rescue? In Africa, Rwanda in particular, both urbanization and population growth are rapidly increasing, something that calls for an appropriate sanitation technology in addressing the issue at hand in order to meet its management and sustainability. More often in rural areas in Africa, children faeces are unsafely disposed. There is less care to ensure that either the child uses a latrine directly or clean the child's stool into a latrine (Supply, Programme et al. 2005). This is very an alarming state that calls for an improved sanitation in Africa. In due respect, new sanitation approaches and ideas on hygienic excreta management that value human excreta represented in terms of plant nutrients and organic matter would be a timely (Rosemarin 2003). Well, through research and innovations; Eco-San toilet technology is thought to address more problems other than environmental issues. This is a closed-like loop system that provides Ecological Sanitation separates human excreta and urine to be used as a recycled nutrients fit to increase agricultural productivity. This new sanitation approach is needed for essentials like human faeces, urine and grey water that can be recycled as manure to boast agriculture.

Global Sanitation: current situation:-

Sanitation concerns have lately become global in that the whole world is facing more or less same problems of hygiene and health. In Africa, since 1990 around 189million people gained access to sanitation. However, as a result of population growth, 200million more people lack access now than in 1990 (Body-Gendrot 2011). This rapid growth and urbanization is linked to the proliferation of informal settlements are often accompanied by environmental degradation. About 62% of the urban population in sub-Saharan Africa lives in informal settlements (Tsinda, Abbott et al. 2013) Globally, was found that Ecological sanitation could be the beginning of a new public health revolution. During the 20th century we have witnessed several public health revolutions including universal childhood immunizations, the eradication of smallpox, improved water supplies, the green revolution with its improved food yields and expansion of primary health care. The one public health problem that has proved intractable this past decade has been a lack of sanitation for about half the population of the world. The solution to global sanitation with key features of eco-san is the prevention of pollution and disease caused by human excreta, management of human urine and faeces as resources rather than as waste, and recovery and recycling of the nutrients. In the natural world, excreta from humans and other animals play an essential role in building healthy soils and providing valuable nutrients for plants. Conventional approaches to sanitation misplace these nutrients, dispose of them and turn the cycle into a linear flow.

Situation in Rwanda:-

Sanitation plays a vital role in preventive health and quality of life. In respect to this, through the National Sanitation Policy (NSP), the GoR has made the provision of sustainable sanitation services one of the priorities of the National Development Agenda. This covers particularly liquid and solid waste, industrial waste, nuclear waste, e-waste, health-care waste and hygiene (Ibid). Eco San technology is not new in Rwanda. It was introduced way back around 2007 in these particular provinces (North and South) of Rwanda. Rwanda is one of the sub-saharan African states with great commitment to achieve sanitation goal (Kayitesi 2008). Today, national development pattern is growing at a high rate, and with the population too increasing, it portrays and raises a clear signal to environmental, health, sanitation and hygienic issues. Generally, water and sanitation utilities in African cities and towns are very weak.

They are characterized by intermittent supplies, frequent breakdowns, poor maintenance, and unqualified personnel in management and depleted finance (Cross and Coombes 2013)& (Ayoola, Lawal et al. 2012). More to this, it is evident that high population growth inevitably leads to food insecurity that too leads to severe environmental and hygienic problems as well. It is a landlocked and highly populated in Africa. The population trend projects a 12.9m people by year 2020 (Sano 2007).

The country is also faced with clean water crisis and other environmental risks as a result of population growth. A case in point is Northern Rwanda, a highly populated province, volcanic by nature, with its people living in bad conditions as a result of this heavy congestion. The majority of the population here still air practices open defecation; this in public health terms is the riskiest sanitation practice of all. It also has the greatest economic impact with considerable social costs including loss of dignity, security and privacy (Varela-Ortega, Blanco-Gutiérrez et al. 2011). The end result to this kind of practice is fatal as a result of diseases and illness, especially to the young and elderly members in the various communities due to pathogenic spread. Residents use nearby bushes,

water bodies and channels since they lack toilets or have mismanaged what used to be used as toilets. As a result, the ground water gets contaminated easily due to the exposition human waste in an open air environment.

This means its sanitation infrastructure must be paid attention to and given priority come what may. In Rwanda, Kigali city is beautiful and clean, however, the use of septic tank system will in one way or the other contaminate its ground water. This is a country where there is no waste water treatment plant as of today. It once started its ecological sanitation system in Northern and Southern provinces but at end of the day it collapsed. So, there is a need to carry out a field survey to find out why and how this Eco-San project failed.

In many developing countries, Rwanda in particular, there is a total and urgent need for Ecological sanitation toilet system. This is a small country with a very high population that needs high attention in as far as address sanitation issues are concerned. Most countries in Africa use septic tank systems or flush discharge system whereby it needs a lot of water and at the end of the day contaminates our ground water. The ecological sanitation toilets are not running well in Rwanda due to improper use and management that has resulted into some challenges.

Statement of the problem:-

Death due to diseases from poor sanitation is a serious global issue (Jonathan, et al., 2018). With the aftermath of genocide against Tutsi, Rwanda went through tremendous changes in rebuilding her socio-economic and cultural, and political history. The country was hit by challenging taste of time during the reconstruction process. Many of the sectors including health were equally dead.

However, faced with such a demanding task of health related issues, sanitation and hygiene in both rural and urban towns became a centre of focus. In respect to this, Rwanda has made remarkable progress in access to improved sanitation in households. A report by WATSAN Policy (2010) claimed that almost all households with toilet facilities, the rate of open air defecation dropped to 6% in 2009. However, observations on the ground continue to reflect the unsanitary condition of existing latrines, thus calling for the need to quality improved and unimproved conditions of sanitation (Mukasine–Biography , Nyirishema and Mukasine 2011).

In Rwanda, the most commonly used type of latrine in rural areas is the pit-latrine. Nevertheless concerns are being raised about the limitations of this technology in relation to poor handling while empting and decomposing off the waste when filled, bad odour and the flies, risking pollution of both ground and surface water in some particular geographical contexts. As a matter of fact, the latter challenge is real in the volcanic region in Rwanda. The rocky terrain prevents people from digging deep pits

Now the argument for Eco-San technology is; besides the water required for anal cleansing,Urine Diversion Dehydrated Toilet (UDDT) use requires no water. Indeed, the less water that enters the composting chamber, the easier it is kept smell-free (Kjellén, Pensulo et al. 2012, Tilley, Strande et al. 2014).The ecological sanitation existed in the two districts of Musanze (Northern Province) and Huye (Southern province), but eventually failed as time went by. It was realized that in these two districts/provinces, sanitation became a real problem with diseases like cholera, dysentery mainly caused by continued mismanagement and improper use of existing eco-san toilet systems. Goals to rectify the situation were set up in the country's Vision 2020 and the Economic Development and Poverty Reduction Strategy (EDPRS). In Africa, deaths are more seen in Diarrhea than any other lack of sanitation disease. It estimated to 4.2 million deaths comparison as shown in the figure 3 below.

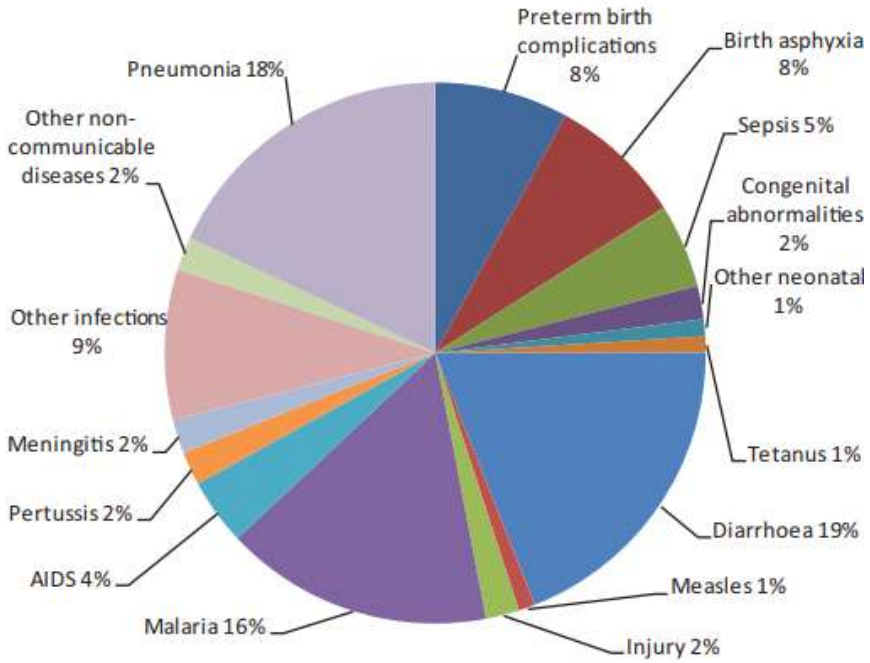

Figure 3 Estimated causes of deaths in Africa, 4.2 million/year

It was observed that the eco-san toilets are not in good shape. And the respondents would say that toilet is often shared, and there is a big odor problem so leading to cleaning problem, too much flies and others had problem of getting a toilet whenever they needed it.

Squatting position was observed as an issue. Because of mismanaging and poor planning led to forgetting like disabled personnel, people were not thought in planning. "*When these toilets were built, no deliberations were thought of; to disabled; everything is built and done too unfit the usual person". From disabled man asked.*

Most people fear to have accidents due to poor materials used to construct these Eco-san toilets. One family told us about their fearness to send their children to these toilets so they prefer using the bushes nearby leading to open defecation.

Figure 4 Some of the Pit latrines in Gahunga sector Burera district

Figure 5 Eco-san toilets (after)

What is Ecological Sanitation?:-

Ecological Sanitation is not a specific technology, but new philosophy –based on ecosystem –oriented view materials flows of dealing with what is presently regarded as waste and waste water for disposal It considers human excreta and waste water not as wastes but as natural resources.It applies the basic natural principle of closing the loop by using modern and safe sanitation and reuse technologies. Ecological sanitation (Eco San) is not a new concept. Long ago, most of the cultures have grasped the value of urine and faeces for agricultural purposes for centuries, and latrine designs based on the concepts of ecological sanitation have been used in Asia and parts of

Africa for hundreds of years. Those who have ever planted a tree in a full pit latrine can be said to be practicing Eco San. (Chootip)(Sugden 2003). It is recognition that human excreta and wastewater from households are a valuable resource (not a waste to be disposed off), it should be retained and rendered into an economically useful fertilizer.

The basic principle of ecological sanitation is "Closing the Loop on Sanitation", which implies that the nutrients in human excreta – after proper sanitization - are recycled as a fertilizer resource for crops which provide food for humans (Chootip) Ecological sanitation opens up a wider range of sanitation options than those currently considered.

ECOSAN SYSTEM crosses more than one sector when implemented and managed well. (Eco-san as a cross-sectorial approach) Among others are: Integrated water resource management, Sustainable agriculture and conservation of soil fertility, It addresses the Health concerns through reducing and eliminating the Pathogens in human excreta., It overcomes the problem of food insecurity by recovering of nutrients to increase the yield and crop production., Resource conservation, Flood protection, Business and labor promotion.

Where Eco-san has addressed the sanitation problems:-

This shows where and how the Eco-san toilets have addressed the sanitation problems. Dehydrating Eco – toilets has been used in Vietnam for so long and mostly in Northern Vietnam. And for about 37 years it has been introduced in countries like China, Mexico and Sweden. The Vietnamese used Double vault toilet of which was modified by Chinese later.

The Vietnamese toilet comprises of the handling chambers

Ash is added after a "long call" which mixes with faecal matter and the sun rays directly to ecosan toilet kills and destroys pathogens and works on decomposition. Double vault uses two chambers where one side is used and when filled use the other one of which the first goes through decomposition process and vice versa. The ash helps to repel any cockroaches, flies and odor smell. The toilet is meant to recycle the waste for economical use since it does not fill up.

Urine is collected in a container behind the toilet and paper used in anal cleaning is burnt. The Vietnamese succeeded and addressed the problem of Food insecurity by applying the fertilizer to the rice plantations and other farms. They only had a problem to some farmers who could empty the toilets for fertilizers whenever they wanted without any attention to retention time ! At the end the faeces were sometimes spread on fields.(Winblad 2004)

China modified the Vietnamese version and at later years came up with the squatting pan with urine diversion made of plastic.

Central America and Mexico, India and Sri Lanka, Palestine all implemented the Eco-San toilets projects and succeeded. However Sweden, Norway, Ladakh in India, Zimbabwe in Africa implemented composting type of toilets and recorded success.

Research Methodology:-

The study used qualitative research method since we need to go into deep the question of existing ecological sanitation failure. In qualitative method is principally investigative research. It is used to expand an understanding of underlying and origin of detailed reasons, views, thoughts and motivations. It gives visions and understanding into the problem whereby it helps to develop ideas and hypotheses for potential quantitative research deeper into the problem. Some common methods include focus groups and the individual interviews, and participation or observations. The sample size is typically small, and respondents are selected to fulfill a given quota. The qualitative method research examines the why and how of the decision making then it will give the reason why and how the existing ecological sanitation toilets project failed in Musanze and Huye district in Rwanda.

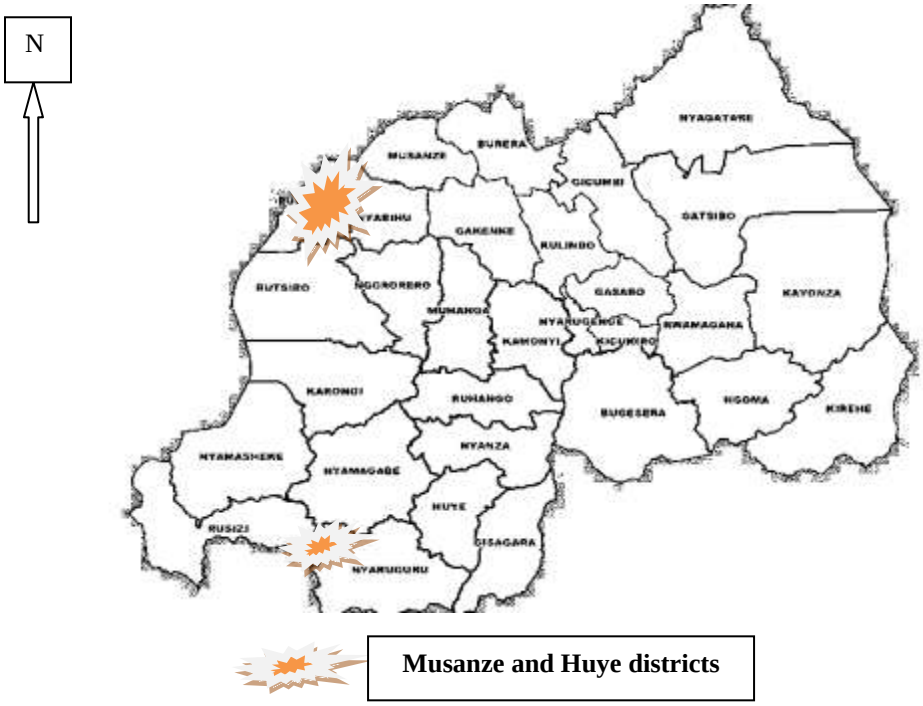

Figure 6 Map showing Districts

Methods and techniques:-

The research study considered a case study approach where the two districts of Musanze and Huye were identified. Reason being, these two lived the taste of Eco-San technology that never lived the desired dream and have got some of the poorest sanitation facilities today. Other characteristics of these areas include poor drainage systems, and the high density of settlements with volcanic terrain.

Respectively, the primary and secondary data was gathered through the field survey and literature review. The primary source of information was obtained through key informants and other respondents (interviews) through random sampling, filled (closed-ended) questionnaires and observations. Secondary data were directly obtained from previous academic works and official documents.

Study Frame Work:-

The framework and Technical route of the researcher from its start of concept to the end of completion. The ideology of Eco-san came about when Rwanda was trying to develop and in fact was to prioritize among others the

sanitation as it is in Millenium Development Goal /Sustainable Development Goal (MDG/SDG) Goals. Otherwise, the eco-sanitation in Rwanda by the researcher focused mainly on northern district as it continues to in population and they faced challenges in using eco-san toilets which was supposed to address the sanction concerns. The researcher came up with management strategies to the challenges with recommendations.

Key informants and local respondents' interviews

Just like many other science fields, voices have been raised that any investigation should be done with the people and not on or for people for if we are to have a thorough understanding of the needs and concerns of residents (Tsinda, Abbott et al. 2013). Therefore, during data collection on the challenges and management of ecological sanitation, key informants were identified and scheduled for interviews. In-depth interviews were organized for key informants to capture deeper insights on sanitation that would help in better understanding of what happened and why. And for the local residents, a house hold survey to capture numerical data on sanitation facilities and income through a random sampling technique was carried out according to the population of the study area. And at least most of the stakeholders/service providers involved in sanitation was consulted in order to come up with unbiased data. This was conducted between January, February and March 2018. Out of the 100 targeted household, 80 households were interviewed giving a non-response. The head of household or another adult (18 years and over) answered the questionnaire on behalf of the household.

Field survey:-

Primary data collection involved in, the field trips and observations. A number of service providers and users of Ecological sanitation were reached at to capture all the management related issues and challenges being faced in the provision of Eco-San toilets and the attitudes of the end users. The field study started unannounced visits with an informal talk to a few community members and then continued the walk to observe the condition of sanitation facilities as well as any evidence of open defecation around the house and backyards.

On-site private and public sanitation visits was carried out; an eye for detail to witness what exactly happens. From this, first hand information through interviews and observations were considerably obtained. The findings of the survey were supplemented by the qualitative research, undertaken to find out more about the challenges and management issues embedded to Eco-San technology in Rwanda.

Questionnaire design:-

A closed-ended questionnaire was designed and used to capture about 150 respondents through a simple random sample from the two districts of Musanze and Huye. The questionnaires were pilot tested before being administered to house communities, and the personnel involved got trained before use. To meet the target, the drafted questionnaires were set in a way that it was easy to understand. Freedom of expression was keenly observed. Majorly the concerns raised in the questionnaire include; the general questions (Bio-data), management and challenges of Eco-San toilets, attitude on waste handling, improved sanitation facilities and the social and cultural traits regarding hygienic practices. The educational levels of the participants were also represented as shown in the table below. The educational levels were considered to ensure that the participants would read and easily interpret the questions which were in the questionnaire. To ensure proper understanding, the questionnaires were also interpreted in the local language. Participants were assumed to understand the questions.

Data analysis and control:-

The manipulation of both numerical and non-numerical data involved the following stages. The breakdown in organizing, editing and interpreting the transcribed and categorized data yielded more systematic results required for this research endeavor. Quantitatively, data was analyzed using SPSS package whereas thematic analysis was used to develop themes (sub-themes) with reference to objectives set. In order to improve the validity of the data, a triangulation strategy was used. This strategy involved collecting information from a range of sources (household survey, observations, and interviews).

There was thorough editing of data especially those that did not correspond to the questions asked. Those that fitted well were considered and handled with care. Quality control prevailed as all the instruments used were administered in the language well understood by respondents through training of the research assistants on how to present, interview and communicate. A desk study to complement on the collected data (primary), interviews and

observations from the field was considerate to capture the existing literature. This had the advantage of filling gaps in data for one method, which results in strengthening the overall quality of the results.

Ethical considerations:-

Ethical considerations were given priority and participation in this study was voluntary and all respondents gave verbal informed consent to their participation in the research. Participants were given the opportunity to ask questions and had chance refuse .Permission was sought from relevant authorities prior to the study.

Challenges And Discussions:-

Introduction:-

The "closing loop" contributes a lot to the sanitation which leads to sustainable development. The main objective for the sanitation is to minimize hygienic risks and protect the environment and returning of the nutrients to the soil. Most of Asians and Europe countries mentioned above, concentrated on Good management of eco-san toilets leading to its cleanness and positive results.

Africa and Rwanda in particular can apply the same technology to address sanitation problems while solving the food insecurity concerns. The population is growing at high rate mostly in urban areas and the development is needed therefore Ecological sanitation should be one of the priorities. Eco-san toilets depend on proper management, we no longer or we don't have to think of "sit and flush" or "squat, deposit and store" situation. Let's Ecological sanitation holds a new attitude, of which the users must have confidence in and practice day-to-day. The combination of Education, Information, Communication resources are strongly needed in Eco-san toilets project as it was seen to be insufficient. The combination of the three; can promote the public awareness. Ecological sanitation projects should be owned by end users. Ownership should be felt and done through government officials. The government has a big role of breaking the culture of being shun of faecal matter where we get fertilizers. It has to be taught that it is a closed loop where plants should benefit. Importantly, this part gives an overview of the results collected and analyzed during the research study carried out in Musanze and Huye districts in the Northern and Southern part of Rwanda. The interpreted and analyzed results were based and aligned to the main objective of the study; to improve Sanitation through Eco-San technology by recycling the nutrients found in Human Excreta, by specifically focusing on the challenges and management of Eco-San toilets, propose and present an introduction to Eco-San concept, principles and technologies, determine the local residents' thoughts and understanding of sanitation, cleanliness and other health related issues, explore and inspect the characteristics of ecological sanitation toilet system which exist in these two provinces and study and investigate the suitability, correctness, accuracy and exactness of ecological sanitation.

Data and information collected and gathered from the field and respondents is of paramount importance in establishing well the existing gaps that formed background to investigate the subject matter. The captured information represented 150 respondents in general.

The critical insight into the existing challenges and management of eco-san technology in the districts of Musanze and Huye was basically to determine a number of factors that would pave way for a sustainable eco-san system desirable for the local communities around. The discussion lies heavily on the community attitude (acceptability) and feasibility of eco-san technology and putting in much consideration of the socio-economic trends that best describe management ladders entrenched in the existing health policies. Other issues like culture/traditional customs and beliefs on waste handling, basic hygiene practices will be put into consideration to get a general clear view of the existing management challenges.

All the 150 respondents who participated in the study were from household level. The demographic data of the respondents that participated in the study shows that 59 (53%) were females and 71(47%) males. The marital status of the respondents were 110(73%) married, 33 (22%) single and 7(5%) divorced. Of the 150 respondents sampled 118 (79%) were heads of the households and the remaining 32(21%) were members of the household. Sex, age and marital status were considered to be important factors in the management of the new ecological system. For example, most households found with married couples had an average of 4 people. This greatly affected the management of the new ecological system. They shared the eco-san toilet and as a result, the toilet would get full easily hence would require frequent emptying.

Challenges:-

The ecological sanitation systems remain new and limited to majority of the population in Musanze and Huye districts. This has led to challenges in the adoption of this new system. Most the challenges are technical, institutional and individual.

Lack of legal framework:-

One of the main challenges was lack of regulations governing sanitation and in particular for Eco-san systems. Even though world health organization issued guidelines on the need for regulations and sustainable policy on sanitation, most countries have not yet adopted them. These guidelines include safe use of waste water, grey matter and excreta. The lack of regulations has greatly hindered on the usage of human excreta as manure in both districts. For example officials from urban centers prohibited movement of human excreta from one place to another. This enforcement was to prevent spread of communicable diseases. Although there are no strict laws being applied to the conventional sewage system, the new Eco-san system has faced strict guidelines hence limiting its usage.

Limited Technical capacity:-

Limited technical capacity on Eco-san technology and system was one of the challenges in this thesis. Most communities lacked skilled manpower to design and even construct the Eco-san toilets. 11% of the respondents considered limited technical knowledge as one of the other major challenges. Technical capacity remains a challenge as the locals needs to be trained and be aware of the eco-san system as a friendly user. It was found by the researcher through education level analysis and it can help in training approach to address the limited technical capabilities to the residences.

Limited Knowledge:-

During the study, it was discovered that only 65 out of 150 (43%) respondents, had been trained on the usage of ecological sanitation systems. Of the 65 respondents, only 35% were educated through awareness campaigns and 28% through village/ward meetings. Only 23% and 14 % came to about ecological sanitation through peers /family members and the media respectively. Through key informants, it was discovered that some key technical people like community development officers and other district local leaders were not involved in the dissemination of information about ecological sanitation systems which were being introduced. It was discovered that only 7 of out 15 the community development officers had knowledge about the new technology introduced. This implies that they never participated in the planning and implementation of the project. This eventually resulted into the poor utilization of the new sanitation system.

According to World health Organization (WHO) and UNICEF, following introduction of new system, ample time should be given to communities for them to adapt. A study that was conducted in Kabale district, western Uganda revealed that 80% of the respondents who were knowledgeable about the utilization of ecological sanitation toilets eventually influenced the 20% who lacked the knowledge to use the new system (Tumwebaze, Orach et al. 2011).Therefore according to the study conducted in Kabale, for a new system to be successful, at least 80% of the intended users should have the knowledge. According to other studies conducted like in Ethiopia, it was discovered that slightly more than a half of the people who had latrines did not use them at all. In Europe, the use of urine and feaces in agriculture was considered weird. Training and proper education is vital for any project to be successful.

The Cost of construction:-

Approximately n=21(14 %) of the respondents considered the cost of construction of Eco-San toilet to be high. Of these, approximately 78% used the income generated from farming and other activities to finance the construction of the eco-san. The rest received assistance from friends. The cost was considered to be high because the majority of the respondents were low income earners. The cost of construction of an eco-san toilet was considered to be higher than that of pit latrine due to the materials used. Pit latrines can be constructed using local materials like wood, mud and even be roof with grass.

This finding however was opposite of the study that was conducted in Uganda, Wakiso District where the cost of construction of Eco-San toilet was considered to be cheaper than other toilets. The study conducted in Pakistan revealed similar findings like in Uganda that the cost of construction of Eco-San toilet was affordable .

Social factors:-
Out of the 150 respondents that participated in the study, n=97 (65%) observed culture and religion as the major hindrances to the adoption of ecological sanitation toilets. Most Muslims rejected the eco-san toilets because of the design and they also considered the use of human excreta as a taboo. Muslims normally wash after defecating or urinating, hence they preferred water borne toilets. According to the study that was conducted in Kabale district, approximately 30% of the people who accepted to use eco-san toilets were Muslims.

Although the project commenced with a low uptake by Muslims, continued information dissemination and education resulted into an increase in the number of Muslims that embraced the project. Eco-San users gradually increased. Similar technology has been in applied in Muslim dominated communities like Pakistan. Culture is another challenge. Most people consider handling human excreta as a taboo and unhygienic. Eco-san toilets can be designed for those who prefer squatting or sitting [65] and to cultures that do anal wet cleaning after defecation. This type of system could probably be easily adopted by Muslim Communities. The use of feces as fertilizers is regarded as disgusting among most community members.

Discomfort:-
Bad smell from the eco-san toilets was one of the major challenges. Majority avoided using the eco-san toilets because of the bad smell. This was more witnessed in the urban centres where space was limited. To prevent bad smell, majority of the households visited used ash. This also poised a big challenge. It was reported that at times ash blocks the toilets. The bad smell also attracted big flies. On the field visit, all the toilets had flies. The big green and blue flies caused a lot of discomfort among the residents. This was one of the reasons some avoided using the eco-san toilets.

High population density-
A high population density hindered the use of ecological sanitation systems in the two districts. The average size of each family was about 5 persons. This affected the cleanliness and emptying. This high number of people per eco-san toilet meant frequent emptying hence most people preferred using alternative systems.

Lack of hand washing facilities:-
Most ecological sanitation systems lack permanent hand washing facilities. Presence of a hand washing facilities improves hand washing practices. Unlike conventional sewage systems which are installed in areas with steady supply of water, most Eco-san systems tend to be constructed in areas with limited water supply. Most households know the significance of hand washing but lack the facilities. The absence of hand washing facilities at Eco-san systems is a great challenge.

In summary, the user has a high responsibility on the Eco-San toilet as they require more attention than pour-flush or pit toilets and are more complex to maintain. There is a needful of thorough user sympathetic and obligation with commitment is vital. The solution in the maintenance of Eco-San toilets, there should be regular monitoring. The main challenges associated with Eco-San toilets can be overcome with effective training, user understanding and maintenance. (McKinley, Parzen et al. 2012). The closed loop approach to sanitation that Eco-San provides ensures the nutrients in excreta are returned to the soil, instead of polluting the environment. Nevertheless, eco-san toilet provide sustainable solution for the multi problems related to water, sanitation, health, hygiene, malnutrition, quality of agriculture production, environment and atmosphere, construction, operation and maintenance of the same is an important aspect to deal with. The main challenges of the ecological sanitation systems in Huye and Musanze were majorly in the implementation, utilization and operation. The Ecological sanitation project of both districts was greatly affected by technical inadequacies, management challenges and inaccurate utilization of the eco-san toilets by residents leading to poor sanitation.

Poor implementation of this eco-san project was as a result of lack of clear laws and policies. This research also put into consideration the eco-san acceptance by level of education, sex and the level of income. Most respondents had a negative view on the poor functioning of the eco-san system due to culture, religion and other factors such as management and technical capacity. The level of education was key factor in the acceptance and utilization of the eco-san toilets. Women were uncomfortable on the usage of eco-san toilets. There was a low acceptance level on the usage of eco-san toilets among Muslims. The usage of human excreta as fertilizer is still limited due to lack of technical knowledge to sanitize the human excreta into manure and poor attitude. This has greatly hindered scaling up of the project. The demand of ecosan toilets remains low even though its concept is considered to be sustainable

and ecological. The demand of eco-san toilets remains low especially in urban areas hence needs to be improved. Proper physical planning, improved technical capacities, favorable policies and environment are key elements which can improve demand of eco-san toilets in urban areas. A healthy environment, safety, cleanliness, privacy and convenience can also create increased demand on the eco-san toilets.

Eco-san toilets are suitable for places with water scarcity, rocky areas or areas where the water table is high or lack alternative sanitation system or rural areas which have vast land where fertilizers can be applied for farming or areas which experience frequent flooding. Regular update on technical guidelines and standards on the materials and technologies used in the planning and implementation of eco-san system is vital. Involvement of local leaders in the implementation of the project is very vital in the success of eco-san system and scale up. Due to difference in geographic locations, environment and other social factors, there is a need to carry out assessment for suitability of the eco-san project prior to its introduction to the community. There is a need to urgently address these challenges to avoid escalation of poor sanitation and hygiene.

Much has been learned about ecological sanitation systems from the many units in use in the world today. In China and Vietnam hundreds of thousands of rural households have double-vault toilets and many recycle their products in agriculture. In Latin America there are many thousands of units of similar types. In North America and Scandinavia a large number of eco-toilets of various designs have been on the market for well over a generation (mainly used in vacation houses). In Ladakh and Yemen dry toilets have been used for hundreds of years. In India, and Africa there are growing numbers of eco-toilets in operation. Among these, there are successes and there are failures, and we can learn from both.

Results:-

Data and information collected and gathered from the field and respondents is of paramount importance in establishing well the existing gaps that formed background to investigate the subject matter. The captured information represented 150 respondents in general. The critical insight into the existing challenges and management of eco-san technology in the districts of Musanze and Huye was basically to determine a number of factors that would pave way for a sustainable eco-san system desirable for the local communities around. All the 150 respondents who participated in the study were from household level. The demographic data of the respondents that participated in the study shows that 59 (53%) were females and 71(47%) males. The marital status of the respondents were 110(73%) married, 33 (22%) single and 7(5%) divorced. Of the 150 respondents sampled 118 (79%) were heads of the households and the remaining 32(21%) were members of the household. Sex, age and marital status were considered to be important factors in the management of the new ecological system.

Table 1 shows the age grouping of the respondents

Age	Number	Percentage
18-27 years	23	15
28-37	48	32
38-47	55	37
48 plus	24	16
Total	150	100

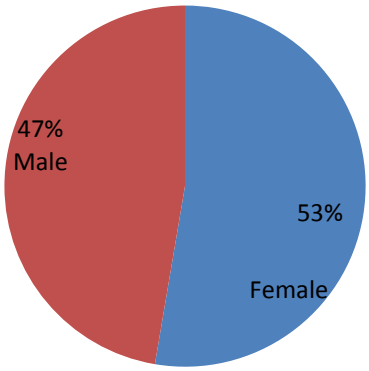

Figure 7:- Sex distribution of respondents

Socio-economic profile of residents Huye and Musanze districts:-

Source of Income/occupation:-

Huye district is situated in the southern province. It is a fast growing town economically. The district has a population of 314,022 inhabitants with an average of 540 inhabitants per square kilometer. Because of economic reasons, most people are migrating from rural areas to the urban centre. Musanze district is also fast growing district. It is a tourism hub. It has a population of about 368,264 and population density of 690 per square kilometers as of 2012 population. This has resulted into an ever growing population. Majority of the respondents in the study were peasants (64%) as shown in table 10. Determining the source of income was vital in our study because we discovered that one of the major challenges experienced while installing the new system was the cost of construction. 74% of the respondents who were employed or doing business was in urban centers and not practicing agriculture.

Table 2 shows Respondent's occupation

Occupation	No. of respondents	Percentage
Peasants	96	64
Employed	36	24
Business	18	12
Total	150	100

Table 3 Educational status of the respondents

Educational level	Number of Respondents	Percentage
Primary	22	15
Secondary	78	52
Tertiary	50	33
Total	150	100

This was significant in the understanding of the usage of the ecological sanitation systems. The least literate respondents were from the rural areas.

House Tenure:-

The houses were a mixture permanent and semi- permanent .The semi-permanent were constructed with wooden poles and roofed with iron sheets whereas permanent bricks, cement, roofed with iron sheets or tiles.64% of the permanent houses were in urban setting. During the study, it was observed that around n=96 (64.6%) of the respondents owned houses where as n=53 (35.4%) were tenants.88% of those who were found to be tenants were

dwelling in the urban centres. House tenure is very vital factor while designing a sanitation system. The average size of each family was about 5 persons. The highest family size was 8 persons while the smallest was 3 persons.

Local Government Unit (LGU):-
The interview with the key informants that was conducted showed that the implementation of the ecological sanitation project involved every leadership level in the two districts. The figure below shows leadership hierarchy in the district systems in Rwanda. This leadership hierarchy was responsible for the implementation of the project.

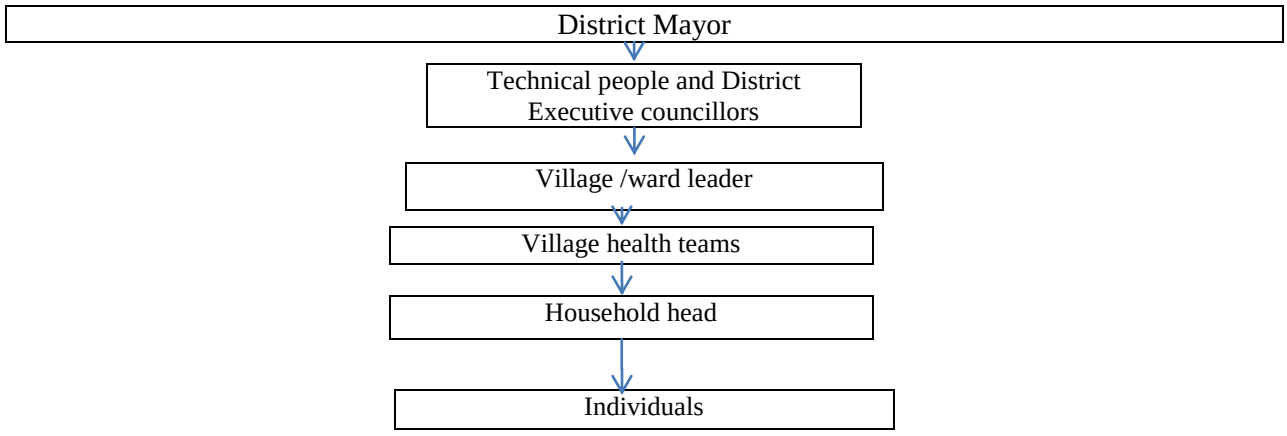

Figure 2:-Local Government unit chain

The district leadership and technical people were involved in the implementation of the ecological sanitation system project. However during a discussion with some key informants (environmental officer, health officer and water officer), it was discovered that not all leaders at different levels participated in the implementation of the project

Status of toilet or latrine usage in the district:-
All the respondents who were sampled had eco-san toilets. However, n=65(43%) of the respondents had alternative sanitation systems. The toilets are neglected and some are used in improper way. The status is not all well established as it needs management and ownership. The local leaders at lower levels have upper hand to make a change. Otherwise the status of the toilets is not to standard.

Respondents' awareness of sanitation, hygiene and health:-
During the study, all the respondents agreed that for one to have good health, sanitation and hygiene was a key. Table 4 and figure 5 summarizes the respondents' level of understanding of the relationship between health, sanitation and hygiene. Abbreviations in the table; SA - Strongly Agree, A - Agree, D - Disagree, SD –Strongly.

Table 4 Survey table

	Percentage			
Variable	SA	A	D	SD
1. Proper sanitation promotes health among people.	67	33		
2.The interventions applied in promoting sanitation reduce spread of diseases among people by Creating clean environment. ,	55.3	33.3	11.3	
3.Diseases and environmental pollution due to poor Sanitation arises from improper waste disposal.	73	16	5	6
4.Improvement of sanitation and health among people can be achieved through proper maintenance of toilets	40	20	27	13
5.Sanition can be improved through health education And knowledge dissemination.	33	15	47	5
6. Peoples' attitude affects sanitation and health.	67	13	12	8

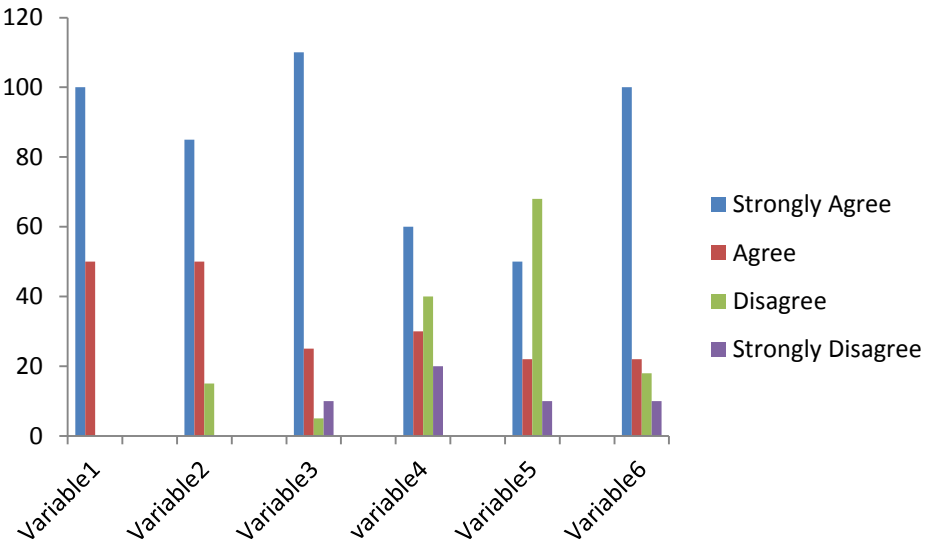

Figure 9 Respondents' in relation to variables

Participants awareness about ecological sanitation:-
During the study, it was discovered that 65 out of 150 (43%) respondents, had knowledge about ecological sanitation. Of the 65 respondents, only 35% were educated through awareness campaigns and 28% through village/ward meetings. Only 23% and 14 % came to about ecological sanitation through peers /family members and the media respectively. Table 5 shows the source of information on ecological sanitation among the respondents.

Table 5 Respondents' source of information about eco-san systems

Source of Information	Number	Percentage
Awareness Campaigns	23	35
Village Meetings	18	28
Peers/family	15	23
Media	9	14

Through key informants, it was discovered that some key technical people like community development officers and other district local leaders were not involved in the dissemination of information about ecological sanitation systems which were being introduced. It was discovered that only 7 of out 15 the community development officers had knowledge about the new technology introduced.

Field observations; Ecological sanitation systems in Musanze and Huye districts.:-
The materials which were used in the construction of the eco-san toilets in the two districts were bricks, cement and they were roofed with iron sheets. The cost of construction of an eco-san toilet was considered to be higher than that of pit latrine due to the materials used. Pit latrines can be constructed using local materials like wood, mud and even be roof with grass. The average distance of the ecological sanitation toilet from the main house was 4 meters. However in some cases, especially in urban settings, the distance would even be 2 meters. Bad smell from the eco-san toilets was one of the major challenges. Majority avoided using the eco-san toilets because of the bad smell. The big green and blue flies caused a lot of discomfort among the residence.

Many people are not willing to eat vegetables produced under such fertilizer (a woman influencing her children in a household). High cost of UDD toilets (173.500 Frw bricks made or 310U$ & 67.200 Frw for sheeting made or 120 U$). Gray water used for kitchen garden irrigation urine mixed used on vegetable crops in replacement of nitrogen compound mineral fertilizers

Availability, Utilization and Maintenance:-

All households that participated in the study had ecological sanitation systems. Only 65.6% of the Eco-san toilets were being utilized. Many respondents cited bad smell, culture, religion as some of the reasons they were not utilizing the Eco-san toilets. Poor maintenance observed in the study was due to many factors such too many people sharing one toilet, negative attitude towards handling of human excreta, lack of knowledge. Table 6 shows factors that were put into consideration while assessing the availability, utilization and maintenance. The assessment was done during the field visit.

Table 6 Toilets status in Burera district Rwanda

Condition of the toilet	Yes	No
Eco-san toilet at the home	100%	00%
Being utilized	65.6%	34.4%
Cleanliness	32.3%	67.7%
Good status	32.3%	67.7%
Bad Smell	36.3%	63.7%
Cleanliness around the toilet	8%	92%
Presence of flies	100%	0%
Received training on the operation.	19.6%	80.4%

Respondents' Views on the Usage of Eco-san toilets

Rosenquist in 2015 conducted a study which revealed that people tend to reject products from sanitation systems. This is quite observed most especially during information dissemination about ecological sanitation systems. However with increased education and frequent knowledge dissemination about ecological sanitation, this attitude changes with time. For fear of spread of diseases and bad smell, the usage of human excreta as fertilizers during farming is not easy for many farmers to adopt (Mayo and Mubarak 2015). However, most communities get influenced by a few people who get adapted faster (Tumwebaze, Orach et al. 2011, Tumwebaze, Orach et al. 2013).About 61% of the respondents who were willing to handle human excreta and use it as fertilizers whereas only 14 % could sell it to other farmers. This was observed in the rural areas. In addition 25% of the respondents, who rejected the idea of handling human excreta, acknowledged that human waste could be a good source of nutrients for agricultural purposes. This suggests that, with repeated education and training, most people tend to adopt with time.

Residents' willingness to use ecological sanitation systems (Eco-san toilets):-

The respondents were asked whether they were willing to use the Eco-san systems. Bias of this question was avoided during the analysis. Reasons given for unwillingness to use the Eco-san systems are summarized in Table 7.

Table 7 Reasons given for not using ecological sanitation toilets

Reason given	Number of respondents.
Unhygienic	54
Bad odor	48
Difficult to use	13
Not adapted to local environment	07
Difficulty in emptying	28

Respondents' perception on human excreta

Table 8 Respondents' perception and views on human excreta Number

Question	Yes	No
Do you consider human waste to be useful?	68	82
Can decontaminated human excreta be used as manure?	137	13
Would you prefer using feaces as manure?	67	83
Would you prefer using Urine as manure?	123	27
Would you buy food stuffs fertilized by decontaminated human excreta	83	67

As shown in table 8, 68 respondents consider human waste to be useful whereas 82 disagree. 137 have a feeling that sanitized human excreta can be a good source of manure. These findings show a positive perception on the usage of human excreta as manure. Most respondents preferred use of Urine as fertilizer compared to feaces. Reasons given are; it is easy to use and has less bad smell compared to feaces.

Out of the 150 respondents that participated in the study, 97 (65%) observed culture and religion as the major hindrances to the adoption of ecological sanitation toilets. Others were economic (14%), lack of technical knowledge (10 %) to operate the new system. The 11% even don't know what ecological sanitation was all about. Table 9 shows the challenges to the adaptation of the ecological sanitation systems.

Table 9 challenges observed in Rwanda

Challenges	Percentage
Culture and Religion	65
Economic reasons.	14
Lack of technical knowledge	10
No opinion	11

Respondents' views on places suitable for Eco-san toilets:-

As shown in table 10 below, most respondents suggested that Eco-san toilets were most suitable in rural areas. The reason given was that, most people who practice agriculture is rural areas hence would easily use the human waste as manure. Unlike in urban areas, it would be easy to transport the human waste from the toilet to farmland. Those who suggested public places considered the fact that eco-san toilets need minimum maintenance unlike toilets.

Table 10 Respondent's views on places suitable for Eco-san toilets

Places suitable for Eco-san toilets	No. of participants
Rural	93
Urban	35
Public places e.g. hospitals, schools	13
Not sure	09

In this study, only 43 of 150 respondents (27%) were willing to handle urine and feaces. This low proportion of the people willing to handle the human excreta greatly affected the usage and emptying of the eco-san toilets. Various factors such as culture (38%), religion (19%), fear of contracting infectious diseases (30%), and lack of knowledge (13%) were the reasons why most people rejected the idea of handling human excreta. At a community level, handling human excreta is seen as a taboo and inconsistent with cultural norms and values. In some communities, mixing ash with feaces was considered to be an act of witchcraft. In addition, officials of urban centers prohibit movement of human excreta from one place to another. This is being enforced to prevent spread of communicable diseases. The community members suggested that the use of Eco-San toilets would be more appropriate in rural areas. And if such project was to be successful in urban areas, then necessary laws should be put in place. Most Muslims rejected the ecosan toilets because of the design and they also considered the useof human excreta as a taboo. Muslims normally wash after defecating or urinating, hence they preferred water borne toilets. According to the study that was conducted in Kabale district (Katukiza, Ronteltap et al. 2012) , approximately 30% of the people who accepted to use eco-san toilets were Muslims.

Although the project commenced with a low uptake by Muslims, continued information dissemination and education resulted into an increase in the number of Muslims that embraced the project. Eco-San users gradually increased. Similar technology has been in applied in Muslim dominated communities like Pakistan (Nawab, Nyborg et al. 2006).Culture is another challenge. Most people consider handling human excreta as a taboo and unhygienic. Eco-san toilets can be designed for those who prefer squatting or sitting (Mayo and Nkiwane 2013) and to cultures who do anal wet cleaning after defecation. This type of system could probably be easily adopted by Muslim Communities.

Approximately 14 % of the respondents considered the cost of construction of Eco-San toilet to be high. This is the opposite of the study that was conducted in Uganda, Wakiso District where the cost of construction of Eco-San toilet was considered to be cheaper than other toilets (Nekesa 2007).

The study conducted in Pakistan revealed similar findings like in Uganda that the cost of construction of Eco-San toilet was affordable (Nawab, Nyborg et al. 2006). The cost considered to be high because the majority of the respondents were low income earners.11% of the respondents also considered technical problems as one of the other major challenges. This challenge was more experienced during the initial stages of the program.

The community members recommended that the designs should be simple and the technology should also accommodate water for anal cleaning, because some of community members were Muslims.The constraints the may restrict the usage of new technology can be minimized by identifying them at the planning stage. These constraints include mainly religion, culture and financial. This can be overcome by involving community members in the planning and implementation of the new technology. This also results into sense of ownership by the community members(Mayo and Nkiwane 2013). Although the not all stakeholders were involved in the planning and implementation of the new system, the masons and casual laborers who built the eco-san toilets were local people. The challenge of negative attitude on the reuse of human excreta as manure can be overcome by routine education and training. The government needs to subsidize on the construction of the ecological sanitation systems so that it becomes affordable.

Many local variables influence the choice of an eco-san system:-

Climate:-

temperature, humidity, precipitation and solar radiation. In dry areas it will be easiest to sanitize faeces through dehydration, whereas composting may be more successful in humid areas.

Population density and settlement pattern: the availability of space for on-site/off-site processing, storage and local recycling.

Social/cultural:-

the customs, beliefs, values and practices that influence the design of the social components of a sanitation system, its acceptability by a community. (It should be noted, however, that these things are not static, and that new practices are constantly evolving in most societies.)

Economic:-

The financial resources of both individuals and the community as a whole to support a sanitation system.

Technical capacity: the level of technology that can be supported and maintained by local skills and tools.

Agriculture: The characteristics of local agriculture and homestead gardening. Institutional support – legal framework, extent of support for the eco-san concept in government, industry, financial institutions, universities and NGOs.

According to data analysis, the observation was that people in Northern Province in Rwanda, most of the existing ecological sanitation toilets are mismanaged and no longer in use.

Conclusions and Recommendations:-

In Rwanda, Northern Province in particular (Musanze-Burera district) the challenges are mostly contributed by poor management of existing and not designed well ecological sanitation toilets. It is in this view that it is recommended to make public awareness on ecological sanitation merits and how to handle the situation rightly. The findings and conclusions discussed in this paper and the study recommended: Trainings should be done on ecological sanitation at lower levels: This is done through both formal and informal trainings. People should be trained and differentiate between sanitation, health and hygiene. Monitoring and evaluation: This is strongly needed because if left for the locals only without the authorities intervention it may cause other problem like poor handling of feaces of which contains a lot of pathogens compared to urine may cause other out spread of diseases . Research: the more research is needed as the project may be used for other uses. Apart from nutrient recovery, there is also biogas production which gives methane and carbon dioxide and these two gases are greenhouse gases which may lead to climate change. So there is much research and more studies to be done to help people in Rwanda and Africa in general. However, all challenges should be recognized and overcome by the application of new Eco-San concept, principle and Technology but Management and follow up takes a big role.

Declarations:-

Author contributions:-

Julius NKUSI produced the draft paper outline and the first draft, Professor Rongchang Wang supervised the writing, revised and applauded on the draft before submission.

Acknowledgements

The author would like to acknowledge the financial assistance of the Fundamental Research Funds for the Central Universities in China (Tongji University).

Competing interest

The author declares that they are no competing interests.

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