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THE JOURNAL OF KENYA NATIONAL COMMISSION FOR UNESCO

The Kenya National Commission for UNESCO is a government institution with a dual mandate of promoting Kenya's national interests in UNESCO and UNESCO's international interests in Kenya, regionally and globally. Kenya National Commission is a state corporation that derives its mandate from UNESCO and the UNESCO Act, 2013. The Commission was first established as a department in the Ministry of Education soon after Kenya became the 73rd member state of UNESCO in April 1964. Kenya National Commission is the focal point for all UNESCO affairs in disciplinary scope that cuts across government agencies, academia, Non- governmental Organizations (NGOs), Civil Society Organizations (CBOs) and individuals dealing in UNESCO areas of competence.

As the intellectual arm of the United Nations, UNESCO serves as a laboratory of ideas and clearing house for collecting, exchanging and disseminating information in UNESCO areas of competence. The *Journal of the Kenya National Commission for UNESCO* is a fulfilment of the UNESCO mandate and is an initiative of the Board of the Commission, pioneered by the Chairman of the Board. The Journal is also a product of dedication by the Secretary General and a team from among the staff members, who championed its production and publication.

Among the critical roles of Kenya National Commission for UNESCO, is to share knowledge and advice government on policy. KNATCOM anticipates that the dissemination of this journal shall influence improved performance of various Ministries, Departments and Agencies aligned to the Commission, the Government of Kenya and the world at large.

Journal of the Kenya National Commission for UNESCO Guide to Contribtors/Authors

Journal of the Kenya National Commission for UNESCO is an official Journal of the Kenya National Commission for UNESCO. JKNCU is a bi-annual publication published in January and July each year. Manuscript submissions focusing on a range of issues in the thematic areas of education, natural sciences, social and human sciences, culture, communication and information across Kenya, Africa and other parts of the world are welcome. The Journal publishes original unpublished works, short communications, rapid communications, notes and records, literature and book reviews, and policy pieces.

Interested authors are advised to submit their manuscripts in electronic forma in MS Word (Times Roman, Size 12, double spaced) by email to knatcom.journal@unesco.go.ke. The articles should meet the following requirements:

i. Title page with a short running title, full names of author, the author's institutional affiliations and email contacts for the corresponding author should be identified with an asterisk

ii. Abstract (150-200 words) and keywords

iii. Main text should not exceed 6000 words

iv. Brief acknowledgments where financial and material support should also be mentioned and can contain grant and contribution numbers

v. References - The complete reference list should appear alphabetically by name at the end of the paper. Reference journal articles, article by DOI, book, book chapter and online documents accordingly.

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x. Editorial Policies and Ethical Considerations

Rules of good scientific practice, require that:

- The manuscript should not be submitted to more than one journal for simultaneous consideration.
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- No data, text, or theories by others are presented as if they were the author's own ('plagiarism'). Proper acknowledgements to other works must be given
- Research articles and non-research articles (e.g., Opinion, Review, and Commentary articles) must cite appropriate and relevant literature in support of the claims made. Excessive and inappropriate self-citation or coordinated efforts among several authors to collectively self-cite is strongly discouraged.
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- For manuscripts reporting medical studies that involve human participants, a statement identifying the ethics committee that approved the study and confirmation that the study conforms to recognized standards is required.

EDITORIAL TEAM

INTRODUCTION BY THE SECRETARY GENERAL

It is with great delight, that I introduce the inaugural issue of the *Journal of the Kenya National Commission for UNESCO*. This inaugural issue comes at an opportune time when society is in need of new information in the areas of education, sciences, culture and information and communication.

While taking an interdisciplinary approach, this journal promotes peace for sustainable development, intercultural dialogue and ethical principles and access to information and knowledge, which is a right to humanity. These are strategies for cohesive societies as envisioned by UNESCO.

The *Journal of the Kenya National Commission for UNESCO* is peer reviewed by a panel of experts creating an enabling field for intellectual collaboration. This journal disseminates findings and recommendations from research papers expected to inform decision-making and policy formulation in the areas of education, sciences, culture and information and communication.

I urge all researchers and stakeholders to contribute to building knowledge in these areas by publishing in the next volume of the Journal.

Dr. Evangeline Njoka, MBS

Secretary General/CEO

Education

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Nigerian Admission Policy and Female Enrolment in Science, Technology, Engineering and Mathematics (STEM) in Abubakar Tafawa Balewa University, Nigeria

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Abstract

Although there are many international policies to promote gender equity in education, the Federal Government of Nigeria adopted 45% (Merit), 35% (Catchment Area), and 20% for education less Privileged States (ELPS) and Science to art ratio as 60:40, neglecting the female quota. Consequently, women continue to experience more gender disparity in STEM enrolment. Statistics from Abubakar Tafawa Balewa University, Nigeria (ATBU) show enrolment disparity in favour of the males at an average of 24.7% enrolled between 2015 to 2018. The study aimed to establish how admission policy contributes to female enrollment in STEM courses in ATBU. The theory of liberal feminist was used and adopted a descriptive research design and a mixed method. Further, the sample size comprised 405 students, 15 lecturers, six students 'parents, and six deans. It used descriptive statistics to analyse the data quantitatively and qualitative information thematically. The study results revealed that while quota admission policy to the less privileged states helps to a greater extent in enrolling more females in STEM courses, the admission policy on catchment areas negatively influences. Therefore, the study recommends a policy developed by the Ministry of Education to assign a females ratio in STEM to ensure gender parity in enrollment.

Keywords: **Admission policy, Female Enrolment, STEM, Gender Parity, Nigeria**

Introduction and Background of the Study

The role of education in human development cannot be over-emphasised as education is considered the bedrock of political, social, and economic development. Moreover, qualitative education is an instrument of change, invention, and innovation. (Alude & Idogho, 2012). Thus, the learners' creativity, resourcefulness, and imaginative abilities increased more as they go through the various educational levels and programs (Alude & Idogho, 2012).

The study of Science, Technology, Engineering and Mathematics (STEM) courses gives students a more excellent opportunity to understand the relationship between school, community work, and global enterprises to favorably compete in the new and changing world (Akpoghol & Ugo 2016). The importance of STEM education cannot be over-emphasized, as it drives economic growth and permeates every part of society's lives. STEM develops students' mind, their critical thinking skills and improves their abilities (Edzie, 2014). However, despite the importance of STEM in economic and societal development, there still exists a gender gap in STEM.

In the United Nations (U.N.) Millennium Declaration, member countries avowed to promote gender equity and women's empowerment as effective means to combat poverty, hunger, and diseases and stimulate genuinely sustainable development. However, although progress has been made to increase women's participation in many fields, UNESCO figures reveal that women made up a minority of the world's science researchers (UNESCO, 2010).

Goal four of the Sustainable Development Goals (SDGs) ensures inclusive and equitable education and promotes lifelong learning opportunities. The goal ensures that all girls and boys complete primary and secondary schooling by 2030 and provide equal access to affordable vocational training to eliminate gender and wealth disparities to achieve universal access to a quality higher education.

Globally, women are underrepresented in STEM. International organisations like the UNESCO, European Commissions, the Association of Academies and Societies of Sciences in Asia (AASSA) stressed this fact (UNESCO, 2015). In the European Union, 16.7% of the average of Information and Communication Technology specialists are women. It is only in Romania and Bulgaria that women hold more than 25% of these roles (Catherine, 2018).

In India, women earned over half of the undergraduate degrees in both Information and Technology and Computer 50.7% and sciences 54% fields respectively but remain underrepresented in Engineering and Technology undergraduate degrees with an overall 31.4% in 2018 (Government of India 2019). More so, in 2019, Undergraduate women in japan represented only 15.4% of engineering majors and physical science majors (Government of Japan, 2020).

Ngozi (2015) pointed out that women constitute more than half of the world's population, yet only a tiny proportion is in STEM. As a developing nation, Nigeria needs more Scientists, Engineers, and Mathematicians to help the country get along with the developed nations and develop its technologies and sustain them (Ngozi, 2014). Their impact though STEM should therefore, be sought for and encouraged.

The admission policies guide and regulate admission into university education in Nigeria. The country has not initiated a national policy towards gender equity in access to universities. However, the admission policy admits a given number of students (quota system). As a result, a certain number of students are admitted to the University according to catchment areas or educationally disadvantaged states disregarding gender equity. This study will try to establish the extent to which admission policy contributes to female enrolment in STEM.

The current guideline on admission in Nigeria shows the distribution as follows: the proportions by Merit (45%), Catchment area (35%), and disadvantaged states (20%) according to NUC (2009). Even though the policy allows a higher ratio of science-based disciplines to Arts (60:40,) there is no specific gender policy showing the proportion attached to the number of females to males admitted, which is a concern.

Table 1.1 shows the national enrolment at the universities for all courses. It also shows the gender enrolment disparity in Nigeria from 2015-2018.

Table 1. National Enrolments into Universities in Nigeria 2015 - 2018

YEAR	FEMALES	MALES	TOTAL	% OF FEMALE	% OF MALE
2015	149,569	210,003	353,599	41.6%	58.4%
2016	166,088	218,354	388,442	42.2%	57.8%
2017	182,961	235,337	418,304	42.9%	57.1%
2018	189,619	232,634	422,253	44.9%	55.1%
TOTAL	**688,243**	**896,328**	**1,582,598**	**44.5%**	**55.5%**

Source: National Bureau of Statistics (NBS), Annual Report (2019)

Table 1 indicates that the number of both male, and female students enrolled has been increasing significantly over time in the Nigerian Universities. However, the number of female students was fewer than male students between 2015 and 2018 (NBS, 2019).

Further, disparity exists in favour of males in the enrolment in STEM courses into the Nigerian Universities. And more evident in Engineering, Environment, and Technology, where 16% and below females enrolled from 2015 to 2018. In the faculty of Science (Mathematics inclusive), only 40% and below enrolled. And it is more glaring when compared to the number registered, for instance, in the Arts/Humanities, Education, and Law disciplines with 52.6%, 58.8%, and 54.8%, respectively, in 2018. Hence a significant concern that this study sought to unearth.

STATEMENT OF THE PROBLEM

In Nigeria, the level of females in STEM enrolment and participation is deficient compared to their male counterparts, especially in Engineering and Environmental technology courses, with less than 15% of females enrolled. Statistics from Abubakar Tafawa Balewa University, which is a University of Technology where STEM courses are taught, there exists disparity in enrolment in favour of male students because only 30.8%, 22.5%, 23.9%, & 23.2% in 2015, 2016, 2017, & 2018 respectively were females with an average of 24.7% against males (75,33%). This disparity usually leads to inequity, low participation, and income disparity between males and females.

The Federal Government of Nigeria adopted the admission policy criteria of 45% for

Merit, 35% for Catchment Area, and 20% for Education Less Privileged States (ELPS). Further, the Federal Government stipulated admission policy ratios for Science and arts as 60:40, forgetting the female quota proportion. However, despite these interventions gender gap still exist. Hence, this study hoped to establish the extent to which Nigerian admission policy contributes to female enrollment in STEM courses in Abubakar Tafawa Balewa University, Bauchi, Nigeria.

OBJECTIVES OF THE STUDY

The study sought to determine the extent to which admission policy contributes to female enrolment in Abubakar Tafawa Balewa University, Bauchi, Nigeria.

Theoretical Framework

Theories of gender equality will be used to guide this study. It stressed the Feminist theories which try to describe women's oppression, explain its causes and effects, and prescribe strategies for women "s liberation (Tong, 2009). The main goal of the feminist theory is to eschew women "s oppression to achieve gender equality. The theory is characterised by an individualistic emphasis on equality (Khattak, 2011). It is seen as focusing on individual rights and the concepts of justice, equality, and equal chances, where legal and social policy changes are seen as means for engineering women's equality with men (Maynard, 1995).

Liberal feminism stressed that women should have the same opportunities as men, including the same educational and employment opportunities. Liberal feminism theory has a belief that women and men are rights-bearing and autonomous human beings. The liberal feminists' idea holds that the reduction of gender segregation in occupational roles is paramount to achieving women's equality. Liberal feminists believe changes in equal opportunities and educational policies, e.g., the National Curriculum, will end patriarchy (Agassi, 1989).

LITERATURE REVIEW

Nigerian Admission Policy

Due to the over-concentration in one University leaving others for some reasons, the Nigerian government established a central placement examination body, the Joint Admissions and Matriculation Board (JAMB). The board was mandated to regulate admissions into universities, colleges, and polytechnics (Nwadiani & Igineweka, 2005; Kanyip, 2013; JAMB, 2015). However, this study hoped to establish whether the Joint Admission and Matriculation Board ensured gender equity in enrolment, especially in Abubakar Tafawa Balewa University, Bauchi.

The federal government initiated and promoted a national character policy that ensures equal opportunity for all university education. One of the policy objectives is equal opportunity for all and to ensure proper implementation and application of the federal character principle, where everyone is allowed to equally participate in the socio-economic and political development of the country (Odigwe and Swem, 2016). However, the admission policies of the nation do not take care of the gender concerns as far as enrolment in STEM in Nigerian Universities is concerned. Therefore, this study tried to establish no specific national policy towards gender parity in STEM enrollment.

The quota system is one of the strategies used in equalising educational opportunity

through its influence on admission matters. Odigwe & Swem (2016) believe that the quota system is a principle that stipulates the number of candidates from each State of the federation. The quota system encourages giving specific percentages to states of the country and balancing the gender gap both in admission in general and STEM enrolment in particular.

The policy on education for less privileged states is another issue in applying admission policy under the federal character of Nigeria. According to the Federal Government of Nigeria, Adamawa, Bauchi, Benue, Borno, Benue, Niger, Plateau, Yobe, and Jigawa, Taraba, Zamfara Kano, Kaduna, Katsina, Kebbi, Kwara, Gombe, Bayelsa, Ebonyi, Kogi, and the Sokoto States are the educationally disadvantaged states in the country (Okwori, 2003; NUC, 2009),. However, even though the policy allocated a quota of (20%) to the less educationally disadvantaged states, there is no specific proportion assigned to women in their admission. Even with their peculiarity, which this study tried to establish.

The catchment area is the following Policy in the Nigerian admission policy, which seeks to promote equalisation of educational opportunity. The catchment area is seen as the geographical location where a university is established. This policy stipulates that the states close to each University should receive particular preferences concerning admissions.

The current guidelines on access are as follows according to NUC (2009) and Omeje (2016): Merit (45%), catchment area (35%), disadvantaged states (20%) even though the policy stipulates the percentage of sciences-based disciplines to Arts as (60:40, sciences: arts ratio). This study established how admission policies of the Federal Government of Nigeria, specifically regarding quota to educationally disadvantaged states, and catchment areas, contribute to female enrolment in Abubakar Tafawa Balewa University, Bauchi.

Female Enrolment in STEM

In the African continent, the highest enrolment of women in tertiary education is much lower than men's. Still, women enrolment in science courses is much lower (Appiah-Castel et al., 2020). Huyer and Westholm (2020) studied women's enrolment in tertiary-level engineering, medical, and health-related courses in Africa, the Caribbean and Latin America, and Asia. The research shows that participation in engineering courses ranges from 1.6% in Kenya to 26.5% in Colombia. Also, for medical and health-related disciplines, where women are represented worldwide, the rate ranges from 24.7% in Kenya to 68% in Nicaragua, except for 77% in the Philippines.

Legewie and DiPrete (2014) studied the provision of Math and Science in U.S. high schools. The study found that the stronger the Math and Science orientation of the school's curriculum, the smaller the gender gap intentions in STEM fields. In contrast, studies in Europe show that encouraging women to go for science subjects in school does not necessarily lead to subsequent female enrolment in STEM fields. For example, curriculum reform in England between 2006 and 2008 increased female students taking science courses (Homer et al., 2013). However, this increase did not lead to growing participation in STEM higher Education (Broecke, 2013).

In Brazil, female enrolment in tertiary education has increased, but participation in STEM programmes is still low compared to their male counterparts. The gap in STEM education that is essential for the future of

work is a challenge that has to be tackled if economic gender parity is ever to be attained (Lima et al., 2020).

Gender Parity in STEM Courses

Gender equality is especially serious in Latin America due to prejudices or cultural norms that influence women's behaviour. In this context, the W-STEM project seeks to improve strategies and mechanisms to attract, access, and guide women in Latin America in STEM higher education programmes (WEF, 2020). For example, there is a project with practical workshops for high school girls in robotics, electronic circuits, and information systems in Uruguay. However, women tend to prefer other areas, and engineering careers remain a reticent space for women, the majority chosen by men (Delgado et al., 2019). This study hope to establish if the same phenomena is found in Nigeria.

Currently, the distance to parity in terms of enrolment in Higher Education in Brazil has reached a score of 1.37. Still, when considering the graduates from STEM-related programmes, this number drops to 0.37, with the parity in Information and Communication Technologies graduates reaching 0.11 (WEF, 2020).

The gender gap is being slowly reduced worldwide. However, at the current rate, gender equality should only be achieved in 99.5 years (WEF, 2020). The situation is particularly problematic in the STEM area. In Europe, for example, higher education institutions, such as those that are part of the Fostering Women to STEM (FOSTWOM) project, care about the problem of low STEM graduates percentage and the resultant decrease in the number of women practicing professions in STEM areas (FOSTWOM, 2020).

In Nordic countries, the rate of young STEM graduates is approximately 20% (Honeypot 2018). In Italy and the United Kingdom, this percentage reaches 30%, but few women exercise a scientific-technological profession (Honeypot, 2018). There is intense pressure for women interested in science and mathematics to go to Health (Honeypot, 2018).

RESEARCH DESIGN AND METHODOLOGY

This study employed a descriptive survey design. Mixed research method was also adopted where both qualitative and quantitative data were generated, and hence a triangulation design was used to enable the researcher mix the qualitative and quantitative data.

TARGET POPULATION

The target population of this study consisted of the six (6) Deans of Faculties at the University, 77 lecturers of fifth-year students, 60 parents/guardians, and 2025 fifth-year students of the various departments of the University.

SAMPLE SIZE

The six deans of faculties were taken as a census. Whereas 15 lecturers of fifth-year students were drawn, and 12 parents were selected using a simple random sampling technique. Thus, the study drew a total number of four hundred and five (405) students from 2025 students targeted for this study which represent 20% (Mugenda, 2013).

PRESENTATION OF FINDINGS, INTERPRETATION, AND DISCUSSION

The study's objective sought to determine how Nigeria's admission policies contribute to female enrollment in Abubakar Tafawa Balewa University. The findings are presented and discussed below:

Table 2: Admission Policy

ITEMS	RESPONDENTS	DISAGREE		UNDECIDED		AGREE	
		F	%	F	%	F	%
Awareness of the admission quota in the Universities based on Merit (45%), catchment area (35%), and disadvantaged states (20%).	Students	-	-	-	-	391	100
	Lecturers	-	-	-	-	15	100
Female students are given a specific percentage in the admission policy.	Students	391	100	-	-	-	-
	Lecturers	15	100	-	-	-	-
Nigerian University admission policy on catchment area contributes to more female enrolment in Abubakar Tafawa Balewa University Bauchi.	Students	381	100	-	-	-	-
	Lecturers	15	100	-	-	-	-
Admission Quota is given to the Education less Privileged States (ELPS) help in enrolling more female students in Abubakar Tafawa Balewa University, Bauchi.	Students	98	25.1	49	12.5	244	62.4
	Lecturers	-	-	-	-	15	100
Not giving a specific number to females in the admission policy contributes to low female enrolment in STEM courses.	Students	273	69.8	98	25.1	20	5.1
	Lecturers	13	86.7	-	-	2	13.3

Source: Students and Lecturers Questionnaires

To answer the question that "the admission quota in the Universities is based on the Merit (45%), catchment area (35%), and Education Less Privileged States (ELPS) (20%)." The results from the analysis in table 2/1 revealed that all the students, 391 (100%) and the lectures 15 (100%), agreed that they were aware of Nigeria's university admission policy to university education. Also, they are aware of the distribution formula for admission to universities in Nigeria. Therefore, as follows; merit (45%), catchment area (35%), and ELPS (20%).

The admission policy of Education Less Privileged States (ELPS) exists due to the inequality in some levels of education across the country. Some 19 States (mostly States from Northern Nigeria) are regarded as ELPS. The policy states that 20% of admitted students should go to these States. Whereas the catchment policy addresses indigeneity, it states that 35% of applicants should be indigenes or close neighbours of the State where the school resides.

The finding shows that the students and the lecturers indicated that they were aware of the university admission policy and the distribution of the admission formula in Nigerian universities. Moreover, the findings of the study on whether the respondents are aware of the university admission policy in Nigeria through merit distribution is (45%), catchment area (35%), and Education Less Privileged States (20%) is supported by NUC (2009) which has categorically spelled out the admission guidelines in Nigeria. It explains the distribution by proportions of Merit (45%), Catchment area (35%), and Education Less Privileged States (20%) (Omejie et al., 2016).

On whether Female students are given a specific percentage in the admission policy, the study's findings were shown in table 2/2. The result reveals that all the students, 391 (100%) and lecturers, 15(100%) disagreed that female students are given a specific quota in the admission policy of the country. This is because the Nigerian admission

policy into universities does not specify any number or proportion assigned to females.

This is seen during the admission of students to ATBU in the last few years, which showed a wide disparity in the number enrolled, with the majority of those admitted being males. The finding is supported by Najib et al., (2019) study, which noted that female students in the most educational system in Nigeria are underrepresented, particularly in the area of Mathematics, Physics, Chemistry, and Technology, i.e., electrical, mechanical, and civil engineering.

As to whether there is a specific number for the females admitted according to the policy is also in line with the study conducted by Musa (2015) and Omeje et al. (2016), which stressed that the admission policy in Nigeria, though adopted and emphasizes 60: 40 Science to Arts ratio, does not set aside specific ratios to the females.

To answer *whether Nigerian admission policy on students' admission within the catchment area contributes to more female enrolment in Abubakar Tafawa Balewa University.* The study results in table 2/3 reveal that all the students 391 (100%) and lecturers 15 (100%) disagreed that Nigerian students admission policy within the catchment area contributes to more female enrolment in Abubakar Tafawa Balewa University Bauchi.

Both students and lecturers strongly disagreed that the Nigerian admission policy of students' admission in the catchment area led to fewer females being admitted. As more and more applicants were denied access basically because of the policy.

It is worth acknowledging that some countries in Africa, like Kenya and South Africa, adopted policies that ensure maximum opportunities for females to access higher education in STEM courses in their countries. Still, Nigeria emphasises the equal opportunity for enrollment in universities based on their geographical location with no specific ratio for females in STEM. Hence the reason for low females in STEM courses in the country (Kalai, 2010).

During an interview with the Deans of students on whether Nigerian admission policy on students' admission within the catchment area contributes to more female enrolment in Abubakar Tafawa Balewa University. The response of the majority obtained was represented by one who had this to say:

The quota policy on the catchment area, which allows applicants from the states around University, negatively affected the enrolment of girls in this University. Because many parents are unwilling to send their daughters to other states for studies, they prefer to send them to universities close to them. As a result, very few were admitted into the University from the non-catchment areas, thus blocking much more qualified females' acceptance in the University. (Dean, Male, ATBU, July 2019).

Also, the responses of the majority of the parents of students obtained were represented by one who had this to say:

I will not let my daughter be far away from me, mainly because of the current insecurity situation of the country. She might be abducted or kidnapped in the process. But if it's a male child, I have no problem. (Male, July 2019).

To answer the question as to whether *Admission Quota given* to the Education Less *Privileged States* help in enrolling more female students in Abubakar Tafawa Balewa University, Bauchi. Table 2 shows that more than half 244 (62.4%) of the students strongly agreed that the admission quota given to the Education Less Privileged States of the country help in enrolling more female students in Abubakar Tafawa

Balewa University, Bauchi, 98 (25.1 %) of the students disagreed. Only 49 (12.5%) of the students were neutral. On the other hand, all the lecturers, 15 (100%), agreed that the admission quota given to the Education Less Privileged States helps in enrolling more females in Abubakar Tafawa Balewa University, Bauchi.

All the North East states in Nigeria are classified as among the Education Less Privileged States. Hence they are given a specific number of students to enroll from the region. NUC (2009) provided that the educationally backward states include Adamawa, Bauchi, Benue, Borno, Niger, Plateau, Yobe, Jigawa. Taraba, Zamfara Kano, Kaduna, Katsina, Kebbi, Kwara, Gombe, Bayelsa, Ebonyi, Kogi, and the Sokoto States.

The finding shows that all the lecturers (100%) and the majority of the students (62.4%) strongly agreed that giving a quota to the Education Less Privileged States may help enroll more female students in Abubakar Tafawa Balewa University, Bauchi. This is seen in the admission list of the students as a significant number of those admitted were from the Education Less Privileged States. The findimgs align with NUC (2009) in Musa (2015) and Najib et al (2019) that 20% of the overall admission should be assigned to the educationally less advanced states of the federation.

The response of the majority of the Deans obtained was represented by one who had this to say:

Because of the policy that stresses giving an admission quota of 20% to the education less privileged states in the country, the universities are witnessing an increase in the number enrolled. The policy helps in enrolling more females from the states as well. (Dean, Male, ATBU, July 2019).

The response of the majority of the parents on whether Admission Quota given to the Education Less Privileged States help in enrolling more female students in Abubakar Tafawa Balewa University, Bauchi was represented by one who had this to say:

The quota system to the educationally backward states helps no small measure in ensuring more of our daughters got admitted to the University. Many of our daughters could withstand the competition for admission into the University as there are so many applicants from the educationally advanced states of the country. (Male, July 2019).

The quota given to the educationally backward states helps in enrolling more females in the universities and the STEM-related course. The study observed that were it not for the policy, and many students would not be given admission to the University.

The finding of this study on quota admission to the education less privileged states help in enrolling more female students in Abubakar Tafawa Balewa University, Bauchi is in contrast to the survey by Odigwe and Swem (2016). The study observes that assigning a specific quota to the educationally disadvantaged states of the federation negates the principle of equality, and thus it should be open to all.

Another question on *whether stating a specific number of females in the admission policy contributes to low female enrolment in STEM course shows* from the analysis in table 2/5 that majority of the students 273 (69.8%) and lecturers 13 (86.7%) agreed that not giving a specific number stated in the students' admission policy to universities by gender contributes to low female enrolment in STEM courses. On the other hand, only 20 (5.1%) of the students and 2 (13.3%) of the lecturers disagreed. And a quarter of the students, 98 (25.1%), were undecided. They remained neutral as they were not sure that a specific number of females in the admission policy contributes to low female enrollment

in STEM courses.

This means that the admission policy does not set aside any specific number of students admitted by gender. This is seen as the majority of the students (69.8%), and lecturers (86.7%) strongly agreed with the notion that lack of assigning a specific figure by gender to be enrolled in the University by the Joint Admission and Matriculation Board (JAMB) contributes to low female enrolment in STEM courses. The students and the lecturers believe that if a specific number of females are stated, more females will be enrolled in the university and STEM courses in particular.

The findings align with a study conducted by Garba (2013) on gender enrolment in higher education in Nigeria. The study noted that to witness an increase in enrolment and participation of females in STEM programs, females should be given a specific ratio in the admission policy of Nigeria. However, it is also clear that in the NUC (2009) distribution of the admission quota, there was no particular gender ratio in the policy. Hence, it tends to affect the number of females admitted to the universities as a whole and ATBU in particular.

SUMMARY OF FINDINGS

From the objective of the study, the study had three (3) findings. The study established that all the respondents strongly agreed that they are aware of Nigeria's admission policy and the admission quota to less privileged education states. The policies help to a greater extent in enrolling more females in STEM-related courses. And lastly, the study also reveals that the admission policy on catchment areas negatively influences the enrolment of females in STEM courses.

CONCLUSIONS OF THE STUDY

Based on the findings of the study, it is logical to conclude that while quota admission policy to the education of the less privileged states helps to a greater extent in enrolling more females in STEM-related courses. On the other hand, the general quota admission policy on catchment areas negatively influences the enrolment of females in STEM courses.

RECOMMENDATIONS FROM THE STUDY

Based on the analysis of the data presented and the conclusion made, the study, therefore, recommends practice recommendations as:

(i) The Federal government should review and amend the National Policy on Education to create a female quota section to expand access and equity for female education in higher education, especially at the university level and STEM.

(ii) The federal government should maintain the Admission quota to the less disadvantaged states.

Practice Recommendation

(i) Sensitisation programmes should also be organised for both the parents and teachers so as to have a change in attitude towards the education of the females so as to motivate more females to enrol in STEM related courses.

Recommendations for Further Research

From the findings of this research work, and since the study sought to establish extent to which admission policy contributes to female enrolment in STEM courses in Abubakar Tafawa Balewa University, Bauchi, and similar research should be conducted on:

- The effect of admission policies on female across the federal universities Nigeria.

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Teaching Reflective Thinking in Institutions of Higher Learning in Kenya as a Means For Sustainable Development

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Abstract

The aim of this paper was to demonstrate that reflective thinking is fundamental in developing a culture for life-long learning that is essential in education for sustainable development. This is anchored on an observation that in this contemporary age of technological advancement and complexity of information that is available for human beings to process, a need to develop an education curriculum that enhances individual ability to re-think, re-visit approaches and re-design decision making and problem-solving techniques in different contexts of life is necessary. However, available research on quality and teaching methodologies reveal that education in most African countries, and Kenya in particular, is largely centred on teaching learners what to think rather that how to think; with rote learning as the major challenge. Thus, their reflective and creative abilities are supressed, undermining their resourcefulness in society. But this situation can be alleviated through a deliberate use of the reflective thinking model in teaching and learning, especially, in higher learning institutions in order to enhance a life-long commitment to learning with an aim of promoting both individual and collective sense of responsibility towards sustainable development. Since the paper is largely philosophical in nature, the method of analysis and argumentation has been used to make sense of information obtained from library research. However, reference to practical scenarios in Kenya is also made to instantiate some of the issues raised.

Keywords: **Reflective thinking, Life-long leaning, Education curriculum, Sustainable development.**

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Introduction

Higher education in many developing countries is a necessity for survival. However, education policy-makers continue to express concern about the poor state of higher education (Odhiambo, 2011, p.299). The World Bank's report on quality of education in Kenya revealed that there are high rates of student enrolment which has in turn compromised quality in learning. Additionally, "pedagogical practices continue to be very traditional in many higher education institutions, with overreliance on rote learning and outdated curricula that tend to be excessively theoretical" (2019, 51). Contemporary society has become more complex, dynamic state of technological development that makes a lot of information and knowledge available and changing more rapidly. It is against this background that this paper attempts to propose an infusion of reflective thinking in the delivery of curriculum in institutions of higher learning because it can enhance the culture of lifelong learning that is fundamental for creativity and sustainable development.

Statement of the Problem

The system of education in many African countries with special reference to Kenya seem to place more emphasis is largely teacher-centered and dominated by examinations at the end of term or semester in order to determine promotion of learners from one level to another. The focus of the learners is mainly to pass through the system and get certificates to use when seeking for employment. The result of this is that learners' reflective abilities are suppressed since all that one needs to do is to cram what was delivered in class or from the textbooks and give it back to the teacher when it is demanded of them. Consequently, most graduates' self-initiative and creative potential is overshadowed due to lack of exposure to reflective thinking skills which are necessary for confronting life's opportunities and challenges towards sustainable development. This paper, therefore, gives a general account what reflective thinking entails, demonstrating its usefulness to life-long learning, without which graduates cannot fully contribute to sustainable development. This paper is guided by the following questions:

(a) What is the state of education in higher learning institutions in Kenya?

(b) What constitutes reflective thinking?

(c) How can reflective thinking be applied in higher learning institutions in Kenya?

Materials and Method

The paper is a result of a desktop review of related research on the value of reflective thinking in teaching and learning as well as published empirical research on the quality and methodology issues in higher education in Africa and Kenya in Particular. A descriptive, analytic and evaluative method has been utilised in making sense of the information and evidence gathered from experience and the literature search.

Literature Review and Discussion on State of Higher Education in Kenya

Higher education institutions play a significant role in society because they "are often the only institutions with some capacity to undertake research and

to generate the knowledge required for development" (Onyango, 2011, p.300). Kenya's economic blueprint Vision 2030 identifies higher education as the means through which Kenya's development goal of being a middle income and industrialised country will be realised (GoK, 2007). This implies that the kind of education experiences subjected to learners at this level, are sufficiently grounding them to holistically contribute to nation building.

As articulated in Kenya's education 'master plan' (MoEST, 2007), quality education is demonstrated when focus is shifted from merely passing exams to an approach that enhances discovery of talents and the development of analytical, cognitive and creative potential, enabled by proper utilisation of available resources. A study conducted by Wanzala (2013) pointed out that there is a general laxity in the control and maintenance of quality in the history of higher education in Kenya. This entails both quality of infrastructure and the educational output evidenced in the caliber of students graduating from the increased number of universities. The issue of quality of learning and research in higher learning institutions has generally been a subject of discussion in many forums and prompted further investigation (Anderson 2015; Kagondu & Marwa, 2017).

There are many challenges facing Kenya's higher education that have consequences on the learners' ability to confront the fast-changing world. Research done by Onyango (2011) points out Brain drain, unemployment and the rush by students to enroll in universities abroad for courses offered locally as key concerns for education stakeholders. Additionally, many stakeholders continue to lament that Kenyan universities are producing graduates who are ill-equipped for the world of work (Onyango 2011; Kagondu & Marwa, 2017). In order to counter the challenges of quality in learning/ research, to enable graduates effectively impact society (Ludeman et al., 2009) asserted that, higher education institutions in Kenya needs to focus on nurturing the independence of learners and putting their needs at the center of all that they do in the education context. This, I think, is because cultivating independence is basic for self-drive which opens the path to creativity of individuals in their quest for knowledge. As such, deliberate infusion of reflective thinking in teaching and learning is a sure catalyst for unlocking autonomy and enhancing life-long learning by all means available.

Reflective Thinking

The education theory and practice in most parts of the world can largely be tied to the Enlightenment ideology and movements that emphasised reason and science. Thus, fostering critical thinking has largely been considered a specific trait of genuine education and one of the most important aspects of the educational process in general (Wagner, 2008). In fact, most universities such as in Kenya have adopted it as a common course for all students. Reflective thinking is a key component within the critical thinking discourse (Ennis, 1985). It is geared towards deliberative digestion of knowledge with an aim of either relating it to experience or re-applying it in different contexts. It encompasses a mental process of finding ways which will lead to production of new knowledge and experiences in the context of previous knowledge and development of alternative ways.

It is important to point out that in most literature; reflective thinking has often been either submerged in critical thinking or viewed as synonymous to it. Reflective

thinking is partly a process of critical thinking, making it a second order activity, only that while critical thinking has other component tied to it such as logicality, its reflective component is judgment oriented, and generative in nature (Facione, 2000). This had earlier been reflected in Dewey (1910, p.4), observation that "thought denotes belief resting upon some basis, that is, real or supposed knowledge going beyond what is directly present. It is marked by acceptance or rejection of something as reasonably probable or improbable". On the other hand, reflection implies that "something is believed in (or disbelieved in), not on its own direct account, but through something else which stands as witness, evidence, proof, voucher, warrant; that is, as ground of belief" (Dewey, 1910, p.8).

The Ancient Greek Philosopher Socrates set the ground for the tradition of questioning (that is deemed as evaluative and reflective) in philosophy. He believed that an unexamined life is not worth living and entailed the need for people to think through what they hold to be true and to live lives informed by decisions that were clearly interrogated and not just from their surface value. He believed without systematic probing questioning, people could not rationally justify their knowledge claims (Paul & Elder, 2006). Thus, he established the fact that one cannot depend upon those in "authority" to have sound knowledge and insight, and established the culture of asking deep questions that probe profoundly into thinking before we accept ideas as worthy of belief. He established the importance of seeking evidence, closely examining reasoning and assumptions, analysing basic concepts, and tracing out implications not only of what is said but of what is done as well. Socrates set the agenda for the tradition of reflectively questioning common beliefs and explanations, carefully distinguishing those beliefs that are reasonable and logical from those that are not.

Paul and Elder further analysed the Socratic dialogues and reveal that Socrates had varied intentions in employing the art of questioning but that what stands out strongly is his employment of fundamental analytical and evaluative skills in seeking for distinctions between concepts such as 'justice' and 'injustice' 'piety' and 'impiety' among others (2006, p. 68). Thus, reflection, questioning and discussion constitute a good method of lasting education.

The need for a reflective thinking paradigm in education was first propounded by John Dewey, who is a prominent personality in philosophy of education. In his landmark book titled *How We Think,* Dewey first wrote that "The essence of critical thinking is suspended judgment; and the essence of this suspense is inquiry to determine the nature of the problem before proceeding to attempts at its solution. This, more than any other thing, transforms mere inference into test" (Dewey, 1998, p.74). It is important to notice that Dewey's emphasis is not on critical thinking as such but on the componenet of suspending judgement, in which case one has an opportunity to break then focus keenly on the problem confronting him or her before designing a solution for it. Thus, implicit in Dewey's position above is fostering in learners reflection which prompts them to step back and think about how they should solve problems. He defines defines 'reflective thought' as "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (1910, p. 6). For him, a refelective thinker as one who is open minded and is keen on questioning

assumptions and/or "going beyond what is directly present" (Dewey 1910, p.4). He or she recognises that learning requires regular practice in examining one's thoughts, an accurate assessment of it, and efforts towards improving it. Dewey further identified two phases that characterise reflective thinking. First is a doubt, confusion and hesitation status in which thinking occurred. This can be likened to suspended judgment in order to "stop first" then get into the process of ascertain received information/knowledge before settling or arriving at a conclusion. Second is a research and questioning that is aimed at finding ways to clarify one's doubt and ultimately sort out any confusion.

Kolb (1984), and Kolb and Kolb (2005) regarded learning as knowledge creation through the transformation of an individual's experiences. Among other processes needed, they single out reflective thinking and observation as the most fundamental. In other words, whereas experience and reason are important sources of knowledge, learning cannot take place without reflection. This has shifted focus to what other scholars have referred to as reflective learning which can be described as "a process that leads to reflection on all sources of knowledge that may contribute to understanding a situation, including personal sources and experience" (Colomer, Pallisera, Fullana, Burriel, & Fernández, 2013, p.365).

Scholars from the critical thinking movements have also fallowed in the footsteps of earlier thinkers to insist on the centrality of reflective thinking in education. For example, Lipman (1991) argues for a reflective education paradigm which regards learning as participation in a community of inquiry which aims at enabling learners to achieve understanding that facilitates responsible action. The students are challenged to figure out things independently with insight from what they have either learnt in class or researched on their own. In turn, the teacher's role is that of a facilitator who stimulates inquiry and curiosity in the learners. Wokabi, F., in reference to Lipman, notes that in the reflective paradigm, the focus of the educational process is "not merely acquisition of information but discerning relationships in the subject matters under investigation and figuring out how knowledge can be generated, evaluated and applied effectively" (Wokabi, 2011, p. 29). He further recognised the importance of a community of inquiry approach to teaching and learning as means for leaning to learning. In contrast is the standard paradigm to learning in which "education is merely the transmission of knowledge from those who know to those who don't know" (Wokabi, 2011, p. 29).

Lifelong Learning

Lifelong learning has been variously conceived in education literature, and is sometimes confused with adult learning and education. In this paper, the term is perceived as a culture born out of a conscious realisation that learning is a continuous process that is not necessarily restricted to a formal education context but rather builds on such a context to extend to other areas of life. It is a unique kind of learning that an individual is conscious about, is flexible to context and continues throughout life. To this end, Brenan & Njeri (2019) opined that, to be an effective learner, there is need to accept that learning is a life-long process which never ends. Part of its success, they suggest, is to make one's mind open to new ideas and their ultimate execution.

The essence of lifelong learning should be to build a yearning for new knowledge and seeking for possibilities of applying knowledge and skills in different contexts

that life presents to people, not once but, always. Indeed, one of the four basic assumptions that featured in UNESCO's classic report, *Learning to Be*, was that, "only an over-all, lifelong education can produce the kind of complete man the need for whom is increasing with the continually more stringent constraints tearing the individual asunder. We should no longer assiduously acquire knowledge once and for all, but learn how to build up a continually evolving body of knowledge all through life—"learn to be." Additionally, Quality Education, which is named as one of the 17 development goals (SDG Goal 4) constitutes ensuring "inclusive and equitable quality education and promote lifelong learning opportunities for all" (UNESCO, 2016).

Theoretical Analysis

This paper is anchored on the theory of reflective learning that is abstracted from (Dewey, 1933) reflective thinking paradigm which entails a deliberate and continuous use of thought/reason by learners to examine knowledge and beliefs together with the grounds and implied conclusions. This cultivates in learners an awareness and ability to be in charge of their own learning as well as relate it to other components of their being in different learning contexts.

Reflective thinking is a break from mere memorisation of facts and content in education. It can be understood as a process in which a learner deliberately looks back at received knowledge and past experiences in order to make sense of them, learn from them and improve on them when need to do so arises. It is a kind of metacognition in which an individual re-visits his or her thought, gained knowledge or experience, and focused on using information gathered from different sources to make judgment in relation to his or her actions and desired beliefs/goals. This in turn makes reflective thinking to be an important necessity in education in contemporary society. This is in agreement with Gough's observation that,

Perhaps most importantly in today's information age, thinking skills are viewed as crucial for educated persons to cope with a rapidly changing world. Many educators believe that specific knowledge will not be as important to tomorrow's workers and citizens as the ability to learn and make sense of new information. (Gough 1991, p. 25).

The ability for a learner to engage in careful and reflective thought has been viewed in various ways: as a fundamental characteristic of an educated person, as a requirement for reasonable citizenship in a democratic society and more recently, as an employability skill for an increasingly wide range of jobs. The task of a reflective thinker is to figure out how the any gained knowledge and received impacts one's life experiences and that of society.

Contemporary society has become more complex; there is a continuously dynamic state of technological development that makes a lot of information and knowledge available and changing more rapidly. There is therefore need to prompt people to constantly rethink, revisit their approaches to decision making and redesign their decision making and problem-solving approaches in different contexts of life. Thus, it is increasingly important to prompt reflective thinking during learning to help learners develop strategies to continually assess and apply new knowledge to the complex situations in their day-to-day activities. The component of deliberate and conscious continuity of the reflective process in the learning experiences is what should sustain the culture of lifelong learning.

From the foregoing, lifelong learning is crucial for the realisation of sustainable development and quality education in the 2030 Agenda for Sustainable Development. Thus, nurturing it in this time and age is necessary. In this paper, teaching reflective thinking in higher learning institutions, by way of infusion into content and methodology, is one possible means for enhancing the culture of lifelong learning. This is because such thinking inculcates a habit of curiosity and self-drive towards incremental improvement of one's thinking and responsible action. In the long-run, learning and the learning process in the education context becomes an impetus for more learning throughout one's life.

Reflective thinking provides students with an opportunity to revisit the educative process with the aim of singling out the positive and negative learning that arose. This yields what can be referred to as reflective learning- a process that leads to a keen consideration of all sources of knowledge that may contribute to understanding a situation, including personal sources and experiences.

Application of Reflective Thinking in Higher Education

The habit of reflective thinking can be nurtured and developed into a way of life. Learners in higher education institutions can learn "how to learn" besides "what to learn". One way to achieve this end is to infuse reflective teaching and learning methodologies and continuous reflection demanding assignments (such as critiquing journal articles, analysing and relating case studies), during the designing and implementation of curriculum at college and university level. This agrees with a study that was done by Colomer, Pallisera, Fullana, Burriel and Fernández who concluded that, "reflective learning methodology helps students become more aware of the learning process; it encourages critical thinking and analysis of their own capabilities, proposing both strategies for improvement and new strategies for addressing challenges arising during the learning process" (2013, p.369). It also enables learners to identify their own learning needs and connect it to future learning.

Some of the reflective teaching and learning methodologies considered, in this paper, as essential in enhancing reflective thinking include asking evaluative questions, dialogical approach to learning, and use of interactive technologies. One way to achieve this end is to infuse reflective teaching and learning methodologies, together with continuous reflection demanding assignments (eg., critiquing journal articles, analysing case studies, determining application and workability of theories and concepts) during the designing and implementation of curriculum at college and university level. In my opinion, testing lower order thinking skills on Blooms taxonomy should be left to primary and secondary school learners.

Questioning

The Socratic Method of teaching that we pointed out earlier is representative of the epistemological value of questioning, and can be deliberately applied in any subject area. It is characterised by the teacher creating an environment in which the learner is systematically probed with an aim of making him or her to carefully think through his/ideas and assumptions. This can be referred to as dialectical method whose main traditional approach consist in question and answer. However, it can be scaled a little bit higher to allow learners engage in self-questioning too. At the

instructional level, Socrates advocated for the infusion of questions that enable students to be reflective of the content learnt and/or generated. This, I believe, is the beginning point of developing a culture of lifelong learning. In this regard, I borrow Richard Paul's (2015) idea that reflective thinking should be an aspect of the content learned in every discipline. Asking question has a very important role in the development of reflective thinking skills. As pointed out by "open-ended questions posed to the students at teaching process will increase their awareness. When higher-order thinking questions are used by students and teachers reflective thinking is developed" (Akdemir, Zeki , & ATAŞ , 2016, p.169).

There is a flip side to the questioning method which requires that students be enabled to question the teacher's knowledge too. In the standard approach, the teacher is viewed as the all-knowing dispenser of knowledge, the learners passively consume whatever the teacher presents and their questions are ignored or discouraged while the teacher's answers are valued, memorised and produced on demand during examinations. The consequence of this, Paul asserts, is that students get the impression that, "knowledge can be obtained without a struggle, without having to hear from more than one point of view, without having to assess evidence, without having to question assumptions, without having to trace implications, without having to analyse concepts, without having to consider objections" (Paul 2015). The implication of this is that creativity will be hampered, and even in the work force, people will wait to be supervised in order to function. Thus, content should be used as a basis for stimulating the learners to assess and utilise it in other contexts as well as related content. They should be encouraged to question and inquire as the best way to learn.

Dialogical Approach to Teaching and Learning

Dialogue is an important aspect in learning to learn since both the teacher and learners view themselves as contributors as well as beneficiaries of the educative experiences. Paul (2015) call this the dialogical approach to learning which he contrasts with the didactic approach that characterise most current academic instruction in higher learning institutions. The model proposed here posits dialogue and dialectics as the methodological strategy that helps overcome egocentric and socio-centric thinking and thereby facilitate the achievement of a community of learners that continue the culture of learning throughout life. As was earlier pointed out, the focus of any educational process should be to enable individuals independently and collectively "figure out how knowledge can be generated, evaluated and applied effectively" (Wokabi, 2011, p.29).

Discussions and peer teaching/learning go along way with the dialogical approach to teaching and learning. A classroom in which there is a give and take moment, as well as agreement on issues of mutual concern is necessary for reflective thinking. The space given in the learning process for learners to listen to each other's perspective on an issue allows other members of the team to think about what is being conveyed and afterwards they are better placed to give positive criticism, revise their own ideas, improve on them or generate new ones altogether. The teacher, as facilitator, needs to ensure a flexible and collaborative classroom environment in which, even though scientific thinking in the subject is maintained, reflective thinking skills are also enhanced in the process. The ability to learn from others as well as participate in the generation of knowledge is a habit that begins to develop in a classroom set up and

is highly likely to continue throughout life.

Use of Interactive Technologies

This is a means of teaching and learning that opens up the students' ability to interact with information and knowledge from other sources as well as build their confidence in doing independent research and discovery. In this regard, access to smarts phones, tablets and the internet could go a long way in setting the foundation for continued learning and discovery. In the World Bank Policy Report that was cited earlier, one of the interventions given for improving education quality and relevance at the institutional level is "innovative curricular and pedagogical practices" (World Bank, 2019, p.58). It further points out that,

The focus of curricular and pedagogical reforms should be on modernising program content and making delivery more effective. In their efforts to provide incentives for higher education institutions that were interested and willing to transform their educational approach, the Kenyan authorities must encourage the universities to move away from traditional teaching methods and make teaching and learning more interactive, collaborative, and experiential (World Bank, 2019, p. 61).

The use of interactive technologies in learning is highly recommended because when learners engage in, for instance, independent e-research, they develop self-learning skills. Further, modernisation of programmes content by use of platforms such as google classroom, near pod, and zoom among others makes delivery and interaction more effective (World Bank 2019).

We can infer from the foregoing that interactive and hands on experience in teaching and learning is necessary in higher education because technological advancements come along with new information and knowledge that necessitates flexibility and continued learning. The question to ask at this point is whether higher learning institutions in Africa enable their students to use interactive technology to independently locate and generate knowledge on their own? Learning to learn can be achieved when, for example, students are presented with complex problem solving scenarios that require them to find solutions of their own by either applying received knowledge because they can reflectively figure out relationships, or by independently researching on their own with the use of interactive technologies available for them.

Recommended Model for Reflective Thinking

Reflective thinking model which fosters lifelong learning can be nurtured in higher learning institutions. The three approaches to teaching and learning seen as applicable to the this endeavour can all be achieved through creating a conducive environment during learning sessions or by the kind of assessments the teacher employs to determine whether students have learnt to learn, and developed an independent drive to seek and generate new knowledge. Assignments that entail, for instance, evaluating the worth of people's ideas, critiquing journal articles, figuring out how research can be applied in other contexts, and examining the basis and worth of course material presented are all possible means that can be used in higher learning institutions to foster the habit of reflective thinking throughout one's life.

The cyclic reflective thinking model proposed here has been coined from the key concepts of its constituent parts, that is, Assumption identification and analysis,

Metacognition and Critique (AMC). The model proceeds from the basic contemplation of personal and shared experiences geared towards identifying any learning from them, evaluating and judging either a thought or situation, to the more complex process of build on these foundations with an aim of eliciting a change in the learner' personal beliefs and ultimately challenge his or her prior assumptions. Open-mindedness is fundamental to the entire process while interactive technologies pointed at earlier serve as an intermediary for learning to learn at any given point on the cycle.

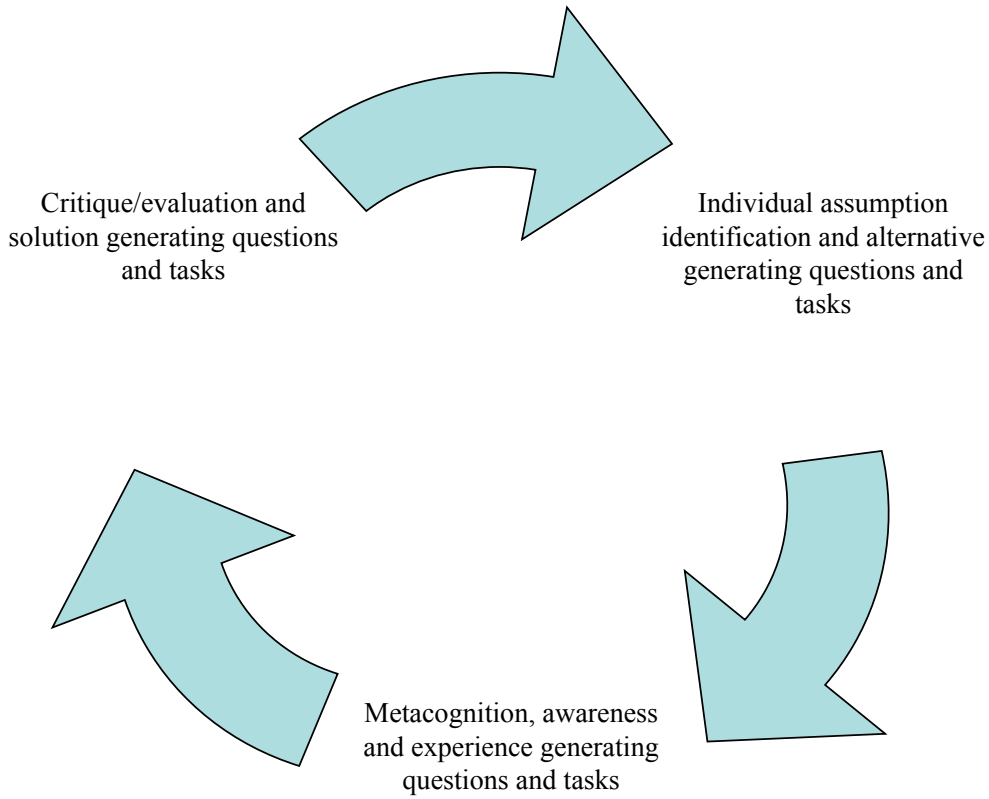

Figure 1: The AMC model of reflective thinking

Conclusion

From the findings of this study, it was evident that quality of teaching-learning and research in higher learning institutions in Kenya is wanting. The approaches used by educators are examination/rote memory oriented model which contributes to cramming of information rather than the reflective model which cultivates metacognition, life-long learning, and autonomy. When learners rely on the teacher to produce knowledge, their creative potentials are suppressed and can therefore not contribute meaningfully to the sustainable development agenda. It is on that account that this study recommended creation of a deliberate culture for lifelong learning through the reflective thinking model that is complimented by open-mindedness and use of interactive technologies in the entire process.

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Education as a Strategy to Prevent and Counter Violent Extremism in Africa: The Case of Somalia and Nigeria

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Abstract

Africa has been confronted by the wave of violent extremism. Northern Nigeria is the home of Boko Haram; the Horn of Africa, Al Shabaab; Sahel region, al-Qaeda in the Islamic Maghreb (AQIM); North Africa, Al-Qaeda and so forth. Governments and bodies waging for international peace have embraced more kinetic strategies to prevent and counter violent extremism. However, the phenomenon is unrelenting. So this work surveyed literature on education and violent extremism in Northern Africa and the Horn of Africa to explore what role education may play in countering and preventing violent extremism. The study drew information from previous surveys, reports, peer reviewed journals, case studies, and books. Earlier studies have shown that in Africa particularly Northern Nigeria and Somalia have limited access to quality and life-long education. The two countries equally are the home of Boko Haram and Al-Shabaab terrorist groups respectively. In Northern Nigeria, the region has been left behind in terms of development for decades and it has the highest rates of illiteracy compared with other regions of the country. In Somalia, the majority of Al-shabaab members are the youth who missed the opportunities of formal education following the collapse of the governance system since 1991. The results demonstrate that education cannot stop violent extremism but it can play a role in equipping learners resilience against violent extremism. The paper recommends that governments and Ministries of Education should support ambitious measurement and research agenda to close the data gaps and continue action-oriented research and innovation on how to prevent and counter violent extremism through education in different contexts.

Keywords: **Education, Violent Extremism, Countering violent extremism, Africa**

Introduction

The incidences of violent extremism (VE) are on the rise across the world. These incidences are not isolated in any one region or country but spill across many countries. This rising trend is worrisome as it puts fear in the minds of the general population and begins a vicious cycle of suspicion, mistrust and exclusion among communities along the lines of religion, race, colour, gender, nationality and socio-economic status among many others (UNESCO, 2017). On this, Africa has not been left behind. The continent has been confronted by the wave of VE. Northern Nigeria is the home of Boko Haram; the Horn of Africa, Al Shabaab; Sahel region, al-Qaeda in the Islamic Maghreb (AQIM); North Africa, Al-Qaeda and so forth. The causes of this phenomenon have been manifold. Conventional factors such as poverty, marginalisation, unemployment, illiteracy, bad governance, religious ideologies and so on continuous to drive the phenomena (Abdalla, 2015). Most studies have revealed that religious ideologies have the potential to penetrate both the educated and uneducated populace. According to Abdalla (2015) the youth are driven towards militancy and violence under the conviction that they are fulfilling their religious duty to restore to Islam its "lost glory". They believe that restoring such glory has to go through a reciprocal violent struggle against the forces that violently stand in their way of realising their Islamic Utopia on earth, namely, the secular western powers of the world and their ally ruling regimes in the Arab and Muslim world.

Furthermore, in their book about *Engineers of Jihad,* Diego Gambetta and Steffen Hertog identified relative deprivation as a powerful motive for educated youth to join a radical religious group (Muro, 2017). Although, the data the authors had analysed, excludes Islamic terrorists groups such as Boko Haram in Nigeria, Al-Shabaab in Somalia, and the Taliban in Afghanistan. So from the above analysis it is clear that religious ideologies, one of the causes of VE has the capability to penetrate in educated or uneducated population. That is why perhaps, overriding security discourse which has often been deployed to respond to the VE have been failing. For example, extralegal security measures including assassination, imprisonment, air strikes, killing drones, torture and surveillance of suspected individuals and groups. In fact the use of extralegal measures has further served the militants' self-fulfilling prophecy about the glorious past of Islam (Abdalla, 2015). It is against this backdrop, this paper seeks to interrogate what role education can play in countering and preventing religious ideologies that are causing VE in Africa. The paper presents a brief discussion of educational access and quality. It then brings two country scenarios. That is VE with diversity in education provision in Nigeria and Somalia. Finally, the author interrogates what kind of education can promote resilience against VE.

Educational Access and Quality

In 2019 there were 105 million children of primary and secondary school age who were not enrolled in school more than in 2000 globally. This growing trend is mainly due to the increasing number of out-of-school children among adolescents and young people of secondary school age (UNICEF and Africa Union Commission, 2020). In Africa, Western Africa remains the region

with the highest number of out-of-school children: two out-of-school children out of five are living in Western Africa. This is followed by the Eastern Africa region, which is home to one third of Africa's out-of-school children of primary and secondary school age (UNICEF and Africa Union Commission, 2020). Surprisingly, these two regions of African continent are the home of Boko Haram and Al Shabaab groups with terrorist credentials, these groups that have remained a threat to peace and security continentally. Again, one could wonder about the future of Africa when we have such huge number of children out-of-school, considering the continent would require knowledgeable and skilled manpower to drive its economy.

COVID-19 pandemic containment measures have had a devastating impact to education access and quality. With more than a complete year of schooling lost in many parts of the world, learning poverty is estimated to rise to 63 percent in developing countries. The pandemic runs the risk of eroding hard-won achievement in access to schooling and learning. Moreover, such high levels of illiteracy are an early warning sign that all global educational goals and other related sustainable development goals are in jeopardy (World Bank, 2021). Prior to the COVID-19 pandemic, the world was already grappling with a learning crisis. Millions of children and young people were not on track to develop the relevant skills they need to learn effectively, transition smoothly into getting a job or starting a business, or otherwise contribute to their communities. Inequalities (including those associated with poverty, gender, disability, migration status, ethno-linguistic status, and other socioeconomic conditions) have kept millions of children from assessing equitable and inclusive quality education further intensified and became exposed by the pandemic (UNICEF and Africa Union Commission, 2020). In other words, World Bank report (2018) revealed that worldwide, hundreds of millions of children reach young adulthood without even the most basic life skills. Even if they attend school, many leave without the skills for calculating the correct change from a transaction, reading a doctor's instruction, or interpreting a campaign promise- let alone building a fulfilling career or educating their children. This dire state is what has kept especially African countries forever developing. Countries in Africa have failed to tap its enormous youth demographic dividends, the resource with huge potential to transform the continent. These has left most youth vulnerable to terrorist groups or rebels who have kept causing havoc in some regions of the continent. This keeps me wondering what needs to be done to equip youth with quality education. And what kind of education we need to equip youth to be resilient from terrorist ideologies or to enable them engage in conflicts non-violently? The next section we are going to look at two cases of African countries, focussing on education and VE. The two countries are the home of venomous Boko Haram and Al Shaabab terrorist organisations.

Boko Haram and Education in Nigeria and Neighbouring Countries

Nigeria, once well respected for its role in restoring stability in some conflict-torn states in Africa, is now in need of the international community's assistance to guarantee peace and security in her own territory. Since July 2009 when Boko Haram engaged Nigerian security forces in a short-lived anti-government uprising, the group has grown to become a serious national, regional, and international concern (Onuoha, 2014). Boko Haram's ideology is

based on extreme Islamic teaching which rejects most Western ideas and institutions. This rejection earned the group its popular name: Boko Haram literally means "Western education is forbidden." Its core objective is to replace the secular Nigeria state with a regime that adheres to strict Islamic Sharia, law, applicable throughout the entire country (Onuoha, 2014). The group is against western values and civilisation regardless of the benefits or not to the larger society.

This terrorist group originated in the Northern Nigeria where there is high level of illiteracy and child destitution. There are over 15 million destitute in Nigeria whose number is greater than the population of Togo, Sierra Leon, the Gambia and Liberia put together. More than half of these number, which constitute mostly children live in Northern Nigeria **(**Ngbea and Achunike, 2014). The bulk of the Boko Haram members are drawn from relatively lower social standings or members of the lower class. Some were settlers while others were descendents of the *Shehu's* slaves who were not privileged to have acquired some form of Western education, and had settled around the 'troubled spots' in the Northern Nigeria (Bintube, 2015). As Ogbogu (2015) amplifies that the region is characterised by high unemployment rates, illiteracy as well as absence of basic amenities, these has made the area a fertile ground in terms of recruitment for Boko Haram. It is in such places where people have been denied opportunity to go to school as well as have meaningful economic sources of livelihood that recruitment is the easiest. Boko haram leaders are aware of it and of course are maximising the advantages of that obvious truth. The long and short of it is that with entrenched poverty, illiteracy and unemployment, we cannot eliminate the menace of Boko Haram or similar security threats (Ngbea and Achunike, 2014). Compared to the South, this region since independence could not match the southern economic and educational development. Most probably, this fact, in addition to the south's educational advantage, is due to the location of Nigeria's natural resources, which are mostly in the southeast (Delta region). Northern Nigeria, the home of Boko Haram has been marginalised by previous government (Cook, 2014). What is posing a challenge in offering education in Northern Nigeria is Underdevelopment and marginalisation of the region. Thus, there is high level of illiteracy in one way or the other that has contributed to a fertile ground for Boko Haram ideologies to flourish unlike the southern region.

Religion particularly some versions or interpretations of Islam has provided favourable conditions for development of Boko Haram. Cook (2014) observes that Northern Nigeria is largely the creation of the jihad of Shehu Usman Dan Fodio, whose Fulani followers still dominate the religious and political aristocracy of the region 200 years after his death. Shekau, the leader of Boko Haram, does adduce the example of Dan Fodio's purification jihad, which targeted syncretistic Muslims almost exclusively. Boko Haram founder, Yusuf was successful in forming the movement because he was very good in presentations of arguments and manipulating the ignorance. His approach was to direct his attack against the state and the leaders whom he accused were behind the sufferings and deprivation people were suffering from (Cook, 2014). As he was speaking the reality of the situation in Nigeria and the call for implementation of Islamic Sharia as the solution, many people, particularly the youths, who were evidently in the midst of poverty, hopelessness and illiteracy, easily fall prey to his exposition of their suffering and whom they viewed as courageous and frank (Bintube, 2015).

The Boko Haram leader realised that for the movement to achieve its objective, he had to form coalitions with political leaders in the North. As such, Yusuf formed an alliance with Ali Modu Sheriff, a politician and wealthy businessman who became Governor of Borno State. Yusuf allegedly promised to deploy his influence and religious authority to provide political support for Sheriff if, upon becoming Governor, Sheriff would implement Sharia (Jerome**,** 2015).

As it can be seen above, the level of illiteracy in the Northern Nigeria is extremely high; this gap is bridged with Koranic education which have since created favourable climate for radicalisation to happen. Ogbozor (2016) study found there is a high rate of enrolments in Koranic schools; in Borno State, Northeast Nigeria, about 72 percent of the total enrolments in Koranic schools. Most of the students are left in the care of their Koranic teachers because the parent of the children cannot afford to take care of them. However, these students in the absence of parental supervision often fall victims of ideological beliefs and teaching impacted by their teachers. Most of the students may have been radicalised to join Boko Haram in the process. Most members of the Boko Haram members are students of the Koranic schools in Northeast Nigeria (Ogbozor, 2016). So, it is extremely important for parents to monitor and contribute to learning of their children to counter situations where radicalisation is happening in education setting. Furthermore, Ilechukwu (2014) posits that in the Northern Nigeria, the population of Almajiris (street boys) is over 8 million. This population has features that make it ideal for exploitation by Boko Haram:

- It involves children relocated or separated from their family and friends to the guardianship of Mallams in towns;
- It is restricted almost exclusively to boys;
- The curriculum of the Koranic schools is concerned primarily with teaching the sixty chapter of the Koran by rote memorisation;
- Each school serves 25 to 500, from ages of 6 to 25 years; and,
- These schools are largely autonomous from government oversight.

Regrettably, the government of Nigeria appears to have neglected its duty to ensure that in all learning institutions, the content of curriculum does not advance religious extreme ideologies that could be a threat to peace and security.

Regionally, the Boko Haram insurgency has emerged as one of the greatest threats to human security, for example, in the Lake Chad region with a total area of 427,500 km^2, which covers/ Cameroon, Chad, Niger and Nigeria (Oyewole, 2015). The four countries with shared borders in the Lake Chad have witnessed growing pressure to counter the Boko Haram insurgency. At the domestic and regional levels, the threat of cross-border attacks, arms trafficking and terrorist recruitment, and the crises that are related to refugees are alarming in the Lake Chad region. In addition to these, the campaign of terror constitutes a threat to foreign interests in the region. Series of attacks have been recorded against foreign citizens and businesses in the region. The record of foreign victims of Boko Haram attacks and kidnappings includes United Nations (UN) staff, French citizens, Britons, Germans, Lebanese, Italians, Chinese, Greeks and Koreans. Moreover, the ideological statement of the insurgent campaign is particularly targeted against Western values and influences in the region

(Oyewole, 2015). As at mid-2016, the violence has caused approximately 20,000 deaths, with about 2.6 million internally displaced persons and 170,000 Nigerian refugees. The situation is more pronounced in some rural communities in Northeast Nigeria, Far North Region of Cameroon, Southeast Niger, and the Lake Chad region of Chad (Ogbozor, 2016).

Studies have shown that the rate of primary education enrolment in the Lake Chad Basin is lower than each country average. The difference between the national gross enrolment rate (GER) and Borno State, Northeastern Nigeria is alarming (Gross primary enrolment rate 21% compared to national GER 82). Borno State is the birthplace of Boko Haram extremist group (Ogbozor, 2016). Far North region of Cameroon and the LCB region of Niger enrolment rates are equal compared to their national averages. Diffa region of Niger has the lowest education enrolment compared to national average. These figures suggest that the Lake Chad Basin is probably the less developed areas of each country that make up the basin's conventional areas (Ogbozor, 2016). According to Oyewole (2015) more than 150 schools have been closed in the far north region of Cameroon, while the education system has virtually collapsed in north-eastern Nigeria. Boko Haram has recorded a series of attacks against schools and colleges in northern Lake Chad region on the ideological note of discouraging enrolment in Western education as opposed to Islamic education in the region (Oyewole, 2015).

Conflicts Context and Education in Somalia

Somalia is one of the countries that can be classified as a failed state. The problem began in 1991 when president Barre was overdrawn. Barre's rule was characterised by discrimination, violence and dictatorship. Many renegade armed groups began to challenge his rule in the 1980s and in 1991. Barre was ousted from power with no dominant group emerging to exert authority over the whole of Somalia (Mbugua, 2013). Consequently, Mbugua (2013) notes that in the last two decades Somalia has been engulfed by chaos without a central authority leading to collapsed economy, loss of livelihoods to millions of people, breakdown of educational infrastructure and neglect of physical infrastructure and a crash of social services.

Following the breakdown of governance systems, radical groups emerged imposing radical religious ideology upon the people. The predominant group is Al-Shabaab. The Al-Shabaab Al-Mujahidiin is an off-shoot of Somalia's Islamic Courts Union which evolved from a grass-roots community driven Islamic Jihad movement inspired by Somali Islamic scholars who were trained in Saudi Arabia as Wahhabi sect followers (Ali, 2008). The majority of the members of this group are the youth who missed the opportunities of formal education following the collapse of the governance system. Education sector was one of the causalities following the fall of the state. The breakdown of law and order following the collapse of the state destroyed whatever vestiges of the system still survived. Armed militias plundered school furniture and fixtures; school compounds became homes for displaced people; and school playgrounds were converted into graveyards. There were times, especially in the early 90s, when it was almost impossible for citizens to think about education. The quest to survive and satisfy basic needs left no time to organize schooling, much less to focus on planning for the future (Cassanelli and Abdikadir, 2005).

Studies have revealed that the youth in Somalia are hindered from effective participation in peace building and development due to illiteracy, lack of economic opportunities, unemployment, breakdown of family and social ties and other cultural inhibitions. Over 70% of the youth in Somalia are under the age 30. These are the youth who grew up in the absence of a central government; they are illiterate and as a result have strong allegiance to their clans or religious groups (Mbugua, 2013). Compared to out-of-school youths, youths who got an opportunity to access education were less likely to participate in political violence (Ofosuy and Tesfaye, 2018). The author elaborates that to some extent being in school reduces isolation by allowing students to form positive social bonds with peers, teachers and others in their community or by giving them social standing and acceptance, access to education may undermine the recruitment and participation of youth in violence. However, the Ofosuy and Tesfaye (2018) warns that if in-school youth sees a bleak future and expects the government to do more to address educational and employment concerns, these frustrations can cause support for political violence, perhaps, to pressure the government to address their concerns. The youth may also support or sympathise with others who use force because they are no formal nonviolent channels to express their grievances or, if they exist, they are unsure of how they operate or their efficacy. This provides an explanation why well-off, educated men join the ranks of jihad in the developed world. Due to unmet expectations of their career, engineers are joining terrorist groups (Muro, 2017). This is a situation that can happen even to youth in developing countries of Africa despite the fact that the contexts are different.

An Education that can Boost Resilience to Violent Extremism

Beyond being a basic human right, education done right improves social outcomes in many spheres of life. For individuals and families, education boosts human capital, improves economic opportunities, promotes health, and expands the ability to make effective choices. For societies, education expands economic opportunities, promotes social mobility, and makes institutions function more effectively (World Bank, 2018). However, education in general will not prevent and counter violent extremism (P/CVE). Training to gain knowledge and skills for a career or on a topic is the difference for a holistic education that develops critical thinking, values for citizenship and respect for diversity. Specific teaching aimed at these latter aspects is vital for CVE (Tony Blair Institute for Global Change, 2016). Bar-Tal and Rosen (2009) believes that schools are the best platform to wage war against VE in a number of ways. One, education in schools is sure to reach a whole segment of a society (i.e., the young generation) because schools are compulsory and all children and adolescents are required to attend them. Two, schools are often the only social institution that can formally, intentionally, and extensively achieve the mission of peace as they have the authority, the legitimacy, the resources, the methods, and the conditions to carry it out. Three, schooling takes place during children's formative years, and the young generation, which still is in the process of acquiring a psychological repertoire, is least affected by the dominating ethos and is more open to new ideas and information. Finally, the young generation is required to learn the messages and information transmitted in schools and often treats them as truthful, and, therefore, it is possible to ensure that students at least will be exposed

to them. As such, in the context of Northern Nigeria and Somalia where many children are out of school, the war against VE may be jeopardised to some extent. And as it has been noted above this kind of education should foster critical thinking, creative thinking, collaboration, self awareness, multicultural competencies and empathy and so on. In other words, UNESCO (2016) recognises that education can help young people develop the communication and interpersonal skills they need to dialogue, face disagreement and learn peaceful approaches to change; help learners develop their critical thinking to investigate claims, verify rumours and question the legitimacy and appeal of extremist beliefs; help learners develop the resilience to resist extremist narratives and acquire the social-emotional skills they need to overcome their doubts and engage constructively in society without having to resort to violence; foster critically informed citizens able to constructively engage in peaceful collective action. By promoting respect for diversity, peace and economic advancement, education can be a buffer, against radicalisation and VE (UNESCO, 2018).

Schools could play a critical role in cultivating resilience against VE. As Davies (2009) explains schools can foster value pluralism and integrative complexity to build resilience to singular messages. They can build confidence to argue, disagree, agree with teachers, authorities, leaders, and potential manipulators as well as each other; challenge binary thinking, black and white truths, them, and us; and searching for multiple truths, not one truth. And they can enable encounters, networking and platforms across schools and other agencies to generate the necessary diversity. More especially, we can better understand diversity when we encourage children to tell their life stories, and sharing these across different groups, as well as gain confidence in speaking and the power of narrative. Furthermore, Miller (2013) says that young people should be enabled to explore, in the safe space of a classroom, some of the fundamental questions of what it means to be human, what we understand by identity and community, how to live in our rapidly changing societies and how to promote what is just and honourable. To achieve this noble goal, UNESCO (2017) suggests that educators need to pay particular attention to the personal challenges of learners as they struggle with issues of well-being, identity and meaning and are tempted to turn to charismatic leaders for answers. This implies motivating, supporting and equipping teachers with appropriate skills and tools to understand their own biases and subsequently build the defences to VE narratives at the level of individual students. It can also be helpful to connect teachers with other concerned professionals in the community from the justice, social and child protection sectors in view of providing learners with relevant and timely assistance on the full range of issues that they may be struggling with. In addition, Samantha de Silva (2016) argues that teachers can be trained to detect early signs of violent ideologies without being burdened with complex topic such as countering violent extremism without being equipped with the necessary tools and proper support. Miller (2013) adds that teacher training curriculum should developing teachers' cultural awareness to facilitate the promotion of shared values; confidence to challenge extremism; theological knowledge to draw out shared values of respect, tolerance; and theological knowledge of Islam to challenge the religious justifications of Al Qaida-inspired VE. It is worth noting that teachers

who take the role of educating to preventing and countering violent extremism can themselves be targeted; therefore, it is critical that they are not viewed as informants that could not only undermine the teachers' relationship with the students but also their role in the community (Miller, 2013). Furthermore, teachers themselves can foster tolerant attitudes when they apply pedagogical methods, such as peer-to-peer learning, experiential learning, team work, role play and other approaches that stimulate critical thinking and open discussion (UNESCO, 2018). Tony Blair Institute for Global Change (2016) reiterates that passive or banking educational techniques that are teacher-centred can fail to build resilience amongst young people, and can often do harm than good, being associated with indoctrination. Student-centred approaches that incorporate dialogical methods, critical pedagogy and co-operative learning should be fostered. Unfortunately, going by earlier studies most children in schools are not learning. They have missed skills and competencies to keep them resilient from violent religious ideologies in the one hand, on the other, to handle conflicts non-violently.

In Fergus (2012) work, policies to foster safe, discrimination-free school environments are encouraged. A whole-school approach is critical to foster safe and supportive school environments and to build capacity to initiate and sustain teaching and learning. However, Sieckelinck, Kaulingfreks and De Winter (2015) argues that many schools want to provide a safe learning environment for their children by employing anti-bullying programmes or zero tolerance strategies on physical aggression. From an educational perspective on VE, though, it is problematic if a safe environment would mean that no sensitive political issues could be addressed out of fear for offending a person or a group. On the contrary, what is needed is school environment where it is safe to talk about politics and ideals. This underscores the need to have well trained and experienced teachers in school who could actualise this noble initiative of equipping learners with requisite skills to P/CVE.

Most researchers of peace believe that educating for peace is likely to be among the central strategies to confront the wave of VE. Sieckelinck, Kaulingfreks and De Winter (2015) have proposed the curriculum that involve teaching children explicitly the mechanisms behind radicalisation and conspiracies; showing them how and when they are seen as easy targets by extremist groups; teaching resilience against black and white views and demonstrating the seductive character of a Utopian worldview as earlier noted, while not discouraging ideals for change. Sieckelinck, Kaulingfreks and De Winter (2015) adds that an educational perspective that allows us to approach these youths in the classroom as emerging political agents who may adopt an extreme ideology to escape from their everyday life world in which one runs considerable risk ending up victim or villain, with often little in between. Unlike the intelligence and security perspective, an educational outlook allows youth, through extensive educational interaction, to probe identities that differ from the expectations and demands by the mainstream environment. This kind of education is critical to prevent especially those highly educated humans from joining VE groups because of religious ideologies. Those youths who are struggling by all means to achieve the glorious past as it was witnessed during the time of Prophet Mohammed. The time they are

made to believe that life was fair as human rights were respected and the society was prosperous.

Conclusion and Recommendations

For years, governments and bodies waging for international peace have embraced more kinetic strategies for P/CVE. For example, use of bombs, heavy artilleries, missiles, heavy airstrikes, rockets, machine guns, warplanes, warships though have reduced the phenomena in the one hand, and on the other, have caused more devastating effects such as killing thousands of innocent humans, depriving resources meant for development, and loss of properties. To make matters worse, the phenomena of VE has kept metastasising and un ending. As seen from above, education cannot stop VE from happening, but it could play a very critical role in developing a resilient society against VE. In an African context, specifically from the two cases we have interrogated, missed education opportunities and extreme religious ideologies have in one way or the other contributed to VE in the one hand, on the other, education institutions failure to offer the kind of education that could boost learners' resilience against VE. Furthermore, failed states characterised with weak economies as witnessed by the case of Somalia, could fail to provide educated youth with employment opportunities or the good quality of life, hence relative deprivation could drive youth to VE. As such, this work is providing the following recommendations:

1. Governments and Ministries of Education should support ambitious measurement and research agenda to close the data gaps and continue action-oriented research and innovation on how to address P/CVE through education in different contexts;

2. Governments should establish inclusive systems of education that could fulfil every learner's potential. The curriculum should be flexible and relevant recognising diverse needs of learners even in context of conflicts; and,

3. Right to education. Governments and development partners should strive to provide free basic education. This would offer youth requisite knowledge and skills necessary in labour market. This would prevent some of vulnerable and unemployed youth especially in an African context from joining terrorist organisations.

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Leveraging ICT to Widen Access to Higher Education in Kenya

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Abstract

We argue for ICT leverage to curb limiting barriers and aid widening access to higher education in Kenya. Impediments to higher education access in Kenya include affordability, flexibility, institutional limited capacities, lack of opportunities for education mobility and lifelong learning. A qualitative content analysis methodology appreciated Kenya's robust ICT infrastructure with great potential to tap into ICT based open and distance learning, learner centered E-learning and blended learning as some of the affordable and flexible strategies for widening access to higher education. In particular, ICT greatly enhances flexibility for working population because it fits in their work demands and personal commitments. ICT has huge potential to moderate access barrier to persons living with disabilities and rural dwellers. It is flexible to working class, lifelong learning enthusiasts and mobile learners. Ubiquity, reusability and portability of ICT based learning resources, contribute to affordability, hence contribute to widening access to higher education. Prioritising education using ICT's, with deliberate and targeted efforts by leaders and decision makers, is key to investing more resources in ICT and developing policies that prioritises widening access to education through ICT's.

Keywords: **Leveraging ICT's; Widening Access; Higher Education; Kenya**

1.0 Introduction

Enhancing higher education access, affordability and flexibility, are evolving concerns to institutions of higher learning the world over, as guided by the United Nations (UN) sustainable development goal (SDG) number four. The goal is to ensure inclusive and equitable quality education and promoting lifelong learning (UN General Assembly, 2015). Specifically, target 4.3, aims for equal access for all women and men, to affordable and quality technical, vocational and tertiary education, including university education by the year 2030. This endevour is more pronounced in the wake of COVID-19 pandemic, that has disrupted learning delivery the world over and necessitated ways to survive rather than thrive in higher education provision. This imply that education is clearly a reforms concern that need to be accorded the significance it deserves, more so in the developing world such as Kenya, exhibiting weak educational infrastructures and skewed national development priority areas.

Globally, higher education institutions (HEI's) have been considered a focal point of knowledge and its application, contributing to society's advancement through fostering of innovation and training (Woldegiorgis, 2021). According to Bayusuf et.al., (2021), higher education in Africa has expanded significantly over the past several decades, although the majority of the population remains unable to access the limited number of higher institutions of learning, with a wide gap in access between and within countries. According to Teffera (2021), African higher education recorded a huge growth in the past decade despite the enrolment rate remaining among the lowest in the world (under 10% on average, but 5% for most). Notwithstanding funding challenges in higher education, Kenya has made significant progress in higher education expansion as evidenced by the rise in number of HEI's over a 10-year period between the year 2002 and the year 2012 and substantial investments in ICT's in higher learning (KNBS, 2020).

According to UNESCO (2017), the UN-SDG's are attainable, if key partners, including governments; the private sector, civil society and stakeholders across the world, do their part. Leveraging ICT's in higher education in Kenya in one of the innovative strategies with the potential to widen access to higher education and enable learning without the limits of distance, geography, age, qualifications, finances and more recently, pandemics such as COVID-19. This is possible since most higher education activities, could be made available online and sometimes offered free of charge, hence expanding its reach to marginalised sectors of society with necessary support infrastructure.

The purpose of this study is to focus innovations for widening access in higher education in Kenya, towards ICT based solutions and interventions, and to make higher education access affordable and flexible to learners. This is particularly in response to rapidly expanding demands for higher education and existing access challenges.

1.2 Statement of the Problem

Educational systems the world over, ought to provide equal opportunities for all citizens and eliminate barriers to education access.

According to Shafique and Mahmood (2010), educational institutions play a key role in providing opportunities for people to learn information society knowledge and skills for the advancement of society in the digital age. Despite attempts to address equity by expanding the existing higher education systems to allow more access and promote equal distribution at the local, regional and national level, Kenya still suffers from barriers that limit access to higher education.

While many Kenyans continue to live in rural and remote areas with significant demand for education which remain unmet, access to higher education remains unaffordable and out of reach for many citizens. The challenge of ensuring equity of access to higher education is one that affects high, middle and low-income countries alike (McGowan, 2016). The brick and mortar settings of institutions of higher learning and the traditional way of knowledge delivery and transfer through physical lecturers, is not flexible to sections of society such as persons living with disabilities (PLWD's). The working class and people living in geographically distant and infrastructural alienated regions are also marginalised by traditional ways of knowledge delivery. Furthermore, the declining funding by the government limits the capacities of higher education institutions to expand in response to the rapid increase in population and increasing demand for higher education. There is need therefore to leverage the power of information and communication technologies (ICT's) in Kenya to widen access to university education for all.

2.0 Methods

The study adopted the qualitative research methodology, and was conducted using the content analysis research design strategy. This includes reviewing relevant secondary text sources, documents, websites, and journals for appropriate content, relevant to the study. The document/content analysis checklist was used in data collection and content analysis technique, was used to analyse the data. Data presentation was done using qualitative textual description of analysis approach.

3.0 Results

3.1 Key Education Highlights from the Kenya Economic Survey 2020

The Kenya National Bureau of Statistics (KNBS) in its report dubbed Kenya economic survey 2020, for the period 2015 to 2019 informed that, the population of Kenya grew by more than fourfold within a period of 50 years to 47.6 million in 2019. From the report, it is evident that, many Kenyans (68.8%) continue to live in rural and remote areas and have significant demand for education, which remain unmet. The report further states that, 3.5 % of Kenyans had attained University level education by 2019. This implies that, the ratio of students in higher education for every 100,000 population is relatively low. Over the period under review, public chartered universities remained constant in number at 31 for three years, while the number of students placed by Kenya Universities and Colleges Central placement Service (KUCCPS) to public and private universities increased by 30.5% (68,550 in 2018/19 to 89488 in 2019/20). This implies more pressure on available resources and facilities in Kenyan universities (KNBS, 2020).

Furthermore, KNBS (2020) accounts that the development expenditure for the state department for University education declined by 9.1% to Ksh. 9.2 billion in

financial year 2019/2020. This undermines capacities of Universities in terms of facilities to adjust to the growing numbers of students and population. In addition, the implementation of government policy to ensure 100% transition from primary to secondary education is expected to further increase demand for university education and up the pressure on facilities later on. The report also indicated a decline in enrolment of adult education learners, which dropped by 1.6% from 212,441 in 2018 to 209,082 in 2019. This hampers lifelong learning efforts by the government and those interested in it for personal or professional development.

3.2 Impediments to Higher Education Access in Kenya

UNESCO (2017), regards education as a public good and a global common good. Additionally, education is regarded as a fundamental human right and a basis for guaranteeing the realisation of other rights. While the statement holds, many factors impede higher education access and sustainability in Kenya (a member of UNESCO) leading to gaps in education access. Affordability, flexibility, institutional physical locations, limited capacities of higher education institutions (HEI), lack of opportunities education mobility and lifelong learning, are among the major reasons impeding many from accessing higher education in Kenya. Further, as COVID-19 pandemic continue to rage havoc globally, the rural-urban divides, digital divides and education access gaps among the population of Kenya and the developing world, continue to widen (Trahar, et. al, 2020). According to Kandri (2020) close to 90% of all primary, secondary and tertiary learners in the world, were unable able to physically go to school due to COVID-19 pandemic.

Kenya being a low-to-middle economy and more than half the population living below the poverty line, the economic situation impedes many from prioritising University education. While public funding for higher education continues to decline, Universities are compelled to seek alternative funding to breach the funding gap. According to Biggs and Tang (2007), it is becoming a norm rather than an exception to fill the gap left by the decreasing public funding shortfall by charging higher students fees. Costs of higher education, therefore, remain out of reach for many potential learners in Kenya, hence limiting their access to higher education. Recent calls to increase university fees threefold in public universities in Kenya, is expected to further degenerate the situation, in the likely event that it is approved and implemented. UNESCO's science report dubbed *The Race Against Time for Smarter Development* (UNESCO, 2021), exposed its worry whether the current level of funding of tertiary education including HEI's in Africa will enable them focus on their core mandate of teaching, development and deployment of new state-of-the-art technologies. This calls for innovative ways leveraging ICT's to focus on its core mandate.

Education flexibility in terms of time, space and curriculum delivery is desirable in widening access to education to reach a larger section of the population. Traditional ways of knowledge delivery in Kenya through physical lectures in a "brick and mortar" setting is limited by time and space, making it inflexible to many, hence preventing many potential learners from accessing university education. Working class potential learners with the urge to expand their skills are limited in their quest to further their education due to the fixed learning times and geographic locations of institutions.PLWD's in Kenya are not fully catered for, in the design of

"brick and mortar" set up of many HEI in Kenya. Furthermore, many HEI's do not provide enough support to PLWD's in the learning process hence limiting their access to University education. Additionally, people learn through different ways and at varying speeds, but the traditional way of physical lecture delivery assumes a level "playground" where learners learn through the same way and at the same speeds. This limits learning and hence access to education to many learners perhaps with learning disabilities, such as learners with dyslexia medical condition characterised with sever learning difficulties.

Potential learners living in rural, remote and far-flung regions could be locked out of access to university education considering the costs, time and effort required to physically move to other regions seeking education. The decision to enroll in a university, may partly be influenced by the geographic location of the institutions, especially for the working class who may prefer an institution near their place of residence and work, to enable them balance their work, education and family responsibilities. Institutional resource constraints, coupled with declining development expenditure funding to HEI's (KNBS, 2020), to a large extend hinders access to university education in Kenya. Lack of space and limited capacities, inadequate teaching facilities and staff in Universities, limits and indirectly controls the number of learners who can be admitted into educational programmes offered by HEI's in Kenya. Lack of education mobility opportunities, arising from autonomy of universities in Kenya, leads to development of own curricular, even for related courses. This practice hampers education portability and mobility initiatives necessary for widening access to higher education. Learners should be able to conditionally move from one institution to another and progress with their studies without much restraint. Joining advanced stages for the same programme in a different university should additionally be possible for learners, without which learning will be limited to a geographic location, time and space. This negatively affects and limits access to mobile students and workers in an increasingly global and mobile world.

Lifelong learning is a phenomenon that provides opportunities and promotes learning throughout the life of an individual. This is due to the believe that there is no end to learning, and that learning ought to happen as long as an individual possess capabilities to learn. HEI's focus on academic work alone and churning out graduates, limits access to people interested in lifelong learning opportunities for self-growth and development, necessary for improving the quality of life among members of society. HEI's are supposed to be agents of change in society, but lack programmes for adult learners and persons interested in lifelong learning and skills for personal and professional development and growth, and not certificates as envisioned by traditional universities. This lack of relevant lifelong learning opportunities hinders and limits access to education especially to adult learners.

4.0 Discussion: Opportunities and strategies to Widening Access to Higher Education

UNESCO (2020a), attributes the responsibility of education development in member states to respective ministries in charge of education, and are tasked with the responsibility of reviewing the purpose of their education systems in light of the ambitions of the UN-SDG's. This places Kenyan higher education institutions at the

center of innovations to seize the opportunity and leverage ICT's to curb higher education access limiting barriers, and help widen its access in Kenya through flexible and affordable strategies, for the benefit of all. ICT's have improved and enhanced the quality of education and learning process in higher education the world over, despite operational challenges that exist. ICT based education ranging from accessing self-study courses on the internet; to complete electronic classrooms without the need for traditional infrastructure such as physical classrooms have been witnessed. These are witnessed in HEI's of the developed world, and continue to be increasingly and successfully leveraged in higher education institutions of the developing world such as Kenya with optimistic results.

4.1 Key ICT Highlights from Kenya Economic Survey 2020

The Kenya economic survey 2020 (KNBS, 2020), reports the proportion of conventional households using mains electricity in Kenya as the main source of power more than doubled from 22.7% in 2009 to 50.4% in 2019. This is affirmative and desirable for enabling and widening access to education through ICT's as it promotes and supports the uptake of electricity powered ICT equipment in the country. Additionally, Kenya through its rural electrification programme (REP) managed to transmit electricity to most parts of rural Kenya. This again enabled access to electricity in remote and rural areas, and thus promoted the uptake and use of electricity powered devices such as laptops, smartphones among others, suitable for digital learning.

According to KNBS (2020), the coverage of fourth generation (4G) network, improved drastically by 42%, following significant deployment of trans-receivers, which increased from 7,469 in 2018 to 17,744 in 2019. This implies improved internet speeds and ability to carry multimedia content necessary for education delivery to homes and places of work. Fibre to the home (FTTH) subscription increased by 52%, while fibre to the business (FTTO) subscription grew by 43.3%. Furthermore, utilisation of the available bandwidth capacity improved significantly to 43.5% in 2019 compared to 25.0 % in 2018. Utilised undersea bandwidth more than doubled from 1.1 million Mbps in 2018 to 2.7 million Mbps in 2019.

The key ICT highlights has many implications for widening access to higher education in Kenya. More and more Kenyans are embracing the use of internet technology, as there is increasing demand for higher internet and communication speeds suitable for transmission and delivery of multimedia educational content to homes and places of work as evident in the increasing FTTH and FTTO network subscriptions. The power and contribution of ICT's in education can, therefore, no longer be ignored, as Weller (2011) aptly puts it that, technology is an autonomous system that affects all other areas of society including education. With its immense potential, ICT's could, therefore, be leveraged to widen access to education since both consumers and producers of education are embracing its use.

4.2 ICT Based Solutions to Widening Access to Higher Education in Kenya

"*To shift to a sustainable future, we need to rethink what, where and how we learn to develop the knowledge, skills, values and attitudes that enable us all to make informed decisions and take individual and*

collective action on local, national and global urgencies" (UNESCO, 2020a).

Whereas Universities in Africa have been working on virtual learning prior to COVID-19 in an effort to bring down costs and expand access to education, COVID-19 served to accelerate that need as HEI were forced to go digital (Bayusuf et. al., 2021). The pandemic, therefore, accelerated processes that were already underway, to transition more content to virtual learning platforms. According to Perrotta (2020), early responses from the educational institutions involved training faculty, and rushing to change their traditional curriculum to fit an online environment, mindful of technology, learning management systems, and various online learning platforms that learners could access.

Bhagat and Kim (2020), opines that although painful, COVID-19 presented itself as a rude awakening to everyone involved in the higher education including learners, instructors, policymakers, and society alike. Tapping into its robust ICT infrastructure and increasing investment, Kenyan institutions of higher learning embraced strategies that promote efforts to widen access to higher education through ICT's. For instance, with the help of regional partners such as African Higher Education Centers of Excellence for Development Impact (ACE Impact) and local partners such as Kenya education network trust (KENET), ICT based Open and distance learning, student centered E-learning, and blended learning strategies were implemented. In some cases, instructors made connections with students through text messaging platforms such as WhatsApp or telegram (Bayusuf et. al., 2021). This helped widen access to higher education in Kenya to sections of the population which would otherwise have been left out. UNICEF (2020), reports that 1.5 billion students in 190 countries were not able to attend school physically due to COVID 19 pandemic, and ICT's came in handy to save some.

4.2.1 Affordability: Reducing Costs of Education Delivery through ICT's

According to McPheea & Pickren (2017), advancements in ICT in the current information society has provoked the need for a paradigm shift, with many education providers embracing open and distance learning (ODL), as an innovative and cost-effective approach of delivering their pedagogical responsibilities Particularly during the COVID-19 pandemic. ICT based open and distance learning is, therefore, an affordable, effective and efficient way to widen access to higher education. Pannen (2007), argues for open and distance learning, as a feasible, inexpensive, and "easy" mode of education, with the potential to widen access to University education for many learners. Through affordable and flexible technological interventions such as use of compact disks (CD's), e-mails and internet for instance, lessons could be delivered to students in multimedia enriched formats to deliver learning materials to learners wherever they are without compromising the quality of instruction. According to Lembani et. al., (2019), distance education (DE) is capable of delivering quality university education to geographically marginalised and dispersed African students.

UNESCO (2020b) reports that COVID pandemic has forced higher education sector to undergo various forms of operational changes in addition to adjusting course delivery methods. Thus, conventional limitations of time and space are eliminated through open and distance learning, as

learners could be engaged affordably, without considerations of time, space and geographic distances. Churton (2006) recognises the ability of open and distance learning to provide adults with another opportunity for education, while reaching those disadvantaged individuals limited by time, distance, or disability, and updating the knowledge base of workers at their places of employment and places of residence.

4.2.2 Flexibility: Overcoming Limitations of Learning Resources, Time and Space

During the COVID-19 pandemic, HEI's made a dramatic transition from traditional face-to-face learning to passive and active remote learning in a very short time period (Kandri, 2020). Through ICT's, education lessons could be delivered through the internet, enriched with multimedia and hypermedia content such as video, animations, graphics and audio content to enrich and maintain the quality hence improve the learning process. Students could learn through the internet at their own pace, time and convenience hence breaking the barriers and limitations of fixed learning time, geographic and physical locations as well as reducing the costs of accessing higher education.

According to Sussanto et.al.,(2019), technology adds flexibility in the delivery of pedagogy and on how teachers present new knowledge and receive feedback from learners in an engaging and captivating experience. Opportunities to replay and revisit the lessons improve learning, particularly for persons with learning difficulties, who perhaps may unnoticeably lag behind in the learning process during the traditional learning delivery modes. This strategy is equally useful in enhancing staff skills through e-pedagogy to improve the quality of learning delivery and hence the quality of education in HEI in Kenya.

4.2.3 Equity in Access: Addressing Limitations in Abilities

Using technology, persons living with disabilities are accorded an opportunity to receive support from HEI, with the deliberate effort to provide and use of assistive technologies to widen access to them. According to Reyes et.al., (2020), HEI's has been adopting measures based on virtual formulas that arise as options or complements to traditional face-to-face and more traditional practices through the use of ICT. This fact has enabled the inclusion of many people including PLWD's, previously excluded from higher education. Assistive technology toolbars could easily be implemented to provide functionalities such as screen readers to convert text into sound for people with serious visual impairment. Screen magnifiers and text enlargers could be implemented to help people with mild visual impairment, be able to read with improved comfort. Persons with learning difficulties apart from replaying recorded videos for emphasis to improve the learning process could benefit a lot from text readers able to convert text to speech.

4.2.4 Strategies for Implementation

Blended learning is a strategy, useful for HEI's implementation of ICT's, to widen access to higher education in Kenya. E-Learning courses supported by printed materials and occasional face-to-face meetings on campus, could help widen access in resource constrained environments. This is whereby, limited available resources

could be utilised and shared by alternating learners at different times, and supplemented with multimedia materials through the Internet to enrich student experience and knowledge of content. According to Sussanto et.al., (2019), e-learning allows accessibility essential in complementing with the traditional way of teaching. Well implemented blended learning strategies has the potential to double enrollments in HEI's, without much pressure on the available resources e.g. teaching staff and facilities, hence able to bring more learners onboard, hence widening access to higher education.

Where infrastructure exists, Kenyan institutions and governments both local and national working together, could tap into an ICT network to facilitate collaboration and establishment of online based institutions e.g., open online university. This is a purely online-based institution established by sharing, collaborating and pooling resources together with the support of the governments to cut on costs and optimise returns for national good. Education is delivered through learning management systems software used to deliver, track, and manage learning instructions on the internet. This strategy in addition to widening education access to many, is suitable to harmonise curricular and delivery between collaborating institutions for education mobility and widening access to people living in remote and rural areas affordably. According to Teffera (2021), many efforts have put in place in Africa to expand access to higher education through distance, online and virtual means, despite long-standing ambivalence attributed to quality, delivery and integrity.

To promote and support lifelong Learning initiative to reach persons interested in self and professional development, localised and specialised open online courses (OOC's) borrowing from the model of massive open online courses (MOOC's) common among universities in the developed world, need to be initiated and promoted in society by universities to suit the needs of the local population. Open online courses promote lifelong learning among the members of society and encourages updating of life and professional skills. This is contrary to the traditional education models where for instance, without the requisite minimum qualifications, some learners would not be accepted into colleges of their choice and would not be hired for positions in which they would be otherwise qualified (Editors of the Salem Press, 2011).

There is need for open online courses to be self-paced and learner driven to save on resources and costs. This model of delivery has the potential to reach many adult and lifelong learning enthusiasts with requisite technology skills. According to Kaliisa and Picard (2017), the spatial distribution of ICT coupled with the need for lifelong learning opportunities has enabled ODL to move from the periphery to the mainstream of university education policy and practice. OOC's offered through ODL could be funded through public-private partnerships and offered to citizens free of charge and through the internet for flexibility and ease of access.

5.0 Summary and Conclusion

Kenya and the rest of the developing world, experience many challenges in their quest to widen access to quality, affordable and flexible higher education opportunities for all, in accordance with the UN SDG's. Despite their efforts to widen access to higher education, key impediments still impede its

efforts including the high costs of education occasioned by dwindling higher education funding and external support, inflexibility of delivery modes, time and places and lack of mobility and lifelong learning education opportunities. With its robust investment in ICT infrastructure, Kenya and the rest of the developing world, stands a very high chance to leverage the power of ICT to widen access to higher education to all, through ICT based Open and distance learning, student centered E-learning, blended learning as well as establishment of a school on the internet.

In conclusion, it is conceivable for Kenya and the rest of the developing world to tap into its great ICT infrastructure potential to innovate and widen access to higher education and to make higher education in Kenya more accessible, flexible and affordable. This beneficially accords equal education opportunities to all. With accessibility barrier flattened using ICT's, PLWD' and other marginalised sectors of society, such as people living in rural dwellings and others, will be brought on board to have equal education opportunities. Regarding flexibility and mobility prompted by ICT use in higher education, working class, and mobile members of society will have an opportunity to further their studies and update their skills. This helps in improving their productivity and contribution to the economy. The comparatively lower cost of production of technology-based education activities, their re-usability and portability helps brings down the cost of accessing higher education and make it much more affordable. It is imperative upon decision makers in Kenya and the rest of the developing world, including institutions of higher learning and the political leadership, to make deliberate and targeted efforts to invest more resources in ICT, including in regions marginalized and lagging behind as far as infrastructure is concerned, and develop policies that prioritises education for all through ICT's. With proper efforts and investment in education through ICT's, more people will be accorded equal opportunities to access higher education hence widening access to higher education. These efforts also contribute to citizen's participation in educational programmes aimed at improving the living standards of the people in line with the United Nations sustainable development goals, which prioritises education as a factor of human and national development. Since the study was based on a qualitative approach, authors recommend further empirical study on the subject, to uncover more impediments to higher education in Kenya and to be able to generate actionable statistics that can specifically inform decision making on leveraging ICT's to widen access to higher education In Kenya.

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Social Inclusion Impact among Learners with Intellectual Disability Participating in Unified Schools' Programmes in Kenya:

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Abstract

Participation in sports has contributed positively to persons living with Intellectual Disability(ID) as documented in the impact of Unified Sports though an out of school activity. In Kenya, children spend most of their time in school ,thus a need for Unified Schools Programme activities that provide an opportunity for learners with (out) intellectual disabilities to participate in play and sports. They also need to work together in inclusive youth as well as whole school engagements. This study aimed at evaluating the perceived effects on social inclusion among participating learners. The research tool had both structured and unstructured questions thus, mixed research method was used specifically to cater for both quantitative and qualitative data. The study targeted 40 schools that had a special unit within the same environment and had fully implemented the three Unified School Programme Activities. To calculate the sample all the school administrators were purposively sample and 2 teachers per school who had been trained, 2 learners (1 with and 1 without ID) and a parent of each were randomly picked making a sample size of 280 respondents. Research questionnaires for the survey were adapted from a pool of questions and were administered one on one basis by trained research assistants who also conducted interviews and Focus Group Discussions.Ethical clearance and consent were acquired before the study commenced. Statistical Package for Social Sciences software was used to analyse data. Descriptive statistics was used to calculate frequencies that was then presented in tables and graphs. Findings revealed that implementation of the Unified Schools programme activities resulted to improved social inclusion. It is recommended that the programmes to continue and be expanded to all schools in Kenya.

Introduction

The Kenya system of education has sports programmes for all learners including those with disabilities, both for recreation during extra-curricular activities and talent development for competitions. Advances to achieve global inclusive system of education have gained impetus in the recent couple of years (Kabita & Ji , 2017). Including learners with disability in the same classes with those without disability is associated with increased acceptance and accommodations in all school programmes. Highly recorded successful outcomes of inclusion are among learners living with physical impairments, integration of hearing and visually impaired (Olsson & Hwang, 2008). Unfortunately, in Kenya, learners with intellectual disability only enjoy similar school environments but learn separately in the established special units (Favazza et.al., 2016; Mwangi. et.al., 2020). It would therefore not be too farfetched to conclude that learners with intellectual disability encounter reduced opportunities for social interaction and other relevant life skills from their peers without intellectual disability. It is evident that most children interact more during free play and sports activities undertaken during leisure time or organised physical activities at school. United Nations (UN) agencies including United Nations Educational, Scientific and Cultural Organisation (UNESCO), United Nations International Children's Emergency Fund (UNICEF) and World Health Organisation (WHO) in Kabita & Ji (2017) appreciate and embrace benefits of inclusive engagements for social and mental development of citizens. The extra mile to ensure individuals living with intellectual and developmental disabilities fully benefit from inclusion. This is especially in out of school participation in Unified sports that youths engage in organised by the Special Olympics, year-round sports programmes as well as national and international competitions. Reflecting on the gains of Unified sports, Special Olympics has expanded the scope by initiating Unified Schools Programmes that introduced inclusive youth and whole school engagement (Holly et.al., 2017) to foster social inclusion of youths with intellectual disabilities in the school community. There are over 100,000 youths in 135 countries across the globe and Kenya is one of the beneficially. The programme is implemented in 141 schools across 15 Counties where learners with intellectual disability get opportunities to work together in three Unified Schools Programmes activities (Unifies sports, Inclusive Youth and Whole school engagement) in the same environment reaching out to over 8,000 learners with ID, 8,000 students without ID and 2,000 teachers. The success of any programme is measured by evaluation of the key performance indicators as per the programme's objectives. Studies show that the Unified Champion Schools Programmes that had implemented three unified activities (Unified sports, Inclusive Youth and Whole school engagement) have yielded positive results for both students with and without intellectual disability in the USA.

The transition to the Competency Based Curriculum (CBC) in Kenya has two curricula. Age based for learners who do not vary significantly in abilities from what is considered norm while the stage based is for learners considered to have significant disabilities. The stage based consists of four levels: foundation, intermediate,

prevocational and vocational levels (Kenya Institute of Curriculum Development (2017) that opens progression for learners with disability. Implementation of programmes in schools with emphasis to inclusion are likely to boost more acceptance of learners with disabilities and promote attainment of relevant skills required in the society. The current study sought to evaluate the impact of the Unified Schools Programme activities on social inclusion and emotional learning outcomes among learners with intellectual disability and those without in selected primary schools in Kenya.

Objective: To assess the perceived changes on social inclusion and emotional outcomes among learners with and without intellectual disability participating in Unified Schools Programmes implemented in selected integrated unified primary schools in Kenya.

Research Design: The study adopted mixed method research design. The research collected both qualitative and quantitative data. According to Schooneboom. (2017), mixed method research design advances the systematic integration of quantitative and qualitative data within a single investigation. The current project was an evaluation of the impact of Unified School Programmes and used questionnaires that comprised of both structured and unstructured items for participants to respond to permitting a more complete and synergistic utilisation of data collection and analysis.

Study Participants: The study participants were school administrators, teachers, learners and parents in the schools participating in Unified Schools Programme activities. The target population was over 10,000 spreads in the 141 schools that had implemented the Unified School Programme activities across fifteen Counties in Kenya as form the year 2018. The sample size was calculated using Yamane (Glenn, 2009) formula to estimate the sample size of 400 from the targeted population of 10,000. A 95% confidence level and p=0.5 (maximum variability) was considered in formulating the following equation:

Demographic Information of Study Participants:

The gender variable of the study participants was used to compute the response rate per category.

Table 1: Gender of the Study Participants

Study Participants	Variable.	Male	Female	Sampled	Response rate
Sch. Administartors (n=37)		19(51.4%)	18(48.6%)	40	92.5%
Teachers (n=64)		29(45.3%)	35(54.7)	80	80.0%
Learners(n=64)	Gender	37(57.8%)	27(42.2%)	80	80.0%
Parents(n=61)		26(42.7%)	35(57.3%)	80	76.2%
Totals			231	280	

Results from Table1 above show that there was 37/40 (92.5%) return rate from school administrators, 64/80 (80.0%) from teachers, 64/80 (80.0%) from learners and 61/80 (76.2%) from parents with an overall return rate of (82.2%) which was considered appropriate for the study. Results from the quantitative data is presented in tables and graphs while the qualitative data is presented in thematic areas. Responses from each of the category on the perceived social inclusion after participating in Unified School Programme activities.

The current study concentrated on social inclusion for learners with and without intellectual disabilities who participated in the Special Olympics initiated Unified Schools Programme Activities (Unified sports, Inclusive Youth and Whole school engagement). Therefore, there was need to show the distribution of the two categories of the learners using the split half computation. The results on the selected demographic information are shown in table 2.

Table 2: Split Learners Demographic Information

Variable		**Learners with ID (n= 32)**	**Learners without ID (n= 32)**
Gender	Male	20 (62.5%)	17 (53.1%)
	Female	12 (37.5%)	15 (46.9%)
Age Category	Under 12	3 (9.4%)	0
	12 - 18	20 (62.5%)	32 (100%)
	19 - 25	9 (28.1%)	0

Table 2 ;shows that there was a balance in the category of leaners as planned. The research team had requested for a learner with ID and a partner without ID to participate in the study from each school. Gender representation indicated that there were more male learners in the two groups. However, learners with ID had the higher number (62.5%) compared to (53.1%) among those without ID. The contrast there were more female among learners without (46.9%) compared (37.5%) with ID. Learners with ID spread along the three age categories with majority being 12-18 (62.5%) followed by 19-25 (28.1%) and under 12 (9.4%) years of age in that order. The learners without ID were all 12-18 (100%) years of age. While learners without ID were within the expected age category for primary school those with ID had a few older ones than the average age expectations mainly because some may have began school while advanced in the entry age or had remained in the school longer as compared to those without ID who sit for examinations and proceed to secondary education.

Table 3: Leaners' Involvement in Unified Schools Programme Activities

Type Activity.		Yes	No
Unified Sports		61 (95.3%)	3 (4,7%)
Inclusive Youth Engagement		61 (95.3%)	3 (4.7%)
Whole School Engagement		46 (71.9%)	18 (28.1%)
Nature of involvement in Unified Sports and duration		Count	Percent
Learner's role in Special Olympics Unified Sports	Unified Sports athlete	32	50.0
	Unified Sports Partner	31	48.4
	Don't understand question	1	1.6
Number of years learners have participated in Special Olympics Unified Sport	Less than 1 year	30	46.7
	1 -2 years	25	39.1
	3 - 4	3	4.7
	5+ years	6	9.4
Sample		64	

It was necessary to confirm if learners were indeed participating in the Unified Schools Programmes activities. Table 3 above show that a majority (93.5%) of the learners who took part in the study were involved in Unified Sports either as athletes or partner and an equal percentage were involved in Inclusive Youth engagement while (71.9%) were involved in Whole School engagement activities. Most of the learners were in these activities for a duration of one year to two years in line with the period the unified schools programme activities have been implemented among year one schools.

In addition, the responses on observed changes among learners without intellectuals by the school administrators was important. Their responses on the extent of truthfulness in selected statements is presented in Table 4 below.

Table 4: Observed Changes among Learners according to School Administrators

	Almost never true	Usually not true	Occasionally true	Usually, true	Almost always true
A learner would feel comfortable carrying on a conversation with a learner with an ID at school	5 (13.5%)	1 (2.7%)	(18.9%)	17 (45.9%)	7 (18.9%)
A learner would try to avoid talking to a learner with ID in the corridors	22 (59.5%)	8 (21.6%)	3 (8.1%)	1 (2.7%)	3 (8.1%)
A learner would feel uncomfortable if a learner with an ID was in their class	19 (51.4%	12 (32.4%	3 (8.1%)	2 (5.4%)	1 (2.7%)
A learner wouldn't know how to respond if a learner with ID started to talk to them	16 (43.2%)	8 (21.6%)	5 (13.5%)	5 (13.5%)	3 (8.1%)
A learner would feel comfortable working on a school project with a learner with ID	2 (5.4%)	0	5 (13.5%)	21 (56.8%)	9 (24.3%)
A learner would feel uncomfortable introducing a learner with ID to their friends	19 (51.4%)	9 (24.3%)	5 (13.5%)	3 (8.1%)	1 (2.7%)
A learner would feel uncomfortable spending time one-on-one with a learner with ID	18 (48.6%)	12 (32.4%)	3 (8.1%)	2 (5.4%)	2 (5.4%)
A learner would feel comfortable if a learner with ID were to ask them to sit together during lunch	2 (5.4%)	1 (2.7%)	3 (8.1%)	23 (62.2%)	8 (21.6%)
Sample			**37**		

School administrators gave diverse perceptions on the observed overall behaviour of learners without ID towards their peers with ID. Most of the question statements were based on negative treatment that would have existed before implementation of Unified schools programme activities. It was evident that after participation in the Unified School Programmes, 59.5 % of the school administrators indicated that learners without ID no longer tried to avoid their peers with ID and 51.4% also observed that the learners without ID did not feel uncomfortable when those with ID were in their classrooms. A further indictor was that 62.5% reported that learners without ID were comfortable having lunch and working on a school project together with their pees with ID. This implies that there were gains towards positive behaviour change toward learners with ID across the participating schools.

Question: What are the perceived changes/ impacts after the implementation of unified schools programme activities? Among the learners; Friendship and social interactions, learners have become more active and happier, learners are gaining physical fitness'

Further, the teachers are considered the primary care-givers in the Kenyan school setting for the fact that they spent more time with the learners during learning hours. It was concluded that the teachers would also give their perception on the possible difference they observed among the learners who participated in the Unified Schools Programme activities. The results are presented in Table 5 below.

Table 5: Teachers' Perception on Learners' Social Inclusion and School Engagement

Social Inclusion and School Engagement	**No difference**	**Neutral**	**Moderate difference**	**Big difference**
Providing more sports opportunities for learners with ID	(3.1%)	4 (6.3%)	18 (28.1%)	40 (62.5%)
Helping promote leadership and advocacy skills among learners with ID	2 (3.1%)	2 (3.1%)	34 (53.1%)	26 (40.6%)
Increasing participation of learners with ID in school activities	2 (3.1%)	8 (12.5%)	6 (9.4%)	48 (75.0%)
Increasing confidence for learners with ID	-	2 (3.1%)	25 (39.1%)	37 (57.8%)
Helping promote leadership and advocacy skills among learners without ID	2 (3.1%)	4 (6.3%)	26 (40.6%)	32 (50.0%)
Increasing participation of learners without ID in school activities	2 (3.1%)	7 (10.9%)	15 (23.4%)	40 (62.5%)
Sample	**64**			

A big difference was reported amongst learners' social inclusion and school engagement in the provision of more sports opportunities 62.5% increased participation of learners with ID 75.0%) as well as confidence 57.8% increased participation among learners without ID had a big difference (62.5%). Promoting leadership and advocacy had moderate difference 53.1% among learners with ID while there was a big difference 50.0% among learners without ID.

The learners also had an opportunity to indicate the changes they had achieved after participating the Unified Schools Programme activities. The extent of truthfulness in selected statements is presented in Table 6.

Table 6: Behaviour Change among Learners without ID towards Peers with ID

After Participating in the Unified Schools programme	Not true	A little true	A lot true	Very true
I would feel comfortable carrying on a conversation with a learner with ID at school	0	6 (18.8%)	10 (31.3%)	16 (50.0%)
I wouldn't know how to act around a learner with ID	7 (21.9%)	6 (18.8%)	11 (34.4%)	6 (18.8%)
If I see a learner with ID in the corridor, I would try to avoid talking to him or her	22 (68.8%)	3 (9.4%)	7 (21.9%)	0
If a learner with ID asked me for my phone number, I would give it to him or her	8 (25.0%)	4 (12.5%)	8 (25.0%)	12 (37.5%)
I would feel uncomfortable if a learner with ID was in my class	19 (59.4%)	1 (3.1%)	11 (34.4%)	1 (3.1%)
If a learner with ID started to talk to me, I wouldn't know how to respond	8 (25.0%)	7 (21.9%)	10 (31.3%)	7 (21.9%)
I would feel comfortable working on a school project with a learner with ID	3 (9.4%)	7 (21.9%)	8 (25.0%)	15 (46.9%)
I would feel uncomfortable introducing a learner with ID to my friends	22 (68.8%)	2 (6.3%)	4 (12.5%)	4 (12.5%)
I would feel uncomfortable spending time one-on-one with a learner with ID	19 (59.4%)	3 (9.4%)	8 (25.0%)	2 (6.3%)
If a learner with an ID asked to sit together during lunch, I would feel comfortable sitting with him or her	3 (9.4%)	5 (15.6%)	11 (34.4%)	13 (40.6%)
I would feel uncomfortable if a learner with an ID hung out with me and my friends	20 (62.5%)	2 (6.3%)	9 (28.1%)	1 (3.1%)
Sample	**32**			

After participating in the Unified School programmes majority of the leaners without ID revealed that they would not; avoid talking to peers with ID (68.8%), feel uncomfortable if a learner with ID went into their classes (59.4%) or feel uncomfortable introducing a learner to their friends with ID to friends (68.8%), or spend time one-to-one (59.4%) nor hanging out with him or her 62.5%. However, a small minority indicated that it was very true they felt comfortable; carrying on a conversation (50.0%), working on a school project (46.9%) and having lunch together (40.6%) with a learner with ID.

Finally, parents as key stake holders had been informed of their children participation in the Unified Schools Programme activities that brought together learners with and without intellectual disabilities in the schools where the children attended. The parents were asked to indicate perceptions on any behavioural difference they observed among their children after participating in the Unified activities. The results are presented in table 7 below.

Table 7: Parents' Perception on the effects of Unified School Programmes Activities on their Children

My child	No difference	Very little difference	Neutral	Moderate difference	Big difference
Spent time with teammates from Special Olympics outside of school	2 (3.3%)	2 (3.3%)	6 (9.8%)	25 (41.0%)	26 (42.6%)
Have a friend with ID over to your house	2 (3.3%)	2 (3.3%)	7 (11.5%)	16 (26.2%)	34 (55.7%)
Stand up for people with ID if others are mean	2 (3.3%)	0	9 (14.8%)	19 (31.1%)	31 (50.8%)
Eat a meal with people from either programme outside of the program	2 (3.3%)	1 (1.6%)	12 (19.7%)	22 (36.1%)	24 (39.3%)
Introduce people with ID to their other friends	1 (1.6%)	4 (6.6%)	3 (4.9%)	17 (27.9%)	36 (59.0%)
Choose people from either program as a partner in a game					
Go together with someone with ID a sports match, movie, or other activity in the community.	1 (1.6%)	2 (3.3%)	2 (3.3%)	15 (24.6%)	41 (67.2%)
Sample	**61**				

Parents' responses on specific observed changes in their children after participating in Unified Schools Programme activities. Only simple majority of the parents indicated big difference save from increased social interaction among learners with and without ID to sports events and community events at 67.2%. Focus group discussion with parents had these to state;

Question: What are some of the behaviour changes that you have observed in your child since joining unified schools' programme? A response one parent; 'My child is able to interact with other children even at home'

Discussions: Study findings revealed an overall positive behaviour change among leaners with and without ID. The notable one was a comparison between learners' knowledge on social inclusion before participation in the Unified Schools' Programme activities whereby majority 46.9% of learners without ID indicated that they sometimes found it hard to get along with their peers with ID. After participation, all learners (100%) had developed friendship and increased self-confidence. There was a 75% increase in participation of learners with ID compared to 48.4% before implementation of Unified schools programme activities. The results agree with Szumski et.al. (2020) who found out that an inclusive classroom, predicted a reduction of negative attitudes toward people with disabilities and increased interesting interactions among students. The study findings further showed that 75.5% of learners without ID had big difference in attitude change towards learners with ID, 73.0% of teachers had become more aware

of the contributions of leaners with ID to the school and a 64.4% reduction in bullying, teasing or use of offensive language towards learners with ID.

Conclusions: The study concludes that implementation of the Unified Schools programme activities resulted to considerable positive impact to both learners with and without ID. It was evident that the learners got opportunities to interact more during unified sports, learnt new skills in inclusive youth and whole school engagement activities. There was room for learners with and without ID to work together thus, increased social interactions, better associations with other children in their neighborhoods, more participation in community activities. It is recommended that the Unified Schools Programme to be expanded to include all leaners in Kenya and there is need to measure the actual outcome based on experimental parameters against perceived effects.

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Institutional Challenges and their Influence on Female Enrolment in Public Technical Institutions in Kenya: Case of Kakamega County

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Abstract

There have been tremendous initiatives that have been put in place in the past years in Kenya to increase women participation in Technical, Vocational, Education and Training (TVET) courses by the government and other educational stakeholders. However, the underrepresentation of women in TVET engineering courses in Kenya is still evident. The study established institutional factors that influence enrolment of female students in TVET engineering courses in public TVET institutions in Kakamega County, Kenya. 3 registrars from TVET Public institutions, 3559 students in engineering departments, 62 tutors and one County TVET Officer formed the target population. Random sampling technique was used to get the number of students and tutors respondents while Purposive sampling was employed to get information from the County TVET officer. A sample size of twenty percent (20%) was determined from the target population. Questionnaires interview schedule tools were used. Data was analysed using descriptive and inferential statistics. Research revealed that Institutional determinants such as out-dated technology, teacher attitude and behaviour and lack of presence female role model were found to positively influence girls' enrolment in engineering courses. The study recommends that the Ministry of Education should update technology infrastructure in TVET institution and attach successful engineering females to TVET as role models.

Keywords: **Female, Enrolment, Institutional factors, Role model and TVET.**

1.0 Introduction

Engineering skills facilitates social, economic, political and cultural development of any nation. Women, who receive spatial skills from engineering as a profession, benefit from them and their families. Provision of Technical skills to women in any country reduces poverty, improve productivity, slow the population growth rate, and offer its children a better future (World Bank, 2010). Hence, Technical and Vocational Education and Training (TVET) is a key instrument of a nation in accelerating economic development and poverty alleviation according to Sessional paper no. 1 of 2019. Economic development may be limited if women are still lagging.

Sustainable Development Goal (SDG) 4 pays attention to equal TVET access to both male and female and increase of technical and vocational skills according (UN 2015). Although benefits of women participating in engineering are known, women enrolment in TVET engineering courses is lower than that of men both in developed and in many developing countries (UNESCO, 2016)**.** For instance, only 9% women are engineers in the United Kingdom workforce, 11% in the USA, 14% in Australia (Cherotich, 2016). Challenges facing enrolment of women in engineering courses are numerous; they can be gender related challenges such as gender stereotypes that view engineering as a field for men. Women are viewed as soft, weak and they cannot measure up to the hardness associated with engineering courses. A study by Badekale(2003) in Netherlands revealed that there were a high percentage of women in chemical engineer ing (7.5%) and Applied Mathematics (10.8%). However, the study indicated that electronic, mechanical and civil engineering courses were not attractive to women as they were regarded as dirty jobs. In Nigeria for instance, it was found out that low enrolment of female students in TVET courses was so serious that no student had registered craft and artisans' courses (Adewale and Adhuze, 2017). In Sub-Sahara Africa the role of TVET institutions in empowering women is greatly unrecognised and therefore as it was found by Luggah and Umoh (2018) available opportunities are underutilised.

In most developing countries, TVET is characterised by high gender disparities in enrolment. A case study on selected countries carried out by UNESCO (2010) on improving the participation of female students in TVET programmes revealed that, there are fewer female students in TVET, 91 per cent of the countries studied such as Columbia, Japan and Kenya. In Egypt, in 2014, 10% women enrolled for engineering courses (UNESCO, 2014). Okeke (2005), Yakubu (2006) and Ayonmike, Chinyire and Shirley (2014) agreed that enrolment of women in technical education in Nigeria remained low (20% in 2015) due to challenges such as poor entry levels, gender stereotypes, poor societal perceptions of technical education, labour market misconceptions and weak policy frameworks. Okoye (2016) confirms that some parents may feel that engineering would be tough for their girls and they may not be able to meet the demanding nature of the subjects. This paper focused on institutional factors influencing female enrolment in TVET and their recommendations. Further, Kenya Vision 2030 identifies TVET as one of the tool to spur industrialisation. According to the Kenya Economic Survey, the government has paid a lot of attention to

TVET by increasing funding in the subsector (Republic of Kenya, 2020). Besides, Sessional Paper no.1 of 2019 notes, the number of TVET institutions has increased by 10.3 per cent to 2,191 in 2019 (Republic of Kenya, 2019). Students are admitted centrally through Kenya Universities and Colleges Central Placement Service (KUCCPS) hence providing them with an opportunity to join an institution of their choice. Kenya like any other developing country has been faced by institutional challenges such as lack of female role models in engineering and inappropriate training environment in terms of facilities which may lead to low enrolment of women in engineering courses.

1.1 Statement of the Problem

There has been great emphasis in the recent years, on revamping and re-branding of TVET sector by Kenyan government as a tool for socio economic development in realisation of sustainable development goal no. 4 on gender equality and the Kenya Vision 2030.Enrolment of female students over the years has been faced by several challenges despite the efforts by governments to increase women in TVET. Sessional paper no.1 of 2019 highlight major policies to be implemented to attain gender equality in TVET. Though, statistics in Kenya show that total enrolment in TVET has increased due to registration of more TVET institutions yet gender gap still exists in engineering courses. In Kakamega County, there exists a gender gap of 4435 more men than female in engineering courses. Several studies have been done to establish the causes of TVET gender gap. The current study focused on institutional factors such as role models, teacher factors, technology and infrastructural facilities and their influence on female enrolment in public Technical institutions, Kakamega County.

1.2 Objectives of the Study

The study aimed at achieving the following objectives:

(i) Establish the influence of presence of role models on female student's enrolment in TVET engineering courses in public technical institutions in Kakamega County.

(ii) Examine the influence of teacher attitude and beliefs on female student's enrolment in TVET Engineering courses in courses in public technical institutions in Kakamega County.

(iii) Find out the influence of availability of technological infrastructure on female student's enrolments in TVET engineering courses in public technical institutions in Kakamega County.

2.0 Literature Reviewed

Moletsen and Reddy (2011) explains that institutional determinants such as entry requirements, lack of female role models in engineering and inappropriate training environment in terms of facilities may lead to low enrolment of women in engineering courses. This paper has reviewed institutional factors such as presence of female role models, tutor's attitude, level of technology and infrastructural facilities.

Presence of Female Role Models

Ofsted (2011) study on girl's career aspirations noted that role models shape young women's career choices. Therefore, the need for more female role models in engineering cannot be underrated since evidence has shown that meetings with

professionals have significance in girl's career aspirations. The role models can be female engineers outside colleges and those that are tutors in these institutions. Female teachers influence positively girl's perceptions and confidence in engineering. They help to dispel myths about gender-based abilities among boys and they act as role models to girls. The UNESCO (2016) global education monitoring report notes that girls taught by female teachers do well in science courses and are likely to follow Science, Technology, Engineering and Mathematics (STEM) careers. However, a report by UNESCO, (2017) on cracking the code: Girls and women's education in STEM indicates that not all studies establish a correlation between female teachers and girl's performance in STEM since other factors play a role. Notwithstanding, many studies have shown that there is always a clear relationship between the availability of female teachers and influence on girls in STEM courses. For instance, an analysis of data in over 78 countries by UNESCO revealed that the presence of female teachers in secondary school had a positive correlation to girl's enrolment in engineering, manufacturing and construction but a negative correlation to male teachers (UNESCO, 2017). Hence, there was need for the study to confirm if lack of role models influences female enrolment in public technical institutions in Kakamega County.

Teacher Attitude, Beliefs and Behaviours

Further, teacher's attitude, beliefs and behaviours influences girl's choice of study careers (UNESCO, 2017). This view is supported by Carlone (2004) in women and engineering statistics in the United Kingdom, where evidence has shown that teachers can be consciously or unconsciously biased towards the women in STEM subjects, they view boys to be better and abler to tackle science related activities than girls. This has led to some teachers advising boys to pursue science subjects to a greater extent than girls. This was confirmed by 77% of students in this study. In the UNESCO report on STEM (UNESCO, 2017), it highlights several studies that were done in different countries to show evidence of how teacher's attitude can influence girl's attitude towards Mathematics and Sciences which are a requirement for entry into engineering courses. For instance, a study done in the United Kingdom found out that 57% of teachers have subconscious gender stereotypes in relation to STEM. These stereotypes can be passed to students through instruction, which may influence girl's outcome in the choice of their careers. The perception of a teacher on the ability of learners, depending on their sex discourages students from enrolling or continuing with engineering or other STEM Subjects. For instance, in Latin America it was noted by (TERCE, 2013) that 8%-20% of Mathematics teachers believed that Mathematics is lighter for boys to learn than girls this lowers the teacher's expectation for girl's performance in class.

Female teachers competence is another teacher factor that influences enrolment in that they find themselves confident in Mathematics and Science in lower levels of education but the confidence decreases in secondary levels a critical stage of career choices, since girls are influenced more by same sex teachers than boys this situation affects the choices of careers in STEM. Studies have confirmed that gender stereotypes are compounded by other factors such as ethnicity and beliefs held by teachers that influence the outcome of girls in Mathematics especially in Africa. For, instance a study by Okoye and Ekon

(2016) on reasons for low female enrolment in Akwa Ibom state in Nigeria revealed that 60% of female engineering students observed that teachers discourage girls from performing well in engineering through negative talks in class and heavy assignment which affects learner's performance. However, 69% of the lecturers disagreed to the idea of discouraging but 61% agreed that female students cannot cope with the rigorous activities in engineering.

A study carried out in Zimbabwe by Matope and Makotose (2015) on factors that influence enrolment of female students in engineering; case study of Mutare Polytechnic revealed that subjects are labelled as those that fit males and those for females. In this study 77% of female students and 53% of the lecturers agreed that school labelling of subjects was still present. The school curriculum officer insinuated that courses such as home science, nursing, medicine are suitable for females while engineering, metal work and woodwork are masculine.

Level of Technology and Infrastructural Facilities

Physical facilities such as laboratories and workshops tend to favour men since women lack the physical strength to work with some of the machines (Nguyen, 2000).This was further supported by Buang.et.al. (2016) in a study in Malaysia that availability of physical facilities such as classrooms has a positive influence on female student enrolment in TVET institutions. Other institutional factors such as incompetent trainers and mismatch of curriculum with the labour market demand were also found to have contributed to the low enrolment. (Rono et al., 2014).

In Kenya, just like other countries enrolment of women in TVET engineering courses has continued to face several challenges, despite the fact that the total TVET population is increasing. The Sessional Paper No. 1 of 2019 identifies TVET challenges such as poor spatial distribution of TVET centres, negative attitude towards TVET institutions, less number of TVET centres and inadequate number of competent tutors. Other challenges are gender related like entry behaviour challenges, self-perception on ability of women, intimidation by men and environmental factors that are associated with institutional set up (Cherotich, 2016). Further, at the secondary school level girls perform poorly in the science subjects that are a prerequisite for enrolling in engineering courses due to the masculine nature given to the subjects by teachers and the society (Ngugi & Muthima, 2017). While the teachers can unconsciously communicate negative attitudes towards engineering, a study done in Ireland found that 57% of teachers held some gender stereotypes subconsciously in relation to STEM subjects. In other studies, female students have been found to be positively influenced by perceptions in engineering by female teachers or engineers. Presence of female role models helps to dispel the sex-based myths of innate abilities among boys and girls (UNESCO, 2017) evidence that is yet to be established in TVET institutions in Kakamega County.

With government support to TVET institution, it was wise to establish if the situation is still the same currently. At the national level, the enrolment of students generally in TVET institutions has increased overtime. Figure 1 shows the national TVET enrolment by gender from 2015 to 2019.

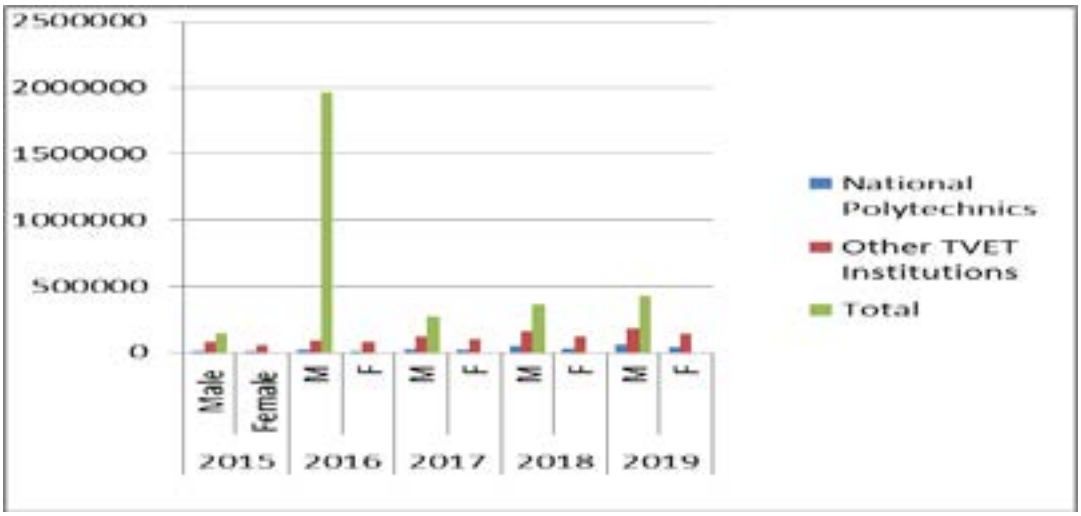

Figure 1: National TVET enrolments from 2015 to 2019
Source: Kenya Economic Survey 2020

Despite the overall increase of the total students' population, male students were at 57.2 % by 2019 while female students were at 42.8% a concern for the gender gap. Table 1shows the gender gap between male and female of engineering courses in Kakamega Public Technical Institutions in the County 2020 .

Table 1: Engineering Student Enrolment in Technical Institutions Kakamega County

Institutions/Courses	**Electrical and electronic**		**Mechanical and automotive**		**Civil and building**	
	M	F	M	F	M	F
Shamberere TTI	110	09	274	37	266	27
Sigalagala National Polytechnic	719	110	677	34	1054	316
Bushiangala	264	02	269	06	383	04
Mumias West	13	09	03	03	-	-
Butere	160	14	156	11	137	08
Friends Kaimosi College	190	02	147	01	206	0
Total	1456	146	1526	92	2046	355
Gender gap	1310		1434		1691	
Total	**1602**		**1618**		**2401**	

Source: Kakamega County TVET Office (June 2020)

Table 1.1 shows the total enrolment of students in engineering courses in Technical Institutions in Kakamega County. The gender gap is evident in all the courses electrical, mechanical and civil are very high. Female students continue to lag behind especially in taking up prestigious technical courses in TVET institutions, hence the study to establish why this is so in order to inform policy.

3.0 Methodology

The study was conducted in Kakamega County, Kenya. It targeted 3 public technical and training colleges: Sigalagala, Shamberere and Bushiangala. The target population of this study, constituted 3 registrars, one from each college, 62 tutors in engineering departments, 3 559 students in engineering department. Descriptive survey research design was used. Data collection was done through administration of questionnaires to get answers on influence of role models, teacher attitude and behaviour, availability of physical infrastructure on female enrolment from tutors and students while in-depth interview was used to get information on the same from registrars and County TVET officer. The analysis employed both qualitative and quantitative methods. Both descriptive statistics and inferential statistics were used. Regression analysis was used to show relationship of variables.

4.0 Findings and Discussion

The study findings and discussions are guided by following objectives;

(i) Establish the influence of presence of role models on female student's enrolment in TVET engineering courses in public technical institutions in Kakamega County.

(ii) Examine the influence of teacher attitude and beliefs on female student's enrolment in TVET Engineering courses in courses in public technical institutions in Kakamega County.

(iii) Find out the influence of availability of technological infrastructure on female students enrolments in TVET engineering courses in public technical institutions in Kakamega County.

The study collected information on presence of role models and availability of technological physical facilities. Registrars and tutors were interviewed while students filled in questionnaires. Students were asked to indicate the degree to which they agreed or disagreed on how institutional factors contributed to enrolment of female students in their department. The responses are given in Table 2.

Table 2 Students' Response on Institutional Factors on Female Enrolment

No	Item statement	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
1	Unfavorable selection criteria/requirements	29 (9.5%)	52 (17.0%)	43 (14.1%)	162 53.1%)	19 (6.2%)
2	Gender biased engineering curriculum materials	34 (11.1%)	120 (39.3%)	35 (11.5%)	84 (27.5%)	32 (10.5%)
3	/lack of role models	44 (14.4%)	70 (23.0%)	40 (13.1%)	124 (40.7%)	27 (8.9%)
4	Peer pressure to do other courses perceived for women	10 (3.3%)	39 (12.8%)	19 (6.2%)	175 (57.4%)	62 (20.3%)
5	Inadequate physical facilities in engineering department	0 (0.0%)	51 (16.7%)	9 (3.0%)	171 (56.1%)	74 (24.3%)
6	Out-dated / poor technology in engineering department	18 (5.9%)	61 (20.0%)	29 (9.5%)	163 (53.4%)	34 (11.1%)

Findings in table 2 show that 181(59.3%) of students agreed that unfavorable selection criteria (requirements) at the institutional level hinders female students' enrolment in engineering programmes in public technical training institutions in Kakamega County. Only 43 (26.5%) of the students, disagreed with this statement. From the interviews, the registrars confirmed that a student does not need Physics as a prerequisite requirement but many people are not aware of the same and so students who did not do well in Physics and Mathematics shy away from engineering.

Secondly, 151 (49.6%) of students agreed that negative comments by male engineering staff is a hindrance towards girls enrolling in public technical training institutions in Kakamega County. This may lead to drop outs or discouragement of those who would want to enrol by those who drop out. However, 114 (37.4%) appeared to disagree with the statement while 40 (13.1%) were not sure. The result shows that tutors at times do scold female students and this affects future prospects on enrolment of female for the course. At least 159 (52.1%) of students agreed and 92 (30.2%) strongly agreed that lack of role models inhibits girl's admission to engineering courses in public technical training institutions. This means that girls do not have someone to look up to (in terms of profession) that could motivate them to apply for engineering courses since it appears to be male dominated. Lack of role models, therefore remains a main challenge in encouraging female enrolment as noted by other researchers such as (Ofsted, 2011). These findings agrees with Carlone (2004) and Kiwana et al., (2011) where the results showed 77% and 58% respectively of the respondents agreed that male teachers consciously or unconsciously discourage female students by the comments they make in classrooms. Most of the students175 (57.4%) agreed and 62 (20.3%) strongly agreed that peer pressure results to low number of females seeking vacancies in engineering courses. This means that peer

pressure is one of the factors that may affect girls' decision to join engineering courses in the study area.

Study results also revealed that most of the students 245 (80.4%) agreed that inadequate physical facilities in engineering department discourage girls from applying for various courses. Further, 197 (64.5%) of students agreed that out-dated technology that is being utilised in the department contributes to low enrolment of female students. This means that institutions with adequate and standard engineering facilities will attract more female students compared with those that have inadequate resources to facilitate effective learning. Registrar No. 3 in the interview said that:

Cost of SET courses for both parents and college, lack of workshops and tools and high failure rate discourages many girls from registering for engineering courses.

Considering that the world is changing, it is important that public technical training institutions update their technological resources to attract female students who seem to prefer institutions that have advanced and current technological facilities and resources to aid their learning (UNESCO, 2016). The out-dated facilities fail to match the current engineering technology climate. The research responses are as provided in Table 3.

Table 3 ; Teachers' Response on Institutional Factors on Female Enrolment

No	Item statement	Strongly Disagree	Disagree	Not sure	Agree
1	Male students get more attention in classrooms than female students from lecturers/ lack of role models	3 (25.0%)	7 (58.3%)	2 (16.7%)	0 (0.0%)
2	Gender biased engineering curriculum materials	2 (16.7%)	8 (66.7%)	0 (0.0%)	2 (16.7%)
3	Technical subjects are practical oriented and therefore attract less female students	1 (8.3%)	5 (41.7%)	0 (0.0%)	6 (50.0%)
4	Inadequate physical facilities in engineering department that do not favour women	2 (16.7%)	6 (50.0%)	2 (16.7%)	2 (16.7%)
5	Male students dominate the work stations during practical work than female students	1 (8.3%)	6 (50.0%)	0 (0.0%)	5 (41.7%)

Findings in Table 3 indicate that half 6(50.0%) of the lecturers agreed that due to technicality of engineering programmes, majority of female students do not apply for engineering courses hence which results to low numbers of admissions. Result showed divided opinion where 7(58.3%) of tutors disagreed that male students dominate work stations during practical work compared to female students whereas 5 (41.7%) agreed. This means that domination of engineering students during practical activities at times acts as a hindrance towards higher enrolment by students in public technical training institutions in Kakamega County, Kenya.

In addition, tutors disagreed 10 (83.3%) that male students receive more attention compared to female colleagues in public technical training institutions in Kakamega County. This means that in the engineering department, all students irrespective of their gender receive equal attention without discrimination hence not affecting or determining enrolment. Result also indicates that 10 (83.4%) of tutors disagreed that the engineering curriculum materials are gender biased. This coincides with the response provided by students who indicated that the curriculum materials being used in engineering programmes is not gender specific but cut across all profiles.

To test the null and alternative hypotheses, a linear regression analysis was computed at 95.0% confidence level. The null hypotheses stated that: There is no significant influence of institutional determinants on female students' enrolment in TVET. The model analysis outcome is presented in Table 4 .

Table 4: Model Summary on Influence of Institutional Determinants on Female Enrolment

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.594[a]	.353	.289	.86860	.353	5.463	1	10	.042
a. Predictors: (Constant), Institutional determinants									

Findings in Table 4 show the correlation coefficient of the regression is R=0.594 which is above average positive and the R square is 0.35.3 implying that 35.3% of change in female students' enrolment in TVET engineering courses can be explained by institutional determinants in Kakamega County. This suggests that 64.7% of female students' enrolment in TVET engineering programmes can be as a result of other determinants not considered in this model. The F- change statistics shows that there exists linearity ($p<0.05$) between institutional determinants and female students enrolment in TVET engineering programmes. Table 5 presents the regression coefficient result for the third independent variable against dependent variable.

Table 5 Coefficientsa Institutional Determinants Influence on Female Enrolment

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
B		Std. Error	Beta			
1	(Constant)	1.423	.787		1.808	.101
	Institutional determinants	.634	.271	.594	2.337	.042
a. Dependent Variable: female enrolment						

The linear regression equation is:

$$y = 1.423 + 0.634\beta y = 1.423 + 0.634\beta$$

The regression coefficient is significant (p=0.42). Null hypothesis was rejected and Alternative hypothesis accepted at (p<0.05) showing that there is significant influence of institutional determinants on female enrolment in TVET engineering courses. The coefficient suggests that, a unit change in institutional determinants, female students' enrolment in TVET engineering programmes increases by 0.634. This means that institutional determinants contribute significantly to enrolment of female students in TVET engineering courses. From the interviews two registrars indicated that lack of awareness on changes of entry requirement, lack of female role models, out-dated technology and inadequate facilities led to low enrolment. This was echoed by both tutors and majority of students.

5.0 Conclusions and Recommendations

5.1. Conclusions of the Study

The study makes the following conclusions

1. The findings show that there has been a steady increase in enrolment of both male and female students in TVET, but very few female students in engineering.
2. The study reveals despite the many efforts by the government the concerns of teacher attitude, behaviour and beliefs towards women in engineering continue to hinder female students from enrolling in engineering courses.
3. Lack of role models and inadequate modern facilities influence female students' enrolment greatly.
4. That outdated facilities that are not technologically updated discourage female students from joining engineering courses.

5.2. Recommendations of the Study

To increase enrolment of female students in TVET this study makes the following recommendations;

1. There is need to implement all the set strategies to encourage female students to join TVET engineering courses.
2. There is need to build capacity to sensitise tutors on the need to encourage more girls to enrol and change their negative attitude towards female students enrolled in engineering.
3. Finally, TVET successful engineering females can be attached to TVET institutions as role models and motivate female students.
4. There is need for the Ministry of Education TVET section to ensure availability of and updated female attractive engineering technological infrastructure.

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Challenges of Covid-19 and Online Learning on Children in the Informal Settlements of Nairobi: Parents' Perspectives

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Abstract

Millions of children risk being out of school physically and emotionally unless governments take inclusive actions to bring all children to the learning table. When COVID-19 was discovered, and the unprecedented expected infection rates, schools were closed. Despite the efforts by the government to provide education through alternative means, disparities in access to distance learning programmes within the vulnerable households from marginalised and informal settlements were more disadvantaged due to lack of internet connectivity as well enormous challenges in accessing television and radio sets. The Snowball method was used to identify the unit of analysis. From a survey of 50 out of a targeted 80 households, parents' perspectives were sought on the challenges their children were experiencing during the covid-19 schools' closure. Google forms were used to administer a questionnaire to some parents while others took telephone interviews. The survey was conducted on the person that was identified by the households' as the one to take the survey. This study sought to identify the challenges that are experienced by children in the informal settlements of Nairobi. The study findings identified several challenges ranging from lack of space to read, TVs, radios, Smartphones, internet connectivity, electricity and household chores, especially for the older siblings. Adapting virtual learning for all may need internet connectivity and cost-effective and affordable bundles. Parental preparedness and sensitization on their role in enhancing their children's education are recommended.

Keywords: **Informal Settlements, Covid-19, Parents' Perspectives, Schools' Closure, Virtual Learning, Kenya**

Introduction and situating the problem

When COVID-19 was discovered, and the unprecedented expected infection rates, more than 1.8 billion children in 186 countries were affected by school closures (UNESCO, 2020; World Bank, 2020). This only worsened the situation for some children and it might exacerbate increase education poverty (Save the Children, 2016; World Bank, 2019). About 258 million children are not in school and these are mainly in Low and Middle-Income Countries (LMICs) (UNESCO, 2020a), that frequently have perennial calamities; natural disasters, and manmade disasters that present peculiar challenges for the education system. This has continued to create education gaps that continue to affect innocent children. Before the COVID-19 pandemic, 127 million primary and secondary school-age children and young people living in crisis-affected countries were out of school in 2019, or almost one-half the global out-of-school population (INEE, 2020). In 2019, the out-of-school rate for children and young people of primary and secondary school age living in countries affected by crisis was 31 per cent for girls and 27 per cent for boys.

Kenya as a signatory to international and national conventions and agreements commits the government to ensure the provision of universal basic education for all children regardless of gender, social-economic, age or geographical location. The Kenya Constitution (2010) obligates the government to provide free and compulsory basic education which is of good quality to all learners without discrimination. However, the provision of education of good quality to all learners became an uphill task for the government due to the outbreak of the COVID-19 Pandemic. This is due to the lack of infrastructure to ensure continuity of learning. With all the educational institutions closed, after the first COVID-19 infection was reported, the education. Alternative ways of Learning were only in place after 2 months. The Kenya Institute of Curriculum Development prepared programmes for learners but not all learners were able to access them due to connectivity. The Challenges for accessing quality education occasioned by the learners' socio-economic backgrounds, the digital divide among teachers and the lack of infrastructure to ensure continued learning through the use of technology became glaring. This calls the governments to be more proactive and put in measures for a resilient education system that ensures that all the learners and especially those from disadvantaged socioeconomic backgrounds continue receiving quality education even in times of crisis.

For almost 11 months during the period of school closures, the Ministry of Education (MOE) provided virtual, television and radio lessons to support the continuity of curriculum coverage and learning. This was especially for primary and secondary classes. Kenya Institute of Curriculum Development (KICD) that hand the mandate from the MOE prepared timetables for every day including Saturdays. Despite these efforts, there were many reports especially from print, digital and social media platforms about disparities in access to distance learning programmes with vulnerable households from marginalised and informal settlements being more disadvantaged due to lack of internet connectivity as well enormous challenges in accessing television and radio sets.

2.0 Overall Objective

This study focuses on challenges experienced by learners from the informal settlements of Nairobi.

2.1 Specific Objectives of the Study

(i) To examine the challenges experienced by children in virtual learning in the informal settlements of Nairobi from the parents perspective.

(ii) To examine/identify strategies to enhance participation in online learning.

2.2 Justification of the Study

The right to education is documented and guaranteed by a series of human rights treaties and protocols. Governments are introducing several measures to maintain the spread of the disease by introducing lockdowns, curfews, school closures, but the short term impact of this is affecting children differently especially those in marginalised regions. Since Dakar 2000, there has been tremendous progress in both quantitative and qualitative growth in education across much of the developing countries. Notably, many of these developing countries in Sub-Saharan Africa have implemented FPE programmes. Kenya has taken several steps towards the development of education development. Some of the major milestones are documented in several documents namely: Sessional Paper Number 1 of 2005; Sessional Paper Number 14 of 2012; The Constitution of Kenya (2010) and the Kenya Vision 2030 (Ndung'u, Thugge & Otieno, 2011). Even though the national policies document the importance of education in national development, communities in Northern Kenya still have low levels of education access, retention and completion. Several reasons for low education participation have been cited; economic, cultural, social, geographical, environmental, and political (Gichuhi, 2021; Chitescu & Lixandru, 2016). This calls for innovative strategies to address issues affecting education demand and supply. Parents, during the covid-19 pandemic, have been considered as the front–line responders and who may be combining multiple roles to respond to the household needs as well as struggling to balance remote work and online learning, or to equip their children with everything they need to learn in a virtual setting.

3.0 Related Literature Review

The literature on challenges of Covid-19 on learning is scanty given the newness and abrupt scenarios being experienced in the world. The literature search is done through the web engines for published studies, blogs and policy beliefs. With this sudden and unprepared shift away from the classroom in many parts of the globe, schools, universities and colleges were caught unprepared especially on alternatives off face to face spaces especially in developing countries (World Bank, 2020). Fifty-three per cent of children in low- and -middle-income countries were unable to read and understand a simple text by age 10 (World Bank, 2019). The COVID-19 pandemic is amplifying the global learning crisis and has disrupted learning for more than a billion students globally. It's estimated the extended periods of school closures could increase the learning poverty rate to 63 per cent, leading to significant negative effects on learning and human capital development.

A survey conducted by UNESCO, UNICEF and World Bank found that online and TV were the most used modalities, being offered in 90% and 87% of countries respectively, followed by paper-based take-

home materials (85%) and radio-based remote learning (61%). Despite the high uptake of the various online modalities, stark differences across income groups reflect great inequality in access to the technologies required for remote learning (UNESCO, UNICEF and World Bank, 2020). Comparatively, Eastern and South African regions had the highest minimum share of students who could not be reached (49%). Learners in rural areas consistently represent the vast majority of those who could not be reached, irrespective of the country's level of economic development. Overall, three out of four students who could not be reached live in rural areas, but in low-income countries, the percentage is even higher (UNICEF, 2020). The use of diverse media is critical; as online tools will reach only a small share of students (approximately 50% of students in middle-income countries and 10% in low-income countries have access to the internet and a device). Hence, other platforms are needed to reach poorer students with some content. Without explicit policies to reach more vulnerable households, only rich and educated families will be able to cope with the shock (World Bank, 2020). Uwezo (2020) study on access to digital learning among developing countries, found on average, 22 out of 100 learners were accessing digital learning during the period of school closures. In addition, children in higher grades; classes 7 and 8 and those in secondary schools were preferred and had a higher probability of accessing digital learning in the households. Most of the parents whose children were in private schools were able to create several alternatives for continued learning and were twice as likely to access digital learning compared to their counterparts in public schools (Uwezo, 2020).

The World Bank places a lot of importance on what it dabs as the Coping Phase of the pandemic. More than 140 countries implemented some type of remote learning where about 120 countries implemented multiplatform strategies: combining online tools, with SMS, radio, TV, and distribution of printed material (World Bank, 2020). Intergenerational benefits of education can only be realised if the governments minimise the magnitude of the out of school children and youth. The commitment of Sustainable Development Goal No.4 that emphasises the provision of quality and inclusive education for all in access, retention, completion and transition to being achieved by 2030, is a clarion call for reimagining and redesigning new ways especially given the covid19 disruptions (World Bank, 2020). UNESCO, (2020) has already raised a red flag on the global benchmark of access; only 88% of children complete primary school, 72% of adolescents completes lower secondary school and 53% of youth complete upper secondary school.

4.0 Methodology

A mixed-method design that involved a combination of both quantitative and qualitative approaches was adopted. For quantitative data, the study used an online tool, a questionnaire, which was transmitted through a Google form and telephone interview/conversations for qualitative data. These methods were chosen because of the sensitivity of the covid-19 period and in observance to the Ministry of Health protocols to keep social distance and to avoid paperwork. In addition, the use of the online tool has the advantages of access to individuals in distant locations, the ability to reach difficult to contact participants in difficult contexts, and the convenience of having automated data collection, which reduces researcher time and effort. This method has been used by diverse people

for diverse activities and contexts. Virtual communities have flourished online, and hundreds of thousands of people regularly participate in discussions about almost every conceivable issue and interest (Horrigan, 2001; Wellman, 1997).

Face-to-face interview or in-person interviews enables the researcher to capture verbal and non-verbal questions, and can also help the researcher to know whether to stop the interview, when to stop and if the interviewee is enthusiastic for more probing or not. However, online interviews have their disadvantages. Online survey research and virtual telephone interviews have the limitations of uncertainty over the validity of the data and sampling issues, and lack of face-to-face interactions can enhance falsification that may lead to ineffective data. Interviews may choose just to responding with what they think is the right answer or what the interviewer wants to hear. To ensure validity and reliability and to avoid some of the pitfalls of online surveys, the tool was pretested with a total of 12 randomly picked households, 3 from each region. After the pretesting, the questions were ordered logically and the questions were made short and precise. Moreover, the purpose of the survey was also explained in detail before the interview and within the questionnaire. To get the representative unit of analysis, households, the snowball method was used. This method was considered for the fact that many families were locked down in the households and potential participants were, therefore, difficult to find.

4.1 Research Design

This study is based on a descriptive research design to understand the challenges of online learning during covid-19 school closure. This design helps the researcher to identify characteristics, frequencies trends and categories. The design also allows the researcher to use both qualitative and quantitative methods to draw conclusions that can be used in policy frameworks and implementation.

4.3 Sampling Frame and Sample Size

The sample frame is drawn from a population of households that resides in informal settlements of Nairobi. To get a representative sample of the households, the informal settlements were homogenously grouped as one zone from 4 purposely chosen areas, Kahawa West, Soweto, Githurai 44, Baba Ndogo, and Githogoro. These areas were targeted because many times when informal settlements are defined, mainly they target Kibra, Mathare among others and ignore challenges hidden under "other vulnerable areas" of Nairobi. Twenty households were picked using a snowball method from each of the 4 areas to give a sample of eighty households. All the 80 household heads were contacted through telephone calls to check readiness, consent and to check if they consent, whether they could access a Smartphone for the survey. About 30 households declined to cite lack of time (33%), not wanting to give information that they are not sure of the agenda (50%), and some just ignored the call continuously and therefore declined the survey (17%). Among the 50 that remained, only 40 (80%) had access to a Smartphone. The rest, 10 (20%) agreed to a telephone interview. Selected households had the option of identifying the respondents. In most cases (70%) mothers opted for both the survey and interview. Respondents were informed about their rights and requirements as respondents, as well as the objectives of the study. Before any survey or interview, consent was sought and obtained. Ethical consideration was taken very seriously. In

the absence of any formal documentation from the relevant offices due to lockdown and MoH protocols, and it is only those households who consented through a telephone call were considered for the survey.

5.0 Findings and Discussions

In this paper, we argue that despite any disaster, leaving children off the school system for a longer period can create inequity and a host of generational gaps that might be difficult to deal with in the long term. Education investment can fundamentally raise people's aspirations, set values and enrich lives (Psacharopoulos and Woodhall, 1985). To realise greater equity and inclusion in education, there is a need to increase efforts to collect and analyse data on the most marginalised segments of the population (UNESCO, 2014). Intergenerational benefits of education can only be realised if all the stakeholders in education realise the benefits of education and can do what is within their means to have eligible children in school (MoE, 2019).

To try and answer the research questions, as well as gain a better understanding of the realities of distance learning, the responses were analysed using descriptive statistics as well in thematic forms.

Describe how Remote Learning can be Described in your Household

A majority (97 %) of the parents mentioned some form of reading at home, any school material available at home was useful regardless of age or curriculum content that they would have covered if the schools were open. Old textbooks, storybooks, revision papers were generally the most popular (88%) forms of materials used during the school closure. A small minority (14 %) were able to use Smartphone's to download some online materials for revision only. Parents with children at home, 3 in 4 (75%) said at least one child was engaging in some form of distance learning. Of those, one in three (33%) used a school-issued device to learn from home while another 1/3 (33%) of respondents said their child was relying on a personal laptop. This spelt out the differences in what parents' perceived remote learning.

Compared to last year, do you think your children are feeling more optimistic or pessimistic about learning virtually?

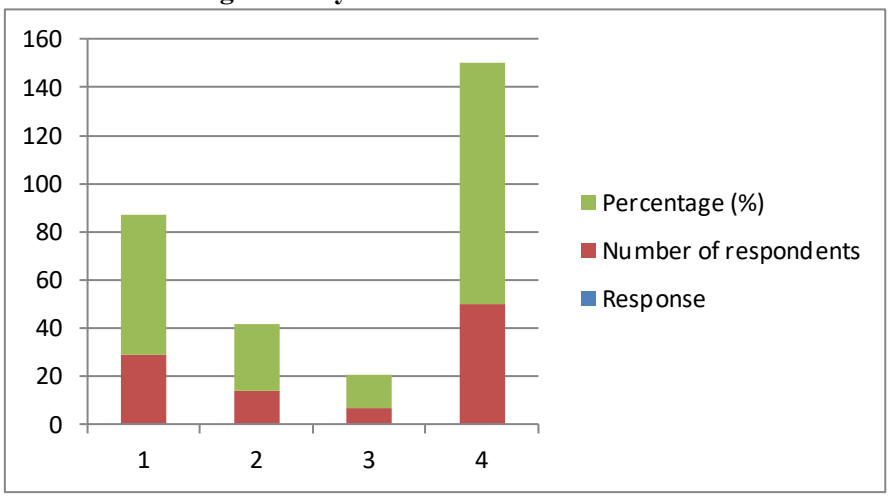

Figure 1: Children's optimism or pessimism about virtual learning

COVID-19 brings with it feelings like anxiety, stress and uncertainty and they are felt especially strongly by children of all ages (UNICEF, 2020). Though difficult to describe optimism for someone, parents were able to describe the situation their children were in from the small discussions and some actions at home. About 58% reported their children had a positive attitude towards the COVID-19 situation, and they were looking forward to opening school and continue with learning. Parents (74%) reported that many children were taking the school closure as a long holiday they never had and were optimistic to get the best results from the situation even it meant sleeping for several hours. Only 14% reported that their children were feeling hopeless and were pessimistic about their performance when school reopened. This was a mixture of examination class students; class 8 and form 4 and other assorted classes. Hence, it was difficult to contribute it to examination anxieties.

The 3 biggest challenges children are currently facing while learning from home

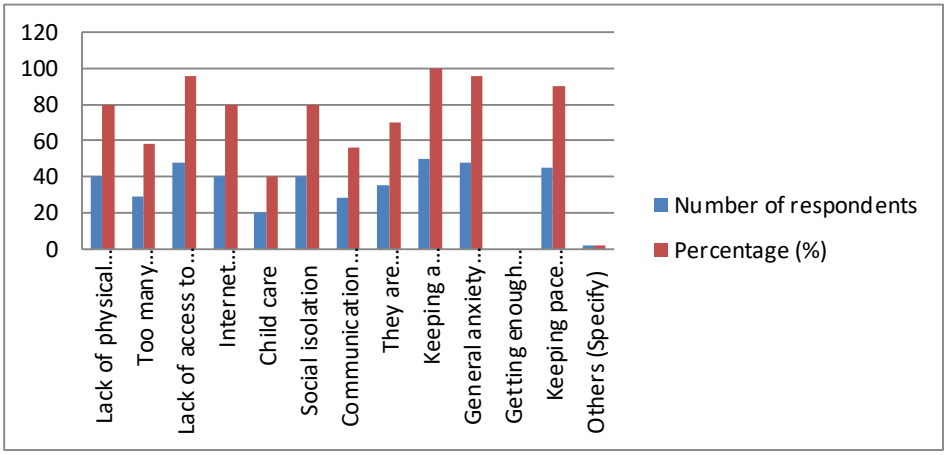

Figure 2: Challenges children are experiencing by learning at home

From Figure 2, the majority of the parents reported a lack of reading space (80%), lack of the tools needed to learn (96%), lack of internet connectivity (80%) and feeling of social isolation from friends (80%). These challenges are genuine. Access to a computer or internet connection is generally low even in urban centres household (Gichuhi et.al., 2020) which in times of a pandemic it limits any online teaching and learning.

Children have all the types of equipment needed to do learning at home

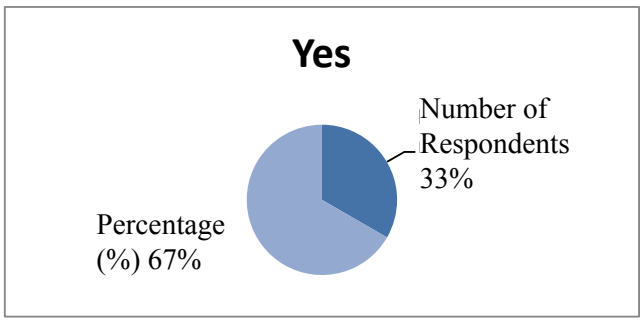

Figure 3: Types of equipment for learning availability

If no, why and what do you do to facilitate their running?

The majority (90%) of parents cited TVs and radios. Just a minority (15%) of the households were using smartphones from their parents. This however was conflicting with the parent's schedules as the majority of times the parents were using them. About 10% of the parents reported having their children visit the neighbours' houses to access the TVs or radios to the problem of electricity. Uses of smartphones were not very common given that even the schools don't allow them. No household mentions laptops or tablets. Before COVID-19, many households and schools were not allowing their children and students to handle a phone either at home or in school. Schools had even developed prohibitive rules against the use or carrying of phones to school as also reported in other geographical regions outside Kenya (Odhiambo, 2016; Muls et.al., 2020). In today's distance learning environment, every child or class requires a laptop, a Smartphone or a tablet. Making smartphones easily accessible to learners guarantees them an equal chance of accessing education through modern technology.

If no, why and what do you do to facilitate their running?

The majority (67%) of those who didn't bother to facilitate their children with learning gadgets cited a lack of confidence in the use of technology. This was backed by their unavailability at home to monitor and sometimes lack of knowledge to know how to control their children accessing unwanted information from the internet. Only 10 % of parents reported feeling confident that their children can safely use the gadgets securely without monitoring. According to Baltacı (2019), those, particularly of younger age, spend most of their time on social media, updating their contacts and status. Cao et al., (2020) indicated that social media users spend many hours communicating with an acquaintance and reading new posts while ignoring the negative consequences of problematic usage in particular with family and friends.

Many parents (48%) especially those with mature children in class 7, 8 and at the secondary level were feeling frustrated that they were being forced to equip their children with technology gadgets and they are not mature enough to control themselves from unwarranted sites. Common and intensive use of social media especially by adolescents and university students may bring adversities such as problematic social media usage, social media addiction, and fear of missing out (FOMA) (Hamutoglu, Topal, & Gezgin, 2020). Under normal circumstances, 50% of the parents buy phones and other gadgets for their children after finishing the secondary cycle.

About 30% of the parents cited lack of finance to buy "such things", "we are under lockdown, and basic things are primary".

Do your children have a dedicated space where they can attend online classes from home?

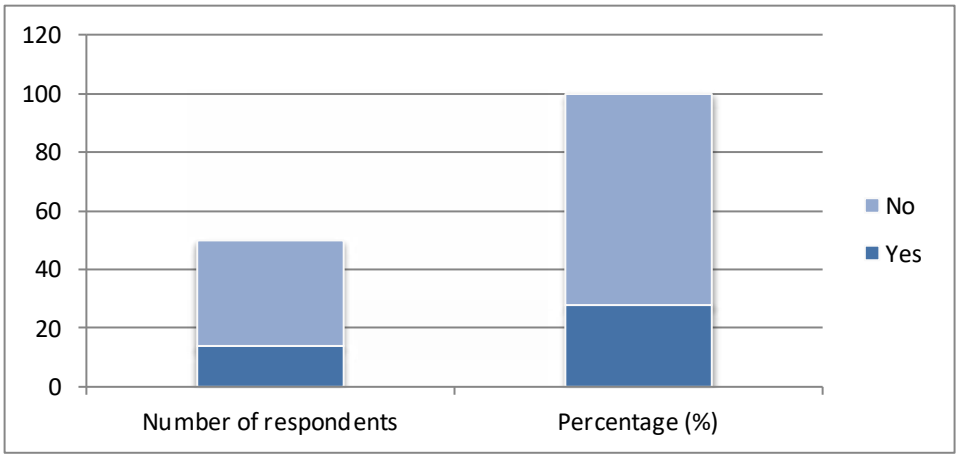

Figure 4: Learning space at home

From the table 36 (72 %) mentioned no space. Given the size of the houses in the informal settlements, this finding was expected. The majority (80%) of the households live either in a one-roomed house or in one bed roomed house with a 1 bedroom, kitchen and a sitting room.

"Learning is always disrupted given the environment and depending with the size of the household", a parent's explanation.

If you are employed, or you are self-employed, how many days do you work in a week?

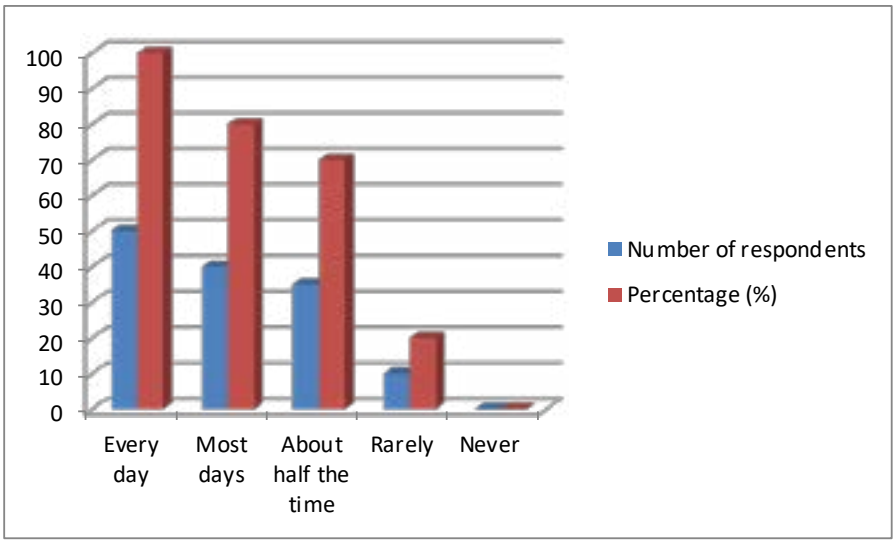

Figure 5: Employment and the number of days worked

This question captured the time parents were at home with their children. Given that the majority (99%) of the household is self-employed: many own retail shops, small vegetable vendors, Boda boda operators, it meant that they were still busy despite the lockdown within the local region. Most of the time, children were left on their own or under the care of the older siblings especially for the parents who are engaged every day. This diminished the parents monitoring of the children and also the time the older sibling would be concentrating on studies.

How satisfied are you with the current learning from home/virtual arrangement?

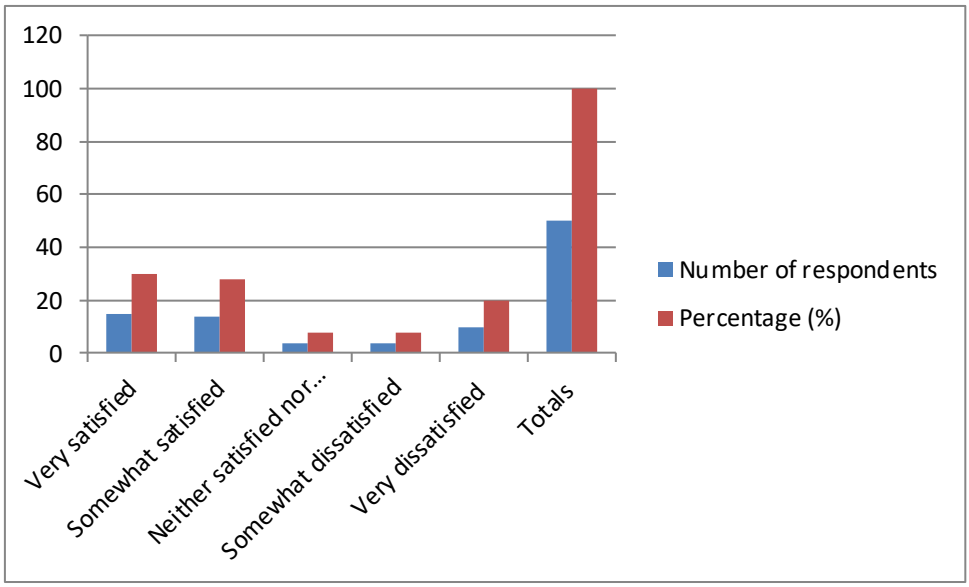

Figure 6: Level of satisfaction with the current virtual learning

From figure 6, many parents reported no satisfaction in virtual learning. This is mainly due to lack of the needed tools, lack of space, lack of electricity among other factors that have been discussed in the foregoing sections.

Strategies to improve remote learning

In your opinion, what would you need to be improved for children to learn remotely?

The 2020 covid-19 crisis presented an opportunity for refocusing and rethinking the use of technology for learning in many households. People started rethinking differently on the role of social media utilization in content delivery, but Internet connectivity may be a barrier to many households. Despite, the government creating learning alternative interventions, the majority (80%) of parents interviewed, expressed pessimism in the household expenditure in buying data bundles for learning and to respond to the Kenya Institute of Curriculum Development (KICD) timetables for 7 days a week. The cost according to them is unaffordable within the prevailing economic circumstances and with uncertainties of economic lockdowns due to covid-19 in the low-income households. Ninety per cent (90%) of the households cannot afford continuous use of the internet for all children. The success of virtual

learning depends on reliable and high-speed broadband infrastructure that is cost-effective and affordable to many (Gichuhi et.al., 2020). Since internet infrastructure in most African countries is in private hands, internet connectivity is unattainable at the speed and quantity required if children must use it. Cleary et al. (2006) argued that internet connectivity programmes should connect students and teachers from all geographical divides. In Kenya, however, internet access across rural areas is expanding because of infrastructure improvements and the availability of inexpensive smartphones (Gichuhi et al., 2020). Many participants (90%) hopefully felt this should be also extended in the informal settlements.

"With devolution, we are likely to have internet in our neighborhoods in the near future if an the County Government prioritizes it"
A parent with a child in class 7

It was noted that many parents (42%), regretted that the government project of one tablet per child failed and that would have been a major solution. They wished the government can rethink the project and implement it especially because of the uncertainties presented by covid-19.

Many parents (75%) believed that children should either remain at home without the presence of any learning going on or parents can assume they are on a long prolonged holiday.

"Otherwise, little learning goes on without the presence of a teacher to clarify difficult terms or mark for the children to know when they are right or long"
A parent who is a boda boda rider.

A minority of parents (25%) expressed the need for teachers to be allowed to make paperwork assignments that can be monitored now and then for feedback. Parents should have been empowered to engage and participate in the education of their children in a more organised way. This confirmed the findings of Kathula (2020), that the household demands and livelihoods interfered with the children's private studying which compounded the loss of learning time due to school closure.

Many parents (68%), thought that the government needed to cushion the families through cash transfers for necessities. If this is done, parents will have at least some money for food and buying bundles for their children. From the past pandemics' experiences and the impact of economic crises, cash transfers are effective in shielding vulnerable households, including those in the informal sector, from its adverse effects (FDS, 2020). Covid-19 was an awakening call to any parent in the informal settlements; the majority (70%) mentioned the need to have reading materials at home as they would have complemented the reading and learning continuity. This was mainly in the households (65%) without television sets.

Conclusion

This study shows the challenges that are experienced by children in the informal settlements of Nairobi. No doubt the challenges are dire and they affect the families and as much as the children. The challenges stem from lack of virtual learning tools, lack of internet, lack of reading space to lack of guidance by the parents due to the nature of their livelihoods.

Recommendations

Covid-19 has prompted the thinking and has redefined the technology space for households and learners. To create an inequitable and inclusive education, education stakeholders should facilitate affordable internet connectivity for all students and especially for students in informal settlements to enable them to access learning and access more resources. This can be done by supplying online bundles periodically. The online bundles would ensure that every student has access to educational resources regardless of their location. The total ownership costs, capital and operational, can be factored into institutions' budgets to enable stakeholders to plan.

There is a need to collaboratively build parents' capacity on how they can gainfully be engaged with their children's education especially with the new Competency Based Curriculum (CBC) implementation. There is a need to have a proactive framework on the preparedness and sensation process for parents and especially to understand their role in enhancing learning even at home. Adapting virtual learning for all may need internet connectivity and cost-effective and affordable bundles. As the unprecedented covid-19 continue to create ad-hoc school closures and affecting teaching and learning, there is a need to design working strategies to mitigate the negative impact. With children at home in a prolonged period, parents have realised their unprecedented unpreparedness to handle their children's learning in the absence of school and the teacher.

Recommendations for Further Studies

While the work to transition face-to-face instruction to online environments would mean a lot of technological preparedness, financial obligations and good planning, it is worth it because preparing for disasters is more cost-effective than responding to a crisis. For online learning to be effective, cost-effective and efficient, there should be multi-sectoral and multi-stakeholders preparedness. This must be done prior, during and after a crisis. Covid-19 gives a government, parents and other education stakeholders, a window of opportunity, "to build back better" or to borrow good lessons to "build forward better". A large scale study is important to find out the level of preparedness among education and other sectoral departments of governments in the management of education crisis in future.

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Remembering the Phelp–Stokes Commission Report in Kenya: Historic Recurrence and Lessons From the Past

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Abstract

This paper uses the concept of historic recurrence to argue that the Phelps–Stokes Commission Report of 1924 provides useful lessons for policymakers in the education sector in Kenya. Using a critical review of relevant secondary and primary written materials, this article shows that reflection on past trends in any given field has the potential to provide useful lessons for effective policy formulation. Based on the analysis of reviewed literature, there is overwhelming evidence that the potential of the study of history has in most cases been neglected by policymakers in Kenya. This may be due to a lack of appreciation of history and/or the reluctance of policymakers to involve historians in policy formulation and implementation. The analysis of the Phelps-Stokes Commission Report thus sheds light on the recurrence of historic events and lessons offered by the study of the past. Revisiting the recommendations of the Phelps-Stokes Commission thus provides a case for reflecting on the usefulness of past trends in the formulation and implementation of present and future reforms in the education sector in Kenya.

Summary: This paper examines the Phelps–Stokes Commission Report and the lessons it offers to policymakers in the education sector in Kenya.

Keywords: **Historic recurrence; Convergence and divergence; Phelps-Stokes Commission; Education Sector Reforms; Competency Based Curriculum.**

Introduction

The introduction of the western and modern system of education in Kenya is credited to the Christian missionary activities of the 19th and 20th centuries. Pioneer missionary societies in Africa in general and East African in particular, advocated for a mission that combined the objective of converting Africans to Christianity with the secular goal of raising their "material standards of living" (Hotchkiss, 1937). The thinking behind this view assumed that Africans could only be enticed to convert to Christianity if they were exposed to western education and trained in new methods of trade and agriculture (Hotchkiss, 1937).

Evangelism thus represented the fundamental method that the pioneer mission societies used in their endevour to change African culture. Christianity was to provide the moral and cultural bases for this ideal; and western education and vocational training skills were to be imparted to Africans, to make them "master- builders of their new world and civilization" (Sifuna, 1975). The provision of western education and other services were thus simply complementary approaches used to entice Africans to convert to Christianity (Mugambi, 1977).

It can thus be argued that the missionary societies introduced and monopolised the provision of western education in Kenya up to 1911. But, due to the challenges associated with missionary education; the colonial government was forced to intervene and streamline the sector after 1911. This intervention resulted in the Phelps–Stokes Commission's visit to the country in 1924. The visit and the subsequent report by the Commission marked a pedagogical shift in African education and training.

Using the concept of historic recurrence (Trompf, 1979), this paper uses extrapolation to draw parallels from the Phelps–Stokes Commission Report and the CBC education system. The article thus examines the significance of remembering past trends to inform the present and the future. To contribute to the emerging field of historic recurrence, this paper aims to answer the following related questions; what have been the recurring trends in curriculum reforms in Kenya? What are the areas of convergence and divergence in the Phelps-Stokes Commission Report, the 8-4-4 system, and the CBC? What lessons does the Phelps-Stokes Commission Report offer to the policymakers in Kenya? These and other related questions thus form the research problem of this paper.

Early Missionary Education in Kenya

In their pursuit to convert Africans to Christianity, pioneer Christian missionaries were faced with several challenges. Chief among them was the challenge of convincing Africans to convert to the new religion. Missionaries quickly learned that the conversion of Africans to Christianity was an exasperating activity. This was because Africans lived in a close-knit society and any sign of rebellion was met by ex-communication from the group. Consequently, to take up Christianity and give up society's ways of living was asking for trouble. With this realisation, Christian mission societies devised the idea of an industrial mission. An industrial mission entailed a combination of Christian teaching, a deliberate effort to uproot Africans from his or her culture, and the provision of

western education. The establishment of schools and provision of basic western education in Kenya was thus a systematic and deliberate strategy by the missionary societies aimed at transforming Africans into Christians (Hotchkiss, 1937).

In the formative years of the introduction of western education, most Africans resisted the temptation to join the pioneer missions' schools. Consequently, the initial growth of the pioneer missions' schools was slow and time-consuming. The situation, however, slowly improved so that by 1910, many missions' schools had more pupils than they could effectively handle. Consequently, these schools were of low quality since they were staffed with teachers who had low training and experience (Kay, 1973).

These weaknesses and the meagerness of mission education combined with African opposition against the relevance of missionary education acted as a spur for the intervention of the colonial government in the provision of African education. It should be noted that, although the missionary education was in most cases inadequate in content and delivery, it had raised the African appetite for a more secular, formal, and appropriate form of learning. Africans began to demand an education that would make them fit in the emerging capitalist colonial system (Fearn, 1961).

Subsequently, the colonial government established the East African Education Commission in 1911. Professor J. Nelson Frazer was appointed the chairman of the Commission (Bogonko, 1992). The Commissioners were tasked with making recommendations for a workable structure of education for the colony. Interestingly, the Commission was directed against proposing any plans for formal and literary education of Africans in the colony. The colonial government expected the Commission to come up with a plan for the development of industrial education for Africans (Sifuna and Otiende, 2006).

Frazer Commission toured the country, collected views from various stakeholders, wrote and presented a report to the Education Board. The highlights of the report included: establishment of an industrial apprenticeship scheme for Africans. This scheme was to train Africans to become masons, carpenters, and recorders. The Commission argued that both the settlers and the government needed this form of trained labourers; limit African access to literary education. The Commission blamed African agitation for a functional and formal form of education on the exposure to literary learning; African education was to be managed by missionary societies. The Commission argued that African education was to be accompanied by Christian learning and that any kind of education whether industrial or technical was mischievous if imparted without Christian morality; the establishment of a Department of Education. According to the Commission, education in Kenya was to be offered along racial lines; namely European, Asian, and African. Europeans were to be given an academic type of education; Asian were to be given a mixture of academic and industrial training; while Africans were to be taught purely industrial education; and the appointment of a Director of Education to implement the above recommendations (Sifuna and Otiende, 2006).

The colonial Education Board approved the Commission's proposals and James R. Orr was appointed the first Director of Education in 1912. The Education Board also approved grants-in-aid support to

eight church societies to enable them to provide trade training (KNAMSS/54/63) [1]. However, the introduction of trade training did not diminish the importance attached to religious education by missionary societies.

The insistence on religious education made many parents and pupils disillusioned with missionary education. Africans wanted a functional and formal education system that would enable them to fit and benefit from the emerging capitalist system in colonial Kenya (KNA, NZA/12/13: 1928). Subsequently, pupils in mission schools began to demand for a functional and secular education system, and the teaching of English. African demands meant that the Frazer Commission had failed to adequately address the challenges that faced African education.

With these shortcomings, the colonial government was once again forced to intervene and solve the challenges faced by African education. These challenges included: Africans' agitation for formal, relevant, and functional education; the colonial government's conviction that mission schools had become centres of rebellion against the government; and missions' inability to adhere to the education standards and training set by the colonial government in 1911, (Kenya Colony and Protectorate, 1919).

The outbreak of the First World War in 1914, forced the colonial government to shelve its planned intervention in African education. The war absorbed most of the territory's energy and resources. Consequently, it was not until 1919 that African education received the government's attention on the advice of Mr. J Orr, the governor appointed the East African Protectorate Education Commission, to examine the state of education of all the races in the protectorate (Kenya Colony and Protectorate, 1919).

In its report, the Commission recommended that the government should not only be more involved in the provision of African education but also allow the missions to continue running most schools. To the Commissioners, the continued dominance of the missions had to be allowed based on the importance of character-building through religious education. Consequently, the Commission advocated for more enhanced cooperation between mission societies and the government (KNA, NZA/12/13: 1928).

The Commission also recommended reforms in African education. Subsequently, the British government appointed an Advisory Committee on Native Education in British Tropical Africa in 1923. The Committee was mandated to investigate and make recommendations on the development of education in British colonies in Africa. The Advisory Committee, popularly known as the Phelps-Stokes Commission, toured East Africa in 1924, (Jones, 1929).

Review of the Phelps-Stokes Commission

The genesis of Phelps-Stokes can be traced to a fund donated by Ms. Caroline Phelps-Stokes a New York philanthropist in 1909, hence the Phelps-Stokes Fund. The fund was set up principally for education and the welfare of black communities in the United States of America (USA). Dr. Thomas Jesse Jones served as the fund's Director of Education.

In 1912, the Phelps-Stokes Fund Trustees, requested Dr. Thomas Jesse Jones, to undertake an extensive study of educational facilities for blacks in the United States. The 1917 Negro Education Survey Report enhanced Jones's reputation as an authority on the education of African Americans. Subsequently, various American Mission

1 Kenya National Archives Records

Boards turned to him for assistance in studying the problems of colonial and mission schools in West, East, and Southern Africa. Following this request, Jones travelled to Europe to gain the cooperation of colonial offices and Foreign Mission Boards for a study that would resemble his previous work in the USA (King, 1971).

Funded by the Phelps - Stokes Fund and American Denominational Mission Boards, a six-person Commission, headed by Dr. Jones and including a black African educator James E. K. Aggrey, travelled throughout West and Southern Africa from September 1920 to July 1921 and compiled a report. The report, Education in Africa: A Study of West, South, and Equatorial Africa by the African Education Commission, was published in November 1922. Like in the case of Negro Education in the USA, the report emphasized the importance of agricultural and industrial training, community needs, and differentiation between education for future leaders and the majority of the population. The report, further, called for the creation of advisory boards of education to coordinate the activities of missions and colonial governments as well as the introduction of the Jeanes Fund system of supervisory teachers for rural schools (King, 1971).

In considering Jones's recommendations, the British government established an Advisory Education Commission and in 1923 requested the Phelps–Stokes Fund to undertake a similar survey of East Africa. Funded by Phelps-Stokes, the mission societies, and the British government, the second Commission, including Jones, Aggrey, and South African educator Charles T. Loram, travelled to Ethiopia, Kenya, Uganda, Tanganyika, Rhodesia, and South Africa, from January to July 1924 (King, 1971).

The Terms of Reference of the Commission included: to examine the provision of education in the areas to be studied; to investigate the educational needs of the people in the light of the religious, social, hygiene, and economic condition; to ascertain to what extent these needs have been met; to assist in the formulation of plans designed to meet the educational needs of the natives; and to make available the full result of the study (King, 1971).

Following the Terms of Reference, the Phelps-Stokes Commission undertook the survey and wrote a detailed report. The report findings can be summarised under four main headings, which the chairman Jones called "the Four Essentials of Education for Blacks in Africa" (King, 1971). These four essentials embraced health, home life training, industry (including agriculture), and recreation.

Taking cognisance of the findings, the Commission recommended the following: enhanced cooperation between the government and missions in African education. The Report recommended that the government was to provide adequate teacher-training centres and shoulder more responsibility in this area; African education to focus more on training in agriculture, industry, and the adaptation of education to the local needs. To implement this recommendation, the Commission proposed the establishment of Jeanes school and the Native Industrial Training Depot (NITD); missionary societies and the government to provide access to higher education for Africans. Consequently, the Commission urged the colonial government to establish a teachers' college at Kikuyu; English to be used as a medium of instruction in the upper African classes; and expansion of African girls' education.

The Jeanes School and the Native Industrial Training Depot

To implement the above recommendations, the Commission called for a drastic departure from the few years of literacy and vocational training that were then prevalent in most mission schools. Further, the Commission implored colonial education officials to make schools more adaptable to serve the welfare of African communities in rural areas. By adaptation, the Commission meant using schools as instruments for directing rural social change.

By drumming support for the adaption method of learning, the Commission argued that "Africans were virtually destined to live in rural areas and, therefore, ought to be educated in and for such a life" (Lewis, 1954). Given this understanding, the Commission urged that the primary objective of education be based on five pillars. These pillars were, "character development, improvement of health, imparting agricultural and handicraft skills, bettering family life and providing sound and healthful recreation" (Lewis, 1954).

The Commission, further, advocated for a pedagogical shift in African education. To this end, the Commission urged the Education Board to emphasise practical subjects rather than literacy education. To the Commission, education was to "expressly serve utilitarian purposes of the society" (Painter, 1966). It was this utilitarian benefit of education that led the Commission, to propose the establishment of the Jeanes Schools and the Native Industrial Training Depot. The proposal to establish the Jeanes school was also informed by the realisation that,

formal education could only reach a small segment of African society and that grassroots efforts at the village level, were required to reach the mass of the population. With two years of practical training, the Jeanes teachers were therefore expected to instruct rural Africans in health and sanitation, childcare, general home economics, and agricultural development (PC/NZA/3/10/114: 1929-1930).

With the adoption of the above recommendation coupled with financial assistance from the Carnegie Co-operation of New York, the first Jeanes School in Kenya was established at Kabete, 1925. Further, NITD, a trade training institution was also established. NITD was to provide fourth and fifth-year mission apprentices with necessary occupational skills. Such skills were needed by the Public Works Department of the government and by the European settlers. Indeed, pressure from settlers meant that NITDs received more funds from the government than the Jeanes School. Both education systems, however, represented a deliberate attempt to steer African education along narrowly utilitarian lines, to ensure the development of a peaceful, Christian, and non-political rural peasantry (Sifuna and Otiende, 2006).

Implementation of the Phelps–Stokes Commission Report and African Response

In the immediate months after the release of the Commission's report, the colonial government put in place measures to implement it. First, the government enacted the colony's first Education Ordinance in 1924. Under the Ordinance, all schools and teachers were to be registered and the Director of Education was empowered to inspect all schools. Indeed, the Education Ordinance provided a system of tripartite reciprocal arrangements in financing African education. This tripartite arrangement involved the missionary societies, the

colonial government, and the Local Native Councils (LNCs). The LNCs had been granted powers to vote levies and to set up new schools (Sifuna and Otiende, 2006).

Secondly, the colonial government and the missionary societies increasingly turned to the adaptation's method of education, which was to prepare the youth for Christian living in the rural areas. To achieve this adaptation objective, mission-trained teachers and their wives were sent to the Jeanes School at Kabete for further training. The pioneer Jeanes school couples were essentially trained as community development agents with knowledge of health, agriculture, and village industries. The trained couples were expected to work partly through the school, but not to become school oriented.

On their return to the villages, the trained couples were credited as the "bearers of light to the villages". They taught the rural people new hygiene methods, skills for building modern and improved houses, improved planting and spacing of maize, as well as giving encouragement in planting groundnuts and vegetables (Sifuna and Otiende, 2006). To a large extent, therefore, Phelps–Stokes Commission Report was successfully implemented in Kenya.

Ironically, while the first Jeanes couples supported and even reinforced the community spirit, they would later form the cadre of the first educated elite, who were to become vocal in questioning the usefulness of community-centred training. They subsequently opposed any attempt to inject greater rural bias into the school curriculum. A shift was occurring in what the Jeanes-educated members demanded of the colonial education. An earlier generation had generally accepted the adaptation trade training and apprenticeships because they had seemed to offer Africans in the rural areas the opportunity to master European technical expertise.

Skilled labourers had also enjoyed economic benefits from missionary societies' training in the early years of missionary education. However, with the reorganisation of labour systems after the First World War, trained African teachers gradually began to perceive that manual training and agricultural education could only lead to manual employment. Most Africans perceived manual employment as subordinate and low-paying positions in the emerging colonial order. Indeed, the worldwide depression of the late 1920s and resultant colonial policies that discriminated against African participation in commerce drastically reduced available trade positions. Subsequently, Africans accelerated their demand for an academic type of education, which would lead to higher-paying white-collar jobs. The adaptation schooling ran counter to such demands.

Curriculum Reforms in Kenya

Since independence, in 1963, Kenya has sought to rectify the anomalies created by the colonial education structure. The belief that education holds the key to promoting social and economic progress has played an important role in the growth and spread of education in Kenya. Consequently, reforms in the education sector have been geared towards the provision of appropriate skills and knowledge that can be used to contribute to a productive society.

Several Commissions have, therefore, been formed to address challenges facing the education sector and craft a more responsive educational system. These Commissions include; the Kenya Education Commission (Ominde Commission) of 1964 (Republic of Kenya, 1964); the National Committee on

Educational Objectives and Policy (Gacathi Commission) of 1976, (Republic of Kenya, 1978); the Presidential Working Party on the Second University (Mackay Commission) of 1981 (Republic of Kenya, 1981); the Presidential Working Party on Education and Manpower (Kamunge Commission) of 1988 (Republic of Kenya, 1988); Commission of Inquiry into the Education system of Kenya (Koech Commission) of 2000, (Republic of Kenya, 2000); and the Task Force on the Re-alignment of the Education Sector to the Kenya Vision 2030 and Constitution of Kenya 2010 (Odhiambo Commission) of 2012 (Republic of Kenya, 2012). Two of these Commissions, the Presidential Working Party on the Second University and the 2012 Task Force on the Re-alignment of the Education Sector to the Kenya Vision 2030 and Constitution of Kenya, are of interest to this paper.

The Presidential Working Party on the Second University in Kenya was mandated to; investigate ways in which education could make school leavers from primary and secondary levels self-sufficient, productive in agriculture, industries, and commerce; devise an education system that could ensure that students acquired technical, scientific, and practical knowledge vital for self and salaried employment, lifelong skills, and nation-building; and to investigate the feasibility of establishing a second university in Kenya.

The first two of the above recommendations, closely mirror the Phelps–Stokes Report on the emphasis on making schools more adaptable to serve the rural areas and self–sufficiency of the learner. Indeed, both the Phelps–Stokes Commission Report and the Mackay Commission Report, emphasised the need to invest more in agricultural, trade, and technological courses rather than literacy education that was geared towards white collar employment. The recommendation of the Presidential Working Party led to the introduction of the 8-4-4 system of education in 1985 in Kenya (Republic of Kenya, 1981).

Since its inception, however, the 8.4.4 system of education has been faced numerous challenges. These challenges included the jumbled implementation of the system. To many observers, the new education system was rather hurriedly implemented without proper planning and due process. Little or no effort was spared to assess the universal access to quality technical teachers, textbooks, workshops, and equipped science laboratories both at primary and secondary levels; lack of transition clauses and time frames from the previous system. The task force that crafted the recommendation to this system of education did not provide transition clauses and time frames from 7-4-2-3 system to 8-4-4; bulky textbooks and a heavy workload for pupils. With the coming of the 8-4-4 system, textbooks got merged and thus became bigger and the workload for students became heavier; and sycophancy and political chest-thumping. The rolling out process of 8-4-4 was accompanied by myriad episodes of sycophancy by politicians resulting in the ostracism of those that dared question the speedy implementation of the education system (Amutabi, 2003).

With the above challenges, the 8.4.4 system failed to tackle the challenges that it was meant to solve. Consequently, there was the establishment of the Task Force on the Re-alignment of the Education Sector to the Kenya Vision 2030 and Constitution of Kenya 2010. The Task Force developed

Sessional Paper No. 2 of 2015 on, Reforming Education and Training in Kenya. The Sessional Paper urged that the education sector be guided by a national philosophy, emphasising Kenya's human and economic development. The Sessional Paper also called for reforms in Kenya's education and training sectors (Republic of Kenya, 2017).

The envisaged reforms were to guide the development of the individual learner in a holistic and integrated manner, while producing intellectually, emotionally, and physically balanced citizens. The Sessional Paper further recommended the adoption of a Competency Based Curriculum. The new curriculum entailed the establishment of a national learning assessment system and the early identification and nurturing of talents. The introduction of national values and national cohesion were also to be integrated into the school curriculum.

Further, Kenya Vision 2030 and Sessional Paper No. 2 of 2015 placed a strong emphasis on the importance of science, technology, and innovation in the school in the school curriculum as opposed to academic type of learning. To achieve the above the sessional paper called for the provision of deliberate policies, appropriate pedagogical approaches, and sufficient resources to lay a strong foundation for the development of relevant skills. Besides innovative, vocational, and technical skills considered important for meeting the demand for skilled labour and Kenya's goal of industrialization was to be catered for in the mainstream curriculum, (Republic of Kenya, 2017). In short, the CBC is based on seven core competencies to be achieved by every learner in basic education. These are:

- Communication and Collaboration;
- Self-efficacy;
- Critical Thinking and Problem Solving;
- Creativity and Imagination;
- Citizenship;
- Digital Literacy; and
- Learning to Learn, (Republic of Kenya, 2017).

It was expected that the CBC system of education will tackle most of the challenges that have bedeviled Kenya's education sector since the colonial period.

Phelps- Stokes Recommendations and the CBC: Areas of Convergence

The government of Kenya has over the years made efforts to reform the education sector in Kenya to improve the learner's welfare and meet the country's development goals. From a policy perspective, the government has learned from history by periodically updating the education system and policies to address emerging issues in Kenya and around the world. However, most of the new education policies in Kenya have been implemented without assessment of the challenges that faced past reforms. A case in point is the formulation of the 8-4-4 system of education and the CBC. This paper has shown that there are many areas of convergence between the Phelps–Stokes Commission report, the 8-4-4, and the CBC. Consequently, one may ask, to what extent did the Phelps–Stokes Commission Report, its implementation and challenges inform the adoption of the CBC?

The core recommendation of the Phelps–Stokes Commission called for an education system that would make the learner best suited for self-efficacy life in rural areas. In this regard, the Commission called for an education system that would speak to: the moral character development of the individual through the inculcation of Christian values in education; development

of the learner's lifelong skills through the exposure to appropriate technology in industry and agriculture; improvement of family health and family life; and the improvement of the learner's health;

The Commissioners argued that the improvement of an individual's welfare was to be the central concern of the education system. On its part, the 8-4-4 system of education also emphasised the self-development of the individual through: development of the learner's lifelong skills; self –efficacy of the learner through self -employment and/or salaried employment; exposure of the learner to productive agricultural methods; exposure of the learner to appropriate technical, scientific, and practical knowledge; and the development of the learner's moral character.

The above two systems of education though separated by many other education reforms addressed similar concerns. These concerns are also central to the CBC. The CBC was mooted to correct the weakness inherent in the 8-4-4 system of education. The CBC is thus centered on the practical demonstration of acquired competencies. It is oriented towards an Outcome-Based System of education in which learners are supposed to practically apply their skills in solving problems in society. This is similar to what the Phelps–Stokes Commission recommended almost 100 years ago. Consequently, there are many areas of convergence between the Phelps–Stokes Commission Report, the 8-4-4 system, and the CBC. All the three systems emphasize self–efficacy, investment in moral character, and adaptation to the changing environment.

From the above, the paper asks to what extent did the Phelps–Stocks Commission Report inform the drafting of the CBC? What are the recurrent issues in the Phelps–Stokes Report and the CBC? It is the view of this paper that the drafters of the CBC did not involve historians in their deliberations, yet there is historic recurrence in the two systems. Just like the establishment of the Jeanes School and the Native Industrial Training Depot, the CBC has great potential to transform social, economic, and political development in Kenya if properly implemented.

However, how it was formulated and implemented is a clear indicator that stakeholders in the education sector have not learned from the historic challenges that undermined the Phelps– Stokes Commission Report and the effectiveness of the 8-4-4 system of education. It is, therefore, important to study the past trends for the effective implementation of the present and future reforms. The proponents of the CBC must therefore be cognizant of the recurring trends, convergence in the trends, and the challenges that have bedeviled the education sector in the past. Policymakers are therefore called upon to involve historians in all aspects of policy deliberations.

Conclusion

This journal article has used historical literature review methods to reflect on the usefulness of the Phelps–Stokes Commission Report on policymaking in the education in Kenya. The article has demonstrated that "if history has lessons to impart to the policymakers, they are to be found par excellence in the recurring patterns" in the education reforms in Kenya (Trompf, 1979). The paper has thus argued that policymakers in the education sector need to involve historians when crafting education reforms and policies in Kenya. The paper has shown that there is a lot of convergence between

the Phelps- Stokes Commission report, the 8-4-4 system of education, and the CBC. If the policymakers had involved historians in their deliberations, then unwarranted and cyclic reforms in the education sector would have been avoided. Indeed, a reflection on the past haphazard implementation of the education reforms in Kenya points out to the need for the government to concentrate on effective implementation instead of periodic curriculum reviews. The idea of overhauling the education systems only confuses the sector due to the unpreparedness on the part of the government to implement the new system. In order not to repeat mistakes of the past, policymakers need to reflect on the importance of history in shaping the present and the future. History like a strategic plan is important in policymaking and implementation.

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Status of Learners' Psychosocial Wellbeing and Safety in Nairobi Informal Settlements Amid the COVID-19 Pandemic

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Abstract

The health crisis from the Covid pandemic slowed down gains in education across the world, particularly on school retention and psychosocial well-being of school age going children. This study was conducted in 2021 to assess the learners' psychosocial well-being and safety since the onset of Covid pandemic for low-cost primary schools of Mukuru informal settlement in Nairobi. The research design was mixed method, with a survey questionnaire administered to 20 head teachers and 60 teachers, in-depth interview with 6 teachers and focus group discussions with 32 pupils from 4 schools. From the findings, the learners faced a myriad of challenges such as stress, anxiety, emotional and physical abuse, increased number of school drop-outs and unsafe learning environment. Despite existence of regulations for psychosocial support for learners within the school and community, the support was weak and uncoordinated, making learners vulnerable, particularly in crisis context. To address the concerns, capacity building of the teachers, parents and other key actors is essential to provide psychosocial support and safety of learners in the informal settlements.

Keywords: **Learners, Psychosocial, Well-being, Protection, Informal Settlement.**

Introduction

The world has faced learning crisis compounded by a health crisis since 2020 (World Bank, 2020). COVID-19 is likely to slow down education gains and the speed of achieving the goals and targets of SDG 4. The global closure of education institutions caused major interruption in students' learning that contributes to a long-term intergenerational poverty cycle. According to World Bank (2018), the learning crisis results in learning deficits, and mainly affecting the poor households, with parental education, socioeconomic status, and conditions at home remain, being the largest predictors of learning outcomes. Mechanisms of support to children from vulnerable families are needed to reduce the learning gaps and mitigate effects of crisis situations for resilience.

In Kenya, the rights of the children rights are articulated in the national legislative and policy framework aligned to the Convention on the Rights of the Child (CRC) and the African Charter on the Rights and Welfare of the Child (UN, 2016). Article 53 of the 2010 Constitution of Kenya recognises children protection from abuse, neglect, harmful cultural practices, all forms of violence, inhumane treatment, and punishment, and hazardous or exploitative labour. The operationalisation of the legal framework is further enforced through policy instruments and guidelines specifying the procedures and directions for stakeholder implementation of the child protection system (NCCS, 2011). The 2015—2030 Mental Health Policy recognises children and adolescents as vulnerable groups, often prone to mental disorders, if their environment does not promote care, affection, love, stimulation for cognitive abilities or other emotional and social support (UNICEF, 2016). That enforces the need for the actors to take due diligence to address child protection issues facing the children and adolescents in their setting.

The psychosocial well-being of learners is a crucial ingredient for quality education, that encompasses, thoughts, emotions, and behaviour and social experience in natural settings. Learners' psychosocial problems can arise from stigmatisation, lost hope, chronic poverty, inability to meet basic needs, and inability to fit in the societal roles (INEE, 2010). However, learners' well-being is illustrative of holistic health condition; physical, cognitive, emotional, social, physical, and spiritual. The learners' experiences are expressed when they; participate in meaningful social role, feel happy and hopeful, and maintain good behaviour. Essentially, psychosocial well-being and safety, is about positive social relations, supportive environment, coping mechanism through life skills, protection, and access to quality services.

The onset of COVID pandemic created destabilisation situation for families, with measures being put in place to address concerns in learners psychosocial well-being and access to quality education in crisis context. Bozkurt et.al. (2020) argues, in crisis context, parents and teachers are overburdened between regular daily and professional duties and emerging educational roles. In another context, Fabiola (2021) notes, in El Salvador children were exposed to violence in their early years that led to social, behavioural, learning, and emotional impairments. These crisis situations cause learners to experience of trauma, psychological pressure, and

anxiety of various degrees, with emergency situations causing schools and families into highly stressful environments. This necessitates a pedagogy of care, affection, and empathy, and also support to address school dropout and poor attendance that undermine quality and equity in education. This means context of crisis situations differs in diverse settings. In this paper, the focus is the psychosocial well-being and safety for learners from schools in the informal settlements in Kenya.

Context

In Kenya, Nairobi County with a population of 4.3 million people (KNBS 2019) was the most affected County by COVID-19. The County has an estimated 2.5 million people living in low-income areas including the informal settlements. In the midst of COVID-19, the County was greatly affected by cessation of movement where people could not get in or out while the curfew limited the time for people to work especially the small business owners. The families especially in the informal settlement had limited ability to meet the social, economic, and psychological well-being of their children and the unemployed young adults.

The Mukuru informal settlement consists of approximately 30 villages and is home to over 700,000 people, majority being low-income earners. Available statistics shows about 30% of the low-income earners in Nairobi lost their jobs with restrictions due the COVID- 19 pandemic. The prolonged schools closure led to increased cases of child abuse including neglect, violence, and sexual abuse due to inadequate parental supervision, care and nurturance have been on the increase. Girls were the most affected with various forms of abuse, including early pregnancy and marriage which end their education abruptly.

There was inadequate information on the psychosocial well-being and safety of the learners since the onset of COVID pandemic in the informal settlement schools. To address the concerns, UNESCO was to build the capacity of teachers and parents in addressing the impact of Covid pandemic of the children in the information settlement. The goal is to establish innovative approach in child protection. Evidently, the COVID pandemic created stressed and anxious in school communities, particularly, with disruption of learning programmes.

This paper describes the status of the learners' psychosocial well-being and safety for the schools in the Mukuru informal settlements of Nairobi since the onset of COVID-19 pandemic. The discussion articulates the threats to cognitive, emotional, and social well-being of learners since the onset of Covid pandemic, the extent learning environments are safe and secure, and mechanisms in place for learners' psychosocial support and well-being.

Methodology

The research was designed as mixed method utilising quantitative and qualitative approaches. The study respondents were headteachers, teachers and pupils from 20 low cost primary schools in Mukuru informal settlements of Nairobi. A survey questionnaire was administered to 20 headteachers and 60 teachers providing information on learners' psychosocial issues, violence incidents and impact of the COVID pandemic. The use of in-depth interviews with 6 teachers and Focus Group Discussions with 38 pupils for grade 5, 6 and 7, elicited individual experiences in the community and within the school settings.

The data was analysed in thematic areas including use of descriptive statistics.

Findings and Discussions

The experiences of psychosocial well-being and safety of learners in the informal settlements are described in four thematic areas: psychosocial issues facing learners; access and safety of learning environments; impact of COVID pandemic; and existing mechanisms for psychosocial support for learners.

Psychosocial Issues Facing Learners

Since the onset of COVID, learners expressed facing isolation and lacked emotional support from peers, as they had limited social interactions. The views of teachers on psychosocial issues affecting the learners indicates that Stress (66.1%) and anxiety (62.7%) were the highest psychosocial issues affecting learners (Figure 1). Negative peer pressure among boys and girls contributed to early sex initiation and drug abuse.

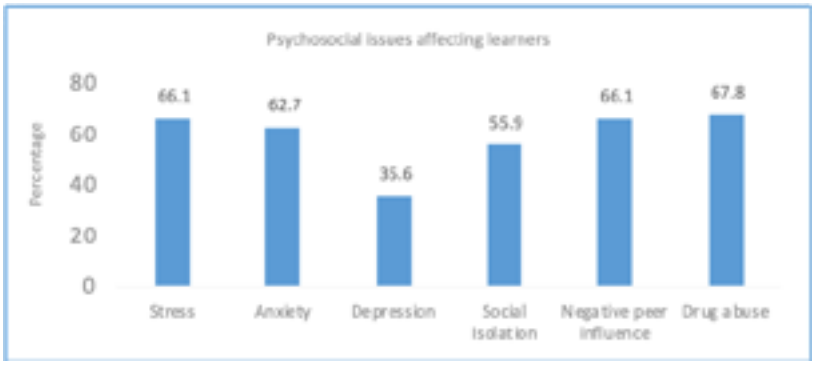

Figure 1: Psychosocial issues affecting learners since onset of Covid 19

Other forms of psychosocial issues were, anxiety, depression and other stress related problems that threatened the learners' ability to be happy, healthy and engage effectively in learning. The stressful conditions made the learners vulnerable in school and even at home. In school, one teacher narrated the situation facing the learner: The teacher said:

"When the schools opened during the COVID pandemic, I noticed some of the learners were withdrawn. .... those pupils who used to be talkative and pleasant, they seemed to be having some issues. When I talked to them, they had issues at home, it also appeared they came to school hungry and had other problems at home. ...their parents had lost jobs, others indicated they are neglected and feelings of discrimination."

The learners were afraid and ashamed to discuss their psychosocial challenges. The parents' economic circumstance after their job losses, made their children vulnerable. The children were withdrawn and felt neglected and, or discriminated.

The teachers identified challenges that face learners as illustrated in Figure 2. Majority stated unsupportive parents (59.3%) and heavy domestic work (59.3%). Other challenges are divorce/separation (57.6%), domestic violence (57.6%) and alcoholism in the family (52.5%). The concerns in unsupportive parents are linked to learners lacking learning materials, inadequate parental guidance, and abuse of drugs.

Figure 2: Challenges facing learners since the onset of Covid

With high incidences of divorce/separation, male parents absconded their parental responsibilities, with mothers forced to cater for the feeding and education of their children. Incidences of parental neglect due to drunkenness were admitted by the teachers and the learners. One teacher reported:

"Our pupils face many issues at home. Like now we have a girl whose where, the mother and father are drunkards. She is left to take care of the house chores and prepare her younger siblings. Despite that, she is determined to be in school."

The COVID-19 pandemic has affected learners in the informal settlements by making their situation worse off. Akasha (2021) argues, if children are stressed for longer periods of time, it impacts their ability to concentrate in learning. The prolonged exposures in a crisis, can cause severe psychological and social consequences (UNICEF, 2016). These situation calls for or individualised support in addressing a learner's psychosocial concern.

Protection of Children Against Violence

The study sought to establish the status of safety of learners at home and in school. Wessells, and Kostelny (2021) notes, violence against children is a pervasive problem that imposes heavy burdens of physical, psychological, and social suffering. In the Mukuru informal settlement, majority of the head teachers (89.5%) reported incidences of violence and psychosocial issues (Figure 3). About 89.5% of the headteachers reported neglect by parent/ caregiver (89.5%) followed by physical abuse (57.9%), emotional abuse (57.9%) and anxiety (52.6%). Other incidences are bereavements (47.4%), anger (42.1%), child labour (42.1%) and defilement/rape (36.6%).

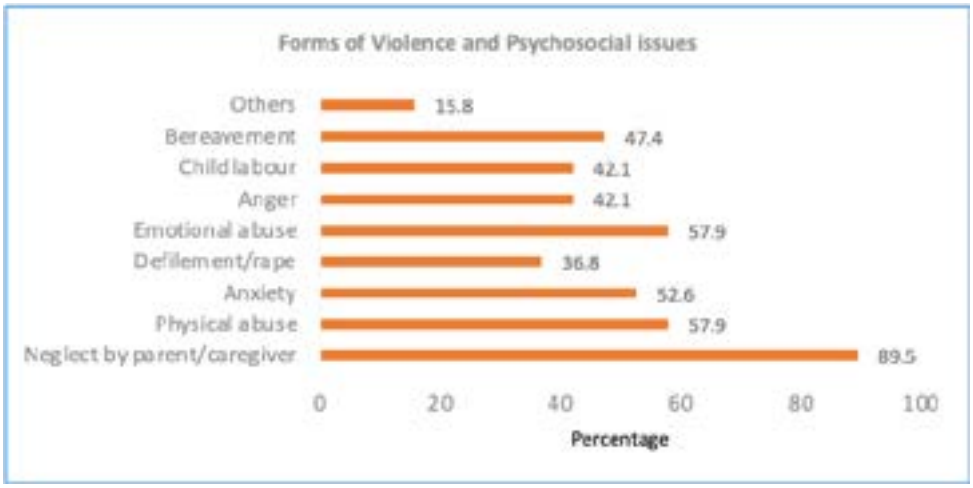

Figure 3: Reported forms of violence and psychosocial issues against learners

Parental neglect and other forms of abuse have detrimental effects on the wellbeing of the affected children. Of concern was the fact that learners faced physical and emotional abuse. One teacher reported:

"In several instances, the pupils would inform me they were physically and psychologically abused. Some said they were denied food at home because playing with their friends. These pupils were affected emotionally."

Physical and emotional abuse has a detrimental effect to a child that can cause stunted physical development of the child's brain, mental and health related issues. As Kiptoo-Tarus (2020) noted, the COVID pandemic has led to women, girls and children facing increased and multiple challenges of physical and psychological violence. In some case, it ends up in family confinement, isolation, and economic vulnerability.

Learners are vulnerable and, therefore, require protection in situations where they face psychosocial. In school, teachers are appointed also to provide guidance and counselling, and provide support to learners who require psychosocial support. A headteacher in one of the schools said:

"Several learners in our school face psychosocial issues especially during the COVID pandemic. I constituted a team of two males and two female teachers to work together and support the learners…. if we did not address most of the learners would have ended up depressed. Most of our learners' face challenges including abusive language."

The use of peer among teachers allows sharing responsibility and experiences for better handling of the learners. Beteille, Molina, Pushparatnam and Wilichowski (2020) argue, teacher effectiveness in crisis situation is in three phases; coping, managing continuity, improvement, and acceleration. A collaboration between teachers, school management teams and parents provide opportunity for effective to support tor learners in stress management and psychosocial support.

The emphasis is that parental support for children is the cornerstone in child protection. It was a positive aspect when parents sought teacher support in problems that face their children. One teacher said:

"Parents normally come to school telling us, teacher, can you talk to my child? One parent asked me to talk to her daughter… she said, there's a problem, she does not open up to me…. So sometimes, there are things these that children are not able to say to their parents …. we call them, we sit down with them, at least they are able to open up to us… ''

According to Chibuike-Chukwuere, Jacobus-Pienaar and Sehularo (2020), parents can be in a state of helplessness and hopelessness, to the extent they seek support from teachers. In depressed situations, the children may be in a state of poor emotional control and anxiety. It is no surprise that the parents confide and consult teachers to address the psychosocial wellbeing of their children.

It is important to have safe learning environments where learner feel secure, that promote child protection. The schools in the informal settlements have to encourage collaboration with parents for comprehensive psychosocial support in the school environment. Akasha (2021) noted, access and safety of learning environments is critical when protecting learners. The school managers and teachers with the relevant stakeholders need to facilitate prevention of violence against children.

Impact of COVID Pandemic

Learners in informal settlements were severely affected from the COVID pandemic. The limited opportunities and facilities to access online learning was a stressful scenario. Parents did not have the required capacity to support their children homestay, and this affected their psychological wellbeing. These caused frustration as children struggled with emerging challenges. In one school, a pupil said:

"I was abused emotionally by the mother of my friend. She told me that am a bad influence on her daughter who is my friend. I felt like killing myself."

With home stay prolonged, social relations among the children was limited, and adults did not recognise the impact they have on children when they deduce perceive deficiencies in behaviour. Children, like adults, have different thresholds for containing pain and stress.

The pupils reported incidences of negative peer pressure as common especially since the onset of COVID-19. There was concern about single parents who were overwhelmed by responsibilities and rarely noticed their children's psychosocial needs. One pupil said:

''I always have to keep to myself…. I think my parents are not interested in me…they don't listen to me. In most cases my parents are too busy, and they focus on their own activities. They don't notice how I suffer.".

The learners sought for support from, and it was a consolation that did seek support. Some resorted to use the child toll free line (116) to solicit for help.

As schools opened, student indiscipline cases increased because the majority of the learners were left unsupervised as their parents and caregivers went to work. Some of the learners were affected and isolated themselves and this led to poor performance in school. Kathula (2020) observed that teachers had a role to play to protect the learners from the dangers of psychosocial issues that affected their learning.

Existing Mechanisms for Psychosocial support for Learners

The government developed a COVID emergency response plan to support the education system during and after the Covid-19 pandemic. The plan is to support learners through creation of a favourable environment to facilitate their bouncing back to wellness. The interventions included; building the capacity of teachers on psychosocial support, providing appropriate psychosocial support to the learners and teachers, work with partners and relevant agencies to develop child protection systems (MOE, 2020). The goal is to ensure the healthy, safety and well-being of learners including those with special needs education and disabilities and teachers. The strategies included; strengthening child protection systems and providing debriefing to pupils and teachers.

Figure 4 shows the support services for learners facing violence and psychosocial issues. Guidance and counselling (89.5%) and psychosocial support services were the most mentioned by the headteachers. Other services offered were to the learners were medical assessment support (42.1%), access to justice (31.5%) and financial support (21.1%).

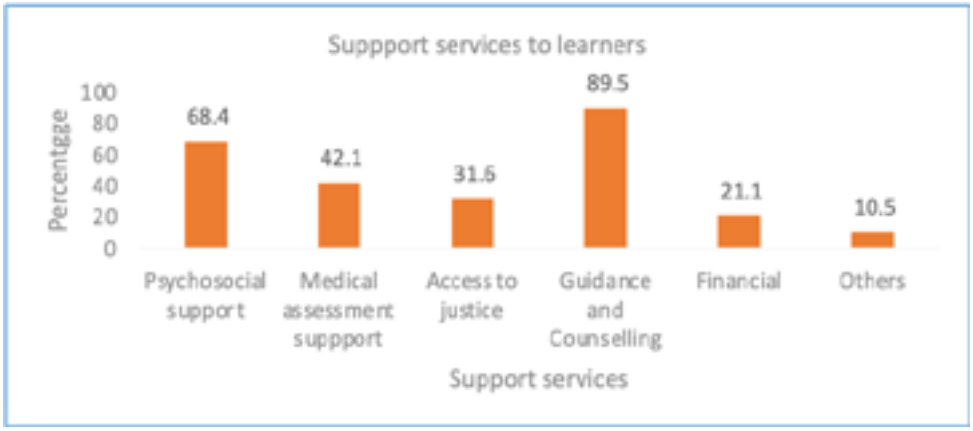

Figure 4: Available support services for learners facing violence and psychosocial issues

Psychosocial support is about showing a continuum of love, care, and protection to the child. It improves the learners cognitive, physical, emotional, social, and spiritual well-being. It is important that learners have adequate access to quality psychosocial services. However, the challenge was children did not easily access justice due to weak linkages with child protection actors outside the school.

Support mechanism for learners calls for schools to have partnership with the relevant government departments, non-governmental organisation, community-based organisation, and religious organisations. Some organisations do provide some support to the learners in the informal settlement schools. One teacher said:

"In our school, the catholic church is the school sponsor. The members of the Church do from time-to-time support learners who

are needy by providing food, clothes and even sometimes finances to the needy homes. We always receive some people that bring some food and bring clothes, you know, at the end of each, we it is to look up for the honourable pupil."

Similarly, an account of the organisations that provide support to the schools and learners in the slum areas was narrated by another teacher, who said:

"The organisations that support our schools include a CBO called Dream and the government, water was connected by the Nairobi Metropolitan Services."

There are support mechanism for child protection in school and school community. However, the concern is the weak linkages in coordination to support the learners from the low-cost schools in the informal settlements. The mechanisms for supporting and protecting children are documented and coordinated by the National Council for Children Services. The national child protection system brings together diverse actors to response to the needs of the vulnerable children in crisis situations (NCCS, 2011).

Conclusion

The rights of the children in accessing equitable and quality education are a national commitment. However, learners in informal settlements are weighed down by the myriad of psychosocial and child abuse issues that affects their cognitive, emotional, and social well-being. The learners faced violence and psychosocial issues such as anxiety, depression especially after the commencement of COVID-19 pandemic. The life in the informal settlement areas faces numerous psychosocial issues and child protection concerns.

Though child friendly learning environments are critical, learners in the informal settlement schools, are in educational environment that is unsafe with significant child protection risks. The adverse effects of COVID pandemic have made children are highly vulnerable due to poverty, orphaning, disability, or discrimination with high absenteeism and drop out in education (INEE, 2010). The lack of parental support makes teachers the last resort for learners to seek attention for their psychosocial issues. The learning environments have to be safe and secure to advance the protection of the psychosocial well-being of learners.

The available psychosocial and child protection services in the informal settlements did not adequately respond to learners' needs. The key support systems for learners namely teachers and parents also appear to be overwhelmed by various psychosocial issues. Parents are not adequately engaged in the education/ learning process of their children. There is a need to re-examine case management protocols and procedures for children in need of care and protection in the informal settlements.

In overall, to address learners psychosocial and safety of well-being in the informal settlement, calls for sensitisation of school management and communities through support to the schools and parents. The capacity building strategies in the informal settlements should be in the form of empowerment of teachers and parents with life skills education and competencies in child protection and psychosocial support.

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Informal Microfinance and Rural Households' Climate Variability Resilience: Analysis of their Contribution and Determinants in Tharaka South Sub-county, Kenya

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Abstract

*Climate variability affects rural households through effects on access to capital assets. Informal microfinance institutions could thus contribute to rural households' climate variability resilience by facilitating them to access capital assets. However, there is a lacuna on detailed analysis of the contribution of informal microfinance institutions towards building the resilience of rural households to climate variability. The study, therefore, analysed the contribution of informal microfinance institutions to rural household's climate variability resilience and the underlying determinants based on the sustainable livelihoods framework. The study employed a descriptive and multistage sampling design. Data analysis was done using thematic analysis, descriptive statistics and Kendall's tau-b correlation analysis. Informal microfinance institutions contribute to rural household's climate variability resilience by enabling access to capital assets. This is shown by their positive and significant contribution to access to healthcare (τb = 0.372**, P<0.01), education (τb = 0.448**, P<0.01), inputs of crop production (τb = 0.447**, P<0.01), and inputs of livestock production (τb = 0.473**, P<0.01). Moreover, there was a positive and significant relationship between rural household's climate variability resilience and the contribution of informal microfinance institutions to the resilience (τb = 0.91**, P<0.01). Informal microfinance institutions should thus be considered as a source of climate finance and a key policy strategy in building rural households climate variability resilience. Informal microfinance institutions contribution to rural household's climate variability resilience is determined by their characteristics such as members sex (τb = +0.017, P>0.05) and loan interest rate (τb = +0.109*, P<0.05). This relationship could be leveraged to enhance their contribution to rural household's climate variability resilience.*

Keywords: **Climate variability, Capital assets, Informal microfinance institution, Livelihoods, Resilience.**

I. Introduction

Climate variability is the deviation of climatic elements above or below the long-term average value (IPCC, 2014). Climate variability has significant impacts on rural livelihoods in Sub Saharan Africa (IPCC, 2007). According to IFAD (n.d.), poor people in rural areas of developing countries are the most vulnerable to impacts of climate variability due to low adaptive capacity, high exposure, and high sensitivity to its effects. This is caused by high dependence on climate sensitive economic activities and the natural resources base, high dependence on rain fed agriculture, low access to capital assets, inadequate safety nets, and occupation of hazardous and fragile areas (WFP *et al.,* 2009; Kandji, 2006; Haworth *et al.,* 2016; Wilkinson and Peters, 2015). In Kenya, climate variability has negatively affected agricultural production especially due to an increase in the frequency of droughts and is increasingly blamed for the deteriorating livelihoods in rural areas (Mutimba *et al*., 2010; Okoti *et al.,* 2014; Herrero *et al.,* 2020). The drought cycle in Kenya has become shorter over the years, from every ten years, down to every five years, further down to every 2–3 years and to the current situation where every year is characterised by some dry spell (Institute of security studies, 2011).

According to Ziervogel and Calder (2003) climate variability manifests as shocks and stresses that impact livelihoods through effects on access to capital assets. Response to the effects of climate variability thus involves enhancing access to capital assets and livelihood strategies (Badjeck *et al.,* 2009). This could be achieved through microfinance institutions that enable low-income people to accumulate and manage capital assets by providing them with loans, savings, and other financial services (Agrawala and Carraro, 2010; Hammil *et al.,* 2008; Haworth *et al.,* 2016). Microfinance institutions enable people to generate incomes, create jobs, access education, and access healthcare and make life choices that best suit their needs (Mushuku and Mayisha, 2014). In addition, microfinance enables households to diversify income sources and smooth temporal consumption patterns in response to shocks and stresses (Scheyvens, 2015; Agyir *et al*., 2015).

Microfinance includes formal and informal microfinance institutions. Informal microfinance institutions include rotational savings and credit associations (ROSCAs) and accumulated savings and credit associations (ASCAs) (Kaburi *et al.*, 2013). They are community-based organisations that provide loans, savings, and other financial services mainly to low-income people who have little or no access to formal financial services (Thrikawala *et al*., 2013). Informal microfinance institutions are thus based at the local level, and are prevalent in rural areas of low-income countries where they have been in existence since the precolonial period (Mairura and Okatch, 2015; Haworth *et al.,* 2016). According to Boissiere *et al*. (2012), Mertz *et al*. (2009), and Tschakert (2007), impacts of climate variability are context-specific and thus successful response actions should build on existing strategies that reflect the local socioeconomic and environmental context. Microfinance institutions have a great but yet inadequately recognised potential in building the resilience of low-income households to climate variability (Moser and Gonzalez, 2015).

There is a lacuna in detailed analysis on the contribution of informal microfinance institutions in building rural household's resilience to climate variability. This is particularly in developing countries where they are the major source of financial services for the rural poor who are often marginalised by the formal finance sector (Hammil et al., 2008; Tilakaratna, 1996). Moreover, limited studies have done a detailed analysis on the contribution of informal microfinance institutions in building rural household's resilience to climate variability, especially through contribution to their access to capital assets.

Past studies on the role of microfinance institutions on resilience to climate change and variability (Moser and Gonzalez, 2015; Agrawala and Carraro, 2010; Hammil *et al.,* 2008) mainly focused on formal microfinance institutions as opposed to informal microfinance institutions. Also, previous studies on factors influencing resilience to climate change and variability (Perez *et al.,* 2015; Mondal *et al.,* 2016; Kolawole *et al.,* 2016; Sujakhu *et al.,* 2018; Žurovec and Vedeld, 2019 Nnadi *et al.,* 2019; Framstad *et al.,* 2018; Okafor and Akokuwebe, 2015; Obisesan, 2014; Tomlinson and Rhiney, 2018; Fagariba and Shaoxian, 2018; Iheke and Ogodike, 2016; Mlenga and Maseko, 2015; Dong *et al.*, 2015; Muttarak and Lutz, 2014; Iheke and Nwaru, 2014) did not consider the contribution of informal microfinance institutions particularly in terms of access to capital assets as a factor in their analysis. Besides, studies on microfinance, and climate change and variability in the study area including (Kiplimo *et al*., 2015; Gioto *et al*., 2016; Recha *et al*., 2017a; Recha *et al*., 2017b) did not analyse the contribution of informal microfinance institutions in building rural household's resilience to climate variability. Although Haworth et al. (2016), Hudner and Kurtz (2015), Bryan *et al.* (2013), and Gash and Gray (2016) identified informal microfinance institutions as a tool for adaptation to climate change and variability, they did not undertake a detailed analysis to show their actual contribution especially in terms of access to capital assets, nor the relationship of their contribution to households climate variability resilience.

Furthermore, limited studies have analysed the factors that determine the contribution of informal microfinance institutions in building the resilience of rural households to climate variability. Past studies that analysed the factors influencing performance in informal microfinance institutions focused on participation (Mwangi and Kimani, 2015; Anggraeni, 2009; Varadharajan, n.d; Muturi, 2012), and savings mobilization, credit access, and loan repayment performance (Ngendakuriyo, 2014; Aderinto *et al.,* 2011; Anggraeni, 2009; Opata and Nweze, 2009; Essien *et al.,* 2016; Nawai and Sharrif, 2012; Pasha and Negese, 2014; Gedela, 2012; Lasgni and Lollo, 2011; Atakora, 2013; Onyeagocha *et al.*, 2012; Sangwan and Nayak, 2020). They thus did not analyse the determinants of the contribution of informal microfinance institutions to rural households to climate variability resilience, particularly in terms of access to capital assets.

However, Kipesha (2013) and Scheyvens (2015) noted that the performance of an organisation is a function of different internal and external factors that that influence its operations. Gwasi and Ngambi (2014) found that institution-specific indicators are major determinants of microfinance

institutions' performance. Further, Hermes and Hudon (2018) noted that the direction of the relationship between characteristics of microfinance institutions and their performance is local context specific. Knowledge of the factors that determine the contribution of informal microfinance institutions to rural households' climate variability resilience could thus help to identify the factors that could be leveraged to enhance their role in resilience building (Hermes and Hudon, 2018; Aveh, 2018).

The study first analysed of the climate variability, trends and effects, and households' resilience to climate variability to gain an understanding of the local vulnerability context. It then analyzed the contribution of informal microfinance institutions to rural household's resilience to climate variability based on household's access to capital assets. Also, the study analysed factors that determine the contribution of informal microfinance institutions in building the resilience of rural household's to climate variability. The study will help to enhance the contribution of informal microfinance institutions in building rural household's resilience to climate variability.

2. Theoretical Framework

The study was based on the sustainable livelihood framework. The sustainable livelihood framework is an analytical framework that seeks to understand people's access to capital assets and how they convert them through livelihood strategies to achieve desirable livelihood outcomes including more income, improved food security, improved wellbeing, sustainable use of the natural resource base, and reduced vulnerability (Connoley-Boutin and Smit, 2016; DFID, 1999). The framework was thus chosen since climate variability affects rural livelihoods through effects on access to capital assets (Ziervogel and Calder, 2003) and response to the effects involves enhancing access to capital assets (Badjeck et al., 2009).

The sustainable livelihoods framework views people as operating within a vulnerability context that is shaped by different factors including shocks, trends and seasonality (DFID, 1999). The vulnerability context affects people's livelihoods through the effect on access to capital assets and thus outcomes of livelihood strategies (Connolly-Boutin and Smit, 2016; DFID, 1999; Badjeck et al., 2009). The core outcome of the sustainable livelihoods framework is therefore to enhance resilience to shocks, trends and seasonality by building a household's capital assets (DFID, 1999; Agyir et al., 2015; Piya et al., 2012; Badjeck et al., 2009). Climate variability is one aspect of the vulnerability context since climatic trends, shocks and seasonality frame the external environment in which people exist and operate (DFID, 2004).

The process of accessing capital assets and converting them into livelihood outcomes through livelihood strategies is mediated by structures and processes (Chambers and Conway, 1992; Ellis, 2000). Structures include private and public organisations such as households, member groups and the community while processes are the policies, legislations, culture, institutions and power relations that determine how structures operate and interact (FAO, 2008; DFID, 1999). Structures and processes by determining access to capital assets and how institutions and individuals operate and interact shape impacts and responses, and

determine the level of resilience to shocks, trends and seasonality in a socioecological system (DFID, 1999; Carney, 2003; Adger, 2000; Agrawal, 2010).

3. Materials and Methods

3.1 Study area

The study was conducted in Tharaka South Sub-county is part of Tharaka Nithi County and lies in semi-arid Eastern Kenya (Figure 1). It covers a surface area of 637 KM2 and has a population of 75,250 people living in 18,466 households (Government of Kenya, 2019). The sub-county therefore has a population density of 118 people per KM2 and the average household size is 4 people (Government of Kenya, 2019). It has three main livelihood zones including the mixed farming zone, marginal mixed farming zone, and the rain fed farming zone (Government of Kenya, 2008). The people are largely agropastoralists with agriculture accounting for over 70% of their income (Kirraine *et al.,* 2013). Tharaka South Sub-county is marked by a high prevalence of informal microfinance institutions. Recha (2013) found that formal financial institutions were almost non-existent in Tharaka with informal microfinance institutions being the main source of financial services.

The sub-county also has high vulnerability to climate variability. It lies in an arid and semi-arid area characterised by high poverty levels, unreliable and erratic rainfall, high recurrence and intensity of droughts, frequent famines, and high rates of acute malnutrition among young children (Recha *et al.,* 2013; Orindi and Ochieng, 2009). The sub-county has a bimodal rainfall pattern and temperatures range between 24 to 37 degrees centigrade (Government of Kenya, n.d; Kabui, 2012). The sub-county falls in the dry/savannah climatic zones under the Köppen-Geiger climate classification (Köppen, 1936). It has three major climatic zones including the lower midland 4, lower midland 5, and the intermediate lowland 5 (CIAT, n.d.). The proximity of the area to Mount Kenya means that climate is influenced by the El Nino/Southern oscillation, the inter tropical convergence zone, latitude, altitude, and sea surface temperature among other factors (Odingo *et al.,* 2002)

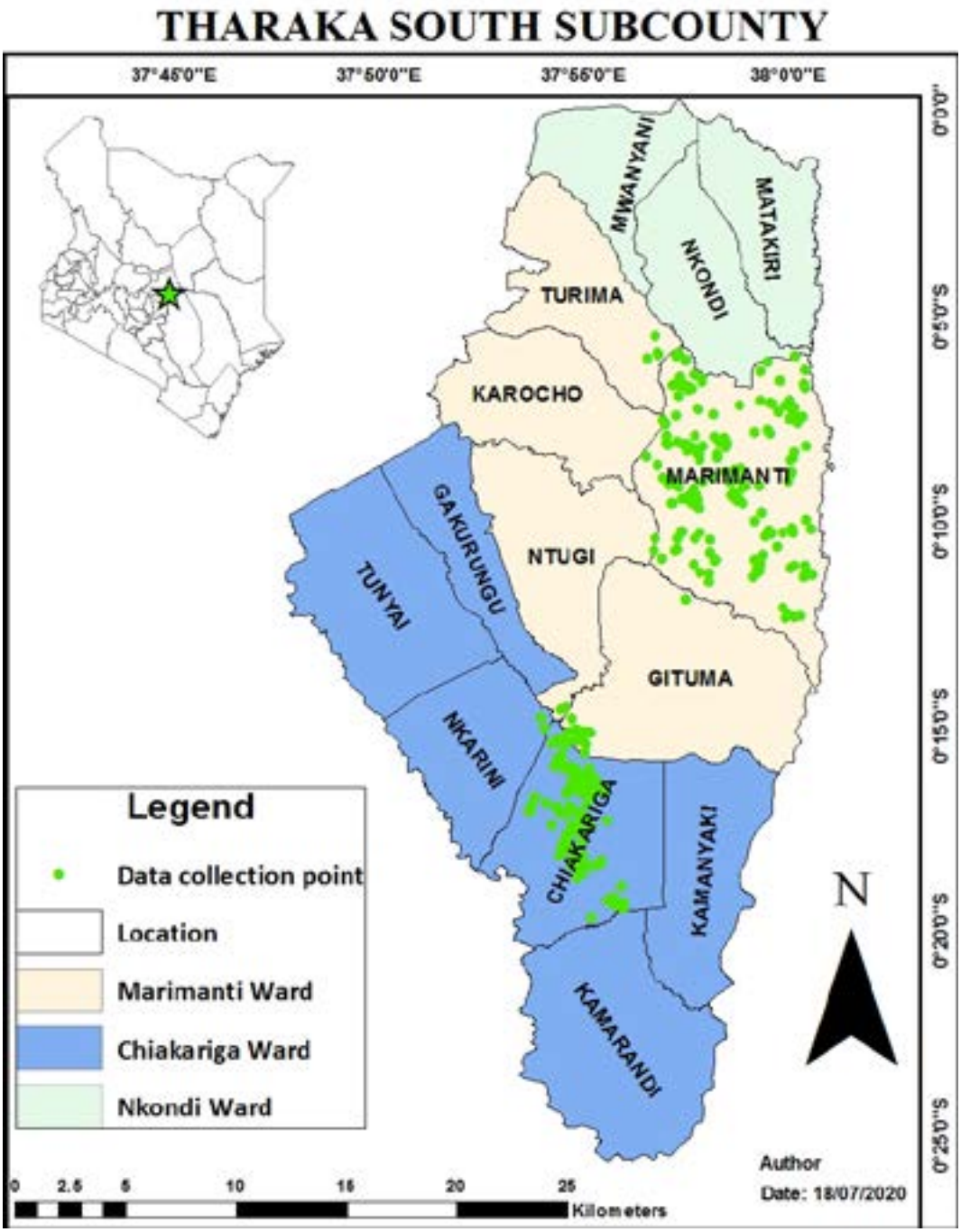

Figure 1. Location of the study area in Tharaka South Sub-county (Source: Author).

3.2 Sampling Procedure

The study used a descriptive study design and multi-stage sampling design. This first involved random selection of two locations, Marimanti and Chiakariga, for the study. Then 177 informal microfinance institutions to be involved in the study were identified based on data sourced from the department of social services. These included 89 informal microfinance institutions in Chiakariga Location, and 88 informal microfinance institutions in Marimanti Location. The number of informal microfinance institution's to be involved in the study per study location was determined using proportional probability sampling. Systematic sampling was then used to select 36 informal microfinance institutions for the study i.e., 18 per location, by picking every 5th informal microfinance institution from the lists. Based on Cochran's Equation 1 (Robb, 1963), a sample size of 385 respondents was derived. One respondent was interviewed per household which means 385 households were studied.

Proportional probability sampling was used to determine the number of respondents to interview per informal microfinance institution. In doing this, the total number of respondents (385) was divided by the total number of informal microfinance institutions selected for the study (36) to determine the number of respondents to interview per group and a figure of eleven respondents arrived at. The eleven respondents were then chosen from each informal microfinance institution using systematic sampling with the member's lists forming the sampling frames. The sampling interval for each informal microfinance institution was determined by dividing the total number of members listed by eleven.

3.3 Data Collection

The study used both primary and secondary data. Primary data was collected through observation, semi-structured questionnaire surveys, focused group discussions, and key informant interviews. A reconnaissance survey of the study area helped to identify aspects of local livelihoods that are most affected by climate variability and also informed development of the research tools including questionnaires, focused group discussion schedule, and key informant interview schedules. The household survey questionnaires were administered to members of informal microfinance institutions chosen as respondents at their individual households. A second questionnaire meant to gather information on individual informal microfinance institutions was also administered to an informed official for each group.

Pilot testing of the data collection instruments was done by administering questionnaires to a sample of respondents who were not among those selected for the study. The instruments were also tested for reliability using Cronbach's alpha (Cronbach, 1951). A coefficient of 0.784 was arrived at indicating good reliability. The validity of the instruments was evaluated through expert consultation. Data collection was done with the assistance of a mobile-based georeferenced data collection system called kMACHO (kMACHO Partners, n.d.). Data from various data collection methods were validated and harmonised using methodological triangulation.

Rainfall data was sourced from Climate Hazards InfraRed Precipitation with Station data (CHIRPS) for a period of 38 years from 1981 to 2018. CHIRPS incorporates 0.05 degrees resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and drought monitoring.

3.4 Data Analysis

Qualitative data was analysed was done using thematic analysis while quantitative data was analysed using descriptive analysis and Kendall's tau-b (τb) correlation analysis. Climate variability was analysed based on the variation of annual rainfall over the last 38 years i.e., 1981-2018 using the coefficient of variation. The Mann-Kendall (Z) test was used to calculate the trends in climate variability.

3.5 Computation of Variables

A composite index was computed to measure the household's climate variability resilience and called the household climate variability resilience index. The composite index was computed based on household's access to capital assets including expenditure on access to education, healthcare, inputs of crop production, and inputs of livestock production in the past year as indicators.

Also, a composite index was computed to measure the contribution of informal microfinance institutions to household's resilience to climate variability and called the contribution of informal microfinance to the household climate variability resilience index. The composite index was computed based on the proportion of the contribution of informal microfinance institutions to household's access to capital assets including expenditure on access to education, healthcare, inputs of crop production, and inputs of livestock production in the past one year as indicators. This was calculated by dividing the contribution of informal microfinance institutions on household expenditure on a capital asset divided by the total household expenditure on the capital asset.

In computing a composite index, the indicators were first normalised using the Min-Max normalisation. The indicators were weighted using the pairwise ranking matrix. The composite index was then computed using the formula:

Where:

CI = Composite index

w_i = Weight of variable

Zi = Variable index value

n = Number of variables

The composite index was tested for accuracy and robustness using uncertainty and sensitivity analysis. Uncertainty analysis was done using the propagation of standard errors approach i.e., based on uncertainties of index components as in Kirchner (2001). Sensitivity analysis was done using multiple regression analysis whereby the coefficient of determination (R2) indicated the amount of variation in the composite index which can be explained by the model's components as in Hamby (1995).

4. Results

4.1 Climate Variability, Trends and Effects

Analysis of inter-annual rainfall variability from 1981 to 2018 using coefficient of variation found a coefficient of 0.243 indicating climate variability. Analysis of the trend in intra-annual rainfall variability from the year 1981 to 2018 using Mann-Kendall (Z) statistical test found a positive non-significant trend ($Z=1.52$, $P>0.1$) indicating climatic patterns are becoming increasingly variable. Trend analysis of annual rainfall amount found a negative trend that was not significant ($Z= - 0.93$, $P>0.1$) indicating rainfall amounts are decreasing and the patterns are erratic and unpredictable.

A sample of 385 respondents was interviewed to find out local people's perception of climate variability. Local people were found to have perceived climate variability as observed by 87% (n = 335) of the respondents who said local climatic patterns have changed to a high extent. This includes perception of decrease in rainfall amounts (56%, n = 216), erratic and unpredictable rainfall patterns (39%, n = 150), and fluctuations in local temperatures mainly marked by increased incidences of above normal temperature levels and erratic temperature regimes (5%, n = 19). Participants in the focused group discussions and key informant interviews observed that there has been increased severity, duration and frequency of droughts.

Besides, local people have perceived impacts of climate variability on their livelihoods as observed by (99%, n = 381) of the respondents. The majority of the respondents observed that climate variability affects local people's livelihoods through the effect on access to capital assets and livelihood strategies. This includes effects on health (88%, n = 339), education (87%, n = 335), crop production (97%, n = 373) and livestock production (93%, n = 358).

4.2 Household Climate Variability Resilience Index

Household's resilience to climate variability was measured using the household climate variability resilience index. The index was computed based on household expenditure on access to education, expenditure on healthcare, expenditure on access to inputs of crop production, and expenditure on inputs of livestock production in the past one year (Table 1).

The household climate variability resilience index was then tested for accuracy and robustness using uncertainty analysis and an uncertainty of 0.029 arrived at indicating very high certainty. Further, the index was analysed for sensitivity using multiple regression analysis and a coefficient of determination (R^2) of 0.999 arrived at giving indicating very high sensitivity.

The household climate variability resilience index was found to range between 0.050 and 1.137 with a mean of 0.172, a standard deviation of 0.159, and a high skewness of 2.237.

4.3 Contribution of Informal Microfinance Institutions to Household's Climate Variability Resilience.

About 81% (n = 311) of the respondents held that informal microfinance institutions help in building resilience to climate variability. Moreover, 76% (n = 293) of the respondents said informal microfinance institutions help in building resilience to climate variability by providing member's with financial capital through savings, loans and dividends. The member's households use this financial capital to access capital assets including access to education, healthcare, inputs of crop production, and inputs of livestock production.

The study revealed that 97% (n = 373) of the households spent on access to healthcare. Informal microfinance institutions contributed to access to healthcare in 51% (n= 196) of the households. The household's healthcare expenditure included: transport, drugs, medical fees, health insurance, prescribed food, and equipment. The household's total expenditure on access to healthcare among surveyed households in the past one year was KShs. 6,960,340 (1 USD = KShs. 100) with the average expenditure per household being KShs. 18,079.BThe informal microfinance institutions contributed KShs. 2,036,100

to the household's expenditure on access to healthcare over the past one year with the average contribution per household being KShs. 5,302. Informal microfinance institutions, therefore, contributed 29% of the household's total expenditure on healthcare over the past one year. Besides, Kendall's tau-b correlation analysis found a positive significant correlation ($\tau b = 0.372^{**}$, $P<0.01$) between the household's expenditure on healthcare and the contribution of informal microfinance institutions to the household's expenditure on healthcare. This indicates that informal microfinance institutions have a positive significant contribution to household's access to healthcare.

Further, 94% (n = 362) of the households spent on access to education. Informal microfinance institutions contributed to access to education in 79% (n = 304) of the households. The household's expenditure on education included; school fees, books, stationery and other learning materials, and school uniforms. The household's total expenditure on access to education among the surveyed households in the past one year was KShs. 27,918,510 with the average expenditure per household being KShs. 72,516. The informal microfinance institutions contributed KShs. 8,313,200 to the household's expenditure on access to education over the past one year with the average contribution per household being KShs. 21,593. Informal microfinance institutions, therefore, contributed 30% of the household's total expenditure on education over the past one year. Moreover, Kendall's tau-b correlation analysis found a positive significant relationship ($\tau b = 0.448^{**}$, $P<0.01$) between the household's expenditure on education and the contribution of informal microfinance institutions to the household's expenditure on education. This indicates that informal microfinance institutions have a positive significant contribution to household's access to education.

The study found 97% (n = 373) of the households spent on crop production. Informal microfinance institutions contributed to access to inputs of crop production in 63% (n = 243) of the households. The household's total expenditure on inputs of crop production among the surveyed households in the past one year was KShs. 5,577,605, with the average expenditure per household being KShs. 14,487. The informal microfinance institutions contributed KShs. 1,602,680 to household's expenditure on inputs of crop production over the past one year with the average contribution per household being KShs. 4,163. Informal microfinance institutions, therefore, contributed 29% of the household's total expenditure on inputs of crop production over the past one year. Kendall's tau-b correlation analysis found a positive significant correlation ($\tau b = 0.447^{**}$, $P<0.01$) between the household's expenditure on inputs of crop production and the contribution of informal microfinance institutions to the household's expenditure on inputs of crop production. This indicates that informal microfinance institutions have a positive significant contribution to household's access to inputs of crop production. Informal microfinance institutions were also found to contribute significantly to household's access to specific inputs of crop production (Table 2).

Moreover, 89% (n = 343) of the households spent on inputs of livestock production. Informal microfinance institutions contributed to access to inputs of livestock production in 51% (n = 196) of the households. The household's total expenditure on inputs of livestock production among the surveyed households in the past

one year was KShs. 4,523,270, with the average expenditure per household being KShs. 11,749. The informal microfinance institutions contributed KShs. 1,117,750 to household's expenditure on access to inputs of livestock production over the past one year with the average contribution per household being KShs. 2,903. Informal microfinance institutions, therefore, contributed 25% of the household's total expenditure on inputs of livestock production over the past one year. In addition, Kendall's tau-b correlation analysis found a positive significant correlation ($\tau b = 0.473^{**}$, $P<0.01$) between the household's expenditure on inputs of livestock production and the contribution of informal microfinance institutions to the household's expenditure on inputs of livestock production. Informal microfinance institutions were also found to contribute significantly to specific inputs of livestock production (Table 3).

4.4 Contribution of informal microfinance to the household climate variability resilience index

The contribution of informal microfinance institutions to household's climate variability resilience was measured using the contribution of informal microfinance to the household climate variability resilience index. The index was computed based on the proportion of informal microfinance institution's contribution to household's expenditure on access to education, access to healthcare, access to inputs of crop production, and access to inputs of livestock production in the past one year (Table 4).

The contribution of informal microfinance to the household climate variability resilience index was then tested for accuracy and robustness using uncertainty analysis and an uncertainty of 0.046 arrived at indicating very high certainty. Further, the index was analysed for sensitivity using multiple regression analysis and a coefficient of determination (R^2) of 0.857 arrived at indicating very high sensitivity. The contribution of informal microfinance to the household climate variability resilience index was found to range from 0.000 to 2.274 with a mean of 0.670, a standard deviation of 0.609, and a moderate skewness of 0.604.

4.5 Relationship between Household's Climate Variability Resilience and the Contribution of Informal Microfinance Institutions to Household's Resilience

To determine the relationship between household's climate variability resilience and the contribution of informal microfinance institution's to household's resilience. Kendall's tau-b correlation analysis was used to calculate the relationship between the household climate variability resilience index and the contribution of informal microfinance to the household climate variability resilience index. A positive correlation ($\tau b = 0.91^{**}$, $P<0.01$) was found indicating that informal microfinance institutions have a significant positive contribution to household's climate variability resilience.

4.6 Determinants of the Contribution of Informal Microfinance Institutions to Rural Household's Cimate Variability Resilience.

Determinants of the contribution of informal microfinance institutions to rural household's climate variability resilience were analysed by finding the relationship between their characteristics and the contribution of informal microfinance institutions to household's climate variability resilience index using Kendall's tau-b correlation analysis (Table 5).

5. Discussion

The study aimed to analyse the contribution of informal microfinance institutions on the resilience of rural households to climate variability. The study found that the local climatic conditions are becoming increasingly variable. Climate variability in the study area manifests through increasingly erratic and unpredictable rainfall patterns, a decrease in rainfall amounts, more severe and frequent droughts, and increasing fluctuations and amounts of temperature. A decrease in rainfall amounts coupled with an increase in levels and frequency of above normal temperature events could lead to an increase in evapotranspiration rates, reduction in streamflow levels, and deterioration of the condition of the natural vegetation. These findings are in agreement with Recha *et al.* (2013) who found that that the frequency and intensity of drought in semi-arid Eastern Kenya have increased to almost being an annual phenomenon. The Government of Kenya (2007) noted that the climate projection for Kenya includes longer and more frequent dry spells interspersed with intense but unpredictable rainfall episodes.

Climate variability was found to be impacting rural households through the effect on access to capital assets and livelihood strategies, and thus the quality of livelihood outcomes. This aligns with Ziervogel and Calder (2003) who observed that climate variability affects people's livelihoods through the effect on access to capital assets and livelihood strategies and hence their livelihood outcomes. Climate variability affects health which could lead to a decrease in economic productivity, and adaptive capacity thus enhancing vulnerability to climate variability. This stems from the resultant unfavorable conditions, food insecurity, increase of social ills, water insecurity, and an increase in disease vectors. Climate variability was also found to negatively affect people's access to healthcare due to effects on income levels hence capacity to access the services. This is in agreement with WHO (2003) who noted that the health of Kenyans is influenced by extreme climatic events which increase incidences of vector-borne and water-borne diseases. Patz and Kovats (2002) in a study of hotspots in climate change and human health demonstrated the association between the El Nino cycle and the risk of malaria infection in Africa, Asia, and South America. According to Badjeck *et al.* (2009), changes in food availability and affordability due to climatic disturbances exacerbate the effects of health issues on households and communities.

The study found that climate variability negatively affects access to education by affecting the capacity of local people to meet educational costs and invest in facilities needed to provide quality education. Climate variability impacts also create conditions that hinder school attendance and performance including food insecurity and escalation of social ills. Impacts of climate variability on education reduce access to knowledge and skills and hence livelihood opportunities and adaptive capacity. Randell and Gray (2016) noted that climate risks may reduce children's school participation, slowing progress toward human development goals and poverty alleviation in rural Ethiopia. Also, Akuegwu *et al.* (2012) found a significant relationship between the effects of climate change and the performance of academic staff.

Climate variability also affects crop and livestock production. Effects of climate variability on crop and livestock production, the mainstay of the local economy, could lead to a reduction in income levels, food insecurity, and unsustainable use of natural

resources, and thus lead to more vulnerability to climate variability. A study by Omoyo *et al.* (2015) in Lower Eastern Kenya revealed that crop yields vary in response to change in climate parameters. Moreover, according to Galvin *et al.* (2015) and Lyimo and Kangalawe (2010), climate variability causes pasture and water scarcity leading to a reduction in livestock production, a decline in herd sizes, and enhancement of poverty among rural households. Moreover, Olusola (2014) in a study on climate change effects among agricultural households in Nigeria found climate variability affects the food and nutritional security of farmers through negative effects on livestock and crop production.

Local households are mainly marked by low levels of resilience to climate variability. This could be due to low access to capital assets and hence poor performance of livelihood strategies, including production and entrepreneurship activities. This could be the case for members of informal microfinance institutions since they are mainly constitute low income people who hence have lower access to capital assets. Ritchie (2007) in a study of community-based financial organisations in India, Sri Lanka, and Indonesia deduced that they are frequently relied upon as a source of financial services by low-income earners in remote areas due to low access to formal financial services. This is affirmed by Kandji and Verchot (2006) who found that low access to agricultural inputs makes the agricultural sector in the East African Community particularly vulnerable to climate variability. Inadequate inputs and support services hinder the attainment of sustainable livestock production in many countries (Steinfeld and Mack, 1995). The low levels of resilience to climate variability could also be due to high dependence on the natural resources base and climate-sensitive livelihood activities. This is in the backdrop of increasingly unfavorable climatic trends that make local people more vulnerable to impacts of climate variability. Also, marginalisation and hence poor access to development opportunities and services could contribute to the low access to capital assets and thus low resilience to climate variability. This is in line with Mude *et al*. (2007) who observed that rural ASAL populations in Kenya are poor, highly marginalised, and highly dependent on an unsustainable diminishing natural resource base. The fact local people occupy an arid and semi-arid land could also contribute to the low resilience to climate variability. Qaisrani *et al.* (2018) observed that rural livelihoods in semi-arid areas are increasingly exposed to climate impacts such as rising temperatures, erratic rainfalls, and more intense and frequent climate-related extreme events which introduce new risks to the already vulnerable communities.

The study found that informal microfinance institutions have a significant contribution to rural household's resilience to climate variability. Informal microfinance institutions contribute to rural household's resilience to climate variability by providing members with financial capital. This is in agreement with (Hammil *et al*, 2008; Tilakaratna, 1996; Allen, 2002; Wassie *et al*, 2019) who observed that informal microfinance institutions provide more affordable, flexible, and easily accessible financial services thus helping address the financial marginalisation that poor people face in accessing formal financial services. The financial capital provided by informal microfinance institutions enables members to access, enhance and diversify their capital assets based on which they undertake livelihood strategies leading to desirable livelihood outcomes including better incomes, food and nutritional

security, improved wellbeing, improved natural resource base, empowerment and thus reduced vulnerability. This concurs with Agrawala and Carraro (2010) who found that microfinance institutions provide low-income people with loans, savings, and other financial services that enable them to accumulate and manage capital assets thus building resilience to climate change and variability. Access to capital enables households to fill their adaptation deficit and leads to poverty alleviation hence resilience to climate risks (Schyvens, 2015).

Also, the financial capital provided by informal microfinance institutions enables rural households to access technologies and essential services which are vital in resilience building. They enable households to diversify their livelihood activities increasing the number of options they draw from and reducing exposure and sensitivity to climate variability. Scheyvens et al (2012) noted that microfinance institutions provide loans that help poor households to increase and diversify their income sources thus increasing resilience to climate variability. Access to financial capital through informal microfinance institutions helps to smooth household consumption patterns and provides members with risk sharing and transfer mechanisms in the face of shocks and stresses by stabilising their income flows. Catholic Relief Services (2012) concluded that microfinance institutions cushion members against shocks and stresses through consumption smoothing over time and risk pooling during hardship periods. Besides, the financial services of informal microfinance institutions act as safety nets during disasters and facilitate rapid post-disaster recovery by providing easy access to liquidity which also cushions households from asset erosion through cheap disposal of assets in an attempt to cope. According to Ncube *et al*. (2016), sustainable and reliable access to savings provides families with an effective cushion against shocks and allows them to keep their productive physical assets even in times of crisis.

The financial capital provided by informal microfinance institutions enables households to invest in inputs of crop and livestock production which enhances productivity and incomes and hence livelihoods resilience. This agrees with Amanja (2015) who observed that informal finance organisations are the most suitable source of financial capital for rural small-scale farmers given the remoteness and disaggregated nature of their value chains. Access to inputs also enhances the resilience of agricultural activities. This includes access to agrochemicals that control pests and diseases, manure to improve soil conditions, fertilisers to hasten and increase production, feed supplements to address the scarcity of pasture, and irrigation activities to reduce direct dependence on rain-fed agriculture, and access to tree seedlings to undertake agroforestry thus improving local agroecological conditions and the natural resource base. Informal microfinance also enables diversification in agricultural production by providing capital to invest in different products including access to diverse seeds and planting materials, access to insemination services, and purchase of good quality livestock. These findings are confirmed by Ncube et al. (2016) who found that adaptation to climate change and variability involves increased access to agricultural inputs such as fertilisers, use of drought-resistant crop varieties, pest and disease control, and increased irrigation. Komba and Mchapondwa (2018) observed that microfinance institutions are an important tool in reducing the vulnerability of the poor to climate risks by providing them with the means to diversify, accumulate and manage assets needed to reduce

susceptibility to shocks and stresses and to deal better with their impacts. Moser and Gonzalez (2015) observed that microfinance institutions contribute to adaptation and mitigation strategies by financing tree planting activities and creating awareness on sustainable agriculture.

The study found that the financial capital provided by informal microfinance institutions enables members to access healthcare services which increase people's health and capacity to undertake livelihood activities and thus resilience. Informal microfinance institutions are also avenues for access to health support programs since some are in essence health peer groups that support members in addressing health issues. Besides, informal microfinance institutions enable members to subscribe to health insurance schemes that cushion them against climate-related health risks. By supporting agricultural production and providing the financial capital to purchase food, they help to improve food and nutritional security which improves the health status in member's households. This aligns with Pronyk (2007) and Brannen (2010) who deduced that participation in microfinance programs improves health outcomes. Bloom and Canning (2019) noted that access to healthcare increases labor productivity and income levels, and hence livelihoods resilience. Microfinance supports agricultural production thus improving household income levels and food security (Osman, 2014; Fletschner and Kenney, 2011; Mokhtar, 2011).

The study found that the financial capital provided by informal microfinance institutions improves access to education by enabling members to meet educational expenses including school fees. Access to education increases people's knowledge and skills, and hence access to livelihood and employment opportunities. Education also increases the capacity and willingness to learn and adopt new skills and technologies. In addition to formal education, informal microfinance institutions enable members to access knowledge and skills through training seminars, extension services, and shared learning which improves the capacity to cope and adapt to the effects of climate variability. This is in agreement with Agyir et al. (2015) who deduced that education enhances adaptive capacity by increasing the capacity to learn, reducing ignorance, and broadening access to livelihood and employment opportunities. Furthermore, Knowledge and skills upgrading is a powerful adaptive strategy for individuals, families, and communities that enables them to make broader choices in response to climate shocks and stresses (Perry et al., 2010; Toya and Skidmore, 2005). Besides, Rocco et al. (2015) observed that farmers' strategic decisions are shaped by multiple factors, including training experience. Likewise, Tomlinson and Rhiney (2018) noted that participants in farmer field schools were more aware of climate change issues and perceived themselves as having a higher adaptive capacity compared to non-participants despite having access to similar resources.

Informal microfinance activities also enhance member's social capital that enables them to engage in mutual support activities such as making contributions in support of members who are in need thus enhancing their climate variability resilience. It provides a form of mutual insurance against risks through risk pooling and sharing mechanisms between members. This is in line with Mersland and Eggen (2007) who found that the social networks created through membership to informal microfinance institutions improve social capital of which has a direct impact on resilience. Besides,

Osbahr et al. (2008) observed that the ability to reciprocate through informal institutions, local connections, and family ties are the most significant mechanisms used to buffer households against climate risks disturbance. Perry et al. (2010) noted that social networks and relationships enable people to support each other during difficult times, reinforces collective action, and sharing of ideas and technologies which results in higher adaptive capacity. Social capital also forms the basis of informal microfinance savings and lending activities. According to Mushuku and Mayisha (2014) and Chiteji (2002), lending activities in informal microfinance institutions are based on social capital which determines the financial worth of members and provides social collateral by tapping on preexisting relationships and continued interactions.

Furthermore, social capital facilitates collective action which enables shared learning, empowerment, community-based natural resources management, and better governance. It improves member's performance in entrepreneurship activities by increasing their market access, bargaining power and efficiency due to economies of scale. They enable members to mobilise capital resources to invest in capital-intensive assets and activities such as value addition. Membership to farmer's associations enhances social capital which augments a household's resilience to climate variability by increasing access to information, access to resources, access to markets, and better access to resilience-building technologies (Iheke and Ogodike, 2016; Wall and Marzall, 2004; Sadri et al, 2018). Furthermore, elements of social capital including connectedness, mutual trust, social norms, and values are the basis for good governance, coordination, and peaceful coexistence which creates an enabling environment for climate variability resilience-building activities.

Informal microfinance institutions empower members by enhancing their access to capital assets and collective actions leading to climate variability resilience. This reinforces members' transformative capacity by fostering their financial independence and dignity. Empowerment of members also augments their participation in development and policy decision-making processes hence ensuring that development activities and policy frameworks are people-centered and sustainable, and thus effectively contribute to resilience-building. This aligns with GGLN (2014) who found that informal microfinance institutions improve the transformative capacity of women and low-income people by enhancing their involvement in decision-making processes. Governance arrangements that encourage local level participation and control in decision making, good leadership, broad-based collective action, and community cohesion are vital in dealing with uncertainty and change (Jones et al, 2010; Below et al, 2012; Ratner, 2013).

The characteristics of informal microfinance institutions have positive and negative effects on their contribution to rural household's climate variability resilience. This is by creating conditions that either enhance or constrain the social and financial performance of informal microfinance institutions and thus capacity to contribute to rural household's resilience to climate variability. This is in line with Kipesha (2013) and Scheyvens (2015) who noted that the performance of an organisation is a function of different internal and external factors that influence its operations. Also, Mokhtar (2011) found that the performance of a microfinance institution is influenced by borrower's characteristics, business characteristics and loan and savings

characteristics. According to Hermes and Hudon (2018), the most important determinants of performance in microfinance institutions include their characteristics such as size, age and age; their funding sources; the quality of organisational governance.

The membership characteristics of informal microfinance institutions could affect their contribution to rural household's resilience to climate variability by affecting member's participation. The higher contribution of informal microfinance institutions to climate variability resilience among women could thus be due to their higher participation. This is in agreement with Anderson and Baland (2002) who deduced that participation in informal microfinance institutions is higher among women than men in Kenya. In addition, gender has a strong significant effect on participation in informal microfinance institutions with men, all else being constant, being less likely to participate (Guerin, 2006). The higher contribution of informal microfinance institutions to climate variability resilience among married people could also be due to their higher participation. This is in line with Kadigi (2013) who observed that married people participate more in informal microfinance institutions due to having familial obligations and thus the need to generate adequate income. Furthermore, Anderson and Baland (2002) observed that married borrowers also prefer to join informal microfinance institutions to avoid household conflicts caused by the existence of different spending preferences between spouses. On the other hand, the low contribution of informal microfinance institutions to climate variability resilience among older people could be due to the lower participation of older people. This aligns with the observation by Kedir et al., (2011) that older household heads are less likely to participate in informal microfinance institutions, have lower education, and are more risk-averse.

The membership characteristics of informal microfinance institutions could affect their contribution to rural household's resilience to climate variability by affecting member's informal microfinance performance. Member's informal microfinance performance affects their access to loans and savings and hence the contribution of informal microfinance institutions to rural households resilience. The higher contribution of informal microfinance institutions to climate variability resilience among more educated people could thus be due to higher informal microfinance performance given the higher access to knowledge on microfinance and production, and investment skills. The higher contribution to rural household's climate variability resilience by informal microfinance institutions that conduct training to their members could also be due to higher financial management skills and capacity to invest more wisely and hence higher informal microfinance performance. This is affirmed by Abraham (2014) who found that a higher level of education is associated with a greater ability to access and comprehend information on credit terms and conditions which improves informal microfinance performance. Also, Haile (2015) observed that the training of participants has a positive effect on the performance of microfinance institutions.

Moreover, the characteristics of members affect their dependence on informal microfinance through effects on household's access to resources, financial burden, and vulnerability. This could explain the lower contribution of informal microfinance institutions to household's resilience in larger households since they could have less dependence on informal microfinance

institutions due to having more diverse income sources and labor to engage in livelihood activities. This aligns with Yehuala (2008) who found that bigger households have less demand for credit.

Moreover, higher crop and livestock production is associated with a higher contribution of informal microfinance institutions to climate variability resilience because greater production means greater demand for financial capital, and hence services of informal microfinance institutions. Higher crop and livestock production also means that the members have greater capacity and purpose to participate in informal microfinance institutions, and hence have higher informal microfinance performance. Greater perception of climate variability could translate to greater need and thus investment in resilience-building strategies. This thus leads to greater demand for informal microfinance financial services thus increasing the contribution of informal microfinance institutions to climate variability resilience.

Besides, the leadership characteristics of informal microfinance institutions affect their governance and management and hence social and financial performance. This in turn has an effect on the capacity of informal microfinance institutions in providing services to members and hence contribution to households resilience to climate variability. The low contribution to rural household's climate variability resilience in informal microfinance institutions having a long-term of office for leaders could thus be due to the negative effect on their performance. This is in agreement with Anyango et al. (2007) who found that a long term of office could cause unequal power relations leading to failure in governance as a few dominant and powerful leaders exploit the less powerful members. Moreover, the association of more officials in informal microfinance institutions with a higher contribution to rural household's climate variability resilience could also be due to more officials leading to higher informal microfinance performance. This aligns with Waithaka (2013) who found that the size of the board has a significant positive effect on the performance of a microfinance institution since it means greater management effort, broader linkages, and hence access to capital assets. Manderlier et al. (2008) found that the size of the board has a positive impact on operational efficiency.

Also, informal microfinance institutions whose leaders have had an experience of more years could perform better hence the greater contribution to rural household's climate variability resilience. According to the resource dependence theory, the experience of a leader is a resource that leads to better microfinance performance (Heentigala, 2011). The higher contribution of women-led informal microfinance institutions to rural household's climate variability resilience could also be due to higher performance. This is confirmed by Galema et al. (2009) who noted that female leaders are more prudent and thus effective in managing microfinance institutions. Similarly, informal microfinance institutions whose leaders hold positions in more groups could be having a higher contribution to climate variability resilience due to higher performance. This is in agreement with previous studies including (Ali and Wise, 2009; Hattel et al., 2010; Heentigala, 2011) which found that being a leader in multiple microfinance institutions increases performance since it results in greater experience and expertise.

Informal microfinance institutions having more educated leaders could be better

managed and governed and hence perform better which leads to a higher contribution to rural household's climate variability resilience. This is in agreement with previous studies that gathered that the level of education of the leader is associated with higher microfinance performance including (Waithaka, 2013; Saidu, 2019; Heentigla, 2011). However, although Laonnou and Serafeim (2010) concluded that paying remuneration to leaders increases an organisation's performance by enhancing their motivation and the organisation's capacity to retain skilled and competent leaders. The study found that informal microfinance institutions that paid allowances to their leaders contributed less to climate variability resilience. This could be due to such leaders awarding themselves allowances in a manner that negatively affects the group's financial performance.

The savings and lending characteristics of informal microfinance institutions affect the level of savings, access to loans, loan repayment, and capacity to meet member's financial needs, and hence contribution to household's resilience to climate variability. This is because the savings and lending terms and conditions determine the favorableness of informal microfinance services thus access to financial capital and informal microfinance performance. This aligns with Ebisa et al. (2013) who found a significant positive relationship between loan access and performance of microfinance institutions. Therefore, the association between a longer loan repayment period and the higher contribution of informal microfinance institutions to climate variability resilience could be due to a positive effect on informal microfinance performance. A longer loan repayment period could make the informal credit more favorable and accessible and hence increase access to financial capital and contribution to rural household's climate variability resilience. This agrees with Mokhtar (2011) who noted that the loan repayment period and repayment amount have a positive effect on borrowers' loan repayment performance. Moreover, Pasha and Negese (2014) found a strong association between the suitability of the loan repayment period and informal microfinance performance. The positive relationship between the length of the grace period and the contribution of informal microfinance institutions to rural household's climate variability resilience could be because of greater favorableness and access to loans and higher ability to repay, and hence informal microfinance performance. This is in line with Alemayehu and Lemma (2014) who observed that farmers prefer a longer grace period since it offers a comfortable loan repayment period and hence more favorable credit terms.

Informal microfinance performance could also explain the higher contribution to rural household's climate variability resilience in informal microfinance institutions that follow up on their borrowers. According to Haile (2015), follow-up of borrowers has a positive influence on loan repayment performance in microfinance institutions since it ensures better investment of credit. Also, informal microfinance institutions that don't depend on external funding could have high informal microfinance performance and thus the higher contribution to rural household's resilience to climate variability. Such informal microfinance institutions could have higher lending capital, financial self-sufficiency, and sustainability, and hence capacity to meet members' financial needs and thus contribute to rural household's climate variability resilience. This agrees with Christen et al. (1995) who noted that capital adequacy and thus ability to meet financial requirements enhances the performance of microfinance institutions.

Al Azzam and Mimouna (2012) found that access to loans from commercial banks has a negative influence on the performance of microfinance institutions because it reduces their repayment rates and increases risks.

The informal microfinance institutions having higher interest could be maintaining the higher rates due to greater credit demand which translates to greater loan access, loan repayment performance for example to secure an opportunity for future borrowing amidst the high demand, higher earnings through interests charged on borrowers, and hence higher informal microfinance performance. This is in agreement with Fries and Taci (2002) who concluded that the interest rate of a financial institution determines its revenue and profitability and thus performance. A higher minimum savings contribution per cycle means higher amounts of savings mobilized and hence higher lending capital, greater financial self-sufficiency, and higher financial sustainability, and hence informal microfinance performance. This could explain the reason why a higher amount of savings per cycle is associated with the higher contribution of informal microfinance institutions to climate variability resilience. Conversely, a longer savings contribution cycle means less amount of capital is mobilized which translates into lower financial self-sufficiency, lower financial sustainability, and hence lower informal microfinance performance. This could explain why a longer savings contribution cycle is associated with the lower contribution of informal microfinance institutions to rural household's climate variability resilience. These findings are in agreement with Wambugu and Ngugi (2012) who observed that microfinance institutions need to be self-sustaining to achieve their outreach potential and provide adequate financial services to poor people.

6. Conclusion

Climate variability impacts rural household's through the effect on access to capital assets and thus livelihood strategies and livelihood outcomes. Rural households are also marked by low levels of climate variability resilience which could be due to dependence on climate sensitive economic activities and hence higher exposure and sensitivity, and low adaptive capacity. Nevertheless, local people are not passive recipients of climate variability but respond through various strategies including informal microfinance institutions. Informal microfinance institutions contribute significantly to building rural households resilience to climate variability by enabling them to access to capital assets based on which they undertake livelihood strategies leading to desirable livelihood outcomes and hence resilience. Informal microfinance institutions are therefore a source of climate finance in rural areas and should be considered as a key strategy in policies, strategies, and programs for building rural household's resilience to climate variability. The contribution of informal microfinance institutions to rural household's resilience to climate variability is determined by various factors including their characteristics. Context-specific understanding of determinants of the contribution of informal microfinance institutions to rural household's resilience to climate variability could help to identify factors that could be leveraged and how they could be manipulated to enhance their contribution to rural household's climate variability resilience.

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Tables

Table 1: Computation of the Household Climate Variability Resilience Index

Computation of the household climate variability resilience index				
Variable	Total household's expenditure (KShs.)	Average variable index value	Variable weight	Average weighted variable index value
Expenditure on healthcare	6,960,340	0.090	4	0.362
Expenditure on education	27,918,510	0.036	3	0.109
Expenditure on inputs of crop production	5,577,605	0.088	2	0.177
Expenditure on inputs of livestock production	4,523,270	0.042	1	0.042
Average composite index value				0.172

Table 2: Contribution of Informal Microfinance to Household's Access to Inputs of Crop Production

Contribution of informal microfinance to household's access to inputs of crop production					
Expenditure	Household's total expenditure (KShs.)	Contribution of informal microfinance institutions to household's expenditure (KShs.)	Proportion of informal microfinance institutions contribution (%)	Kendall's tau correlation (τb) between household expenditure and contribution of informal microfinance institutions	
				Coefficient (τb)	Sig. *(p)*
Fertiliser	68,720	30,940	45.02	0.552**	0.000
Manure	49,600	14,350	28.93	0.709**	0.000
Seeds/planting materials	941,105	322,520	34.27	0.459**	0.000
Pesticides/herbicides	1,089,820	338,200	31.03	0.409**	0.000
Irrigation water	88,560	5,050	5.70	0.380**	0.000
Storage facilities	487,700	220,000	45.11	0.799**	0.000
Farmland	643,800	203,700	31.64	0.675**	0.000
Labour	1,517,000	340,300	22.43	0.486**	0.000
Tools	386,960	100,900	26.08	0.504**	0.000
Market/transport costs	304,340	26,900	8.84	0.270**	0.000
TOTAL	5,577,605	1,602,680	28.73	0.447**	0.000

Table 3: Contribution of Informal Microfinance to Household's Access to Inputs of Livestock Production

Contribution of informal microfinance to household's access to inputs of livestock production					
Variable	Household's total expenditure (KShs.)	Contribution of informal microfinance institutions to household's expenditure (KShs.)	Proportion of informal microfinance institutions contribution (%)	Kendall's tau correlation between household expenditure and contribution of informal microfinance institutions	
				Coefficient (τb)	Sig. *(p)*
Fodder	482,450	90,900	18.84	0.628**	0.000
Supplementary feeds	65,320	7,780	11.91	0.520**	0.000
Pastureland	1,012,550	282,600	27.91	0.571**	0.000
Medicine/pesticides	506,060	145,130	28.68	0.371**	0.000
Insemination services	3,950	300	7.59	0.606**	0.000
Water	761,610	281,840	37.01	0.698**	0.000
Shelter	282,610	67,800	23.99	0.512**	0.000
Tools	169,100	60,500	35.78	0.657**	0.000
Labor	1,070,690	164,800	15.39	0.665**	0.000
Market/transport costs	168,930	16,100	9.53	0.282**	0.000
TOTAL	4,523,270	1,117,750	24.71	0.473**	0.000

Table 4: Computation of Contribution of Informal microfinance to the household climate variability resilience index

Computation of contribution of informal microfinance to the household climate variability resilience index				
Variable	Proportion of informal microfinance institutions contribution	Average variable index value	Variable Weight	Average weighted variable index value
Contribution to expenditure on healthcare	29.30%	0.270	4	1.080
Contribution to expenditure on education	29.78%	0.356	3	1.069
Contribution to expenditure on inputs of crop production	29.37%	0.268	2	0.535
Contribution to expenditure on inputs of livestock production	24.19%	0.228	1	0.228
Average composite index value				0.670

Table 5: Kendall's Tau-b correlation Analysis on the Relationship between the characteristics of Informal Microfinance Institutions and the Contribution of Informal Microfinance Institutions to Household's Climate Variability Resilience Index

Kendall's tau-b correlation analysis on the relationship between the characteristics of informal microfinance institutions and the contribution of informal microfinance institutions to household's climate variability resilience index				
#	Variable	Values of the categorical variables	**Coefficient (τ_b)**	**Sig *(p)***
1	Member's sex	1 = Male, 2 = Female	+0.017	0.691
2	How member's household is headed	1 = Male headed, 2 = Female headed	-0.005	0.906
4	Age of the member		-0.029	0.477
5	Member's marital status	1 = Married, 2 = Separated, 3 = Single, 4 = Widowed, 5 = Divorced	-0.020	0.617
6	Level of education	1 = None, 2 = Nursery school, 3 = Primary uncompleted, 4 = Primary completed, 5 = Secondary uncompleted, 6 = Secondary completed, 7 = Tertiary/college	+0.022	0.578
7	Member's household size		-0.038	0.298
8	Member's household agricultural production (Value of crop and livestock production)		+0.171*	0.000
9	Member's perception of climate variability	1 = High, 2 = Low	-0.034	0.424
10	Member's vulnerability to climate variability		+0.096*	0.017
11	Number of years member has belonged to informal microfinance institutions		-0.070*	0.050
12	Number of groups member belongs to		-0.026	0.508
13	If member holds leadership position in the group	1 = Yes, 2 = No	+ 0.017	0.681
14	Amount of savings in groups i.e., contribution per month (KShs.)		+ 0.015	0.673
15	Loan access i.e., number of times member received loans from the groups		+ 0.055	0.129
16	Age of the group in years		-0.061	0.089
17	Number of members in the group		-0.052	0.152

18	Group composition by gender		+0.001	0.984
19	Ability of the group to fully meet its financial needs	1 = Yes, 2 = No	-0.012	0.771
20	If the group belongs to an umbrella organisation	1 = Yes, 2 = No	-0.025	0.555
21	If group organizes trainings for its members	1 = Yes, 2 = No	-0.061	0.593
22	Group's length of term of office in years		-0.174*	0.000
23	Number of group officials		+0.011	0.780
24	If the group gives allowances to officials	1 = Yes, 2 = No	+0.100*	0.018
25	Number of years the group leader has been an official in informal microfinance institutions		+0.005	0.890
26	Level of education of the group leader	1 = None, 2 = Nursery school, 3 = Primary uncompleted, 4 = Primary completed, 5 = Secondary uncompleted, 6 = Secondary completed, 7 = Tertiary/college	+0.021	0.595
27	Gender of the group leader	1 = Male, 2 = Female	+0.104*	0.014
28	If group leader holds leadership position(s) in other groups	1 = Yes, 2 = No	+0.089*	0.034
29	Group's length of savings contribution cycle		-0.013	0.755
30	Group's length of full-cycle		-0.019	0.647
31	Group's minimum savings contribution per cycle		+0.009	0.809
32	Group's loan interest rate		+0.109*	0.007
33	Group's length of loan grace period		+0.215*	0.000
34	Group's maximum loan repayment period		+0.037	0.357
35	If group follows up on loan borrowers	1 = Yes, 2 = No	-0.041	0.329
36	If the group seeks external funding	1 = Yes, 2 = No	+0.024	0.572

Modelling of Pump Efficiency using Neural Networks and Support Vector Regression

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Abstract

The operation of pumps requires considerable amounts of energy depending on the size of the pump and the pumping demands. Depending on how efficient the pump is, significant amounts of energy are lost – in the form of heat – during pumping operations. To ensure that the pumps operate optimally, the pumps' efficiency is often used as one of the performance indicators. Analysis of the pump efficiency requires laborious, tedious, costly laboratory measurement of the pump's exit pipe pressure head, the elevation head, the velocity head, the pump's impeller's revolution per minute (RPM), pump's electrical power input, and the pump's discharge. To circumvent these challenges, modelling of pump efficiency is used as a supplement and/or an alternative to the laboratory measurement of the pump efficiency-based variables.

In this study, machine learning models are used to simulate pump efficiency based on laboratory observations. These machine learning models include: a single-layer (artificial) neural network model, ten multiple-layer (deep) neural network models, and three support vector regression (SVR) models. The objective of this study is to evaluate efficacy of the machine learning models to simulate pump efficiency. Results suggest that the deep neural networks outperformed both the artificial neural networks and support vector regression models.

The results further show that the deep neural networks outperformed the rest of the machine learning models, and they had Nash-Sutcliffe efficiency (NSE) , percent bias error (PBIAS), coefficient of determination (R2), root mean squared error (RMSE), and Willmott's degree of agreement (d1) of 100%, <|0.133%|, 1, <0.08%, and >0.99, respectively, in the training phase, and >93%, <|1.4%|, >0.93, <1.7%, and >0.91, in the testing phase.

Keywords: **Pump Efficiency, Artificial Neural Networks (ANN), Deep Neural Networks (DNN), Support Vector Regression (SVR), Radial Basis Function (RBF), Machine Learning, Modelling.**

Highlights

- DNN outperform the rest of the machine learning models in modelling pump efficiency.
- Increasing complexity of the DNN does not significantly improve their performance.
- RBF-based SVR is superior to the rest of the SVR-based models.

1. Introduction

Pumps are the most energy consuming part of hydraulic systems. In the USA, pumps consume 80% of the electrical energy, particularly in the drinking water distribution systems (Carter, 2017). The national electricity consumption by pumps is at 25–30% in Poland (Szychta & Figura, 2012), which is slightly above global consumption of 20% (Yates, 2003). During a life cycle of a typical pump (~20yrs), the energy cost accounts for 55% of the total cost. This is followed by the maintenance cost which gobbles up 29% of the pump's life cycle cost. Surprisingly, the initial cost and the installation cost each account for 8% of the total cost during the pump's life cycle (Grassiano, 2017).

Generally, the energy efficiency of a pump declines as the pump ages. The pump performance is affected by factors such as the pump type and environmental factors, among other influences. In the geothermal heat pumps (GHPs), for example, the performance depends on the characteristic of the groundwater, the geothermal well pump, and the heat pump. On the other hand, outside air temperature variation affects an air-source heat pump (Kavanaugh & Rafferty, 1997); whereas the compressor speed affects the performance of the solar assisted heat pump (Chaturvedi et al., 1998).

A study that was conducted in the Galt House East Hotel and 140 waterfront office buildings in Louisville, Kentucky – which have the biggest installation of GHPs in the USA – shows that GHPs use 53% of the energy demand of non- GHPs, resulting in energy savings of US$25000/month (Ozgener & Hepbasli, 2005).

In general, the energy losses from the pump-based hydraulic systems are categorised into two groups: the major losses, which stem from friction along the pipeline, and the minor losses that are caused by changes in flow direction along the pipeline (e.g., due to bends and fittings). Other factors include the fluid flow instability-based pressure pulsation, the faulty impellers, the faulty diffusers, and the associated vibration result in the energy loss during pumping operations. Prolonged faults and vibration result in the wear and tear of the pumps and the decline in the pump operational performance. The pump performance is mostly assessed based on the pump efficiency. Pump efficiency values of >60% are generally acceptable, and 50—60% are the most common pump efficiency values (U.S. Department of Energy (DOE), 2005). Opportunities to improve pump efficiency, through repair and replacement of the faulty parts, are often missed because the pump inefficiencies are not easily noticed. Assessment of pump performance involves measurement of the pump efficiency variables such as the electrical power input, the elevation head, the velocity head, the pressure head, and the revolution per minute (RPM). However, the laboratory measurement of pump efficiency

is always costly and time consuming. Modelling of pump efficiency has been used as an alternative to the measurement of pump efficiency.

A number of modelling approaches have been deployed to model pump efficiency. Pump efficiency has been determined from the numerical method that is based on the unconstrained gradient approach-based optimization algorithm (Anagnostopoulos, 2009). Multi-objective optimisation has been used to assess the performance of a heat pump (Ahmadi et al., 2016). Exergy analysis-based optimization has been used to assess the performance of the heat pump (Bilgen & Takahashi, 2002; Torres-Reyes & Cervantes de Gortari, 2001). Other studies have used both the energy and exergy-based optimisation to assess the energy and exergy-based efficiency of the ground-coupled heat pump (GCHP) (Esen et al., 2007; Hepbasli, 2005; Yan et al., 2016), and solar assisted GHPs (Ozgener et al., 2005). Computational fluid dynamics (CFD)-based numerical analysis of pump efficiency has been used in most of the pump design-based studies (Anderson et al., 2000; Medvitz et al., 2002).

Even though machine learning techniques have not been used in pump efficiency, these techniques have gained popularity in modelling other water engineering applications (Achieng, 2019c, 2019a, 2021; Achieng, Zhu, et al., 2019; Achieng & Enderlin, 2021; Achieng & Zhu, 2019). The support vector regression (SVR), the artificial neural network (ANN), and the deep neural network (DNN) models are increasingly being used to model water quality (Noori, Yeh, et al., 2015; Speight et al., 2019)a proper methodology was proposed to determine the uncertainty of support vector machine (SVM, the retention dam's trap efficiency (Parsaie et al., 2018), the weir discharge coefficients and head losses (Haghiabi et al., 2017; Parsaie & Haghiabi, 2017), and the river dispersion coefficient (Noori, Deng, et al., 2015). ANN consists of three layers: the input, hidden, and output layers. The ANN uses neurons as the computational elements. The neurons are activated by the activation functions. DNN is structurally the same as the ANN. However, the DNN has more than one hidden layer. On the other hand, the SVR models use kernels as the computational elements.

In this study, the efficacy of modelling pump efficiency is investigated based on the ANN, DNN and SVR models. Pump efficiency was modelled for a vertical axial flow pump.

2 Methods

2.1 Laboratory Pump's Data Collection

Machine learning models are trained by mapping input variables to the desired known output variable. The actual pump efficiency is determined based on actual measurements of the pump's electrical power input, the flow rate, and the total hydraulic head. The total head is determined by measuring the elevation head, the pressure head, and the velocity head. The elevation head is measured as the distance between the reservoir's water surface and the centerline of the pump discharge pipe. The velocity head is computed from the measured pump's water discharge through a 1.829-m discharge pipe. The pump water discharge is measured using a weighing tank. The pump's discharge pipe flow rate is regulated using a discharge valve. The valve has a plate that has six holes. The flow rate can be reduced by swinging the valve lever to any of the holes. Putting the valve on the first hole allows full discharge, whereas

putting the valve onto the second hole to the sixth hole progressively reduces the flow rate from 95% to 10%, respectively. Besides the discharge, the pump's electrical power input is read off from the inverter; the pressure head is recorded from the pressure gauge; and the pump's impeller RPM is measured using a tachometer. Further details about the laboratory data collection can be found in Achieng (2019).

2.2 Actual Pump Efficiency

The actual pump efficiency is calculated by dividing the pump power output by the electrical power input. The power input comes from the power unit – the electric motor. An internal combustion engine can also be used as a power unit. The power output is computed as the product of the flow rate and the total hydraulic head. The power efficiency is expressed as shown (Koor et al., 2016; White, 2011; Winoto et al., 2000):

$$E=\frac{\gamma Q H}{P_e}\times 100 \quad (1)$$

Where: E is the actual power efficiency (%); is the electrical power input (kW); is the discharge/flow rate (m3/s); is the pump total hydraulic head (m); is the specific weight of water (9.81 kN/m3).

The total head is formulated from Bernoulli Equation (Méhauté, 1976; White, 2011) as shown as:

$$H=\Delta z+\frac{\Delta P}{\gamma}+\frac{V^2}{2g} \quad (2)$$

Where: ΔP is the discharge pressure head; is the water velocity through the pump discharge pipe; is the gravitational acceleration (9.81m/s2).

2.3 Architecture and Training of Neural Network Models

Designing, training, and testing are fundamental components towards creating any machine learning framework. The design of a neural network – otherwise known as topology or the structure of the neural network – encompasses the number of hidden layers contained between the input and output layers of the network; and the number of neurons per hidden layer. The neural network model used in this study is represented as shown in Figure 1 below.

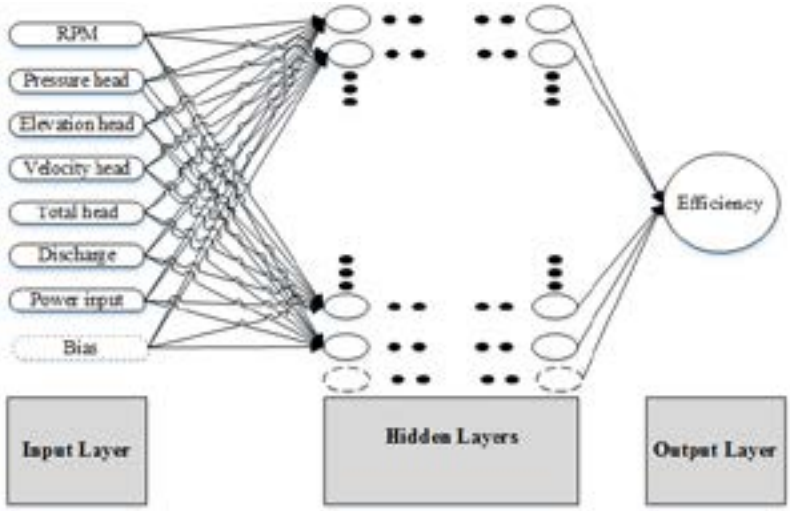

Figure 1. ***The neural network model simulating pump efficiency. The circles in the hidden layer are neurons. Each hidden layer has one dotted circle that represents bias term.***

The neural network topology dictates the number of variables contained in the neural network model. The aim of training a neural network is to minimise the mean squared error between the neural network model and the observations. This error function is called the cost function or the loss function. In order to get the optimal neural network model parameters (weights and biases) that minimise the mean squared error, and thus fitting the model onto the observations, the cost function must be minimised with respect to the model parameters. Suppose we have training examples $(\mathbf{x}_1, y_1), (\mathbf{x}_2, y_2), \ldots, (\mathbf{x}_n, y_n)$ where x is m-dimensional input (e.g. RPM, discharge pressure head, pump elevation head, discharge velocity head, and electrical power input) and y is a 1-D output/target variable (the actual pump efficiency), with a neural network with hidden layers and neurons per layer. The number of weights and the biases of the entire neural network are $K \times K \times L$ and $K \times L$, respectively. Thus all weights and biases are put in a vector such that:

$$W = \begin{bmatrix} 1stLayer: w_{01}^{1}, w_{02}^{1}, \ldots, w_{0K}^{1}; w_{11}^{1}, w_{12}^{1}, \ldots, w_{1K}^{1}; w_{21}^{1}, w_{22}^{1}, \ldots, w_{1K}^{1}; \ldots; w_{J1}^{1}, w_{J2}^{1}, \ldots, w_{JK}^{1}; \\ 2ndLayer: w_{01}^{2}, w_{02}^{2}, \ldots, w_{0K}^{2}; w_{11}^{2}, w_{12}^{2}, \ldots, w_{1K}^{2}; w_{21}^{2}, w_{22}^{2}, \ldots, w_{1K}^{2}; \ldots; w_{J1}^{2}, w_{J2}^{2}, \ldots, w_{JK}^{2}; \\ LthLayer: w_{01}^{L}, w_{02}^{L}, \ldots, w_{0K}^{L}; w_{11}^{L}, w_{12}^{L}, \ldots, w_{1K}^{L}; w_{21}^{L}, w_{22}^{L}, \ldots, w_{1K}^{L}; \ldots; w_{J1}^{L}, w_{J2}^{L}, \ldots, w_{JK}^{L} \end{bmatrix} \quad (3)$$

Note that, the biases associated with all neurons in the L layers are also put in the vector W such that all bias terms take the superscript "0" e.g., w_{01}^{1} is the bias term associated with neuron 1 in the current layer 1.

Based on model parameter W, the cost function of a neural network model is expressed as:

$$J(W) = \frac{1}{2n}\sum_{i=1}^{n}(f(x_i; W) - y_i)^2 \quad (4)$$

In order to find the model parameters that fit the output, the cost function with respect to W is minimised. Random initial guesses of the model parameters in W are made and the parameter values simultaneously updated by taking small steps. These steps are partial derivatives of W with respect to a give parameter. The small steps are implemented by multiplying the partial derivatives with a small number (often less than 1) before updating the parameter. Taking small steps ensures that the minimum value of $J(W)$ is not missed. However, small steps that are too small mean that it takes a longer time period to reach the minimum $J(W)$, and bigger steps mean that the minimum may be missed by jumping over the i.e. $J(W)$ not converging to the minimum or even diverging from the minimum value. The constant multiplied by the partial derivative of $J(W)$ is called the learning rate, and each step involving updating the model parameter vector W is called an iteration or an epoch.

The objective function (cost function) that is optimised can be represented as:

$$minimize \underbrace{J(W)}_{w_{0k}^{l}, w_{jk}^{l}} = \frac{1}{2n}\sum_{i=1}^{n}(f(x_i; W) - y_i)^2 \quad (5)$$

(For a given number of steps, the simultaneous updates on the model parameters (biases and weights) can be implemented as:

$$forstepssS, \begin{Bmatrix} temp0 := w_{0k}^{l} - \alpha \frac{\partial}{\partial w_{0k}^{l}} J(W) \\ temp1 := w_{jk}^{l} - \alpha \frac{\partial}{\partial w_{jk}^{l}} J(W) \\ w_{0k}^{l} = temp0 \\ w_{jk}^{l} = temp1 \end{Bmatrix} \quad (6)$$

Where: α is the learning rate; := is the assignment operator; *temp*0 is a temporary variable that holds the bias parameter value during the update in a given step; *temp*1 is

a temporary variable that holds the weight parameter value during the update in a given step.

Note that the parameter update is carried out until the cost function is zero or small enough. This process of moving from the initial guess to the final minimum value of the cost function is called gradient descent. The computation sequence in the neural network model can be visualised as shown in **Figure 2** below.

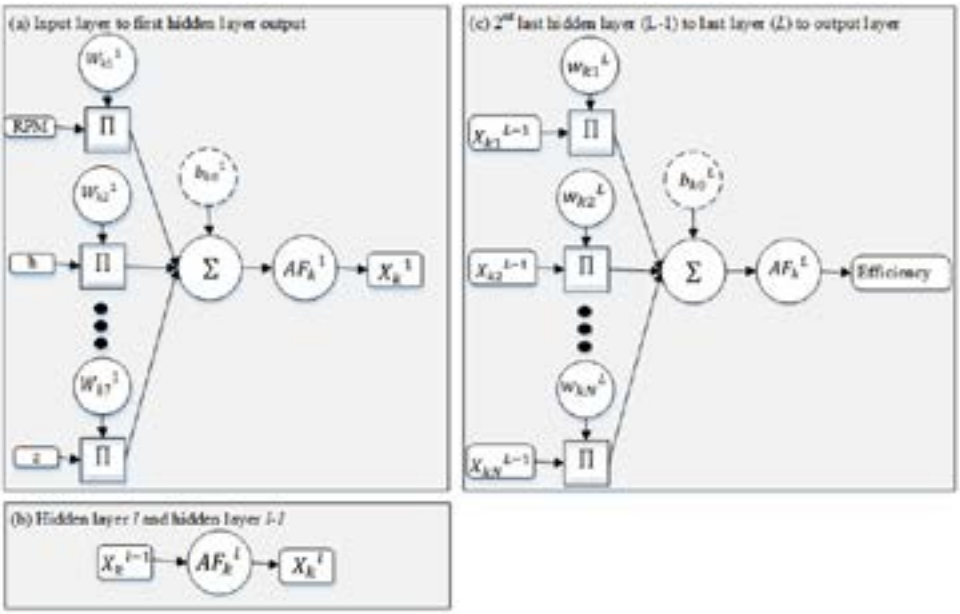

Figure 2. ***Computation Sequence (a) between input layer and first hidden layer, (b) between hidden layers, and (c) between the last hidden layer and the output layer. NOTE: RPM is the revolution per minute of pump impeller; h is pressure head; and z is elevation head.***

A total of ten neural networks models were used to simulate the pump efficiency: An artificial neural networks (ANN) model and nine deep neural networks (DNN) models. The DNN containing two hidden layers was named DNN2, the DNN that contained three hidden layers was named DNN3, and so on.

2.4 Training Support Vector Regression Models

Given training examples a multi-variate regression model between the input variables (e.g. the RPM) **x** (m-dimensional) and the output variable (the pump efficiency) *y* (1-D) is formulated as shown below:

$$f(x:w) = w_1x_1 + w_2x_2 + \cdots + w_{m-1}x_{m-1} + w_mx_m + b \quad (7)$$

Where: $(w_1, w_2, \ldots, w_{m-1}, w_m)$ are weights of the input variables $(x_1, x_2, \ldots, x_{m-1}, x_m)$ and ***b*** is the bias. The weights can be put in a vector*w*. The objective of the SVR model is to find a regression model that not only fits the data, but is also not very complex. Therefore, the objective function that is optimized, should be optimised to

reduce error and to get a suitable model of appropriate complexity. A tradeoff parameter is incorporated in the objective function that strikes a balance between model complexity and minimising the error.

Unlike the neural network, the objective function (i.e., the cost function) of a support vector regression model is constrained cost function. Moreover, the SVR's cost function is absolute error function, while a neural network's objective function is squared error function. The SVR's cost function is constrained by the support vectors – a subset of the training examples that is used for optimization. The support vectors are points that lie outside the *-insensitive* tube/zone. The *-insensitive* tube/zone is the zone within which the error between the model the observation is assumed to be negligible. The size or radius of the tube is . The constrained cost function of SVR is optimized with respect to the weight vector and the tradeoff variable *C*, as represented below.

$$\underset{w,b,C}{minimize}\, J(w,b,C) = \|w\|^2 + C\sum_{i=1}^{n}|f(x_i;w) - y_i|, i = 1,2,\dots,n \quad (8)$$

The SVR cost function is often formulated as shown below:

$$\underset{\mathbf{w},b,C}{minimize}\, J(\mathbf{w},b,C) = \|\mathbf{w}\|^2 + C\sum_{i=1}^{n}(\xi_i + \xi_i^*) \quad (9)$$

Subject to:

$$(w_1x_1 + w_2x_2 + \cdots + w_{m-1}x_{m-1} + w_mx_m + b) - y_i \le \varepsilon + \xi_i^* \quad (10)$$

$$y_i - (w_1x_1 + w_2x_2 + \cdots + w_{m-1}x_{m-1} + w_mx_m + b) \le \varepsilon + \xi_i \quad (11)$$

$$\xi_i, \xi_i^* \ge 0 \Rightarrow \sum_{i=1}^{n}(\xi_i + \xi_i^*) \ge 0 \quad (12)$$

Where: ***ξi and ξi**** and are slack variables that measure how far the target points are, above and below respectively, from the *-insensitive* tube/zone.

Lagrange method is used to solve the SVR constrained cost function by merging the cost function and its constraints, using Lagrange multipliers as multiplicative factors to the constraints which are summed with the cost function, into a single equation (Lagrange equation). Partial derivatives of the Lagrange equation are taken with respect to each of the constraints, and the results are equated to zero. The partial derivatives are simplified and substituted back to the constraints expressions, and into the cost function itself. The resulting expression is a cost function that is solved using the quadratic programming numerical method. The resulting Lagrange equation is expressed as:

$$\begin{aligned}\underset{\mathbf{w},b,C,\xi_i,\xi_i^*}{\text{minimize}}\, L(\mathbf{w},b,C) = {} & \frac{1}{2}\|\mathbf{w}\|^2 + C\sum_{i=1}^{n}(\xi_i + \xi_i^*) - \sum_{i=1}^{n}(\eta_i\xi_i + \eta_i^*\xi_i^*) \\ & - \sum_{i=1}^{n}\alpha(\varepsilon + \xi_i - y_i + w\cdot x_i + b) \\ & - \sum_{i=1}^{n}\alpha^*(\varepsilon + \xi_i^* + y_i - \mathbf{w}\cdot\mathbf{x}_i - b)\end{aligned} \quad (13)$$

Subject to the constrained:

(ηi, ηi≥0*

αi, α i≥0)* (14)

Partial derivatives of the Lagrange equation are equated to zero to give:

$$\frac{\partial L}{\partial w} = \mathbf{w} - \sum_{i=1}^{n}(\alpha \mathbf{x}_i - \alpha^* \mathbf{x}_i) = 0 \quad \Rightarrow \quad \mathbf{w} = \sum_{i=1}^{n}(\alpha - \alpha^*)\mathbf{x}_i \tag{15}$$

$$\frac{\partial L}{\partial b} = (\alpha^* - \alpha\ ) = 0 \tag{16}$$

$$\frac{\partial L}{\partial \xi_i^*} = C - \eta_i^* - \alpha^* = 0 \quad \Rightarrow \quad \eta_i^* = C - \alpha^* \tag{17}$$

Since $w = \sum_{i=1}^{n}(\alpha - \alpha\ )x_i$ from the partial derivative of the Lagrange function, which can be substituted into the SVR function (), the dual formulation-based SVR function is expressed as:

$$f(x) = \sum_{i=1}^{n}(\alpha_i - \alpha_i^*)\langle \mathbf{x_i}, \mathbf{x} \rangle + b \tag{18}$$

By substituting the above partial derivatives back into the Lagrange function (equation 6.1), we get constrained optimisation formulation called "dual formulation". The dual formulation-based constrained optimization problem is set up as:

Constraint to:

$$0 \le \alpha_i, \quad \alpha_i^* \le C; \quad \sum_{i=1}^{n}(\alpha_i - \alpha_i^*) = 0 \tag{21}$$

Non-linear SVR optimization in dual formulation is represented as:

$$\textit{maximize: } L(\alpha) = \begin{cases} \frac{1}{2}\sum_{i=1}^{n}(\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*)\,\langle \phi(\mathbf{x_i}), \phi(\mathbf{x_j}) \rangle & (22) \\ -\varepsilon\sum_{i=1}^{n}(\alpha_i + \alpha_i^*) + \sum_{i=1}^{n} y_i(\alpha_i - \alpha_i^*) & (23) \end{cases}$$

Constraint to:

$$0 \le \alpha_i, \cdots \alpha_i^* \le C; \cdots \sum_{i=1}^{n}(\alpha_i - \alpha_i^*) = 0 \tag{24}$$

In the non-linear SVR, the dot-product of the mapped input variables $\langle \phi(x_i), \phi(x_j) \rangle$ is replaced is replaced with a kernel $K(x_i, x_j)$ i.e. $\langle \phi(x_i), \phi(x_j) \rangle = K(x_i, x_j)$. Therefore, the non-linear SVR optimisation in dual formulation is often represented as:

Constraint to:

$$\textit{maximize: } L(\alpha) = \begin{cases} \frac{1}{2}\sum_{i=1}^{n}(\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*)\,K(\mathbf{x_i}, \mathbf{x_j}) & (25) \\ -\varepsilon\sum_{i=1}^{n}(\alpha_i + \alpha_i^*) + \sum_{i=1}^{n} y_i(\alpha_i - \alpha_i^*) & (26) \end{cases}$$

Constraint to: $0 \le \alpha_i, \quad \alpha_i^* \le C; \quad \sum_{i=1}^{n}(\alpha_i - \alpha_i^*) = 0$ (27)

The regression function, in dual formation, of the non-linear SVR is given by:

Where: $(\alpha_i - \alpha_i^*)\phi(\mathbf{x_i}) = \mathbf{w}$

2.5 SVR kernels

Three SVR kernels are used to simulate the pump efficiency in this study. The first kernel is the radial basis function (RBF) kernel. This kernel follows a Gaussian process and is expressed as shown below:

$$K(x,x_i)=exp(-\gamma\|x-x_i\|^2) \quad (29)$$

Where: γ =RBF kernel parameter which is set by the user when fitting the SVR regression model.

Unlike RBF, the linear kernel does not have any kernel parameter, and it is expressed as:

Unlike RBF, the linear kernel does not have any kernel parameter, and it is expressed as:

$$K(x,xi)=x\hat{}T\,xi \quad (30)$$

The polynomial kernel of second degree (quadratic kernel) is the third SVR kernel that is used in this study. It has one kernel parameter – the degree of the polynomial – and is expressed as:

$$K(x,x_i)=(1+ x^Tx_i)^d \quad (31)$$

Where: ***d*** =degree of the polynomial. The value of d is 2 for quadratic kernels.

Quadratic programming (QP) (Frank & Wolfe, 1956; Gould & Toint, 2002) – a numerical method that involves optimising a given quadratic objective function subject to one or more constraints that are linear equality and inequality – is used to solve optimisation involving minimising regression slope, during which the hyperparameters () and kernel parameters (for non-linear SVR) are solved for, in both linear and non-linear SVR, and therefore implemented in this study.

2.6 Evaluation of Performance of the Pump Efficiency-based Machine Learning Models

The performance of the machine models, in simulating pump efficiency, was determined based on the widely used models performance indices: the coefficient of determination (R2), the Willmott's degree of agreement, the Nash–Sutcliffe model efficiency coefficient (NSE), the percent bias error (PBIAS), and the root mean square error (RMSE).

$$R2 = \left(\frac{\frac{1}{n}\sum_{i=1}^{n}(O_i - \mu_O)(m_i - \dot{m_i})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(O_i - \mu_O)}\sqrt{\frac{1}{n}\sum_{i=1}^{n}(m_i - \dot{m_i})^2}} \right)^2 \quad (33)$$

$$d1 = \left[1 - \frac{\sum_{i=1}^{n}|O_i - m_i|}{\sum_{i=1}^{n}\{|O_i - \mu_O| + |O_i - \mu_O|\}}\right] \quad (34)$$

$$NSE(\%) = \frac{\sum_{i=1}^{n}(O_i - m_i)}{\sum_{i=1}^{n}(O_i - \mu_O)} \quad (35)$$

$$PBIAS(\%) = \left[\frac{\sum_{i=1}^{n}(m_i - O_i)}{\sum_{i=1}^{n} O_i}\right] \times 100 \quad (36)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(m_i - O_i)^2} \quad (37)$$

where O_i is the laboratory observed/actual pump efficiency (%); μ_O is the mean pump efficiency (%); $(\acute{m}_i)$ is the modeled recharge pump efficiency (%); is the mean modeled pump efficiency (%); and is the number of samples.

3. Results and Discussion

3.1 Actual Pump Efficiency

The actual pump electrical input efficiency – that is based on measured pump variables –increases with increase in the pump water discharge from the discharge of 0.002 (m3/s) and briefly plateaus at a discharge of 0.026 (m3/s), as shown in **Figure 3**. The peak actual electrical input efficiency is about 45%. Further increase in discharge beyond peak efficiency leads to a decrease of efficiency to a minimum of 10% – which corresponds to a maximum discharge of 0.052 (m3/s). The low maximum efficiency can be attributed to the fact that the pump is relatively an old pump (about 50 years old).

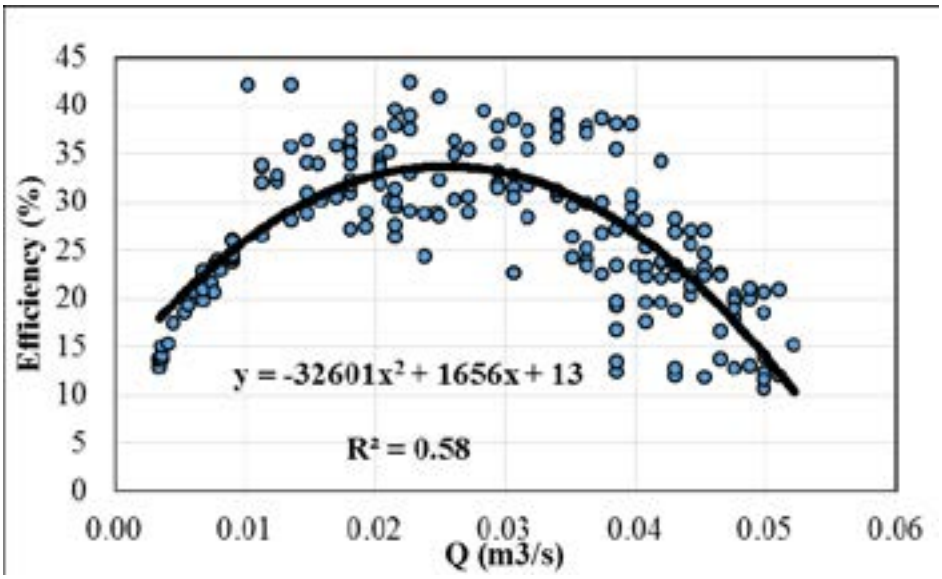

Figure 3. ***The pump flowrate (Q) versus the actual pump efficiency.***

3.2 Training the Neural Network: Parameter Optimisation

To model the pump efficiency within the neural networks framework, ten neural networks were trained by minimising the squared error between the modeled and the actual pump efficiency. The coefficient of determination (R2) was also monitored alongside the mean squared error. The neural network models were considered fully calibrated when the squared error was minimum and the R2 was maximum, and both stopped changing with further training. Beyond the iteration of 1e+4, the root means squared error (RMSE) and the R2 values across all the neural networks models stabilise as shown in **Figure 4.** The RMSE declines to a value of near zero, whereas the R2 increases to 1 with further training beyond 10e+4 iterations. The iteration value of 10e+5 was chosen as the optimal value. With respect to the number of neurons per hidden layer, the RMSE and the R2 stop to decline and increase, respectively, beyond 150 neurons, as shown in **Figure 5.** Therefore, 200 neurons per hidden layer was

used as the optimal number of neurons for the neural networks models. The learning rate regulates the rate of gradient descent during optimisation of the neural networks. The learning rate values typically take a value greater than zero, but smaller than 1. During training, relatively smaller learning rate values make the neural network models approach optimal squared error values slowly, whereas relatively large learning rate values may cause the models to overshoot the minimum squared error and/or diverge. The squared error of most neural networks models seems to be minimum for learning rate values of 0.0001 to 0.1, as shown in **Figure 6**. Therefore, the learning rate value of 0.001 was selected as the optimum value. The oscillation of the error during training of the neural networks models could be attributed to the tendency of these models to get stuck in the local minimum.

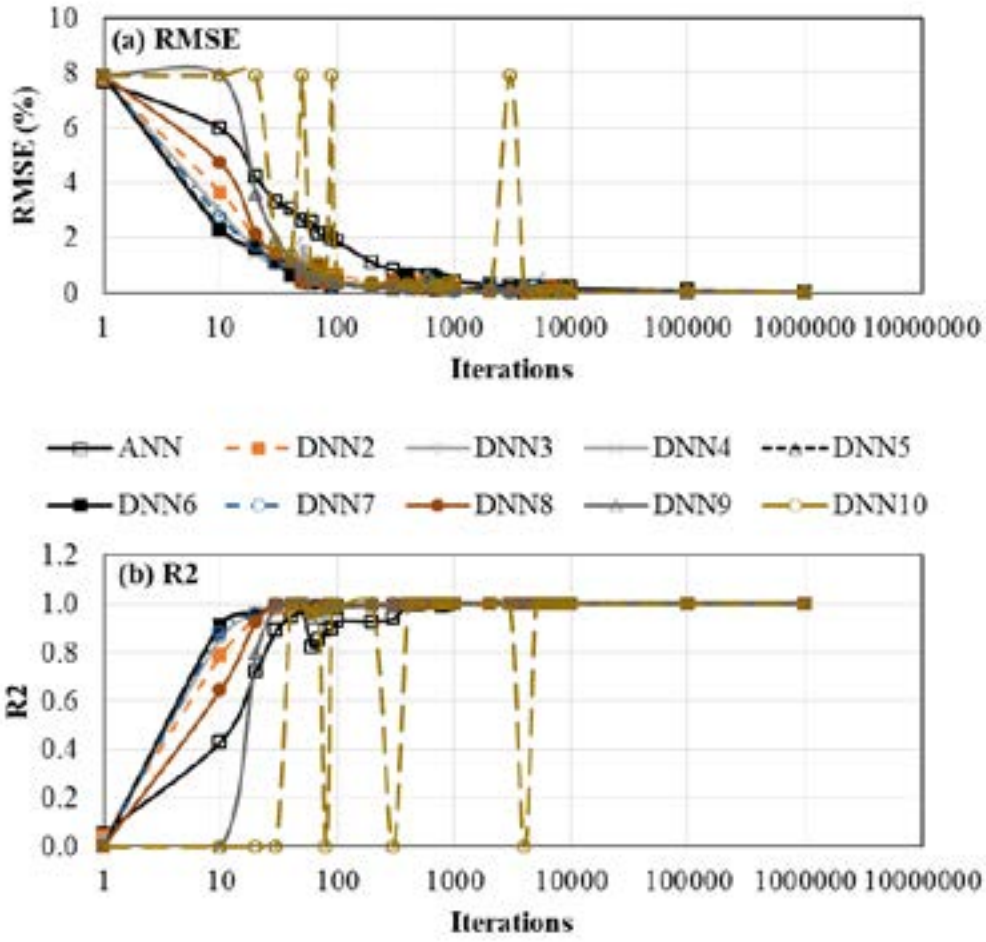

Figure 4. ***Optimisation of the number of the iterations when training the neural networks models***

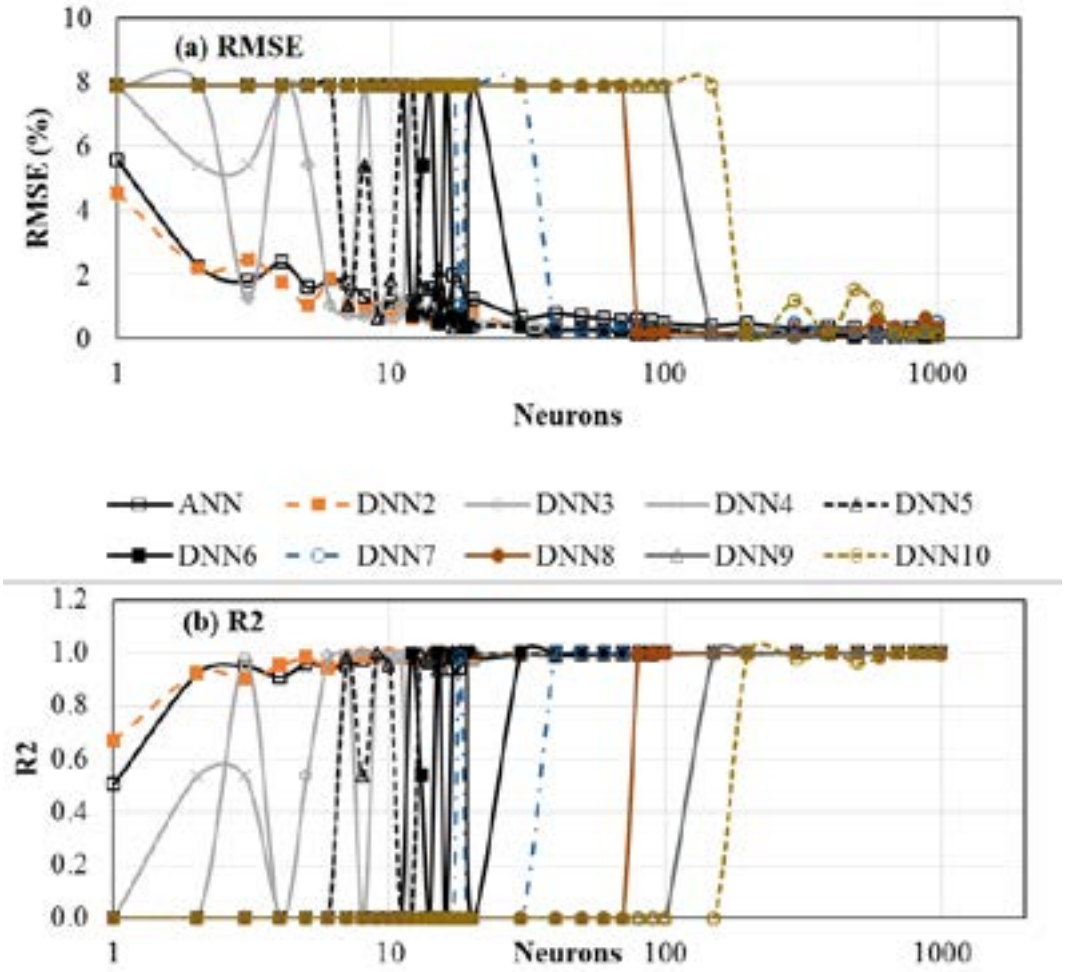

Figure 5. ***Optimisation of the number of the neurons per hidden layer when training the neural networks models.***

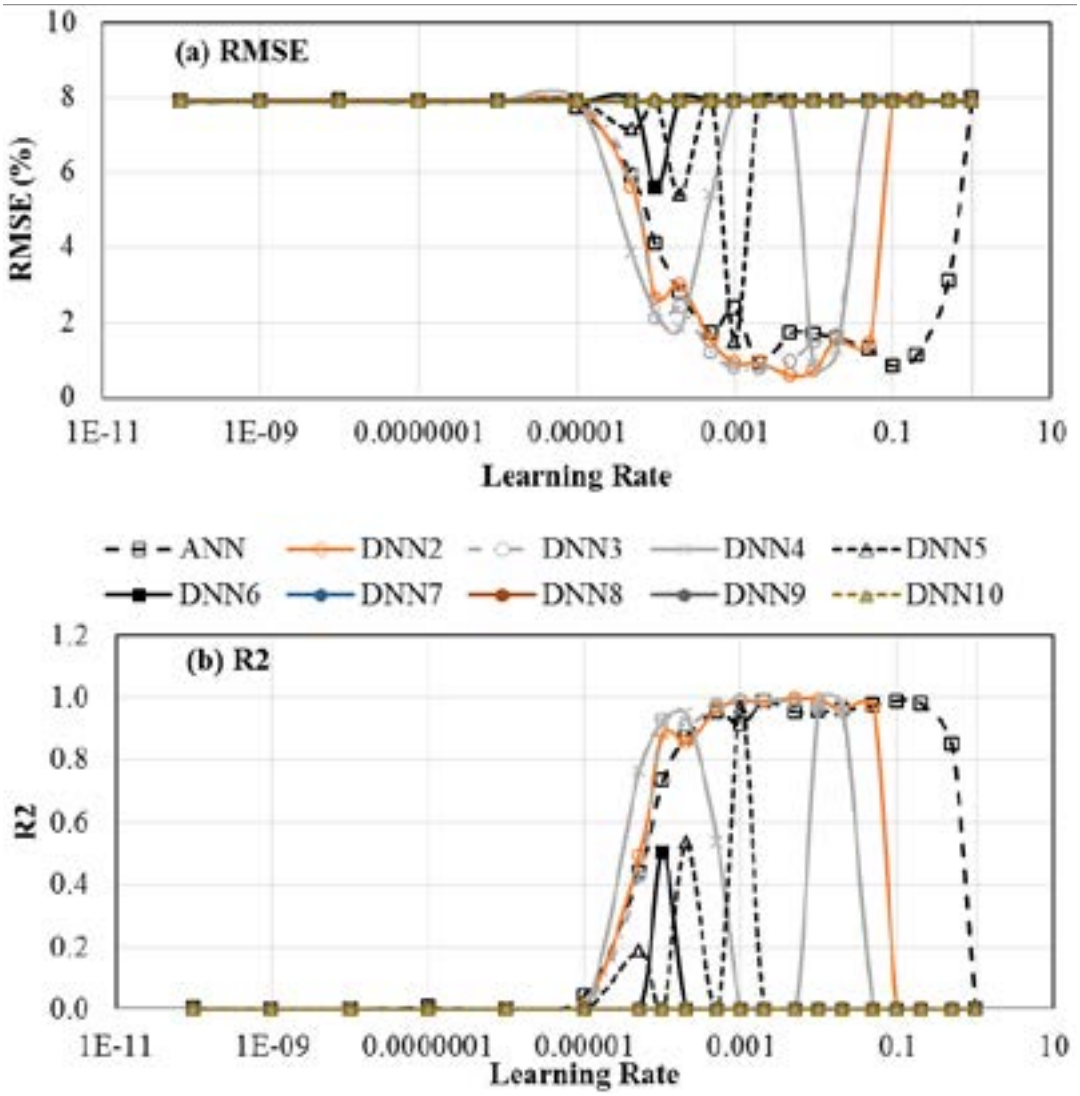

Figure 6. ***Optimisation of learning rate values when training the neural networks models***

3.3 Training the Support Vector Regression Models: Parameter Optimisation

The support vector regression (SVR) models were also trained by minimising the squared error. However, instead of using gradient descent, a Lagrange-based approach was used. The Lagrange-based optimization method is used because an SVR model's objective function is constrained optimisation. Therefore, the objective of optimising SVR models is to obtain the optimal value of hyperparameter C that minimises the squared error between actual and modeled pump efficiency. As can be seen in **Figure 7**, the RMSE declines with increase in C. Beyond a C value of 100, there is no further change in RMSE of the three SVR models. The R2 also increases as C increases, and plateaus at C values greater than 100. The optimal C value of 1000 was used as the optimal value across the three

SVR models. Notice that unlike the neural networks models, the decline of squared error is smooth because the SVR models do not get stuck in local minimum (Wang et al., 2009). Apart from the hyperparameter C, the RBF-based SVR also has parameter "gamma" that has to be optimised. Optimization results show that the squared error does not change as the gamma value is increased from 1e-8 to 1e+8 as shown in **Figure 8.** Therefore, a gamma value of 0.001 was used. This can be attributed to the fact that the gamma optimisation was done after finding the suitable C value. Moreover, the constant RMSE of 0.6% is already small during training of gamma.

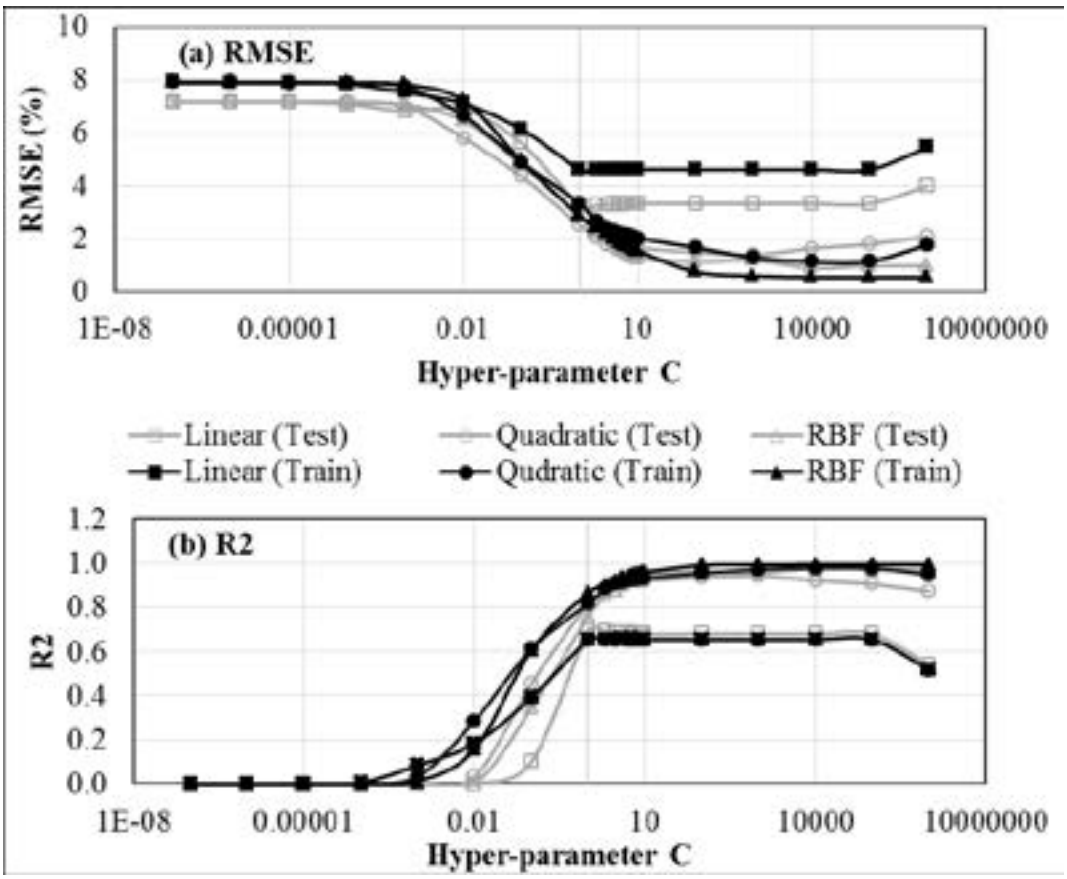

Figure 7. ***Optimisation of hyperparameter C when training the support vector regression models***

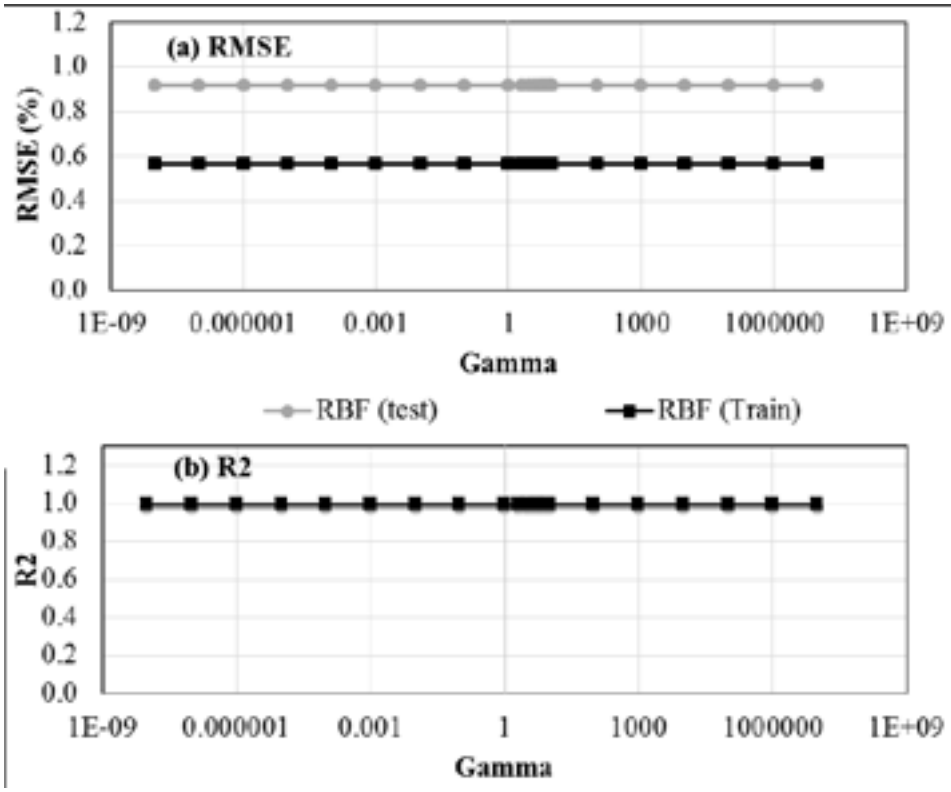

Figure 8. ***Optimisation of gamma when training the RBF-based support vector regression models***

3.4 Modeled versus the Actual Pump Efficiency

To evaluate the performance of the machine learning models, the modeled pump efficiency was compared with the actual pump efficiency in both training and testing phase. Comparison in the testing phase is done to validate the calibrated models. The trained neural networks-based modeled pump efficiency had a close to 1:1 correlation as shown in **Figure 9 (a)**. The validation results suggest that the trained neural network models were optimal since the corresponding trained models maintained near perfect correlation in the testing phase as shown in **Figure 9 (b)**. However, the validated neural network models had relatively larger bias compared to the trained models as shown in **Figure 9 (b)**. The actual correlation coefficients for the trained neural network models are plotted in the Taylor diagram that is shown in **Fig. 10**, and those of the tested neural networks models are shown in **Fig. 11.** Besides the correlation coefficient, performance of these neural network models was determined and tabulated in **Table 1.** The trained models performed well in simulating pump efficiency with NSE, PBIAS, R2, RMSE, and d1 of 100%, <|0.15%|, 1, <0.1%, and >0.99, respectively, as shown in **Table 1.** The corresponding testing phase values of NSE, PBIAS, R2, RMSE, and d1 were >93%, <|2%|, >0.93, <2%, and >0.91, respectively, as shown in **Table 1.**

Table 1. Performance of the trained and tested neural networks and support vector regression models for the pump efficiency

Models		Trained					Tested				
		NSE (%)	PBIAS (%)	R2	RMSE (%)	d1	NSE (%)	PBIAS (%)	R2	RMSE (%)	d1
Neural Networks	ANN	100	-0.1583	1.000	0.092	0.995	97.6	-0.32	0.98	1.02	0.95
	DNN2	100	0.0003	1.000	0.001	1.000	97.7	-0.28	0.98	1.00	0.95
	DNN3	100	-0.0002	1.000	0.001	1.000	97.0	0.45	0.97	1.13	0.94
	DNN4	100	-0.0004	1.000	0.000	1.000	96.6	0.77	0.97	1.21	0.94
	DNN5	100	0.0160	1.000	0.006	1.000	93.2	0.73	0.93	1.70	0.91
	DNN6	100	-0.0141	1.000	0.010	1.000	96.2	1.34	0.96	1.27	0.93
	DNN7	100	-0.0038	1.000	0.002	1.000	97.3	0.42	0.97	1.07	0.94
	DNN8	100	0.0199	1.000	0.010	0.999	97.9	0.88	0.98	0.96	0.95
	DNN9	100	-0.0045	1.000	0.002	1.000	97.4	0.40	0.97	1.06	0.95
	DNN10	100	-0.1329	1.000	0.080	0.996	98.1	0.25	0.98	0.91	0.95
Support Vector Regression	RBF	99	-0.2025	0.995	0.566	0.963	97.6	-0.36	0.98	0.92	0.94
	Quadratic	98	-0.3420	0.979	1.150	0.939	92.2	-2.14	0.93	1.66	0.90
	Linear	65	0.7503	0.655	4.635	0.701	67.9	-0.57	0.71	3.35	0.78

The trained SVR-based modeled pump efficiency also had good correlation with the observed pump efficiency in both the training and testing phase as shown in **Figure 12 (a)** and **Figure 12 (b)**, respectively. The actual correlation coefficients for the trained and tested SVR-based pump efficiency models are plotted in the Taylor diagram that is shown in **Figure 13** and **Figure 14**, respectively**.** The linear SVR-based model seemed to struggle to simulate the pump efficiency compared to the RBF and quadratic-based SVR models. This is further evident in **Table 1**, with the linear model having NSE, PBIAS, R2, RMSE, and d1 of 65%, 0.75%, 0.66, 4.6%, and 0.70, respectively, in the training phase; and NSE, PBIAS, R2, RMSE, and d1 values of 68%, -0.57%, 0.71, 3.35%, and 0.78, respectively, in the testing phase.

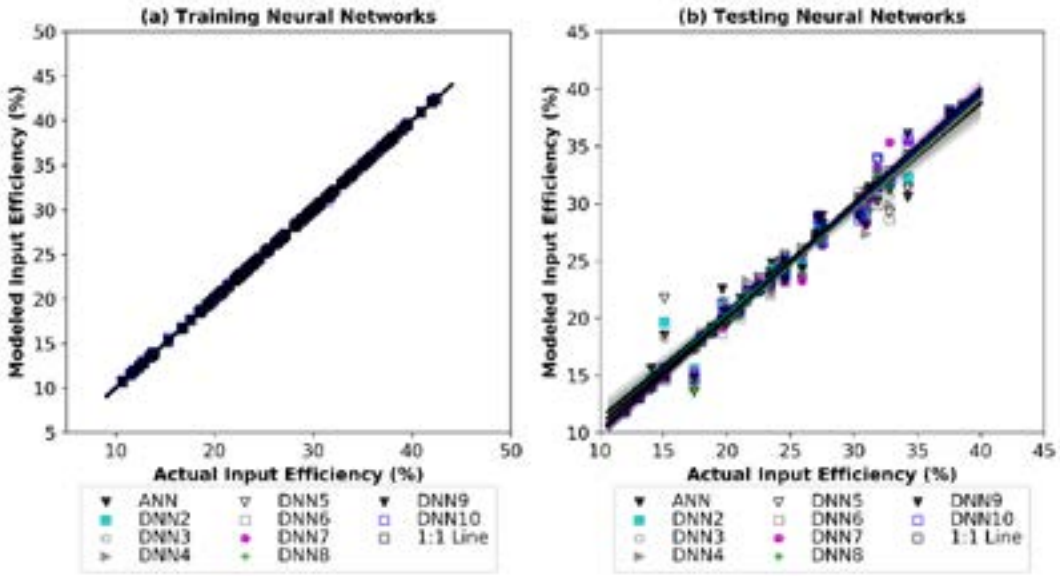

Figure 9. ***Calibrating/training and validating/testing the neural networks models for pump efficiency***

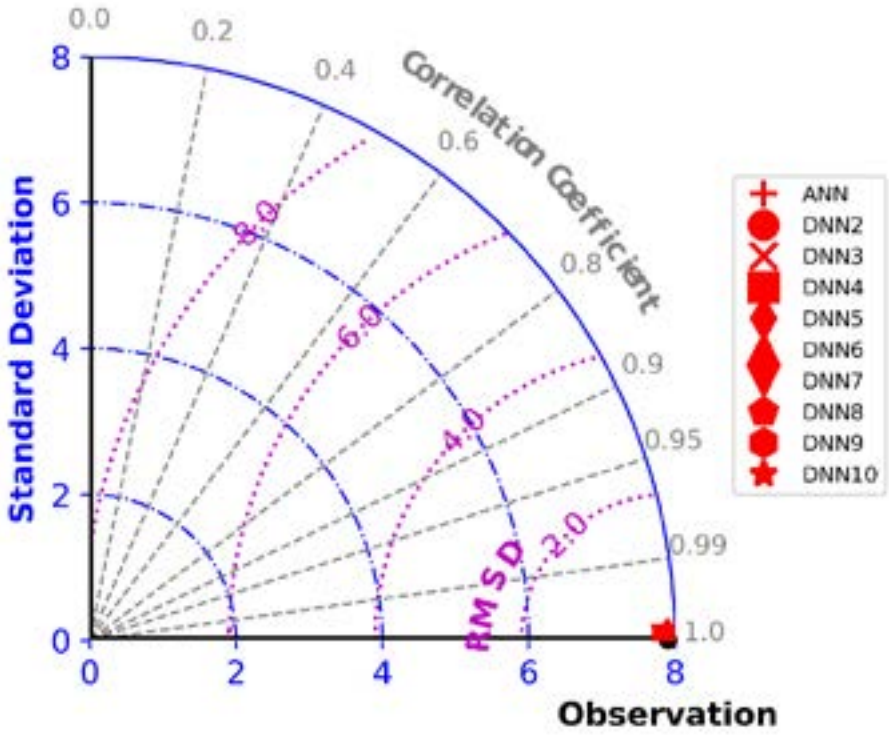

Figure 10. ***Taylor Diagram of the trained neural networks models for pump efficiency***

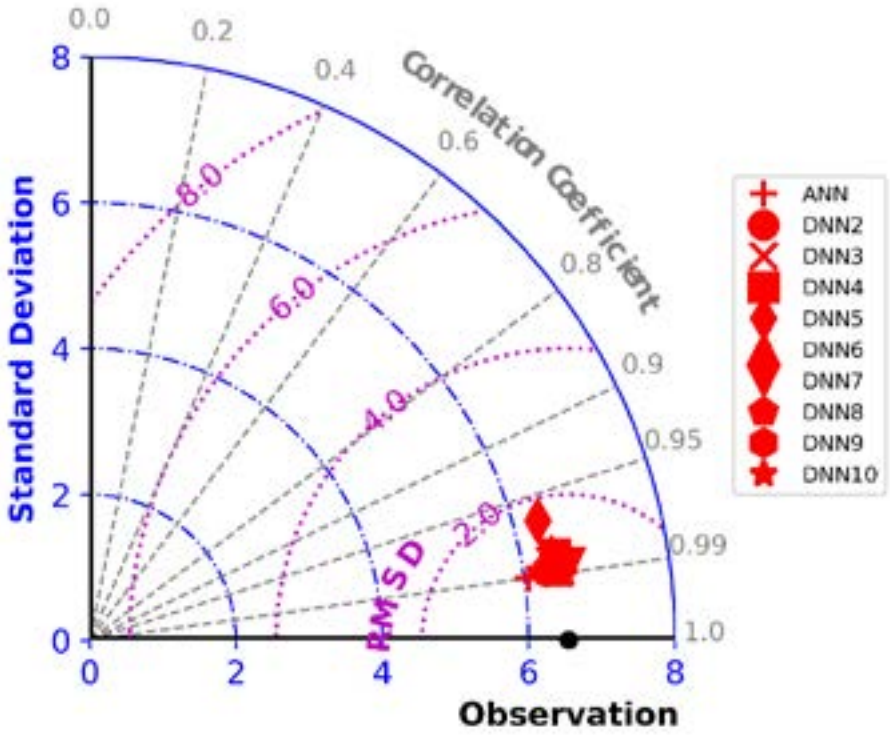

Figure 11. *Taylor Diagram of the tested neural networks models for pump efficiency*

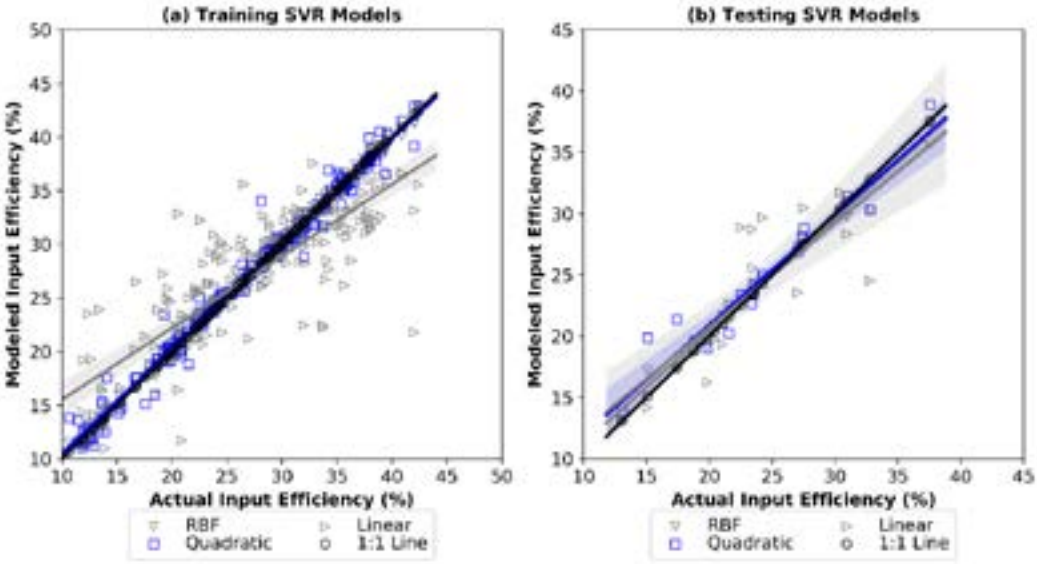

Figure 12. *Calibrating/training and validating/testing the support vector regression models for pump efficiency*

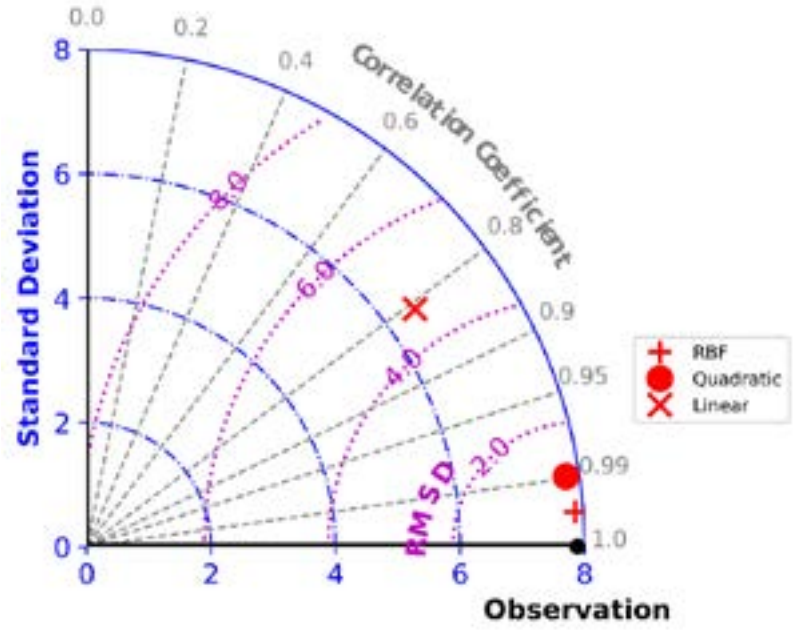

Figure 13. *Taylor Diagram of the trained support vector regression models for pump efficiency*

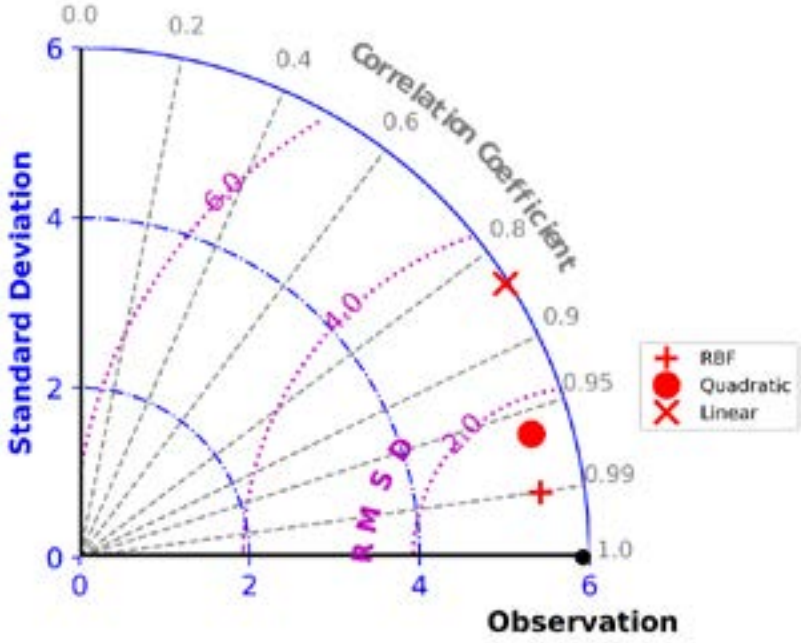

Figure 14. *Taylor Diagram of the tested support vector regression models for pump efficiency*

Conclusions

The neural networks and support vector regression have the potential of simulating pump efficiency. Overall, the deep neural networks outperformed both the artificial neural networks and the support vector regression models. Even though nearly all the deep neural networks models seemed to have outperformed the artificial neural networks model in simulating pump efficiency, the difference in the performance of the deep versus that of the artificial neural networks model was not significant. Therefore, increasing complexity of the neural networks, with respect to the number of hidden layers, do not necessarily significantly improve the performance of the neural network model. We make following specific conclusions from this study:

(i) Both neural networks and support vector regression models can be used to model pump performance.

(ii) The deep neural network marginally performs better than artificial neural network in modelling pump performance.

(iii) The support vector regression models do not get stuck in local minimum, and they are relatively faster to train than the neural networks models. However, the performance of the support vector regression models was found to depend on the kernel that is used in the training phase.

(iv) The RBF-based support vector regression model was superior to both linear and quadratic-based support vector regression models.

5. Data Availability

The data used in this study can be made available upon reasonable request from the author.

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Application of Landsat-8 Satellite and Remote Sensing in Monitoring Pollution and Salinity in Freshwater Bodies

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Abstract

The annually and rapidly increasing anthropogenic activities and natural pedo-climatic perturbations that result in pollution of freshwater resources are a major global challenge. Even though the demand for fresh water is high and increasing, monitoring, management and conservation of the resources is still a major challenge. Pollution and salinity of freshwater bodies lead to alteration of aquatic ecosystems where aquatic plants may die, and animals may migrate or die besides altering the use of the resource and its productivity levels. Among freshwater monitoring systems, remote sensing technology has been widely used in the developed and newly industrialising nations for identification, detection and monitoring of freshwater pollution and salinity levels. Therefore, this paper presents a literature review of remote sensing using Landsat satellites that have been successfully used for monitoring pollution and salinity in freshwater ecosystems. The review provides useful information that will be used towards improving management of the freshwater bodies for a healthy environment for the aquatic biotic systems and human use. The study found that Landsat-8 is a very useful, reliable and effective satellite for monitoring freshwater pollution and salinity.

Keywords: **Remote Sensing, Satellite, Water quality, Chlorophyll-a, Salinity, Organic and Inorganic matter.**

Introduction

The rapidly increasing anthropogenic activities including industrialisation and industrial effluents disposal in freshwater bodies, water transportation, and agriculture and natural pedo-climatic perturbations result in pollution of freshwater resources causing a major global challenge. Even though the demand for fresh water is high and increasing despite the uneven spatial distribution of the resource, monitoring, management and conservation of the resources is still a major challenge. Pollution and salinity of freshwater bodies lead to alteration of aquatic ecosystems where aquatic plants may die, and animals may migrate or die besides altering the use of the resource and its productivity levels.

Even though the monitoring and management of freshwater bodies remain a big challenge, remote sensing has been found to be a useful technology in this endeavor. Remote sensing has also been capably used to overcome the challenges experienced in the application of in-situ sampling and measurement of fresh water which is financially costly and time consuming (Wang & Yang, 2019). Remote sensing is a collection of varied technologies (satellites and electromagnetic radiation sensitive sensors), wavelength and band-based techniques for celestial, geocentric, aquatic, terrestrial and atmospheric observations. Remote sensing also aids the acquisition of information of part or the whole of the earth surface without any physical contact with the target under investigation (Guo *et al*., 2020). In observing usefulness of surface fresh water sources, Singh & Gupta (2016) indicated the vitality of water as a source of life on earth. Landsat satellites were found to be useful technologies where remote sensing is used to detect, monitor and effectively manage freshwater resources by identification and establishment of pollution and salinity levels. Sivabalan & Pramaraj (2018) found that water is a vital indicator of the level of development of a given country and that the hourly, daily, seasonal and multi-year time scales water resources data is provided and ascertained by engagement of satellites which enable effective water resources management and use.

Fresh water pollution and salinity is usually contributed to by increased saline inlets, eroded surrounding saline rocks, increased temperatures, increased industrial and agricultural chemical (organic and inorganic) refuse disposal into freshwater bodies. In addition, increased acidity of precipitation arising from disposed industrial gases in the atmosphere also result in freshwater pollution. Oil spillage, algal bloom and decomposition and increased thermal conditions may also cause pollution and salinity of freshwater bodies. Further, Singh & Gupta (2016) and Sivabalan & Pramaraj (2018) posits that suspended sediments, algae, chemicals, dissolved organic matter (DOM), thermal conditions, aquatic biotic life forms, pathogens and oil spillage affect the quality of water, hence the need for remote sensing in water resources studies. These challenges to freshwater bodies pose a major challenge to freshwater management globally. However, freshwater monitoring can significantly improve the management of the resource. Dekker & Erin (2012) also noted that monitoring of quality of fresh water is a pragmatic sampling and analysis of the resource with the objective of availing useful information about a given water body and its characteristics. The

study also established that the spatial and spectral information about the earth may be contained in an earth observation image.

The use of Landsat-8 as an earth observation and earth imaging satellite that are used for studies on freshwater pollution and salinity have been broadly discussed (Avdan *et al*., 2019 and Newman & Doucette, 2019). Singh & Gupta (2016) indicated that satellites have onboard passive or active sensors where own source of illumination is provided by the active sensors (radar, scatterometer and altimeter) and measures the signals scattered back from the earth surface target, while passive sensors detect earth reflected or emitted natural radiation. Kumar & Velmurugan (2015) also identified the application of optical and thermal sensors on satellites for monitoring water dynamism and expansivity. Further, the sensors use varied wavelengths and bands for measurements and coverage for earth-based objects, surface area and water bodies. Near Infrared (NIR) reflectance-based algorithms records reflectance from chlorophyll-*a* in water, where reflectance of blue and green parts of the electromagnetic spectrum indicated density of phytoplankton and dissolved organic matter in coastal waters. The study also indicated that 700 nanometers (nm) in NIR regions is the peak of reflectance ratio while a reflectance of 670nm in the red region indicated *Ch-a* absorption peak.

Kløve (2006), Klemas (2011), Dekker & Erin (2012) and Kumar & Velmurugan (2015) established that space-borne systems such as satellites, space shuttles and spaceships and air-borne systems such as aircrafts, drones and balloons with onboard sensors may be used to detect, monitor and collect data on water resources on the surface of the earth and may be sources of bathymetric and cartographic materials. Further, Casagli *et al*. (2017) stipulated that ground based devices such as Terrestrial Laser Scanning (TLS), Infrared Thermography (IRT) and Interferometric SAR (GB-InSAR) are significant in enabling monitoring of landslides and mapping and can also be used for water resources data collection. These ground-based instruments can potentially be mounted on ground platforms such as vans, buses and satellite masts are. Moreover, Kumar & Velmurugan (2015) also indicated that thermal and optical sensors may be mounted on ships and boats and used to collect spatio-temporal water data. Satellite hyperspectral sensors record light energy reflected by pigments in algae and suspended particles in water, which is analyzed in three or more frequencies for levels of algae, turbidity, sediments suspended in water and water clarity (Kløve, 2006). Bagchi & Bussa (2019) also indicated that electromagnetic energy in a water body determines radiance recorded by remote sensing, where longer spectroradiometer wavelengths are registered for water bodies with suspended sediments such as clay and silt. Further, the study observed that satellite sensors use the visible reflected infrared and thermal infrared bands within the electromagnetic spectrum to monitor water quality based on chemical, biophysical pollutants and salinity levels. In addition, the study indicated that nearly all incident light energy (Near Infrared and Middle Infrared) wavelengths are absorbed by clean water indicating low reflectance, therefore a suitable technique for discrimination of water bodies from vegetative and terrestrial surfaces on earth. Dekker & Erin (2012) also determined that energy reflected or emitted by a water body and its properties are measured by remote sensing, where spectroscopy principles enable measuring varying earth components based on their varying properties at different wavelengths.

Moreover, Bagchi & Bussa (2019) found that the molecular structure of water and presence/absence of impurities vary water spectral characteristics (spectral signature/ spectral response pattern) effectively varying the wavelengths of incident radiation, where absorption or scattering of reflected energy is recorded while water quality is indicated by the registered remaining signal.

Fresh water pollution may be determined by monitoring presence of algal blooms, coloured dissolved organic matter (CDOM), total suspended matter in water, deposited solid sediments (mud, silt and sand), industrial effluents, agrochemical refuse, oil spills, pathogens and anthropogenic wastes which lead to water pollution and salinity (Liu *et al*., 2010; Dekker & Erin, 2012; Singh & Gupta, 2016; Bagchi & Bussa, 2019 and Kyryliuk, 2019). Singh & Gupta (2016) also determined that NIR spectrum and emergent radiance from water surface is increased by suspended sediments in water. According to Dekker & Erin (2012) water pollution may result from sediment deposition at the bottom of the water body where bathymetric remote sensing enables vertical height and depth determination. Bagchi & Bussa (2019) also determined that blue light is strongly absorbed by chlorophyll-*a* at wavelengths ranging from 400 to 500nm, while red light is strongly absorbed at approximately 675nm by chlorophyll-*a*. Notably, chlorophyll-*a* concentrations are indications of possible algal bloom and algal toxicity of fresh water thereby leading to water pollution. Clark *et al*. (2017) established that algal blooms in the United States of America (USA) fresh aquatic systems and estuaries were located using the red to NIR of the spectrum (long-wave spectral bands) through MERIS imagery. Zhang *et al*. (2012) also indicated that quality of water is affected by salinity levels thereby impeding efficient use of the resource.

According to Wang & Yang (2019), chlorophyll-*a*, CDOM and suspended sediments primarily determine the water colour. Dekker & Erin (2012) also indicated that chlorophyll-*a* was an indication of mass of phytoplankton, trophic levels and status of water nutrients. Remote sensing can significantly improve freshwater resources management (WRM) which is currently a major challenge globally. The Sustainable Development Goal 3 advocates for Global Health and well-being of all the people on earth. This goal can be achieved through effective monitoring and management of freshwater resources which are used for drinking, agriculture and industrial raw material and processing. Satellite based sensors can also measure freshwater levels, pollution and salinity levels (Sheffield *et al*., 2018). Information on freshwater pollution and salinity levels will improve water policy and decision making and effective supply, use and management of the freshwater resources.

Methodology

Library and online secondary sources were used to review the use of Landsat-8 satellite for monitoring freshwater salinity and pollution. The study covered history of Landsat-8 satellite and remotes sensing, in their application in monitoring freshwater water salinity and pollution. In addition, the study covered uses, advantages and challenges of the remote sensing technology.

Discussion

The use of Landsat satellites by National Aeronautics and Space Administration (NASA) in collaboration with United States Geological Survey (USGS) to collect earth observation and imaging data began in 1972. The images produced by the Landsat Thematic Mapper (TM) (Specifically the

Landsat with TM instrument on board) were used to determine the area of drainage basins, Total Suspended Sediments (TSM) concentrations, algal blooms detection and water quality monitoring (Daya, 2004 and Bagchi & Bussa, 2019). The Landsat also archives data with significant volumes.

Landsat-8 is a Landsat Data Continuity Mission (LDCM) and was launched by NASA on February 11, 2013, on Atlas-V 401 rocket at Vanderberg Air Force Base (VAFB), SLC-3E, California, USA. The Landsat-8 is linked to a sun-synchronous orbit at 701 and 703 km perigee and apogee altitudes respectively and is inclined at 98.2248^0 (Newman & Doucette, 2018). Chen *et al*. (2017) also indicated that the satellite was designed to last 5 to 10 years. The satellite has a revisit period of 8 days with a mission of earth imaging and has onboard Enhanced Thematic Mapper Plus (ETM+) sensor. The ETM+ has a capability of collecting 725 scenes daily and swath width of 185km with 15 to 30 m resolution (Newman & Doucette, 2018).

The Landsat-8 satellite aids cartographic accuracy and has Thermal Infrared Sensor (TIRS) and Operational Land Imager (OLI) sensors with 9 bands. OLI 7 bands can be used for collecting data on global landmass, land cover and change in land use, while 2 spectral bands of deep blue coastal and cirrus band of shortwave infrared bands can be used for measurement of quality of water and high and thin clouds detection. Landsat-8 was used to monitor the diversion of wastewater in Santa Monica Bay, California, USA where OLI was used to monitor Chlorophyll-*a* concentrations for algal bloom detection while TIRS detected Sea Surface Temperatures (SSTs) (Trinh *et al*., 2017 and World Meteorological Organisation (WMO), 2020).

The landsat-8 has more bands and improved radiometric resolution and geometrically improved than earlier Landsat satellites and is used to collect important ecosystem data on lakes and ponds (Feng *et al*., 2019). Zhang *et al*. (2012) also observed that Landsat TM was used to detect water salinity in Florida Bay, USA. Meanwhile, a study in Lake Biwa and the Coastal aquatic systems of Wakasa Bay in Japan used spectral decomposition algorithm, where chlorophyll-*a* concentration (an optically active compound) and biomass of phytoplankton and primary productivity for the two water bodies was determined by Landsat-8 (Yadav *et al*., 2019) Further, Sheffield *et al*. (2018), Avdan *et al*. (2019) and Zefrehei *et al*. (2020) noted that assessment of water quality through observation of DOM, water salinity as well as chlorophyll-*a* concentration, may be based on the satellite. Further, Matta *et al*. (2017) found that spatial change in colour of glacial lakes depended on size of a glacier and availability of turbid water on the Himalayan Mountains when monitored by Landsat-8. The study also indicated that the Landsat-8 had multispectral sensors that exhibited blue, green, red and infrared channels.

According to Wang & Yang (2019), the Landsat-8 satellite is used for monitoring water colour in aquatic systems while Zhang *et al*. (2012) and Newman & Doucette (2018) observed that Landsat-8 was also used to collect data on both land and ocean surface characteristics therefore a useful instrument for management of water resources. Further, Permatasari *et al*. (2019) revealed that the Landsat-8 OLI multispectral radiometry for imaging is advanced and provides improved images and useful data on lake water trophic levels. In addition, Ihlen & Zanler (2019) reported that the satellite provides high quality and timely data of images

based on visible and infrared technologies where coastal and aquatic resources and continental resources are monitored. In light of the Landsat-8 spatial and temporal resolution capabilities, better images and useful data and numerous successful and useful freshwater resource management, pollution and salinity monitoring studies conducted using the satellite. The satellite is the best for freshwater pollution and salinity monitoring (Newman & Doucette, 2018; Avdan *et al*., 2019; Feng *et al*., 2019; Ihlen & Zanler, 2019; Permatasari *et al*., 2019 and Zefrehei *et al*., 2020). In addition, the Landsat-8 data can be accessed at open source (earthexplorer.usgs.gov). The satellite was operational as at June 2020 (Satellite Imaging Corporation, 2017 and WMO, 2020).

Landsat TM and ETM+ have been monitoring and collecting data on freshwater resources from space for a considerable amount of time (Xie *et al*., 2008). The numerous advantages of Landsat-8 make the satellite a useful instrument in monitoring of freshwater bodies where algal bloom and decomposition may alter water quality (Waxter, 2014). The satellite can detect algal bloom in freshwater bodies by measuring the colour of surface water.

According to Wang & Yang (2019), there is a significant improvement and increased popularity of use of Landsat satellite technology in monitoring and management of fresh water and freshwater resources in China. However, the study also indicated that physical and anthropogenic pollutants still remain a major challenge to freshwater management in the country. Even though China has made significant strides in development and use of satellite technology and remote sensing, Kenya is significantly challenged in terms of the large spatial extent, uneven distribution of freshwater bodies, low level of technology and inadequate technical expertise in remote sensing. Therefore, this study will avail vital information on use of Landsat-8 in freshwater monitoring which will improve management of the freshwater ecosystems in the country. Additionally, knowledge on Landsat-8 and remote sensing will improve accessibility and use of the data on freshwater properties in Kenya.

Use of Landsat-8 will improve monitoring of the freshwater bodies in Kenya which will in turn result in clean fresh water for domestic and recreational fishing. Besides, the conservation will improve freshwater ecosystems hence sustainable aquatic life survival. Waxter (2014) found that monitoring of freshwater systems will improve management and conservation hence reduction in cyanobacterial toxins. These toxins endanger human life. In addition, Waxter's study established that Landsat technology is used for description of spatial patterns of freshwater turbidity. The improved monitoring and management of fresh water will reduce pollution. Fresh water pollution increases water PH, temperature, and specific conductivity and also alters concentration of chemicals in the water. Pollution also reduces dissolved oxygen in freshwater bodies which in turn significantly alters the freshwater ecosystems and biotic life forms.

Landsat-8 can also be used to detect and monitor spatial coverage and changes of freshwater vegetation (Xie *et al*., 2008 and Waxter, 2014). The freshwater weeds such as hyacinth that pollutes freshwater bodies such as Lake Victoria, Lake Naivasha and Lake Baringo in Kenya, can also be monitored and therefore can be effectively controlled. Wulder *et al.,* (2019) argued that apart from monitoring both terrestrial and aquatic vegetation, Landsat satellites

with TM and ETM+ is used for monitoring the benthic aquatic properties in freshwater bodies with optically short depths. The freshwater depth monitoring will improve aquatic ecosystems hence conservation of the aquatic biotic systems. This will improve freshwater ecosystem productivity in Kenya.

Even though the discussed Landsat-8 satellite plays a significant role in monitoring freshwater pollution and salinity levels, the high cost of the satellites, accuracy and reliability besides accessibility, analysis and interpretation of the satellite data still remain a challenge to developing nations where limited internet access and adoption of technology is still limited. (Xie *et al*. (2008) also argued that the Landsat technology is limited in spatial resolution hence coverage of phenomena where community level coverage is advised. The meso-scale coverage of water resources and a long revisit period of 8 days, temporal resolution limit consistent monitoring and acquisition of data on freshwater bodies. Additionally, Xie's study revealed that Landsat-8 remote sensing is affected by weather conditions where heavy clouds and rainfall may reduce the image quality especially.

Conclusions

Remote sensing using satellites such Landsat-8 is a quick mode of water resource data collection, more particularly on freshwater pollution and salinity. The Landsat-8 remote sensing satellite reaches physically inaccessible areas such as mountain tops and glaciated landscapes. In addition, Landsat-8 detects and monitors presence of cyanobacterial biomass concentration, an indication of presence of toxicity of algal blooms and algal decomposition leading to water pollution. The instrument also determines water consumability, detects and determines biophysical components of the column (depths) and bottom of water reflectance (turbidity) and salinity levels. The use of Landsat-8 remote sensing satellite also improves water resources management and effective decision making on fresh water supply and use. The collected freshwater data can also be used in improving decision making and applied in planning and engineering of water resources. The use of Landsat-8 data in management of freshwater resources in Kenya is still limited. Additionally, studies should conduct to cover the other physical properties of water such as PH, temperature, turbidity, specific conductivity and chemical concentrations in the freshwater bodies especially in Kenya. Further, remote sensing studies should be conducted on the anthropogenic waste disposal into freshwater bodies in Kenya. In view of the limited analysis and interpretation capacity of the remotely sensed data using the Landsat-8 satellite, further studies should be conducted on ways of improving use of the data from the instrument to improve freshwater conservation and freshwater resources management.

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Microbial Composition and Abundance in Drinking Water Sources Within Narok Town and its Surrounding, Kenya.

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Abstract

Narok, a fast growing town in Kenya's Rift Valley faces major challenges of water provision due to its arid and semi arid location and there is need to ascertain the quality of water used by the residents. Multiple Tube Fermentation method was used to undertake water quality assessment. Total coliforms ranged between 2.3 x 10^1 MPN/100ml and 1.1 x 10^3 MPN/100ml during the dry season and 4.6 x 10^2 MPN/100ml and 1.1 x 10^3 MPN/100ml during the wet season. Faecal coliforms ranged between 0.9 x 10^1 MPN/100ml and 3.9 x 10^1 MPN/ 100ml during the dry season and 2.3 x 10^1 MPN/100ml to 2.4 x 10^2 MPN/100ml during the wet season. Pathogenic bacteria were isolated; E. coli, Shigella spp, Enterobacter spp, Proteus spp and Salmonella spp. The water sources contained bacteria levels higher than recommended levels. Proper waste management, separation of water pans meant for human and animal consumption and use of hygienically placed and maintained water tanks should be implemented to improve drinking water quality at the point of use and protect water sources from contamination. Other climate smart environmentally sustainable sources of drinking water such as rainwater harvesting and shallow wells should be explored.

Key words: **Narok, SDG 6, drinking water, microbial analysis, water pans.**

Introduction

Water is an enabler to development. One of the greatest challenges faced by rapidly developing urban centres in Africa is provision of sustainable sources of potable water (Stephanie *et al.,* 2017). This problem is compounded in highly water stressed environments such as arid and semi arid areas. Narok is a rapidly growing town located in the water stressed Rift Valley region in Kenya. The onset of the COVID-19 pandemic is going to increase water required by populations thereby further straining available water sources (USAID, 2021).

Microbial quality of water can be determined by presence and quantity of microorganisms. These microorganisms in drinking water are a major concern to consumers, water suppliers, regulators and public health authorities (Nicholas, 2015). One of the most widespread and serious classes of water quality contaminants, especially in areas where access to clean, safe water is limited, is pathogenic organisms such as bacteria, protozoa and viruses. These organisms pose one of the leading global human health hazards. Globally, 500,000 children were reported to have died from diarrheal disease, a majority of which are caused by unsafe water, inadequate hygiene and poor sanitation (GBD, 2015). In Kenya, the disease burden attributed to waterborne infections like typhoid and dysentery is estimated at 19500 including 17,100 children under the age of 5 (WSP, 2012) representing approximately 70- 80% of health issues in Kenya. The greatest risk of microbial contamination comes from consuming water contaminated with pathogens from human or animal faeces (Alexander *et al*., 2015). In addition to microorganisms introduced into waters through human or animal faecal contamination, a number of pathogenic microorganisms are free- living in certain areas or are, once introduced, capable of colonising a new environment (WHO, 2003). The potential of drinking water to transport microbial pathogens to great numbers of people, causing subsequent illness is well documented in countries at all levels of development (Nicholas, 2015). In addition, bacterial community structure has been found to differ significantly with seasons (Maja *et al*., 2021). Post treatment contamination of storage reservoirs and contamination of mains from repairs have been identified as causes of distribution-system contamination linked to illness (Craun and Calderon, 2001, Hunter *et al*., 2005).

The best means of safeguarding against the presence of waterborne pathogens in drinking water is the application of the multi- barrier approach that includes assessment of the entire drinking water system, from the watershed or aquifer and intake through the treatment and distribution chain to the consumer to assess the potential effects on drinking water quality and public health. The primary purpose of drinking water quality guidelines is the protection of public health (WHO, 2006). Diseases related to contamination of drinking water constitute a major burden on human health. Interventions to improve the quality of drinking water provide significant benefits to health. Faecally derived pathogens are the principal concerns in setting health-based targets for microbial safety (Lisa *et al*., 2019). The objective of zero *E. coli* per 100ml of water is the goal of all water supplies (WHO, 2006). Environment

Protection Agency (EPA, 2006) states that the Heterotrophic Plate Count should be no more than 500 bacterial colonies per milliliter. The total coliform positive should be no more than 5.0% of the samples (EPA, 2006). Presence of faecal coliform and *E.coli* indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes in these wastes can cause diarrhea, cramps, nausea, headaches or other symptoms. These pathogens may pose a special risk for infants, young children and people with severely compromised immune systems. Every year, more people die from the consequences of unsafe water than from all forms of violence, including war and the greatest impacts are on children under the age of five (WHO, 2002). Unsafe or inadequate water, sanitation and hygiene cause approximately 3.1% of all deaths- over 1.7 million deaths annually and 3.7% of Disability Associated Lost Years worldwide (WHO, 2002).

For decades, water scarcity has been a major issue in Kenya, caused mainly by years of recurrent droughts, poor management of water supply, contamination of the available water and a sharp increase in water demand resulting from relatively high population growth (Samantha, 2011). In Kenya, 87% of the urban population enjoys access to at least basic water service compared to 50% of rural inhabitants (UNICEF, 2017). Bacterial, protozoal, viral diarrhea and typhoid fever are the most commonly reported waterborne diseases (UNICEF, 2013). Increasing access to improved drinking water; SDG 6, is critical to make meaningful gains towards meeting the SDGs and even other sustainable development milestones such as Vision 2030 and the Big 4 Agenda (UN, 2018). Bacterial and protozoal diarrhea, hepatitis A and typhoid fever are the most common diseases spread through contact with food or water contaminated by faecal matter or sewage. The microbiological quality of drinking water is a concern to consumers, water suppliers, regulators and public health authorities alike (WHO, 2006). The potential of drinking water to transport microbial pathogens to great numbers of people, causing subsequent illness is well documented in countries at all levels of development (Nicholas, 2015).

The objective of this study was to determine the quality of water in Narok town and its environs with respect to microbial composition and abundance. This is a first step towards providing data that can inform evidence towards management of water resources within the arid landscape and development of policies and strategies aimed at addressing SDG 6.

Materials and Methods

Study Site

21km of the Narok- Bomet highway (B3) running between Narok town ($1^0$5'15.1548" South and $35^0$52'37.4304"East and Katakala centre (1.1001^0 South and 35.7701^0 East) was used as a transect line with 20 km distance on either side to strategically select three water sources which included rivers, water tanks and water pans at points where water for domestic consumption was sourced by the community.

Study Design and Sample Collection

Sampling was undertaken during dry and rainy seasons.

Sample size was determined as per the formula by Israel (2009).

$$n = \frac{N}{1 + N\,(e)^2}$$

Where: N = Population size (households)

n= Number of samples

e = Level of precision

$$n = \frac{56315}{1 + 56315\ (0.05)^2} = 398 \text{ samples.}$$

100ml of water was collected for each of the 398 samples from river water, pan water and water tanks (66 samples per water source, per season) using sterile Duran bottles, covered and kept in an ice box then transported to the Maasai Mara University Biological Sciences laboratory for analysis within 6 hours.

Presumptive Test

Samples of treated water were inoculated into Mac Conkey broth double strength and single strength media with Durham tubes as per standard methods (Lenore *et al*., 1989). Incubation was done at 35°C for 24 and 48 hours. Samples from non- treated water sources were diluted (1: 10) then inoculated into double and single strength Mac Conkey broth media. Undiluted samples were also inoculated into double and single strength Mac Conkey broth media. Incubation was done at 35°C for 24 and 48 hours. The tubes were checked for presence of growth and gas production. The Most Probable Number (MPN) was determined using the MPN index (Lenore *et al*., 1989).

Confirmatory Test

Inoculums from positive tubes (growth and gas production) in the presumptive test were inoculated into Brilliant Green Lactose (Bile) Broth (BGLB) (incubated at 35°C) and Tryptone water (incubated at 44°C). After 24 hours, each broth tube was examined for growth and presence of gas in the Durham tube. To each tube of tryptone water, approximately 0.1ml of Kovacs reagent was added and mixed gently. Presence of indole was indicated by a red colour forming a film over the aqueous phase of the medium and the MPN was determined as described by Lenore *et al*., 1989.

Completed Test

From Brilliant Green Lactose Bile (BGLB) broth tube of the highest dilution showing growth and gas production, a plate of Eosin Methylene Blue (EMB) agar was streaked then incubated at 37°C for 24 hours and the Gram Stain technique (Cheesbrough, 2004) was done on each colony after incubation. Thereafter, those colonies which were Gram negative were inoculated into TSI agar, Simmons Citrate agar, Urea media, MR-VP broth then incubated for 24–48 hours at 37°C. The media was then observed for changes in colour, appearance and reaction to added reagents. Results obtained were compared to the reactions expected for typical coliforms and the bacterial isolates were then identified according to the procedure described by Arlington (1992).

Results and Discussion

From this study, it was found that the MPN (Most Probable Number)/100ml values for total coliform bacteria in the study areas were beyond WHO recommendations. During the dry season, total coliform count of 0.9 x 10^1 MPN/100ml was recorded in the water tanks and 4.6x10^2 MPN/100ml in the rainy season (Table 1). These findings correspond to a study by Abok *et al*., 2018 on microbiological quality and contamination of water sources in Isiolo town where ground and surface water sources were contaminated with microorganisms beyond national regulatory standards levels. Similar findings were obtained by Mbaka *et al.,* (2017) in a study on the water quality of shallow wells in Keiyo Highlands, Kenya where mean levels of faecal coliforms during the dry and wet season ranged between 4.04 MPN/1ml

and 31.56 MPN/100ml respectively. In Enkare Narok and Ewaso Ng'iro rivers, the total coliform count recorded was 2.3 x 10^1 MPN/100ml and 1.1x10^3 MPN/100ml during the rainy season (Table 1). These findings were lower than those obtained by Ombaka and Gichumbi (2012) and Shittu *et al*., (2008) on Irigu River Meru South where the total coliform concentration was found to be more than 2.42 x 10^3 MPN/100ml in the dry and wet season and Sokori stream and Lafenwa river in Nigeria where analysis of bacteria in drinking water and water used for swimming purposes were found to have a total coliform count of 1.8 x 10^3 MPN/100ml respectively. Opisa *et al*., (2012), in a study on faecal contamination of public water sources in informal settlements of Kisumu City, Kenya found the water sources to be highly contaminated. Findings from this study also indicated the presence of faecal coliform bacteria in the water samples collected from all of the water sources under study. The concentrations ranged between 0.9 x 10^1 MPN/ 100ml in the water tanks, 3.9 x 10^1 MPN/100ml in the water pans during the dry season and between 2.3 x 10^1 MPN/100ml in the water tanks and 2.4 x 10^2 MPN/100ml in Enkare Narok river during the rainy season (Table 1). The increase in numbers during the rainy season can be attributed to contamination from surface run off resulting from rainfall.

In this study, the bacteria isolated from the water sources were *Escherichia coli, Shigella* spp, *Proteus* spp, *Salmonella* spp, *Enterobacter* spp, *Klebsiella* spp and *Citrobacter* spp (Table 2). These are pathogenic bacteria and they pose health risks to the residents who consume without any form of treatment. The water analysed from the rivers in the present study was found to contain *E. coli*, *Shigella* spp, *Proteus* spp and *Salmonella* spp. These findings concur with studies by Musyoki *et al*., (2013) where bacteria isolated from the Nairobi River and Athi River included *Shigella flexneri*, *Salmonella typhi*, *Salmonella paratyphi,* and *E. coli* and those of Silas *et al.,* 2011 on Njoro River where it was reported that the river was heavily contaminated with *Salmonella typhimurium, S. typhi,* and *E. coli*. The water samples collected from the water tanks in the study area were found to contain *E. coli, Enterobacter* spp, *Klebsiella* spp and *Citrobacter* spp. However, from some of the water storage tanks, there was no growth observed. The findings from the current study correspond with those of Nwachukwu and Ume (2013) who isolated *E. coli, Klebsiella* spp, and *Enterobacter aerogenes* from various drinking water sources in a local area of Eastern Nigeria. Ngwa and Chrysanthus (2013) analysed bacterial composition of well water sources in Bambui student residential area, Cameroon, and found out that the well water samples from the locations under study were highly contaminated with *E. coli, Klebsiella* spp and *Enterobacter* spp. Katiyar *et al*., (2013) analysed drinking water samples in Delhi, NOIDA and Meerut and identified various kinds of bacteria. They revealed that *E.coli* and *Pseudomonas* were more abundant when compared with *Enterobacter* and *Klebsiella*. A study of bacteriological quality of drinking water sources of Hail, Saudi Arabia conducted by Abdullah *et al*., 2016 found out abundance of *E. coli* (26.66%), *P. aeruginosa* (12.22%), *Klebsiella* (8.88%) and *Salmonella* (6.66%) from the samples analysed. In the current study, bacteria isolated from the water pans were *Enterobacter* spp and *Shigella* spp during the dry and rainy season respectively. These results are similar to a study carried out in Abeokuta in Nigeria by Shittu *et al*., 2008 where the water samples from surface water sources were found to contain *E. aerogenes* and *Shigella* spp. The findings in this study

were higher than those recommended by the WHO, EPA and KEBS for irrigation and drinking water. This study has provided evidence on water quality status of water sources used by local community members that can inform public health interventions to safeguard public health in Narok. The public should be educated against direct consumption of water from the rivers and water pans. Efforts should be made to protect the water sources from pollution by instituting community based water resource management for example by strengthening existing Water resource User Associations (WRUAS).

Conclusion

The water sources widely used in Narok are heavily contaminated with faecal and total coliform bacteria and not suitable for direct consumption. Possible sources of water contamination include disposal of human waste into the water and contamination with rain water runoff from shallow pit latrines. Some of the treated water was found to be contaminated at the point of use but not at the source. This could be an indication of leakage of old and unrepaired pipes, bursts along water pipelines and unhygienic handling of water at the point of use. Most of the residents used underground concreted tanks that were refilled periodically but were also prone to contamination from rainwater runoff and seepage from pit latrines because they were on the same level as the ground. Water pans could have been polluted mostly via animal and human excreta through rain water runoff and direct defecation. Bacterial contamination was higher during the rainy season than the dry season which can be attributed to contamination of the water sources through rain water runoff. Proper solid and liquid waste management, separation of water pans meant for human and animal consumption and use of hygienically placed and maintained water tanks should be implemented in order to improve drinking water quality at the point of use and protect water sources from contamination. Exploration of climate smart environmentally sustainable sources of drinking water such as rainwater harvesting and shallow wells will be a major step towards achieving water security in Narok.

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Table 1*: Faecal Coliform and Total Coliform Diversity during the Dry and Rainy Seasons in Water Sources in Narok Town and its Environs.*

	Faecal coliforms MPN/100ml	Faecal coliforms MPN/100ml	Total coliforms MPN/100ml	Total coliforms MPN/100ml
	DRY SEASON	RAINY SEASON	DRY SEASON	RAINY SEASON
Enkare Narok	2.3×10^1	2.4×10^2	1.1×10^3	1.1×10^3
Ewaso Ng'iro	2.3×10^1	2.1×10^2	1.1×10^3	1.1×10^3
Water Pans	3.9×10^1	7.6×10^1	2.4×10^2	1.1×10^3
Water Tanks	0.9×10^1	2.3×10^1	2.3×10^1	4.6×10^2
Katakala	1.5×10^1	1.25×10^2	2.13×10^2	8.7×10^2

Table 2: Microbial Diversity (%) in Water Sources during Dry and Rainy Season in Water Sources in Narok Town and its Environs.

	Katakala		Water Pans		Water Tanks		Enkare Narok		Ewaso Ng'iro	
Bacterial Isolates	Dry Season (%)	Rainy (%)	Dry Season (%)	Rainy (%)	Dry Season (%)	Rainy (%)	Dry Season (%)	Rainy (%)	Dry Season (%)	Rainy (%)
E. coli	100	0	0	0	30	19	63	36	59	0
Shigella spp	0	100	0	100	0	0	37	32	0	50
Enterobacter spp	0	0	100	0	16	15	0	0	0	0
Klebsiella spp	0	0	0	0	45	13	0	0	0	0
Citrobacter spp	0	0	0	0	0	29	0	0	0	0
Proteus spp	0	0	0	0	0	0	0	32	41	17
Salmonella spp	0	0	0	0	0	0	0	16	0	33
No Growth Observed	0	0	0	0	45	24	0	0	0	0

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Spatial Cox Modeling and Mapping of the Teacher Attrition in Public Schools and Post-Primary Institutions in Kenya

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Abstract

Teacher attrition has continued to pose a challenge to the quality of education offered in both developed and developing countries, Kenya included. Relatively little research has been done on modeling teacher attrition in Kenya. This study aims at explaining pattern of teachers' attrition and identify high-risk geographical areas, to assist policymakers to come up with appropriate intervention measures. The study presents the hierarchical Cox spatial model and mapping of teacher attrition in Kenya, using the Integrated Nested Laplace approximation approach. The study utilised data from the Teachers Service Commission for teachers in public schools and post-primary institutions, employed up to 2014. Age, gender, Job group, salary, location of the school, and type of exit affect teacher attrition. The model indicates a linear decrease in risk to exit with age, and higher job groups and a linear increase in risk with gender, resignation, and dismissal. A teacher in the North-Eastern and North-Western region and parts of the Coast has a higher risk of exiting. There is a need for the government to come up with appropriate and well-informed strategies and interventions to curb teacher attrition and target the identified regions

Keywords: **Hierarchical Spatial Cox Model, Teacher attrition, Education, Integrated Nested Laplace approximation, Kenya.**

1. Introduction

Teacher attrition or teachers' exit from service is among the most critical issue in education and poses a big challenge to both developed and developing countries. Teacher attrition according to Crandell & Howell (2009) is the leaving of the profession permanently for alternate occupation or due to retirement or a teacher moving to a different school. In this research, teacher attrition refers to all permanent losses of teachers from the teaching profession through retirements, death, voluntary resignation, transfer of service, and dismissal. Teachers' exit from service is used interchangeably with teacher attrition.

According to the International Taskforce for EFA (2010) and Mulkeen (2010), attrition rates vary widely between countries. In the Organisation for Economic Co-operation and Development (OECD) countries, attrition rates vary between 2 per cent and 14 per cent per annum. OECD data reveals that Canada has an annual attrition rate of 2.4 per cent in public schools mainly due to retirement and change in career (International task force for EFA, 2010).

Teachers' attrition and low retention, coupled with problems like over-enrolment, poor working conditions in Sub-Saharan African countries are even more challenging, (Education International 2007; International task force for EFA, 2010; UNESCO, 2014).

A survey in six Anglophone Sub-Saharan Africa countries, Kenya included, reported an average rate of attrition of 4%, attributed to retirement, resignations, death, and dismissal (Education International, 2007). The sub-Saharan African countries had ratios above these (UNESCO, 2015). Kenya had a pupil to teacher ratio of 57 to 1 in 2011 for primary schools while the secondary school ratio was 31 to 1 in the same year using data from Kenya National Bureau of Statistics (KNBS, 2017). However, pupil-teacher ratios measured at the national level could mask the disparities among regions and schools; hence, ratios in some schools could be much higher. However, Kenya has made good progress in achieving pupil: teacher ratios of 39 to 1 and 29 to 1 in public primary education level and public secondary school level respectively against the recommended 40 to 1 and 35 to 1 respectively. However, teacher shortages still exist despite this achievement (Kenya Ministry of Education, 2019).

Factors such as salary, gender, working conditions, level of education and age, influence teachers' exit decisions (Borman & Dowling, 2008). Modelling these factors to determine their influence on teacher attrition and identification of high-risk areas, requires robust and predictive models. Some factors associated with teachers' exit from service can be influenced by changes in policy (International Task Force on Teacher for EFA, 2010), hence the need to understand the causes and patterns of teachers' exit from service.

Carver-Thomas and Darling-Hammond (2017) focused on school characteristics, teacher characteristics, main teaching subjects, and teaching conditions as predictors for teacher turnover. The study indicated that age of a teacher and dissatisfaction due to lack of opportunities for advancement were related to high leaving rates. Nguyen (2020) carried out a study on teacher attrition in geographically rural states in Kansas. The study aimed to examine the effect of teacher and school characteristics on teacher turnover.

Traditional methods like simple attrition and standard regression models have mostly been applied in studying teacher attrition. However, these methods ignore censoring and do not reveal much information on teacher attrition (Willet & Singer, 1991). Survival analysis methods have been applied in modelling the survival time of teachers in service (Mwambi & Alii, 2015a; Mwambi & Alii, 2015b; Vagi *et al.,* 2017) since the data consists of event occurrences and censored observations. Survival analysis focuses on examining time until a specific event or endpoint. This could be time to exit from employment for an employee or, time until a component fails. Survival analysis handles censored data or incomplete data, such as teachers' survival time in service. Here, teachers who were still working are assumed to be censored.

A competing risk model was used by Imazeki (2005) to study teacher labour mobility within and out of the teaching profession. The study examined the influence of district and teacher characteristics on teacher attrition. Multilevel discrete-time survival analysis was implemented by Newton *et al* (2011) to study teacher and school characteristics on the influence of an individual's teacher's decision to leave a school. To investigate the relationship between preservice teacher quality and teacher attrition, Vagi *et al* (2017) implemented the survival discrete-time hazard model. The study indicated that preservice teacher quality was significantly and strongly associated to remaining in the profession in the first two years of employment.

The semi-parametric Cox proportional hazards (PH) model (Cox, 1972) is the most popular and commonly used model in the analysis of time-to-event data including teachers' exit from service (Adams, 1996; Hansel *et al., 2015*). This model is simple and makes no distribution assumption for the survival times while providing reasonably good estimates of regression coefficients. Hence its application in this study.

While the frequentist version Cox proportional hazards model and the parametric Weibull model are used to determine a combination of explanatory variables influencing teachers' survival time in service (Mwambi & Alii, 2015a; Mwambi & Alii, 2015b); there is a need to account for spatial variation. The spatial variation reveals some underlying factors in the survival patterns of teachers and helps identify counties with the highest rate of exit of teachers, which assists policymakers to come up with the right intervention measures. A Cox hierarchical spatial model captures such spatial patterns (Martino *et al.*, 2011).

Bayesian hierarchical modelling for spatial data has generated a lot of interest to many researchers in recent years (Banerjee *et al*., 2004; Bivand *et al., 2015*). More so, modelling of frailties and inclusion of spatial effects into survival models has become very attractive and popular among the Statisticians due to the availability of computation methods for fitting such models (Martino *et al.*, 2011; Bivand *et al.,* 2015).

Several studies have implemented hierarchical spatial modelling and mapping. Kazembe *et al* (2007) implemented a spatial Cox regression model to analyse child survival and explain the influence of both individual-specific factors, malaria endemicity, and group-specific environmental factors approximated by geographical location in Malawi; the Sub-district level was considered for Geographical location and used in the spatial analysis.

Hierarchical spatial logistic regression modelling and mapping have been

implemented in the study of the prevalence and continuation of female genital mutilation/cutting in Kenya (Achia, 2014). The study implemented the Integrated Nested Laplace Approximation (INLA) using the INLA library in R (Martino & Rue, 2009) for inference for latent Gaussian models (Rue *et al*., 2009). The study aimed at identifying parts of the country where the women intended to continue with the practice and geographical areas where the vice was more rampant for proper intervention strategies.

The objective of this model is to determine factors associated with teacher attrition and explain the pattern of teachers' exit using important covariates and at the same time account for spatially correlated differences in the hazards among the counties.

This study, therefore, implements the hierarchical spatial modelling approach (Besag *et al*., 1991; Martino *et al.,* 2011) to study the risk of the exit of teachers in Kenya, considering important factors. The Integrated Nested Laplace Approximation approach was implemented using the INLA library in R (Martino & Rue, 2009), due to its computational efficiency. Hierarchical models make it possible to borrow strength from neighbouring regions and the whole geographical region, to get stable estimates based on small area sizes within sectors.

In this study, the Teachers Service Commission data was used for teachers in public schools and post-primary institutions. Along with the survival times of the teachers in service, their individual- specific covariates are also captured in this data. The survival time is the response variable, where all those teachers who have exited are considered to have failed while those still working by the end of this study are said to be censored. Studies on modelling teachers' survival time in service using Bayesian hierarchical modelling and spatial mapping are rare in Kenya, hence the motivation to carry out this research.

2. Methodology

2.1 Data

In this study, the data is provided with counties where the teacher worked. The Teachers Service Commission secondary data was used for 2000 proportionally stratified selected teachers in public schools and post-primary institutions. The post-primary institutions included all public teacher training colleges including the Kenya technical training college, national polytechnics, Kenya technical training institutes and vocational training colleges at the time of data collection. Currently all Technical and Vocational Education and Training (TVET) functions have been transferred to the ministry of education. The data captured the date of hire and exit (for those who had already left employment) for each teacher. The data consisted of 1810 teachers who were still working up to October 2014 and 190 teachers who failed or exited through dismissal, mandatory retirement and voluntary retirement and so on. Teachers who continued working at the end of the study were assumed to be censored. For teachers who had continued teaching up to the end of the study period, their survival time was known at that point, and their censoring occurred to the right of their last known survival time. Hence this is right censoring. Since all teachers who left or exited had known reason and the exact time they exited was known, left censoring and interval censoring were not applicable. one important assumption we make concerning our survival data is that censoring times are random and independent from the actual survival times.

2.1.1 The Response Variable

Here the response or outcome variable is the survival time of a teacher in service. This represents the number of years from the date a teacher was hired to the date of exit or censor (those who were still working at the time of data collection).

2.1.2 Covariates

Along with the survival times of the teachers, their individual- specific covariates are also used in this model. These include gender (coded as F for female teachers and M for Male teachers), age (coded as 0 for teachers less than or equal to 35 years) while those above 35 years old were coded as 1). This was done to separate young teachers who had stayed in the profession for a shorter time compared to their older counterparts who had stayed for a longer period. The African Union (2006) defined youths as those between 15 years and 35 years. The word youths and young people are used interchangeably. The covariate Job group initially had eleven Job groups, some with few cases. Hence, it was thought prudent to classify lower Job groups (F, G and H) as A, Average Job groups (J, K and L) as B, above average groups (M and N) as B and the highest Job groups (P, Q and R) as D. The salary was allocated in Kenya shillings according to the Job group.

The province where the teacher worked was coded as wprov. The eight provinces in the country were used. The county variable included all the 47 counties in the country and was included only as a spatial random effect. The type of exit for teachers who had left the profession was coded as exit. This variable initially had 10 levels; however, some types of exits had few cases per category, hence they were meaningfully combined as indicated; death coded as 0, contract expiry and mandatory retirement as 2, dismissal and retire on public interest as 4 and leaving service early voluntarily through resignation, retire on medical grounds, transfer of service, and voluntary early retirement and retire at 50.

Factors determining the survival time of teachers in service consists of many other factors. However, due to data limitation, this study dealt with the above factors that were captured for each teacher in the TSC data. However, the factors used in this study are relevant and give information on attrition patterns in Kenya.

2.2 Data Analysis and Model Formulation

This study investigates factors associated with teacher attrition and sorts to explain the pattern of teachers' exit using important covariates and at the same time account for spatially correlated differences in the hazards among the counties. The Cox regression model is implemented in this study due to its popularity and simplicity. It does not assume any distribution form for the baseline hazard and still provides good estimates of the regression coefficients. The frequentist version of the Cox PH model was subjected to the proportional assumption test using the survival package and Cox-zph function in R, based on the scaled Schoenfeld residuals. The test was carried out for each covariate. Then the Bayesian spatial Cox model is implemented. All statistical analyses are carried using the Free statistical software R version 4.0.3 (R Core Team, 2020).

Suppose is the observed survival time to exit or censoring for in the . Let be the vector of covariates for individual teachers, and represent the coefficients for linear

effects on a vector of covariates x.

Then the normal assumption of proportional hazard is given by:

$$h(t\_i/(\beta x\_i))=h\_o\,(t\_(i))\,exp(\beta x\_i) \quad (1)$$

Where is the baseline hazard at time t.

Since the data allows for the inclusion of counties, we can include the regional term to the Cox proportional hazards model in (1) which now becomes:

$$h(t\_i/(\beta x\_i))=h\_o\,(t\_(i\ \ ))\ \ exp\,(\beta x\_i+\Omega\_i) \quad (2)$$

is the unstructured spatial effect which will account for the differences in hazards among the different counties. Adding the spatial structured random component (Besag *et al.*, 1991) model (2) becomes

$$h(t\_i/(\beta x\_i))=h\_o\,(t\_(i\ \ ))\ \ exp\,(\beta x\_i+\Omega\_i+\omega\_i) \quad (3)$$

Fitting model (3) above assumes a semi-parametric additive linear predictor such that,

$$h(t\_i/(\beta x\_i))=exp(\eta\_i) \quad (4)$$

Where $\eta\_i=\psi\_o+\beta x\_i+\Omega\_i+\omega\_i$ is the linear predictor, and $\psi\_o=\log(h\_o\,(t\_i))$ is the log baseline hazard effect at time t.

$\Omega\_i=f\_u\,(u\_i)$ is a spatially unstructured component that is independent and identically distributed with zero mean and unknown precision τ_u.

$\Omega\_i=f\_s\,(s\_i)$ is a spatially structured component that is assumed to vary smoothly from one region to another; and is modelled as an intrinsic Gaussian Markov Random Field assigned an intrinsic Conditional (iCAR autoregressive) prior with unknown precision τ_s (Rue & Held, 2005).

The CAR prior has the form

$$P(\omega_i/\omega_{ij}\ j\neq i)=N\left(\sum_{i-j}\frac{\omega_i}{m_i};\ 1/m_i\,\tau_s\right) \quad (5)$$

Where m_i is the number of neighbours of county $_i$.

$i\sim j$ indicates that the two counties are neighbours.

The latent Gaussian field for this model is $\varepsilon=\{\psi o,\{\beta\kappa\},\{fs(.)\},\{fu\ (.)\},\{\eta\_i\ \}\}$ with the hyperparameter vector $\phi=\{\tau\beta,\tau s,\tau u\}$ and every element in ϕ is assigned independent Gamma prior.

In this study, model 1 was composed of the unstructured spatial random effect along with the covariates, model 2 the structured spatial random effect with the covariates and finally, model 3 included both the unstructured and structured random effect with the covariates. Each model was fitted to the study data.

2.2.2 Bayesian inference, Model comparison, and selection

The R library INLA was used to carry out the Bayesian inference (Martino & Rue, 2009) to implement the Integrated Nested Laplace approximation approach for Latent Gaussian models (Rue *et al.,* 2009; Rue & Martino, 2007).

The Deviance information criterion (DIC) was used for model comparison and selection. It is a hierarchical modelling generalization of the Akaike Information Criterion (AIC). An advantage of the DIC over the AIC and Bayesian Information Criterion (BIC) is that it can easily be calculated from the samples generated by a Markov Chain Monte Carlo (MCMC) simulation or in R-INLA. In AIC and BIC, it is a requirement that the likelihood is calculated at its maximum over the parameter, which is usually not available

from the MCMC simulation. Hence, since we are dealing with Bayesian model selection then DIC is the most appropriate in this study. DIC is a measure of model complexity and fit, given by

$$DIC = \bar{D} + P_D \quad (6)$$

$\bar{D}$ is the deviance of the model evaluated at the posterior mean of the parameters and gives the fit of the model to the data.

P_D is the effective number of parameters that assess the complexity of the model.

Small values of $\bar{D}$ indicate a good fit, and small values of P_D indicate a parsimonious model. Therefore, a small sum of DIC values indicates the preferred model.

3 Results

3.1 Cox PH Proportional Assumption test

The results in Table 1 below indicate that no covariate violates the proportional hazard assumption at a 5 % level of significance. The global value is also significant.

Table 1: Proportional hazard assumption P values

Variable	Rho	Chisq	P
Age1(35)	0.0002	4.79e-06	0.9983
Male	0.0747	1.04+00	0.3078
Job group B	0.1140	2.37e-02	0.8777
Job group C	-0.0419	3.15e-01	0.5746
Job group D	0.0281	1.45e-01	0.7035
Salary	-0.6500	9.17e-01	0.3381
Nairobi	-0.0616	7.32e-01	0.3924
Coast	0.0045	3.77e-03	0.9510
Eastern	-0.0556	6.04e-01	0.4369
North Eastern	0.0039	2.69e-03	0.9587
Nyanza	0.0197	7.21e-02	0.7883
Rift Valley	0.0046	3.85e-03	0.9505
Western	0.0551	5.89e-01	0.4430
Exit 5	-0.1418	3.68+00	0.0552
Exit 0	0.0176	5.56e-02	0.8135
Exit 4	0.0179	6.26e-02	0.8024
Exit 2	0.1376	2.99+00	0.0838
GLOBAL	NA	1.12e+01	0.8442

3.2 Hierarchical Spatial Cox Modelling

The explanatory variables age, gender, Job group, salary, Province, County and type of exit were fitted to the hierarchical spatial Cox regression models (3) appropriately; from previous studies by Mwambi & Alii (2015a; 2015b), these explanatory variables were found to be statistically associated with the survival time of teachers. Bayesian inference was carried out using INLA from the *R-INLA* package.

Model 1 was composed of the unstructured spatial random effect along with the covariates.

Model 2 was composed of the structured spatial random effect with the covariates and finally,

Model 3 was composed of both the unstructured and structured random effects with the covariates.

Comparison and selection of the models were done using the DIC values from (6).

Table 2 below presents the results for model comparison and selection, giving the effective number of parameters P_D and the DIC values for each model considered. Results indicate that model 2 with a structured spatial random effect is the best fitting model since it has a lower DIC and P_D values.

Table 2: Model selection Results

Model	DIC	P_D
Model 1	1240.61	36.39
Model 2	1240.26	35.92
Model 3	1240.70	36.38

The results suggest an average risk of exit of teachers across the counties of the mean 1.8404e-04. We found teachers aged 35 years and above are 97% less likely to exit the profession compared to those aged 35 years and below (HR=0.028,95% C.I: 0.001,0.077); There is a linear increase in risk to exit with gender (males) by about 32% (HR=1.32,95 % C.I:0.95,1.85) compared to female teachers. Job group C for job groups M and N increase the risk by about 4.79 (95 % C.I:1.98,11.3) fold; higher job groups P, Q and R with a risk of 1.80 (HR=1.80,95 % C.I:0.42,6.15) fold compared to lower Job groups F, G, and H. It is apparent there is a higher risk to the exit of teachers in the North-Eastern region of Kenya with 43% ((HR=1.43,95 % C.I:2.46,6.13) as compared to Nairobi, while Western with risk (HR=0.67,95 % C.I:0.3,1.64). On types of exits, dismissal and retirement on public interest tend to have the highest risk of (8.85 e+04,95 % C.I:7.38+01,5.17e+09 and death has a risk of (4.41e+04,95 % C.I:3.79e+01,2.49 e+09) indicating that they linearly increase the hazard to the exit of teachers.

Table 3: Mean Hazard Ratio, the Associated Standard Deviation, and 25% and 95% Credible intervals for the Association between Teacher attrition and Significant Explanatory Variables

Model 2 with structured spatial effect					Model 3 with unstructured and structured spatial effects			
Variable	**Mean**	**SD**	**0.025 quant**	**0.975 quant**	**Mean**	**SD**	**0.025**	**0.975**
Intercept	1.84e-04	1.15e+02	2.95e-09	2.27e-01	1.92e-04	1.15e+02	3.06e-09	2.39e-01
Age								
Age0(<=35)	ref				ref			
Age1(>35)	2.80e-02	1.68	1.01e-02	7.68e-02	2.68e-02	1.70e+00	9.37e-03	7.49e-02
Gender								
female	ref				ref			
male	1.32e+00	1.18e+00	9.53e-01	1.85e+00	1.33e+00	1.18e+00	9.55e-01	1.85e+00
Job Group								
A	ref				ref			
B	2.14e+00	1.31e+00	1.24e+00	3.63e+00	2.14e+00	1.31e+00	1.24e+00	3.64e+00
C	4.79e+00	1.56 e+00	1.98 e+00	1.13e+00	4.83e+00	1.56e+00	1.99 e+00	1.34e+01
D	1.80e+00	1.98e+00	4.2e-01	6.15e+00	1.80e+00	1.98 e+00	4.22e-01	6.18e+00
salary	9.9 e+00	1.00 e+00	9.9 e+00	9.9 e+00	9.9 e+00	1.00 e+00	9.9 e+00	9.9 e+00
province								
Nairobi	-	ref			ref			
Central	5.7e-00	1.52 e+00	2.6e-01	1.36 e+00	5.7e-01	1.52e+00	2.6e-01	1.36 e+00
Coast	4.6e-01	1.70 e+00	1.6e-01	1.31e+00	4.6e-01	1.70 e+00	1.6e-01	1.31 e+00
Eastern	4.8e-01	1.56 e+00	2.10e-01	1.20e+00	4.8e-01	1.56e+00	2.1e-00	1.20e+00
North Eastern	1.43e+00	2.27e+00	2.50 e-01	6.13 e+00	1.43 e+00	2.27 e+00	2.50 e-01	6.13 e+00
Nyanza	5.00 e-01	1.57 e+00	2.10 e-01	1.24 e+00	4.90 e-01	1.57 e+00	2.10 e-01	1.24 e+00
Rift Valley	5.30 e-01	1.54 e+00	2.30 e-01	1.28 e+00	5.20 e-01	1.54 e+00	2.30 e-01	1.28 e+00
Western	6.70 e-01	1.54 e+00	3.00 e-01	1.64 e+00	6.70 e-01	1.54 e+00	3.00 e-01	1.64 e+00
Type of Exit								
Exit1	-	ref						
5- leaving service early								
(e.g., resignation, retire early)	2.55e+04	1.10 e+02	2.19e+01	1.43e+09	2.55e+04	1.10e+02	2.18e+01	1.44e+09
0- death	4.41e+04	1.10e+02	3.79e+01	2.49e+09	4.42e+04	1.10e+02	3.79e+01	2.50e+09
4- Dismissal and retire on public interest	8.85e+04	1.02e+02	7.38e+01	5.17e+09	8.89e+04	1.12e+02	7.40e+01	5.21e+01
2- Retire mandatory & contract expiry	9.42e+03	1.10e+02	8.09e+00	5.31e+08	9.37e+03	1.10e+02	8.03e+00	5.30e+08
Random Effects								
Unstructured& structured	18520.46	18355.84	1268.93	66967.93	18207.17.	18143.35	1242.78	66286.09

3.2.1 Spatial Mapping

Figure 1 and 2 ***presents spatial hazard ratio maps of risk of teacher's exit in Kenya based on fitting the hierarchical spatial models***

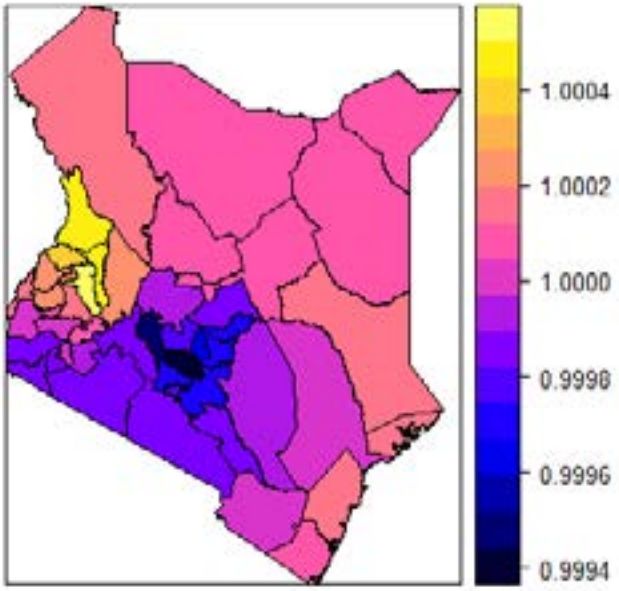

Figure 1: ***Spatial hazard ratios for teachers' exit in service predicted from the model with structured spatial random effect.***

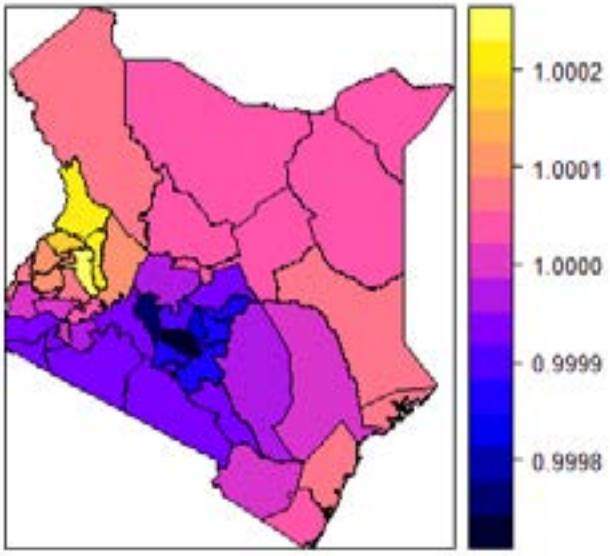

Figure 2*: Spatial hazard ratios of teachers' exit from service predicted from the convoluted model*

Figures 1 and 2 present the maps of the spatial hazard ratio of teachers' exit predicted from the model fitted with a structured random effect and with both unstructured and structured spatial random effects respectively. It is evident parts of the Northern, North-Eastern, North-Western, and parts of Coast have higher risks of teachers' exit from service. Counties with high risks include West Pokot, Baringo, Lamu, Mandera, Marsabit, Wajir, and Garissa. It can also be noted that counties in the central and southwest parts have relatively low risks to exit.

4.0 Discussion

This study utilised the Bayesian hierarchical Cox spatial modelling to establish the relationship between the survival time of a teacher and the covariates, and account for any spatial variation in the risk of teachers' exits among the various counties in Kenya. We used the computationally simpler approach known as the Integrated Nested Laplace Algorithm with the *R INLA* package in R, to fit the Besag, York, & Mollie (Besag *et al*., 1991) models, as opposed to the traditional Markov Chain Monte Carlo (MCMC) approach.

Past studies reveal that teachers' characteristics, remuneration, and location of the schools, experience, and specialization need to be considered (Bowman & Dowling, 2008; Mwambi & Alii, 2015b). Younger teachers as revealed in this study tend to have higher risks to exit than older teachers. Similar results have been reported in other studies (Bowman & Dowling, 2008; Ingersoll *et al*., 2014; International Task Force of Teachers for EFA, 2010; Nguyen, 2020). This may be explained by the fact that younger teachers are more aggressive and experimental and may easily find their way to greener pastures as compared to their older counterparts.

This study also reveals that female teachers tend to stay longer in the profession before exit as compared to their male counterparts (HR= 0.028, 95% C.I: 0.001, 0.077); consistent with past studies (Ingersoll *et al.,* 2014). This could be attributed to the fact that men are providers for the family especially in the African social setting and, therefore, are looking for better opportunities. However, other past studies that were done in the US (Bowman & Dowling, 2008; Guarino *et al.*, 2004) contradict these results; they found female teachers to be more likely to leave their posts than male teachers. This could be explained by the fact that female teachers leave early due to pregnancy and childcare responsibilities (Marvel *et al.,* 2007).

Salary in this study tends to decrease the risk to the exit of teachers, though to a small extent. Past studies (International Task Force for EFA, 2010; Kadzamira, 2006; Mwambi & Alii, 2015a) indicate higher salaries are associated with lower risks to exit from service. This is in line with the literature review on the same; that there is a link between teacher motivation, performance, and job satisfaction (VSO, 2002). Nguyen (2020) also indicate that increase in salary results in job satisfaction of the teachers. The task of the government is to continuously ensure that the teachers' pay is motivating enough for better performance and job satisfaction. Teachers' salaries should be reviewed from time to time to adjust to changing economic times.

The locality of the school affects the exit of teachers (International Task Force for EFA, 2010). It can be noted from spatial mapping that counties in the central and southwest parts of the country have relatively very low risks to exit. The other counties in the North-Eastern, North -Western and Coast regions tend to have high risks. It is

worth noting counties with relatively high hazard ratios are mainly located in the areas gazetted as hardship areas. These areas have very limited availability and accessibility to basic social services and amenities, transport and communications services and even basics like food and water. Areas in the North-Eastern parts of the country have also been experiencing a lot of insecurity. Studies indicate that in African developing countries some attrition is encouraged by conditions within the teaching environment such as poor living conditions of teachers. Teachers are not housed within schools and find it difficult to get affordable accommodation and the few that are housed live in deplorable conditions (International Taskforce on Teachers for EFA, 2010).

Factors focused in this research may not be exhaustive due to data limitation on teacher attrition, which is evident in Sub-Saharan Africa (International Taskforce on Teachers for EFA, 2010). The secondary data used does not contain all the information including the factors such as level of qualifications, subject speciality, and the school working conditions. However, the available factors used in this study are relevant and reveal the attrition patterns in Kenya. There's a need for government to invest in longitudinal data tracking of teachers' employment.

5.0 Conclusion

Bayesian hierarchical spatial modelling has been applied mostly in epidemiology in disease mapping and not in studying teacher attrition. This research has applied hierarchical spatial modelling to establish the relationship between the survival time of a teacher and the covariates. Hierarchical spatial modelling also assessed variations in teachers' exits among the various counties in Kenya. Therefore, there is a need to apply such models in the study of teacher attrition. It is also evident that factors like age, gender, job group, salary, and location of the school affect the decision of the teacher as to whether to stay or leave the profession. Some of these factors are responsive to policy changes. Such findings can be beneficial to the government, educational administrators, and planners in coming up with better retention programs and strategies. The spatial maps have also shown that teachers working in hardship areas like North- Eastern, parts of Rift Valley and Eastern and parts of Coast are at higher risks of exit. These findings are very important, as they will help policymakers identify counties with the highest risks to exit of teachers and hence assist in coming up with well-informed intervention measures, like providing proper security and monetary incentive such as hardship allowances to retain these teachers. There is a need for the government to retain the already trained and experienced teachers for better quality education and achievement of education for all (EFA) goals. Further research could focus on spatial distribution and mapping of ICT usage in teaching in public and private schools in Kenya during the Covid-19 pandemic. Comparisons could then be made between public schools and private schools. Performance of the schools could also be correlated with ICT usage in learning.

Consent

The secondary data was obtained from the Teachers Service Commission with permission from the Ethics Review Committee, Pwani University accredited by National Commission for Science, Technology and Innovation, KENYA, and from the Teachers Service Commission Kenya. All teachers' identifiers were removed.

Declaration of competing interests

The author has no competing interests.

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Do Policies Influence Female Enrolment in Technical Vocational, Education and Training Engineering Courses in Kenya?

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Abstract

The objective of this paper is to establish if educational policies in Kenya influence enrolment of female students in engineering courses in Kenya's Technical Vocational Education and Training institutions. The study employed descriptive survey research design. The target population were, 3559 students in engineering departments, 62 tutors, three TVET Public institutions registrars and one County TVET Officer. Random sampling was used to select the institutions and purposive sampling were employed to select the County TVET Officer. Sample size was determined using Morgan and Krejcietable. Data was collected using questionnaires and oral interview. Data was analysed using descriptive and inferential statistics while the hypothesis was tested using linear regression analysis. The study revealed that policies such as cost sharing influenced female enrolment negatively in engineering courses since fees is not affordable to majority of the students. Further, lack of awareness on admission policy, and TVET progression structure policy in Kenya negatively influenced enrolment. The study recommends that the government through ministry of education TVET department should improve the level of awareness to prospective students and society on policies related to cost sharing, the TVET progression structure and admission policy requirements to TVET institutions especially in rural areas. This can be done through public meetings by both governmental and nongovernmental channels, religious and community leaders who reach out to a larger audience. Training should also be provided to career counsellors in secondary schools to create awareness on the progression structure and other relevant policies.

Keywords: **Female Enrolment, Funding, Policy, Progression Structure.**

1.0 Introduction

Globally, economists agree that there is a positive relationship between skills acquisition and development of a country. Technical and Vocational Education and Training (TVET) is a key instrument in any nation in accelerating economic development in order to alleviate poverty according to Sessional paper 1 of 2019 (Republic of Kenya, 2019). Kenya like any other Country recognises TVET institutions in helping to alleviate unemployment problems to both women and men. Majorly, engineering skills facilitate social andeconomic, transformation of any nation. Women, who receive skills from engineering as a profession, benefit them and their families (World Bank, 2010).A study done in South Africa by Najoli (2019) on the effectiveness of Women in Technical Education and Development Programme on Enrolment of Women in TVET suggested the need for reminding students the importance of TVET skills in innovation both in the business and the labour market.

Studies in Organisation for Economic Cooperation and Development (OECD, 2015) countries have shown that only 15% of students commence for engineering courses in tertiary education. In most of the developing countries, there is low enrolment of women in engineering courses. For instance, in 2014, Egypt had 10% of women enrolled for engineering courses (UNESCO, 2014).In Tanzania, Kaaya and Waiganjo (2015) under a study on factors affecting women enrolment in technical institutions in Tanzania, identified financial factors such as unaffordable user charges and parental factors such as low level of income affected women enrolment in TVET in Tanzania. Studies have shown that factors such as social, policy related, cultural and psychological barriers hinder women from participating in engineering courses (UNESCO, 2010). On social and policy factors, studies have been done in countries such as Columbia, Australia, Egypt, Zimbabwe (UNESCO, 2017). These studies have shown that, many governments have developed policies to solve the problem of underrepresentation of women. For instance, in Zimbabwe a study by Matope (2007) revealed that the government introduced laws which necessitated that there was equal pay to both male and female, reduction of discrimination of sex when offering jobs and provide paid maternity leave for female engineers. Despite all these still few female students were attracted to engineeringcourses. According to a study by (Kaaya &Waiganjo, 2015) female students account for 8% and therefore policies in the country and the world should be implemented to achieve gender parity. In China women have equal rights and an opportunity to get education.This is stated in the various laws such as China education law which enable the government to work on eliminating gender disparities and help increase efforts on training women in vocational skills (UNESCO, 2017). This study focuses on cost sharing policy, TVET progression structure and admission policy and their influence on female enrolment in public technical institutions in Kenya.

TVET in Kenya

In Kenya the legal framework for education in Kenya is contained in various documents such as the Kenya 2010 Constitution and

the Sessional Paper No. 2 of 2015 that proposed a progression structure for TVET as an avenue to increase the students' attractiveness to TVET institutions and improve the negative perceptions towards TVET Sector. In addition, the National Education Sector Program (NESP) 2013–2018 advocates for quality education for sustainable development. This has led to Reforms that have been done to realign the education sector to the 2010 constitution and the Kenya Vision 2030 which hopes to make Kenya a medium and industrialized economy. The TVET reforms are contained in TVET Act 2013 which created regulatory bodies such as Technical and Vocational Education and Training Authority (TVETA). In its second medium term plan of Vision 2030, Kenya identified key policy actions that the government will use to increase support for policies and institutions committed to promoting gender equity. It is meant also to fully implement policies for protection of rights for women. For TVET or TVETA, the plan was to establish a central admission service for TVET government sponsored students; establishing vocational training centre at constituency level and at least one technical college at county level; institutionalization of quality assurance and accreditation system and monitoring, evaluation, reporting and inspection in TVET; to establish a TVET authority which has already been done; streamlining management and assessment of industrial attachment process; and establishing labour market information system and other survey instruments for data on actual employability of TVET graduates in partnership with industry (Republic of Kenya, 2012).This plan has been actualized but it has not yet yielded much results as indicated in Ministry of Education report of 2019. Low enrolment of female students in engineering courses is still being experienced.

The Policy Framework for Education and Training – Reforming Education and training in Kenya (Republic of Kenya, 2012; Republic of Kenya, 2019) highlights specific education related policies that were developed to take care of gender parity in TVET education. The gender policy in education (2008) provides a planning framework for gender-responsive education at basic and post-secondary levels. It highlights key concerns in education including disparities, retention and transition rates, and negative social-cultural practices and attitudes. The policy formalizes the rights and responsibilities of all people involved directly or indirectly in the education sector. Further, it is expected to contribute to the elimination of such disparities (Republic of Kenya, 2014).

The government of Kenya has increased the number of TVET institutions by 10.3% per cent from 1987 in 2018 to 2191 in 2019 which has led to a general increase in total enrolment in TVET institutions by 19.7% per cent from 359,852 in 2018 to 430,598 in 2019 (Republic of Kenya, 2020). This increase is also attributed to expansion of existing TVET institutions and reforms meant to improve TVET image and to create awareness about the subsector. Other policy interventions include increased funding to the subsector through Higher Education Loans Board (HELB) to TVET students, scholarships and grants (Education Sector Report, 2019). Despite all these efforts women have continued to be underrepresented in TVET institutions in engineering courses as also noted by (Muthima, 2015; Cherotich, 2016, Republic of Kenya, 2019.

Enrolment in TVET institutions in Kenya

Table 1 shows enrolment in TVET institutions in Kenya from 2010 to 2019. From the table, enrolment has been increasing over the years for both male and female students. This could be attributed to increased efforts by government to improve and rebrand TVET. However, gender gap still exists. It was highest in 2014 and lowest in 2016. This enrolment covers all courses offered in TVET. According to Kakamega County Website (www.kakamega.go.ke), in the updates on Education Science and Technology dated 8 August 2011 the Chief Executive Officer highlighted that there is low enrolment in TVET institutions and specifically in building and automotive engineering. This was supported by a report in a conference held in Sigalagala in 2018, which indicated that the gender gap in engineering is 80.9%. Further, Table 2 shows student enrolment in Kakamega County in Kenya according to sex and programmes.

Table 1: Total Enrolment in TVET by Sex from year 2010–2019 in Kenya

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Male	41973	53586	77360	88064	89765	90772	113963	154581	205142	246484
%	50.78	52.62	60.58	59.49	60.59	58.49	56	56	56	57
Female	40680	48173	50431	59945	58377	63404	88593	120558	158,742	184112
%	49.22	47.38	39.42	40.51	39.41	41.51	44	43	44	43
Gender gap	1293	5413	26829	28119	31388	27368	16776	34023		62372
%	(1.56)	(5.32)	(21.01)	(19)	(21.19)	(17.63)	(8)	(13)	(12)	14
Total	82653	101759	127691	148009	148142	155176	202556	275139	363884	430598

Source: Kenya Economic Survey, 2020

Table 2 shows the enrolment of students in TVET in Kakamega County by June 2020. The table shows that among the four engineering courses offered the gender gap exists more in Mechanical and automotive engineering and its lesser in Civil and Building course that the study considered.

Table 2: Engineering Student Enrolment in Technical Institutions Kakamega County

Institutions/Courses	Electrical and electronic		Mechanical and automotive		Civil and building	
	M	F	M	F	M	F
Shamberere TTI	110	09	274	37	266	27
Sigalagala National Polytechnic	719	110	677	34	1054	316
Bushiangala	264	02	269	06	383	04
Mumias West	13	09	03	03	-	-
Butere	160	14	156	11	137	08
Friends Kaimosi College	190	02	147	01	206	0
Total	1456	146	1526	92	2046	355
Total	**1602**		**1618**		**2401**	

Source: Kakamega County TVET Office (June 2020)

1.1 Statement of the Problem

There has been a great emphasis in the recent years on revamping and re-branding of TVET sector by Kenyan government. This is because its seen as a tool for socio economic development. Major government policies have been implemented that have led to an increase in enrolment. Despite the overall encouraging trend of female participation in TVET, there are areas where significant gaps still exist. One such area of concern is TVET engineering courses. Further,there are less studies on how policy has influenced female enrolment in Technical Vocational Education and training in engineering courses. This study focused on assessing if educational policies such as cost sharing policy (user charges), progression structure and admission policy (entry requirements) in Kenya influence enrolment of female students in TVET engineering courses in Kakamega County, Kenya.

1.2 Objective of the Study

The study aimed at achieving the following:

(i) Establish the influence of cost sharing (user charges) on female student's enrolment in TVET engineering courses in public technical institutions in Kakamega County, Kenya.

(ii) Examine the influence of awareness on TVET progression structure on female student's enrolment in Engineering courses in public technical institutions in Kakamega County, Kenya.

(iii) Find out the influence of admission policy on female student's enrolments in TVET engineering courses in public technical institutions in Kakamega County, Kenya.

2.0 Literature Reviewed

According to the Sustainable Development Goal (SDG) 4 there is need for member countries to ensure inclusivity and equitable quality education and promote lifelong learning opportunities for all. Target 4.3 indicates the need for reducing barriers to ensure equal access for all women and men to affordable and quality technical education. One of the global concerns is gender inequality in education. Further, SDG 5 on elimination of discrimination in education emphasis that policies should be made to help overcome gender inequality(The 2030 Agenda for Sustainable development goals, 2015).Empowerment of girls and women makes an important contribution to realisation of other goals and targets like goal number one poverty eradication and number 3 good health and wellbeing.

The Education 2030 Framework for Action, is a tool aimed at helping the international community achieve SDG 4 on education, it recognises gender equality as a guiding principle linked to the realisation of the right to education. Further, states clearly that girls and boys, women and men, must be equally empowered 'in and through education (UNESCO, 2018). Research shows that though there is an increase in women participation in basic education, gender disparity is more in technical education. For instance, the Global Monitoring Report in education, 2018 indicates that only 4% of countries have achieved parity. Overall, there are more females than males in technical education in almost all regions. Some countries in Southern Asia are almost closing the gap, while sub-Saharan Africa is the only region where women and men do not graduate or enrol in technical education at the same rate (Global Monitoring Report in Education, 2018). However, in many countries; although women outnumber men as graduates, few women are enrolled

in science, technology, engineering and mathematics (STEM) courses. In Chile, Ghana and Switzerland, women account for less than one-quarter of all STEM courses.

Several factors attributed to this are stereotyping, policy, institutional and social cultural have influenced female enrolment (UNESCO-UNEVOC 2010). Many nations have come up with policies to tackle the complexities of factors influencing female enrolment in TVET engineering courses. For instance,a study on cracking the code; girl's participation in STEM done by (UNESCO, 2017) indicated that countries such as USA, Australia and Canada had gender budgeting in TVET education. This study focused on policy factors such as cost sharing policy (user charges), TVET progression structure and TVET Admission policy (entry requirement).

Cost Sharing Policy (User Charges) in Kenya

Funding is one of the challenges facing TVET in many nations (UNESCO, 2017). Countries like Malaysia have adopted public private partnership as way of improving TVET. In Kenya, the Report of the Presidential Working Party on Education and Manpower Training for the Next Decade and beyond (The Kamunge Report, 1988) proposed the need for cost sharing of financing education by government, parents and communities. Oviawe (2018) on a study entitled Revamping Technical Vocational Education and Training through Public-Private Partnerships for Skill Development agrees that inadequate funding by governments is a challenge facing TVET sector. Over the years the government has increased funding through Higher Education Loans Board, Constituency Development Fund and Public –Private Partnership. 1988). In Kenya, for instance, fees and other user charges are paid differently depending on the course and the institution one decides to join. Studies have shown that engineering courses are more expensive than others due several requirements such as aprons and workshop facilities (World Bank, 2017).

Despite government creating several ways of funding TVET, some potential students and parents are not yet aware of the same. A study by Kiplangat&Muthima (2020) in ElgeiyoMarakwet County in Kenya on awareness levels of existing sources of funding for vocational education and training revealed that despite the existence of several sources of funding, results from principals and tutors showed that very few students benefited from it. According toKaaya and Waiganjo (2015) a study done in Tanzania on factors affecting women enrolment in technical institutions, where250 respondents were given questionnaire to fill. The findings indicated that finance is a challenge to female student many could not afford fees and cater for other expenses. Parents who had low incomes did not support women to join science fields. This study endeavours to find out if this in the case in Kakamega. Kenya like any other developing country has been faced by policy challenges in influencing participation of female students in engineering (Ruto, 2015). Over the years the government has come up with measures to encouragefemale students to enrol in STEM courses. Further,Kenya as a member of the United Nations, subscribes to its policies, and offers opportunities to all students through provision of scholarshipsThis study sought to seek if the same case applied to technical institutions in Kenyan Kakamega County.

TVET Progression Structure

In Kenya, Sessional paper No. 1 of 2005 proposed a progression structure for TVET, which gave opportunity for learners to advance to higher levels i.e., from an artisan to a PhD holder and in turn earn higher incomes. This led to establishment of Technical Universities in Kenya to promote technical skills among the youth. A study

in Bangladesh showed that many female students after graduating with a TVET diploma remain without going up the ladder compared to men. The progression for women in TVET to the university was found to be at 5% (World Bank, 2018). The study indicated that TVET globally is viewed as a sector for weak students and therefore many people are not aware of reforms in career progression in this sector.

Many studies have been done to establish the level of awareness of progression structure among staff and students. A study by Kiplangat and Muthima (2020) seeking to establish the awareness levels of howthe TVET progression structure contributes to enrolment in vocational training centres shows that 60.2% of students and 44.3% tutors agreed that it contributed. The study paid attention to both men and women in vocational centres enrolment while this study focused on female enrolment in engineering courses specifically institutions. Figure 1 shows the Kenya TVET progression structure.

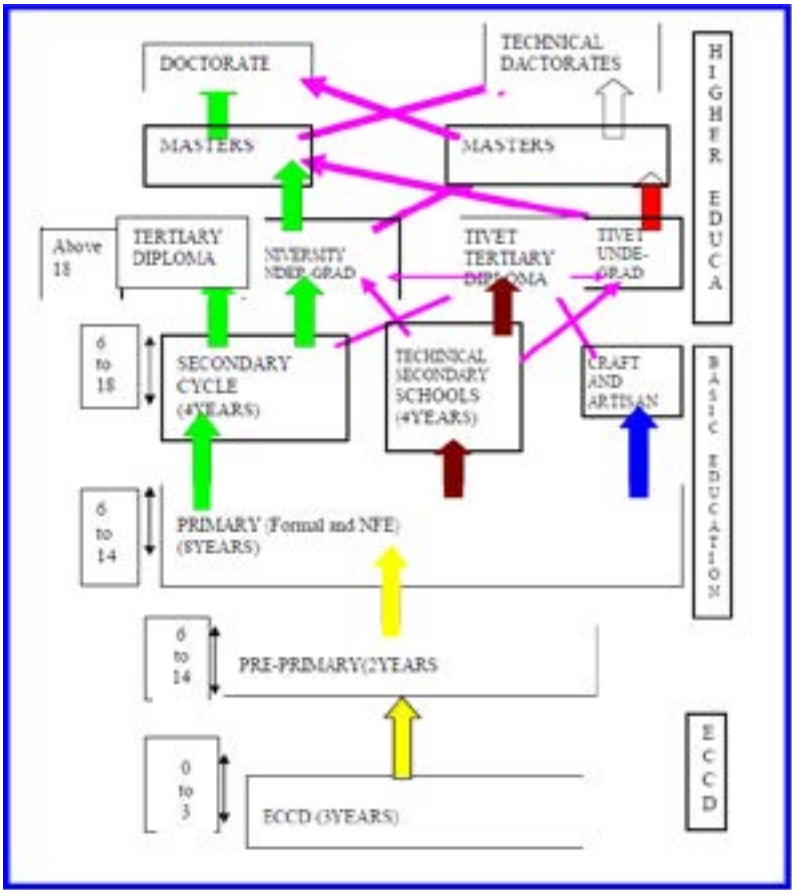

Figure 1: Structure of the TVET progression structure in Kenya.

Source: Ngugi and Muthima (2017:13)

The structure indicates that a student is able to join TVET after completing primary educationfor a certificate course of two years or join a youth polytechnic. Further, a learner can proceed to the university up to Doctorate level if he pursues a certificate, then a diploma, Masters and later a Doctorate in TVET. This means that a student can start as a grade test person, then move to an artisan (certificate) technician (Diploma) and a technologist/graduate (Higher national diploma/graduate respectively) according to Kenya's TVET structure.

Admission Policy (Entry Requirement)

Due to lack of common admissions in the institutions, TVET has faced problem of access in the past among others. (Republic of Kenya, 2012). The government through TVET Act of 2013 established the Kenya Universities and Colleges Central Placement Service (KUCCPs) to coordinate admission, promote equity and access for students to TVET institutions in Kenya (Republic of Kenya, 2019). For one to do an engineeringdiploma course in TVET one requires to score a C- and above in Kenya Certificate of Secondary Education (KCSE) or to have done a certificate course in the same field. For a craft certificate one need to score a D and above in KCSE while an artisan courses a D- andbelow is required. The study paid attention to finding out if students are aware of the entry requirements.

Sessional Paper No. 14 of 2012 highlights major challenges facing TVET despite the efforts by government in Kenya. The challenges include; low enrolment of female students in Science Mathematics and Engineering courses as a major concern; low enrolment in TVET institutions could be due to the high cost of technical training and lack of awareness of the requirements to join TVET programmes. The result is that most trainees end up in cheap alternative programmes whose graduates do not acquire the requisite skills necessary for the world of work (Republic of Kenya, 2012). After successfully completing primary or secondary education, students can join technical or vocational training programs. Artisan and trade programs offered in vocational training centres are available for primary school graduates allowing them to attain a diploma and certificate awards. Those who graduate from secondary school and score at a D and C- in Kenya Certificate of Secondary Education (KCSE) can join technical training institutes and institutes of technology (Republic of Kenya, 2012).

Despite this progress, inadequate knowledge on entry requirement in engineering is one of the challenges where the school leavers are not aware what do they require to join this sector. (Najoli,2018). Studies have shown that there is a lot of relationship between mathematics and science as a pre requisite for joining engineering courses (Matope & Makotse, 2007; UNESCO, 2017; Cherotich, 2016). A study done by Najoli (2018) show that the deans of students informed the study that the causes of gender differences in gender enrolment included, heavy entry grade for Science Technology, Engineering and Mathematics (STEM) courses for female students. This study focused on finding out how entry requirement have influenced enrolment of female students in Kenya.

Several studies have been carried out in Africa to establish causes of low female enrolment. For example, a study carried out by Ebenehi and Baki (2015) in Nigeria on challenges of enrolment in technology education reveals that weak policy such as

inadequate funding, admission policy, poor supervision, evaluation, lack of curriculum reviews and inadequate infrastructural facilities affect the enrolment of students in TVE in Nigeria. Handling of examinations by one examination body to determine entry to University, polytechnics and other technical colleges was a challenge since each examination has different objectives. The study listed other factors which included low budgetary allocations, inadequate training of teachers and lack of scholarship for certificate courses. The study focused on factors that influence the TVET sector in general and failed to specify which courses were being studied and if these factors affect female or male learners which this current study intends to address.

In Zimbabwe, it seems things were different from Nigeria since a study carried out by Matope and Makatose (2007) on factors influencing female engineering students as a career choice in Mutare Polytechnic, revealed that the Zimbabwean government had come up with policies to encourage females to enter engineering as 92% of lecturers and 93% of female students in engineering indicated in their responses. These policies made provisions for remunerating equally both female and male, reduced sex discrimination in engineering related jobs and paid maternity leave to attract female students in engineering. This led to increased enrolment and many females were attracted to engineering. Unfortunately, the situation in Ghana isdifferent thesector is still viewed by the society and students as one for those students who cannot use their "brains" according to a study done by (Nsiah-Gyabaah, 2009) on Technical and Vocational Education and Training in Ghana. In Rwanda, a national TVET policy was approved in 2008 and an integrated TVET system concept was developed to help in provision of quality education in TVET. Though these policies are in place, a study done by Maringa and Maringa (2013) on quality of TVET in Rwanda and enrolment factors of access and equal opportunity found that female trainees in TVET schools were 35% compared to male trainees who were 65%. This shows that female representation is still a challenge in the sub-Saharan region.

There are several commissions such as the Report of the Presidential Working Party on the Second University in Kenya (The Mackay Report, 1981), which suggested the integration of technical and vocational education in the education system. Further, the Report of the Presidential Working Party on Education and Manpower Training for the Next Decade and beyond (The Kamunge Report, 1988) also recommended the cost sharing in education where education financing was to be shared by government, parents and communities. The 2011 taskforce for realignment of education with the 2010 constitution spelt out the need to review the education gender policy of 2007 and implement the policies such as gender mainstreaming, increase of funding through scholarships for girls, provision of loans through Higher Education Loans board and affirmative action. All these measures have been put in place since independence to realign the education in Kenya with global agenda for education (Republic of Kenya, 2012). Despite all the initiatives engineering has not attracted female students in TVET institutions in Kenya as expected.

This is evidenced by a study that was carried out by Wataka (2013) in Bungoma county of Kenya on factors influencing female enrolment in science based courses which

revealed that policy factors such bursary awards, scholarship, user charges and provisional of infrastructural facilities in TVET influence choice of career in science based courses by female students in tertiary colleges. These findings were supported by Khaguya (2014) in the study on factors influencing enrolment of female students in science based courses in western province. The study examined psychological, cultural and financial factors and the results revealed that financial factors had the greatest influence in the enrolment of students in technical institutions. This study, however, did not find out how Policy factors such as user charges, progression structure. Wataka's study was conducted in 2013 while the current study was carried out in 2020 in a different county 8 year after and still the policy factors were a key contributor of low female enrolment in TVET.

3.0 Research Methodology

This study adopted a descriptive survey research design, which is commonly aimed at describing characteristics of variables in a situation. Orodho and Njeru (2003) explain that the design is reliable in both quantitative and qualitative studies where people's opinions, attitudes and perceptions are needed. Hypotheses were formulated both null and alternative that tested if there was a significant influence of policy determinants on female student's enrolment in TVET engineering courses in public technical institutions in Kakamega County. The study was carried out in Kakamega County of Kenya. The variables studied included; user charges, awareness of progression structure and admission policy. The target population of this study constituted a County TVET officer, 3 registrars of 3 TVET institutions in charge of admissions, 62 tutors in engineering departments who teach, train and interact with the students, 3559 female and male diploma and certificate students in engineering department who are the consumers of the courses. Census approach was employed for the registrar's. Random sampling was used to select the three institutions. (Shamberere, Bushiangala and Sigalagala). Morgan and Krejcie (1970) table for sample size determination was used to establish the right sample size.A fraction of 0.098 was attained by dividing the sample size (351) by target population (3559). 20% population of the tutors was employed as suggested by Gall (1992). Purposive sampling was employed to select County TVET officer to provide accurate information on the area of study. Questionnaire and interview Schedule were used as the data gathering instruments. Piloting was done in Butere technical college which is one of the colleges in the Kakamega County and a sample of 1% of the respondents was used. An analysis of the responses was done during piloting to ensure validity and Reliability. Pre-test and Alpha method was used to obtain a coefficient of 0.679 and 0.698 for students and tutors questionnaires respectively. Close ended items in questionnaires were analysed using descriptive statistics such as frequencies, percentages, and means. While the open ended questions, were organized into themes. Standard deviations were used to show the centralisation and describe the distribution of scores in participant's responses on the rating scales. Narrations were given from interviews. Statistical Product and Service Solution (SPSS Version 23.0) aided in data coding, entry and analysis. Linear regressions were used to show relationships between independent and dependent variables. Data was presented in texts, tables, pie charts and graphs. Ethical considerations' such

as anonymity and confidentiality of the respondent were taken care of by informing the respondents that the information given will be for academic research purpose only and they should not write their names in the questionnaires.

4.0 Results and Discussions

The study findings and discussions are guided by following objectives;

(i) Establish the influence of cost sharing (user charges) on female student's enrolment in TVET engineering courses in public technical institutions in Kakamega County, Kenya.

(ii) Examine the influence of awareness TVET progression structure on female student's enrolment in TVET Engineering courses in courses in public technical institutions in Kakamega County, Kenya.

(iii) Find out the influence of admission policy on female atstudent's enrolment in TVET engineering courses in public technical institutions in Kakamega County, Kenya.

The study sought to find out if policy factors influence female enrolment in TVET engineering courses. To answer the research question, do policies influence female enrolment in TVET engineering courses? The study focused on three policies namely: cost sharing (user charges), TVET progression structure, and Admission policy (entry requirement). Data was collected from TVET engineering students, tutors and registrars from three public technical training institutions in Kenya. The government of Kenya has provided a lot of funding for TVET students for the last 8 years to revitalise the sector. This study endeavoured to find out if these initiatives have increased female enrolment in engineering courses in TVET institutions. This is because there are so many students who complete both primary and secondary schools and do not transit to the next academic levels according to the ministry of education science and technology strategic plan.

First, both female and male students were asked to indicate how much they pay per every academic year for their programmes. Results are presented in Figure 2.

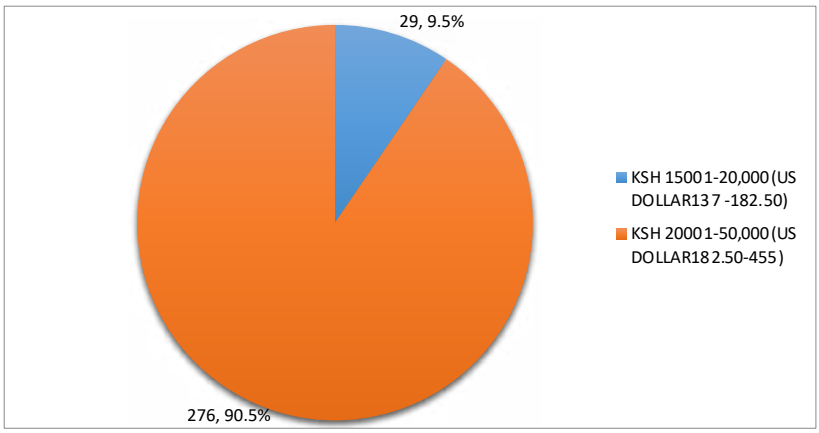

Figure 2: Amount of Fees Paid by Engineering Students in an Academic Year.

Results show that majority 276 (90.5%) of engineering student's fees ranged from KSH20, 000(US Dollar 182.50 at an exchange rate of Ksh 110) to KSH50, 000(US Dollar 455) per academic year whereas only 29 (9.5%) indicated that their fees for one academic year ranged from KSH15001 (US Dollar 137) to KSH20, 000 (US Dollar 182.50). To confirm if the fee was affordable to students, the results are presented in Figure 3.

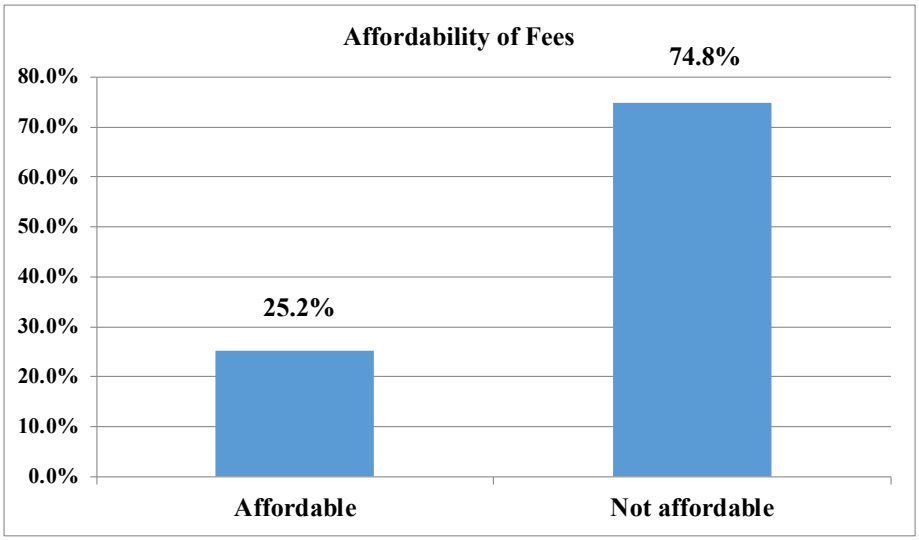

Figure 3: Whether Engineering Course Fees is Affordable (Affordability Opinion).

Observably,majority 228 (74.8%) of students believed that the fees chargeable per year for engineering students was not affordable with only 77 (25.2%) indicating that fees charged for engineering course was affordable. This implies that to most students, fees are high and it may fail to encourage high enrolment by prospective female and males in TVET colleges. These findings agree with (Muhonja, 2012; Khaguya, 2014; Muthima, 2015; Okoye, 2016) that financing of engineering courses is expensive due to other charges like examination fees, internship fees and equipment for practical learning like the tool box among others.

Tutors and students were then asked to indicate if there exist other sources of financing apart from parents. The combined responses are given in Table 3.

Table 3: Other Sources of Financing apart from Parents

Awareness of other sources of financing	Tutors		Students	
	Frequency	Percent	Frequency	Percent
Aware	11	91.7	231	75.7
Not aware	1	8.3	74	24.3
Total	**12**	**100.0**	**305**	**100.0**

Table 3 results show that 11 (91.7%) of tutors and 231 (75.7%) of students were aware of other sources of financing for student's fees in an academic year. 1(8.3%) tutor and 74 (24.3%) students were not aware of other sources of finances. These findings agree with Kiplangat and Muthima (2020) in a study done in ElgeyoMarakwet County, Kenya which revealed that 55.8% tutors and 37.2% regular students were aware of government support in vocational training centres. However, the percentage of the students in the vocational centres that were not aware in was higher at 62.8 %.

To find out if students were aware of the TVET progression structure, tutors and students were asked to indicate whether they were aware of the TVET progression structure policy in the country to help them know if they can proceed from one level to the other once they finished with the first stage, they were in. The results from both students and lecturers are given in Table 4.

Table 4: Students Awareness of TVET Progression Structure Policy

	Tutor Response on Student Level of Awareness		Students Level of Awareness	
	Frequency	**Percent**	**Frequency**	**Percent**
Yes	11	91.7	75	24.6
No	1	8.3	230	75.4
Total	**12**	**100.0**	**305**	**100.0**

According to 11(91.7%) lecturers, most of their students in the department understand the TVET progression structure while 75 (24.6%) of students indicated that they were not aware of the TVET progression policy. This may imply that lack of awareness of the TVET progression structure policy could be one of reasons for low enrolment of female students in TVET engineering programmes in Kakamega County. This agrees with the suggestion by Cherotich (2016) to create more awareness on the progression structure to help learners move from one stage to another.

Students were asked whether unfavourable selection criteria for student joining TVET engineering courses affected female student's enrolment in engineering programmes. The results are presented in Figure 4.

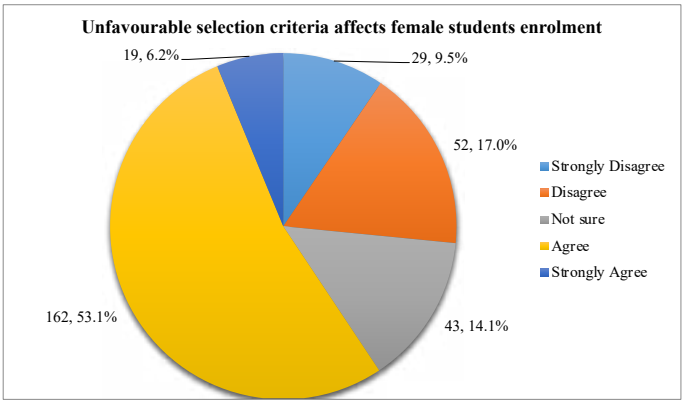

Figure 5. Whether unfavourable selection criteria affect female student's enrolment.

Findings in Figure 4 show that 162 (53.1%) of students agreed that unfavourable selection criteria entry requirements) hinders female students' enrolment in engineering programmes in public technical training institutions in Kakamega County. Only 52 (17.0%) of the students, disagreed with this statement. This implies that, the criteria developed by Kenya Universities and College Central Placement Service in admitting students in engineering programmes appears to favour male gender compared to female who generally are known to perform poorly in STEM subjects. This is, therefore, likely to contribute to their low enrolment in the TVET institutions in the study area. From the interviews, the registrars confirmed that the policy of students doing Physics as a prerequisite requirement to do engineering is no longer there but many people are not aware of the same and so students who did not do well in Physics and Mathematics shy away from engineering.

Further, Registrar No. 1 also indicated that:

The entry requirements in relation to subject combinations make girls to shy away from applying for engineering courses.

To test the hypothesisthatthere is no significant influence of policy factors on female students' enrolment in TVET engineering courses**,** a linear regression analysis was computed at 95.0% confidence level. The null and alternative hypotheses were*:*

H_{01}: There is no significant influence of policy determinants on female students' enrolment in TVET engineering courses .

H_{a1}: There is a significant influence of policy determinants on female students' enrolment in TVET engineering courses.

The model of analysis outcome is presented in Table 5.

Table 5: Model on Influence of Policy Determinants on Female Enrolment

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.618[a]	.382	.320	.84911	.382	6.182	1	10	.032
a. Predictors: (Constant), Policy determinants									

The correlation coefficient of the regression is R=0.618 which is a strong positive and the R square is 0.382, implying that 38.2% of change in female students' enrolment in TVET engineering courses can be explained by policy determinants in Kakamega County, Kenya. The F- change statistics shows that there exists linearity ($p<0.05$) between the independent and dependent variables. Table 6 presents the regression coefficient result for the second independent variable against dependent variable.

Table 6: Coefficients of Policy Factors Influence on Female Enrolment in TVET Engineering Courses

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
B		Std. Error	Beta			
1	(Constant)	1.877	.574		3.270	.008
	Policy determinants	.469	.189	.618	2.486	.032
a. Dependent Variable: female enrolment						

The linear regression equation is:

$y=1.877+0.469\beta$ (1)

Equation 1.1 can be interpreted that there exists a positive coefficient ($\beta=0.469$) between policy determinants and female students' enrolment in TVET engineering courses. The regression coefficient is significant ($p=0.32$) leading to the rejection of the null hypothesis ($p<0.05$) and acceptance of the alternative hypothesis that there is a significant influence of policy determinants on female enrolment in TVET engineering courses in Kakamega County, Kenya. The coefficient suggests that a unit change in policy determinants, female students' enrolment in TVET engineering programmes increases by 0.469. The analysis shows that there is a significant influence of cost sharing, progression structure and admission policy on enrolment in TVET engineering courses. This means that cost sharing (user charges), lack of awareness of progression structure in TVET and admission policy (entry requirement) are great contributors in low female enrolment.

5.0 Conclusions

This study concluded that:

1. Despite the many policies that have been put in place to support the TVET sector, due to high cost of fees in, cost sharing policy influences female students in enrolling in TVET institutions and they shy away from the engineering courses.
2. The admission policy requirement (entry requirement) is also a deterring factor especially the lack of knowledge that physics is no longer a requirement for one to do engineering it's an added advantage.
3. Progression structure is not known to many, therefore, female students may not join TVET in fear of remaining in the lower cadre courses or levels.

4. Recommendations

The study recommends the following:

(i) Since cost sharing policy influences female enrolment negatively, the national government through the Ministry of Education should increase the capitation funds through HELB loans and bursaries to enable many girls whose parents are unable to raise the required fees access funds to enable them undertake engineering programmes (especially examination fees).

(ii) If admission policy (entry requirement) is influencing enrolment of female students negatively the ministry of education through TIVETA can provide revision of the requirements and also training to teachers in basic education, who are majorly the career counsellors on the entry requirements to TVET engineering courses.

(iii) The government through the Ministry of Education should ensure awareness of the progression structure through campaigns especially in the rural areas where academic performance is low.

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Flood Vulnerability and Risk Mapping in Tana River River County, Kenya, Using Multi-Criteria Decision Analysis and GIS

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Abstract

Flood is one of the major recurring and seasonal environmental problems in Kenya and often causes huge losses of life and economy through destruction of property. The increase in magnitude and frequency of floods and landslides are attributed to human activities in the most vulnerable areas and climate change phenomena such as Indian Ocean Dipole. Among the notable and vulnerable areas is the Tana Delta. The flood vulnerability mapping of the region is crucial for wetland management, early warning system and development of response initiatives. The purpose of this study was to develop flood vulnerability maps for flood prediction in the study area. GIS-based methodologies were used to map the distribution and extent of floods and landslides which include spatial distribution models such as Digital Surface Model (DSM), Digital Elevation Models (DEM) and Landsat Imagery. Geographical Information System (GIS)/Remote Sensing (RS)-based multi-criteria approach was used to select the flood causal factors and vulnerability assessment. Relative weight of each factor was determined using Analytical Hierarchical Process (AHP). The first step in the flood vulnerability analysis was to identify the factors. Then each factor was analysed with satellite images in the GIS environment, weighted and overlaid to produce the flood vulnerability maps. The results show that although very highly vulnerable areas cover the smallest proportion in the study areas (6%) a sizable proportion of areas has substantial vulnerability (20%). The extremely low and minimal flood vulnerability classes cover 11.1% and 27.4%, respectively. The model predicted that a total of 217,882 hectares of land would be inundated during a rainy period. Areas that are under highly vulnerable in the study area include Garsen North, Mikindu, Chewani and Kipini West. The extremely highly vulnerable areas are: Garsen Central and Garsen South. All these areas are within high and extremely high hazard zones and are dominated by low elevation and slope degree. These vulnerability maps are critical in mapping the flood and landslide events in order to develop a clear roadmap to an early warning system.

Keywords: **Flood hazard mapping, Flood exposure mapping, Environmental vulnerability to floods, GIS, Tana River.**

1.0 Introduction

Flood is a major natural hazard with immeasurable impact, affecting over 170 million people annually across the world (Kowalzig, 2008). Climate change and land use changes have increased the frequency, seasonality, and magnitude of extreme weather events such as floods and earth movement processes (Kazakis *et al*. 2015) and may occur more frequently in the future (Rahmati *et al*. 2016; Ajjur & Mogheir, 2020). In 2019 for example, there was a record-breaking temperature rise in the Indian Ocean—a phenomenon called Positive Indian Ocean Dipole or Indian Ocean "El Niño". This resulted in heavy rains in Kenya and other East African countries (Tanzania, South Sudan, Ethiopia, and Somalia) which caused massive floods and landslides (Lu and Ren, 2020). Urbanisation is also a key factor to increased flood vulnerability in the cities through increasing runoffs (Cloke *et al*. 2013; Mu, 2021).

Kenya's economy remains highly susceptible to climate variability due to overdependence on climate sensitive sectors such as water industry, energy industry, forestry, tourism, and agriculture, which employs 70–75% of the workforce, contributing 25–30% of GDP (Otolo & Wakhungu, 2013). In Kenya, over 800,000 people (about half the population of Nebraska) are affected by the floods every year countrywide (Quandt, 2016). These floods are widespread in low-lying counties in northern, eastern, northeastern, and coastal low altitude areas (between 0–1500 m above sea level). These counties include Turkana, Marsabit, Kisumu, Samburu, Garissa, Mandera, Wajir, Lamu, Tana-River, Taita-Taveta and Narok (Otolo & Wakhungu, 2013; Ouma and Tateishi, 2014). Additionally, floods are common on floodplains of the major rivers such as the lower Nzoia River at Budalang'i plains, the lower Tana River, and the lower Nyando River at Kano Plains (OCHA, 2018).

Remote Sensing (RS) and Geographic Information System (GIS) methodologies have made significant contribution in analysing the impact of natural hazards such as floods (Chawan, 2020; Rahman, & Di, 2020; Najafi, 2021). Although the use of GIS-based multi-criteria analysis in the flood vulnerability assessment was not popular until 2000 (Kazakis *et al*., 2015), in Correia *et al*. (1999) GIS has been recognised as a powerful means to integrate and analyse data from various sources to produce flood vulnerability maps. MCDA-GIS techniques have been used in spatial modelling and analysis of natural hazards (Malczewski, 2006; Scheuer *et al*., 2011; Solín, 2012).

Multi-Criteria Evaluation (MCE) is useful tool for an analysis of flood causal factors for the purposes of ranking them from the most to least preferred (Kazakis *et al*., 2015; Ajjur & Mogheir, 2020; Gourav *et al*. 2020). MCDA tool could be used to integrate environmental, technical, and socio-economic objectives to make the best decision (Ghanbarpour *et al*., 2013). Analytical Hierarchical Process (AHP) is a multi-criteria decision tool that has been used in other studies (Li *et al*., 2009; Mastin, 2009) to solve complex decision-making problems.

Along the lower Tana-River basin and major areas of Tana-River County and Garrisa County, floods rage havoc every year causing huge losses of lives and economy.

According to Maingi & Marsh (2002) five major reservoirs have been built over the past fifty years in the upper basin for power generation as well as for reducing water velocity. These reservoirs have significantly changed the hydrological regime of the Tana River, with a 20 % decrease. However, with growth of urban centers along the Tana-River and land use changes which have led to increase in the surface runoff (Otieno *et al*. 2019), floods continue to displace many people in the area. In year 2019, the heavy precipitation due to Positive Indian Ocean Dipole affected over 144,000 people in the coastal counties. To address the environmental hazards such as floods and landslides, flood management tools are critical (Degiorgis *et al*., 2012). The aim of this paper is to carry out flood vulnerability assessment and generate flood vulnerability maps in the Tana River County in Kenya.

2 Methodology

2.1 Study Area

The study was carried out in the western half of the Tana River Basin, in Tana River County, Kenya (Figigure 2.1). The Tana River Delta is located on the Kenyan coast between the towns of Garsen, Lamu and Malindi and extends roughly over 1300 km^2. The county lies within 0°07'S and 38°26' E and 3°06'S and 39°12'E. The elevation of the area ranges from 0 to 503m on the highest (Figure 1). The area generally slopes from the north to the south. Tana River County covers an area of about 35,375.8 km^2 and a population of 315,943 (KNBS, 2019). The region is one of the poorest in Kenya and its indicators of human well-being are extremely low (UNDP Kenya, 2018). The main subsistence activity is farming, fishing, and livestock-keeping (Leauthaud, 2009; Duvail *et al*., 2012; Leauthaud *et al*., 2013). The area is generally dry and prone to drought. Rainfall is erratic, with rainy seasons in March–May and October–December.

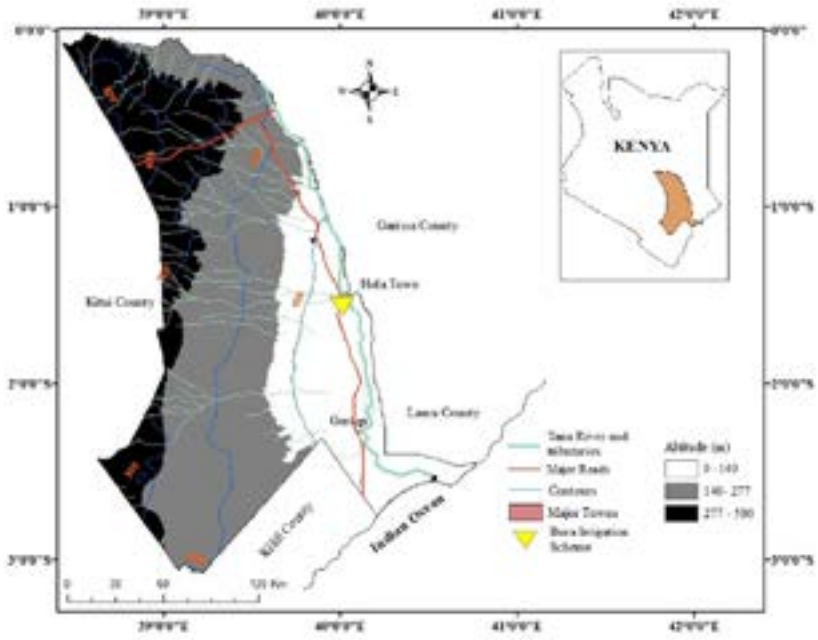

Figure 2.1: Map of Tana-River County (Developed from Diva GIS data).

2.2 Methods

GIS-based Multi-Criteria Decision Approach (MCDA) for flood vulnerability assessment was used (Kazakis *et al*., 2015a). Different parameters are used in different studies depending on the area of study. In this study seven parameters were selected, namely, slope (in degrees), distance from major drainage, land use/land cover, drainage density, soil, rainfall, and altitude. To determine the relative impact weight of these causative factors, the Analytical Hierarchical Process (AHP) was used to get a composite flood hazard index (FHI) (Saaty, 1990a, 1990b). The input data required for creating susceptibility maps were the digital elevation model (DEM) map with a ground resolution of 30 m by 30m[1] , land-use map[2], the Tana River watershed boundary map, nand the floodplain extent map[3]. The map of each factor was transformed to right projection coordinate system[4] and later converted to raster format. Moreover, these factor maps were reclassified to five classes using reclassify tool in ArcMap. Figure 2.2 shows summary of methodology.

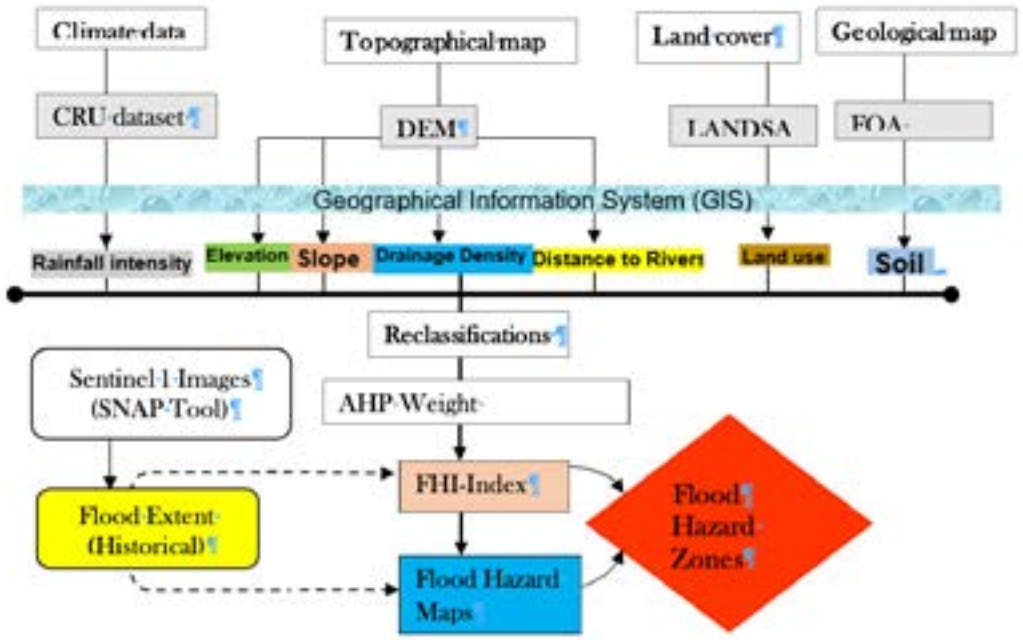

Figure 2.2: Flowchart of MCDA for flood risk analysis

2.2.1 Dataset Preparation

The selected factors for hazard mapping were drainage density, distance to rivers (DR), elevation, Land use/Land cover (LULC), precipitation, slope and soil. The datasets of all these factors were converted to a raster grid with 30 x 30 m cells for application of the AHP method and weighted overlay analysis. Sentinel 1 GRD products were used to validate the actual flooded areas. To extract the flood water extent for validation of the flood hazard maps, SAR data was used. These are Ground Range Detected (GRD) products that include focused SAR

1 *From Earth Observation Research Centre (EORC) ALOS GDSM (Global Digital Surface Model*

2 *From Landsat-8 images, which were obtained from Earth Explorer*

3 *Sentinel 1 images*

4 *From WGS_1984_ to UTM_Zone_37N*

data that was detected, multi-looked, and projected to the right coordinate of WGS-84 Earth ellipsoid model on ground range. To correct the ellipsoid projection of the GRD products, the terrain height specified in the product's general annotation was used.

(a) Drainage Density: Using hydrology tool in ArcGIS, flow accumulation raster was made using DEM fill. This was converted to vector shape file for better visibility. Line density tool was used to calculate drainage density. The drainage line for the study area was calculated using field calculator which enabled to perform calculations that are not included as built-in functions within ArcGIS.

$$\text{Drainage density} = \frac{\text{Total Length channels (m)}}{\text{Basin area (m}^2\text{)}} = m^{-1} \quad (1)$$

The drainage density layer was reclassified into five classes (1–5) using the natural breaks schemes: class 1 (0.0347-0.259), 2 (0.26-0.351), 3(0.352-0.424), 4(0.425-0.549), and 5 (0.55-0.876). Class 1 is the lower drainage density while class 5 is the highest drainage density. With respect to flood potentials, the class of higher drainage density is the most vulnerable area. The denser the drainage network is, the higher the flow accumulation paths are and consequently highly vulnerable to flooding (Islam & Sado, 2000).

(b) DEM preparation distance to rivers, elevation and slope: A mosaic of Digital Elevation Model (DEM) was created from ALOS Global DSM data (JAXA) with resolution of 30 by 30 m. Using this DEM, the slope in degree, elevation and distant to rivers were calculated using hydrology tools. Distance to rivers was calculated using Euclidean Distance tool (Spatial Analyst Tools in ArcGIS).

(c) Land use/cover map: The land use map was produced from multispectral Landsat-8 Operational Land Imager (OLI) images (path/row of 166/060 and 167 /062 of Jan 2017) with resolutions of 30 by 30 m pixel (Table 1) employing an unsupervised classification method with 30 classes which were reclassified to 5 classes. The reclassified LULC classes were; forest, low dense vegetation/shrub land, water, cropland, and bare lands.

(d) Annual rainfall map: Annual rainfall map was prepared from Monthly CRU (Climate Research Unit) datasets[5]. Thereafter the 'netcdf' was converted to file a format that can be read in ArcMap using multidimensional tools (make Netcdf raster layer). After the conversion, months were separated from bands and annual rainfall maps generated. It was then interpolated to cover the region and the study area was clipped using raster clipping tool. Finally, annual average rainfall map was generated.

(e) Soil map preparation: The soil map was prepared from FAO (Food and Agriculture Organisation) dataset (Table 2.1). These are a set of Digital Soil Map of the World (DSMW) in ESRI shape file format. SWAT[6] soil data download guide was used to interpret the soil types and properties relevant to water holding capacities. DSMW shape file in ArcGIS was launched and the area of the study was extracted using data frame properties of the study area projected coordinate shape file.

5 *Source: Climate Research Unit (UEA) website (http://www.cru.uea.ac.uk/data)*

6 *Source: Soil and Water Analysis Tool database (https://swat.tamu.edu/data/)*

Table 2.1: Summary of Dataset's Properties

	Type	Path	Row	Date/Year	Resolution	Source
1	Landsat-8 OLI/TIRS C1 level-1 & Level-2	166–167	060–062	Jan 2017	30 m	USGS
2	DEM/DSM			2019	30 m	JAXA
3	Precipitation			2011-2016	100 m	CRU (Climate Research Unit)
4	Soil Map			2019	100 m	GEO Network
5	Sentinel 1-(GRD) products			2019	5 m	ESA (European Space Agency)

2.2.2 Dataset Reclassification

This was mandatory for overlay analysis to give the same value to range of pixels for example 1–50 (actual range value) is assigned 1 (new single value for the entire range). Five classes were made for better results. The following datasets were reclassified into 5 classes using natural breaks method using reclassify tool in Spatial Analysis Tools: DEM, slope in degree, rainfall, drainage density and distance to major drainage line. The other two data sets of soil and land use were reclassified into their original classes' number since these were not possible to reclassify further.

2.2.3 AHP and Determination of Relative Weights of Each Parameter

The weight of each parameter was determined using Analytical Hierarchy Process (AHP) (Saaty 1991). AHP-based multi-criteria decision is used in process of ranking and prioritisation. When making decisions, hydrologists and engineers often use heuristic and experimental judgments from the public who are the end-users (Leauthaud-Harnett *et al*., 2013, 2016). To determine the aims and to formulate the decision-making process, opinions of 12 experts from fields of hydrology were collected using scales shown in Table 2.2. An eigenvector was then developed in Excel using pairwise comparison matrix to weight the standardised raster layers.

Table 2.2: Saaty Scale for Various Elements Comparison (Saaty, 1990)

Scale	Judgment of preference	Description
1	Equally important	Two factors contribute equally to the objective
3	Moderately important	Experience and judgment slightly favor one over the other
5	Important	Judgment and experience important favor one over the other
7	Very strongly important	Judgment and experience strongly important favor one over the other
9	Extremely important	The evidence in favor of one over the other is of the highest validity
2, 4, 6, 8	Intermediate preference between adjacent scales	When compromised is needed

The relative significance of these criteria was evaluated in scale of 1 to 9, where 1 was less important and 9 was more important criteria (Table 2.3). After all the factors have been sorted on the basis of their relative importance, a pairwise comparison matrix was created for deciding each important weight comparison. A 7 by 7 matrix was developed where diagonal elements were equal to 1. The values of each row illustrate the significance between two parameters. The first row in Table 2.3 illustrates the importance of drainage density compared to other parameters which were placed in the columns. In this study, for example, drainage density was significantly more important from soil and therefore assigned value 7. Therefore, the row had the inverse values of the pairwise comparison (e.g., 1/7 for drainage density).

Table 2.3: Eigenvector for AHP Determination

	DD	DR	Elev.	LULC	R/f	Slope	Soil	Total
Drainage Density (DD)	1	2	2	3	3	5	7	23.0
Distance to Rivers (DR)	1/2	1	1	3	3	4	6	18.5
Elevation	1/2	1	1	3	3	4	6	19.5
Land use (LU)	1/3	1/3	1/3	1	2	4	5	13.0
Rainfall (R/f)	1/3	1/3	1/3	1/2	1	4	5	11.5
Slope	1/5	1/4	1/4	1/4	1/4	1	3	5.2
Soil	1/7	1/6	1/6	1/5	1/5	1/3	1	2.2
Total	3	6	5	11	12	22	33	

Consistency

After creating the eigenvector matrix of the AHP, consistency was confirmed (Table 2.4). Consistency Index is the numerical measure of how values were assigned and whether the value reflects the true relative weight of the parameter. If the consistency index is below certain values, the values are consistent and if it is above, there was a need to go back and do the ranking.

Table 2.4: Random Index (RI) for Consistency Ratios (CR) Computation

N	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The vulnerability factors were organised hierarchically in the matrix. Based on the factor importance in comparison to other factor, the prioritize factor rating value technique was used to assign the numerical value to each factor. The factors' numerical value assignment was based on expert knowledge and literature reviews. The average of these factors in hierarchy was used to calculate the weights and eigenvalue along with consistency ratio (CR) based on Saaty scale (Table 2.4) expressing that the eigenvalue λ_{Max} and total number *n* factors are the same for consistency comparison matrix. The Consistency Index (CI) was calculated as follows:

$$C = \frac{(\lambda \text{ max-}n)}{(n-1)} \quad (2)$$

where, n denotes number of factors, and λ_{Max} is the eigenvalue.

The consistency of the comparison matrix was assessed by using the consistency ratio (CR), expressed as:

$$CR = \frac{CI}{RI} \quad (3)$$

where CR denotes Consistency Ratio of the generated comparison matrix (Table 2.5).

Normalising the matrix means dividing each element in every column by the sum of that column. The decision rule for CI is that CR values of 0.1 or less is acceptable reciprocal matrix. In this study the CR values obtained in table 2.5 using λ_{Max} =7.72, n=7 and CI=1.32 thus CR=0.09 which is below 0.1 and, therefore, the weights efficiency was affirmed.

Table 2.5: Normalised Flood Parameters

Criteria	DD	DR	Elev.	LU/LC	R/f	Slope	Soil	Mean	W_i
Drainage Density (DD)	0.33	0.39	0.39	0.27	0.24	0.22	0.21	0.30	**3.0**
Distance to Rivers (DR)	0.17	0.20	0.20	0.27	0.24	0.18	0.18	0.21	**2.1**
Elevation	0.17	0.20	0.20	0.27	0.24	0.18	0.18	0.21	**2.1**
Land use	0.11	0.07	0.07	0.09	0.16	0.18	0.15	0.12	**1.2**
Rainfall (R/f)	0.11	0.07	0.07	0.05	0.02	0.18	0.15	0.09	**0.9**
Slope	0.07	0.05	0.05	0.02	0.02	0.01	0.09	0.04	**0.4**
Soil	0.05	0.03	0.03	0.02	0.02	0.01	0.03	0.03	**0.3**
CR									**0.09**

2.2.4 Flood Hazard Index and Final Flood Vulnerability Maps

After normalising the values for each parameter, an overlay analysis was used to develop the final flood maps. The overlay analysis is a method that is applied to identify site suitability tests (Ajjur & Mogheir, 2020). The output map of vulnerable areas includes the combination of the above seven factors. Specifically, the seven maps that were developed after the classification method were combined using a weighted linear combination approach in a GIS environment. Using the numeric overlay requires each factor to be multiplied by its percentage weight and then all factors added together to yield the final map of hazardous areas (Gemitzi *et al*., 2006):

$$S=w_i x_i \quad (4)$$

where, S is the final map of hazardous areas, wi is the weight of factor, and xi is the rate of the factor i.

Table 2.6: Weighted Values

	Parameter	Class	Assigned Rank	Weight
1	Drainage Density (Km^2)	0.0347–0.259	2	3
		0.260–0.351	4	
		0.352–0.424	6	
		0.425–0.549	8	
		0.550–0.876	10	
2	Distance to rivers (m)	<200	10	2.1
		201–500	8	
		500–1000	6	
		1000–2000	4	
		>2000	2	
3	Elevation (m)	0–96	10	2.1
		99–185	8	
		186–263	6	
		264–366	4	
		367–580	2	
4	Land use	Forest	2	1.2
		Shrub/Low dense vegetation	4	
		Crop land	6	
		Range/Barren lands	8	
		Water	10	
5	Precipitation (mm)	603–717	2	0.9
		718–842	4	
		843–974	6	
		975–1129	8	
		1130–1264mm	10	
6	Slope (degree)	0–0.4432	2	0.4
		0.4433–1.995	4	
		1.996–6.648	6	
		6.648–17.73	8	
		17.74–56.51	10	
7	Soil	57	8	0.3
		356	4	
		737	3	
		774	6	
		881	1	
		913	2	
		966	7	
		987	5	

3 Results

3.1 Thematic Maps of Flood Parameters in Study Area

The first parameter was drainage density (Fig 3.1a). High values of drainage density show areas of concentrated flow and thus higher flood hazard potential. Most part of the area has moderate to low drainage densities and only small region has the highest drainage density. The results showed that most high-altitude areas to the north and western part of the Tana River County have low flow accumulation and are covered by low dense forest.

The second parameter was distance to major rivers (Figure 3.3f). Although the rivers are dominated by first- through third-order streams, there are few notable fourth- through sixth-order streams. The main river, Tana river is beyond sixth-order stream and most other rivers flow to this main river. The closer the proximity of an area to river the more the vulnarable the area to flood risk. Class 1 (0–200 m) rated extremely high, 2 (201–400 m) high, 3 (401–1000 m) moderate, 4 (1001–1500 m) low and 5 (>1500 m) extremely low. The area is low in stream distribution and most parts are under extremely low and low vulnerability in respect to the major rivers (54% and 21%, respectively). Areas that are high vulnerability and extremely high vulnerability represent the smallest proportion (7% and 6%, respectively).

The third parameter was elevation (Figure 3a). The five classes of elevation were: 1(0–96 m) 2(99-185 m) 3(186-263 m) 4(264–366 m) and 5 (367-580 m). The lower elevation areas receive most inflows from high elevation areas and are thus prone to flood hazard and was rated 10. The fourth parameter was land use/land cover (Figure. 3.3g). The land use map of study area shows that larger proportion of the area is rangelands covering an area of 18765.4 km^2 (49.1%) and cropland which covered an approximate area of 11700.80 km^2 (30.6%). Other land use/land cover classes were low dense vegetation (12.7%), forest (6.8%) and water (1.09%). In terms of vulnerability classes, water was rated extremely high and rangeland rate high. Forest and low dense forest was rated very low and low respectively.

The fifth factor was rainfall (Figure 3.3b). Rainfall intensity was classified into 5 classes namely: 1 (603–717 mm), 2 (718–842 mm), 3 (843–974mm), 4 (975–1129 mm) and 5 (1130–1264 mm). In flood affinity, class 5 with high average annual rainfall was classified as extremely high and 1 as very low. The sixth parameter was the slope in degrees (Figure 3.3d). For purposes of overlay analysis, the slope map was reclassified into 5 classes namely: 1 (0–0.4432) extremely high, 2 (0.4433-1.995) high, 3 (1.996–6.648) moderate 4 (6.648–17.73) low and 5 (17.74-56.51) extremely low.

The seventh factor was soil (3.3e). In the study area, eight soil structure types were identified. In terms of area coverage, the most dominant soil was the loam (737) and clay (774) covering a total area of 20971.0 km^2 (55%) and 7164.57 km^2 (19%), respectively. The least common types of soils are loam (356) and sandy-clay loam (913) each covering only 2%. In terms of soil texture, high values of bulk density correspond to sandy soils and low to clayey soils. Lower bulk density soils have high water holding capacity and low percolation rate. These soils have high affinity for water holding and thus highly vulnerable to flooding. Therefore, clay soil (966) was assigned higher values than Loam (57). Consequently, karstic formations and lacustrine deposits (clays, marbles, and loam) was rated 8 while sand-clay loam (737) rated 1.

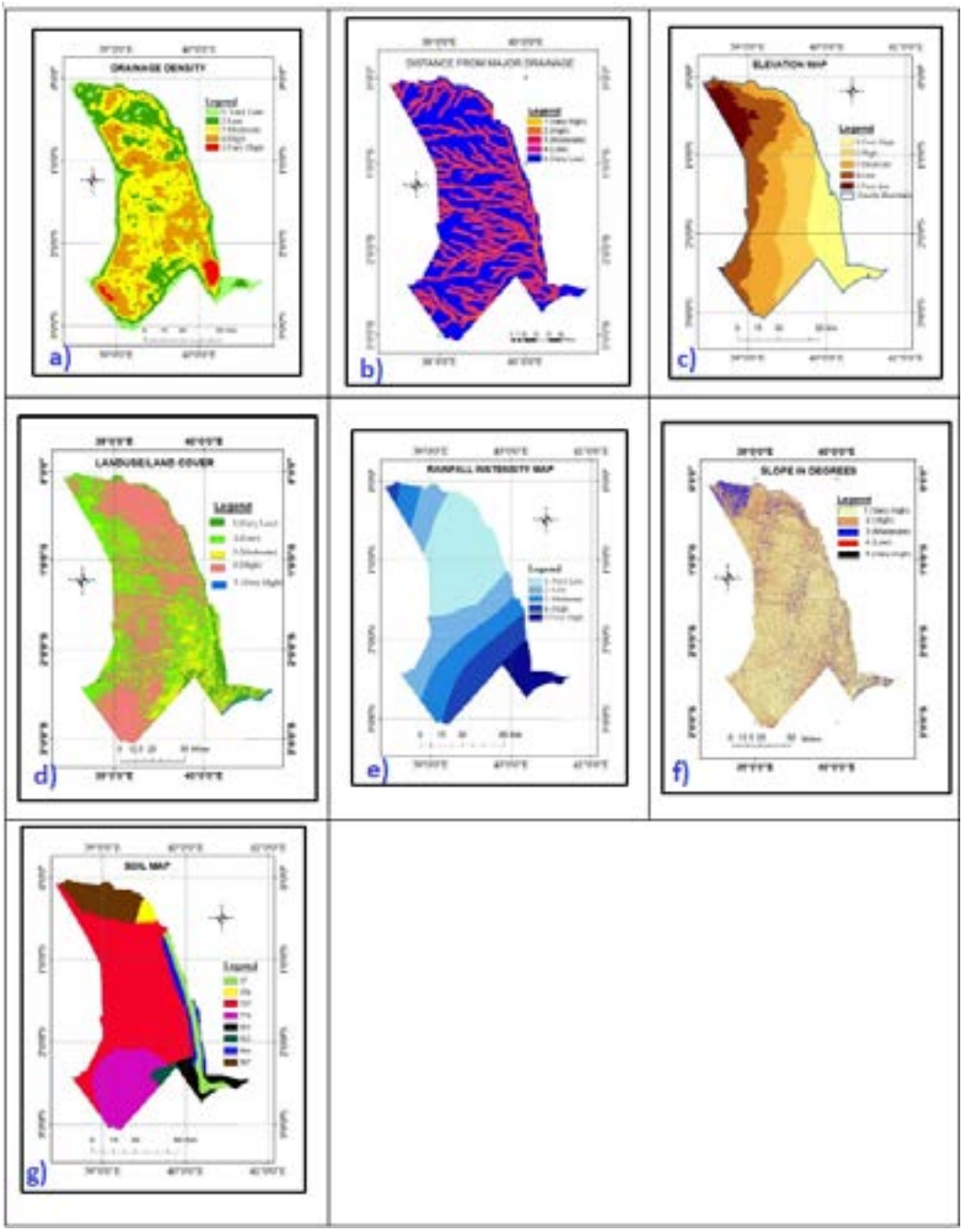

Figure 3.1: Flood vulnerability causal factors: (a) Drainage density; (b) Distant to rivers; (c) Elevation); (d)) land use classes and cover; (e) Precipitation; (f) Slope in degree; and (g) Soil.

The Normalised Differential Vegetation Index (NDVI) was used to confirm the accuracy of the vegetation distribution in the classification (Figure 4). In NDVI, the values obtained vary in the range between -1.0 and +1.0. Typically, vegetated areas have values greater than zero while bare soil have positive values near zero and negative values showing clouds and water. The high NDVI of 0.5871 indicate forested areas and low values of 0.2073 are a region of low to no vegetation cover. Forest was ranked least (2) while water as most vulnerable (10). In the reclassified map (Figure 3.2h) water and bare lands had a high index and was ranked extremely high and high in flood vulnerability, respectively.

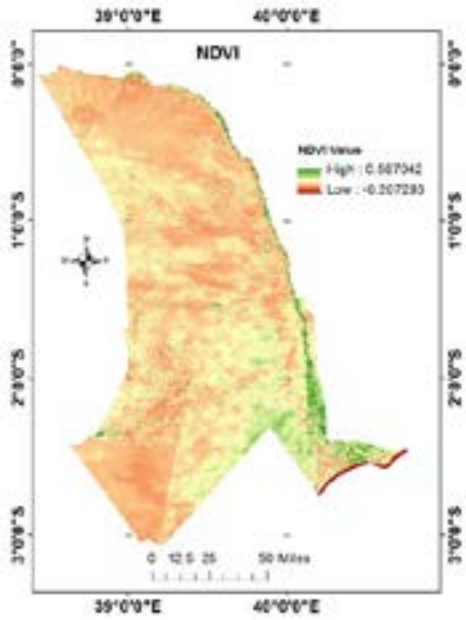

Figure 3.2: NDVI map

3.2 Flood Hazard Analysis

Maps of the inundated areas were developed in combination of the above parameters using the overlay tools in the GIS environment. These factors were weighted and overlaid to produce the flood vulnerability map (Figure 3.3). The flood hazard map was classified into five classes. The areas rated as very high and high represent areas highly susceptible to floods.

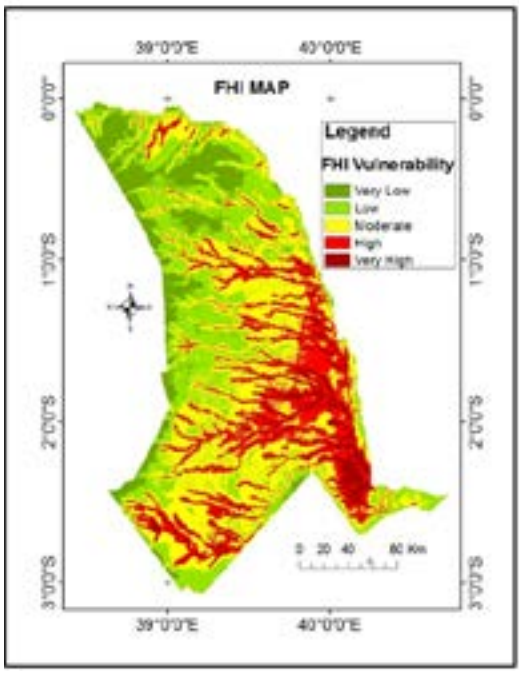

Figure 3.3: Weighted overlay vulnerability map of the study area

The results showed that extremely low and minimal risk classes cover 11.1% and 27.4%, respectively. Areas with very low and low risk index (39% combined) lie in central, west and northern part of the study area (Fig 3.4). These areas represent a safe zone for flood mitigation planning and evacuation. The administrative areas that lie within these low-vulnerability zone include Jara, Bangale, Chewele, Sala and Madogo. These areas are within high elevation, low slope in degrees, low drainage density, and flow accumulation.

For moderately vulnerable areas, it covers the largest proportion of the study area (35.9%). Most parts of these areas lie in low elevation and slope degree. In the land use map, these areas are mainly in agriculture and pastoral dominated areas (Figure 3.3g). These areas include Hirimani, Wayu and Garsen West but are surrounded by areas of high and extremely high flood susceptibility (Figure 3.4). Areas that are under high vulnerability were relatively significant and represent 19.5% (Figure 3.5) and include Garsen North, Mikindu, Chewani and Kipini West. The extremely highly vulnerable areas represented the smallest proportion (6.1%) and cover the areas of Garsen Central and Garsen South. All the areas that lie within high and extremely high vulnerable zones are dominated by low elevation and slope degree.

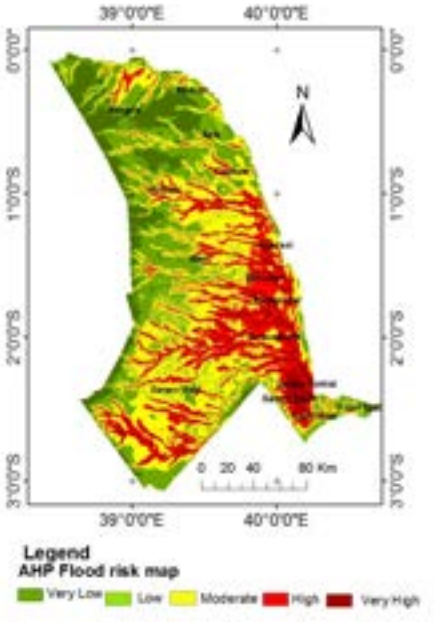

Figure 3.4: AHP flood vulnerability map showing high prone locations in the study area

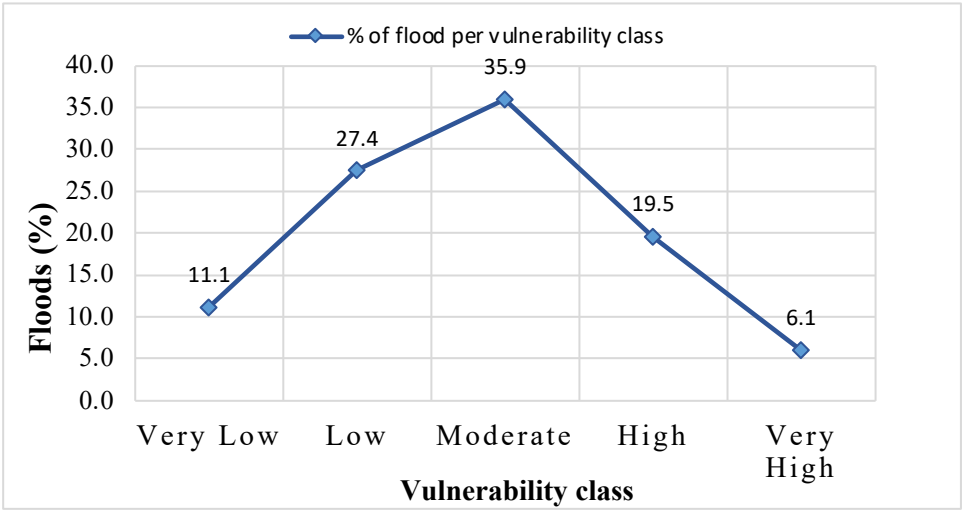

Figure 3.5: Percent vulnerability classes

In terms of land size, high vulnerability and very highly vulnerable areas covers 6997 and 2178 km^2, respectively. On the other hand, the largest class (35.9%) —moderate vulnerability covers 12895 km^2 and low vulnerability covers 9855 km^2 (Table 3.1).

Table 3.1: Area in Square Kilometers of the Flood Exposure Classes.

Value	Area (km^2)	Area (%)
Very Low	3989.67	11.11
Low	9855.87	27.44
Moderate	12895.4	35.90
High	6997.31	19.48
Very High	2178.82	6.07
	35917.07	**100**

4. Discussion

4.1 Flood Hazard

The modified methodological approach used in this study was inspired by various earlier work (Leauthaud *et al*., 2013; Malczewski & Rinner, 2015; Ouma & Tateishi, 2014b; Rahmati *et al*., 2016; Saaty, 1991). In all these studies, it was found that flooding and landslide are phenomena triggered by the combination of many different factors that falls into two criteria: hazard and vulnerability. While there were many potential flood predisposing factors, only major seven factors were used in this study. Using the AHP rating, drainage density was the most influential parameter in flood mapping (30%). Other significantly influential parameters were the distance to major drainage and elevation (21% each).

Records of historical flood events (Duvail *et al*. 2012) support the indications of the FHIS analysis through the recurrent flooding along the Tana River. Although very highly vulnerable areas cover the smallest proportion in the study area (6%) a sizable proportion of areas have substantial vulnerability (20%). The model predicted that a total of 217,882 hectares of land would be inundated during rainy period. This results support the findings of Leauthaud *et al*. (2013) that used water balance model and satellite data (MODIS) to characterized floods in the poorly gauged Tana Delta. According to Leauthaud *et al*. (2013) while flood extents over 100 and 200 km^2 were observed 22% and 4%, respectively of the time and covered less than 10% of the area.

Land use and land cover determines the flood affinity of the area (Malczewski & Rinner, 2015). In the study area, an estimated 2178.82 km^2 predicted to be under extremely vulnerable is dominantly used for agriculture. Most areas under low dense vegetation are predicted to have low to moderate flood risk. Most forested areas have low to extremely low risk of flooding. These results support the studies conducted elsewhere (Elkhrachy, 2015 and Danumah et al 2016) which reported that areas with vegetation had low affinity to flooding. In other studies, conducted elsewhere in Kenya, Olang & Fürst (2011) and Otolo & Wakhungu (2013) noted that land use that are highly degraded are more exposed to flooding. The degradation arises primarily due to unregulated anthropogenic activities as proxy of increasing human population.

The land use modification that resulted from agricultural expansion is one of the notable threats to the hydrology in Kenya (Calder, 1992). Compound by the unavailability of proper land use and water-management strategies, this degradation is seen to amplify hydrological processes that are related to soil erosion, surface runoff, and sedimentation in river channels (Kundu *et*

al., 2008; Kateb *et al*. 2020). As seen in other studies (Haan *et al*., 1994; Islam & Sado, 2000; Kazakis *et al*., 2015; Nyarko, 2002; Rizeei *et al*., 2016) zones with more rainfall was given high affinity for flooding than zones of low rainfall. In that regard, zone 5 with high rainfall intensity is more vulnerable to flooding as compared to zone 1 and was rated 5. In zone 5 the annual average rainfall is between 1130 and 1264 mm while zone 1 is between 603 and 717 mm (Figure 3). This results corroborates with the findings in Duvail *et al*. (2012) who reported higher affinity to flooding on areas located in the lower Tana Delta.

The Tana Delta landscape is composed of a complex mosaic forests, woodlands, floodplain, grasslands, and other wetland types that accommodates exceptional biodiversity values (Duvail *et al*., 2012). However, most hectares of adjacent land in the delta have low elevation and have been converted to agriculture. Most are subsistence agriculture but also some are commercial plantations by the government initiatives and private investors. They are, therefore, on the list of high-risk zones. Few hundred hectares of the riverine forest grow along the main river and its tributaries, and are characterised by the presence of many endemic species that are range-restricted (Leauthaud *et al*., 2013). These riverine forest has low affinity to flooding and was rated low to floods.

While soil is not the main factor influencing the flood occurrences, intense rainfall is likely to cause more rapid and greater surface runoff with clay soils than with sand. Most areas in high susceptible areas had sandy-clay loam (881) and sandy-loam (57,966) with low bulk densities. These soils with lower bulk density have high water holding capacity. High water retention capacity and low infiltration contribute to increased surface runoff and thus flooding. Other studies conducted elsewhere (Islam & Sado, 2000; Kazakis *et al*., 2015) noted that in areas characterised by tertiary sand, ferritic soil strongly desaturated and high drainage density, floods are frequent.

In the study area, Garsen North, Mikindu, Chewani and Kipini West were located in the lower elevation and had high flow accumulation and thus the flood vulnerability maps depicted these areas as highly vulnerable to floods. Ouma & Tateishi (2014) noted that floods occur because of the rapid accumulation and discharge of runoff waters from upstream to downstream, which is caused by very heavy rainfall. Like the findings in this study, most highly vulnerable areas have high flow accumulation and drainage densities. The spatial and temporal scales of floods vary according to drainage densities (Islam & Sado, 2000; Li *et al*., 2009).

4.2 Methodological Significance

The proposed methodology in this study for the estimating the flood hazard areas can be valuable tool for identifying and mitigating the damaging effects of floods. As shown in other studies (Elkhrachy, 2015; Kazakis *et al*., 2015; Ouma & Tateishi, 2014; Rahmati *et al*., 2016; Youssef *et al*., 2011), these methodologies have proven helpful in mapping vulnerability to natural hazards such as floods. The validation technique that uses historical flood events and Sentinel 1 GRD products provides a useful modified FHIS index as used in flashflood mapping in St. Katherine road, southern Sinai, Egypt (Youssef *et al*., 2011).

The analysis of exposure of an area to flooding is the most crucial part of risk analysis in that it figures out whether exposed to a hazard constitutes a risk (Ouma & Tateishi, 2014). Flood mapping is the

process of finding the degree of vulnerability of an area to flooding. According to Ouma & Tateishi, (2014) the process of mapping involves the selection of bio-physical and/or socio-economic factors of an area: the combination of the selected factors with the decision maker's preferences allows a user to create a composite suitability index. This process results in a multi-criterion and multi-parametric decision-making problem. To solve the combination of seven parameters, this study used numeric overlay approach in GIS environment. By doing so, this study contributes to the growing literature on the use of hydrological modelling in characterising floods following previous recommendations to use "tailor-made" and "site specific" models (Degiorgis *et al*., 2012; Solín, 2012; Chawan *et al*. 2020).

Vulnerability analysis of flooding can be done on three criteria: land topography, drainage system and land use activities (Danumah *et al*., 2016). Flood hazard and risk assessment maps can be created using GIS-based hydrological observations of the frequency, magnitude and duration of flood events, as well as DEMs (Digital Elevation Models) that characterize the topographic basin within which flood events occur. The vulnerability map produced depicts good trends in conformity with similar studies carried out in the area (Leauthaud *et al*., 2013). The MODIS satellite imagery in their study asserted that the major land use in the area was bare lands and agriculture (45%).

4.3 Management Significance

Flood risk maps are useful tool in showing the weaknesses in a flood defense system and the patterns of vulnerability of human infrastructure and wildlife habitat (Ouma & Tateishi, 2014). Efficient food risk mapping is becoming increasingly vital in risk analysis due to rising human population density in flood prone areas throughout the world (Youssef *et al*., 2011). Moreover, land use changes and climate changes that affect flood dynamics in developing countries, need the hazard forecast tools. DEM has been used in several ways to aid flood mapping and modeling (Norman *et al*., 2010; Mu *et al*., 2021). They have been used as integral part of GIS database for hydrological flood modeling for spatial extent of flood. However, a combination of parameters has proved useful. This methodology can be augmented with water balance modelling and satellite data to provide a useful tool for flood risk mapping in ungauged basins.

An understanding of the seven selected flood parameters is essential for the management of water resources. According to Leauthaud *et al*. (2013) these characteristics seem to have remained identical throughout 1963–2011, despite the construction of five dams. These flood vulnerability maps provide an ensemble of flooding characteristics—flood extent and vulnerable areas that are essential in flood forecasting and management. These maps are useful in defining the current flood-prone zones as well as safe zones. Finally, this study highlights the idea that river parameters such as drainage density, distant to major rivers and elevation are the main generator of floods within the Tana River County. This result is important in the current context of hydroelectric infrastructure development on the Tana River.

5. Conclusion and Recommendations

As natural disasters increase in frequency, intensity and severity in Kenya, the country continues to suffer a disproportionate number of hazard events and associated losses in infrastructural investment, lives, and other main economic investments. The adoption of technologies can provide a wide range of tools for hazard forecasting and

planning. This methodology highlights the areas prone to flooding. These tools can be used to forecast areas that are likely to be flooded due to rise in water level in a river or due to flash flooding. The methodology of risk mapping can be improved by use of hydrologic modeling in 2D or 3D for efficient processing and management of landslides and floods.

Analysis of flood prone areas is imperative in finding areas that are at risk of flooding during rainy period or heavy downpour. It also helps the floodplain development control measures for reducing the impact of flood. These results and methods provide a useful tool for the prediction of potential flooding areas and for the better organisation of a flood management plan. These results need to be integrated in development of early warning system and flood management plans by the county and national governments to reduce the routing damaging effects of floods every year.

The results, therefore, can be used to support policy options and catchment strategies geared towards flood risk management. Moreover, this spatial vulnerability estimation will help policy makers, local community, and other partners to understand the required hazard mitigation and adaptation measures. Further analysis is needed on the extent to which disaster risk reduction is mainstreamed in policy making schemes (environmental, political, socioeconomic, and cultural) especially with the current system of governance with devolved systems. The role of county governments and national government in emergency response, planning, coordination, and research is redundant. Efforts should be geared towards setting up the long-term adaptation mechanisms for the vulnerable communities and development of early warning systems that includes the preparedness and effective response mechanisms.

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Establishing a Performance Efficiency Index For Construction Projects in Kenya

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Abstract

World over, the construction industry continues to receive unparalleled criticism due to deplorable performance with many projects failing to meet clients' expectations. The inefficiency in the projects during execution is a bane, a challenge that is more severe and chronic in developing countries. In Kenya, the problem is congruent and continues to negatively impact on development plans. Additionally, no singular construct exists to objectively measure the various facets constituting the performance of a project. This study, aimed at establishing a Project Performance Efficiency Index (PPEI) that can be used to measure performance efficiency in projects and plan improvement measures. This survey was carried out and data collected from 360 projects in the construction industry of Kenya. Factor Analysis (FA) and Structural Equation Modeling (SEM) were applied on the data to develop the Index, the second order model for the index yielded $\chi 2$ statistics = 234.737, Degrees of freedom = 117, $\chi 2$/degrees of freedom = 2.006, RMSEA Value = 0.079, GFI Value = 0.780, NFI Value = 0.804, IFI Value = 0.949, CFI Value = 0.946, PNFI Value = 0.764 and PCFI = 0.798. The index was validated with typical construction projects and received 94% approval ratings from practitioners via Delphi technique. The study findings contribute to theory and practice. The Efficiency Enablers established add to the existing Built Environment Body of Knowledge in the area of construction project management and forms a basis for future research. In practice, the PPEI developed, enables practitioners to measure and improve performance during execution. The findings point towards the need to rethink Technical Efficiency in projects as well as implementing the PPEI framework as a baseline tool to management of projects in Kenya.

Keywords: **Construction projects; Performance Efficiency Index; Kenya**

Introduction

The construction industry plays cardinal role in providing the physical developments which help in improving social and economic needs of a country. This is amplified and can be inferred from its exponential growth. Turner and Townsend (2018) postulate that the global construction industry grows at a rate of USD 0.3 trillion annually. Therefore, the growth is projected at USD 10.6 trillion in 2021 compared to USD 7.4 Trillion in 2010. Relatedly, according to Global Construction perspectives and Oxford Economics (2013) the GDP growth in the global construction industry was forecasted to grow by 3.5–4.0% annually. It's therefore clear from the foregoing, that the current state of the construction industry generally looks bright but the performance is not optimum.

In Kenya, evidence suggests that the construction industry is growing and is a crucial sector for the growth of the economy. According to the reports of Kenya National Bureau of statistics (KNBS, 2020) and the Kenya Economic Outlook (2020), In 2019, the construction sector registered a growth of 6.4 per cent compared to growth of 6.9 per cent in 2018. The total government expenditure on roads grew by 10.0 per cent to KSh 169.9 billion in 2019/20 from KSh 154.5 billion in 2018/19. Development expenditure rose by 15.5 per cent to KSh 111.7 billion in 2019/20. Additionally, the construction of Phase 2A section 1 of the Standard Gauge Railway (SGR) from Nairobi to Naivasha covering a rail distance of 120 kilometers was completed in September 2019 at a cost of KSh 150.0 billion. Among other notable developments thus far include; the completion of the Single-track Standard Gauge Railway (SGR) from Mombasa to Nairobi, expansion and modernisation of Outer Ring Road, Expansion of Ngong Road, Construction of Kenya Western Bypass, Dongo Kundu bypass and Nuno-Modogashe Road (KRB, 2018). Besides this, the Big Four Agenda- that defines the Government`s priorities and development path for the 2018–2022 planning cycle -provides impetus for increased construction activities for the next five years. This paper argues that for Kenya to realise the vision in its development blueprint, the construction industry must operate at optimal performance through enhanced efficiency in the management of construction projects than its presently done.

Despite the critical role and the mega projects currently on-going in Kenya, most projects do not achieve their planned cost, time and quality objectives among other performance measures. These problems occur both in the public and private sector projects but more pronounced in the public sector projects and have assumed a chronic trajectory spanning over five decades. Accordingly, authors have dedicated time and resources researching on the concept of project performance, associated problems and how to enhance success in the management of construction projects (Gwaya, 2015; Munano,2012; Muchungu, 2012; Masu, 2006; and Wanyona, 2005). It's however, interesting to note that despite spending considerable time spanning to decades studying this subject, the trend of poor project performance is still persistent. This paper submits that there is need to rethink efficiency management in addressing performance problems in the construction industry of Kenya.

Literature Review

2.1 Performance Measurement in the Construction Industry

It is becoming increasingly difficult to ignore the significance of performance measurement in public and private sector construction organisations given the rapid changes in the construction industry in terms of developments in technology, financial instruments, and complex project execution. The lack of application of performance measurement in the construction sector, despite its importance, is due to several reasons but mainly the lack of information and insufficient training on how to use it (Costa *et al*. 2004). The construction industry is an important contributor to the economy of a country; however, it has quite an unstable nature (Toor and Ogunlana, 2009). As a result of rapid change and increasing uncertainty in terms of technology, budgets and operational processes, the construction industry has become more complicated and dynamic (Albert, 2001). Consequently, the need for improving the performance of the construction sector is wholly apparent. To achieve performance improvement, measurable objectives must be set and then used to determine critical success factors and performance measures.

The traditional indicators of cost, quality and time (the Iron Triangle) are still being utilised by the construction industry as primary measures of performance despite their deficiency in measuring project successes (Haponava and Al-Jibouri, 2009). Recently, however, measuring success has shifted from these traditional measures to include a wider comprehensive set of metrics of project lifecycle, starting from the initial feasibility phase to the final closedown phase. Performance measurement has not become widely used in construction industry. Therefore, performance measurement is needed to assess how well they have been working, how well they are presently working, and, more significantly, how well they will work in the future so that the aspects in which they are failing can be recognized and corrected (Ankrah and Proverbs, 2005). Jones *et al.* (2008) also argued that the construction industry should change to be more focused on main drivers such as customer satisfaction, leadership, quality agenda and team and process integration.

In the construction industry, two aspects of performance can be measured: either the success of the organisation's performance, or the success of the project. Ankrah *et al.* (2005), in an attempt to clarify further, suggested performance measurement has been characterized as the organisational task of designating statistics to entities and the registration of actions in order to offer motivation that provides on-going development. In the construction industry, performance measurement is considered to be an organised technique to evaluate performance by evaluating the inputs, outputs and final project outcomes. In construction projects, the aim of performance measurement is to evaluate and improve quality and efficiency of the project execution process, in addition to identifying potential areas for future improvement.

Whilst there is an increasing understanding of the significance of PMSs among construction companies for monitoring and controlling performance, regrettably, this awareness has not been transferred into action in the construction industry (Takim and Akintoye, 2002). Despite this, there are many existing PMSs, whether currently practiced or merely developed and used in academia. These can be categorised across four aspects: construction project performance; construction productivity,

project viability, and project quality. Given the project-based nature of the construction industry, the current measurement systems that are driven by the market and consequently based on measures of profitability, are not appropriate for measuring and improving performance of construction projects (Ankrah and Proverbs, 2005). In the construction industry, any project performance measuring concepts can basically be divided into a macro level (assessed at the end of project) and a micro level (assessed during project stages). Analysis of performance on the macro level is considered useful for determining future business strategies; whereas analysis of performance on the micro level is useful for determining a project's progress and completion (Cha and Kim, 2011). This study sees performance at micro level being critical and a cardinal input for macro level performance of the project, as such, the study posits that efficiency performance management during the project execution should be given due priority.

2.2 Existing Measurement Systems and Models in the Construction Industry

(a) The Balanced Scorecard, BSC

The BSC model was designed in 1992 by Kaplan & Norton as a new method to measure the performance of the four business "dimensions": - (i) Financial; (ii) Customers; iii) Business processes; and (iv) Learning and innovation. Learning and innovation are considered to be "leading indicators"; whereas the focus of the BSC is towards financial measures, which are considered "lagging indicators". This represents one of the weaknesses of BSC models, as well as causing many problems in its performance. Letza (1996) states that this method must be integrated with the participants' goals and general strategies, so that the BSC can translate the strategies into goals to measure them. It measures previous activities, known as lagging indicators, as used in many organisations. The BSC model also has the potential to use leading measures when an organisation translates its strategies and visions into a comprehensive framework.

(b) European Foundation for Quality Management, EFQM

In 1989, the EFQM Excellence Model was shaped by European Foundation for Quality Management for quality management purposes. Its focus was to improve overall organisational quality, and it is unique in that it distinguishes between results (PMs) and organisations' enablers (Westerveld, 2003). The EFQM model uses nine fundamental concepts of excellence to enhance the continuous improvement of an organization. These are results orientation, people development and involvement, customer focus, continuous learning, innovation and improvement, leadership and constancy of purpose, partnership development, management by process and facts, and public responsibility (Beatham *et al.* 2004).

The EFQM Excellence Model has been utilised by companies in the construction industry and others such as manufacturing, finance, insurance, and as part of management through Total Quality Management. It is suggested for use as a means of self-assessment in order to benchmark with other organsations, as a guide for improvement, an approach to thinking, and a structure for the organisation's management system (EFQM, 2010). Beatham *et al.* (2004) added that the purpose is to conduct a regular review of an organisation's activities. The main aim for implementation of the EFQM model is to identify the performance improvement areas (Beatham *et al.* 2004).

The key distinction between EFQM Excellence Model and the BSC is that the EFQM model is designed to deal with best practice; whereas the BSC model is focused on communication and performance measurement. However, the EFQM model is criticized as being less comprehensive and less clear than the BSC model despite the shortcomings mentioned previously.

(c) The Contemporary measures of Project Performance

Several researchers have advocated for a wider focus of construction project performance. Some researchers (Zuo, 2011; Billy *et al.,* 2006; Haslam *et al.,* 2005; Ortega, 2000;) have argued that it is important to incorporate safety aspects of the project in performance evaluation because the construction industry is the most unsafe industry due to its high rate of fatalities. In most developing countries, the construction industry is mainly labour intensive and the majority of the workforce working on construction sites is unskilled. The workers are, therefore, exposed to risk and health hazards inherent in construction projects that require adequate safety provisions (Zuo, 2011). Project safety, being a humane issue, needs to be considered separately from time, cost and quality dimensions. Few other researchers (David, 2009; Tabish and Jha, 2011) have given emphasis on dispute resolution which might otherwise lead to disagreements amongst project participants and derail the project objectives. Dispute resolution is part of stakeholder management and hence should be part of project performance evaluation criteria (David, 2009).

(e) Process based models

As Olawale and Sun (2012) pointed out, the basis for many of these studies is the well-known Deming's Plan-Do-Check- Action (PDCA) wheel (Deming, 2000). Deming's PDCA wheel describes a management process, originally used for quality control purposes. Some researchers attempted to adopt it for construction project control while acknowledging the need for modifications. For example, Plate and Wadman (1998) cited in Olwale (2012), criticised the PDCA model as having the drawback of no time-dependent element and not fully describing the whole planning and control situation or its development in time. Olawale and Sun (2012) developed, as a follow up on Deeming`s process-based control model, a project control and inhibiting-factors management model (PCIM). They argued, those factors inhibiting effective cost and time control should be managed.

2.3 A Critic of the Existing Measurement Systems and Models in the Construction Industry

Admittedly, literature is replete with several models that have been proposed to assess performance in projects under broad headings *Critical Success Factors* and *Key Performance indicators*. However, the above studies are faced with several drawbacks. Several authors have found some short comings with them and expressed the doubt whether the true objective of assessment would be achieved. This has to do with the measures in use, the paradigm within which they are being considered, and the nature of the models.

Firstly, those studies have focused neither on the interactions among the key performance efficiency drivers nor on the consequences of performance improvement initiatives being undertaken over time. Importantly, industry players need to be able to measure level of performance efficiency in the execution of projects, identify areas for improvements and evaluate the impacts of various performance improvement

initiatives before implementing them. Such actions are essential as the implementation of the initiatives that do not address priotized areas for improvement, may add little value to industry players' quest to improve performance efficiency and achieve desired project outcomes in the long-run. Secondly, the studies have not taken into account the dynamism nature of the construction process owing to its complexity. Worse still, the existing models have not considered the dynamic nature of the factors themselves operating in the performance of projects during the execution.

To address the above shortcomings and foster efficiency in the execution of projects, this study propounds the need for a model of project performance for the construction industry of Kenya that investigates the interactions and causal relationships between the key performance efficiency enablers and the consequences of the performance improvement initiatives being undertaken over time during projects execution. This is the gap the current study undertook to fill.

3. Study Methods

The study was a survey actualised by way of questionnaire. Authors of research methods (Saunders 2016, Creswell 2014, Bryman2012, and Walliman 2011) believe, Questionnaires are one of the most commonly used data collection techniques within survey research. Furthermore, they suggest that a questionnaire is best suited to a situation where most of the questions are standardised and the researcher is confident that the questions will be interpreted in the same way by all respondents. Even so, the questionnaire is the best tool to be used in descriptive research where the researcher has undertaken some literature review and has understood the subject of research prior to data collection and extending further to draw conclusions from the data collected.

To achieve the objective of the study, the researchers obtained a research permit from the National Commission for Science and Technology and Innovation (NACOSTI) to collect field data. The approval referenced as NACOSTI/P/19/2035 was obtained in time before commencement of fieldwork. Furthermore, in carrying out the questionnaire survey, names of the respondents were omitted to enhance their privacy. The questionnaire tool was piloted and final questionnaire refined in line with pilot study findings. A total of 380 questionnaires were distributed to the public sector projects sampled from the fourteen (14) NCA regional centers. A total of 320 questionnaires were reasonably and adequately completed representing 84.21 percent response rate while 60 questionnaires were not returned. The questionnaires were responded to by the individual project team leaders. Majority of the respondents were project contractors constituting 23.1% this was followed by Project Managers comprising of 20.3%. 16.6%, 12.4% 10.6% and 10.3% of the respondents were Architects, Quantity Surveyors, Civil/ Structural and Mechanical engineers respectively. 2.3% of the respondents comprised of "other" consultant not initially captured in the questionnaire, this was filled by physical planners, Site foremen and clerk of works.

Additionally, 29.1% and 23.1% were residential and road projects respectively. The response for educational, commercial and health projects were equally high at 20.3%, 10.6% and 10.3% respectively. Water and Sewerage projects followed at 6.6%. High demand for residential units in Kenya can account for this condition especially given the crusade by the

government on affordable housing under the Big Four Agenda development blue-plinth The Project Performance Efficiency Index (PPEI) was developed through modeling of key performance efficiency drivers. The statistical techniques of Exploratory Factor Analysis and Structural Equation Modeling were performed.

4. Results and Discussions

4.1 Assessing the Factorability of Performance Efficiency Measurement Variables

In assessing the factorability of the performance efficiency measurement variables, the study found out the correlation for each pair of the variables which is demonstrated with the help of a correlation matrix. The correlation matrix suggested that the sample is characterised by high degree of related variables which could be grouped together. Additionally, before carrying out EFA, the overall significance of the correlation matrix and its factorability needed to be tested with the help of Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy respectively. Although both tests met the minimum criteria for carrying out factor analysis in the dataset, observation of the correlations along the diagonal of the anti-image correlation matrix revealed that 7 variables had their KMO values less than 0.5, which indicates that the dataset, in its current form, is still not suitable for factor analysis (Hair *et al.,* 2006). These variables were iteratively removed one after another starting with the one whose correlation along the diagonal of the anti-image matrix was the lowest (Jahmane *et al.,* 2011). After the removal of seven variables, it was found that all variables had individual KMO values greater than 0.5. This resulted in the improvement of overall KMO measure of sampling adequacy to 0.687. Further Bartlett's test statistics was found significant at 0.000 levels. These measures indicate that the reduced set of variables is appropriate for factor analysis.

4.2 Theoretical Framework of PPE Index

Having established that factor analysis could be applied on the Performance efficiency enablers, Principal Component Analysis (PCA) was employed with Varimax rotation in order to identify the underlying structure of relationships. Due to lack of a priori basis on the number of factors to be extracted, initially all the variables were allowed to load freely on various factors so long as they had eigenvalue greater than one. Further a scree plot for different components was obtained (as shown in figure 1) in order to have an idea about the amount of variance explained by each factor.

Consequently, while identifying the final factors underlying the Project Performance Efficiency Enablers (PPEE), the process was subjected to four conditions: (i) the number of factors fixed at five, (ii) deletion of items with loadings of less than 0.5 or cross loadings of greater than 0.5, (iii) retention of only those factors with at least two items and (iv) the number of factors extracted should account for at least 60% of the variance (Field, 2005; Hair *et al.* 2006; Malhotra and Dash, 2011). Based on these conditions, Factor analysis was iteratively repeated and items deleted sequentially resulting in a final instrument of 25 items. The 25– item 5–factor instrument accounted for 73.023% of the variance in the dataset.

From the analysis and findings (Table 1), it was evident that five variables loaded under factor 1 seem to be associated with Technical Efficiency Enablers Factors (TEE). The second factor comprises five variables which

reflect the *Project Management Efficiency Enablers (PMEE)* of project performance. The five variables under factor 3 represent factors relating to *Contractor Efficiency Enablers (CEE)* whereas the five variables under factor 4 attempt to capture *Client Efficiency Enablers* dimension of project performance. The five variables under factor 5 are associated with External Environment Efficiency Enablers (EEEE). The findings (Table 1) reveals that '*Technical Efficiency Enabler'* is the most important measure of construction project performance efficiency, having the highest eigenvalue of 4.128 and accounting for 19.05% of the variance in the dataset. This is followed by the measure '*Project Management Efficiency Enabler'* with an eigenvalue of 2.865 which explains 11.46% of the total variance. The third most important performance efficiency measure was found to be '*The Contractor`s Efficiency'* with an eigenvalue of 2.415 and explaining 8.58% of the variance while the fourth important measure turns out to be '*Client Efficiency* with an eigenvalue of 1.747 and contributing to 6.98% of the total variance. The last performance efficiency measure in order of importance was '*External Environment influence'* with an eigenvalue of 1.446 hence explaining 5.78% variance on the data set. These five constructs of performance efficiency constitute the Project Performance Efficiency Enablers (PPEE).

In sum, the following constructs were inferred and constituted the PPEI theoretical framework (Figure 2).

Factor 1 Represents Technical Efficiency Measure

Technical Efficiency measure, as shown in Table 1, is considered to be the most important factor amongst all five constructs. In this construct, the highest loading is observed in "clarity of Designs and Details, CoD" (0.995) while the lowest one is found in "Clarity of Construction Method statement, CoCMM (0.978). Theoretically, the variable "Design Changes" should have been loaded the highest given the impact it has on project schedules and cost but results of factor analysis reveal that it emerged second after Clarity of Designs and Details. A closer look at the survey instrument indicates that the respondents perceived Clarity of Designs and Details in project to be critical attribute that require attention in order to avoid time lags in projects. This might be the possible reason why the above variable loaded under *Technical efficiency*. Similarly, the item "*Clarity of Construction Method Statement"* is widely thought to be associated with Contractor Operations. In the current study, this item loaded on Technical Matters. The respondents perceive Construction Method statement a technical matter which may give rise to incorrect work flows that eventually lead to delay in certain activities of the project.

Factor 2 Represents Project Management Efficiency Measure

Project Management Efficiency measure, as shown in Table 1, is considered to be the second most important factor amongst all five constructs. In this construct, the highest loading is observed in two variables "Time Management Factors, TMF" and "Cost & Financial Management Factors, TMF" (0.985) while "Quality Management, QMF" (0.985) was loaded second in the cluster. the lowest items were found in the variables of "Health, Safety & Security Management factors as well as Project Leadership Factors (0.795). It's clear from the analysis that time management is a critical limb of project management. Lim and Mohamed (2000) considered project completion time

to be the first criterion for project success. Other researchers (Kamrul and Indra, 2010; Khosravi and Afshari, 2011) have termed time to be the most important factor in the performance measurement of construction projects. Public sector projects, given the benefits they accrue to the public and the multiplier effect, utmost importance is given to time dimension because the funding of these projects is always done annually based on its progressive performance.

Factor 3 Represents Contractor Efficiency Measure

Contractor Efficiency measure, as shown in Table 1, is considered to be the third most important factor amongst all five constructs. In this construct, the highest loading is observed in "Technical and Managerial capacity" (0.898) while the lowest one is found in "Procurement Efficiency (0.410). A closer look at the survey instrument indicates that the respondents perceived Financial Condition and stability of contractors (FS) as paramount to their efficiency in Projects (0.879). Another important aspect is the Labour Mobilisation ability, LMA (0.881). In the current study, this item loaded on time. Sub-contractors' coordination (SC) remains a key efficiency enabler for contractors and this was perceived as such by the respondents (0.873)

Factor 4 Represents Client Efficiency Measure

Client Efficiency measure, as shown in Table 1, is considered to be the fourth most important factor amongst all five constructs. In this construct, the highest loading is observed in "Top Management Support, TMS" (0.792). Decision making process, DMP as well as Dispute Resolution ability DRA, were loaded equally under this construct (0.741). From the upshot, it's interesting to note that, Client`s Project Financing Ability & Cash flow behavior, PFA was loaded as the 2nd item under this construct (0.756). Naturally, the variable "Project Financing and cash flow behavior" was expected to be loaded highly under this section but results of factor analysis reveal that it loaded below the Top Management Support Variable. This can be attributed to the fact that the respondents could be perceiving financial support and resource mobilisation from the top management as central to successful execution of projects. However, top management support should go beyond the provision of funds and making resources available. Johnson (2006) argues that top management support ought to include aspects such as providing clarity on the project objectives and reassuring project team members that they will be valuable after the project. Changes that would come about due to the project can cause team members to be highly skeptical of their future in the organization. This will directly affect their level of performance towards the project.

Factor 5 Represents External Environment Efficiency Measure

External Environment Efficiency measure, as shown in Table 1, is considered to be the fifth most important factor amongst all five constructs. In this construct, the highest loading is observed in "Stakeholders influence" (0.943). Riots and strikes were loaded seconded in this construct (0.887). Legal Environment influence LEI, (0.779) and Pandemics /Outbreaks was loaded third and fourth respectively. Coincidently, the impact of COVID-19 pandemic disrupted majority projects and the ripple effect has a continuing effect in the construction sector. Stakeholders influence in projects remain a key aspect in execution of government

project. This result reflects the impact of neighbors and adjacent lands on the project. Perhaps the respondents are taking into consideration the view that resistance from the neighbors to the project as a result of poor relationship will affect the progress of the project. The use of project location by others also may affect the project activities, so many times the activities of project may be stopped in such like cases.

4.3 Project Performance Efficiency Measurement Model

The Structural Equation Modelling (SEM) was conducted to test the relationships between the first order constructs (Figure 3) and the second order construct (Figure 4) namely overall project performance efficiency. The test of the second order model implied that project performance efficiency, a higher order latent factor governs the correlations amongst first order constructs: Technical, Project Management, Contractor, Client efficiency and external environmental influence. The second order model yielded the following results of test statistics: $\chi 2$ statistics = 234.737, Degrees of freedom = 117, $\chi 2$/degrees of freedom = 2.006, RMSEA Value = 0.079, GFI Value = 0.780, NFI Value = 0.804, IFI Value = 0.949, CFI Value = 0.946, PNFI Value = 0.764 and PCFI = 0.798. These estimated model fit indexes were adequate. The second order loadings on overall project performance efficiency are 0.32 for Technical Efficiency, 0.25 for Project Management Efficiency, 0.18 for Contractor Efficiency, 0.14 for client efficiency, – and 0.11 for external environment efficiency. From the Structural Equation Modelling, it was deduced that;

PPEI=0.32TEE+0.25PME+0.18COE+0.14CLE+0.11EEE…….. Eqn 1

Where;

PPEI= Project Performance Efficiency Index

TEE= Technical Efficiency

PME=Project Management Efficiency

COE=Contractor Efficiency

CLE=Client Efficiency

EEE=External Environment Efficiency

4.4 Validation and Application of PPE Index.

The practical applicability of the PPE Index was applied to typical construction projects. The practitioners, selected with due consideration to their backgrounds, field of involvement, exposure to the key subject matters of the research objectives, were requested to identify a project which they have been involved in that is on-going which can be used to demonstrate application of the index. Seven projects were suggested and three were selected randomly. The rationale was to evaluate how the PPE Index can be used to depict the performance behavior of a construction project. All the three projects were being public sector projects being implemented various government agencies. The project particulars have been given in Table 2.

The participating project team members were required to assess the adoption of the Efficiency Enablers implemented on the project. The scale given was in percentages from 0% for non-implementation to 100% as a fully implemented on the project. The average of their overall ratings was used as the value for a particular Enabler Score within the Model equation for the eventual summations. The ratings for the PPE Enabler variables were established within a range of 0% to 100% as this could easily be understood in the adoption or implementation of a particular variable for the PPEE.

From the application findings (Figure 5), two issues can be discerned; Firstly, performance efficiency is not optimum, pointing to the challenges of delivering projects with set performance targets albeit with majority projects failing to live up to the expectations of the clients and the general public. Secondly, performance efficiency fluctuates hence not static, pointing to the underlying dynamism behavior of operating variables within the project environment. At the end of the validation exercise, the practitioners considered the PPE Index appropriate for use in measuring efficiency in construction projects and was rated 95% suitable for use by the participating practitioners.

5. Practical Relevance of the Study Findings

The study findings have a practical, societal relevance and use. To begin with, the results of this study are of practical use in the construction industry. The Project Performance Efficiency Index (PPEI) developed, provides an opportunity to industry practitioners to objectively measure the performance efficiency of their projects during implementation and plan improvement measures. Specifically, the results of this research study, inform the project managers on the performance efficiency enablers at play during the execution of construction projects.

Ultimately, the study findings have societal relevance. Essentially, Public sector construction projects are intended to yield built facilities to benefit the general public. Even so, the effects of delayed delivery of construction projects have far reaching impact on the economy and society including but not limited to retarding the process of development, cost overruns and delayed use of the projects which may result in projects not meeting the set objectives. Furthermore, when projects are not delivered as planned, there are lost opportunities as the finished facilities are put to use late than anticipated. It was earlier noted that the construction industry contributes immensely to national GDP and contributes to creation of employment opportunities nationally with a multiplier effect, this is still below the global industry performance and there is need for growth. And as Kenya is geared towards pursuing its development blue- print envisaged in vision 2030, it's important that the implementation of projects is done efficiently and effectively so as to deliver successful building projects within time, budget and specifications. The current study and its findings play a pivotal role in this endeavor.

6. Conclusion and Recommendations

This study aimed at establishing a Project Performance Efficiency Index (PPEI) that can objectively be used to measure the performance efficiency in projects and plan improvement measures. This comes against a background of myriad problems facing execution of construction projects compounded by the fact that no singular construct exists to objectively measure the various facets that constitute the 'health' of a project. The study established five constructs that impact on the performance efficiency in projects, the constructs were named Performance Efficiency Enablers (PEEs) and they comprise of; Technical Efficiency Enablers (TEE). The second factor comprises five variables which reflect the *Project Management Efficiency Enablers (PMEE)* of project performance. The five variables under factor 3 represent factors relating to *Contractor Efficiency Enablers (COEE)* whereas the five variables under factor 4 attempt to capture *Client Efficiency Enablers(CEE)* dimension of

project performance. The five variables under factor 5 are associated with External Environment Efficiency Enablers (EEEE). These five constructs of performance efficiency constitute the Project Performance Efficiency Enablers (PPEE). The structural equation modelling conducted yielded a project performance efficiency index (PPEI) which industry practitioners can use to objectively measure the performance of projects.

In conclusion, the study contributes to theory and practice. The Efficiency Enablers established adds to the existing Built Environment Body of Knowledge in the area of construction project management, particularly in the subject of project performance and forms a basis for future research. In practice, the PPEI developed, provides an opportunity to industry practitioners to objectively measure and improve the performance efficiency of their projects during implementation. Most importantly, in order to enhance efficiency in the performance of construction projects, industry Practitioners should rethink their Technical Efficiency as well as implement the Project Performance Efficiency Index (PPEI) framework developed as a baseline tool to management of projects in Kenya.

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Figure 1*: Scree Plot of Project Performance Efficiency Enablers (PPEEs)*

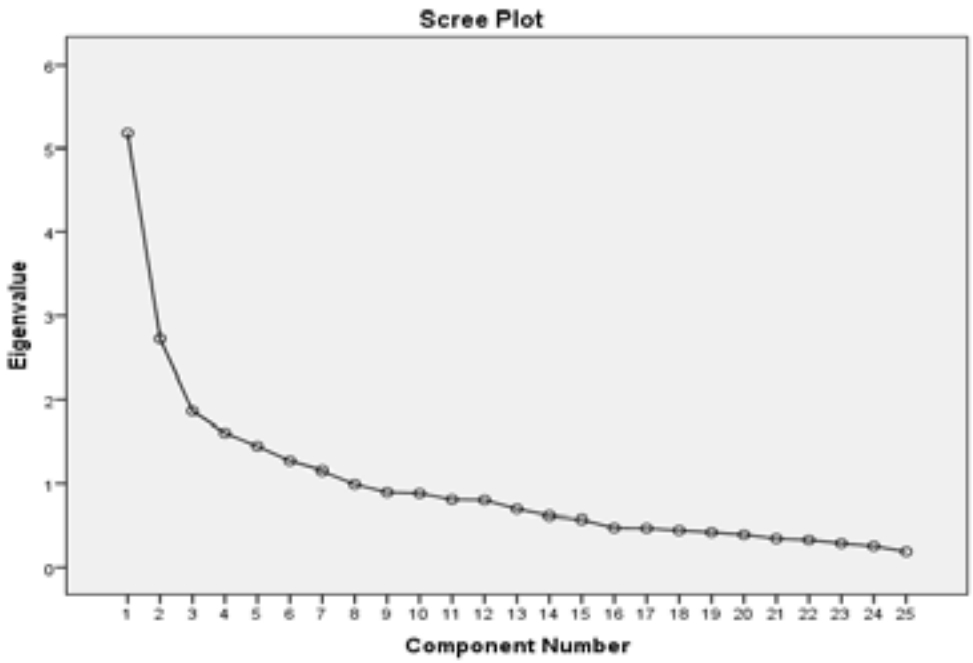
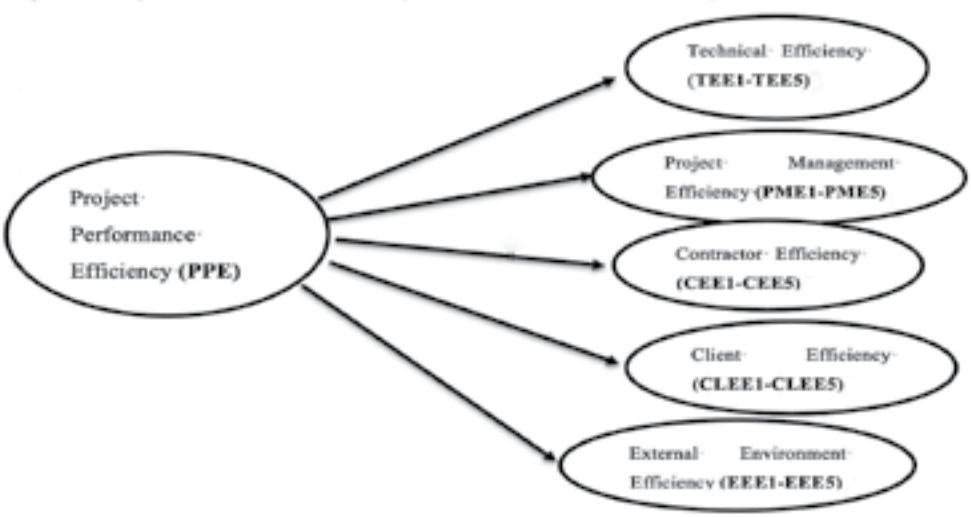
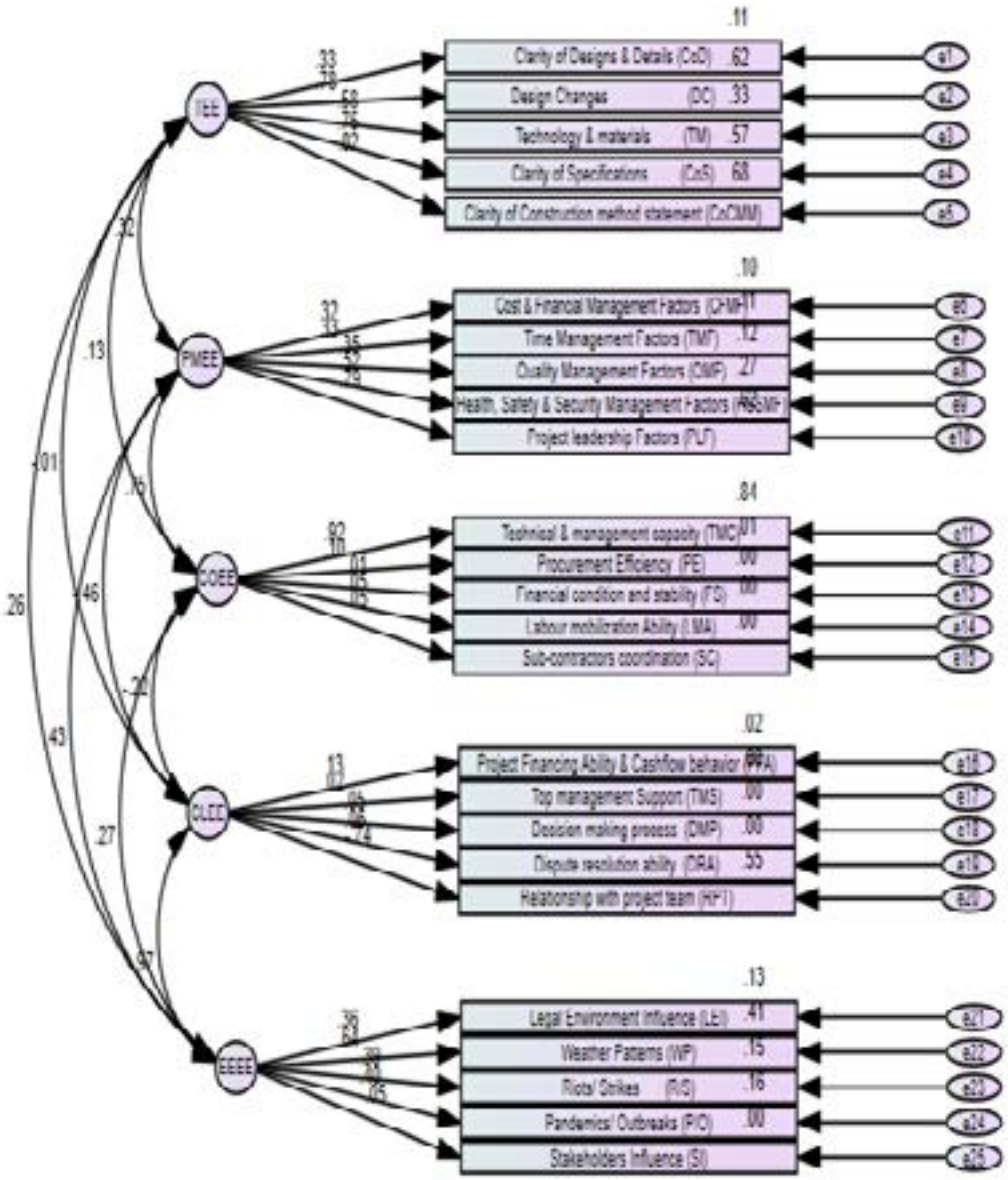


Figure 2: Project Performance Efficiency theoretical framework, PPE



1 Figure 1: Scree Plot of Project Performance Efficiency Enablers (PPEEs), Author`s findings, 2021.
2 Figure 2: Project Performance Efficiency theoretical framework, PPE, Author`s construct, 2021.

Figure 3*: 1st* Order Measurement Model for Project Performance Efficiency[1]



1 Figure 3: 1st Order Measurement Model for Project Performance Efficiency, Author`s finding, 2021.

Figure 4: 2nd Order Measurement Model for Project Performance Efficiency[2]

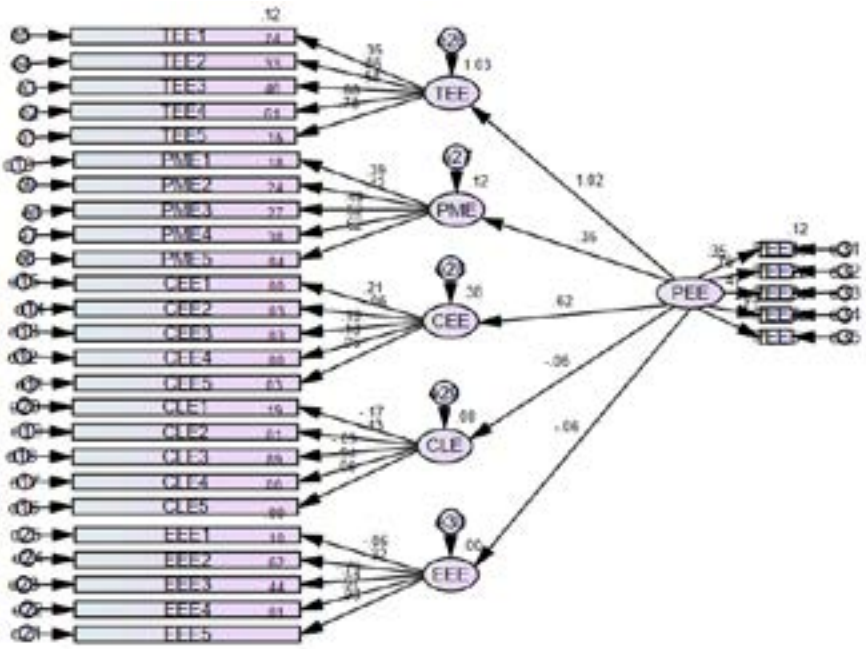
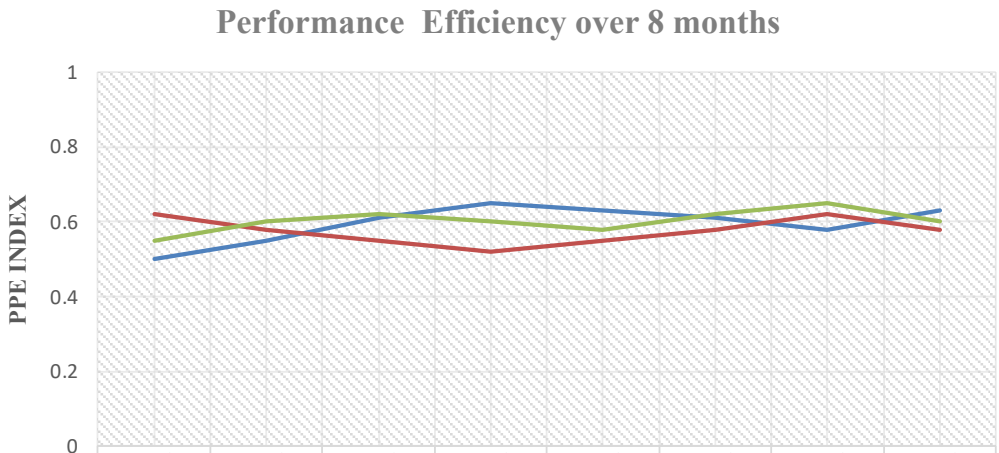


Figure 5: PPE Index validation findings[3]



	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8
A	0.5	0.55	0.61	0.65	0.63	0.61	0.58	0.63
B	0.62	0.58	0.55	0.52	0.55	0.58	0.62	0.58
C	0.55	0.6	0.62	0.6	0.58	0.62	0.65	0.6

2 Figure 4: 2nd Order Measurement Model for Project Performance Efficiency, Author`s finding, 2021.

3 Figure 5: PPE Index validation findings, Author`s finding, 2021.

Table 1. Results for Factor Analysis Performance Efficiency Measurement Variable[4]

	Components				
	1	**2**	**3**	**4**	**5**
Cronbach`s alpha (α)	**0.984**	**0.873**	**0.654**	**0.814**	**0.808**
TEE1: Clarity of Designs & Details (CoD)	.995				
TEE2: Design Changes (DC)	.993				
TEE3: Technology & materials (TM)	.985				
TEE4: Clarity of Specifications (CoS)	.981				
TEE5: Clarity of Construction method statement (CoCMM)	.978				
PMEE1: Cost & Financial Management Factors (CFMF)		.985			
PMEE2: Time Management Factors (TMF)		.985			
PMEE3: Quality Management Factors (QMF)		.806			
PMEE4: Health, Safety & Security Management Factors(HSSMF)		.795			
PMEE5: Project leadership Factors (PLF)		.795			
CEE1: Technical & management capacity (TMC)			.898		
CEE2: Procurement Efficiency (PE)			.410		
CEE3: Financial condition and stability (FS)			.879		
CEE4: Labour mobilization Ability (LMA)			.881		
CEE5: Sub-contractors coordination (SC)			.873		
CLEE1: Project Financing Ability & Cashflow behavior (PFA)				.756	
CLEE2: Top management Support (TMS)				.792	
CLEE3: Decision making process (DMP)				.741	
CLEE4: Dispute resolution ability (DRA)				.741	
CLEE5: Relationship with project team (RPT)				.739	
EEE1: Legal Environment Influence (LEI)					.779
EEE2: Weather Patterns (WP)					.657
EEE3: Riots/ Strikes (R/S)					.887
EEE4: Pandemics/ Outbreaks (P/O)					.775
EEE5: Stakeholders Influence (SI)					.943
Eigenvalue	4.762	2.865	2.145	1.747	1.446
Percentage of variance explained	19.049	11.460	8.578	6.988	5.785
Cumulative percentage	69.049	70.509	69.088	76.075	71.860

4 Table 1: Results for Factor Analysis Performance Efficiency Measurement Variable, Author`s finding, 2021.

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalisation. Rotation converged in 6 iterations.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy=0.69, Bartlett's Test of Sphericity=4137.533,

Significance =0.000

Table 2: Project Particulars for PPE Index Validation[5]

Name of project	**Project A**	**Project B**	**Project C**
Nature of Project	Hostel	Hospital	Administration Block
Project location	Nairobi	Kisumu	Kiambu
Contract Period	76 Calendar weeks	81 Weeks	104 Weeks
Contract Start Date	13th May 2020	4th March 2020	15th Jan 2020
Initial anticipated Practical Completion Date	13th Oct 2021	4th Sept 2021	15th Jan 2022
Time Elapsed	50 Weeks	58 Weeks	66 Weeks
Approved Extensions	8 Weeks	12 Weeks	16 Weeks
Percentage of Time Elapsed	65.79%	71.60%	63.46%
Percentage of work done	58.1%	63.1%	51.8%
Initial Defects liability Period (DLP)	13th April 2022	4th Mar 2022	15th July 2022
Revised Defects Liability Period (DLP)	13th June 2022	13th May 2022	13th Nov 2022
Initial Contract Sum	Ksh.246, 094,184	Ksh.358, 054,400	Ksh.464, 594,320
Net Additions (Appraisal No.01)	Ksh.21, 641,964.95.	Ksh.3,041,180.95.	Ksh.8,005,211.45
Net Additions (Appraisal No.02)	Ksh. 2, 722,240.63.	-	-

5 Table 2: Project particulars for PPE Index validation, Author`s finding, 2021

Social and Human Sciences

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Assessment of Employment Status Effect of Rural Electrification on the Household Well-Being of Proprietors of Micro and Small Enterprises in Kenya.

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Abstract

Kenya's poverty rates remain relatively higher implying low levels of household well-being compared to other lower middle income countries. A developing country like Kenya requires electricity for startup of farm and nonfarm micro and small enterprises to enhance well-being of a majority of the rural inhabitants. It is in this regard that an explanation is sought to investigate employment status effect of rural electrification on the household well-being of proprietors of micro and small enterprises in Kenya. The study adopted a cross-sectional descriptive survey design. The target population for this study comprised 172,554 proprietors of micro and small enterprises registered in Kenya by 2015. The study adopted multistage sampling involving systematic and simple random sampling procedures due to the large target population involved. Primary data from proprietors of rural micro and small enterprises in Kenya forming a sample size of 418 was used. Pearson correlation analysis revealed that there was a strong positive correlation between employee effectiveness and household well-being and a moderate positive correlation between availability of labor and household well-being. A standard regression analysis revealed that only employee effectiveness contributed significantly to the explanation of household well-being. Based on the findings, it was concluded that employment status explained a significant amount of the variance in the value of household well-being among proprietors of micro and small enterprises. It was, therefore, recommended that the government should ensure dedicated institutions and enabling policy and regulatory frameworks for institutions such as Rural Electrification Authority are strengthened with a clear mandate, authority and resources to fulfil the mandate, and accountability for achieving that mandate.

Keywords: **Employment status, household well-being, rural electrification, Proprietors of MSEs.**

1.1 Background to the Study

Well-being has become a policy concern in a range of nations, including the United Kingdom, Bhutan, the United Arab Emirates, and France, as well as at international organisations such as the United Nations and the OECD (Sachs, 2018). Countries with the highest levels of poverty and lower levels of household well-being tend to have lower access to modern energy services–a problem that is most pronounced in sub-Saharan Africa and South Asia (IEA, 2017). In 2014, 1.06 billion people still lived without access to electricity - approximately 15 percent of the global population and almost 3.04 billion people still relied on traditional biomass and kerosene for cooking and heating which is an indication of low level of well-being (IEA, 2017). Countries that enjoy the highest levels of well-being are those that are closest to reaching the 17 SDGs – those that have the highest social capital, the most inclusive and equitable economies, and policies that effectively protect and promote the natural environment (Global Council for Happiness and Wellbeing, 2019).

According to International Energy Agency (2013), 33.6 million people (80 per cent of a population of 42 million) in Kenya lacked access to electricity in 2011. This means that Kenya had the seventh highest deficit in access to electricity in the world. Electricity consumption per capita was 155kWh per year in 2011, as compared to an average 219kWh in all low income countries, 535kWh in sub-Saharan Africa and a world average of 3,045kWh. Generation capacity as of March 2014 was 1,810MW (Republic of Kenya, 2014). Rural areas remain to be the home to the bulk of Kenya's population and similarly the hub of micro and small enterprises. To seize this opportunity, Kenya has developed a national policy aimed at building the capacities of micro and small enterprises through the rural electrification projects (Abdullah & Markandyab, 2012).

In Kenya, electrification gap is larger in rural areas, where only seven per cent of the population has access compared to an urban electrification rate of 58 per cent (International Energy Agency, 2013). There are also significant differences across counties and constituencies. Electricity demand is expected to be 14 times higher in 2031 than in 2010, which will put the Kenyan system under high strain, according to the official Kenyan demand forecast presented in the Least Cost Power Development Plan (Republic of Kenya, 2011). Most rural areas within the regions where the national grid operates still don't have a supply point due to the limitations of the distribution network. Rural communities with a connection to the grid suffer frequent and prolonged outages and poor voltage levels. The dire condition of the distribution network in rural areas with long and undersized feeders, also causes high loses and long response times (Pueyo, 2015).

According to Lee, Miguel and Wolfam (2016), electrification rates remained very low, including for relatively well-off households, averaging 5.5 and 22.3 percent for households and businesses, respectively. However, according to World Bank (2017), Kenya is leading the way in the East African region on how to balance a rapidly growing electrification program with consumer affordability in a financially sustainable manner. There is a substantial decrease in the connection fee charged to household customers – from KES 35,000 ($343) to

KES 15,000 ($147) to be paid in instalments (World Bank, 2017). However, it has been estimated that the burden of power outages on the economy is as high as two percent of GDP and that the country needs a further 1,000 megawatts of generating capacity between 2010 and 2020 (AICD, 2010).

Since 2003, the government of Kenya embarked on a vigorous rural electrification that was aimed at supplying power to rural areas. The rural electrification program in Kenya was enhanced through the formation of Rural Electrification Authority (REA) in the year 2006 that formulated a number of strategies involving the use of grid and off-grid supply systems through diesel stations, wind, solar, biogas and other renewable energy sources (Rural Electrification Authority, 2013). In Kenya, the number of customers connected to electricity increased from 2.26 million in 2013 to 6,456,516 in 2017, translating to an access rate of 72 per cent. During the same period, a total of 15,134 schools were connected to electricity bringing the total number of primary schools connected to 23,496 (Republic of Kenya, 2018).

The potential to generate 7,000 MW of geothermal electric power exists in Kenya (Hope, 2010). However, by the year 2011, only 130 MW had been exploited in Kenya (United Nations Human Settlements Program, 2011). In 2012, 18 percent of the population had access to electricity in Kenya, compared to 14.8 percent in Tanzania and 23 percent in Ethiopia (African Development Bank, 2014). In 2014, electricity produced from Kenya's natural endowments accounted for 56 percent of its capacity, with a large share coming from geothermal origins (19.1%), which continued to grow in 2015 (26.6%). Notably, Kenya owns the largest single geothermal plant in the world in Olkaria IV (140 MW) which produces the cheapest electricity in the country (Millien, 2017).

Building new capacity and extending new transmission and distribution lines are considered Kenya's two main priorities. Consequently, two strategic projects: a quantified roadmap for building new capacity for which KPLC is responsible, and the Last Mile Connectivity project, which was launched by the REA in 2015 have been initiated (Millien, 2017). The Last Mile Connectivity project, aimed at connecting 70% of households by 2017 by extending the grid distribution lines and increasing the number of transformers, targeting 314,000 households within 600 meters of 5,320 selected substations (Lee, Brewer, Christiano, Meyo, Miguel, Podolsky, Rosa & Wolfram, 2014). Kenya targets to improve World Bank Ease of Doing Business ranking from position 80 in 2017 to 45 by 2022 through among others reducing the time taken to connect a business to electricity. This will likely lower the cost of doing business to attract foreign and domestic direct investments and increase job creation (Republic of Kenya, 2018).

1.2 Statement of the Problem

High unemployment levels and high energy costs are among the key issues and challenges highlighted in the Medium Term Plan III that require urgent attention (Republic of Kenya, 2018). According to World Bank (2017), use of electricity and equipment in developing countries improved the productivity and incomes of local small and micro-enterprises and supported improved village infrastructure such as schools, healthcare facilities and markets. According to World Happiness and Well-being Report 2019, Kenya was

ranked position 121 globally with a dismal performance index of 4.5 on a scale of 1–10 (Helliwell, Layard & Sachs, 2019). Kenya's total domestic demand for electricity from 2014 to 2018 increased by 3.5 per cent to 8,702.3 GWh in 2018 with demand for domestic and small commercial consumers increasing by 3.9 per cent to 3,665.9 GWh in 2018 (Republic of Kenya, 2019).

A study by Bezerra, Callegari, Ribas, Lucena, Portugal-Perreira, Koberle, Sziko and Schaeffer (2017) revealed that rural electrification had a positive influence on all dimensions of Human Development Index (HDI) in Brazil. Jimenez (2017) also found that rural electrification leads to increase in employment and incomes in Latin America. Amoah and Amoah (2018) aver that micro and small enterprises in Ghana offered employment of about 82 percent to the working population. Similarly, a study by Dasso and Fernandez (2015) revealed a positive relationship between rural electrification and employment in Peru. In view of the foregoing, it is acknowledged that rural electrification improves well-being of the rural poor through employment. This study therefore sought to establish whether the same trends are also realisable in Kenya.

1.3 Objective of the Study

The objective of this study was to investigate the employment status effect of rural electrification on the household well-being of proprietors of micro and small enterprises in Kenya.

1.4 Research Hypothesis

This study was guided by the hypotheses that employment status owing to rural electrification has no effect on the household well-being among proprietors of micro and small enterprises in Kenya.

2.1 Theoretical Literature Review

2.1.1 Rural Livelihoods Approach

The theoretical anchoring for this study is the Rural Livelihoods Approach. The choice of Rural Livelihoods Approach as the anchor theory for this study was informed by theoretical arguments that proprietors of micro and small enterprises may experience improved livelihoods through enhanced income and employment levels (Chambers & Conway, 1992). Households typically diversify their employment choices by engaging in more than one income-generating activity at the same time, by shifting between different activities over time, or by engaging in livelihood activities in different locations (Goulden, Adger, Allison & Conway, 2013). In poor rural households, sometimes engaging in micro and small enterprises is primarily a means of survival, a way to temporarily deal with risk or to cope with the immediate effects of shocks and stresses (Assan, 2014).

The rural livelihoods approach is essentially a micro policy analysis framework in which the assets are the devices in processes or activities that improve livelihoods. The framework uses 'assets or resources' as a vital feature and shows how these affect 'livelihood survival strategies' with 'livelihood mediating processes' which lead to various 'livelihoods' outcome (Serrat, 2017) as illustrated in Figure 2.2.1.

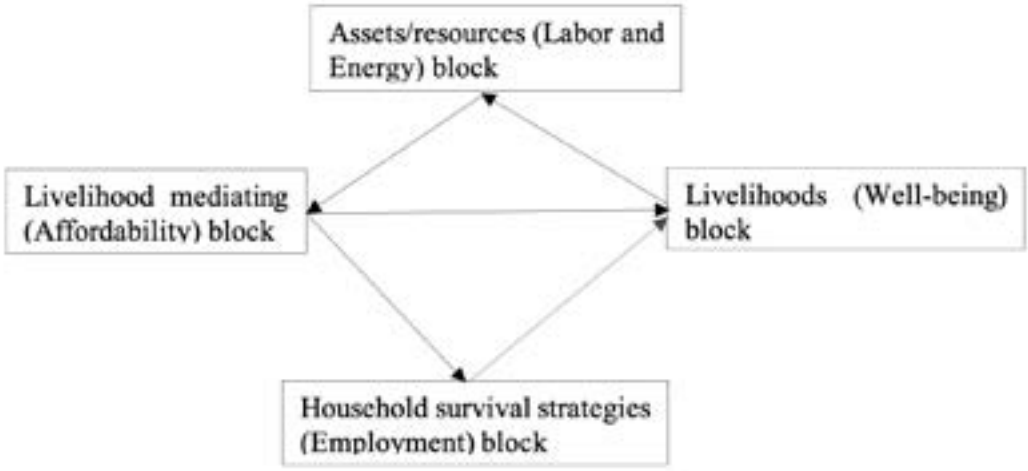

Figure 2.1.1: A Framework of Rural Livelihoods

Source: Author's formulation based on Serrat (2017).

The resources block comprises resources accessed in some way by the household. The term resources refer to stocks of capital that can be utilised directly or indirectly to generate livelihood of the household or to sustain its well-being at different levels above survival. Different types of resources are categorised and distinguished between five capital types as natural capital, physical capital, human capital, financial capital and social capital (Serrat, 2017). Financial capital is the financial resources that people can use to achieve the livelihoods for instance access to electricity while human capital refers to the skills, knowledge, ability to labor and good health that enable people to achieve their desired livelihoods (Flora & Flora, 2013).

Some of the models that have been used to measure livelihood strategies in developing countries include; the sustainable livelihood approach, the rural livelihoods approach, and the livelihood vulnerability framework (Ansah, Gardebroek & Ihle, 2019; Connolly, Boutin & Smit 2016; Sati & Vangchhia, 2017). A common denominator in these models is that livelihood outcomes are appraised from income, dimensions of human wellbeing, social safety nets, and access to public services, with poverty and food insecurity being the outcomes (Sati and Vangchhia 2017; Serrat 2017). For example, the cost of electricity installation and monthly bills at a particular moment in time comprise good determinants of access to affordable energy. A majority of rural households are disadvantaged in terms of access to electricity and employment necessary for enhancing well-being (Godfray, Beddington, Crute, Haddad, Lawrence, Muir, Pretty, Robinson, Thomas & Toulmin, 2010).

Diversification of income generating activities and value addition of agricultural products positively impact livelihoods by improving well-being, incomes, and gender inclusiveness (Rojas-Downing et al. 2017). Households can therefore choose from a range of survival strategies in order to maximize their achievement of well-being rather than being forced into any given strategy as the only option (IFAD, 2012).

Further to the above, through owning and using modern electrical equipment, business performance improves, level of employment is enhanced, a household's social status is dignified and well-being increases (Worku & Mekonnen, 2012).

2.1.2 Employment Status and Well-being

Rural electrification is expected to affect labor market participation through three potential channels: first, household electrification frees up women's time spent in collecting and preparing fuel, and increases the productivity of household tasks through improved technology. It, therefore, increases labor supply and results in more engagement in market based work (Grogan & Sadanand, 2013). Second, having access to electricity creates opportunities to generate income within the home and allows for new types of jobs outside the home, thus potentially increasing self-employment and labor demand (Van de Walle, Ravallion, Mendiratta & Koolwal, 2013). Third, a shift from agriculture-based to non-agriculture-based activities that are associated with growth in productivity and thus, increases in income (Torero, 2015). This is specifically relevant to rural Kenya, which is a predominantly an agricultural economy.

The arrival of electricity allows household members to reallocate labor away from household tasks and towards formal wage labor (Van de Walle *et al*., 2013). The provision of rural infrastructure, including water, electricity, roads, health care and other social services, are a precondition for business creation and increased labor market participation (UN Women, 2015). In lower-income countries, inadequate access to water supply, sanitation, electricity, roads, safe transportation, health care and other social care services is a key factor in explaining the amount of time spent on unpaid work (ADB, 2013). According to Jimenez (2017), access to electricity leads to a 25% increase in labor market participation on average, with a median of 20%. According to Grogan and Sadanand (2013), rural electrification leads to a significant decline in agricultural activities, while non-farm salary work increases. In this way, household electrification could unleash previously unrealised demand for labor and an increase in market work (Dinkelman, 2011).

There has been much economic growth around the globe, but it has been criticized for not being sufficiently 'inclusive' (Gupta, Pouw & Ros-Tonen, 2015) and it has not resulted in a markedly more equitable distribution of household well-being on a global scale (Bourguignon, 2015). Chakravorty, Pelli and Marchand (2014) infers that access to electricity causes expansion of micro-enterprises that create new employment, income opportunities and consequently improves household well-being for the rural population. Adoption of labor saving household technologies (e.g. electric cookers, electric lights, propane gas) leads to significant reduction of time spent on household activities and to a significant level, increase of time spent on economic activities (Grogan & Sadanand, 2013).

Urbanisation in sub-Saharan Africa is taking place without industrialisation (Djurfeldt, 2015). In the absence of manufacturing industries and high-return service sectors to provide skilled nonfarm opportunities, prospects for increased employment and rising incomes in urban areas of SSA remain limited. Micro and small enterprise generating activities provide an important source of primary employment in the rural areas of most developing countries, and it is

assumed that as farm size due to population pressure becomes smaller, the percentage of non-farm employment increases (Hilson, 2016). Micro and small enterprise activities have the potential to play a crucial role in reducing vulnerability to poverty by providing households with a form of insurance against the risks of farming and reducing reliance on natural resources (Simtowe, Asfaw & Abate, 2016).

A study by Squires (2015) in Honduras found that electrification reduces educational attainment. The reduction was accompanied by an increase in childhood employment, suggesting that improved labor market opportunities, due to electricity access, led to increased dropout rates. Shah and Steinberg (2013) present evidence that increases in labor market opportunities reduce childhood educational attainment in a wide variety of settings. Increased adult employment drives children to stay at home to compensate for parents going off to work (Squires, 2015). While it may be desirable for adult household members to work more to earn money, it is less desirable for adolescents to use their time in this way, especially if labor market participation crowds out school attendance and enrolment (Aevarsdottir, Barton, & Bold, 2016).

Amoah and Amoah (2018) carried out a study to investigate the role of micro small and medium enterprises (MSMEs) to employment in Ghana. The study adopted the methodology employed by Ghana Statistical Service (GSS) to undertake a nationwide survey on the Integrated Business Establishment Survey II (2016). It was revealed from the study that the MSMEs in Ghana offered employment of about 82 percent to the working population in the country with marked differences in the regions. Out of the employment offered by MSMEs in Ghana, about 81 percent was for permanent whilst 86 percent was for temporary employment. The study also revealed that the micro enterprises employed larger percentage of the working population than the small and medium enterprises.

Dasso and Fernandez (2015) study the effects of a rural electrification program on employment in Peru. Taking advantage of the program's roll-out across districts over time. They adopt differences-in-differences and fixed-effects strategies to estimate the impact of electrification on labor market outcomes. The results reveal that, among males, the program increases hours of work and diminishes the likelihood of having a second occupation. Among females, the treatment raises employment and earnings and increases the probability of working outside the agricultural sector. Similarly, Libscomb et al. (2013) analyze the effects of electrification on the Human Development Index (HDI) using county-level data from Brazil. Their results indicate that electricity provision is associated with higher levels of HDI. Moreover, their analysis suggests that migration is unlikely to account for the large magnitude of development gains observed. They also estimate large, positive effects of electrification on employment, salaries, and investments in education.

A review of the Mpeketoni Electricity Project, a community-based diesel-powered micro-grid in rural Kenya, found that the use of electricity and equipment improved the productivity and incomes of local small and micro-enterprises, contributed to the mechanisation of agriculture, and supported improved village infrastructure such as schools, markets and water pumps (World Bank, 2017). Interruptions to power supplies potentially affect MSEs' costs of production through the expense of repairing or replacing damaged equipment, the cost of spoiled goods and the additional cost

of alternative sources of energy, such as generators hence reducing their productivity and lowering household well-being among the owners (Cissokho & Seck, 2013).

The importance of micro enterprises in job creation cannot be overemphasised due to a strong correlation that exists between energy consumption and employment - notably through higher household employment following electrification (World Bank, 2017). However, at the same time, micro enterprises are criticised for being not very innovative and productive. Indeed, most studies on MSEs are not able to capture the survival rates of MSEs and, when they do, job creation rates do not seem to differ from those of larger enterprises (Page & Soderbom, 2012). Mulugeta, Fisseha and Mengesha (2016) argue that micro and small enterprises produce largely for the low income group and employ lower levels of labor. Furthermore, many microenterprises are the self-employed type with a low graduation rate into higher size categories and their innovative activities are limited.

3.1 Research Design

Kothari and Garg (2014) defines research design as the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. This study was conducted using a cross sectional survey research design. Houser (2011) reiterates that a cross-sectional survey design provides in-depth information about the characteristics of subjects within a particular field of study. The study is anchored on a critical realist approach philosophy. Critical realism focuses on a complex view of ontology which investigates the properties that societies and people possess that might make them possible objects of knowledge (Bhaskah, 1979). It argues that research should be able to make generalised claims but that the subjectivities of individuals and the meanings instilled within action are central to understanding the external world (Prowse, 2010). It therefore provides a solid epistemological basis for a reflexive well-being research of this type.

3.2 Target Population

Target population includes all the members real or hypothetical set of people, events or objects to which the study wishes to generalise the results of the research (Singleton & Strait, 2010). The target population for this study was 172,554 rural registered micro and small enterprises in Kakamega, Bungoma, Nakuru, Busia, Bomet, Siaya, Kericho and Kirinyaga Counties (Republic of Kenya, 2016). The decision to use the above named counties for this study was based on their contribution to national poverty.

3.3 Sampling Frame

Sekaran and Bougie (2011) defines sampling frame as a physical representation of all the elements in the universe/population from which the sample is drawn. The sampling frame for this study consisted of 172,554 micro and small enterprises registered in Kakamega, Bungoma, Nakuru, Busia, Bomet, Siaya, Kericho and Kirinyaga Counties by 2015 (Republic of Kenya, 2016) making a total of 172,554 in number as shown in Table 3.3.1

Table 3.3.1: Population Sampling Frame

County	Total Registered MSEs.	Total Registered Rural MSEs.
Kakamega	52,470	30,957
Bungoma	17,149	10,118
Nakuru	117,254	69,180
Busia	27,748	16,371
Bomet	14,000	8,260
Siaya	14,114	8,327
Kericho	19,522	11,518
Kirinyaga	30,209	17,823
Total	**292,466**	**172,554**

Source: Republic of Kenya (2016)

3.4 Sample and Sampling Technique

A sample is a subset of a population (Hyndman, 2008) while sampling technique is the process of selecting respondents that constitute a sample (Kothari & Garg, 2014). The study adopted multistage sampling technique to select the sample size. Multistage sampling involves dividing the population into groups or clusters. This type of sampling is suitable for this study due to the large target population involved (Nafiu, 2012). In the first stage, systematic sampling was used to arrive at the choice of the eight counties based on their contribution to national poverty and county ranking as shown in Table 3.4.1. In the second stage, simple random sampling technique using random numbers (Cooper & Schindler, 2006) was used to select the individual proprietors of MSEs from each of the counties involved in the study. This fulfilled the requirements of efficiency, representativeness, reliability and flexibility taking care of systematic bias that may result from non-respondents (Kothari, 2012).

Table 3.4.1: Contribution to National Poverty by County

County	Total Population	Contribution (%)	Rank (Highest to lowest)
Kakamega	1,644,328	4.77	1
Bungoma	1,359,983	3.79	5
Nakuru	1,562,625	3.08	10
Busia	735,294	2.61	15
Bomet	721,873	2.18	20
Siaya	833,230	1.87	25
Kericho	737,942	1.71	30
Kirinyaga	520,585	0.79	45

Source: Republic of Kenya (2014).

Since the target population (172,554) is more than 10,000, Mason, Lind and Marchal (1999) explains that the sample size may be computed by the following formula;

$$n = \frac{z^2pq}{d^2} \quad \text{.....Equation 1}$$

Where;

n is the desired sample size when population is greater than 10,000.

z is the standard normal deviate at 95% confidence level (z = 1.96).

p is the proportion in target population estimated to have characteristic being measured (p = 0.5).

d is the level of statistical significance set (d = 0.05).

Substituting the values into equation 1, the estimated sample size for infinite population was obtained as follows:

$$n = (1.96)^2 (0.5)^2 \div (0.05)^2$$
$$= 3.8416 \times 0.25 \div 0.0025$$
$$= 384.16$$

Correcting for finite population, the following formula was used (Naing, *et.al.* 2006)

$$n^1 = n/ (1+n/N) \quad \text{.....Equation 2}$$

Where:

n^1 = sample size for finite population

N = the target population = 172,554

n = calculated sample size from infinite population = 384.16

Substituting these values into equation 2:

$$n^1 = 384.16/ (1+384.16/172,554)$$
$$= 384.16/1.00223$$
$$= 383.3$$

The calculated sample size was, therefore, 384.

The proportionate sample sizes for each stratum are computed on the basis of the size of the stratum and the target population. In view of the above explanation concerning the sample size, it is ensured that the sample size for each stratum (for this study each county) is the larger value as proportionately computed from the formula above or 30, being the minimum sample size as per the central limit theorem or the total of the particular stratum for a population size below 30. This study, therefore, used a sample population of 418 respondents for data collection as shown in Table 3.4.2.

Table 3.4.2: Sample Population per County

County	Total Reg. Rural MSEs	Proportionality	Sample
Kakamega	30,957	17.94	69
Bungoma	10,118	5.86	30
Nakuru	69,180	40.09	153
Busia	16,371	9.49	37
Bomet	8,260	4.79	30
Siaya	8,327	4.83	30
Kericho	11,518	6.68	30
Kirinyaga	17,823	10.32	39
Total	**172,554**	**100**	**418**

4.1 Diagnostic Results

4.1.1 Reliability Test Results

The reliability for multi-item opinion items were computed separately for the subscales in the MSEs proprietors questionnaires, as shown in Table 4.1.1. The Cronbach's alpha coefficient revealed that the instruments had adequate reliability for the study.

Table 4.1.1: Cronbach's Alpha Results

Scale	No. of Items	Cronbach's alpha	Conclusion
Employment Status	10	.868	Reliable
Household Well-Being	8	.865	Reliable

The subscale employment status composed of 10 items had good internal consistency, α = .868; all the items of this subscale were worth of retention. Deleting any of the items in this subscale would not result to an increase in Cronbach's alpha. On the same note, the internal consistencies for the items in the household well-being questionnaire were adequate enough for the study, α = .865. According to Pallant (2007), a Cronbach's alpha greater than 0.7 is considered adequate. These findings show that the questionnaires were generally suitable for data collection because they adequately measured the constructs for which they were intended to measure.

4.1.2 Validity Test Results

Although pilot study was done to improve external validity of the instruments, internal validity of the constructs was tested by subjecting the survey data to suitability tests using the Kaiser-Meyer-Oklin measure of sampling adequacy (KMO Index) and the Bartlett's Test of Sphericity. This is a prerequisite condition for a factor analysis. Before the extraction of factors, the suitability of the questionnaire data set for factor analysis was assessed for each sub-scale and the result was summarized as in Table 4.1.2.

Table 4.1.2: KMO and Bartlett's Test

Subscale	Kaiser-Meyer-Olkin (KMO index)	Bartlett's Test for Sphericity		
		Approx. Chi-Square	Df	Sig.
Employment Status	.881	1189.656	45	.000
Household Wellbeing	.899	910.693	28	.000

Kaiser (1974) asserts that the Kaiser-Meyer-Oklin measure of sampling adequacy index ranging > .6 is of adequate internal validity and is considered suitable for factor analysis. The Bartlett's Test for Sphericity on the other hand relates to the significance of the study and indicates the validity of responses obtained in relation to the problem that the study seeks to address. Creswell (2014) observes that Bartlett's Test of Sphericity test statistic should be less than .05. In the current study, the value of Bartlett's test for Sphericity is significant ($p<.001$, $p=.000$) for both the subscales of the questionnaire. In addition, the Kaiser-Meyer-hold Olkin indexes are both greater than .6 which is a threshold for sufficient internal validity. Creswell (2014) asserts that if the Bartlett's test for Sphericity is significant, and if the Kaiser-Meyer-Olkin measure is greater than .6, then factorability is assumed and hence use of factor analysis is attainable.

4.1.3 Normality Test Results

Normality of data were tested through the use of formal test using Kolmogorov-Smirnov and Shapiro-Wilk tests, as shown in Table 4.1.3. Initial tests on the variables indicated violation of normality; hence the independent variable had to be transformed first to remove moderate skewness that was observed in the original data.

Table 4.1.3: Tests of Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
Employment Status	.183	307	.355*	.812	307	.140
Household Wellbeing	.271	307	.134	.841	307	.116
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Normality tests in Table 4.1.3 shows the results after transformation. Although normality test by SPSS concurrently indicate both Kolmogorov-Smirnov (K-S) and Shapiro-Wilk test results, this study used the S-W to interpret the normality of the variables. Garson (2012) recommends that Shapiro-Wilk's test should be used for small and medium samples up to n = 2000. Shapiro-Wilk is comparable to the correlation between a given data and its corresponding normal scores, with S-W = 1 when their correlation is perfectly normal. This means that a significantly ($p<.05$) smaller S-W than 1.0 imply that the normality is not met. Hence, the data is normal when Shapiro-Wilk (S-W) >.05. All the variables follow normal distribution given that there were no statistical significant differences noted in any of the variables with their corresponding normal scores as shown in Table 4.4.3.

4.2 Descriptive Statistics

Household well-being was assessed by two measures namely access to basic human needs and meeting social obligations. Respondents generally agreed that employment status due to rural electrification had a positive effect on household well-being. For instance, respondents were in agreement that enhanced employment income due to electrification led to improved nutrition for households. This was confirmed by about 58% of the respondents who participated in the survey with about 7% being ambivalent. This is in line with the assertion by Lazar, Adams, Adger and Nicholls (2020) that wellbeing role of off-farm income is significant, and underscore the importance of the stability and returns from off-farm employment.

Employment status was assessed through three main measures namely cost of labor, employee effectiveness and availability of labor. Ten constructs that underlie the three measures were subjected to factor analysis. Rural electrification had a considerable amount of influence on creating employment which triggered a rise in general well-being of households among proprietors of MSEs. For example, more than 85% of the respondents agreed that access to electricity increases non-farm wage employment with about 10% being indecisive. After electrification, changes of labor allocation across activities might occur and lead to higher level of

employment and productivity. Here, it is particularly the shift from agricultural to non-agricultural activities that is associated with employment and productivity increases. Shifts in labor from agricultural to non-agricultural activities encompasses productive appliance usage, changes in the main occupation and firm creation after electrification. It is important to emphasize that the vast majority of households in rural Kenya are farmers and do not pursue any nonagricultural activity. These findings agree with the findings by Van de Walle *et al*. (2013) that having access to electricity creates opportunities to generate income within the home and allows for new types of jobs outside the home, thus potentially increasing self-employment and labor demand.

4.3 Factor Analysis Results

Factor analysis using Principal Components Method (PCM) approach helped to cluster the common factors and to retain a small number of factors which had the highest influence, as explained by Oso and Onen (2009). According to Kennedy (2010), analysis of principal components is a method which describes interdependencies among the items of a variable and is usually aimed at sorting a few factors which explains most of the information on the variable construct. The extraction of the factors followed the Kaiser criterion where an eigenvalue of 1 or more indicates a unique factor.

All the eight household wellbeing indicators were subjected to factor analysis which was conducted using Principal Components Method (PCM) approach. The results are presented in Table 4.3.1

Table 4.3.1: Total Variance Explained for Household Well-being

Component	Initial Eigenvalues.			Extraction Sums of Squared Loadings.		
	Total.	Variance. (%)	Cumulative. (%)	Total.	Variance. (%)	Cumulative (%)
	4.181	52.264	52.264	4.181	52.264	52.264
	.762	9.528	61.792			
	.643	8.039	69.832			
	.592	7.394	77.226			
	.569	7.106	84.332			
	.483	6.034	90.366			
	.406	5.081	95.447			
	.364	4.553	100.000			
Extraction Method: Principal Component Analysis.						

Eigenvalues associated with each linear component were listed before extraction, after extraction and after rotation as shown in Table 4.3.1. The eight measures of household well-being were subjected to factor analysis and seven items attracted coefficients of more than 0.4. Therefore, the seven statements were retained for analysis. According to Rahn (2010) a factor loading equal to or greater than 0.4 is considered adequate. Further the results showed that there was only one critical factor influencing household well-being which accumulated to 52.264% of the total variance in this construct.

The main loadings in the single component were from items on access to basic family needs and meeting social obligations both of which measured the degree to which the employment effects of rural electrification

had addressed the objective of household well-being among proprietors of MSEs. The two initial sub-concepts on access to basic family needs and meeting social obligations were combined to form 'household well-being'. The single component was therefore named 'household well-being'. From the rotation matrix, there was only one major factor combining the two initial sub-concepts of access to basic family needs and meeting social obligations. This therefore implies that well-being is a composite concept that cannot be broken further. This factor had eight items with very high loadings and significance. The mean of the scales constructed on the basis of the single factor of household well-being, was checked using univariate descriptive under factor analysis. The results are presented on a scale of 1.0 to 5.0 in Table 4.3.2.

Table 4.3.2: Analysis of the Mean for Household Well-being

Definition	Mean	SD
Enhanced Well-being	3.32	.64750

Key: 1.00-1.80 = Strongly Disagree; 1.81-2.60 = Disagree; 2.61-3.40 = Neither Agree nor Disagree; 3.41-4.20 = Agree; 4.21-5.0 = Strongly Agree

The finding indicate that respondents were ambivalent about the effect of rural electrification on well-being which includes increased access to basic family needs and meeting social obligations as indicated by a mean score of 3.32 which lies on the neither agree nor disagree on the ranking scale. The finding is in line with that by Lee, Miguel and Wolfram (2016) that rural electrification in Kenya may reduce social welfare as the costs of grid expansion significantly outweigh its benefits. The finding also resonate with Neelsen and Peters (2013) who explored the impact of electrification on fishing communities near Lake Victoria and did not find any significant difference between communities with or without access to electricity.

All the 10 items describing employment status were also subjected to factor analysis, whose results were presented in Table 4.3.3.

Table 4.3.3.: Total Variance Explained for Employment Status

Component	Initial Eigenvalues.			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1.	3.323	47.472	47.472	3.323	47.472	47.472	2.883	41.179	41.179
2.	1.238	17.691	65.163	1.238	17.691	65.163	1.679	23.984	65.163
3.	.636	9.090	74.252						
4.	.533	7.613	81.866						
5.	.469	6.702	88.567						
6.	.411	5.878	94.446						
7.	.389	5.554	100.000						
Extraction Method: Principal Component Analysis.									

The seven measures of employment status were subjected to factor analysis and six (6)

of them attracted coefficients of more than 0.4 as shown in Table 4.3.3. Therefore, the six statements were retained for analysis. Using factor analysis, only two factors were identified to have a significant influence on explaining characteristics of employment status with cumulative variance of 65.163%. Only these items had an eigenvalue greater than one and had a significant influence on employment status characteristics, explaining 47.472% and 17.691% totaling to about 65.163% of variance on the variable as shown in Table 4.3.3.

The main loadings in the two components were from items on cost of labor, supply of labor and demand for labor, all of which measured the degree to which employment status had influenced household well-being among proprietors of MSEs. The three initial sub-concepts of cost of labor, supply of labor and demand for labor were reduced to form employee effectiveness and availability of labor. The components identified to have the highest influence were; employee effectiveness and availability of labor. A descriptive analysis of the two factors of employment status that were identified through rotation was undertaken by estimating the mean of the scales of each factor and the results are presented in Table 4.3.4.

Table 4.3.4.: Analysis of the Mean for Employment Status

Definition	Mean	SD
Employee Effectiveness	4.1920	.60251
Availability of Labor	3.8900	.81558

Key: 1.00-1.80 = Strongly Disagree; 1.81-2.60 = Disagree; 2.61-3.40 = Neither Agree nor Disagree; 3.41-4.20 = Agree; 4.21-5.0 = Strongly Agree

It was observed that employee effectiveness was the most significant issue regarding employment status as indicated by a mean score of 4.1920, which is equivalent to agree on the ranking scale as shown in Table 4.3.4. It was also noted that availability of labor as a result of rural electrification was similarly an important concern in employment status as indicated by a mean score of 3.8900, which is equivalent to agree on the ranking scale.

Electricity provision can affect employment through different channels. First, it can be thought of as a technological shock that improves household production. Second, it implies a larger time endowment because everyone can work during the night (and not only during the day). Third, it could promote the start-off of new businesses by allowing households to produce goods and services that require appliances (Dasso & Fernandez, 2013). This is consistent with the finding by Van de Walle *et al*. (2013) that having access to electricity creates opportunities to generate income within the home and allows for new types of jobs outside the home, thus potentially increasing self-employment and labor demand. Similarly, the results also resonate with the finding by Torero (2015) that rural electrification leads to a shift from agriculture-based to non-agriculture-based activities that are associated with growth in productivity and thus, increases in income.

4.4 Correlation Analysis

A Pearson Product Moment Correlation Coefficient was computed, with scores on employment status as independent variable and household well-being among proprietors of micro and small enterprises as dependent variable. The scores for both variables were converted into continuous data (ratio scaled data) by computing mean responses per respondent, where high scale ratings implied high employment status and high household well-being and vice versa. The correlation analysis result was shown in SPSS output, as indicated in Table 4.4.1.

Table 4.4.1.: Employment Status and Household Well-being

		Household Well-being
Employee Effectiveness	Pearson Correlation	.632**
	Sig. (2-tailed)	.000
	N	
307		
Availability of Labor	Pearson Correlation	.577**
	Sig. (2-tailed)	.000
	N	307

****. Correlation is significant at the 0.01 level (2-tailed).**

The results of the survey confirmed that there was a positive (r=.632, n=307, p<.05) relationship between employee effectiveness and household well-being among proprietors of micro and small enterprises. Rural electrification is believed to attract skilled labor in rural areas due to improved living standards. This may further lead to production and demand for high quality goods and services in rural areas. The finding also revealed a moderate positive (r=.577, n=307, p<.05) relationship between availability of labor and household well-being among proprietors of micro and small enterprises. Rural electrification may spur development of nonfarm businesses that consequently form the genesis of urbanisation and industrialisation in rural areas. This findings are in harmony with Jimenez (2017) assertion that access to electricity leads to a 25 percent increase in labor market participation on average, with a median of 20 percent.

4.5 Regression Analysis

To estimate the level of influence of employment status owing to rural electrification on household well-being among proprietors of micro and small enterprises, a coefficient of determination was computed. This was done using regression analysis and the results were as shown in Table 4.5.1.

Table 4.5.1.: Employment Status and Well-being

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.645[a]	.416	.412	.49648
a. Predictors: (Constant), Employee Effectiveness, Availability of Labor				

From Table 4.5.1., R-value (.645) for employment status suggest that there is a strong effect of employee effectiveness and availability of labor on household well-being among proprietors of MSEs. The R-square (R^2) value is 0.416, which represents 41.6% variation of household well-being among proprietors of micro and small enterprises as a result of employment status due to rural electrification. Furthermore, to determine whether employment status as a result of rural electrification was a significant predictor of household well-being among proprietors of micro and small enterprises, Analysis of Variance (ANOVA) was computed as shown in Table 4.5.2.

Table 4.5.2.: ANOVA – Employment Status and Well-being

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	53.358	2	26.679	108.234	.000[b]
Residual 74.935 304 .246						
	Total	128.293	306			
a. Dependent Variable: Household Well-being						
b. Predictors: (Constant), Employment Status						

Employment status was a significant predictor of household well-being among proprietors of micro and small enterprises [F (2, 304) = 108.234, p < .05)] as shown in Table 4.5.2. This means that employment status was a significant predictor of household well-being among proprietors of micro and small enterprises. From the results it is clear that employment status explained a significant amount of the variance in the value of household well-being among proprietors of micro and small enterprises.

To show the strengths of the relationship between employment status owing to rural electrification and household well-being among proprietors of micro and small enterprises, regression analysis was done. Regression model coefficients are shown in Table 4.5.3.

Table 4.5.3.: Regression Coefficients for Employment Status and Well-being

Coefficients Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
1	B	Std. Error	Beta		
(Constant)	.626	.099		6.289	.000
Employee Effectiveness	.624	.051	.580	12.304	.000
Availability of Labor	.111	.037	.139	2.955	.003

a. Dependent Variable: Household well-being

Model: $Y=0.626+0.580X_1+0.139X_2$

From Table 4.5.3., there was a positive beta co-efficient of .580 and .139 as indicated by the co-efficient matrix with a p-value = .000 < .05 and a constant of .626 with a p-value = .000 < .05 as shown in Table 4.7.8. Therefore, the constant, employee effectiveness and availability of labor contributed significantly to household well-being. Consequently, the model can provide the information needed to predict household well-being from employment status. The regression equation is presented as follows: $Y=0.626+0.580X_1+0.139X_2$; Where Y = household well-being, X_1 is employee effectiveness and X_2 is availability of labor. This finding is in line with that by Dasso and Fernandez (2015) that rural electrification program increases hours of work, diminishes the likelihood of having a second occupation, raises employment and earnings and increases the probability of working outside the agricultural sector in rural Peru.

4.5.1 Results of Hypothesis Test

The null hypothesis of this study that *'Employment status owing to rural electrification has no effect on the household well-being among proprietors of micro and small enterprises in Kenya'*, was tested through regression as shown in Table 4.5.3. Accordingly, employment status had coefficients of estimate which were significant basing on $\beta_1 = 0.580$ (p-value = .000 which is less than $\alpha = .05$) and $\beta_2 = 0.139$ (p-value = .003 which is less than $\alpha = .05$). The null hypothesis was thus rejected and it was concluded that employment status had a significant effect on household well-being. Consistently, Grogan and Sadanand (2013) recognised that rural electrification affect labor market participation through freeing up time spent in collecting and preparing fuel, and increasing labor supply and engagement in market based work. Furthermore, Van de Walle *et al*., (2013) reiterated that having access to electricity creates opportunities to generate income within the home and allows for new types of jobs outside the home, thus potentially increasing self-employment and labor demand.

4.6 Findings

The study sought to evaluate the effect of employment status owing to rural electrification on household well-being among proprietors of micro and small enterprises in Kenya. This was tested by conducting a regression analysis on the two factors of employment status against household well-being. Descriptive statistics showed that rural electrification had a substantial effect on employment status resulting to enhanced well-being of households. Since a majority of households in rural Kenya are farmers, a shift from agricultural to non-agricultural economic activities enhances both employment, wage levels and productivity.

Factor analysis undertaken using principal component analysis showed that the first two factors explained most of the variance and were, therefore, most important. The two factors were employee effectiveness and availability of labor. The two components were from items on cost of labor, supply of labor and demand for labor, all of which measured the degree to which employment status had influenced household well-being among proprietors of MSEs. The emergence of employee effectiveness and availability of labor suggests that these two determine the decision to hire employees by MSEs. This is consistent with the observation by Torero (2015) that rural electrification

leads to a shift from agriculture-based to non-agriculture-based activities that are associated with growth in productivity and thus, increases in employment.

Pearson correlation analysis revealed that there was a strong positive correlation between employee effectiveness and household well-being and a moderate positive correlation between availability of labor and household well-being. A standard regression analysis revealed that only employee effectiveness contributed significantly to the explanation of household well-being. Given that the regression results demonstrated the existence of significant relationship between employment status and household well-being, the null hypothesis that employment status of rural electrification has no effect on the household well-being among proprietors of micro and small enterprises in Kenya was thus rejected and it was concluded that employment status due to rural electrification had a significant effect on household well-being. This, therefore, implies that an increase in employee effectiveness enhances the level of well-being among proprietors of micro and small enterprises. This is consistent with the findings by Van de Walle *et al*. (2013) that having access to electricity creates opportunities to generate income within the home and allows for new types of jobs outside the home, thus potentially increasing self-employment and labor demand. Analysis of Variance results revealed that both the two factors of employment status (employee effectiveness and availability of labor) of rural electrification were significant predictors of household well-being among proprietors of micro and small enterprises. Regression results indicated that both measures of employment status (employee effectiveness and availability of labor) contribute significantly to household well-being. This findings are in harmony with Jimenez (2017) assertion that access to electricity leads to a 25% increase in labor market participation on average, with a median of 20%.

5.1 Conclusions

The findings of the study indicated that there was a moderate positive relationship between employment status and household well-being among proprietors of micro and small enterprises. It was, therefore, concluded that there was indeed statistical significant relationship between employment status and household well-being among proprietors of micro and small enterprises, with increase in employment status resulting into improvement in household well-being among proprietors of micro and small enterprises and vice-versa. Based on the findings it was concluded that employment status explained a significant amount of the variance in the value of household well-being among proprietors of micro and small enterprises.

5.2 Recommendations

The study is a justification of the fact that the role of rural electrification on micro and small enterprises in Kenya cannot be underestimated and has contributed to improved household well-being in Kenya. Based on the findings of this study, it was concluded that there was a statistical significant relationship between employment status and household well-being among proprietors of micro and small enterprises. It was, therefore, recommended that the government should ensure dedicated institutions and enabling policy and regulatory frameworks to make

sure relevant institutions such as Rural Electrification Authority are strengthened, with a clear mandate, authority and resources to fulfil the mandate, and accountability for achieving that mandate.

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Adoption of Mobile Phones on Diarrhoea Awareness in Resource Constrained Settings

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Abstract

Rural areas in developing countries are resource constrained and communities residing in those areas generally have low levels of health knowledge. Over the last decade mobile phones penetration has greatly increased especially among rural communities which has made them a preferred platform for adoption in health information communication. Current technologies used to raise disease awareness in rural areas are not successful hence a suitable technology is required. The study was conducted in Narok, one of the rural counties in Kenya. The study design was quantitative and was conducted in three parts. Part one was a retrospective chart review of diarrhoea records of children below the age of five years. Part two was a pre-test post-test experimental study of 175 mothers with children below the age of five years from a control and an experimental group and part three was a cross sectional survey on community health volunteers. The experimental group received diarrhoea education messages for three months through a mobile phone-based system. Diarrhoea awareness was compared in the two groups before and after the intervention. After the three months of intervention through educational messages, diarrhoea awareness was found to have improved significantly in the experimental group (effect size= 0.81). Diarrhoea prevention practices significantly improved in the experimental group (effect size=0.643) and the post–intervention comparison of the diarrhoea prevalence from the dispensary data showed that there was a significant difference between the two groups (p=0.040). The study established that the previously used strategies and technologies had failed because they were not suitable for the area. Mobile phones were identified as the most suitable technology for promoting diarrhoea awareness in rural areas which leads to reduced

prevalence. The study concluded that when the right technology for the context environment is used to raise diarrhoea awareness, the awareness increases which leads to improved diarrhoea prevention practices and consequently to reduced diarrhoea prevalence. Mobile phones should be adopted in raising health awareness especially in rural areas where health resources are scarce.

***Keywords*: Information Communication technology, healthcare, disease awareness, diarrhoea, rural communities, information dissemination, mobile phones and disease intervention framework.**

Background

Diarrhoea is defined as the passage of three or more loose or liquid stools per day (WHO 2017). Globally diarrhoea is the second highest killer disease for children below the age of five years (WHO 2018). In Kenya, diarrhoea is the second killer disease for children below the age of five years accounting for over 20% of the deaths in that age bracket (Darvesh et al., 2017; Institute of Economic Affairs Kenya 2018). In Narok County in Kenya, diarrhoea accounts for over forty percent of the mortality in children below five years of age, this high mortality is attributed to poor hygiene practices in the area (AMREF 2015; Kenya Ministry of Health 2015). Diarrhoea can easily be prevented by adoption of good hygienic practices but in rural Narok, people lack that knowledge (Narok County Government 2018). This ignorance is attributed to the ineffective ways used to disseminate diarrhoea prevention information (Tankoi, Asito and Adoka 2016). Consequently the focus of the study was on feasible methods of diarrhoea intervention through information dissemination in rural Narok County.The study focus is on children below the age of five years because they are the most affected by diarrhoea.

Narok County is resource constrained and has more than 90 per cent of the population living in rural areas practising pastoralism (Tankoi,Asito and Adoka 2016). Kenya National Government, Narok County Government and non- governmental organisations have engaged in spirited campaigns through radios, televisions, seminars, posters and public meetings to disseminate diarrhoea information in the rural areas of Narok. These approaches have not been successful due to low levels of literacy among the people, their lifestyle and poor infrastructure (AMREF 2015; UNESCO 2018). Therefore, a new approach to disease intervention which bypasses the existing constraints, namely mobile phones is required (Narok County Government 2018).

Studies conducted in rural areas in developing countries, have indicated that mobile phones enhance health information-delivery, communication and information retrieval over long distances between patients and healthcare service providers (Njoroge et al., 2017). Mobile phones enable consultation between patients and health workers in remote places and facilitate consultations among health workers themselves (Bardosh et al., 2017).

According to the Communications Authority of Kenya report of July to September 2018 the mobile phone penetration is 100.1% country wide and at 60.5% in the rural areas (Communications Authority of Kenya 2018). This high penetration especially in rural areas and government support presents an enabling environment for development of mhealth interventions for rural areas.

Literature Review

Diarrhoea is the passage of three or more loose or liquid stools per day and is usually because of the intestinal tract infection, it is spread through contaminated water sources, food or person to person due to unhygienic conditions (WHO 2017).

According to the World Health Organisation report (2019), every year about 1.7 billion cases of childhood diarrhoea are reported globally. Annually diarrhoea disease causes approximately 525 000 deaths in children under five years of age globally (WHO 2019).

In Kenya diarrhoea prevalence for children below the age of five years is about 16% and over 20% of mortality for children in that age bracket is caused by diarrhoea. (Dioso and Elmi 2017; Kenya Ministry of Health 2016).

Diarrhoea prevalence among children below five years of age in Narok County is documented at 20%, which is higher than the national average, it is a major cause of morbidity and mortality for that age group (AMREF 2015).

Interventions that can be employed to prevent diarrhoea include good sanitation, exclusive breastfeeding, hand washing using soap and drinking clean water (Tankoi, Asito and Adoka, 2016). Diarrhoea can be treated using solutions of clean water, salt and sugar. A two-week supplement of 20 milligrams of zinc tablets improves the outcome of the treatment. Diarrhoea can be caused by drinking water contaminated with sewage wastes, animal wastes, drinking poorly stored water, eating dirty food or eating fish and seafood from polluted water bodies (Kenya ministry of health, 2016).

Nduba et al., (2015) did a study in rural areas of Narok to find out why diarrhoea was very prevalent. The study found out that the community had certain wrong perceptions about diarrhoea that hindered its prevention. The community believed that herbs such as *emunak Ololoto, Sama- gururei* could prevent diarrhoea (Nduba et al., 2015).

Nduba et al. (2015) concluded that the community held such beliefs because they lacked the correct information concerning diarrhoea. According to Nduba and associates the lack of awareness was due to the use of unsuitable strategies and technologies in diarrhoea information dissemination. Okeyo et al. (2019) in a study conducted in rural areas of Narok got similar findings.

Methods

The study design adopted in this study was quantitative. The study was conducted in two parts concurrently. Part one was a retrospective chart review of records of diarrhoea for children under the age of five years. The records were from two dispensaries in two sub-locations in Narok County in Kenya. One of the sub-location was Mosiro (control group) and the other was Enkorika (experimental group). This data was used to determine the prevalence of diarrhoea among children below the age of five years in the two sub-locations before and after the interventional study. Part two consisted of the pre-test post-test prospective interventional study.

Before the study, ethical clearance was obtained from National Commission of Science, Technology and Innovations. The permit number was NACOSTI/P/19/41454/28340. The participants gave informed consent before taking part in the study.

Part One: Restrospective Chart Review

The first chart review was conducted a week before the commencement of the intervention to determine the prevalence of diarrhoea before the intervention. The second chart review was conducted at the end of the intervention to determine the incidences of diarrhoea that occurred during the intervention in the study sub- locations.

Study Population for the Retrospective Chart Review

Anonymous patient's records of children under five years of age who suffered from diarrhoea in the two selected dispensaries in the study areas were reviewed. Mosiro sub-location had 465 children who were under five years of age and Enkorika sub-location had 490 children under five years of age (Narok County Government 2018). Registers that contained data not more than one year old from the date of data collection were included. Registers containing data that was more than a year old from the date of data collection were excluded.

Sampling for the Retrospective Chart Review

Each of the study areas was served by a single dispensary. The Mosiro dispensary served the Mosiro sub-location and Oletukat dispensary served the Enkorika sub-location (Narok County Government 2018). The two dispensaries were chosen through purposive sampling since they were the only sources of clinical data for the study locations. The data for the period between April 2018 and March 2019 were reviewed for the first retrospective chart review. One year was chosen as a sufficient period to demonstrate a clear trend of the diarrhoea prevalence in the area. The second chart review was conducted at the end of the interventional study to determine the diarrhoea prevalence trend from the time the intervention started until the end.

Part Two: Prospective Interventional Study

This phase was conducted concurrently with the retrospective chart review. The prospective pre-test survey was conducted on the mothers with children under five years of age since the children are not capable of responding to questions accurately. The pre-test study was used to measure the level of diarrhoea awareness, adoption of diarrhoea prevention practices and to find out the mother's opinion on the current technologies/ strategies used in diarrhoea information dissemination. The mothers also suggested the characteristics of a suitable diarrhoea information dissemination technology that could be adopted in the area. The study was also used to elicit requirements for the development of the prototype.

Study Population for the Prospective Interventional Study

Homogenous purposive sampling was used to come up with the sample. This technique involved purposively choosing two sub-locations and then purposively choosing participants who met the inclusion criteria from the two groups. In selection of participants for the research, the requirements were; access to a mobile phone, mothers with children under five years of age and availability of mobile phone network in the homestead of the participant. The exclusion criteria used was disabilities, mothers with health training, mothers without access to mobile phones, mothers who did not have children who are below five years of age and men were also excluded from the study.

Sample Size Clculation for the Prospective Interventional Study

With a population of 307 households in the test group and a confidence level of 95% which is the most used confidence level in recent health research and a confidence interval of 5% which is acceptable for a very homogeneous group like our population.

The sample size was computed as follows:

Sample Size (SS)

$SS= (Z^2*(p)*(1-p))/C^2$

$= ((1.96)^2* (0.5)*(1-0.5)/ (0.05)^2 =384.16$

With a finite population new SS= (SS)/ (((SS-1)/pop) +1)

Where new SS is the corrected sample where a finite population exists, and pop is the population.

New SS = (384.16)/ (((384.16-1)/307) +1)

=171

The sample size was increased to 175 participants in each group to take care of dropouts. The participants were chosen through purposive sampling. A pre-test and a post-test questionnaire were used to elicit responses from the participants. The questionnaires were in Maasai language which is the local language of the participants. The pre-test questionnaire was used to elicit information on diarrhoea awareness, adoption of diarrhoea prevention practices, technologies/strategies previously used in disseminating diarrhoea information and the characteristics of a suitable diarrhoea information dissemination technology for the study area. It was also used to elicit user requirements for the mobile phone-based system that was used in the intervention. The validity of the questionnaires was checked by doing a pilot study before the study. The reliability was checked using Cronbach's alpha index, the reliability of the questionnaires was improved to a value of 0.811 which was above the acceptable minimum value of 0.7 (Goforth 2015).

Procedure for Data Collection from the Mothers

Ethical clearance was obtained from the relevant institutions. Invitations to participate in the study were done by the researcher through visiting the primary schools in the two sub-locations and requesting the headteachers to pass the invitations to the mothers through their children. The researcher also visited the dispensaries and requested the nurses to invite the mothers for the study. The researcher displayed posters in the marketplaces and in the dispensaries inviting the mothers for the study.

Screening was done using a questionnaire to select the participants who met the inclusion and exclusion criteria after which a pre-test was administered using a questionnaire. After the pre-test, a mobile phone-based system was developed based on the characteristics of a suitable diarrhoea information dissemination technology proposed during the pre-test. The mobile phone-based system was used in diarrhoea intervention through information dissemination.

The experimental group was exposed to voice messages in Maasai language educating them on diarrhoea signs and symptoms, causes, prevention measures and first aid measures. The participants were allowed to leave a question or a comment if they had any.

Messages were sent four times a week on Mondays, Wednesdays, Fridays and Saturdays for three months. The sample size required for the study was 171 participants, but it was increased to 175 to take care of dropouts, although no dropouts were

reported. On average each time the 175 messages were sent, there were ten failed messages which was 5.7% default rate. In total 48 messages were sent to each mother and 8400 messages were sent in total. Each message was 156 seconds long.

After the intervention, a post-test was conducted on both the experimental and control groups using a structured questionnaire to determine the level of diarrhoea awareness, the level of adoption of diarrhoea prevention practices and the opinion of the mothers on the mobile based system used.

Data Analysis

Before analysing the data, data preparation was done to enhance the quality of the data. This allowed the data to be analysed using Statistical Package for Social Scientist (SPSS) version 25 to find relationships between variables, Excel 2013 was used to calculate the effect sizes.

The differences in diarrhoea prevalence were found significant if the p-values were less than or equal to 0.05. The effect was found small if the effect size was less than or equal to 0.2, medium when the effect size was greater than 0.2 and less than 0.8. The effect was found to be large when the effect size was greater than 0.8.

The process of data analysis followed the steps below:

1. Checking the questionnaire: The questionnaires were checked and those found incorrectly filled or incomplete were discarded.

2. Response coding: A code book was developed to code the responses to numerical values. This allowed the data to be analysed using Statistical Package for Social Scientist (SPSS).

3. Transcription: The codes were translated from the questionnaires to prepare data that was analysed using SPSS.

4. Cleaning: Partial least squares (PLS) data validator and SPSS were used to inspect the dataset for any occurring inconsistencies, missing and outlier values. For any data that required transformation, statistical adjustments were done.

After data cleaning and coding were carried out, descriptive statistics such as mean, p-values, effect sizes, standard deviation, minimum, maximum and proportions were used to capture the general outcome of the research. The descriptive statistics were displayed using tables and bar graphs. Statistical tests such as independent t-test, paired sample t-test and Chi-square test were used to test relevant relationships. To compare the groups before and after the intervention, assess the effect of the intervention and prove similarity in all the study aspects for the experimental and control groups, various statistical tests were used. Statistical tests such as independent t-test and paired sample t-test were used to test the difference in diarrhoea awareness and diarrhoea prevalence. The independent sample t-test was used to determine whether the change in diarrhoea awareness was significant after the intervention. The paired sample t-test was used to determine whether the change in diarrhoea prevalence was significant after the intervention. Chi-square test was used to check the existence of relationship between variables and if the distributions were similar or different for both the experimental and control groups.

Results

Demographics

In the prospective interventional study, 175 mothers from both the experimental and control groups participated which was 100% response rate. In both the experimental and control groups the largest proportion of the respondents were not educated. Majority of the respondents from both groups were livestock farmers and were married. In experimental group most respondents were between 20-29 years of age and 30-39 years in the control group. Most of the respondents in the experimental group had four children while in the control group they had three children. In terms of accessed communication media, majority of the respondents from both groups accessed a radio. Majority of the respondents from both groups said that they mostly accessed information from friends.

Diarrhoea Intervention

The diarrhoea intervention was measured using diarrhoea awareness, diarrhoea prevention practices and diarrhoea prevalence.

Diarrhoea Awareness

The diarrhoea awareness was measured by evaluating knowledge of signs and symptoms of diarrhoea, causes of diarrhoea, prevention of diarrhoea and diarrhoea first aid measures. The results are presented for the pre-intervention and post-intervention diarrhoea awareness for both experiment and control groups.

The comparison between the pre-intervention and post-intervention diarrhoea awareness for both groups are shown in table 1.

Table 1: Pre-intervention and Post-intervention Comparison of Diarrhoea Awareness

Group	Study period	Diarrhoea signs and symptoms	Diarrhoea causes	Diarrhoea prevention	Diarrhoea first aid	General diarrhoea awareness
Control	Pre - intervention	32.48%	51.84%	50.29%	35.66%	42.58%
	Post- Intervention	32.20%	51.70%	51.30%	34.90%	41.35%
	Mean difference	-0.28%	-0.14%	1.01%	-0.76%	-1.23%
	Effect Size	**-0.021**	**-0.007**	**0.093**	**-0.044**	**-0.101**
	P-value	**0.889**	**>0.999**	**>0.999**	**>0.999**	**>0.999**
Experimental	Pre - intervention	33.77%	47.14%	53.31%	36.52%	42.69%
	Post -Intervention	91.22%	79.45%	91.04%	86.70%	87.10%
	Mean difference	57.45%	32.31%	37.73%	50.18%	44.41%
	Effect Size	**0.892**	**0.683**	**0.712**	**0.823**	**0.81**
	P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Control vs Experimental Pre-intervention	Mean difference	1.29%	-4.70%	3.02%	0.86%	0.11%
	P -value	0.606	0.127	0.304	0.629	0.074
	Effect sizes	**0.063**	**0.072**	**0.149**	**0.051**	**0.201**
Post-intervention Control vs Experimental	Mean difference	59.02%	27.75%	39.74%	51.60%	45.75%
	P -value	<0.001	<0.001	<0.001	<0.001	<0.001
	Effect sizes	**0.830**	**0.535**	**0.622**	**0.732**	**0.703**

The pre-intervention general diarrhoea awareness was 42.69% for the experimental group and 42.58 % for the control group. There was no significance difference in the general diarrhoea awareness between the two groups before the intervention ($p=0.074$).

The post-intervention general diarrhoea awareness was 87.10% for the experimental group and 41.35% for the control group. There was a significance difference in the general diarrhoea awareness between the two groups after the intervention ($p<0.001$).

In general, the diarrhoea awareness after intervention for the experimental group increased by 44.41% and decreased by 1.23% for the control group. The intervention caused a large increase in diarrhoea awareness on the experimental group (Effect size= 0.81) but there was no significant change in the control group ($p>0.999$).

Diarrhoea Prevention Practices

The diarrhoea prevention practices are those actions that are done to prevent new infections and spread of diarrhoea. The respondents were asked whether they observed those practices. When need be, the community health volunteers (CHVs) validated the responses e.g., by checking whether there was a toilet in the homestead. The diarrhoea intervention practices were classified under sanitary hygiene, water hygiene and food hygiene. The pre-intervention and post- intervention results comparison for the experimental and control groups are shown in Table 2.

Table 2 : Pre-intervention and Post -intervention Comparisons of Diarrhoea Prevention practices

Sanitary hygiene	**Group**	**Good Practices**		**Mean Difference**	**P-value**
		Pre-intervention	Post -intervention		
Having a toilet	Experimental	41.8%	43.3%	1.5%	0.886
	Control	48.9%	49.4%	0.5%	1.000
Sanitary state of the toilet	Experimental	17.3%	62.0%	44.7%	<0.001
	Control	13.3%	16.0%	2.7%	0.547
Washing hands after toilet	Experimental	38.4%	61.0%	22.6%	<0.001
	Control	37.9%	40.0%	2.1%	0.772
Mean sanitary hygiene	**Experimental**	32.5%	55.5%	23%	<0.001
	Control	33.4%	35.1%	1.7%	0.77
P- values		**0.963**	**0.004**		
Effect sizes		**-0.045**	**0.583**		
Water hygiene					
Boil water	Experimental	44.0%	55.0%	11.0%	<0.001
	Control	27.0%	29.0%	2.0%	0.753
Covering water container	Experimental	51.7%	71.0%	19.3%	0.006
	Control	51.4%	54.0%	2.6%	0.671
Sanitary state of water storage container	Experimental	68.8%	90.0%	21.2%	<0.001
	Control	71.7%	71.0%	-0.7%	0.876
Sanitary state of the water drawing container	Experimental	4.5%	34.7%	30.2%	<0.001
	Control	6.8%	5.0%	-1.8%	0.552
Mean water hygiene	**Experimental**	42.3%	62.7%	20.4%	0.003
	Control	39.2%	39.8%	0.6%	0.89
P-values		**0.742**	**0.001**		
Effect sizes		**0.193**	**0.632**		
Food hygiene					
Boiling of milk before giving to children	Experimental	56.6%	99.0%	42.4%	<0.001
	Control	56.9%	55.0%	-1.9%	0.776
Boiling of food before giving to children	Experimental	61.6%	99.0%	37.4%	<0.001
	Control	64.5%	65.0%	0.5%	0.924
Washing hands before feeding children	Experimental	35.0%	94.0%	59.0%	<0.001
	Control	35.6%	35.0%	-0.6%	0.883
Cleaning Utensils	Experimental	44.9%	97.0%	52.1%	<0.001
	Control	53.4%	47.0%	-6.4%	0.396
Mean food hygiene	**Experimental**	49.5%	97.3%	47.8%	<0.001
	Control	52.6%	50.5%	-1.9%	0.722
P- values		**0.125**	**<0.001**		
Effect sizes		**-0.13**	**0.784**		
General diarrhoea prevention practices	Experimental	36.9%	73.0%	36.1%	<0.001
	Control	37.5%	42.0%	4.5%	0.526
P-values		**0.838**	**0.045**		
Effect sizes		**-0.234**	**0.643**		

In general, the pre-intervention diarrhoea prevention practices were observed at 36.9% in the experimental group and 37.5% in the control group. The test of distribution of proportions showed that there was no significant difference in the general diarrhoea prevention practices within the two groups (p=0.838).

In general, the post-intervention diarrhoea prevention practices were observed at 42.0% in the control group and 73.0% in the experimental group. The test for the distribution of proportions for diarrhoea prevention practices in the experimental and control groups after the intervention showed that there was a significant difference in the practices (p=0.045). The general hygiene practices were better in the experimental group than in the control group after the intervention.

The mean value of general diarrhoea prevention practices increased by 36.1% in the experimental group and 4.5% in the control group after the intervention. The test for the effect of the intervention showed that there was a medium improvement in diarrhoea prevention practices in the experimental group (Effect size=0.643) however there was no significant change for the control group (p=0.526).

Diarrhoea Prevalence

The summary of the diarrhoea prevalence among children below the age of five years three months before the intervention and three months of the intervention for both the experimental and control groups is shown in Table 3

Table 3: Pre-intervention and Post-intervention Diarrhoea Prevalence from the Dispensary Records for both the Experimental and Control Groups

Month		**Experimental area N=490**	**Control area N= 465**
Pre-intervention			
April	2018	11	12
May	2018	12	11
June	2018	9	10
July	2018	11	9
August	2018	11	12
September	2018	12	12
October	2018	11	10
November	2018	10	9
December	2018	10	10
January	2019	11	11
February	2019	12	10
March	2019	12	11
During intervention			
April	2019	10	10
May	2019	8	11
June	2019	6	12
3 months		**Prevalence**	**P-value**
Experimental Pre-study		6.93	0.441
Control Pre-study		6.89	
Experimental Post -study		4.89	0.040
Control Post-study		7.09	
Experimental Pre-study		6.93	0.002
Experimental Post -study		4.89	
Control Pre-study		6.89	0.557
Control Post-study		7.09	

The dispensary diarrhoea records accessed were from April 2018 to June 2019. The pre-intervention data considered was from April 2018 to March 2019. The intervention started in April 2019 and was done for three months. To find out if the intervention had an impact on the diarrhoea prevalence, the data considered was for the three months before intervention and the three months of intervention. The three months before intervention were January, February and March 2019 and the three months during intervention were April, May and June 2019. The comparison between the control and experimental groups in diarrhoea prevalence according to the dispensary data shows that there was no significance difference before the intervention (p=0.441). The post–intervention comparison of the diarrhoea prevalence from the dispensary data shows that there was a significant difference between the two groups (p=0.040).

Mobile Phone as a Suitable Technology for Diarrhoea Intervention Information Dissemination

The technology that was used for the diarrhoea information dissemination during the intervention was a mobile phone-based system. At the end of the intervention the respondents were asked to evaluate the mobile phone technology in its suitability for diarrhoea intervention information dissemination as compared to previous strategies/technologies. The results are shown in Table 4.

Table 4: Use of Mobile Phone as a Suitable Technology for Diarrhoea Intervention Information Dissemination

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Diarrhoea information received on mobile phone is much clear and in language I best understand compared to other technologies/strategies.	82.6%	14.0%	0.0%	2.2%	1.1%
I can access diarrhoea information from a mobile phone any time I want unlike other technologies.	65.1%	26.3%	8.0%	0.6%	0.0%
Mobile phone is a more reliable means of diarrhoea information communication compared to other technologies.	63.8%	28.8%	5.1%	2.3%	0.0%
Mobile phones are portable so I can get information from wherever I am.	60.3%	33.3%	0.0%	0.0%	0.0%
Mobile phones are the most affordable technologies that I can use to get diarrhoea education information.	69.9%	21.5%	4.1%	1.7%	0.0%
Mobile phones keep charge for long compared to other technologies.	60.6%	23.7%	13.5%	2.2%	0%
Mobile phone is the most available technology for diarrhoea information communication.	57.3%	38.8%	2.2%	0.6%	1.1%
Mobile phone is the most user-friendly device for communication for me	70.2%	27.0%	.6%	1.7%	.6%
Mobile phones are interactive allowing me to ask questions and get responses.	51.1%	37.3%	6.5%	3.6%	1.5%
Mean	**64.54%**	**27.86%**	**4.44%**	**1.66%**	**0.48%**

In general, 64.54% of the respondents strongly agreed that a mobile phone is the most suitable technology/ strategy in diarrhoea intervention information dissemination compared to the previously used technologies/ strategies. In general, the participants in the experimental group approved the use of mobile phones for diarrhoea information dissemination at 92.4%.

Discussions

Diarrhea Prevalence

The study was on diarrhoea rates for the children under five years of age because they are the most affected by diarrhoea (WHO 2017). In this study, a mobile phone-based system was developed and used to disseminate diarrhoea information through voice messages in the study area. To determine the impact of the intervention, the diarrhoea prevalence was determined before and after the intervention using a quasi-experimental trial with a control and an experimental group. Data was collected from the dispensaries where the respondents got treated. Before the intervention the diarrhoea prevalence for the children under five years of age for both the experimental and control groups was about 28%, this is above the national prevalence which is 16% (Kenya Ministry of Health, 2016).

After the intervention, the diarrhoea prevalence in the experimental group decreased to 19.6% but there was no significant change in the control group. The 19.6% was an improvement although it was still higher than the national average. Although the intervention was implemented for only three months, the results showed reduced diarrhoea prevalence by about eight percent. From these results, it can be inferred that if the intervention was sustained for a longer period, diarrhoea prevalence may have reduced further. Because awareness interventions involve behaviour change, they are known to take a long period of time before the impact is realized. Consequently, studies showing eight percent reduction in a disease prevalence within three months is significant (Beaulac et al., 2019).

Diarrhoea Awareness

A diseases awareness is building an understanding of a person's health requirements and the potential to be vulnerable to repeated infections by the diseases (WHO, 2019). High disease prevalence is highly attributed to low levels of the disease awareness (Bassi et al., 2018). This study applied a diarrhoea intervention through disease awareness to a sample of the population. To find out whether the intervention worked, pre-intervention and the post-intervention diarrhoea awareness of the control and experimental groups were measured (Luby et al., 2018).

Disease interventions through awareness have been implemented with great success in developed countries. Clasen et al. (2015) points out that such success is due to high availability of communication tools and high levels of literacy. The tools provide the means for the information dissemination and literacy empowers the user to interact with the tools (Aikins and Arthur-Nyarko, 2019).

When information is passed in the language that people understand, the language barrier is overcome and when a tool that is easy to use is adopted, the technology barrier is removed. These are the greatest impediments to the availability of diarrhoea information for the rural people in developing countries (Eze, Gleasure and Heavin, 2016). The mobile phone is an important device to the rural people of Narok because it has many functionalities which are easy to navigate

even by the illiterate (Evans et al., 2018). Due to the myriad uses and low cost, the mobile phone is highly available in rural Narok (Elliot 2018).

The study developed a mobile phone-based system that provided diarrhoea information in the local language through voice messages. The study findings show that the general diarrhoea awareness improved by 44.4% in the experiment group after the intervention but there was no significant change in the control group. The findings concur with the findings of other studies done to raise disease awareness using information dissemination (Ahamed et al. 2017; Hackett et al. 2018; Kim et al., 2015).

Diarrhoea Prevention Practices

The diarrhoea prevention practices were measured to show whether there was a change in behaviour after the awareness intervention. Other studies have shown that to measure the impact of a disease intervention campaign, behavioural change is a good indicator of the impact (Duplaga 2019). The diarrhoea prevention practices were measured by looking at sanitary hygiene, water hygiene, and food hygiene which are the avenues for diarrhoea infections (WHO, 2017).

The general diarrhoea prevention practices were at about 37% for the two groups but improved to 72% for the experimental group after the intervention but changed insignificantly for the control group. The improvement in diarrhoea prevention practices showed that using suitable technology raised diarrhoea awareness which led to improved diarrhoea prevention practices. These findings are consistent with findings of a study done in Nyanza province in Kenya which showed that using a mobile phone-based system raised HIV awareness which improved HIV prevention practices (Jennings et al., 2016).

Effectiveness of the Mobile Phone-based System

The users were asked to evaluate the mobile phone-based system based on the characteristics of a suitable technology that they had proposed. The characteristics that the system was evaluated against were understandable language, availability of the information, reliability, portability, affordability, and long charge retention. Other characteristics were availability of the mobile phone device, usability and interactivity. In general, 64.54% of the respondents strongly agreed that the mobile phone was the most suitable technology in diarrhoea information dissemination for the study environment compared to the previously used technologies/strategies. About 28% agreed, 4.44% were not sure, 1.66% disagreed, and 0.48% strongly disagreed. This shows that after using the mobile phone-based system, the respondents were persuaded that it was better than the previously used technologies/strategies. Many authors who have done studies on the use of mobile phones in healthcare interventions through information dissemination in resource constrained environments have realised similar results to the findings of our study (Hackett et al., 2018; Ling, Poorsat and Chib, 2018; Marufu and Maboe, 2017).

Conclusions

The mobile phone-based system developed was evaluated by comparing the pre-test and post-test level of diarrhoea awareness, diarrhoea prevention practices and diarrhoea prevalence. The findings of the study showed that the mobile phone-based system developed was able to enhance diarrhoea intervention by promoting diarrhoea awareness, diarrhoea prevention practices and reducing diarrhoea prevalence. About

92% of the respondents approved the mobile phone-based system, which is strong evidence that mobile phones are suitable for diarrhoea intervention through information dissemination in resource constrained areas.

Conflict of Interest

The authors declare that there is no conflict of interest in this research.

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An Assessment of Mtaani Radio's Programme on Drug Abuse in Dagoretti Sub-County, Nairobi, Kenya

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Abstract

Community radios are some of the communication channels that can be used to sensitise the communities. Nairobi County has 9 community radios to address community issues and help solve community problems from the grassroots. This study, therefore, seeks to assess the effectiveness of Mtaani radio's OYA OYA programme in combating drug abuse among the youth in Dagoretti Sub-County. The objectoe of this study was to assess the effectiveness of Mtaani radio's OYA OYA programme in combating drug abuse in Dagoretti Sub-county. Qualitative research design method guided the research and used the inductive approach method. 26 participants were sampled using purposive sampling under the non-probability sampling technique. Interviews and focus group discussions were conducted through the use of interview guides to collect data. Mtaani radio has a specific program on drug abuse called 'OYA OYA' which makes a follow up on the topics they discuss on radio regarding drug abuse after a call to action has been made which becomes easier to broadcast change messages. Majority of the youths listen to the programme. The programme has witnessed drug abuse reduction within the community based on the campaigns rolled out by the station severally regarding dangers of drug abuse. The study concluded that OYA OYA was effective in helping reduce drug abuse within Dagoretti Community by offering topics on drug abuse and working with different authorities to come up with a resource Centre that helps rehabilitate drug users. The study recommends Mtaani radio management to use opinion leaders in the community to help minimise drug abuse because they have a bigger impact in terms of influencing communities than just the radio presenters. The government of Kenya through County Administration should enforce laws prohibiting sale of illegal drugs and substances to children below 18 years in order to reduce accessibility of these drugs at tender ages.

Keywords: **Community radio, Programme, Drug abuse**

Introduction and Background of the Study

This study centers on community radio and its function in addressing community issues such as drug and substance abuse. It is in this regard that the study looks at the case of Mtaani radio's *OYA OYA* programme. Mtaani radio is a community radio based at Kabiria, Kivuli Centre in Riruta Satellite, in Dagoretti South Constituency, Dagoretti Sub-county. It was founded in 1997 as a communal venture of Koinonia community and Mtaani Community Based Organisation. It is an empowerment project of the youth in Dagoretti Sub-county (Githethwa, 2018). The station went on air in 2014 operating 24hours every day of the week with an estimated audience of 240,000 listeners. It has a geographical reach of 3 kilometers, broadcasting in Kiswahili and *Sheng* (a local slung used by young people in Kenya most especially in the slums) with a tag line "*Sauti ya Mtaa*" translated as "The Voice of the Community" (Githethwa, 2018). The station serves a community that is under privileged economically inhabited by people living below the poverty line and thus vulnerable to drug abuse issues.

The *OYA OYA* show ('Organising the Youth to be Alert') with a slogan that says "*Kijana badlisha mentality*" ("youths change your mentality") runs every weekday from 3pm to 7pm dedicating Mondays to tackling issues on drug abuse. This programme is segmented into three. The first segment is called Role Call with a slogan "*radar ya madre iko how?*" (How deep is the issue of drug abuse in the society?), whereby the listeners call to give their views about drug abuse. The second segment runs from 4pm to 6pm and it is called '*Madre*' with a slogan "*Taja Mada"* ("Mention the Topic"). This segment tackles various topics on drug abuse and the presenter hosts recovered drug addicts from the community to talk about their experiences and recovery process in order to assist others come out of drug abuse. Experts on issues to do with drug abuse can also be hosted. Some of the topics covered are types of drugs in the community, genesis of the drugs in the area, individual reasons for indulging in drug abuse, where and how addicts purchase drugs, efforts by drug addicts to stop drug abuse, dangers or effects of drug abuse to self, families and the community and areas to get help like rehabilitation centre.

Most of the youth caught up in drug and alcohol abuse are introduced to drugs by people close to them like friends, family members or even school mates (Raini, 2006) and it is argued that informal settlements favor thriving of drugs and alcohol abuse making it a norm for people born in those areas to indulge in drug abuse at some point of their lives as they grow up in the slums. In view of this, Malik (2018) concludes that prevention programs and sensitisation are the need of the hour. Mass communication therefore being the premier agent, the means and the technology for accelerating the rate of transmission (Nwosu, 1995) has become the major tool for social change as well as socialisation in the 21st century and most people if not all depend on it for messages or information. "Change comes about when people adopt new methods of doing things" (Ochichi, 2014, p. 2), and when people stimulate their consciousness through communication, they in turn acquire and share new techniques and skills that bring about social transformation

(White, 2008). "Community media provides a voice to the voiceless and it has the obligation of protecting the small audience they serve" (Nyaruri, 2019, p. 2). In view of this, Mtaani radio seeks to provide a voice to the voiceless by getting the community heard and acknowledged and consequently is the primary mass communication tool for the Koinonia community in Dagoretti Sub-county (Mtaani Radio, 2019).

Literature Review

Community radio is used as a development tool, and many theorists and practitioners of community radio believe that participatory media have the potential to 'solve' some of the problems related to community development (Haugerud, A. and M. Edelman, 2005; Okome, 2003; Munck, 2000; Mohanty, 2003; Mills and Lewis, 2003; Fisher and Ponniah, 2003). Community radio, with its focus on participation particularly of marginalised voices, invites the poor to contribute and to participate in community radio (Tucker, 2013). "Community media provides a voice to the voiceless and it has the obligation of protecting the small audience they serve" (Nyaruri, 2019, p. 2) and in view of this, during post-election violence in Kenya, Pamoja FM, a CR in the slums of Kibera, provided a voice for different communities and worked in calming the entire community down. Community radios help in addressing social, economic, cultural, educational, health, water and sanitation, and disaster-related issues more effectively and strategically (Khan, Khan, Hassan, Ahmed, & Haque, 2017). In Atlanta, Georgia, WRFG Community Radio's "Class Chronicles" program is run by a collective of poor people and community activists who tackle issues of interest to the poor and focus on the political aspects of poverty. Radio Kwizera in Tanzania focuses on peace building, refugee relocation, and reconciliation, by providing 90 hours of programming each week to 250,000 refugees and the local population of Ngara and Kibondo following the need for community building and civil society structures within refugee camps. Moutse Community Radio in Moutse Mpumalanga Province, South Africa, was started in 1997 by a group of rural women who had been mobilising around issues of water shortages, and other community needs.

Development agencies and international non-governmental organisations (INGOs) see community radio as a conduit for messages aimed at fostering behaviour change (da Costa, 2012). In recent decades, the use of illegal drugs has increased at a very fast rate all over the globe. According to the world drug report of 2019 released by the United Nations Office on Drugs and Crime (UNODC) on 26th June 2019 at Vienna, more precise data revealed that the adverse health consequences of drug use are more severe and widespread and globally, about 35 million people are estimated to suffer from drug use disorders and who require treatment services. The report also estimates a 56 percent increase on opiod users and that the opioids are responsible for two-thirds of the 585,000 people who died as a result of drug use in 2017 (UNODC, 2019). Moreover, in the same month and year, a survey dubbed Status of Drugs and Substance Abuse among Primary School Pupils in Kenya 2019, released in June 2019 by National Authority for the Campaign Against Alcohol and Drug Abuse (NACADA) revealed that school children as young as 4 years old are abusing drugs and school pupils are most likely to use drugs during school holidays, going home from school, during weekends as well as during inter-school competitions. NACADA called

for proper sensitisation against drug and substance abuse in schools and enforcement of laws and prevention policies (NACADA, 2019).

Two years later a day to the International Day against Drug Abuse observed on 26th June 2021, NACADA released a report revealing that 16.9% of school-going children were involved in substance abuse. NACADA decries the rise in substance abuse during COVID-19 pandemic. The year's theme is 'share facts on drugs, save lives' (CITIZEN TV FRIDAY NIGHT NEWSCAST, 2021). The participation of key stakeholders in the community and their involvement is essential and awareness programmes in the community need to be done comprehensively, providing facts, healthy alternatives, and messages on how to say 'No' to drugs and this can be achieved through use of community radio programmes to mitigate problems of drug abuse.

Research Methodology

The researcher used qualitative research to explore the capability of Mtaani radio in solving community issues and learn about how Mtaani radio uses its *OYA OYA* programme to combat the problem of drug abuse in its community. The researcher focused on the descriptive method since she was concerned with finding out how Mtaani radio resources were put together and how effective they were for their anti-drug abuse campaigns. The research also used was the Method of Authority since Dagoretti Sub-county members place trust in Mtaani Radio broadcasts since they are usually involved in programme production. The community members as well learnt to evaluate the credentials of the station by evaluating methods the station uses to arrive at conclusions before accepting the ideas proposed (Gladwell, 2007).

This research targeted youth aged between 20 and 35 years old who are listeners of Mtaani Radio and reside in Dagoretti Sub-county. The study sampled 26 participants and this is according to Charmaz (2006) who proposes having 25 participants for a smaller study population. The researcher used interview guides to conduct face-to-face in-depth interviews with the 9 key informants who were interviewed through in person meetings and by telephone. The researcher also engaged in focus group discussions with 8 participants in each of the 2 FGD groups guided by Maughan (2003) who recommends having between 6-12 participants in an FGD group.

This study used non-probability sampling to gather in-depth information and employed the use of purposive sampling in which the researcher deliberately selected informants due to qualities they possessed in terms of in-depth knowledge they have regarding the matter being researched. The data collection instruments were interview guides and the main techniques used in this study for data collection were interviews, focus group discussions, as well as the researcher's direct observation of behaviours, reactions, and impressions from the participants.

Data Analysis

The data collected was analysed using content analysis as a technique of subjective explanation or interpretation of textual data content done through coding and recognition of different themes and patterns (Bengtsson, 2016). The data collected was transcribed and translated into English which is the target language of the study and then coded thematically putting careful considerations on the objective of the study.

Ethical Consideration

Before interviewing the research participants, the researcher orally assured them that the information they provided for the study will not be released to any third party. They were not required to disclose their identities if they did not wish to thus ensured confidentiality and privacy of the information revealed.

Findings and Analysis

The findings were derived from the research which was conducted between 23rd October, 2020 and 22nd December, 2020. The findings addressed the objective: *To assess the effectiveness of Mtaani radio's OYA OYA programmeme in combating drug abuse in Dagoretti Sub-county.*

Variety of content which may not be necessarily provided by commercial stations are offered by community radios to serve their listeners (Al-hassan, Andani, & Abdul-Malik, 2011) and Mtaani radio is not an exception as it has content that targets the youth, women and elderly men. Morning hours, the programmes target the whole community generally, in the afternoon the programmes target mostly the elderly and in the evenings the youth are the target audience. The station has a programme called *OYA OYA* which runs every weekday from 3pm to 7pm dedicating Mondays to topics related to drug abuse. In support of this statement, some of the youth participants said, *"Tunaskizanga Mtaani radio daily especially hapo kwa OYA OYA. Hio ndio show tunaskizanga sana"*. ("We listen to Mtaani radio on a daily basis especially the *OYA OYA* show"). *"Sisi huwa tunatune in juu ya OYA OYA. Si unaona mavijana wanapenda reggae. Saa wanaleta hio reggae na bado message katikati yake so unaona vijana wanaweza kuskiza. Lakini ukisema eti labda mangoma za kitambo za wazee, hawawezi skiza. Saa hio OYA OYA inatuvutianga mavijana juu ya hio reggae na ma MC wako hapo ndani bado wanachangamsha vijana"*. "We tune in because of *OYA OYA*. The youth love reggae and the show has reggae and message for the youth in between and that's why the youth listen. But if you play music for the elderly, the youth won't listen. That's the reason *OYA OYA* attracts youth listenership because of the reggae and the MC on the show also ensure the listeners have a good time").

Drug abuse has been a major challenge in the slum areas where young people are indulging in it from a very tender age. According to the survey by NACADA (2019), children are abusing drugs. This research as well revealed that most teenagers who live in the area are likely to start abusing drugs. This finding agrees to Missie's (2002) study on alcoholism among the youth in Kisumu, Kenya which found out that 73% of the youth were using drugs with most of the first experience occurring within the age group of 15-19 years. According to some participants, *"Kulingana na mimi, kwanza huku ghetto kuna mambo mingi. Unapata mzazi labda anatumia drugs, mtoi anaona. Kama mimi nimesomea hapa Ndoraru hii chuo iko hapa na nilianza kutumia drugs nikiwa class 3 juu mzazi wangu hakuwa anatumia lakini jirani anatumia. Ananituma. Akinituma anipee 10bob ata mi naona ai…mbona huyu ako sawa ata mimi nataka niskie vile anaskia. Saa hivyo ndio unatapanga mtu ameanza. Mara mingi watu wanaanzanga mtu akimaliza class 8 ama ukifika secondary hapo form 2 ndio unaanzanga drugs"*. ("According to me, the slum areas have a lot going on. You find a parent abusing drugs and the child is seeing. I have learnt in this school over here called Ndoraru and I started abusing drugs when in class 3. My parents were not drug abusers

but our neighbour was. The neighbour sends me and gives me 10 shillings when sent. So I see my neighbor feeling nice and I too want to feel as he does. That's how people start. Mostly people start when they complete class 8 or around form 2 in secondary"). *"Mimi nilianza hapo class 8. Juu mi nakumbuka nikianza sikuwa navuta. Hao marafiki nakaa nao wanavuta. Unaona hio harufu ikinipiga, naskia mzuri sana but nikivuta siskii venye napigwa na hio harufu. So nikazoea hio, harufu ikafika mahali nikaona hapana nikaanza sasa mi mwenyewe hadi waleo. Na mimi kwanza sikuanza class 7, nilianza class 4. Sawa? Nanimepunguza. Unaona vile nilikuwa nazikula si hivyo nazikula saa hii. Saa hii ata ni mara moja moja ju nami siku hizi nashinda shughuli"*. ("I started around class 8. I remember I used not to smoke but the friends I dined with smoked. I felt nice when I inhaled the cigarette smoke but when I smoked I didn't feel as nice. I got used to the smoke from cigarettes until today where I smoke cigarettes by myself. In fact, I did not start drugs in class 7; I started when in class 4. But as of now I have minimised on smoking. My intake of drugs now is not as before. Now it's once in a while since I'm always busy with other things"). According to Kenya National Commission for UNESCO (KNATCOM) Deputy Director; "Teenagers on the upper level of teenage hood are likely to indulge in drug abuse because they are becoming a little bit more independent from parental care, they are able to experiment and test different things and are so vulnerable to peer pressure because they want to establish their personalities and are trying to understand themselves, and lastly they have a little bit of access to money and of cause they are very much targeted by alcohol and drug suppliers and it is at that age that most of them try to experiment with drugs".

These are some of the reasons the station decided to have a programme that would address drug abuse in the community. Mtaani radio also addresses other issues affecting members of its host community. Al-hassan, Andani & Abdul-Malik (2011) quote issues of poverty, agriculture, gender inequality, education, and social problems as the focus of programming of community radios since they play major roles in development from the grassroots. Some of the issues addressed by Mtaani radio according to the station's management are violence, drug abuse, family wrangles, insecurity within the community, and physical, emotional and mental abuse among family members among other pressing issues in the community. According to other participants, "Mtaani radio talks about some issues that affect us as a community such that *unapata if MCA ama county hawaongelei vitu zingine kama usafi na story ya maji, then hao wanahabari wanaisema kwa redio yao alafu unapata gava inashughulikia* (if the MCA or county government don't address certain matters affecting the community like cleanliness or shortage of water, then the journalists broadcast it and the county government responds). Even when kids go missing then the station report about it *na hivyo ndio hao hutumikia* (and that is how the station serves the) community". *"Wameongelea drugs mingi kama sanasana huko Kiamboni hizo ma heroin na macoke, hizo mavichuri za kujidunga, kuna zingine watu wanameza alafu saa kuna hizi mangwai. Kuna madre mingi zenye ziko huku Dago zenye Mtaani radio inaongeleanga"*. ("They (Mtaani radio) have talked about so many drugs especially in areas of Kiamboni where you find heroin, cocaine, inject-able drugs, drugs you swallow, and even bhang. There are a lot of illegal drugs in Dagoretti which Mtaani radio talk about"). "Being a community radio, addressing community

issues is the key mandate our radio station. We prioritise issues affecting Dagoretti residents and in matters of national interest, we contextualise it in relation to Dagoretti residents", added one of the journalists at Mtaani radio.

Mtaani radio has a variety of activities and programmes to aid in the reduction of drug abuse within Dagoretti Constituency. Besides the fact that they have a programme advocating for reduction of drug abuse, they organise and visit children homes within the community and deliver basic needs like food and clothes to those homes with help from volunteers within the community. The station as well organises to give food to the street children. The researcher attended some activities conducted by the station for the community and noticed there must be a session on drug abuse to just assist minimise its consumption. *OYA OYA* show presenter mentioned that the station's main tool is to go down to the people, to that affected person, to that drug abuse recovered person and offer them help.

The station uses the recovered drug abuse persons to talk about dangers of drug abuse and its impact in the community and the lives of the young addicts to help campaign against drug abuse. Community radios therefore, have the power to mobilise groups and bring change to societies (CIMA, 2007). In support of this statement by CIMA, one of the key informants from Mtaani radio said; "I lead a group called *OYA OYA* family where we do campaigns against drug abuse; we do charity and even visit the homeless within the community. There is an area in Motoine where no resident could pass because the area was a drug den. That location had both the drug peddlers and young drug abusers who were also street children. People avoided the corridors of that area because most of the youngsters in that location were under the influence of drugs. *OYA OYA* family in conjunction with the station's management decided to visit the location, feed the young people who were there and became their friends. The station then called upon community leaders and NACADA to help in minimising the consumption of drugs in that locality and this in turn saw the reduction of young people who went to idle in that area just to abuse drugs.

Mtaani radio noticed that the area would turn out to be a small village inhabited by drug addicts so they decided to report about the matter, went to the ground and discussed with the young people who resided there, and involved the Nairobi County Commissioner who became involved in campaigning against drugs in the locality which has become a success to the community because consumption of drugs reduced and some of the addicts were rehabilitated". One participant added, *"Mimi nilikuwa mvuta bangi sana na nikalose job yangu ikafika place depression ilikuwa inanimaliza but sasa Mtaani huongea sana kuhusu story za drugs na how msee anaeza come out of it till day flani nkaamua tu kuenda rehab ndio life yangu ikue BA. So now naeza sema huwa sichomi ndom na ata nilianzisha kiosk na nko fiti. So kama hawangekuwa wanaongelea hizi vitu huko kwa redio, vijanaa wengi huku Dago bado wangekuwa wa kuchoma na kuibia watu",* said a participant. ("I used to abuse bhang and I even lost my job until it reached a time depression was weighing down on me but then Mtaani radio address a lot of issues regarding drug abuse and how one can come out of it until one day I decided to go to the rehabilitation Centre to get my life back on track. I no longer use or abuse bhang and I even started a kiosk business and I am doing well. If the station were not talking about issues of drugs, most of the youth in Dagoretti could still be

immersed in drugs and crime").

The vital roles played by community radios are: building vibrant communities, empowering citizens, mobilising groups to actions through availing necessary information, giving voice to the marginalised groups within the community and most importantly bring community needs to the attention of both the local and national government (CIMA, 2007). According to Malick (2018) when it comes to substance use disorder therapy and control, prevention in the community is a vital component and rallying the community by building understanding that addiction to substances is a disease which can be treated and the psychotherapy is available are vital. This is true because Mtaani radio came up with a Resource Centre in an area called Motoine through the help of the Member of the County Assembly, Honorable Mukiri, where the addicts in recovery go to get help and adult education. This is in an attempt to minimise illegal drug consumption by community members.

Mtaani radio through *OYA OYA* family assimilates the recovered addicts in their activities where they get to be sent to different drug dens within the community. The station uses these recovered drug abuse persons to talk about dangers of drug abuse and its impact in the community and the lives of the young addicts to help campaign against drug abuse. All the partners working with Mtaani radio also strive to be involved in their activities once in a while. "We have worked with Mtaani radio on different projects by offering training to their journalists to assist them carry out their projects to completion", project officer at KCOMNET. "We invite community radios to media trainings and at times the regional office supports specific activities by these media outlets", KNATCOM.

In the attempt for community radios to aid in drug reduction within the communities, they face setbacks from concerned government bodies and the community members are aware of their failed attempts. "Drugs here in Dagoretti are readily available. You find them being sold even behind a police station and in some of the kiosks. The drugs have been coded and as you walk towards a kiosk, you give a code and it's handed over to you. It is not difficult to find drugs here in Dagoretti", said one participant. *"Unapata sansee amekam anakuambia since wewe tumeshika sana tunataka utuonyeshe mashimo zote zenye madre hutumika alafu uwauzie hizi tunakupea. Hakuna kubargain nao eti cut yako ni ngapi coz wanakuambia ukikataa kuziuza ama usipomada burungo umepewa then either utawekwa ndani tena ama wakumade. Wewe sasa ndio uko in charge of kuokota pesa kwa hizo mashimo unapeleka kwa hao masansee na wale hawadai kutoa pesa ndio wanamadwa alafu tunadanganywa eti hao ni wezi walishikwa na bunduki na madawa za kulevya wakauliwa. Pretence tu kuonyesha raia eti gava iko job. At times unapata hawa wadosi Mtaani ndio wanawork na makarau kuuza hizi stuff huku chini so unaexpect hii story ya madawa iishe aje huku Dago? Unapata hawa majourna wa Mtaani radio pia hawawezi mulika hawa wasee coz at times hawa wadosi ndio wanawapea pesa ya kufanya miradi huku Mtaani bila hao kujua. Sisi tumekula jela miaka kadhaa na tumeamua kubadilika na ata jamii inajua no wonder siku hizi tuko clean hatuhusiki na madawa".* ("You will find police officers approaching you and telling you that since we have arrested you severally, we want you to show us all the drug dens in the area then we want you to sell to them these ones we are giving you. There is no room to bargain with them about the amount you get after the sale because they issue an instruction

that if you refuse to sell or don't complete the sale in time, it's either they will lock you up again or kill you. You are now in charge of collecting money from these dens and take it to the officers and those who refuse to cooperate are killed and then citizens are lied to that they were thieves caught with firearms and illegal drugs. This is pretense to show the nation that the government is working to eradicate such ills in the society. At times you find out that the rich and powerful in the society are the ones working with the police to sell drugs in the community. So how do you expect issues of drug abuse to come to a stop at Dagoretti? The journalists at Mtaani radio cannot expose these people because they are ones financing them in one way or another without their knowledge. We have been in jail for several years and we decided to mend our ways and even the community members are aware of that. We are clean and are no longer into drug abuse"). "Reporting about drug abuse is a problem here in Dagoretti because this thing involves cartels and high ranking people. I was born in this area of Dagoretti and I have grown up seeing people selling drugs behind a police station, so how do you go and report about that story? You can only be a whistle blower but you can't dig dip to want to find out about the peddlers because you will be risking your life. There are two things in Dagoretti that as a reporter you have to be very careful about. That is covering stories on selling of illegal drugs and land tussles. These are major problems faced by journalists here", said a key informant.

According to some journalists; "Sometimes you want to broadcast a story about drug abuse. You want one of the partners to come on board you host them but they fail. What do you do? It's a challenge". "I personally had a problem working with NACADA. There are too many protocols that even reaching them takes too long before they come for a programme. I don't know maybe they used to feel like we are a small radio, a small community radio and we don't have impact because I see them going to mainstream television and I felt like they have left us at the back. NACADA kept saying wait even when you make a follow up. One time we worked with them was through an international NGO called APHS and that was when we realised we were not literally seen since NACADA came to all the programmes. I don't know if they were paid because when you go to them as a community radio they either ignore or take too long to respond and as a journalist programmes need to run on time."

Summary of the Findings

The study found out that majority of the members of Dagoretti Sub-county start abusing drugs while in primary school and this in accordance to the survey by NACADA (2019). The station has a programme called *OYA OYA* that advocates for drug abuse reduction. The youth in the community mainly listen to *OYA OYA* because it targets them and addresses issues concerning them. Mtaani radio has a key mandate of addressing issues affecting Dagoretti residents. The station holds a variety of activities to just create awareness of dangers on drug abuse and aid in mitigating the adverse effects of drug abuse in the community. They station personnel visit children homes within the community and deliver basic needs like food and clothes to those homes with help from volunteers within the community in order to talk about drug abuse. The station as well organises to give food to the street children and talk to them about drug abuse. *OYA OYA* programme has a variety of topics regarding drug abuse and makes follow ups after a call to action has been made. The community members are involved in most of the programme productions by

the station. Due to the broadcast on drugs, community members are stopping to abuse drugs. NACADA does not respond fast to interviews with community radios yet they reach communities from the grassroots. The police force is not working with the community to help curb drug abuse and arrest drug peddlers rather some are benefiting from the trade. The station however works with other governing bodies to campaign against drug abuse and assimilates recovered drug addicts to become ambassadors against drug abuse within the community.

Conclusion

This particular study attempted to establish the place of Mtaani radio in the community by assessing its anti-drug abuse programme and anti-drug abuse community efforts among the youth of Dagoretti Sub-county. The assessment was done by looking at '*OYA OYA'* programme that Mtaani radio has and to what extent the community members are involved in programme production and activities by the station. The study concludes that community radios have the capacity to address community issues if they work hand in hand with community members and governing authorities. Community radios as well play an important role in change communication in the society.

Recommendations

A key factor that determines the success of the station is the listenership. This mostly depends on the content being broadcasted as well as the way in which the communication is tailored. The listenership also depends on the broadcast airtime for a programme which needs to be carefully agreed on after deep consultation with the target audience of the programme. Other social factors within the community like literacy levels, language used are also a determinant to successful listenership by the community members. If all these factors are considered and put in place, then they will also determine the success of an anti-drug abuse campaign programme.

The success of a community radio relies on its level of community participation in its activities. It ensures community members have a sense of ownership in the station's management and operations and take pride in station's activities so that they come to appreciate the CR's potential as a platform to discuss issues of mutual concern (Howley, 2005). To influence the community the station serves, the management can use opinion leaders in the community because they have a bigger impact in terms of influencing communities than just the radio presenters. So, if CRs can pick out community leaders to speak candidly against certain ills in the community like drug abuse, then it is more likely to be effective rather than just putting up adverts on radio.

CRs also need to mobilise communities themselves so that they have champions within the communities that can spear head their campaigns against drug abuse. The station should continue talking about the rehabilitation centre for individuals who might need it. The station as well needs to create awareness around them because issues of drug abuse are nowadays seen as sicknesses or diseases. Therefore, availing information and creating more awareness on the referral systems will be very effective in aiding to reduce drug abuse within the communities.

NACADA and other community radio stakeholders need to very prompt in responding to access to information requests in order for CRs striving to see a reduction in drug abuse get to have the right information for a cause of action they want to undertake. This is because the future of any nation or society depends largely on

the quality of her youths who are exposed to the dangers inherent in drug abuse in their formative years (Kobiowu, 2006). Accessibility and flexibility should be their priority for matters on drug abuse keeping in mind these stations reach members of the community from the grassroots.

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