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Editorial

Effectiveness of ICT on Teachers' Science teaching to Secondary Schools in Irepodun Local Government Area, Kwara State, Nigeria

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Abstract: *This study examined the effectiveness of ICT on teachers' science teaching to secondary schools in Irepodun Local Government Area, Kwara State. A questionnaire was used to elicit information from respondents. Frequency counts and t-test statistics were used to analyse the data. Findingds of this study revealed that the effect of ICT to science teaching by science teachers was significant. It also revealed that there were no significant differences on the effect of using ICT to science teaching by science teachers towards teaching based on the gender and experience but significant on the school type. Based on the findings, the following recommendations were made; that; ICT Education should be compulsory in all secondary schools in Irepodun LGA Kwara State in order to improve more in their science teaching, the Teacher Registration Council of Nigeria should provide ICT for both the male and female teachers, there should be opportunity to be ICT literate through in-service education for both the experience and less experience science teachers, Government should ensure provision of ICT facilities in the public secondary schools and encourage science teachers to go to seminars and workshops so that they can improve in their science teaching.*

Key Word: Effectiveness, ICT, teachers, science teaching, secondary schools

Introduction

Information communication Technology (ICT) is an indispensable part of the contemporary world. The field of Education has certainly been affected by the penetrating influence of information and communication technology worldwide in particular developed countries. Moreover, ICT has made an impact on the quality and quantity of teaching, learning and the application of ICT in Education has revolutionized teaching and learning in schools. Therefore it is essential to implement ICT in teaching science subjects in secondary schools due to the complex and the abstract nature of some of the subjects (Aina, 2013). The place of ICT in teaching science education in schools cannot be over emphasized considering its promises in effective teaching and learning. This project examines the effectiveness of ICT on

teaching and learning science subject in secondary schools. ICT plays a major role in human activities in everyday living in order to cope and adapt to the demand of the demand of the environment. If the vision of science education is to bring socio-economic development, the role of ICT in science education cannot be over-emphasized (Hannaatu, 2013).
Omorogbe and Ewansiha (2013) said that there is needs qualitative science education in our schools especially in senior secondary schools because of the advancement in science and technology for Nigeria to realize accelerated development in the 21st century, Over the last two decades, there have been repeated calls for reforms and innovations aimed at improving science education in Nigeria. This suggests that there are issues in science education that needs to be improved upon. Science is an organized body of knowledge in form of concepts, laws, theories and generalization.

Education is the total process of human learning by which knowledge is impacted, faculties trained and skills developed. Science education is a field of study concerned with producing a scientifically literate society. It acquaints students with certain basic knowledge, skills and attitudes needed for future work in science and science related fields. There are several issues in science education in Nigeria that needs to be addressed (Omoifo, 2012).

Science is defined as a study of nature and natural phenomena in order to discover their principle and laws. Science has three interrelated aspects: content, process and attitude. Content can be separated into physical, life and earth science. Process involves the fifteen inquiring skills proposed by the American Association for the Advancement of Science (AAAS) which include observing, classifying, experimenting, measuring, inferring, organizing data etc. Attitude concerns openness and objectivities (Urevbu, 2001).

Science is a field of study which probes into the nature of living and non-living things and uses the information to transform, synthesize, analyze, interpret and solve day to day problems in the society. Science has contributed in no small measure in making life worthwhile, interesting, conducive and suitable for mankind. Through the application of science, man ensures the longevity of his existence, science in general affects the society as a result of the interaction that exists between science and technology (Akinkunmi, 2007). Science subjects such as chemistry, physics and biology as basis science subjects still suffer set back in the teaching and learning process. The incorporation of ICT in the study of science subjects is not gathering impressive momentum when compared with other subjects

such as government, economics, mathematics, and English (Akinkoye, 2007).

The rate at which students in our senior secondary schools performance dropped in some of science subjects in favour of other subjects with the type of teachers handling the subjects is a matter that needs urgent attention. When questions are asked from the students on why they did not show interest in offering some science subjects unlike others discipline, the general answer is that the subject is too difficult to comprehend even when some of the students have not attended lesson class once, the wrong notion has been inculcated into them by their seniors they believe without bothering to verify whether it is true or not (Adelokun and Eyengho, 2010) .

Teaching is deliberate intervention that involves the planning and implementation of instructional activities and experience to meeting intended learner outcomes according to a teaching plan. It is also perceived as stimulating, directing, guiding the learner and evaluating the learning outcomes of teaching (Jasper, 2013). Teachers' motivation to use ICT in the classroom is at present adversely influenced by a number of constraints including: lack of time to gain confidence and experience with Technology, limited access to reliable resources, a science curriculum overloaded with content assessment that requires no use of the technology and lack of subject specific guidance for ICT to support learning. This technology can be employed in diverse ways to support different curriculum goals and pedagogy.

Such constraints have often stifled the science teachers the use of ICT in ways, which effectively exploit its interactivity. Consequently, well integrated and effective classroom use of ICT is currently rare. The use of ICT in school science laboratory is driven by rather than transformative of the prescribed curriculum and pedagogy. However, the science teachers tend to use ICT largely to support, enhance and complement existing classroom practice rather than reshaping subject contents, goals and pedagogy. Generally, teachers' motivation and commitment are high and practice is gradually changing. Training teachers in the using ICT in the classroom appears to have had more success in science than in other subjects (Osborne and Hennessey, 2013).

Shedd (2004) examines the incorporating technology in the classroom and the result suggested that anyone preparing to be become teachers must incorporate technology into their class. To become great in Nigeria must need to change her method of teaching and learning of science education

from traditional way of talk and chalk method and reading by carrying books around. The world is in the era of Information and Communication

Technology (ICT) where information is not restricted by time, space and channel (Ajayi and Ojo, 2010). This study observed from previous reviewed that for science teachers to be effectiveness in teaching they have to make use of ICT. In order to determine whether they make use of the ICT in teaching, the moderating variables such as the gender, years of teaching experience and school type were determined. This study, therefore, determined the effectiveness of ICT on teachers to science teaching in secondary schools in Irepodun Local Government Area, Kwara State. Nigeria. Specifically, this study examined the effect at which science teachers uses the ICT to science teaching; the effect of gender of the science teachers towards the use of ICT to science teaching; the effect of years of teaching experience of the science teachers towards the use of ICT to science teaching and the effect of school type of the science teachers towards the use of ICT to science teaching. The study answered four research questions which are what is the effect at which science teachers uses the ICT in science teaching? Does the gender of the science teachers have effect towards the use of ICT to science teaching? Is there effect on the years of teaching experience of the science teachers towards the use of ICT in science teaching? Does the school type have effect on science teachers towards the use of ICT in science teaching? Further more, the study had the following hypotheses (i)There is no significant difference in the effect of gender of the science teachers towards the use of ICT in science teaching. (ii) There is no significant difference on the years of teaching experience of the science teachers towards the use of ICT in science teaching. (iii)There is no significant difference in the effect of school type on science teachers towards the use of ICT in science teaching.

Scope of the study

This study has been carried out in Irepodun Local Government Area, Kwara State, Nigeria which includes science teachers in all Secondary Schools located in Irepodun, Kwara State, Nigeria. The studies were carried out among science teachers in Secondary Schools. Teachers of Biology, Chemistry, Physics, Agricultural science and Mathematics were involved in the study. Variables that were tested in the study were: gender, years of teaching experience and school type and how effectiveness is ICT in Science teaching.

A minimum of eighty (120) science teachers were involved in the study from 24 secondary school purposive sampled from both public and private s

schools. A researcher-designed teachers' questionnaire was used as the instrument for the collection of data from science teachers in the sampled schools.

Methodology

The study type for this research was investigative survey method to explore the effectiveness of ICT on science teachers in science teaching to secondary schools in Irepodun Local Government Area, Kwara State. Target population was Science teachers from selected senior secondary schools in Irepodun LGA. The study was carried out in twenty-four (24) secondary schools in Irepodun LGA. One hundred and twenty (120) Science teachers both male and female were randomly selected for the study. Questionnaire was tool for data collection. Effectiveness of ICT on science teachers' science teachers was also determined in this study with respect to Science teaching. Data was analysed using frequency count, simple percentage and t-test.

Data Analysis and Results

Table 1: Number and Percentages of Teachers' Responses

Variable	Number of teachers	Total	Percentage distribution
Male	78		65
Female	42	120	35
Experience	64		53
Less –Experience	56	120	47
Public	62		52
Private	58	120	48

Table 1 shows the distribution of one hundred and twenty (120) respondents involved in the study. One hundred and twenty (120) respondents were distributed into three variables i.e. gender, experience and school type. There were 78 Male and 42 Female respondents, under experience there were 64 experienced and 56 less-experienced. Under school type, there were 62 public and 58 private schools Science teachers involved.

Research Question 1

What is the effect at which science teachers uses the ICT in science teaching?

Table 2: ***Mean Score and t- test for testing effect of Science Teachers' using ICT in Science Teaching in Irepodun Local Government AreaKwara State, Nigeria***

	Number of respondents	Mean Score	Std. Deviation	T	Dt	p-value
Total	120	81.21	8.9	14.31	119	0.00

Table 2 shows the numbers of responses of science teachers towards the ICT in science teaching in senior secondary schools in Irepodun Local Government, Kwara State, Nigeria. The total number of respondents was 120 science teachers. The mean score was 81.21. The effect of science teachers' using ICT in science teaching was significantly positive since p-value (0.00) < 0.05 (t =14.31; df 79 and p-value 0.00). Thus, the Science teachers had positive effect towards the use of ICT in science teaching generally in the Irepodun Local Government, Kwara State, Nigeria,

Research Question 2:

Does the gender of the science teachers have effect towards the use of ICT in science teaching?

Table 3: ***Mean Scores and t-test for testing effect of Science Teachers' using ICT to Science Teaching based on Gender in Irepodun Local Government Area Kwara State, Nigeria***

Gender	No of Respondents	Mean Attitudinal Score	Standard Deviation	Std. Error Mean	t value	df	p-value
Male	72	73.46	5.6	0.3	59.76	79	0.66
Female	48	72.71	5.8	0.3			

Table 3 shows that the mean scores for male was 73.46 and for female was 72.71 and that no significant difference existed between the score of male and female science teachers using ICT in science teaching since the p-value (0.66) > 0.05. The null hypothesis 1 (Ho_1), which states that there is no significant difference in the score of science teachers towards the using of ICT in science teaching based on gender, is not rejected.

Research Question 3:

Is there effect on the years of teaching experience of the science teachers towards the use of ICT in science teaching?

Table 4: ***Mean Scores and t-test for testing effect of Science Teachers' using ICT to Science Teaching based on years of teaching experience in Irepodun Local Government Area Kwara State, Nigeria***

Experience	No of Respondents	Mean Score	Standard Deviation	Std. Error Mean	T	Df	p-value
Less experience (0-5)	36	83.74	5.9	0.2	1.8	79	0.057
Experience (above 5years)	44	82.94	5.7	0.3			

Table 4 shows the mean scores and reveals that there was no significant difference between the experienced and less experienced science teachers towards the using of ICT to science teaching in Irepodun Local Government Area Kwara State, Nigeria since the p-value (0.057) > 0.05. The mean scores range between 82.94 and 83.74. The null hypothesis 2 (Ho_2), which states that there was no significant difference on the years of teaching experience of the science teachers towards the use of ICT to science teaching based on years of experience, is not rejected.

Research Question 4:

What are the attitudes of science teachers towards science teaching based on their school type?

Table 5: ***Mean Scores and t-test for testing effect of Science Teachers' using ICT in Science Teaching in Irepodun Local Government Area Kwara State, Nigeria based on School Type***

School type	No of respondents	Mean Attitudinal	Standard Deviation	Std. Error Mean	T	Df	p-value
Public	42	72.76	6.55	0.25	-2.43	79	0.02
Private	38	74.87	7.17	0.38			

The results in Table 5 shows the mean score and reveals that there was significant difference in the school type of science teachers towards the using of ICT in science teaching in senior secondary schools in Irepodun Local Government Area Kwara State, Nigeria, based on school type. The mean score ranged between 72.76 and 74.87. The P-value (0.02) is less than 0.05 (p-value < 0.05). The null hypothesis 3 (Ho_3), which states that there are no significant difference in the effect of school type of science teachers towards the use of ICT to science teaching based on school type, is rejected.

Summary of Major Findings

The research findings of this study as obtained from t-test based on the Research questions and hypotheses are summarized as follows:

(i) Science teachers had positive effect towards science teaching using ICT to science teaching in the secondary school in Irepodun Local Government Area, Kwara State Nigeria
(ii) The effect of science teachers towards science teaching using ICT to science teaching in the secondary school based on gender was not significant.
(iii) The effect of science teachers towards science teaching using ICT to science teaching in the Secondary school based on their years of teaching experience was not significant.
(iv) The effect of science teachers towards science teaching using ICT to science teaching in the secondary school based on their school type was significant.

Discussion of Results on the effectiveness of science teachers towards science teaching using ICT to science teaching in the secondary school

In this study, it was found out that effect of Science Teachers' using ICT to Science Teaching in Irepodun Local Government Area Kwara State, Nigeria was significant based on their responses. Science teachers had positive effect towards the use of ICT in science teaching. They are the key to students' success because they play an important role in imparting the knowledge and equipping the students to be useful to themselves and the society. This is in agreement with the findings of Okeke & Onocha (1986) that examined the patterns of relationship between home and school factors and pupils' project and reported that teachers' attitude towards science is a significant predictor of pupils' science achievement as well as their attitude. It is also in agreement with Afolabi (2007) who examined the influence of the science teachers' attitude and gender factor as determinant of pupils' performance in primary science and found out that the attitude of science teachers have greater effect on the students' academic performance. It was established in this study that there was no significant difference in the effect of science teachers towards science teaching based on their gender. The males and the female had similar mean attitudinal score; the reason that alluded to this finding may be due to the fact that, male and female science teachers have realized more the importance of science teaching for their future. This study was in agreement to the study of Abimbola & Abidoye (2013) on the views of Kwara State senior school Biology teachers on the status of ecology teaching in which they reported that there is no significant different between the teaching of male and female science teachers.

It was also revealed in this study that there was no significant difference in the effect of science teachers towards science teaching based on their years

of teaching experience. It may be due to the fact that, the experienced and less experience science teachers are able to concentrate on the most appropriate way to teach particular topics to students who differ in their abilities, prior knowledge and backgrounds. This finding is in agreement with the finding of Abidoye (2017) who observed the influence of gender and experience of senior school Biology Teachers on their Ecology teaching in Kwara State. The findings showed that no significant difference existed in the experience and less experience biology teachers.

It was also found in the study that there was significant difference in the effect of science teachers towards science teaching based on their school type. This shows that private schools' science teachers had more positive attitude toward science teaching than the public science teachers because they feel that is acquaints them with the wealth of knowledge in different areas of life. Since, the mean score of private schools science teachers being greater than that of public schools science teachers in senior secondary schools towards science teaching. It may be due to the fact that private schools are on profit, where the proprietors were up and doing. This is in agreement with the findings of Maliki, Ngban and Ibu (2009) who that analyzed Students' performance in junior secondary school mathematics examination and found out that the students from the rural school performed better than student from urban schools in mathematics examination and also students from private schools performed better than those from public schools.

Conclusions

Based on the findings of the study, the following major conclusions can be drawn. Science teachers had positive effect towards science teaching using ICT in Irepodun Local Government Area, Kwara State Nigeria. The effect of science teachers towards the using of ICT to science teaching based on their gender and years of teaching experience was not significant in the analysis conducted, but it was revealed that the effect of science teachers in private schools are more positive effect than the science teachers in public schools.

Recommendations

Based on the findings of this study, it is hereby recommended that;

(i) ICT Education should be compulsory in all secondary schools in Irepodun LGA Kwara State in order to improve science teaching.
(ii) The Teacher Registration Council of Nigeria should provide ICTs for both the male and female teachers.
(iii) There should be opportunity to be ICT literate through in-service education for both the experienced and less experienced science teachers.

(iv) The government should ensure provision of ICT facilities in the public secondary schools and encourage science teachers to go to relevant seminars and workshops so that they can improve in their science teaching.

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Assessment of Soil Physico-Chemical Properties in Selected Natural Habitats of The Wild Rice (*Oryza Longistaminata)* and their Effects on the Species Morphological Characters

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Abstract: *The aim of this study was to assess variation in some soil physical and chemical properties among four selected natural habitats of the wild rice species (Oryza longistaminata) in Tanzania, and their effects on the species morphological characters. Oryza longistaminata is a perennial wild rice species with agronomically important genes, including genes for tolerance to biotic and abiotic stresses that can be used in rice breeding. In Tanzania O. longistaminata grows sympatrically with the cultivated rice (Oryza sativa) in most rice cultivating areas. The selected natural habitats assessed were located in four districts, namely Bagamoyo, Kibaha, Kilombero and Mbarali. Soil samples were collected at the depth of 0 - 20 cm from the four districts and analysed in the laboratory for soil physico-chemical properties using standard protocols. The species morphological characters were assessed based on the morphological descriptors for wild and cultivated rice species developed by Bioversity International and International Rice Research Institute. One way ANOVA was used to determine the extent of variation in soil physico-chemical properties (parameters) among the four natural habitats of O. longistaminata. Canonical Correspondence Analysis (CCA) was used to determine the effects of assessed soil parameters on the morphological characters of O. longistaminata in the study areas. The study revealed variation in soil physico-chemical properties among the districts. Statistically there were significant differences among the habitats (districts) for most of soil physico-chemical properties investigated. In addition, the assessed soil physico-chemical properties were found to influence variation in morphological characters among O. longistaminata populations from different habitats.*

Keywords: Natural habitat, *Oryza longistaminata*, Soil physico-chemical properties, Morphological characters, Wild rice.

Introduction

Soil is the unconsolidated mineral on the surface of the earth that serves as a natural medium for plant growth (Imran *et al*., 2010). It is the main reservoir

of plant nutrients and water. The physical and chemical (physico-chemical) properties of the soilvary drastically in time and space, depending on the texture, climate, organic matter content, soil biological activity and tillage practices (Alletto *et al*., 2010). Tillage is one of the main causes of spatial and temporal variability in soil physical properties, but its effects have not always been consistent depending on the location and soil type (Green *et al*., 2003). Soil plays an important role in the formation and heterogeneity of habitats that may result into changes in vegetation structure and plant diversity (Rodrigues *et al*., 2018). Therefore, the structure and diversity of vegetation are determined by the discontinuous distribution of biotic and abiotic factors in the habitat. Spatial variation in soil physico-chemical properties occurs as the result of soil forming factors, including time, nature of parent material, topography, climate and organisms (Sağlam *et al*., 2011). Soil physico-chemical properties have effects on plant growth and consequently plant morphology. Evaluation of soil spatial variation is important in agricultural and environmental researches, since the information on soil properties has agronomic applications (Sauer *et al*., 2006). Soil, as the main reservoir of plant nutrients and water is one of the key environmental factors that may affect plant morphological characters.

Morphological variation among plant populations may be caused by either genetic factors or environmental factors (Crispo, 2008). Among the environmental factors, soil properties are the key factor that may influence plant morphological characters, hence morphological variation among populations or sites. There are several soil physical and chemical properties which play various roles in the soil, hence influencing the morphological characters of various plant species, including *O. longistaminata*. For example, soil pH determines the acidity or alkalinity of the soil, which affects the chemical reactions between water and soil minerals (Imran *et al*., 2010). There is a strong relationship between soil pH and nutrient availability because the uptake of various plant nutrients is pH dependent (Marschner, 1986). Moreover, most of the primary nutrients, such as nitrogen, phosphorus and potassium, as well as secondary nutrients, such as calcium, magnesium and sulphur are best utilized by plants at pH ranging from 5.5 to 7.9 (Imran *et al*., 2010). Likewise, several other soil physico-chemical properties of the soil play roles in the soil that may influence plant morphological characters at different levels.

The present study was conducted to assess soil physico-chemical properties in four natural habitats of the wild rice species, *O. longistaminata* and the influence of such properties on morphological characters of the species, which is the only perennial wild rice species in Tanzania. The species is

potential source of genetic resources for rice breeding as ithas genes for tolerance to biotic and abiotic stresses (Kiambi *et al*., 2005). These genes can be introgressed into the cultivated rice in order to improve rice quality and yield or productivity. Knowledge on the soil physico-chemical properties and their effects on the morphological characters of *O. longistaminata* is essential not only for understanding spatial variability in soil characteristics among the natural habitats of the species, but also for determination of a suitable or optimum soil characteristics and conditions for better growth performance of this plant species that may result into higher yield or productivity. However, prior to this study no comprehensive study had been conducted in the study area to assess soil physico-chemical properties in natural habitats of *O. longistaminata* and their effects on the species morphological characters, therefore the information on variation in soil properties and their effects on the morphological characters of wild rice, *O. longistaminata* was inadequate. This study was therefore conducted in order to bridge this knowledge gap.

Materials and Methods

Location of the Study Areas

This study was carried out in four selected natural habitats of the wild rice species (*O. longistaminata*). The natural habitats of O. *longistaminata* were located four districts of Tanzania, namely Bagamoyo, Kibaha, Kilombero and Mbarali (Figure 1). The selection of these study areas was based on availability of the species in high abundance.

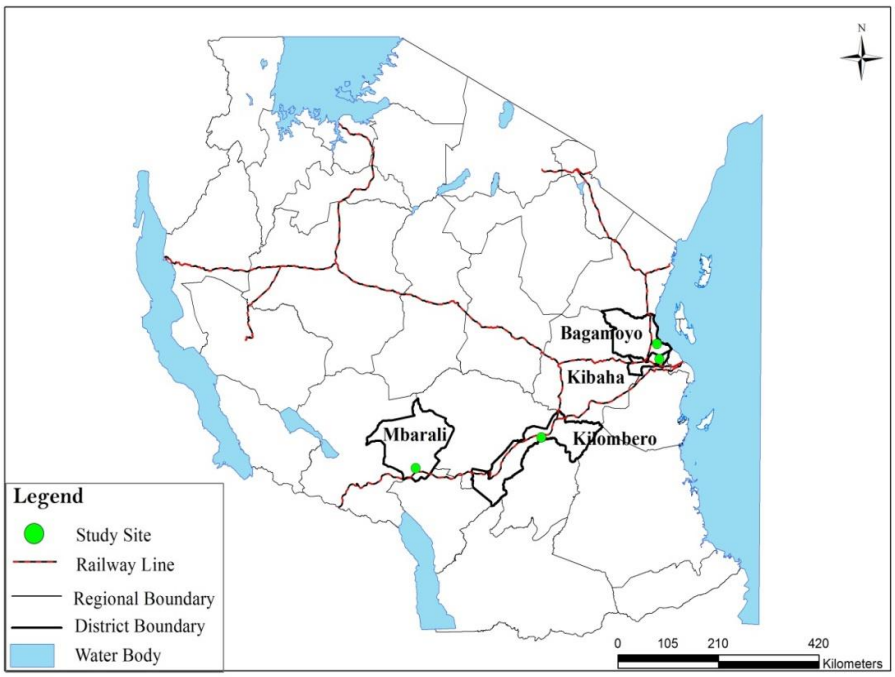

Figure 1: **The map of Tanzania showing the location of study areas (sites)**

Sampling Methods
The study methods involved collection and characterization of both soil samples and *O. longistamata* plants from the four populations. Soil characterization was based on their physico-chemical parameters while characterization of *O. longistminata* was based on their morphological characters.

Soil Sampling Methods
A total of 25 soil samples (consisting of two composite samples each) were collected from the points of collection of *O. longistaminata* data (samples) in each study site for laboratory determination of soil physico-chemical properties. At each sampling point soil samples were collected at the depth of 0 - 20 cm by using soil auger (Sagˇlam *et al*., 2011). This depth was considered because the *O. longistaminata* roots are mostly localized within 0 to 20 cm depth. The two soil samples from each sampling point were thoroughly mixed up before laboratory analysis. In the laboratory the soil physico-chemical properties were determined were soil texture, soil pH, soil organic matter, soil total nitrogen, percentage base saturation, available phosphorus content and cation exchange capacity. These were determined as follows:

Soil texture was determined by using the pipette method as described by Gee and Bauder (1986). The method involved a pre-treatment stage where 80 g of dried, ground soil sample was weighed into a 250 ml flask. 100 ml of water was added followed by 10 ml of 1 M NaOAC and centrifuged for 10 minutes at 1500 revolutions per minute (rpm). The supernatant, which was a clear solution, was poured off and the remaining soil suspension was washed with 50 ml of distilled water, centrifuged and decanted again. This pre-treatment was done to remove carbonates and soluble salts. In order to remove organic matter 4 ml of H_2O_2 was added and the samples were heated until frothing ceased. The purpose of this pre-treatment was to remove soluble salts and organic matter.

Separation of the sand sized particles was done by pouring the treated soil through a 270 mesh (53 μm) sieve followed by washing the sand. All the washings were collected in a 1 litre cylinder. The soil suspension collected in a cylinder was stored for analysis of silt and clay. The sand on the 270 mesh (53 μm) sieve was collected in a weighing dish, dried at 105^0 C and weighed. Determination of silt (2 - 20 μm) and clay (< 2 μm) was done by using the pipette method as described by Gee and Bauder (1986). To the filtrate in a 1 litre cylinder obtained above, 10 ml of hexametaphosphate solution was added and then made to 1 litre with distilled water. The cylinder was covered with a stopper and shaken end-over-end for one minute.

After settling for 4 to 6 minutes at 22^{0} C, a 25 ml volume sub-sample was taken from a depth of 10 cm using a pipette. The solution was placed in a pre-weighed evaporating dish and dried at 105^{0} C. The residue represented the silt fraction. Another 25 ml was taken at a depth of 10 after 6 to 7 hours, and dried at 195^{0} C. The residue represented the clay fraction.

All fractions dried in the oven were cooled in a desiccator before weighing. Determination of the weight of the remaining treated soil was done by adding 10 ml of $CaCl_2$ and 1ml of 1 M HCl to the remaining suspension in the cylinder to prevent the formation of calcium carbonate, and to cause flocculation. After flocculation the clear solution was removed using a siphon and discarded. The soil flocculant was poured into an evaporating dish, dried at 105^{0} C and weighed. The purpose of weighing the treated sample was to compensate for the difference between the original soil weight and the remaining weight after the loss of soil during pre-treatment, solution loss, sieving loss, and the samples removed for pipette analysis. The total oven dry weight of the treated sample was used as a base for calculating the size of the soil fractions. The total weight was obtained using the following formula:

$$Ws + Wp + Wr = Wt$$

Where, Ws = Weight of the sand fraction, Wp = Weight of the fractions taken by pipette (silt and clay), Wr = Weight of the remaining fraction, and Wt = Total oven dry weight.

Data were presented as percentage of sand, silt and clay and texture was determined based on the International Soil Science Society System (ISSSS) textural classification system (Gee and Bauder, 1986).

Soil pH was measured electrometrically using a metrohm E510 pH meter. This was done using 1:1 soil: water mixture, which was allowed to equilibrate for 30 minutes (McLean, 1982). The pH of a stirred suspension was read from the pH meter and recorded as pH in water. To determine electrical conductivity a saturated paste of 2 mm sieved soil was prepared by adding 150 g of soil sample in 500 mL capacity beaker using deionized water. Then the paste of soil samples was introduced to Cyber scan 500 conductometer.

Determination of soil organic matter involved determination of soil organic carbon, which was determined by Walkley-Black potassium dichromate method as described by Nelson and Sommers (1982). For each sample, a 200 mg air-dry soil sub-sample was accurately weighed into 500 ml wide mouth

Ertemmeyer flask to which 20 ml of 1 M $K_2Cr_2\ 0_7$ was added and swirled to disperse the soil and the solution. Then 20 ml of concentrated H_2SO_4 was rapidly added. After shaking the soil-dichromate mixture was left to stand for 30 minutes after which 200 ml of distilled water was added. The resulting solution was then titrated against 0.5 M FeSO4 using O-phenanthroline.

The percentage organic carbon was calculated as follows:

$$\% \text{ Organic C} = \frac{(\text{meg K2 } Cr_2O_2 - \text{meg FeSO4})\ (0.3) \times f}{\text{Weight in g of dry soil}}$$

Where, f = 1.3, a correction factor used to account for carbon that does not oxidize in the procedure.

The organic matter content was then obtained by multiplying the organic carbon concentration by 1.72 (Nelson and Sommers, 1982).

Total soil nitrogen was determined by using semi-micro Kjeldahl digestion (Bremmer and Mulvaney, 1982) and colorimetric determination of the resultant ammonium by color reaction (Indo-phenol blue method). In this method, 0.2 g of air-dry soil was weighed into a Kjeldahl flask. To the sample 0.2 g of copper metal, 0.1 g Selenium (Kjeldahl tablets) and 15 ml of sulphuric acid-salicylate mixture were added. The sulphuric acid-salicylate ($H_2SO_4\ Na_3S_2O$) mixture was used in order to include the nitrate and nitrite forms of nitrogen present in the soil. In order to oxidize the organic matter, 2 ml of hydrogen peroxide was added and then heated to boiling point for 5 minutes. In the mixture, 4 g of K_2S0_4 was added and the mixture digested at 430^0 C using a thermal Kjeldahl apparatus. The nitrogen present in the sample was thus converted to ammonium form and the ammonium was determined calorimetrically using a spectrophotometer. The amount of total nitrogen in the sample was obtained from the calibrated curve of standard NH_4^+.

Available soil phosphorus was extracted using Olsen and Kurtz method, as described by Emteryd (1989). Ortho-phosphate was determined calorimetrically using a spectrophotometer from Ascorbic Acid Method (Allen, 1989). The amount of phosphorus in the sample was obtained from a calibration curve of standard phosphate ion.

Exchangeable bases (Sodium, Magnesium, Potasium and Calcium) concentration was determined by flame emission spectrophotometer, according to Allen (1989). Fivegrams of oven-dry soil samples were put into 250 ml conical flasks. Exchangeable bases were then extracted from the soil samples by introducing 100 ml of 0.4 M Lithium chloride acetate in each flask. The extractions involved shaking for 2 hours and filtering using a suction pump. The filtrates collected were then analyzed for exchangeable cations $Ca2^{+}$, Mg^{2+}, Na^{+} and K^{+} using an Atomic Absorbency Spectrophotometer (Perking Elmer 3100).

To determine Cation Exchange Capacity (CEC) of the soil, five grams of oven-dry soil was weighed into a conical flask and 100 ml of the saturated potassium chloride solution was added. Samples were shaken for 2 hours and filtered using suction pump. The filtrates were analyzed for exchangeable bases. The soil suspensions were rinsed onto the filter paper with 200 ml alcohol until the electrical conductivity of alcohol reached 5 mS per centimeter. This was done to remove excess un-adsorbed Lithium. Then Lithium was exchanged with 100 ml of 1 M potassium chloride solution. This was shaken and filtered and the filtrates collected were then analyzed for CEC using an Atomic Absorbency Spectrophotometer (Perking Elmer 3100).

Assessment of Morphological Characters of *Oryza longistaminata*

Morphological data were collected based on descriptors for wild and cultivated rice species developed by Bioversity International and International Rice Research Institute (IRRI). In each sampling site *O. longistaminata* individuals were randomly sampled at 25 different points (sampling points) within an area of 10000 m^2. A total of 25 samples were collected from each habitat (study site). At each sampling point a total of 5 randomly selected individuals were sampled and their average was calculated and recorded as a single sample. i.e. each of the 25 samples collected from each habitat is the average of 5 individuals, hence a total of 125 individuals were sampled from each habitat. Twelve selected quantitative morphological characters were assessed from each individual sample. The characters assessed were culm length, flag leaf length, flag leaf width, penultimate leaf length, penultimate leaf width, panicle length, number of primary branches per panicle, number of primary branches per node, number of nodes with more than two primary branches, number of grains per panicle, grain length and grain width.The average from four randomly selected *O. longistaminata* individuals were randomly were and sampled from each sampling point In each study site, *O. longistaminata* individuals were randomly sampled.

The culm length was measured (using a tape measure) from the ground level (base of the plant) to the base of the panicle and panicle length was measured from base of the panicle to its tip. Flag leaf was measured from the ligule to the tip of the blade. Penultimate leaf which is the highest leaf below the flag leaf was also measured from the ligule to the tip of blade. The leaf width was measured at the widest portion of the leaf. Awn length was measured from the base to its tip using a ruler. Grain length was measured as the distance from the base of the lower most glume to the tip of the lemma or palea. The grain width was measured as the distance across the lemma and palea at the widest point. All measurements were done using either a tape measure or a ruler. Grain number per panicle and number of primary branches per panicle and number of nodes with more than two branches were determined by counting the respective parts. Measurement, assessment and counting were done soon after heading of *O. longistaminata* individuals.

Data Analysis

Both soil and morphological data were analysed using SPSS version 16 software package. Summary statistics such as mean, standard deviation and standard error of the mean were determined for each of the soil physico-chemical properties and morphological characters assessed. One-way ANOVA was used to determine the significance of differences between sites (habitats) for all assessed soil parameters. Where the comparison showed significant differences, multiple comparison tests were performed. Canonical Correspondent Analysis (CCA) was used to determine the effects of soil physico-chemical parameters on the morphological characters of *O. longistaminata* in the four habitats (districts) in which soil data was used as environmental data and the data on *O. longstaminata* quantitative morphological characters was used as species morphological data. The CCA was based on the mean values of the soildata and the species morphological data.

Results

Variation in Soil Physico-chemical Parameters Among the Four Habitats

The statistical analysis using one-way ANOVA showed significant differences among the study sites (habitats) at $p \leq 0.05$ for all assessed soil physico-chemical properties except the percentage silt content and phosphate ion concentration. The variation in soil physico-chemical properties was as follows:

The percentage Silt Content

The results showed that the percentage silt content of the soils was highest in soil sample from Kilombero with the mean of 17.77±1.536 % followed by that from Bagamoyo (with the mean of 16.035 ± 2.792 %) and the lowest was in soil sample from Kibaha (with mean of 11.705 ± 2.938%).

Phosphate Ion Concentration

The mean phosphate ion concentration in the soil was highest in soil sample from Mbarali, which ranged from 0.11 to 11 mg/kg with a mean of 0.703 ± 0.491 mg/kg followed by that from Bagamoyo which ranged from 0.11 to 3.14 mg/kg with the mean of 0.611 ± 0.169 mg/kg and lowest in soil samples from Kibaha that ranged from 0.05 to 0.18 with a mean of 0.118 ± 0.009 mg/kg.

Soil pH

The pH of the soil samples from the four habitats or districts ranged from slightly acidic to slightly basic. The pH values were highest in soil samples from Bagamoyo, which ranged from 5.03 to 8.86, while that of the soil samples from Kibaha ranged from 5.0 to 7.73. The soil samples from Kilombero had pH value that ranged from 5.56 to 7.06 and soil samples from Mbarali had pH which ranged from 7.01 to 7.86.

The percentage clay content

The percentage clay content was highest in soil samples from Mbarali and ranged from 64% to 95% with the mean of 82 ± 1.92%, followed by soil from Kibaha that ranged from 35% to 98% with the mean of 78 ± 4.44 %. The soil samples from Kilombero had the lowest clay content that ranged from 2% to 84% with the mean of 31.41±0.079%.

The percentage sand content

The percentage sand content of the soil samples from Bagamoyo ranged from 0.2% to 65%, the mean was 22.84%, while that of Kibaha ranged from 0.5% to 30%, the mean was 7.75 ± 2.37. The soil samples from Kilombero had percentage sand content that ranged from 1% to 80% with the mean of 48.55 ± 5.89% and the soil samples from Mbarali had percentage sand content ranging from 0.2% to 30% with the mean of 3.00 ± 1.44%.

Percentage Water Content

The percentage water content of the soil samples was highest in soil samples from Mbarali which ranged from 85% to 90% with mean of 88.05 ± 0.499%, followed by soil samples from Kibaha that ranged from 30% to 90% with the mean of 70.14 ± 4.227%. The percentage water content was lowest in soil samples from Kilombero which ranged from 5% to 75% with the mean of 36.36 ± 4.50%.

Electrical conductivity (electro-conductivity)
Electro-conductivity of the soil ranged from 166.5 to 687 mS/m with a mean of 406 ± 125 mS/m for Bagamoyo soil, from 133 to 856 mS/m for Kibaha soil with a mean of 385.773 ± 49.549 mS/m. Mbarali soil samples had electro-conductivity that ranged from 66 to 157 mS/m with a mean of 105.705 ± 5.695 mS/m and that of Kilombero had 36.1 to 180 mS/m with a mean of 66.777 ± 7.426 mS/m.

The soil Organic Matter Content
The organic matter content was highest in soil samples from Kilombero, which ranged from 1.8 to 3.95% (mean of 2.50 ± 0.130 %) followed by soil samples from Mbarali, which had organic matter content ranging from 1.01 to 2.93% (mean 2.27 ± 0.093 %) whereas soil samples from Kibaha had the lowest organic matter content that ranged from 0.11% to 2.99% with a mean of 1.26 ± 0.200 %.

Total Nitrogen concentration
The total nitrogen concentration was highest in soil samples from Kilombero that ranged from 0.203 mg/Kg to 0.41 mg/Kg with a mean of 0.288 ± 0.012 mg/Kg and lowest in soil samples from Kibaha which had nitrogen concentration that ranged from 0.01 to 0.31 mg/Kg with a mean of 0.120 ± 0.012 mg/Kg. Nitrogen concentration for Bagamoyo soil samples ranged from 0.03 mg/Kg to 1.2 mg/Kg with a mean of 0.208 ± 0.054 mg/Kg and that of Mbarali ranged from 0.1 to 0.26 mg/Kg with a mean of 0.202 ± 0.008 mg/Kg.

The percentage water-filled air space

The mean percentage of water-filled air spaces was highest in soil samples from Kibaha (71.73%) followed by the Mbarali's soil samples (70.27%) and lowest in soil samples from Kilombero (43.21%).

The Cation Exchange Capacity (CEC)

The mean values for CEC of the four study sites, Bagamoyo, Kibaha, Kilombero and Mbarali were 66.65 ± 3.72%, 72.79 ± 2.97, 30.25 ± 1.19% and 55.24 ± 0.56% respectively. Statistically there was significant difference in CEC of the soil samples among the four study sites.

Exchangeable bases

Statistical analysis showed significant difference in exchangeable bases concentration between soil samples from the four study sites ($p < 0.01$). Generally, soil samples from Bagamoyo and Kibaha had higher

concentrations of exchangeable bases (Ca, K, Mg and Na) than soil samples from Kilombero and Mbarali. The soil samples from Kilombero had the lowest concentration of all the four bases as shown in the Table 1.

Table 1: The Mean Concentrations of the Exchangeable Bases in the Four Habitats

	Mean Concentrations of Exchangeable Bases (mg/kg)			
Study Site	**Na**	**K**	**Ca**	**Mg**
Bagamoyo	1.584 ± 0.241	5.444 ± 0.171	10.693 ± 0.365	6.391 ± 0.310
Kibaha	1.982 ± 0.147	4.858 ± 0.132	9.701 ± 0.313	6.485 ± 0.352
Kilombero	0.129 ± 0.004	1.785 ± 0.146	4.625 ± 0.142	2.677 ± 0.116
Mbarali	0.215 ± 0.016	3.074 ± 0.081	6.223 ± 0.152	3.251 ± 0.173

Variation in morphological characters among the study sites (habitats)

The statistical analysis of the species morphological data using one-way ANOVA showed significant differences among the study sites (habitats) for all assessed morphological characters, except grain length. The results further indicated that *O. longistaminata* individuals from Mbarali had highest values for most of the morphological characters assessed followed by those from Kilombero while individuals from Kibaha had the lowest values for most of the morphological characters assessed. Individuals from Mbarali had highest values of flag leaf width, penultimate leaf width, panicle length, number of primary branches per panicle, number of primary branches per node, number of nodes with two or more primary branches and number of grains per panicle. Individuals from Kilombero had highest values of culm length and penultimate leaf length. Individuals from Kibaha had lowest values for all assessed morphological parameters except the awn length and grain length.

The Effects Soil Physico-chemical Properties on Morphological Characters of *Oryza longistaminata* Populations

The analysis of species-environment relationship was done using Canonical Correspondence Analysis (CCA) in which species morphological data was used as vegetation data and soil physico-chemical properties (parameters) as environmental data. Species-environment correlation matrix based on CCA showed strong relationship between the species quantitative characters and the assessed soil physico-chemical parameters. That is, variation in morphological characters among *O. longistaminata* individuals from the study area was highly related to variation in soil physico-chemical

parameters. The results further showed that the CCA ordination in the first three axes was constrained by assessed soil physico-chemical parameters. The first three axes accounted for all (100%) of variations among the *O. longistaminata* samples. That is, the first three eigenvalues were canonical, but the fourth was not, since only three independent constraints could be formed from the soil variables.
Results of the present study also showed that in Bagamoyo among the soil parameters that hadsignificant effects on the morphological characters of *O. longistaminata* were soil electro-conductivity and concentration of exchangeable bases namely, Ca, Mg, K and Na. These soil physico-chemical parameters were found to have moreinfluence on: flag leaf length and width, penultimate leaf length and width and grain length. In Kibaha and Kilombero the soil physico-chemical properties that significantly affected or influenced the morphological characters of *O. longistaminata* were of silt and sand contents as well as total nitrogen concentration. These soil physico-chemical variables influenced awn length, culm length and grain width. In Mbarali soil properties which influenced morphological characters of *O. longistaminata* were cation exchange capacity, soil pH, phosphate concentration, percentage clay content, percentage water content and percentage water-filled pore spaces of the soils. These soil factors had effects on several morphological characteristics, including number of grains per panicle, number of primary branches per node, branching patterns of the panicles and number of nodes with more than one primary branch per node. Soil organic matter content had influence on the panicle length (Figure 2).

The results further showed variation in the extent to which different soil parameters influenced morphological characters of *O. longistaminata* in the four study sites. Therefore, the degree of influence of soil parameters on the morphological characters of *O. longistaminata* varied not only between one soil parameter and another, but also between one site or habitat and another. This is denoted by variation in length of arrows in simple ordination plot (Figure 2). Soil parameters indicated by longer arrows had relatively greater influence on the morphological characters than those indicated by shorter arrows. The results indicated that the percentage water content, phosphate ion concentration, percentage clay content, exchangeable base concentration, pH, percentage sand content and cation exchange capacity had much more influence on the morphological characters of *O. longistaminata* individuals in the study areas. On the other hand, organic matter content, nitrogen concentration and percentage silt content had relatively low effects on the morphological characters of *O. longistaminata* individuals as denoted by shorter arrows in the simple ordination plot (Figure 2).

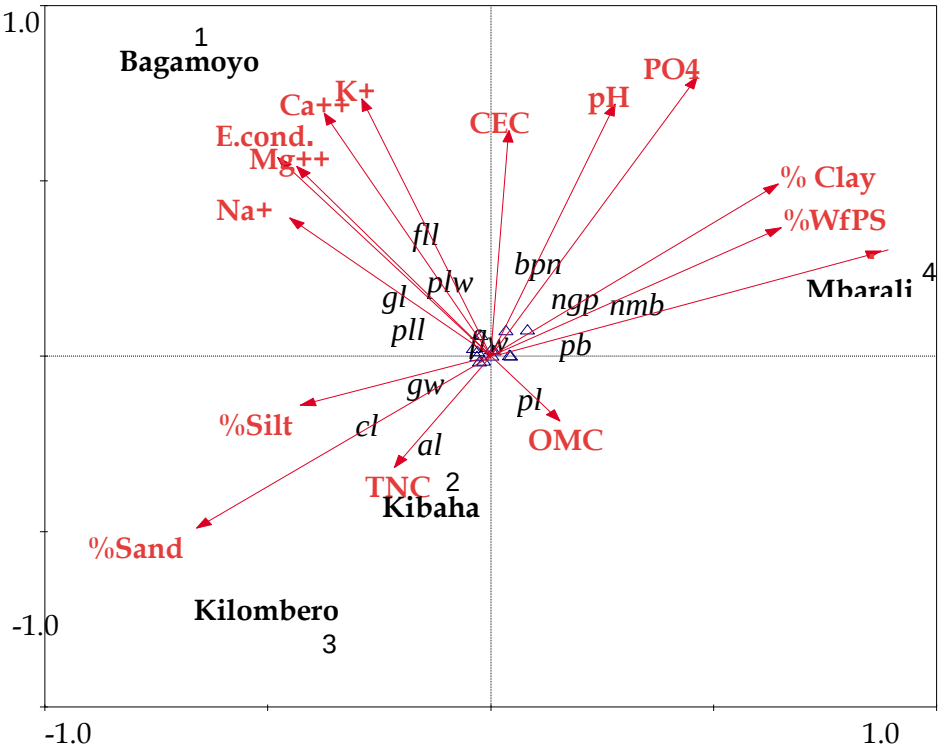

Figure 2: **Simple ordination showing the soil physico-chemical properties affecting the morphological characters of *O. longstaminata* in the four selected habitats**

Legend: al = awn length, gl = grain length, ngp = number of grains per panicle, gw = grain width, pl = panicle length, bp = branching pattern of a panicle, pll = penultimate leaf length, plw = penultimate leaf width, bpn = number of primary branches per node, fll = flag leaf length, flw = flag leaf width, nmb = number of nodes with more than two branches per panicle.

Ca++ = calcium ion concentration, K+ = potassium ion concentration, Mg++ = magnesium ion concentration, Na+ = sodium ion concentration, E.cond. = electro-conductivity, OMC = organic matter content, TNC= total nitrogen concentration, PO_4^-= phosphate ion concentration, CEC = cation exchange capacity, WfPS = percentage water filled pore space, %Sand = percentage sand content, %Clay = percentage clay content, %Silt = percentage silt content.

Discussion

Variation in Soil Physico-chemical Parameters in the Four Natural Habitats of *Oryza longistaminata*

Results of the present study showed spatial variation in soil physico-chemical properties among the four study areas (habitats). Comparison results of soil samples from the four study sites (habitats) based on the soil physico-chemical parameters using One Way Analysis of Variance (ANOVA) showed significant differences among habitats for all parameters studied, except phosphate ions concentration and percentage silt content.

This finding seems to be consistent with what was reported by several other studies that soils tend to vary with time and space (Onweremadu and Akamigbo, 2007; Alletto *et al*., 2010). Studies show that spatial and temporal variation or variability in soil properties between or among localities or sites is something common, and may be caused by various factors (Asadu and Enete, 1997; Green *et al*., 2003; Onweremadu, 2007; Onweremadu, 2008; Sagˇlam, *et al*., 2011). According to studies, there are several factors that can contribute to spatial or temporal variation in soil physico-chemical properties including: changes in lithological origin (Onweremadu, 2008), land use (Asadu and Enete, 1997; Onweremadu, 2007), landscape position (Onweremadu, 2008), tillage practices (Green *et al*., 2003) and soil forming factors (Sagˇlam, *et al*., 2011). The observed variations and similarities in soil physico-chemical properties among the four study areas or habitats are likely to have been caused by some of the factors stated above. Each of the factors may have influence on a particular soil physico-chemical property, or particular soil physico-chemical properties in a particular area. For example, land use and/or tillage practices may significantly influence the levels or concentrations of Ca, K, P, Mg, total nitrogen and organic matter (Akamigbo, 1999). Therefore, the spatial variation in these soil parameters among the study areas (habitats) is probably the result of variation in land use or tillage practices among the study areas, especially in the major rice cultivating areas, such as Mbarali and Kilombero. In general, the variation or variability in soil physico-chemical properties in the areas investigated is likely be caused by variation in climatic conditions, topographical factors, tillage practices, nature of the rocks and soil forming factors.

Further analysis of the results of this study showed or revealed some similarities (lack of significant differences) between Bagamoyo and Kibaha soil samples for most of the soil parameters assessed. Likewise, there were slight similarities (no significant differences) between Kilombero and Mbarali soil samples for most of the soil parameters assessed. In Bagamoyo and Kibaha soil samples the similarities were found in the following soil

properties: percentages of clay, sand and silt contents, phosphate ion concentration, electro-conductivity, nitrogen concentration, and cation exchange capacity. In Kilombero and Mbarali soil samples the similarities were found in the following soil physico-chemical properties: soil characteristics, silt content, electro-conductivity, organic matter content, total nitrogen content, phosphate ion concentration, sodium ion concentration and magnesium ion concentration. Generally, soil samples from Kilombero and Mbarali had higher values for most of the soil parameters investigated than soil samples from Bagamoyo and Kibaha. This is may be due to various reasons. For example, low clay and silt contents in the soil may result from strong weathering and leaching of clay particles (Ihem *et al*., 2014).

Among the soil physico-chemical parameters investigated in the present study, soil pH isone of the most important parameters because of its great influence on other soil parameters. The soil pH influences not only on chemical reactions between water and soil minerals, but also on the availability of several other soil parameters, including nutrient availability in the soil (Imran *et al*., 2010). Nutrient availability, which also influences soil fertility, affects growth performance of the plants, including *O. longistaminata*. According to literature, most of the primary nutrients (such as nitrogen, phosphorous andpotassium) and secondary nutrients (such as calcium, magnesium and sulphur) are best utilized by the plants when the pH range of the soil is 5.5 - 7.9 (Imran *et al*., 2010).In the present study, the pH of the soils in the study sites was within this range, implying that there was optimum soil condition for nutrients utilization by *O. longistaminata* within the study areas. Meanwhile, the uptake of most of the micronutrients takes place at low pH.

The Effects of Soil Physico-chemical Properties on Morphological Characters of *Oryza longistaminata* in the Four Habitats

Both soil characterization results and species morphological characterization results showed significant differences among the study sites (districts) for most of the parameters assessed. The correspondence between the two sets of results may imply causal relationship. Although variation in morphological characters among *O. longistaminata* individuals from the four habitats could be caused bycompetition for resources among plant individuals or species growing in a particular habitat (Sauer *et al*., 2006), species-environment correlation matrix based on Canonical Correspondence Analysis (CCA) showed strong relationship between the species quantitative characters and assessed soil physico-chemical parameters. In general, the results of this study indicated that soil physico-chemical properties influenced variations in morphological characters among *O. longistaminata* populations from the four districts.

The role of ecological factors, including soil characteristics in influencing the extent and distribution of genetic diversity in wild relatives of crop has also been emphasized by several other studies (Nevo *et al*., 1981; Nevo *et al*., 1983). Studies conducted using different genetic markers have quite clearly established the way in which genetic diversity of the plant species varies with variation in soil type (Owuor *et al*., 1997). Generally, the plants (individuals or populations) growing in areas with similar soil characteristics are more likely to be morphologically similar than those growing in areas with different soil characteristics. Literature shows that there is strong relationship between plants' morphological characters and the environmental conditions of the habitat in which the character evolved (Nevo *et al*., 1981). However, plasticity can allow rather genetically similar populations to occur in widely differing environments (McNeill, 1997). Variation among plant individuals growing in habitats with different ecological or soil characteristics may be due to their adaptation to the habitats. According to the study by Rao and Hodgkin (2002) adaptive genetic variation, which is usually quantitative is responsive even to small habitat differences.

Conclusion

The study revealed spatial variation in soil physico-chemical properties in the four natural habitats of *O. longistaminata* investigated, implying that there was significant difference in soil physico-chemical properties among the four *O. longistaminata* habitats (districts) studied. The variations in soil properties observed in this study are likely to be caused by variation in soil forming factors, such as climate, topography and landscapes position among the four habitats. Moreover, the study revealed that soil physico-chemical properties have influence on the morphological characters of *O. longistaminata*. Generally, the species (*O. longistaminata*) was found to prefer soils with pH that ranges from slightly acidic to slightly basic.

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Variation of Proximate Contents in Selected Marine Fish from Tanzanian Coast due to Seasonality and Processing Methods

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The effect of seasonality (wet and dry seasons) and processing treatments (frying and boiling) on proximate composition of selected fish species (Alectis ciliaris, Lethrinus harak, Rastrelliger kanagurta and Siganus canaliculatus) from Tanzania marine waters were assessed. The proximate composition of fish was proved to be altered by the fish feeds, salinity, geographical location, seasons and processing methods. Therefore, the fish samples were purposively collected from four selected locations (Tanga, Bagamoyo, Dar es Salaam and Mtwara) and treated as appropriately. Proximate parameters were determined using AOAC standard methods. The proximate contents varied with changing seasons in all the fish species. Crude protein and lipid contents increased in wet season while moisture and ash contents increased in dry season. The effect of changing seasons in proximate contents was significant ($p < 0.05$) except in ash. Frying process had a significant effect ($p < 0.05$) on proximate contents in the fish species than boiling process except in ash. The derived model accurately predicted the extent of variation of proximate contents with both dry and wet seasons and processing treatment in particular frying. However, it failed to predict the extent of variation of lipid, crude protein and moisture with boiling treatment. Further research is needed to establish the extent of variations of proximate contents due to other processing methods such as steaming and microwaving.

Keywords: *Alectis ciliaris,* processing methods, proximate contents, dry season, marine water

Introduction

Fish are a natural source of polyunsaturated fatty acids, dietary sources of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), a form of omega-3, that has great health benefits (Parker *et al.*, 2019). Fish are also highly proteinous as they contain essential amino acids, which are the building materials of proteins. These biochemical components to be preserved with little or no change (Njinkoue *et al.*, 2016) so that they are

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invariably more or less the same regardless of changing environment and species.

The biochemical composition of fish may be altered by, among others, fish feeds, salinity, geographical location, season and processing methods (Bogard *et al.,* 2015). Geographical locations and seasonal changes do affect the fish environment due to the availability and composition of feeds, which consequently affect the chemical composition of their muscle fillet. The general composition of fish body is the final function of the available food fed by fish and the assimilative capacity of individual fish. Likewise, the fluctuation of water temperature across the seasons (wet and dry) and the activities of fish (reproduction and migration) could influence the biochemical composition of muscles (Bandarra *et al.,* 2001; Olsson *et al.,* 2003). There is a relationship between location and availability of fish on one hand and the climate and oceanographic conditions on the other (Van Der Elst *et al.,* 2005).

The fish consumer consider the flesh texture, taste, protein and fat contents (Pal & Ghosh, 2013). However, fish can be eaten raw but preference is when treated under various processes such as boiling, grilling, frying and may other (Ersoy & Özeren, 2009). These processes tend to improve the flavor, taste, inactivate pathogenic microorganisms and increase shelf life (Bognár, 1998). This could lead to important biochemical changes in composition (Weber *et al.,* 2008). The principal changes that occur during processing are oxidation during heating, which is catalyzed by heat, light and additional trace metals or enzymes that generate free radicals (Loughrill & Zand, 2016). Heat may also cause denaturation and mineral solubilization (Gladyshev *et al.,* 2007).

Changes of the composition of fish due to seasonal variation and processing methods has raised concern to human health (Ozogul *et al.* 2011; Aberoumand & Ziaei-Nejad, 2015). The mineral content of fish is directly related to the type of feed, which can vary with seasons (Khitouni *et al.,* 2014). Similarly, processing methods can cause modification in the proximate, amino acids, minerals and thus change the biochemical composition of fish (Laly & Venketeswarlu, 2016). Variation can occur in fish of same species and different species at different geographical locations (Balogun & Talabi, 1986). The feeding habit and climatological differences between two seasons may affect the biochemical composition of the fish species (Balogun & Talabi, 1986).

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Fish have the ability to absorb minerals not only from their diets but also from water (Lall & Tibbetts, 2009). The exchange of ions from the aquatic environment across gills and skin of fish complicates the determination of the quantitative dietary requirements of minerals (Roy & Lall, 2006). The variation of minerals and proximate contents in tissues of marine and fresh water fishes at different locations and seasons has also been determined (Abdullahi, 2005, Olgunoglu *et al.* 2014, Abdulkarim *et al.*, 2015).

Common processing methods in fish include, among others, frying, boiling, sun drying and smoking. These processing methods usually improve the hygienic quality of the fish (Abdulkarim *et al.* 2015) and inactivate the pathogenic microorganisms (Bognár, 1998). The processing methods can have some effect on the biochemical composition of the fish. Little information is available on the variation of mineral contents in fish (*Alectis ciliaris, Lethrinus harak, Rastrelliger kanagurta and Siganus canaliculatus*) from Tanzania marine waters due to changing seasons and after being subjected to different processing methods. Therefore, the aim of the study was to evaluate the effect of variation of seasons (wet and dry) and processing methods (frying and boiling) on the proximate contents of the selected fish.

Materials and Methods

Sampling

The sampling was conducted at the Indian Ocean seaports i.e. Tanga, Dar es Salaam, Mtwara and Bagamoyo (Figure 1) that experiences wet and dry season annually. The hottest period extends between November and February while the coldest period occurs between May and August. In October to December, north and east of Tanzania experience two distinct wet periods with short rain periods and long rains from March to May. The southern, western and central parts experience one wet season that run from October through to May (Karmalkar *et al.,* 2003).

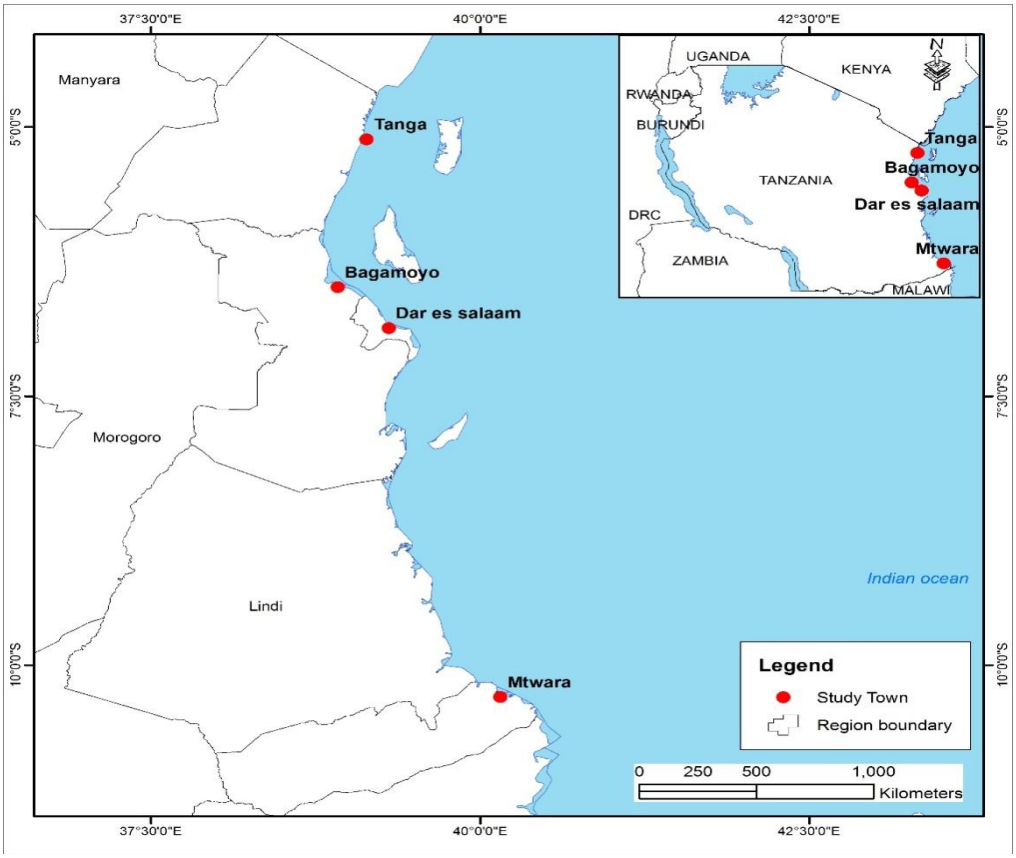

Figure 1: Map of the coast of Tanzania showing the Study areas

The coastal areas of Tanzania are occupied by communities with more or less the same cultures and traditions. Life-earning activities of the coastal communities are mostly agriculture, livestock keeping and fishing. Industrial activities that involve manufactures of textile, furniture, fertilizers, soap as well as mining are also practiced (Francis & Bryceson, 2001; Glauber & Jeppesen, 2014). The industries found in the coastal regions of Tanzania include Cement, Beverages and many others.

Four fish samples of appropriate length (28 - 30 cm) and weight (1.0 - 1.2kg) for each fish species were randomly purchased offshore from each of the four locations (Tanga, Bagamoyo, Dar es Salaam, and Mtwara) during wet and dry season of the year 2017. The selected fish species were the African pompano (*A. ciliaris*), Snappers (*L. harak*), Mackerel (*R. kanagurta*) and Rabbit fish (*S. canaliculatus*). The choice of the fish species for this study was based on their abundance, availability, popularity and ease recognition by consumers. Fishes were kept in polythene labeled bags in a cool box filled with ice cubes and transported to the laboratory for processing and analysis. Analysis of proximate composition was done at the Department of Animal Sciences and Production (DASP), Sokoine University of Agriculture (SUA) in Morogoro.

Sample Preparation
Four fish samples in each of the four species from the four sampling sites were washed several times with tap water to remove slime and adhering blood. The head, scales, gills, tail, fins, bones and internal organs of sampled fish were also removed using clean plastic knife. Only the edible portions of the muscle between the dorsal fin and lateral line were used for analyses. The muscles of the four samples were filleted and randomly mixed together forming a composite. The filleted muscle tissues by species and by location of the catch were then divided into three portions. The first portion were the uncooked therefore considered raw fish fillets while the other two groups were cooked using common household practices, namely frying and boiling.

Deep frying was performed in a domestic frying pan of 2 litres and 25 cm diameter capacity at an initial temperature of 180 °C for 15 minutes (Marimuthu *et al.,* 2014). Sunflower cooking oil extracted from the fatty kernels of *Helianthus annuus* with no other additional ingredients was used as the medium of frying whereby each fish sample was fried using separate cooking oil (oil used only once). After 15 minutes of frying, the fish fillet samples were drained on stainless steel grills, air cooled then packed in labeled aluminum foil in duplicates.

A saucepan covered with a lid was used in boiling of fish sample in one litre cold water with no additional ingredients at boiling point 99–101°C for 12 minutes (Marimuthu *et al.,* 2014). Each sample was boiled using clean (unused) water to avoid contamination and mixture of the nutrients. After boiling, the samples were drained and left to dry and cool then stored in labeled aluminum foil in duplicates. The raw and processed (fried, boiled) fish samples were then stored in laboratory refrigerator at -20 °C until analysis.

Analysis of Proximate Contents
Prior to analysis, the fish samples (boiled, fried and raw) were left to thaw and then oven-dried at 105^{o}C - 109^{o}C for 20 hours to a constant weight. Then, each sample was ground to fine powder using a mortar and pestle for homogeneity. Thereafter, fish sample were then kept in a desiccator ready for further analyses.

Proximate composition analysis was done using Association of Official Analytical Chemists-AOAC methods (Helrich, 1990). Dry matter was analyzed by using clean and dried crucibles that were left to cool in a

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moisture free desiccator. Each crucible was weighed, labeled (W_1) using an analytical balance and recorded. The samples were weighed 2g (W_2) in duplicates then put in the labeled crucibles. The labeled crucibles with samples were transferred using tongs to an oven at temperature105 ^{o}C for 24 hrs until no moisture left. The dried samples in crucibles were removed from the oven and left to cool in a desiccator for 10 minutes before re-weighed (W_3). The percentage of dry matter (DM) was calculated as follows:

$$DM\,(\%) = \frac{W_3}{W_2}\,n\,100 \qquad \textit{Equation 1}$$

where W_1 = Weight of empty crucible; W_2 = Weight of original sample; W_3 = Weight of dried sample and DM = Dry matter.

The ash content was determined in a sample dried in a muffle furnace and incinerated at combustion temperature 550 ^{0}C for 24 hours. Percentage ash content was computed by carrying out the following calculations:

$$Ash\,(\%) = \frac{(W_3 - W_2)}{(W_2 - W_1)}\,n\,100 \qquad \textit{Equation 2}$$

where W_1 = Weight of empty crucible; W_2 = Weight of fresh sample and W_3 = Weight of dried sample

The crude protein was analyzed by determining Nitrogen value through the Kjeldahl standard method according to AOAC. The Nitrogen percentage (% Nitrogen) contained in the samples was calculated by the following formula:

$$\%Nitrogen = \frac{(W_1 - W_2) \times Normality\ of\ HC1 \times N_2 \times 100}{W_3 \times W_4}$$

$$\%Nitrogen = \frac{Titre\ value \times 0.01 \times 14.007 \times 100}{0.5g \times 10\ ml} \qquad \textit{Equation 3}$$

where W_1 = Volume of HCl titrates sample; W_2 = Volume of HCl titrates blank; W_3= Sample weight (g); W_4 = Volume of known aliquot; N_2 = Nitrogen atomic weight and % crude protein = % Nitrogen x 6.25

Crude lipid in the fish samples was determined according to Helrich (1990). Briefly, fish sample (5 gms) (W_1) was placed into a pre - weighed labeled extraction thimble (W_2). Then, the sample dried in an oven at 105 ^{0}C for 30 minutes. Later, petroleum ether (40 mL) was poured into a labeled extraction cup. The labeled extraction thimble with the sample was fitted tallying with the cups and inserted into extraction unit, the Soxhlet Extraction apparatus at 115 ^{o}C for 15 minutes. After reflux extraction, the cups with the thimble were left to cool for 45 minutes. The thimble was moved lower and ether was reclaimed using the apparatus by distilling out some ether. Thereafter, the cup with the pure fat contents was cooled in a

desiccator and later weighed (W_3). The percentage crude fat was calculated as follows:

$$\text{Protein}\,(\%) = \frac{(W_3 - W_2)}{W_1} \text{ n } 100 \qquad \textit{Equation 4}$$

Where W_1 = Weight of sample; W_2 = Weight of thimble and W_3 = Weight of cup after extraction

Data Analysis

Data from this study were analyzed using IBM SPSS package (Version 20) where mean and standard deviations were determined. An independent sample t- test and Levene's test were used to compare the mineral and proximate contents of the fish between the seasons and different processing methods (between raw and fried fish and between raw and boiled fish). The effects of processing methods on mineral and proximate contents in fish species was determined by using Analysis of Variance (ANOVA) in each fish species at 5 % significance level. Concentrations of each mineral in the fish tissue samples and dummies of seasons were fitted in simple linear and multiple regression models to estimate the parameters. The Principle Component Analysis (PCA) as a multivariate analysis technique was used to detect similarities as well as differences of variables in the fish species.

Results and Discussion

Variation of Proximate Contents in Fish between Seasons

Mean contents of ash and moisture in *A. ciliaris* were low in wet season and high in dry season. On the other hand, protein and lipid contents were high in wet season and low in dry season (Figure 2a). There was a significant variation ($p < 0.05$) in means crude protein and moisture contents in *A. ciliaris* between seasons. However, the difference in the mean ash and lipid were not significant. The mean contents of ash and moisture in *L. harak* during wet season were lower than those in dry season. The mean contents of crude protein and lipids were high in wet season than in dry season (Figure 2b). There was a significant difference ($p < 0.05$) in the mean lipids and moisture contents in tissues of *L. harak* between seasons, while there was no significant difference in ash and crude protein contents.

The mean contents of ash and moisture in *R. kanagurta* during wet season were lower than the contents in dry season. On the other hand, crude protein and lipid were higher in wet season than in dry season (Figure 2c).

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There was no significant difference ($p > 0.05$) in mean proximate contents in tissues of *R. kanagurta* between seasons, while a significant difference was observed in lipid content.

The mean proximate contents in tissues of *S. canaliculatus* are summarized in Figure 2d. Ash and moisture contents were lower during wet season compared to dry season. Crude protein and lipid contents on the other hand were high in wet season compared to dry season. Except for ash content, there was a significant difference ($p < 0.05$) in the other proximate contents of *S. canaliculatus* between the seasons.

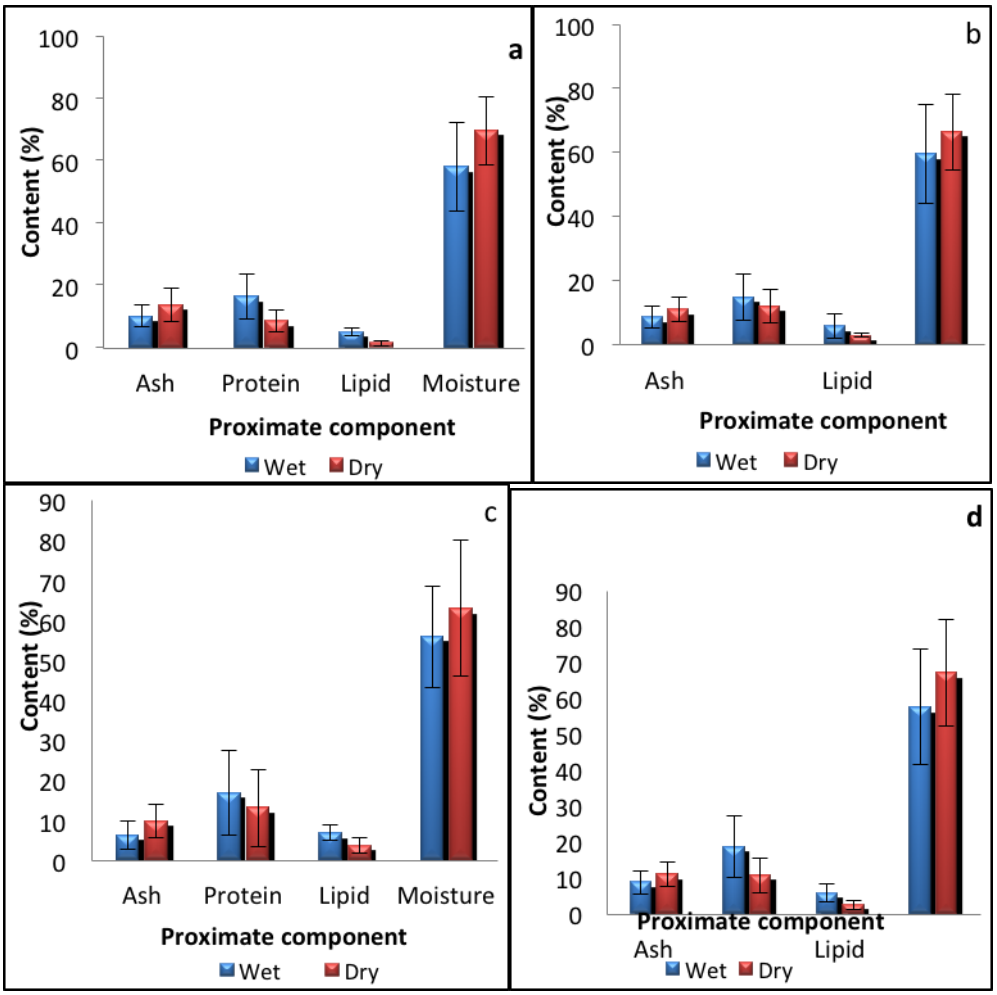

Figure 2: Seasonal Variation of proximate contents in *A. ciliaris* (a), *L. harak* (b), *R. kanagurta* (c) and *S. canaliculatus* (d)

The overall mean concentration of ash, crude protein, lipid and moisture in the selected fish species during wet season that were compared to those collected in dry season as shown in Table 1. Ash and moisture contents in

fish species collected in wet season were lower than in dry season, while crude protein and lipid contents were higher in wet season than those in dry season. There was a significant difference ($p < 0.00$) in lipid and moisture contents in fish between seasons. However, the observed differences in ash and protein contents were not significant ($p > 0.05$).

Table 1: Variation of proximate contents in fish species between seasons

	Ash	Protein	Lipid	Moisture
Wet (%)	8.46±3.51	3.20±1.30	5.89±2.62	57.81±14.41
Dry (%)	11.49±2.20	3.62±1.08	2.69±1.32	66.64±15.38
d.f.	179	190	189	189
F-value	0.00	32.18	57.26	40.20
p-value	0.98	0.00	0.00	0.00

The mean proximate contents results from the four fish species (*A. ciliaris, L. harak, R. kanagurta, S. canaliculatus*) recorded significant variations between season ($p < 0.05$) in some proximate parameters except in ash contents among all fish species, moisture in *R. kanagurta* and crude protein in *L. harak* and *R. kanagurta*. The variation of chemical composition of fish varies greatly with species, sex, age, environment and season (Alemu *et al.* 2013; Sonavane *et al.*, 2017). With these results, it can therefore be assumed that, seasonal variability causes temperature difference. This will apparently affect the fish feed consumption, metabolic rate and energy expenditure at the end, the results of proximate contents will change (Paloheimo & Dickie, 1966).

During wet season, the variation of nutrient contents may probably be due to flowing water exchange and nutrients (Blé & Arfi, 2009). Abundance of food supply can clearly change the biochemical composition of fish species while overcrowding may cause insufficiency of food resulting to variation of fish composition (Deka *et al.*, 2012). It has been reported that differences in quality of the fish diet presumably causes variations in the fish body constituents (Ayuba & Iorkohol, 2013). The results of the this study on ash, lipid and moisture contents concur with those reported by Olgunoglu *et al.*, (2014) who studied Mesopotamian Catfish (*Silurus triostegus*). However, Nargis (2006) who studied *Anabas testudineus* from Bangladesh did not conform with this study. The contrasting results may perhaps be explained by location differences as reported by (Bunnet, 1988).

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The effect of processing treatments on proximate composition

The mean proximate contents in processed fish were compared to those of raw fish as control (Figure 2). The mean ash contents in all fish species slightly decreased in boiled fish but were more or less similar with those in raw and fried fish. Crude protein and lipid contents in all fish species increased in both processing methods, more so in fried fish. On the other hand, moisture contents in all fish species decreased in both treatments, more so in fried fish (Figure 2). With the exception of ash content in *A. ciliaris* and *L. harak*, there was significant difference ($p < 0.05$) in the proximate contents between raw and cooked fish. Furthermore, there was significant difference ($p < 0.05$) in all analyzed proximate contents in *R. kanagurta* and *S. canaliculatus* between raw and boiling processing methods.

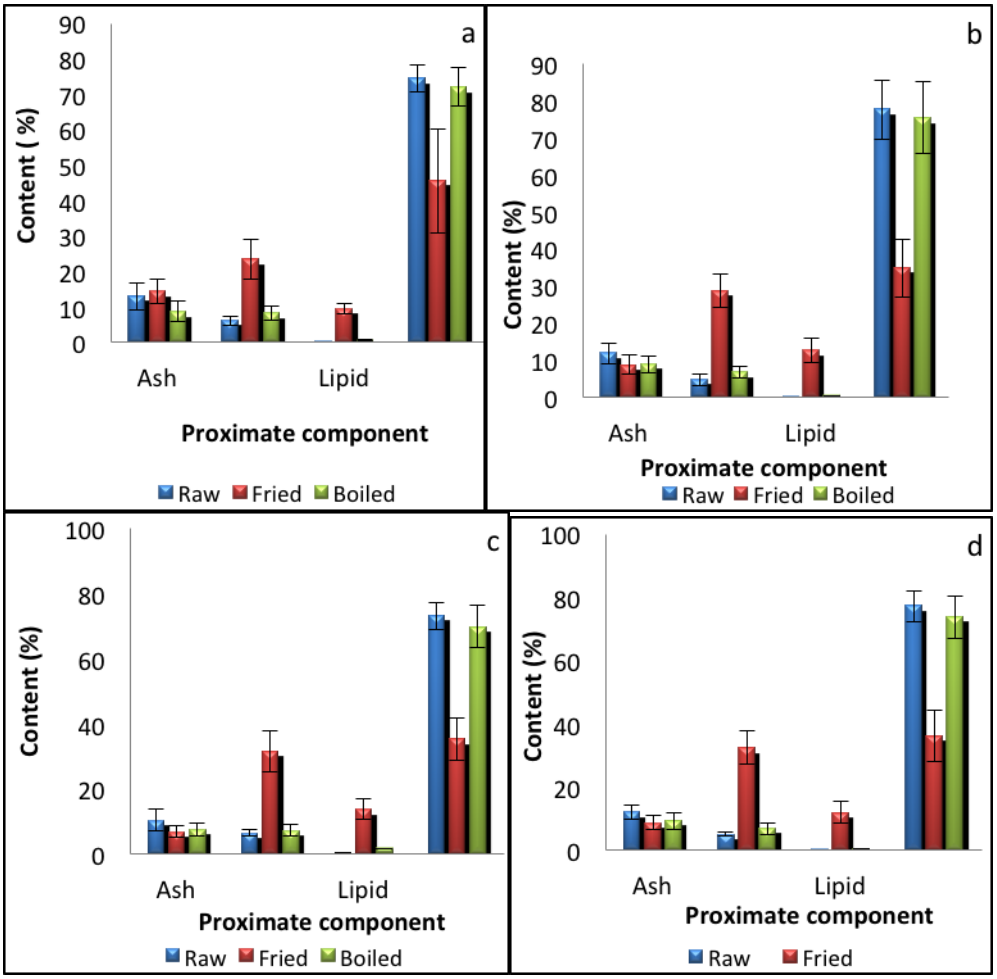

Figure 3: Variation of Proximate Contents due to Processing methods in* A. ciliaris *(a),* L. harak *(b),* R. kanagurta *(c) and* S. canaliculatus *(d)

The overall mean proximate contents in fried fish samples were compared to raw fish and summarized in Table 2. Ash and moisture contents in fried

fish were lower compared to the contents in raw fish. The fried fish showed high protein and lipid contents compared to raw fish.

There was a significant difference ($p < 0.05$) in proximate contents between fried and raw fish except in ash (Table 2).

Table 2: Variation of proximate contents in fried from raw fish

Processing method/ proximate content	Ash	Protein	Lipid	Moisture
Raw (%)	11.80±4.51	2.84 ±1.09	0.27±0.21	75.62±3.65
Frying (%)	9.57±7.99	5.21±2.73	11.89±7.66	38.06±19.28
d.f.	125	81.163	62.29	66.36
F-value	1.13	64.91	158.59	108.67
p-value	0.29	0.00	0.00	0.00

The changes of proximate contents when fish samples were boiled and compared to raw fish are outlined in Table 3. Ash, protein and moisture contents in boiled fish were lower compared to the contents in raw fish. Boiling increased lipid content compared to raw fish. Whereas there was a significant difference ($p < 0.05$) in lipid content between raw and boiled fish, there was no significant variation in other proximate contents between the two processing methods (Table 3).

Table 3: Variation of proximate contents in boiled from raw fish (%)

Processing method/ proximate content	Ash	Protein	Lipid	Moisture
Raw (%)	11.80±4.51	2.84 ±1.09	0.27±0.21	75.62±3.65
Boiled (%)	8.61±4.76	2.21±0.99	0.80±0.14	72.71±5.34
d.f.	125	125	70	109
F-value	0.39	1.36	13.16	6.81
p-value	0.53	0.25	0.00	0.10

The differences of proximate contents between fried and boiled fish samples are presented in Table 4. Ash, protein and lipid contents in boiled fish were lower compared to the contents in fried fish whereas moisture in boiled fish was higher than in fried fish. With the exception of ash content, there was a significant difference ($p < 0.05$) in all other proximate contents between fried and boiled fish and not in ash (Table 4).

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Table 4: Variation of Proximate contents between boiled and fried fish

Processing method/ mineral content	Ash	Protein	Lipid	Moisture
Frying (g/Kg)	9.57±7.99	5.21±2.73	11.89±7.66	38.06±19.28
Boiling (g/Kg)	8.61±4.76	2.21±0.99	0.80±0.14	72.71±5.34
d.f	124	125	124	124
F-value	0.67	133.21	127.35	189
p-value	0.42	0.00	0.00	0.00

The results of proximate composition of the current study showed a decrease of ash and moisture in fried compared to raw fish. Boiled fish had higher lipid content than other proximate contents when compared to raw. The t-test statistical outputs expresses a significant difference ($p < 0.05$) of proximate contents between raw and cooked fish except in ash for both processes and crude protein, lipids and moisture in boiled fish. The decrease of ash contents in processed fish species compared to raw, agreed with (Pomeranz & Meloan, 1994) who considered minerals as the total amount of minerals. The results of proximate contents in processed fish species were in agreement with the studies of (Karimian-khosroshahi *et al.,* 2016; Cristelle *et al.,* 2018). However, the findings of ash and protein contents in this study were not in accord with the report of (Aberoumand & Ziaei-Nejad, 2015) as well as results of ash in the study done by Gall *et al.,* (1983) and (Marimuthu *et al.,* 2012). Deviation of ash contents in the current study from other studies may probably be induced by the duration time used during frying.

Predicting Variation of proximate contents due to seasons

A predictive model was developed to establish the extent of changes in proximate parameters due to seasonal changes. Linear regression analysis was applied to assess the relationship between proximate contents in selected fish species and seasonal changes. The predictive model values of the proximate composition in seasons were determined by the regression equation:

$$Y_i = b_o + bx + \varepsilon_i \qquad \textit{Equation 1}$$

The predicted model results are summarized in Table 5. The percentage (%) of variance in the dependent variable (proximate content) that can be explained by the independent variable (seasons) are 6.3 % for ash, 4.1 % for crude protein, 5.3% for lipids and 4.6 % for moisture) as expressed by the predictive model.

Table 5: Linear regression prediction analysis of proximate composition between seasons

Proximate composition	R^2	(b_0)	Wet Dummy variable (bx)	F value	p value	Predicted value
Ash	0.063	11.50	-3.04	12.69	0.00	8.46
Crude Protein	0.041	11.16	5.56	8.18	0.00	16.42
Lipid	0.053	2.68	3.21	10.61	0.00	4.89
Moisture	0.046	66.67	-8.83	9.12	0.00	57.87

In wet season relative to dry season, ash content is predicted to decrease by 3.04 %, and the decrease is expected to be significantly lower ($p < 0.05$).

Crude protein content is predicted to increase by 5.56 % in wet season compared to dry season. The increase is expected to be significantly higher ($p < 0.05$). Similarly, lipid content in wet season is predicted to increase by 3.21 % compared to dry season, the change is expected to be significantly higher ($p < 0.05$). Furthermore, moisture content in wet season is predicted to decrease by 8.83 % compared to dry season and the change is expected to be statistically significantly lower ($p < 0.05$).

The predictive model values of proximate composition in the fish species between seasons will vary by 8.46 % for ash, 16.72 % for crude protein, 4.89 % for lipid and 57.84 % for moisture. There is a statistical significant contribution ($p < 0.05$) of seasons in variation of proximate contents. This is an indication that the model can accurately predict proximate contents using seasons as a predictor.

Predicting Variation of proximate contents due to processing methods

Multiple regression analysis was applied to assess the relationship between proximate contents found in tissues of the sampled fish species and processing methods (frying and boiling). The findings of the study showed that the predictive model values of the proximate composition due to varying processing methods can be determined by the multiple regression equation:

$$Y_i = b_0 + b_1x_1 + b_2x_2 + \varepsilon_i \qquad \textit{Equation 2}$$

The predicted model results are summarized in Table 6. The percentage (%) of variance in the dependent variable (proximate) that can be explained by the independent variable (processing methods) are 4.60 % for ash, 60.6 % for protein, 59.1 % for lipid and 68.3 % for moisture as described by the

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multiple regression model. The model predicted a decrease in ash contents by 2.14 % in fried fish and 3.09 % in boiled fish compared to raw fish. The changes are expected to be statistically significantly lower ($p < 0.05$).

Crude protein content is predicted to increase by 23.36 % in fried fish and 1.62 % in boiled fish compared to raw fish. The change is predicted to be statistically significantly higher ($p < 0.05$) for fried fish and not for boiled fish.

Table 6: Multiple regression prediction analysis of proximate contents due to processing methods

Proximate content	Processing Method	Model value (b)	t value	p value	F value	R^2	Constant (b_0)
Ash	Frying Dummy (b_1)	-2.14	-2.03	0.04	4.55	0.046	11.71
	Boiling Dummy (b_2)	-3.09	-2.94	0.00			
Crude protein	Frying Dummy (b_1)	23.36	15.31	0.00	145.15	0.606	5.63
	Boiling Dummy (b_2)	1.62	1.06	0.29			
Lipid	Frying Dummy (b_1)	11.62	14.66	0.00	135.66	0.591	0.27
	Boiling Dummy (b_2)	0.53	0.67	0.50			
Moisture	Frying Dummy (b_1)	-37.51	-18.15	0.00	202.46	0.683	75.56
	Boiling Dummy (b_2)	-2.85	-1.38	0.17			

Lipid contents were predicted to increase by 11.62 % in fried fish and 0.53 % in boiled fish. The predicted change is expected to be significantly high ($p < 0.05$) for fried fish and not for boiled fish. The moisture contents were

predicted to decrease by 37.5 % in fried fish and 2.85 % in boiled fish. Like lipids and crude protein contents, the change in moisture content is predicted to be statistically significant for fried fish and not for boiled fish.

The predicted proximate values due to processing methods were 6.48 % for ash, 30.61 % for crude protein, 12.42 % for lipid and 35.20 % for moisture. There is a statistical significance contribution ($p < 0.05$) of both frying and boiling methods to ash content and frying method to crude protein, lipid and moisture. The model can accurately predict the variation of ash content using both processing methods as predictors. However, the model can only predict accurately the variation of crude protein, lipid and moisture when frying processing method was used as the predictor.

Pearson Correlation Coefficients and Principal Component Analysis (PCA)
In determining the relationship between proximate composition, seasons and processing methods, Pearson correlation coefficient and PCA were employed. Table 7 indicates that significant positive correlations were observed for variables between crude protein and ash, lipid and crude protein, moisture and ash, processing method and ash, season and ash as well as season and moisture. However, there were significant negative correlations between lipid and ash, moisture and crude protein, moisture and lipid as well as season and lipid.

Table 7: Pearson Correlation Coefficients of the analyzed variables

	Ash	Crude protein	Lipid	Moisture	Process	Season
Ash	1					
Protein	**0.463**	1				
Lipid	**-0.200**	**0.540**	1			
Moisture	**0.286**	**-0.571**	**-0.926**	1		
Process	**0.218**	0.119	-0.032	0.058	1	
Season	**0.251**	0.097	**-0.230**	**0.215**	0.000	1

Bold values means significant correlation at the $\alpha = 0.01$ (2-tailed).

PCA after varimax rotation was employed in this study. A principal component (PC) was considered significant when its eigenvalue was greater than 1. The measured values were used as variables total six (6) with the concentrations of the nutrients in the different sampling stations as objects (total 192). Based on the loading distribution of the variables, the PCA results indicated that the variables can be represented by two principal components (PCs) that accounted for 67.7 % of the total variance in the original data sets (Table 8).

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Table 8: Rotated loadings of the Principal components

	Principal Component (67.7%)	
	PC 1 (40.2%)	**PC 2 (27.5%)**
Moisture	**-0.951**	0.214
Lipid	**0.942**	-0.175
Crude protein	**0.753**	**0.567**
Ash	-0.054	**0.889**
Season	-0.220	**0.526**
Process	0.024	0.432

Based on the results in Table 8 they indicate that crude protein, lipids (EE) and moisture that contributed 40.2 % of total variance and constituted related group (PC 1), indicating their relationship. Similarly, crude protein, ash and seasons constitute another related group (PC 2). This has been shown in Table 8 where these variables are significantly correlated to each other (p = 0.00). However, the changes of Ash content is related to processing methods and season while moisture and lipids (EE) are negatively related (Table 7).

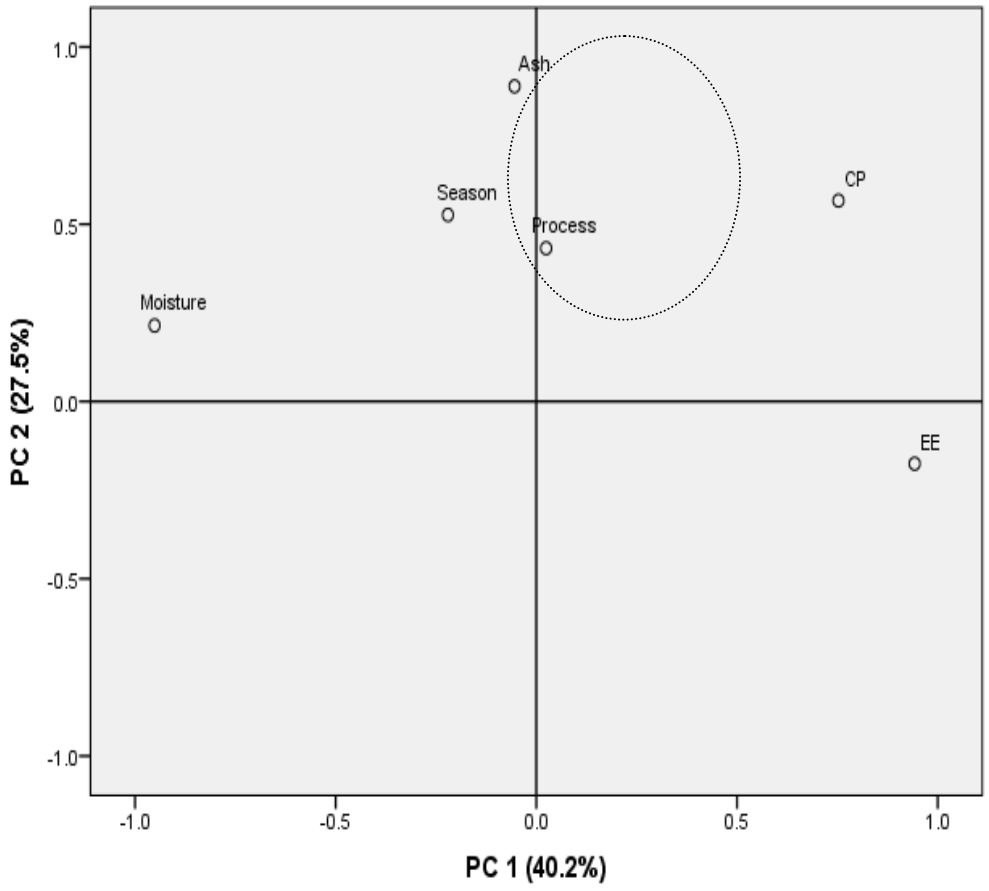

Figure 4: A two dimensional score plot for the variables in the study

The findings indicated that ash content in the fish was more affected by varying seasons as well as processing methods. This is supported by the significant positive correlation between the ash and season as well as ash and processing methods. On the other hand, moisture, lipid and crude protein were not mostly affected by seasons and processing methods.

Conclusion

The findings of the study have shown that proximate contents of fish species varied with changes in seasons (wet and dry). The results indicated an increase in crude protein and lipid contents during wet season but recorded an increase in moisture and ash contents in dry season. In addition, the effect of boiling treatment on proximate contents in fish was lower than that of frying treatment. Whereas ash content was affected by season and processing methods, moisture, lipid and crude protein were not affected by varying seasons and processing methods. The extent of changes in proximate contents due to changing of seasons was accurately predicted by the derived model. In addition, variation of ash contents was accurately predicted by the model in both processing methods. However, the model failed to predict variation of lipid, crude protein and moisture when using boiling processing method.

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Pre-primary Education in Tanzania: Teachers' Knowledge and Instructional Practices in Rural Areas

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Abstract: *Recently, the Ministry of Education Science and Technology though Tanzania Institute of Education introduced a new Pre-Primary Education Curriculum and Syllabus. Consequently, pre-primary teachers were orientated towards implementing the newly-established curriculum. However, little is known on the pre-primary teachers' knowledge and practices vis-à-vis-effectiveness in teaching. This study, therefore, sought to narrow this gap of knowledge by assessing the pre-primary teachers' knowledge and practices regarding the implementation of the curriculum. A descriptive survey design informed this study. A total of 19 rural pre-primary teachers working in six wards in Mwanza and Morogoro regions were recruited to participate in the study. Data were collected using a questionnaire with Likert scales and a classroom observation schedule. The findings reveal that overall, pre-primary teachers had little knowledge (M=2.12,SD=.58) regarding Early Childhood Education. On the other hand, however these teachers were knowledgeable on the importance of play to children (M=2.36, SD=.76) and understood the objectives of pre-primary education (M=2.47, SD=.79). Teachers' instructional practices, however, were unsatisfactory (M=2.07, SD=.62). Statistically, however, their knowledge scores did not significantly correlate with their practice (r = .344, p>.05). On the whole, the pre-primary teachers' instructional practices were unsatisfactory. This suggests a need for continued provision of in-service educational programmes to the teachers.*

Keywords: *Knowledge, Practice, Early Childhood Education, Pre-primary teachers*

Introduction

Research has demonstrated that early years—from conception to eight years of age—are vital for children's growth and development (intellectually, emotionally, socially and physically). As such, quality early stimulation and education experiences at this particular stage of life lays a strong foundation and creates lasting impacts not only immediately for the child and its parents, but also over time in terms of the child's ability to contribute to the community; moreover, opportunities forgone at this stage can rarely be made up at later stages of the child's growth (Hyde, 2006; Shonkoff, 2009; UNICEF, 2013). Thus, providing supportive, caring, responsive

relationships as early in life as possible can help build a strong foundation for a child's future school and life long success.

In fact, a quality pre-primary learning programme has the potential of supporting children to develop the skills that the brain is wired to learn before primary education. Throughout early childhood, there are "windows" of learning. Indeed, what happens in early learning schools should reflect an understanding of developmental milestones, what children can do, and how they learn (Llewellyn, 2017). Since Early Childhood is a crucial stage in human development since it forms the foundation of subsequent development, teachers' knowledge and practices are fundamental when assessing the quality of early education. Tanzania recognises the importance of pre-primary education. This recognition is reflected in various policy provisions such as the Education and Training Policy (ETP), 1995 and the subsequent ETP, 2014.

Pre-Primary Education in Tanzania

The education system in Tanzania comprises two years of pre-primary education, seven years of primary education, four years of ordinary secondary education, two years of advanced secondary education, and three or more years of tertiary/higher education. Until 2015, basic education consisted of seven years of compulsory primary education for children aged 7-13 years. A new policy in education and training, which was promulgated in 2014, has made some structural adjustment to integrate secondary education in compulsory and fee-free basic (public) education from 2016 onwards. In addition, the policy adjusts primary school education from 7 to 6 years. It also makes a pre-primary education a one-year programme and compulsory for five-year-old children. In fact, 3-4-year-olds can be enrolled if they are 'ready' to embark on school. Thus, the structure of the education system can now be described as: 1+-6-4-2-3+. This translates into 1 (or more) year of pre-primary school, six years of primary education, four years of ordinary secondary education, two years of advanced secondary education and three (or more) years of tertiary and/or higher education. In other words, pre-primary and secondary education have become an integral part of compulsory and fee-free basic education, at least in the country's public education system. The education structure, however, is likely to change again since the current ETP is under review.

Pre-primary education in Tanzania was formalised and systematised in 1995 following the introduction of the ETP 1995. By then, it was not compulsory until the introduction of the2014 Education and Training Policy that superseded the former. The purpose of pre-primary education is to prepare children for primary education. Each primary school in Tanzania is expected to have a pre-primary class as part of the school set-up.

Despite this emphasis, participation at this level of education has yet to meet expectations and varies. In 2014, 2015, and 2016, for example, the gross enrolment ratio (GER) for pre-primary education was 37.3, 36.9, and 103.1, respectively. In 2017, the GER was 95.8% (United Republic of Tanzania [URT], 2017) whereas in 2018 it was at 86.1% (President's Office Regional and Local Government – PO-RALG, 2018). The sharp increase in enrolment in 2016 is attributable largely to the implementation of fee-free basic education. The decrease in enrolment, on the other hand, could be explained by 'unmet' expectations associated with the implementation of fee-free education policy. Available information suggest that parents still incur indirect costs for their children's schooling to cover school uniforms, exercise-books and writing materials even in light of the much-touted fee-free education in public schools. To some parents, such contributions no matter how negligible might constitute a burden (HakiElimu, 2017), and hence a throwback.

In fact, it took 10 years after the formalisation of Pre-Primary Education (PPE) in 1995 to produce the 2005 curriculum for PPE. The 2005 curriculum was subsequently reviewed in 2016. As mentioned elsewhere, the one-year cycle PPE curriculum is designed to prepare a child for primary education.

It advocates for a holistic development of child, child-centred approach, individualised instructions, and play-based pedagogy. Moreover, the curriculum advocates for continuous assessment of pupils' progress. It also recommends for the assessment based on the teachers' observations and keeping of each child's progress record on daily basis. To support effective implementation of the curriculum, the Tanzania Institute of Education (TIE) produced curriculum support materials including six textbooks and teacher's guide. Among other things, the teachers' guide provides some guidance on engaging children in playful learning activities, preparation and use of lessons plans, classroom management and management of a day, and daily routine. The orientation of pre-primary teachers with the draft of the newly-established curriculum and curricular materials eight days in 2016. Although teachers were generally provided with a copy of the draft curriculum for implementation, the information available indicate that a good number of the teachers did not have a copy of the curriculum until 2019.The delay was partly caused by the curriculum being finalised for mass production before distribution to the teachers. In truth, teachers have largely relied on their experiences (Shukia, 2014) and, perhaps, the knowledge and skills they had gained during this orientation.

Generally, there is an agreement that teacher's personal factors such as knowledge, qualification, specialised training in early childhood education (ECE) and participation in professional development programmes constitute a common structural variable in the regulation and an important

contributory factor to quality service delivery (Sims, Guilfoyle, & Parry, 2006). After all, well-trained teachers are critical components in engendering a high-quality early childhood education (UNESCO, 2005). In addition, training equips teachers with requisite knowledge and skills to participate in warm, sensitive and responsive interactions with young children, and these interactions and relationships are important determinants of children's learning outcomes (Wylie & Thompson, 2003).

Also, teachers' pedagogical knowledge has the potential of bettering instructional decisions teachers make in the classroom (Shulman, 1986). In fact, teachers' high level of knowledge is instrumental to devising challenging but accommodative learning environments, hence improving learning outcomes. In fact, knowledgeable teachers can anticipate the learners' difficulties and adaptively respond to meet their needs (Keller, Neumann, & Fischer, 2017). However, this paper contends that the relationship between teachers' knowledge and practices is not always linear. There might be classroom conditions, which might influence this relationship, depending on a given locale or operational context.

As Tanzania recognises the importance of a well-trained teacher at the pre-primary education level, the expectation is that a qualified pre-primary teacher must have received at least a certificate of teacher training education with a minimum classification of Grade III 'A' on the government teacher pay scale. Moreover, pre-primary teachers should hold a certificate of teacher education in early childhood education. In statistical terms, there were around 9,045 teaching staff in government pre-primary streams in 2017, a nine percent increase from 8,300 of teaching staff registered in 2016. Of the teaching staff for pre-primary streams available in 2017, about 87 percent were 'qualified'; hence a pupils-qualified teacher ratio (PQTR) of 183:1 in government streams against the standard PQTR of 25:1 [President's Office, Regional Administration and Local Government (PO-RALG), 2017].

The 2017 PQTR is even worse when compared to169: 1 in 2016. Of the 'qualified' pre-primary teachers, however, the majority (76.7%) had never attended teacher education in early childhood development and education, specialised training which is essential for teaching at that level, as expected. Thus, they are more qualified as primary school teachers but 'under-qualified' as pre-primary teachers. Simply put, they were primary school teachers tasked with teaching pre-primary school learners.

Studies done in Tanzania by Mtahabwa (2007), the MoEVT (2010), Shavega, Brugman, and Van Tuijl (2014) and Libent (2015) indicate that most of the pre-primary classes suffer from poor quality teaching and learning due to lack of pre-primary curriculum and curricular materials, 'under-qualified'

pre-primary teachers, high teacher-pupil ratio. We know little, however, about teachers' knowledge on ECE, pre-primary education curriculum and pedagogy in relation to their classroom instructional practices. It is against this backdrop that this study tries to answer three major research questions: (1) What are the pre-primary teachers' knowledge level regarding ECE? (2) What are the pre-primary teachers' instructional practices level regarding ECE? (3) Is there significant relationship between the pre-primary teachers' knowledge and their instructional practices regarding ECE?

The socio-cultural theory and its allied activity theory serve as analytical tool that facilitate the understanding of the teachers' knowledge and instructional practices in the context of this study and their relationships. These theories provide a framework for examining the factors that influence the existing pre-primary teachers' knowledge and practices not only on the basis of immediate and day-to-day classroom practices but also in relation to their background and prior experiences, as well as prevailing social context. The framework, further, works on the assumption that relationships between knowledge and practice are not always smooth. After all, in the course of teaching and learning contradictions and tensions may exist.

Methodology

A descriptive survey design informed this study. A sample consisted of 19 pre-primary teachers' purposively selected from 19 rural pre-primary classes in six wards of Mwanza and Morogoro regions. Data were collected using self-administered questionnaire and an observational checklist, designed by the researchers. The questionnaire had a list of items that assessed pre-primary teachers' knowledge on various pre-primary education issues. The questionnaire consisted of two sections. The first section generated information related to demographic and job characteristics of the pre-primary teachers studied. Teachers' information collected included gender, educational levels, years of experience in the teaching profession, pre- and in-service training courses specifically dealing with early childhood education. The second section, on the other hand, comprised 14 items that measured pre-primary teachers' knowledge.

Specifically, this section explored the teachers' knowledge on daily routine; play in children and learning corners; value of storybook reading and storytelling; teacher-child interaction; Pre-primary Education (PPE) objectives and competences; PPE teaching strategies; assessment strategies in PPE; parents' involvement and child protection measures. Responses were rated using a 3-point Likert-type scale ranging from 'accurate knowledge' to 'inaccurate knowledge' to determine teachers' knowledge.

The observational checklist facilitated the assessment of the teachers' instructional practices. Classroom observations were followed by post-observation interviews. Post-observation interviews served two main purposes: to clarify some of the instructional practices observed that the researchers determined to constitute a gap in understanding based onclassroom observations alone, and to explore perceptions and reasons underlying teachers' actions and their associated meaning from the teachers' perspective.

Observations occurred from the teachers' and children's time of arrival (7.30am) to departure time (11.30am). Pre-primary teachers' practices were assessed by looking at nine (9) dimensions: Planning, organisation of the day's teaching and learning activities, teacher-led session, children-led session, classroom management, availability and use of teaching and learning (T/L) materials, inclusivity, parents' engagement and assessment.

Scoring of instruments

Scores on the 3-point Likert-type response scale were added and averaged to provide an average score of the teachers' knowledge levels for each item and dimension. *Inaccurate knowledge* was defined as 'different answer' or 'doesn't know'; *Partial knowledge* as a teacher seeming to have knowledge, but it is unsatisfactory for fostering quality practice; and *accurate knowledge* as excellent knowledge for practice. The three levels of knowledge scores were operationally defined as<1.80= Inaccurate Knowledge; 1.80-2.29 = partial Knowledge, >2.30 = Accurate Knowledge. In other words, the greater the mean value, the more accurate the knowledge of the teachers.

As regards instructional practices, the scores were on a 5-point Likert-type response scale. The scores were added and averaged to provide an average score of the practices for each teacher. Scores were grouped into five groups. The five levels of teachers' practices ratings were operationally defined as <u><1.80</u>= poor/not observed, 1.80-2.60 = Unsatisfactory, 2.61-3.40 = Fair, 3.41-4.20 = Good, >4.21 = Excellent. That is, if teachers scored a mean of between 2.61 and 3.40, it meant they had fair practice.

Pilot test

Prior to the actual fieldwork, a pilot study was conducted in one public primary school with a pre-primary class attached to it. The objective of the pilot test was to validate the data collection tools and procedures subsequently applied in the field. The pilot study provided a framework for revising and improving the research tools for administration in the final form. Reliability of the tools was checked by testing for their internal consistency using the Cronbach Alpha reliability test. The reliability of the knowledge questionnaire was 0.95 and that of the practice observational

checklist was 0.78. These reliability indexes were sufficient enough for the research instruments to be administered in the field for this study.

Ethical Considerations

The approval to undertake the study was obtained from respective District Executive Directors of Mvomero and Kilombero in Morogoro region, and Misungwi and Ukerewe in Mwanza region. The researchers also obtained verbal consent for participation from every teacher after explaining to them the aim of the study in addition to assuring them that the data so obtained would be treated with utmost confidentiality and for the intended research purpose. In addition, participation was voluntary and, thus, they could withdraw at anytime from the study if they so wished. Furthermore, the researchers used code to ensure the respondents' anonymity and to avoid identifying the participating schools.

Data Analysis

Data were analysed descriptively (using frequencies, percentages, means and standard deviation) and inferentially (Pearson Product Correlation Coefficient) with the help of the Statistical Package for the Social Sciences (SPSS) version 20. Pearson Correlation was used to test relationships, statistical significance was considered at the 0.05 level.

Table 1 indicates that more than half of the pre-primary teachers (57.9%) were females, holders of secondary education and Grade 'A' teacher education certificates. Their experience of teaching PPE ranged from 1 month to 8 years. About 89.5 percent of the pre-primary teachers had never attended any pre-service training course in ECE. About 73.7 percent reported to have attended a nine-day national orientation workshop on the new pre-primary curriculum conducted by the TIE.

Results

Table 1 shows the demographic and job characteristics of the respondents:

Table 1: Demographic and Job Characteristics of the Respondents (n=19)

Demographic and Job Characteristics	No	%
Gender		
Females	11	57.9
Males	08	42.1
Educational levels		
Secondary Education &Grade A certificate	19	100
Experience years in teaching		
<01	07	36.8
01 to <05	09	47.4
05+	03	15.8
Pre-service training courses in early childhood education		
Yes	02	10.5
No	17	89.5

In-service training courses in early childhood education		
Yes	14	73.7
No	05	26.3

PPE Teachers' Knowledge on Early Childhood Education

The study also assessed the pre-primary teachers' knowledge on the pre-primary curriculum components. Specifically, it assessed the following attributes:(1) a daily routine; (2) importance of play in children and learning areas "Corner play"; (3) PPE objectives and competences; (4) PPE teaching strategies; (5) Assessment in PPE; (6) parents involvement in Pre-primary Education; and (7) child protection measures. Pre-primary teachers' knowledge is presented in Table 2:

Table 2: Descriptive Data for PPE Teachers' Knowledge

S/N	Knowledge Items	Inaccurate knowledge	Partial knowledge	Accurate knowledge	Mean	SD
1	Pre-primary daily routine.	4 (21)	9 (47.4)	6(31.6)	2.10	.73
2	Things to be included in a daily routine and reasons.	5(26.3)	10(52.6)	4(21)	1.94	.70
3	Benefits of a daily routine to children.	6(31.6)	7(36.8)	6(31.6)	2.00	.81
4	Importance of play to children.	3(15.8)	6(31.6)	10(52.6)	2.36	.76
5	Learning and play areas 'learning corners' and its contents.	6(31.6)	8(42.1)	5(26.3)	1.94	.77
6	Suitable playthings for young children in the classroom.	5(26.3)	9(47.4)	5(26.3)	2.00	.74
7	The value of storybook reading and storytelling to young children.	5(26.3)	7(36.8)	7(36.8)	2.10	.80
8	How to interact with young children.	3(15.8)	8(42.1)	7(36.8)	2.22	.73
9	Pre-primary education objectives.	3(15.8)	3(15.8)	13(68.4)	2.47	.79
10	Important PPE competences.	2(10.5)	10(52.6)	7(36.8)	2.26	.65
11	Pre-primary teaching strategies.	3(15.8)	10(52.6)	6(31.6)	2.11	.69
12	Ways of assessing PPE children.	3(15.8)	12(63.1)	4 (21)	2.12	.61
13	Ways in which parents can support and improve the PPE classroom quality.	4 (21)	12(63.1)	3(15.8)	1.94	.63
14	Child protection measures that PPE teacher need to be aware of and their role.	5(26.3)	8(42.1)	6(31.6)	2.05	.80
	Overall Pre-primary Teachers' knowledge				**2.12**	**.58**

** *3= Accurate Knowledge, 2=Partial Knowledge, 1= Inaccurate Knowledge*
**Numbers in brackets show percentage of responses*

As Table 2 illustrates, the overall mean score for the Pre-primary teachers' knowledge on ECE practices was 2.12 (*SD = .58*), meaning that the teachers' had little knowledge on ECE practices. Specifically, the findings indicate that 47.4% and 52.6% of PPE teachers reported to have partial knowledge on a daily routine (*M=2.10, SD=.73*) and its contents (*M=1.94, SD=.70*). Besides, when asked about the benefits of a daily routine to children, the teachers reported possessing varying levels of such knowledge. Moreover, most of the PPE teachers (52.6%) possessed accurate knowledge on the benefits of play for young children (*M=2.36, SD=.76*).

PPE teachers were also to define a play and learning areas ('learning corners') and describe the contents of play and learning areas. Only 26 percent of the participating PPE teachers managed to define and describe the contents of learning corners (*M=1.94, SD=.77*). Nevertheless, when asked about suitable playthings for young children in the classroom, 47 percent of the PPE teachers reported to have partial knowledge (*M=2.00, SD=.74*). It is a truism that storybook reading and storytelling have multiple benefits for young children. However, when asked about the value of storybook reading and storytelling for young children, only 37percent of the PPE teachers indicated to have accurate knowledge (*M=2.10, SD=.80*). The majority (88%) of the PPE teachers reported to possess accurate knowledge on understanding the objectives of PPE (*M= 2.47, SD= .79*). Another 63 percent of the PPE teachers reported possessing only partial knowledge on proper ways of assessing young children (*M=2.12, SD=.61*). Additionally, only15.8percentof the PPE teachers revealed to have accurate knowledge on how to involve parents in improving classroom quality (*M=1.94, SD=.63*). With regard to child protection measures, PPE teachers were found to have varying levels of knowledge. Table 3 presents the instructional practices observed among the teachers during the study.

Table 3: Descriptive Data for PPE Teachers' Practices

No.	Dimensions and Items	Mean	SD
1. Planning: Teacher plans sessions based on agreed upon curriculum/guidelines		**2.90**	**1.38**
1	Does the teacher have a curriculum and teacher's guide by TIE	3.24	1.67
2	Teacher has a lesson plan consistent with the curriculum	2.47	1.41
2. Organization of the Day		**2.31**	**1.14**
3	How was Circle Time conducted	2.36	1.30
4	How was the Bye Bye time conducted	2.11	1.02
3 (a). Lesson Preparation		**2.14**	**.99**
5	Lesson prepared according to the lesson plan format	2.13	1.50
6	Teaching aids prepared in sufficient numbers	1.77	.73
7	Teaching materials are relevant to the lesson	1.88	1.07
3 (b). Lesson implementation		**2.40**	**.87**
8	Examples from the local context to illustrate the lesson	2.47	1.28
9	All the children are actively engaged in the lesson	2.63	1.06
10	The teacher's instructions are clear and easy to follow	2.89	1.14
11	Teacher responsive when children ask questions	2.21	1.08
4 (a). Learning materials		**1.73**	**1.07**
12	Learning materials available and accessible	1.57	.69
13	Learning materials enough and safe to use	1.49	.79
14	The learning areas are well-organised.	1.31	.58
4 (b). Children led activities		**1.83**	**.74**
15	All learning areas have children at play	1.27	.46
16	Atmosphere in the classroom is relaxed	1.84	.89
17	Children interacting positively	2.26	1.04

4 (c). Teachers' activities during Play session		**2.11**	**.87**
18	Teacher interacting with individual children	2.29	1.10
19	Teacher paying attention to the children who are not active	2.11	1.07
20	Teacher encouraging children's interaction	1.94	1.16
5.Classroom management		**2.48**	**.96**
21	Classroom rules and teacher's expectations	1.88	1.02
22	Teacher use positive discipline, calm, encouraging and positive language	2.56	1.09
23	Classroom arrangement appropriate	2.22	1.11
24	Furniture developmentally appropriate	1.43	.51
6.Stimulating environment and learning areas		**1.22**	**.36**
25	Are learning areas available? Are learning areas well-organised?	1.22	.48
26	Are learning areas being used?	1.23	.43
7. Inclusivity		**2.31**	**1.01**
27	Teacher involves both genders equally	2.66	1.37
28	Teacher engages children with special needs	1.35	.86
29	Teacher shows appreciation to all the children	3.05	1.29
8. Parent Engagement		**1.43**	**.89**
30	Teacher encourages active parent engagement	1.43	.89
9. Assessment		**1.44**	**.56**
31	Does the teacher assess each child?	1.88	.90
32	Does the teacher keep records of each child?	1.33	.68
33	Teacher communicate the assessment results	1.21	.63
	Overall PPE Teachers Practice	**2.07**	**.62**

**5= Excellent, 4=Good, 3 =Fair, 2=Unsatisfactory, 1= Poor/not observed

Table 3 shows the mean values for the teachers' practice on the nine dimensions and various specific items. The means for all the dimensions and items ranged from 1.21 to 3.24. The overall mean score for PPE teachers' practices was 2.07 (*SD = .62*). This implies that the practices of the PPE teachers, who were assessed during the study, were not satisfactory. Specifically, the findings indicate that the mean for planning was 2.90 (*SD=1.38*), whereby 70 percent and 62.6 percent of the PPE teachers possessed pre-primary curriculum/syllabus and teachers' guide, respectively. However, only 23.6 percent of the teachers planned their sessions based on the agreed upon curriculum/guidelines. Furthermore, despite the teachers having lesson plans, evidence on whether they followed their plans for every lesson with fidelity was largely lacking.

As Table 3 indicates, the organisation of the day was unsatisfactory in many of the schools (*M=2.31, SD=1.14*) visited. For instance, 36.8 percent of the schools' Circle time was not conducted whereas at 15.8 percent of the schools, Circle time took place but there was poor engagement of the children. Also, the sessions were too brief and tended to be dominated by the teachers. Bye Bye time was neither observed in some of the PPE classes whereas in other PPE classes' Bye Bye time took place but the sessions were

rather too short and lacked a conclusion of the day's activities. Teachers' lesson preparations and implementations were found to be unsatisfactory (*M=2.14, SD=.99)* and (*M=2.40, SD.87*), respectively. The study found that 60 percent of the teachers did not even prepare lesson plans. Another 39 percent of the PPE teachers did not prepare teaching aids whereas 44.4 percent of the teachers prepared very few teaching aids, which allowed only a selected child to participate with the majority of the children failing to do so.

Furthermore, learning materials were not available in many of the classes visited (*M=1.73, SD=1.07*). Specifically, 36.8 percent of the classes had few learning materials, with many children seated and idle while waiting for their turn to use those materials. Additionally, many classes had no learning areas which, in turn, affected the conducting of child-led sessions (*M=1.83, SD=1.07*). With regard to the teachers' activities during play session, teachers scores were unsatisfactory for practice (*M=2.11, SD=87*). In fact, the majority of teachers did not encourage children-to-children interactivity (*M=1.94, SD=1.16*). It was further noted that the majority of the classes had poor stimulating environment and learning areas (*M=1.23, SD=.36*). Teaching-learning materials were largely lacking in almost all the classrooms visited. The materials available that were common in a few schools were the alphabet and number charts displayed on classroom walls, letter and number cards, and a few pictures of some objects such as the bloom, bucket, knife, and brush but they were largely unlabelled.

Classroom management was also found to be unsatisfactory (*M=2.48, SD=.96*).For instance, it was observed that the majority of the classes had no rules in place (*M=1.88, SD=1.02*). Some teachers were observed using a mixture of appropriate and inappropriate instructions which children were only able to follow partially (*M=2.72, SD=1.07*). Additionally, many of the classes were observed to have no developmentally appropriate furniture for young children (*M=1.43, SD=.51*). In fact, almost all the classes had similar physical arrangement, with desks arranged in rows, pupils seating facing the teacher and the desks were not of child-like size to meet their physiological needs. The teacher also stood most of the time before the chalkboard in front of the class.

With regard to gender sensitivity, the study established that, the majority of the teachers (55.6%) were gender-sensitive in classrooms (*M=2.66, SD=1.37*), that is, their classroom set-up and management were not favouring one gender (e.g. sitting arrangements, use of teaching and learning materials). However, a child with mental impairment in one of the classes was minimally 'engaged' in the teaching-learning activities. When it comes to engaging parents, 75percent of the teachers did not have any evidence of

parent-teacher partnership (*M=1.43, SD=.89*). Moreover, they reported there was no meaningful engagement of parents in classroom work or meetings.

As Table 3 illustrates, pre-primary teachers failed to produce children's assessment (*M=1.88, SD=.90*) and records (M=1.33, SD=.68) respectively. Additionally, 84 percent of the teachers reported not to have communicated assessment results to the parents (*M=1.21, SD.62*). Implicitly, the teachers did not assess the children as stipulated in the pre-primary curriculum.

Relationship between Knowledge and Practice

A bivariate correlation analysis using the Pearson product-moment correlation coefficient was carried out to determine the relationship between pre-primary teachers' knowledge of ECE and their teaching practice at the ECE level. Results are as presented in Table 4:

Table 4: Relationship between Knowledge and Practice in ECE among Pre-primary Teachers

		Overall Knowledge	Overall Practice
Overall Knowledge	Pearson Correlation	1	.344
	Sig. (2-tailed		.163
	N	19	18
Overall Practice	Pearson Correlation	.344	1
	Sig. (2-tailed	.163	
	N	18	19

Data reveal that there was no significant relationship between pre-primary teachers' knowledge and practice of ECE (r = .344, p>.05). This implies that the respective teachers' knowledge on ECE did not necessarily translate into the required classroom instructional practices.

Discussion

Pre-primary education serves as a foundation for school and life success. As such, teachers are supposed to be knowledgeable enough in various PPE subject content and pedagogical skills in performing their responsibilities as teachers. To ensure the provision of quality early childhood education, it is important to focus on the teachers' knowledge and practice. This study was carried out with the goal of filling a gap of generating vital information on pre-primary teachers' knowledge and instructional practice pertaining to Early Childhood Education in selected Tanzania schools under review. The study was an attempt to answer questions on the extent to which pre-primary teachers are knowledgeable of ECE issues, to what extent is their

related practice adequate, and whether their knowledge and practice correlate.

The findings of the present study revealed that the majority of the PPE teachers had little knowledge on Early Childhood Education. It was apparent from the findings that these PPE teachers' knowledge of ECE was limited to specific areas. For example, pre-primary teachers had little knowledge on things for inclusion in a daily routine, understanding of the learning corners and how to involve parents in improving classroom quality. This limitation could have resulted from a deficiency in the training programmes on ECE. Also, the problem could be attributable to the absence of intensive pre-service and in-service training courses specified in early childhood education. This finding is inline with that of the UNICEF (2017) study, which reported that 72 percent of pre-primary teachers did not have a certificate in early childhood/pre-primary education. Similarly, this study found that 33.8 percent had had no in-service training in the past 12 months. Of those who did have one, 75 percent had participated in the national pre-primary curriculum orientation, which was usually a one-off event.

Regarding the pre-primary teachers' practice of ECE, the study's results generally revealed that their practice was largely unsatisfactory (*M=2.07, SD=.62*). Indeed, 7 out of 9scores for ECE practices were unsatisfactory. These included organisation of the day (*M=2.31, SD=1.14*), Teacher led-lessons [i.e. lesson preparations (*M=2.14, SD=.99*) and implementation (*M=2.40, SD.87)*], children-led sessions [i.e. availability of learning materials (*M=1.73, SD=1.07*), children-led activities (*M=1.83, SD=1.07*)], teachers' activities during play session (*M=2.11, SD=87)*]. Other scores were for classroom management (*M=2.48, SD=.96*), stimulating environment and learning areas (*M=1.22, SD=.36*), parental involvement (*M=1.43, SD=.89*), and children's assessment (*1.44, SD=.56*). These largely unsatisfactory scores could be due to lack of specialised training courses in ECE despite most of the pre-primary teachers possessing teaching certificates. As the UNICEF (2017) pointed out, this lack is alarming because most of the pre-primary teachers are not well-informed about the theories of child development and best practices in age-appropriate instruction, which inevitably affects their practice.

With regard to the relationship between pre-primary teachers' knowledge and their practice, the study found no statistically significant relationship between pre-primary teachers' knowledge and their practice of ECE (r = .344, p>.05). This implies that knowledge does not necessarily translate into actual and requisite practice. This finding is consistent with previous research in abundance. Indeed, this research has demonstrated that teachers' beliefs and knowledge are not always consistent with their instructional practices (see, for

example, Shukia, 2014, Kostopoulou, 2005). Similarly, the findings of the current study confirm the activity theory's assumption that dissonances are an inherent aspect of an activity, which refers to teaching in this context. This could be attributable to several factors including teachers' little knowledge, 'ill-defined' class context (large class sizes, lack of teaching-learning materials, lack of teachers' guidelines, limited time allotted for instruction, etc.) in which teaching takes place, 'under-qualified' teachers, and teachers' beliefs which might contrast with the expected practices. In this situation, teachers tend to rely on their own experiences, background, and beliefs. These aspects might form a basis for inconsistencies between teachers' knowledge and practices observed in this study. Apparently, the teachers' little knowledge about early childhood education, unsatisfactory instructional practices are threatening the realisation of pre-primary education goals, and even potentially translating into children's unpreparedness for primary education.

Conclusion

On the whole, the study shows that pre-primary teachers have little knowledge on ECE and their instructional practices remain largely unsatisfactory. This unsatisfactory teachers' knowledge and practices is attributable to the unavailability of pre-primary curriculum in schools coupled with limited teachers' qualifications as the majority of these teachers did not have a background in early childhood development teacher education. However, the study found no significant statistical relationship between knowledge and practice in ECE among pre-primary teachers studied. In fact, teacher's knowledge was not always consistent with their practices. This could be attributed to the limited teachers' knowledge and prevailing classroom situations. Implicitly, this state of affairs threatens quality delivery of the pre-primary education curriculum and the attainment of the desired pre-primary educational goals. Thus, the study suggests a need to reorient teachers to the pre-primary education curriculum in relation to their knowledge and socio-contextual factors within which instructional practices take place. The study also recommends for supply of curricular materials, and provision of continual in-service teacher professional development programmes to equip teachers with opportunities for reflection and acquisition of new knowledge, skills and evidence-based effective pre-primary practices. In this regard, the continued exposure to practical-based training in their in-service training might be more effective. Furthermore, there is a need to uncover and address factors that undermine the effective marriage between teachers' knowledge and practices.

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The Effects of Repeated Heating on Thermal Degradation of Cooking Oil and its Implication on Human Health - A Review

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Abstract: *Frying is one of the most common food processing methods at household level and in different catering settings. Repeated frying or reuse of vegetable cooking oils is commonly exercised as a cost serving and profit maximization strategy though the practice exposes cooking oils to thermal degradation. The cooking oils in a non-degraded form have nutritional and health supremacy, which are attributed to their fatty acid composition and other minor components. However, the products of thermal degradation due to repetitive use of cooking oil are implicated to destroy their nutritional and health benefits. Besides, the consumption of food products fried with reused oil on the other hand is indicated to pose health risks to the consumers. This has attracted the attention of several researchers to investigate the health risks associated with thermal degradation products of cooking oil. The present review provides an enriched overview and insight into deteriorative effect on cooking oils due to repetitive deep frying and the associated health risks they inflict. The information on repeatedly used cooking oil, degradation compounds, deteriorative effects and other related literatures were gathered through electronic search (Science Direct, Pub Med, and Google Scholar) and desk reviewed. A narrative literature review approach was used in which the different literatures were critically evaluated and summarized with conclusions drawn and inconsistence / gaps in a body of knowledge revealed. The retrieved data demonstrated and confirmed a variety of deleterious health effects ranging from histo-pathological alterations, damage to the alimentary canal (duodenum and colon) and vital organs (change in size of the liver including swelling heart, kidney and testes cells) and rise in blood pressure BP. Though some mitigation approaches are available including the use of antioxidant and adsorbent extracts, their applicability at household and in other catering service settings can hardly be practiced. It's thus important for stakeholders to limit the repetitive use of cooking oil to protect the consumers' health.*

Key words: Vegetable cooking oil, repeated frying, thermal degradation, deteriorative effects, health risks

Introduction

Deep frying is one of the most frequently used and the oldest method of food preparation globally. It is a rapid method of cooking employing usually high temperatures of about 180°C. Frying imparts a characteristic color and flavor to the food thus making fried foods highly acceptable by most people (German and Sherrington 2001). The cooking oil used is mostly of vegetable origin obtained from nut and seeds of plants such as corn (maize), ground nuts (peanut), soybean, olive, sunflower, cottonseeds, palm, coconut and rap seed (German and Sherrington 2001). Suitable vegetable oils for frying are those with high stability to resist chemical changes when exposed to higher temperatures or else they can pose a health risk to the consumer of the fried food product (Goswami *et al.,* 2015). A range of food products such as potato and cassava chips, chicken, fish etc. are prepared by frying mostly using reused cooking oil. The practice of reusing oil for repetitive frying is normally applied as a cost reduction strategy (Ganesan *et al.,* 2017) and profit maximization strategy (Falade *et al.,* 2017). Repeated heating of oil is associated with a chain of chemical reaction such as oxidation, hydrolysis and polymerization (Falade *et al.,* 2017) of which secondary oxidative product are implicated to be responsible for health risks (Goswami *et al.,* 2015).

Furthermore, according to Goswami *et al.* (2015) most of the time the oil is reused over and over again and it is discarded and substituted with new oil, only when it turns out to be foamy, highly viscous, emits bad odour and becomes dark coloured. Sometimes it is never substituted at all; instead fresh oil is added to already heated, thick and highly viscous oil. Though, several studies ((Mohammed and Idris, 2008; Shinde and Gupta, 2015; Guillaume *et al.,* 2018) have exposed the deteriorative effects of thermal oxidation on cooking oils the practice appears to continue. This review article which is enriched with the most recent development and available literature evidences provides an overview of the deleterious health effects of ingestion of thermal degradation products. The article aims at further drawing the attention of stakeholders and create more awareness on the health risks associated with consumption of fried food product prepared from reused cooking oil. This will probably illuminate light and help them to take the required measures and steps to lessen such hazards to produce safer food. The present review used a narrative literature review approach in which the different literatures were critically evaluated and summarized with conclusions drawn and inconsistence / gaps in a body of knowledge revealed. In achieving this, the present review revisited the factors affecting cooking oil, degradation product during frying, the various degradation products, the health effects posed by the thermal degradation products and mitigation approaches.

Nutritional and Health Benefits of Cooking Oil

Edible cooking oils are common ingredients of most of our daily diets with various nutritional and health benefits. They are an essential part of our daily diet because they serve as sources of lipid which is a vital source of energy, a major component of biomembrane and serve as structural units for several hormones (Falade *et al*., 2017; Ganesan *et al.,* 2017). Moreover, the nutritive value and health benefits of cooking oils are massive and these can be attributed to their respective components such as fatty acids in their diversity of forms and proportions that include unsaturated fats; monounsaturated and polyunsaturated fats. Furthermore, other minor components such as the native antioxidants including vitamin A, vitamin E and carotenoids play important roles including protecting cells and tissues from being damaged by free radicals (Falade *et al*., 2017; Gannesan *et al.,* 2017).

Polyunsaturated fatty acids (PUFAs) offer a major fundamental part in mitochondrial membranes and have antiatherogenic properties that reduce serum cholesterol and triglycerides. Similarly, the life significance of prostaglandins, thromboxanes, and leukotrienes are due to arachidonic acid, one of the chief PUFA, which constitutes 10–15% of the total fatty acids in the membranes. Largely, PUFAs strengthens constituents and fluid quality in the membrane and guards the cell (Gannesan *et al.,* 2017).

It is also indicated that dietary gamma-linolenic acid (GLA) (which is an omega-6 fatty acid found in certain oils) prevents cardiovascular diseases (CVD) through enlarging the blood vessels, lessening BP, and evading the incidence of atherosclerosis. Furthermore, GLA hampers the growth of tumors and different cancers. It is found in relatively high abundance in the plant seed oils (Ganesan *et al*. 2017) of evening primrose (7–10 g/100 g GLA), blackcurrant (15–20 g/100 g GLA), borage (18–26 g/100 g GLA) and fungal oil (23–26 g/100 g GLA) (Fan and Chapkin, 1998).

Dietary fats are desirable to support absorption of fat-soluble vitamins and supply the essential fatty acids, linoleic acid (LA) and alpha-linolenic acid (ALA). The long-chain fatty acid family of omega-6 (n-6) and omega-3 polyunsaturated fatty acids (PUFA) are vital constituents of the diet and are compulsory in daily physiological functions as well as for fetal development and neonatal growth. The 'parent' fatty acids are linoleic acid (LA) for the n-6 family and alpha-linolenic acid (ALA) for the n-3 family. These 'parent' fatty acids are considered crucial in mammalian diets; the lack of proper enzymes prevents their endogenous production (Hess and Ross-Jones, 2014). Intake of these omega-3 fatty acids (Gannesan *et al*., 2017) is clinically vital, which reduces the activities of white blood cells and produce moderators of inflammations. Besides, they reduce the ability of blood platelets to liberate thromboxanes and enhance the blood clotting mechanism. Monounsaturated fatty acids (MUFAs) are largely present in

the vegetable oil such as peanut oil, mustard oil, olive oil and canola oil, which avert coronary heart. It is well recognized to have a positive effect on the blood lipid profile and thus reduce the risk of CVD (Gannesan *et al.,* 2017).

Quality parameters of cooking oil

According to Tobolova *et al.* (2014) the quality of cooking oil can be assessed based on physicochemical properties by standard physical methods (such as molecular weight, smoke point, refractive index, viscosity etc.) and chemical methods (such as iodine value, saponification value, free fatty acid content, acid value, peroxide value etc.). Physicochemical properties of cooking oils provide important indicators of quality, purity and identity of cooking oils (Bandyopadhyay *et al.,* 2017). As such these parameters can as well be used to determine their deterioration and limit of use by measuring the quality of frying oil. This review article revisits some of the commonly applied physicochemical parameters and the description of which provides the quality and / or purity implication of each parameter and its application.

Iodine value (IV) *is a* measure of the degree of unsaturation (double bonds) among the fatty acids in a fat or vegetable oil. It determines the stability of oils to oxidation, and allows the overall unsaturation of the fat to be determined (Bandyopadhyay *et al.,* 2017; Zahir *et al.* 2014). Iodine value or number is useful as a guide to check adulteration of oil and also as a process control of oil (Bandyopadhyay *et al.,* 2017). It is also described in chemistry as the number of grams of iodine absorbed by 100 parts by weight of the oil or fat. The higher the iodine value the more the double bonds are present in fat (Osu and Ogoko, 2016), which implies the higher instability of oil to oxidation.

Free fatty acid value (FFA) is a measure of the amount of fatty acids hydrolysed on the triacylglycerol backbone (Tabee, 2008). It is regularly used as common indication of the hydrolytic condition and edibility of oils (Bandyopadhyay *et al.,* 2017) or as a chemical marker for monitoring the quality of frying operations (Tabee, 2008). The increase in free fatty acids could be attributed to hydrolysis of fats in particular the polyunsaturated, mono and diglycerides. The increase in its values increases the rancidity of oil, which may lead into several qualitative defects in oils (Osu and Ogoko, 2016). This parameter is regularly used for evaluation of the suitability of frying oils for human consumption and a value of 2% is defined as the maximum limit for oil rejection (Tabee, 2008).

Acid value is a measure to which the glycerides in the oil had been decomposed (Bandyopadhyay *et al.,* 2017). This is associated with an

increase in acidity which is certainly due to the breaking of ester linkages of triglyceride molecules as a result of heating (Osu and Ogoko, 2016).

Peroxide value (PV) also known as peroxide concentration is a measure of the extent of oxidation or rancidity and an indicator of the quality and stability of fats and oils (Osu and Ogoko, 2016; Zahir *et al.,* 2014). It is one of the methods for determination of hydroperoxides as the initial lipid oxidation products (Tabee, 2008; Zahir *et al*., 2014) and is used to determine the degree of spoilage of the oil (Bandyopadhyay *et al.,* 2017). PV is determined by measuring iodine released from potassium (Zahir *et al.,* 2014) and is expressed as milliequivalents oxygen per kg of fat/oil (Tabee, 2008). According to Venkata and Subramanyam (2016) the standard upper limit of PV for edible oil is 10 $mEqO_2/kg$. The oil with peroxide value between 1 and 5 $mEqO_2/Kg$ are at low oxidation state and between 5 and 10 $mEqO_2/Kg$ are at an average oxidation stage (Shinde and Gupta, 2015). However, because hydroperoxides do not accumulate owing to their instability at frying temperature, PV determination is not suitable for assessment of used frying oils (Tabee, 2008)

Saponification value is a rough index of the molecular weight of the fat or oil. The smaller the saponification value the higher the molecular weight (Bandyopadhyay *et al.,* 2017). The higher the saponification value, the higher the unsaturated level of the oil. The higher the unsaturation level also indicates the higher the instability of cooking oil to oxidation which has a negative effect to oil quality. It also shows the amount of alkali required for conservation of a definite amount of fat or oil into soap. It is used to check the adulteration of fat and oils (Bandyopadhyay *et al.,* 2017).

Refractive index is a vital optical parameter utilized to examine degree of refraction of the light rays passing through one transparent medium to another (Bhuiyan *et al.,* 2016). The refractive index of edible oils can be approximated with the aid of a refractometer in degrees, at 20°C usually. The value obtained is unique for particular oil and can therefore be used as a quality control method to verify adulteration and purity of cooking oil (Bandyopadhyay *et al.,* 2017; Bhuiyan *et al.,* 2016).

Electrical conductivity - The oxidation byproducts (free radicals) produced due to the repeated high temperature treatment (thermal decomposition) of oils affect the electrical properties as they are the major charge carriers and therefore increase the electrical conductivity (i.e., ionic current) of the oil (Bhuiyan *et al.,* 2016). By definition electric conductivity refers to the degree to which a particular material conducts electricity or is the ability of a material to carry the flow of an electric current (a flow of electrons).

p-Anisidine value (p-AV) - Para Anisidine values are a measure of secondary oxidation products in particular aldehyde content in oils, mainly 2,4-dienal and 2-alkenyl oils **(**Flores *et al.,* 2018). Aldehydes are the carbonyl compounds formed by decomposition of hydroperoxides and can be used as markers to determine degradation of peroxidised materials produced by the heating process (Tabee, 2008). This index (p-AV) has been rated as the most dependable for determining fat / oil oxidation as it measures the accumulation of secondary oxidation products, components that are more stable than hydroperoxides. According to the literature **(**Flores *et al.,* 2018), good-quality oils should have p-anisidine values < 10. Although it's appreciated for its reliability, however there is no indication of how other secondary oxidation products such as alcohols, ketones, hydrocarbons etc. are accounted for in this method.

Total polar compounds (TPC) content is the most vital measure for assessing the deterioration of oils and fats during deep frying. During frying, as oil breaks down, many polar compounds such as peroxides, acids, monoacylglycerol, diacylglycerol and cyclic compounds, as well as oxidized monomeric, dimeric and oligomeric triacylglycerol are formed. The maximum permitted TPC level in frying oil in several European countries is 24-27% (Tabee, 2008). According to Riera and Codony (2000) the recommended upper limit of total percentage of polar compound is 25%, the level at which oil must be discarded prior to reuse in cooking or frying processes.

The TOTOX index / value (TV) is an indicator for the total deterioration of fats and oils. According to Flores *et al.* (2018) this index relates the peroxide index to the p-anisidine index, providing a measure of primary and secondary oxidation products. The total oxidation value, or TV, is calculated by the formula TV = (2 x PV) + *p*-AV (Shinde and Gupta, 2015). The lower the TV, the better the quality of oil. Additionally, the TV is greatly correlated to other oxidation measures for vegetable oils subjected to oxidation processes. The good quality value proposed for vegetable oils is TV < 4 **(**Flores *et al*., 2018).

Factors affecting the value of cooking oil during frying

According to Falade *et al.* (2017) the major factors that affect the value of cooking oil during food preparations include temperature, heating period, oil type, level of saturation, and the presence of antioxidant. This review intends to highlight on the contribution of each of those factors to cooking oil degradation during frying.

Temperature and antioxidant constituents – Temperature is considered as the most significant factor when assessing the oxidative stability of fats,

particularly unsaturated fats. This is due to the dependence of oxidation changes on temperature as different hydroperoxides of linoleate, which serve as precursors of volatile flavours decompose at dissimilar temperatures (Guillaume *et al.,* 2018). The rate of oxidation is exponentially associated with the temperature as such the shelf-life of cooking oil also declines logarithmically with rising temperature. An increase in frying temperature raises thermal oxidation and oligomerization reactions of the fatty acids or triacylglycerol molecules and also of the unsaponifiable minor components (Guillaume *et al.,* 2018). Thus, ***antioxidant constituents*** in oil are either thermally inactivated during frying or have their levels severely reduced (Guillaume *et al.,* 2018). Their inactivation or reduction lowers the oxidative stability of cooking oil and becomes prone to thermal oxidation.

Oil type, heating period and level of saturation - Heat treatment of cooking oil above a certain temperature may alter its physicochemical characteristics nevertheless, the resistance and stability of a variety of cooking oils to thermal oxidation differs depending on their fatty acid compositions. Cooking oils with higher polyunsaturated fatty acids are more prone to thermal oxidation than those with higher saturated fat acids (Falade *et al.,* 2017). Yee *et al.* (2018) examined the oxidative alterations in several types of regularly used vegetable oil, namely palm olein (POo), soybean oil (SBO) and corn oil (CNO). The oils were heat treated repetitively at 150°C for five rounds. The oxidation level of the oils was evaluated by examining their individual changes in fatty acid composition, peroxide value (PV), free fatty acids (FFA) value and p-anisidine value (AV). It was observed that SBO and CNO had significantly higher concentration of unsaturated fatty acids (84.1% and 86.2% respectively) compared to POo (56.8%). Consequently PV, FFA and AV value of the sample oil increased according to their saturation levels: POo < SBO < CNO. Therefore, POo was shown to have the greatest oxidative stability against thermal oxidation, followed by CNO and SBO.

AV increased with increasing number of repeated heating for all the three types of oil. AV was positively correlated to the heating time. SBO had the highest AV, followed by CNO and lastly POo. Yee *et al.* (2018) further indicated that the AV of SBO and CNO after heating for five rounds were significantly higher than POo, which were due to the high proportion of PUFA present in SBO and CNO. Moreover, the percentage of linoleic acid ($C_{18:2}^{n6\text{-}c}$), Oleic acid ($C_{18:1}$) and linolenic acid ($C_{18:3}$), the predominant types of unsaturated fatty acids that are susceptible to oxidation are significantly higher in SBO and CNO, compared to POo. Their study documented the highest content of linolenic acid and linoleic acid in SBO (60.27%) trailed by CNO (53.75%) and lastly POo (11.26%). Furthermore, during secondary oxidation, linolenic acid ($C_{18:3}$) and linoleic acid ($C_{18:2}^{n6\text{-}c}$) acids are more readily oxidized than oleic acid ($C_{18:1}$). The total SFA was the highest in

fresh POo (43.2%), which was about three-fold than in fresh SBO (15.9%) and fresh CNO (13.9%), palmitic acid ($C_{16:0}$) being the major SFA for all the three types of oil. Evuene *et al.*, (2013) when evaluating ten types of vegetable cooking oils subjected to numerous frying of fish recorded higher Malondialdehyde (MDA) concentration in groundnut oil sample compared to other vegetable oil samples, except rancid palm oil sample. MDA is one of the final decomposition products of polyunsaturated fatty acids that are found in rancid foods. The higher MDA concentration in ground nut oil sample than in palm oil samples was attributed to its higher composition of polyunsaturated fatty acids than palm oils. The less susceptibility to oxidation of palm oil than other vegetable samples could be due to higher provitamin A activities in palm oil relative to other vegetable oils. The revisited literature implies that though saturated fatty acids are implicated in bad cholesterol and atherosclerosis but offers a positive stability effect in cooking oil during thermal treatment.

This is further evidenced by the results documented by Mohammed and Idris (2008). They tasted the effects of repeated frying on the composition of soybean oil and vanspati, which were used for long deep frying of potato chips at 170, 180 and 190^{o}C. The result indicated changes in frying fatty acid profile in unsaturated fatty acids whereas saturated fatty acids remained constant. Moreover, polyunsaturated fatty acids constantly decreased proportionally to frying time and temperature. For example, hexadecenoic acid ($C_{16:1}$) originally available in fresh soybean oil in trace concentration disappeared completely after deep-fat frying for 16 hours at 170 and 180^{o} C and after 10 hours at 190^{o}C. Octadecenoic acid ($C_{18:1}$) similarly indicated a gradual decrease within 10 hours of frying period and decreased to 23.3, 20.7 and 19.7 at 170, 180, and 190^{o}C in 70 hours respectively. In addition, fatty acid profiles of soybean oil with antioxidant were not totally different from those without antioxidant, except for few minor variations (Mohammed and Idris, 2008).

Antioxidants and activation energy - It is also further indicated that, the different reactions affecting the oxidative stability of cooking oils are energy driven. Available literature (Guillaume *et al.,* 2018) show that 50 Kcal/mol of energy is needed to break the carbon-hydrogen bond on the carbon of linoleic acid, and to instigate free radical formation. The oxygen-oxygen bond of alkyl hydroperoxide needs 44 Kcal/mol to be broken. Thus, this activation energy is clearly achieved at the temperature used during frying (Guillaume *et al.,* 2018). On the hand the activation energy of lipid oxidation is higher in the presence of antioxidants, because antioxidants lower the rates of oxidation by increasing the overall energy of activation. The existing literature data indicates the synergistic effects of temperature, heating

period, oil type, level of saturation, and the presence of antioxidant to cooking oil degradation though the significance of their contribution could vary from one factor to the other.

Degradation compounds in oils subjected to frying

Owing to its composition and a range of external influences, cooking oil is persistently exposed to a series of chemical reactions such as hydrolysis, oxidation and polymerization during a deep-frying cycle. These chemical reactions are influenced by several factors such as temperature of frying, duration of frying, frequency of frying, type of frying oil, antioxidant and type of fryer (Shinde and Gupta, 2015), temperature being the most significant factor (Guillaume *et al.,* 2018). Vegetable cooking oils contain a variety of antioxidants such as tocopherols, phenolics, sterols, butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), propyl gallate (PG), and *tert*butylhydroquinone (TBHQ) which decelerate the oxidation of cooking oil at ambient temperature. Nevertheless, they turn out to be less efficient at frying temperature owing to their losses through volatilization or decomposition (Shinde and Gupta, 2015).

According to Guillaume *et al.* (2018) antioxidants in oil are either thermally inactivated during frying or have their levels severely reduced. During deep fat frying, fatty acids are separated from the glycerol radical as a result of various reactions, and in addition to the free fatty acids, monoglycerides and diglycerides, polymeric trigylicerides or oxidative degradation products such as aldehydes and ketones are some of the substances produced (Testo, 2015). As pointed out earlier the main reactions responsible for cooking oil degradation are hydrolysis, thermal oxidation and polymerization (***Figure 1***).

Hydrolytic degradation products - Hydrolysis is principally activated by the penetration of water from the product being deep fried. The hydrolytic reactions of triglycerides are associated with the formation of large quantities of free fatty acids, diglycerides and monoglycerides (Riera and Codony, 2000). Through hydrolysis, the water attacks the bond between the glycerol and fatty acid and is then itself split into two parts. The one part (an H atom) attaches itself to the glycerol radical and the second part (OH radical) remains attached to the fatty acid radical (Testo, 2015).

Oxidative degradation products - Lipid oxidation on the other hand is a chief cause of food quality deterioration during deep frying of food products as a result of cooking oil suffering from thermal oxidation. The high content of polyunsaturated fatty acids amplifies the vulnerability of oil to oxidation. Cooking oil resistance to oxidation in the heating process relies mostly on its fatty acid composition and antioxidant level. Oxidation of unsaturated fatty acids arises via free radical chain reaction **(**Shinde and

Gupta, 2015). The products of oxidation, that is, free radicals (e.g. if R = fatty acid radical) react with atmospheric oxygen (O_2) to form oxygen-bonded fatty acid peroxide radicals (ROO).

The resulting ROO in turn gains a hydrogen atom H from another fatty acid and becomes a fatty acid peroxide molecule (ROOH) (Testo, 2015). These peroxides, the primary oxidation products, are very unstable and are the initial point (as they decompose) for the formation of several free radicals and secondary oxidation product such as oxidised and non oxidised, which are highly reactive and take part in several reactions (formation of dimers, cyclic monomers, carbonylic compounds, alcohols, aldehyde, ketones, hydrocarbons, etc (Riera and Codony, 2000; Shinde and Gupta, 2015). In the course of food deep frying, primary and secondary oxidation products can be absorbed into fried food. This leads to change in colour, texture as well as essential nutrients and micronutrients (Shinde and Gupta, 2015). As a result of these chemical changes thus the frying process affects the quality of food both nutritionally and in terms of safety.

However, it should be noted that due to the unstable nature of free radicals and hydroperoxides at frying temperature it means that they are not significant in themselves as harmful compounds and only their significance as reaction intermediaries should be recognized (Riera and Codony, 2000). Nonetheless other studies have implicated free radicals in deleterious effects to health. Venkata and Subramanyam (2016) observed that thermal oxidation of cooking oil produces free radicals and dietary consumption of such oil results in detrimental health effects. According to Okparanta *et al.* (2018) free radicals are also capable of damaging DNA in the cell, cause damage to arteries and work as carcinogens, substances that can cause cancer.

Polymerization products – Polymerization is described by Riera and Codony (2000) as a reaction involving polymerisation of triglycerides. According to Mohammed and Idris (2008) polymerization is a chemical process that results in the formation of higher molecular weight compounds called polymers. Testo (2015) further describes polymerisation as a chemical reaction whereby the unsaturated fatty acids in the cooking oil, under the influence of heat, light or metals (Cu, Fe) and by breaking down the various bonds, react to form first dimers (two connected fat molecules) and then polymeric (large number of connected molecules) triglycerides.

These could either be the non-polar dimers or other non-polar oligomers (Riera and Codony, 2000). Polymers and dimmers represent degradation products that are unique to fried foods and are excellent chemical markers

of oil degradation (Mohammed and Idris, 2008). Polymerization affects the viscosity of the oil which becomes more viscous due to the chain formation of the molecules (Riera and Codony, 2000). The non-volatile decomposition products are responsible for the physical changes in oil such are increased viscosity, darkened colour and foaming (Mohammed and Idris, 2008). These products of degradation produced in cooking oils generally have adverse effects on sensory quality, and in some cases also have destructive effects on the consumer's health, above certain concentrations (Riera and Codony (2000). Figure 1 summarises the different degradation of cooking oil during frying.

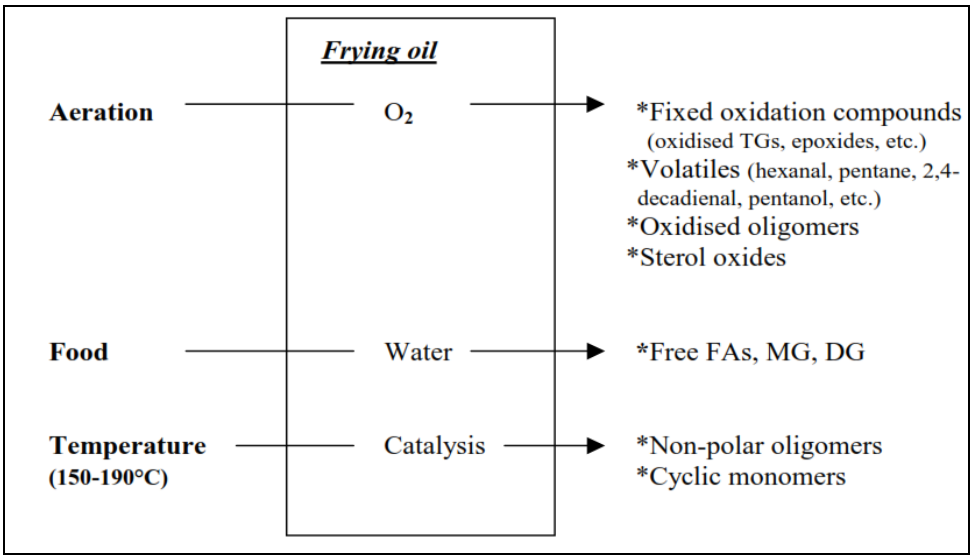

Figure 1: Diagram of the main degradation process and products involved in frying (*Adapted from José Boatella Riera and Rafael Codony (2000)*

Health effects of cooking oil to human health

Edible cooking oils in a non degraded form have numerous nutritional and health benefits to humans nonetheless, their benefits can be destroyed by repeated heating during food preparation that leads to lipid oxidation (Venkata and Subramanyam, 2016). The preparation of food by deep-frying is normally done at a temperature range of between 170° – 200°C which subjects the frying oil to a series of physical and chemical changes (Goswami *et al.*, 2015) such as (i) hydrolysis in which moisture from the fried food vaporizes and hydrolyses triglycerides (TGs) in the frying oil to glycerol, free fatty acids (FFA s), monoglycerides (MGs) and diglycerides (DGs) (ii) thermal Oxidation in which the triglyceride components of the frying oil undergo primary oxidation generating unstable lipid species called hydro peroxides which ultimately breakdown to form secondary oxidation products consisting of non-volatile and volatile compounds. (iii) Thermal Polymerization – upon further exposure to high temperatures

cooking oil produce high molecular cyclic fatty acid (FA) monomers, and TG dimers and oligomers. The resulting oil degradation products due to frying are absorbed with fried food to which the consumer is exposed upon consuming them. These degradation products are associated with a number of health risks as documented by various researchers. According to Venkata and Subramanyam (2016) the quality of dietary oils and fats has been widely recognized to be inextricably linked to the pathogenesis of various deleterious health effects. A more recent study by Flores *et al.* (2018) indicated that deep frying is a possible source of trans-fatty acids. The investigation in hydrogenated and non-hydrogenated vegetable oils indicated their increase when oils are subjected to frying or heating treatments. The intake of trans-fatty acid, especially in high amounts, is associated with systemic inflammation, coronary disease, diabetes, and breast cancer.

Mesembe *et al.* (2004) examined the effects of fresh and thermoxidized palm oil diets on some haematalogical indices in albino rats (Wistar strain). The experimental groups included a group fed on thermal oxidized palm oil (TPO) diet, a group fed on fresh palm oil (FPO) diet and a group fed on normal rat feed (control) only respectively for 14 weeks. They recorded significantly lower packed cell volume (PCV), hemoglobin (Hb) concentration and red cell count (RBC) of the TPO group than that of the FPO group and control group. The white blood cell count (WBC) of the TPO group was significantly higher than that of control group and FPO group.

There were no significant differences between the heamatological indices of the fresh palm oil (FPO) and control groups. They concluded that the chronic consumption of thermal oxidized palm oil diet could result in anaemia and leucocytosis in the rat. Another related study was conducted by Ani *et al.* (2015) to ascertain and compare the effects of consumption of thermally oxidized palm oil (TPO) and thermally oxidized groundnut oil (TGO) diets on some hematological parameters (such as Hb concentration, lower packed cell volume - PCV, erythrocyte sedimentation rate - ESR, white blood cell count –WBC, neutrophil count and lymphocyte count). They observed that TPO and TGO consumption could damage the body's haematological system as it alters Hb concentration, PCV, WBC count, neutrophil and lymphocyte counts. The observed changes were more in TPO fed group, than TGO fed group. The results were generally in agreement with those of previous researchers (Mesembe *et al.,* 2004) which signify the effect of thermal degradation products on human health.

Venkata and Subramanyam (2016) examined the effect of heating edible oils on the formation of free radicals and the harmful consequences of intake of repeatedly heated cooking oil (RHCO) in Wistar rats. Peroxide value of

heated oil, histopathological alterations (red blood cell count and white blood cell count, mean corpuscular volume (average volume of red cells in a specimen), mean corpuscular hemoglobin, hemoglobin and hematocrit (ratio of the volume of red blood cells to the total volume of blood) gives the profile of perturbations in blood), antioxidant or radical scavenging enzyme levels (superoxide dismutase, glutathione peroxidase, cata-lase) and exposure changes in blood biochemistry (glucose, cholesterol, creatinine, protein and albumin) were determined in Wistar rats treated with the repeatedly heated cooking oil **(**RHCO). RHCO showed higher peroxide value compared to unheated (UHCO) or singly heated oil (SHCO).

Histopatho-logical examination illustrated significant damage in jejunum, colon and liver of animals that used oil heated 3 times repeatedly (3RHCO). Their clinical analysis of blood samples revealed elevated levels of glucose, cholesterol and creatinine with decreased levels of protein and albumin in rats' cluster of 3RHCO in comparison to those that received SHCO and UHCO. These results were found to be of concern since the enhancement in such parameters is deleterious to health. They indicate that consumption of heated oils produces indications of altered hematological levels of various blood cells. The findings confirmed that the thermal oxidation of cooking oil produces free radicals and dietary consumption of such oil may result in detrimental health effects. Oxidative stress analysis showed a significant increase in the levels of antioxidant enzymes such as superoxide dismutase, glutathione peroxidase and lipid peroxidation in 3RHCO treated group in comparison to UHCO and SHCO groups. The level of catalase decreased significantly in a similar trend (3RHCO, SHCO and UHCO). The changed antioxidant standing reveals an adaptive response to oxidative stress. Change in the levels of these antioxidant enzymes might be due to the development of reactive oxygen species (ROS) through auto oxidation or enzyme catalyzed oxidation of electrophilic components within RHCO. They hence concluded that, dietary consumption of RHCO can cause genotoxic and pre-neoplastic changes.

Venkata and Subramanyam (2016) findings are consistent with those of previous researchers (Shastry *et al.,* 2011) who evaluated the effects of recycled edible oils (sunflower oil and palm oil) on vital organs of experimental animals (Wistar rats). Their findings demonstrated the alterations in physicochemical characteristics of reused oils. The animals fed with fresh and reused palm oil showed significant increase in the body weight while reused sunflower oil fed group showed a significant decrease.

They related the decrease in weight with oxidation reactions which is one of the key causes of rancidity in fats and oils. This results in the change of major quality variables including nutritional value. The biochemical parameters, SGPT (serum glutamate - pyruvate transaminase), SGOT

(serum glutamate- oxaloacetate transaminase), and ALP (alkaline phoshphatase) increased in reused oils fed groups. The histopathological study illustrated the change in size of the liver including swelling heart, kidney and testes cells in reused oil groups which led to the conclusion that reused sunflower oil and palm oil, can be toxic and may cause huge damage to the vital organs of the experimental animals. Riera and Codony (2000) reported the effects on the hepatic enzymatic activity of the microsome fraction, such as the oxidation systems of the fatty acid chains (cytochrome P450, UDP-glucuronyltransferase, glutation-S-transferase). In their review they attributed some of these effects to very high levels of carbonyl compounds.

Other researchers (Jaarin *et al.,* 2011) in examining the likely mechanism for the blood pressure (BP) raising effect of heated vegetable oils observed that chronic intake of heated palm and soy oils for 24 weeks caused a significant increase in BP. The increase in BP depended on the number of heating repetitions as evidenced by a greater increase in BP when the cooking oils were heated ten times compared to the BP increase when the cooking oils were heated two or five times. They attributed the rise in BP to a higher degree of PUFA lipid peroxidation. They further observed that plasma nitric oxide (NO) which plays a vital contributory role in BP regulation its bioavailability was impaired with repeated heating of cooking oil. The impairment of plasma NO was postulated to be due to generation of free radicals by oxidized oils, such as the superoxide anion, which react with NO to form peroxynitrite. The raise in blood pressure was associated with enhanced phenylephrine-induced contractions, reduced acetylcholine and sodium nitroprusside-induced relaxations relative to the control and rats that were fed fresh vegetable oils. The reduction in plasma NO was indicated to be responsible for the pathogenesis of diet-induced hypertension that resulted from extended intake of heated vegetable oils.

A similar trend was also observed by Chun-Yi Ng *et al.* (2012) when determining the role of swelling in the blood pressure increasing effect of heated soybean oil in rats. Male Sprague-Dawley rats were segregated into four clusters and were fed as follows, in that order, for 6 months: basal diet (control); fresh soybean oil (FSO); five-time-heated soybean oil (5HSO); or 10-time-heated soybean oil (10HSO). After six months, blood pressure had increased significantly in the 5HSO and 10HSO clusters. The aortae in the 5HSO and 10HSO clusters illustrated significantly enlarged aortic wall thickness, area and circumferential wall tension. They concluded that extended consumption of frequently heated soybean oil results in blood pressure elevation, which may be associated with inflammation. Though the findings of both Chun-Yi Ng *et al.* (2012) and Jaarin *et al.* (2011) associated repeated heating of cooking oil with a rise in BP in the test animal

nonetheless their observation of the mechanisms by which this occurs varied between them. The former associated BP elevation with enlarged aortic wall thickness while the latter associated it with enhanced phenylephrine-induced contractions, reduced acetylcholine- and sodium nitroprusside-induced relaxations due to reduced plasma NO.

According to Okparanta *et al.* (2018) chemicals like peroxides and aldehydes are implicated in cell damage and development of atherosclerosis. Free radicals are also capable of damaging DNA in the cell, cause damage to arteries and work as carcinogens, substances that can cause cancer. It is also documented that (Okparanta *et al.,* 2018) an increase in free radicals causes overproduction of Malondialdehyde (MDA). This chemical is indicated to be carcinogenic. Consumption of rancid oil will expose the consumer to accelerated aging, increased cholesterol levels, obesity and weight gain. Day after day consumption raises the risk of degenerating diseases for instance cancer, diabetes, Alzheimer's disease, and atherosclerosis. The breakdown rate and total formation of toxic compounds depends on the type of oil and temperature.

More other studies (Evuene *et al.*, 2013) examined the toxicological potential of ten types of vegetable cooking oils subjected to numerous frying of fish for three consecutive days. The results indicated a marked significant effect on the concentration of lipid peroxidation product Malondialydehyde (MDA) in the various vegetable oil samples. The increase in MDA levels varies with the composition levels of polyunsaturated fatty acids (PUFA). Similarly, the increase in MDA was also associated with a significant decrease in the antioxidant levels (β-carotene and α-tocopherol levels) of the oil samples. This destruction of oil antioxidants implies the decrease in oil oxidative stability. The increase in MDA levels in vegetable oil during repeated fish frying could also be associated with fish oil omega-3 fatty acids in particular eicosapentaenoic acid and docosahexaenoic acid, which are polyunsaturated and hence highly susceptible to oxidation. It is also reported that (Evuene *et al.*, 2013) the ingestion of oxidized edible oils reduces the levels of non enzymatic anti-oxidants in tissues and increases the amount of thiobarbituric acid – reactive substances (TBARS), suggesting an elevation in lipid peroxidation and cellular vulnerability. β-carotene and α-tocopherol are major non-enzymatic antioxidants, which are affected while the amount of TBARS is amplified, signifying an elevation in lipid peroxidation and cellular fragility. Other literatures (Riera and Codony (2000) have documented a certain correlation between the percentage of cooking oil incorporated in the diet and an increase in the Thiobarbituric Acid (TBA) index (secondary oxidation compounds) in the liver, and also a decrease in the plasma tocopherol. Okparanta *et al.* (2018) implicated

formation of free radicals to amplify the risk of developing diseases like cancer or heart diseases along the way.

However, the resultant damaging chemicals and substances due to rancidity do not have immediate harm but can cause harm overtime. Evuene *et al.* (2013) suggested that toxic products such as hydroperoxides and aldehydes, which are generated at high temperature, are absorbed by the food, and subsequently absorbed into the gastrointestinal system and introduced into system circulation after consumption. Riera and Codony (2000) documented an exciting observation of high excretion of endogenous sterols and cholesterol, which increases in line with the increase in the incorporation of cooking oil in feeds.

The genotoxic and carcinogenic risks associated with the consumption of repeatedly heated coconut oil (RCO) have also been evaluated (Srivastava *et al.*, 2010). The polycyclic aromatic hydrocarbons (PAH) were investigated in fresh coconut oil (CO), single-heated coconut oil (SCO) and RCO. The findings showed the existence of certain PAH, recognized to have carcinogenic potential, in RCO when compared with SCO. Oral intake of RCO in Wistar rats caused a significant induction of aberrant cells and micronuclei in a dose-dependent manner. Oxidative stress examination indicated a significant decline in the levels of antioxidant enzymes such as superoxide dismutase and catalase with a simultaneous raise in reactive oxygen species and lipid peroxidation in the liver. Additionally, RCO given alone and along with diethylnitrosamine for 12 weeks induced altered hepatic foci as observed by alteration in positive (g-glutamyl transpeptidase and glutathione-S-transferase) and negative (adenosine triphosphatase, alkaline phosphatase and glucose-6-phosphatase) hepato specific biomarkers. A significant decline in the relative and absolute hepatic weight of RCO-supplemented rats was documented. They concluded that consumption of food prepared from RCO can result in a genotoxic and preneoplastic alteration in the liver.

Some researchers (Adam *et al.*, 2008) studied the consequences of heated palm oil mixed with 2% cholesterol diet on serum lipid profile, homocysteine and thiobarbituric acid reactive substances (TBARS) levels in estrogen-deficient rats. Twenty-four female Sprague Dawley rats were ovariectomized and then separated evenly into four groups. The control group was given 2% cholesterol diet only throughout the study period. The three treatment groups received 2% cholesterol diet fortified with fresh, once-heated or five-times-heated palm oil, respectively. Five-times-heated palm oil resulted into a significant raise in TBARS and total cholesterol (TC) compared to control. There was a significant raise in serum homocysteine in

the control as well as five-time heated palm oil group compared to fresh and once-heated palm oil groups. It was concluded that repetitively heated palm oil raises lipid peroxidation and TC and ovariectomy amplifies the development of atherosclerosis. Feeding with fresh and once-heated palm oil does not cause any harmful effect but repetitively heated oil could be harmful since it causes oxidative damage thus predisposing to atherosclerosis.

Mitigation Approaches of Thermal Degradation of Cooking Oil

Mitigation approaches meant for preventing thermal degradation of cooking oils is important in ensuring their functionality, nutritional and sensory quality. The available documented mitigation approaches include the use of antioxidants and adsorbent extracts and purification of waste cooking oils with water through agitation and decantation. Hemachandra *et al.* (2017) examined the effect of antioxidative extracts on mitigating autoxidation of selected edible oils during deep frying. The effect of extracts of pomegranate (Punica granatum L.) peel, rosemary and oregano on the oxidative stability of Coconut Oil (CO), Virgin Coconut Oil (VCO), Palm oil (PO), Sunflower Oil (SO) and Sesame Oil (SSO) during deep frying of potato chips (170 ± 5 °C/10min) was evaluated. Three anti-oxidative extracts namely, pomegranate pee, oregano and rosemary extracts at 2% (w/w) level were used. The samples were examined for peroxide value (PV) and Thiobabituric Reactive Substances (TBARS). TBARS provide a measure of the formation of secondary oxidative products mainly carbonyls which contribute to the development of off flavour in oxidized oils. The results revealed that both PV and TBARS values gradually increased with the frying cycle across all oil systems tested indicating a gradual rise of oxidation of oils with use. The order of oxidative stability of oils followed the order: SO< SSO< PO< CO< VCO. A significant inhibition of oxidation was observed in all oil systems tested as a result of the plant extracts incorporated into oils during deep frying. The least resistance against oxidation was observed in SSO which is predominantly rich in unsaturated fatty acids while VCO exhibited the highest level of resistance.

Results further revealed that the pomegranate peel powder exerted the strongest antioxidant activity compared to that of the oregano and rosemary extracts. Based on the PV and TBARS values which indicate the generation of primary and secondary oxidative products, the oxidative stability during frying showed the order of SO>SSO>PO>CO>VCO. These results illustrate that the anti-oxidative extracts such as pomegranate peel powder, rosemary and oregano extracts exhibit strong anti-oxidative activity in preventing oxidation of all five edible oils tested and thereby mitigating the generation of both primary and secondary oxidative products. Pomegranate peel extract has been more effective in mitigating oxidation of all oils tested than the rosemary and oregano.

In another study, Rahayu and Supriyatin (2017) examined the role of natural antioxidants and adsorbents in improving the quality of cooking oil that has been used 3 times to fry catfish. An antioxidant noni extract extracted from mature noni fruit and an adsorbent baggase which was derived from waste of sugarcane juice were used. Noni extract are indicated to reduce the number of acid and peroxide value (PV) on used cooking and baggase are implicated to reduce the number of free fatty acids (FFA). Preliminary test end results indicated that cooking oil used on catfish 3 times frying had a PV of 20.2 $MeKO_2$/kg and the number of FFAs of 2.2%, which was already quite high and out of recommended limit. The application of both noni and bagasse on cooking oil registered the lowest peroxide value (0.533 MeK O_2/kg)) compared with administration of bagasse (0.8 MeK O_2/kg) and noni alone (0.67 MeK O_2/kg). The use of noni and bagasse in combination also recorded lower FFAs (1.878%) compared to application of noni (1.94%) and bagasse (2,191%) alone on used cooking oil. Statistical analysis indicated significant variations on both the PV and FFAs in cooking oil and concluded that the use of noni extract and bagasse significantly reduced FFAs and PVon used oil.

Riera and Codony (2000) documented that the simplest purification systems consist of agitating waste cooking oils with water and then decanting and/or centrifuging may be greatly efficient for getting rid of a large fraction of the water, which accompanies these oils, and also for getting rid of solid particles or impurities from the fried foods. Nevertheless, they indicated that the procedure does not permit accurate purification of the oil, as the oil degradation compounds and liposoluble contaminants are retained in the recovered (recycled) oil. They also further reported that such a purification system might be satisfactory for oils with only slight degradation (not exceeding the limit of 25% PC), but with highly degraded oils, this system would not allow recycled oils to obtain rather demanding minimum quality specifications.

In view of these results from previous researchers it can be concluded that the available mitigation approaches can hardly be practiced at housed hold level and in other catering services due to their technological complexity, availability and affordability. It is thus important to limit the repetitive reuse of cooking at household level or in catering serving industries.

Conclusions

The present review article documents numerous nutritional and health benefits edible cooking oils offer to humans when in a non degraded form. The literature further indicates that the value of cooking oil during food preparations is affected by several factors (temperature, heating period, oil

type, level of saturation, and the presence of antioxidant) which demonstrate a synergistic effect to cooking oil thermal degradation though the magnitude of their effect could vary from one factor to the other. During thermal treatments several degradation products are generated due to hydrolysis, thermal oxidation and polymerization reactions and each of the degradation products could play a role on the reported health concerns. The available data further illustrates and confirms that ingestion of higher amounts of thermal degradation products above certain levels could predispose the consumers to a variety of degenerating diseases such as coronary disease, diabetes, cancer, diabetes, Alzheimer's disease, and atherosclerosis. Other documented deleterious effects associated with ingestion of food products prepared from thermal oxidized cooking oils include damage to haematological system which are illustrated by alterations in its parameters and various effects in vital organs of the experimental animals. The rise in BP has also been implicated and attributed to a higher degree of PUFA lipid peroxidation and impairment of plasma nitric oxide bioavailability, which plays a vital role in BP regulation.

Overall the current review provides notable evidence that thermal oxidation has deteriorative effects on cooking oils which is likely to have deleterious effects to human health. It is thus important for the stakeholders to limit the repetitive use of cooking vegetable oil with higher levels of unsaturation in favour of human health. Though mitigation approaches are available however, due to their technological complexity their applicability and functionality at household and other catering service industries can hardly be possible. Thus, limited repetitive use of cooking oil could be a viable approaching to protecting human health.

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Mobile Phones Usage in Improving Access to Cotton Seeds: A Case of Sengerema District, Mwanza Region

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Abstract: *Technological change and adoptability is a fundamental phenomenon from one stage to another. Usually the change to be a change should be demarcated and differentiated from the previous situation as compared to the present situation. The study has identified the value of prompt dissemination of cotton farming practices information in recent years with the aid of mobile phones as a tool for sophisticating farming processes. The major focus was on the application of mobile phones in communication and payment modalities of information between cotton farming stakeholders to speed up the process. The conclusion of the study was based on the data gathered through questionnaires from four hundred (400) cotton farmers in Sengerema District. It was observed that, despite of many people having mobile phones of different nature, they mostly use them to share common information and contributes very minimal on farming practices. Therefore, this study has identified such weaknesses and suggested best practices of using mobile phones among cotton stakeholders in both information dissemination and payment systems. In short, the use of mobile phones in cotton farming practices helped vigorously in spreading information and payments related to agriculture, eventually resulted into good quality and quantity of cotton output.*

Key Words: Mobile phones, Technology, Cotton farming, Information

Introduction

Number of studies describe that the application of mobile phones technology is vital to farmers and supports to the maximum on the crop production (De Silva & Ratnadiwakara, 2010; Duncombe, 2016; Shimamoto et al., 2015; Arinloye et al., 2015; Misaki, Apiola, Gaiani, and Tedre 2018).

The application of mobile phone technology in the crop farming value chain (from the earliest to the final stage of cotton growing) enables both small - scale farmers (SSFs) and large-scale farmers (LSFs) to access farming information that supports optimal decision - making and increases crop productivity. The optimal decision may be on acquiring land/farm, farm preparation, the preferred cotton seeds to be planted, size of the farm, and so many related issues regard to crop production. The farming information includes access to artificial manure, market, loaning financial institutions,

transport facilities and weather information. The positive outcome on the application of mobile phones at transmitting information rapidly to both SSFs and LSFs lead to increased production which improve food security and maximum reduction of poverty in African countries which mostly depend on agriculture as a major economic activity.
Mungera and Karfakis (2013) describe SSFs as people who own between 0.1 and 10 hectares of land while LSFs possess more than 10 hectares per individual and mostly they have an average of more than 15 hectares per each large scale farmer and Small - scale farmers commonly have access to less than 2 hectares of land (NEPAD, 2013; Vanlauwe et al., 2014).

Krone et al., (2016), Mbatia et al. (2013) & McNamara(2009) described that, despite of having very large land for cotton cultivate for both SSFs and LSFs information related to the activities it is very important to be circulated to them so that can stand informed for what they intend to do as far as agriculture is concerned. The easiest way to spread all these information is through mobile phone, and is well accommodated to most of the aspects of cotton production including cultivation seasons and market information.

In Tanzania and Zambia, 75% of the total population derives their livelihoods from agriculture (Kalinda, Filson, & Shute, 2010; Misaki, Apiola, & Gaiani, 2016). Hence, an innovation that increases agricultural productivity cannot be ignored as it improves the livelihood of most farmers. Studies that address challenges facing SSFs and LSFs may be pivotal in reversing a decline in food production and deserve attention (Kalinda et al., 2010). One of the many difficulties SSFs and LSFs face are getting reliable farming information, thus leading to poor and weak decision – making during farming phases (Misaki, Apiola, &Gaiani, 2015). This is one of the reasons that have prompted technology innovators to design mobile phone technology solutions to improve the quality and quantity of information flow. The application of mobile phone technology has, in some studies, been shown to be beneficial to SSFs and LSFs (Aleke, Ojiako, & Wainwright, 2010; Chisita, 2010; Sanga, Mussa, Tumbo, Muhiche, &Haug, 2014).

TCRA 2018; asserts that, mobile phones lead for information transfer, and statistics shows about 99.2% of Subscription Market Share (Zantel – 2% Halotel – 12%, Tigo – 30%, TTCL – 1%, Vodacom – 31%, Airtel 23% and Smart – 0.2%) of Tanzania have mobile phones reflecting that, most of the information can reach to the end user as quick as possible. Not only information, but also money transfer through such networks is also growing with very high speed and reached 96% Mobile Money Subscriptions Market Share (Halotel Money 4%, M-pesa 35%, Airtel Money 26%, Tigo Pesa 30%

and Easy pesa 1%). Since mobile phones play vital role in spread of information and money, then the study on hand has conducted a Systematic Literature Review to explore the application of mobile phones in linking cotton seeds dealers and cotton farmers in Sengerema District – Mwanza Region.

Despite of being informed by researchers like Mahant, Shukla, Dixit, & Patel (2012); Nsimbila, Larsen, &; Kimeme (2014) Saidu, Clarkson, Adamu; Mohammed, & Jibo, (2017) & Saidu et al. (2017) that mobile phones help to spread information but do not address the link between the cotton seeds dealers or agents and cotton farmers in both SSFs and LSFs categories.

Since access to information and an effective and efficient use of the data obtained can improve SSFs' and LSFs' chances to gain competitive advantage in the farming business, the study will conduct **a Systematic Literature Review (SLR) on mobile phone technology** usage in cotton farming projects in Mwanza region specifically Sengerema District which is giant in cotton production of all districts of the region so as to identify obstacles and recommend appropriate future solutions.

Literature Review

The revolutions in crop production, especially cotton started with the mechanical revolution that began with the plow, planter, reaper, and the shift from horsepower to tractor power. The mechanical revolution started after the turn of the 20th century with the replacement of the horse with modern tractors. Meanwhile, due to the advancement of technology, the mechanical approach has been revolutionized by the new availability of computers, software, and satellites which together form, Information Communication Technology (ICT) (Mahant, Shukla, Dixit, & Patel, 2012). This technology enables what is frequently referred to as Precision Agriculture (PA). The precision agriculture technology enables advances from a data-poor to a data-rich environment. Formerly, in mechanical era yields were measured by fields; while with the advance in ICT it is possible to measure yield continuously. With the avail of the Internet services, the farmers' business practices are affected in a similar fashion as it does other types of business (Saidu, Clarkson, Adamu, Mohammed, & Jibo, 2017).

In many successful countries in the world that produces the cotton in great quantity and quality like India, China and USA migrated from mechanical revolution to Precision Agriculture, which possesses the huge potential of ICT to produce, process, store, retrieve and disseminate information like yielding production, market facilitation and financial intermediation services to different stakeholders in the agriculture industry (Mahant,

Shukla, Dixit, & Patel, 2012). Figure 1 (below) depicts the five (05) leading cotton producing countries in the world as per year 2017/2018.

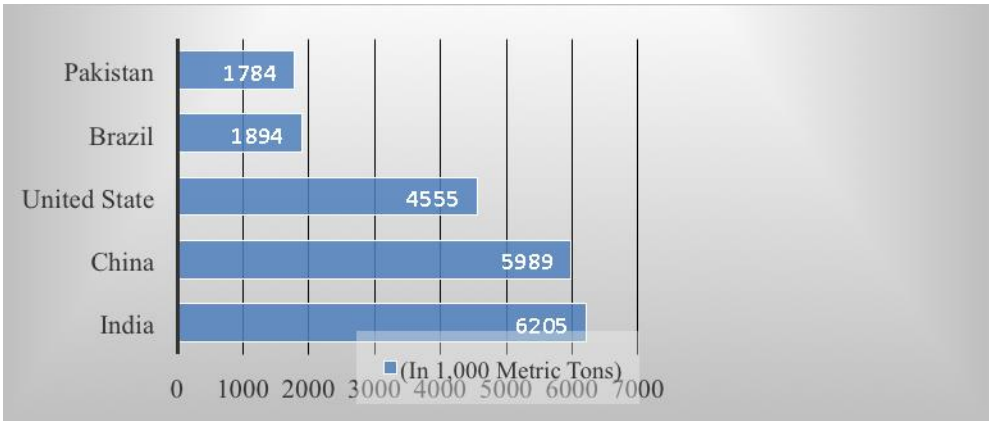

Figure 1: Leading Cotton Producing Countries Worldwide 2017/2018 Year (The Statistics Portal, 2018)

Southern and Eastern Africa is the largest organic cotton production region in Africa. The following Southern and Eastern African countries produce organic cotton: South Africa, Tanzania, Uganda and Zambia. In the past Uganda has regularly been the largest producer of organic cotton fiber in Africa. This position is now occupied by Tanzania due to the many political issues (including the anti-malarial policy) that is currently affecting the organic sector in Uganda. Organic cotton production is currently being trialed in Kenya and efforts are underway to regenerate interest in organic cotton in Zimbabwe (Textile Exchange, 2010).

Tanzania is an East Africa Country which yields cotton as a cash crop for export and internal activities to generate household and national income. The production process of cotton is the major source of household income which relatively employs about 500,000 rural households. More than 90% of cotton is produced in Tanzania are from the southern part of Lake Victoria; Mwanza, Shinyanga, Mara, Tabora, Kigoma, Simiyu, Bukoba and Singida regions (Baffes, 2012). The cotton is produced primarily by smallholders on farms of 0.5 to 10 hectares with an average of 1.5 hectares with a yield of about 750kg of seed cotton per hectare (Nsimbila, Larsen, &; Kimeme, 2014).Traditionally, the type of agriculture conducted in Lake Zone regions are predominantly rain-fed, with the majority of smallholder farmers using hand hoes and animal tracking for tillage, has low-yielding production, lacks access to critical information, market facilitation, and financial intermediation services (Mwangulumba & Kalidushi, 2012).

The moderate quantity of cotton produced in Tanzania particularly in Lake Zone is not associated with rapid delivery of information as a link between cotton seeds dealers and cotton farmers. Information regarding cotton farming practice is not easily accessed by the cotton growers, which is the reason of not producing the right quality and quantity at a proper time. Thus, the study has suggested the way forward in solving this problem to cotton growers, cotton dealers/agents and the market by making them freely interacting and disseminating information instantly through mobile phones as they are requested.

Other Related Works

Saidu et al. (2017) explained that,'e-Kapas' an initiative of utilization of information and communication technologies (ICTs) for delivering appropriate cotton technologies to farmers aiming to improve the efficiency of current manual system by saving time, money and making technologies available anywhere & anytime to users using mobile phones and to connect cotton growers for profitable and sustainable cotton farming in India. Meaning that, all information regarding to cotton faming demands can easily be accessed by using mobile phones at the earliest stage. Therefore, in relation to that, the study on hand will focus at looking on only one aspect which is how the mobile phones contribute on the transmission of information relating to cotton seeds.

Omri, Trish, Liezl, & Kamal (2012) clarified the 'Drum Net', a project of Pride Africa; offers support services to smallholder farmers in Kenya by providing access to information, financial services, and markets. Drum Networks to address the need for access to markets using information technology, efficient business processes, and economies of scale. It combines information, commodity transaction services, and financial linkages into a single business service model that provides access to markets, market information, and credit for the rural poor to support sustainable agriculture and rural development.

Mahant et al. (2012) clarified the role of mobile technology in the Groupe Spéciale Mobile Association GSMA's 'mAgriProgramme', which aims to identify and fund opportunities for mobile communications in the agricultural value chain as an initiative to alleviate food security related problems.

Statement of the problem

Misaki, Apiola, Gaiani, and Tedre (2018), Mbatia et al. (2013) & Mwangulumba & Kalidushi, (2012) emphasized that, mobile phones have great impact at spreading information from one point to another, either by using short messages (SMS) or through the use of social media such as

WhatsApp, Facebook, Instagram, IMO, the few to mention where the information may be bad or good. The studies have tried to point some areas that mobile phones are useful at spreading agricultural information such as access to artificial manure, market, weather (temperature and rainfall), and financial institutions.

However, on crops' information transmission particularly on seeds awareness to farmers by agents/dealers is common to maize, pineapples, and tomatoes simply by dialing *150*43# which is the most common Unstructured Supplementary Service Data (USSD) for the registered members to the mobile network providers. Therefore, studies have not covered on how cotton seeds information can be accessed by cotton famers through mobile phones. The Systematic Literature Review (SLR) explored about the knowledge of cotton farmers towards accessing information thorough mobile phones and provided critical recommendation for succession. The study filled the gap of knowledge of information transmission and on time delivery of cotton seeds to the cotton farmers which required close interaction between cotton seeds agents or dealers and cotton farmers so as to speed up the farming process which is the solution to both cotton farmers and cotton seeds agents/dealers within a lake zone.

The Research Rationale

The rationale of this study is seen in the outcome by supporting the knowledge on how cotton farmers can easily access information related to cotton seeds which can help to facilitating best cotton farming practice as the solution to both cotton farmers and cotton seeds dealers.

The study has emphasized on creation of a strong link of information to all stakeholders of cotton production, market facilitation, and accessibility of the financial intermediation services within the agricultural industry.

In additional to that, the study has transformed Tanzania cotton smallholder farmers to adopt the precision agriculture technology that enriches cotton stakeholders with precise information and cost effective approach about best farming practices by improving the income which relatively employing about 500,000 rural households (Nsimbila, , Larsen, &; Kimeme, 2014).

Furthermore, it is perceived that this study has enhanced the cotton statistical data by; providing accurate data/information, data acquisition and processing, storage, filtering and dissemination for the respective user/stakeholder as per needs.

The General Objective

The general objective of the study is to investigate how mobile phones can improve access to cotton seeds by cotton farmers in Sengerema, Mwanza.

The Specific Objectives

(i) To identify the crucial cotton farming information for both cotton farmers and seeds agents/dealers.
(ii) To assess how the cotton farmers and seeds middlemen interacts each other through mobile phones when transacting cotton seeds.
(iii) To measure the potentials of mobile phones in strengthening information flow and mobile money transaction between cotton farmers and cotton seeds agents/dealers in Sengerema

Constraints encountered during the study process

The possible constraints of the study were as follows:

(i) *Accessibility of the areas;* the production of cotton in Mwanza is mostly experienced in the remote areas and difficult to reach during the rainy seasons. The organization of the study managed to access these areas before and during the rainy seasons by using vehicles which are friendly to the said environment.
(ii) *Language barrier;* the cotton farmers with their greatest percentage were from rural sides where Swahili and English are not their mother languages. The study prepared to recruit research assistants with the great familiar about the mother tongue (language(s)) as per Mwanza region. In addition to that, the data collection tools were presented according to the language which is most spoken in a particular region/area.
(iii) *Poor response from the respondents;* ninety percent (90%) of cotton farmers are from the rural areas; the majority of them, they possess negative attitudes when asking for what they always believe is their rights (ownership). The study explained and provided the general knowledge by offering the aim, objective of the study and how is significant to them.

Methodology

Study design

Due to the nature of the research, the study has employed exploratory research design as it is in the interest to clearly explore the link on how mobile phones can enhance easy access of information regarding to cotton seeds so as to speed the cotton farming practices. The systematic literature review research design has helped to establish priorities in developing operational definitions so as to improve the final research output and eventually to establish the link between dealers of cotton seeds and cotton farmers.

With regards to the approach, the study employed both qualitative and quantitative research approach. Qualitative research involves collecting, analyzing and interpreting data by observing what people do and say. Hence this is crucial in obtaining field views from the farmers and dealers of cotton high bread seeds and creating a better way that these important two parameters of cotton farming can interact and create strong relationship for speeding up the process.

Moreover, a case study or in-depth study involved to acquire specific issues regarding the difficulties that farmers face at acquiring the relevant seeds for cotton cultivation. Quantitative data on the other hand were used for analysis, providing descriptive, comparative and statistical results for the study generalization.

Study place

The research has covered Sengerema District in Mwanza region as a case study. However, in Tanzania there are mainly two cotton regions; Western Cotton Growing Area (WCGA) and the Eastern Cotton Growing Area (ECGA). The WCGA consists of regions of Shinyanga, Simiyu, Mwanza, Mara, Geita, Tabora, Kigoma and Singida and accounts for 97-99% of the total cotton production in the country. The ECGA includes Manyara, Morogoro, Coast, Kilimanjaro, Tanga and Iringa regions and accounts for the remaining 1-3% of cotton production (Mwangulumba & Kalidushi, 2012).

Hence based on the grounds of their contribution, it has been observed that, Mwanza region is a giant for cotton production form the year 2008/09, 2009/10, and 2010/11, 2011/12 of all regions but dropped suddenly at a significant quantity for the year 2012/13 which influenced the authors to select Sengerema District in Mwanza region as the study area focusing on the contribution of mobile phones in speeding up cotton farming practices. The reason of opting for Sengerema District is due to the study done by Cotton & Africa (2014) asserting that, among the districts of Mwanza Region, Sengerema is outshining others for an average of 9% to 11% every year.

Socio-Economic and Demographic Characteristics of Cotton Production Regional wise

The area's main source of income is agriculture, including farming and livestock. Most of the country's cotton is grown in the lake zone, and other crops include sorghum, cassava, tobacco and peanuts. Apart from agriculture, gold and diamond mines are another major source of income. In Mwanza, located along the shore of Lake Victoria, many people work in the fishing industry.

Table 1: Seed Cotton Production from 2008/09, 2009/10, 2010/11, 2011/12, and 2012/2013 in Western Eastern Cotton Growing Areas

Zone	Region	*2008/09*	*2009/10*	*2010/11*	*2011/12*	*2012/2013*
Western	Simiyu					147,564
	Geita					35,730
	Shinyanga	75,744	59,637	33,669	50,206	45,100
	Mwanza	220,808	174,162	105,143	138,383	64,800
	Mara	53,283	10,986	10,705	15,940	20,925
	Kagera	2,559	4,700	1,827	3,734	1,029
	Tabora	13,451	15,650	10,737	14,842	32,700
	Kigoma		1,336	47	386	429
	Singida	1,300	294	753	883	2,000
Total Western		**367,145**	**266,765**	**162,881**	**224,374**	**350,277**
Eastern	Manyara	898	172	490	768	1,496
	Morogoro	307	33	73	564	204
	Kilimanjaro	84	6	33	25	28
	Pwani	84	19	28	120	41
	Tanga	157	5	11	77	35
	Iringa	23	4	1	10	80
Total Eastern		**1,552**	**230**	**636**	**1,564**	**1,884**
Grand Total		**368,697**	**267,004**	**163,517**	**225,938**	**352,161**

Source: Tanzania Cotton Board Annual Report 2013

Sengerema District (Mwanza region) has been selected to be the area of the study since has good population of cotton growers. Most of the dealers of cotton seeds are situated in Mwanza as headquarters in Lake Zone however; they have small offices in other regions of Lake Zone. Therefore, the study has focused in Mwanza region specifically Sengerema district since we expect to receive more information for generalization. However, to cover the entire region is very difficult, because consumes time, more resources and cost, therefore the study dealt with only one district of Mwanza region namely Sengerema District. Coulson, (2016) & Cotton, & Africa, (2014) identified Sengerema District as the giant in cotton production within Mwanza region which provided a base for authors to assume that, the District have vital information for generalization.

Study Population and Unit of Analysis

The study used individuals as the unit of analysis, whereby, the target population of the study covered both large and small-scale cotton farmers. Moreover, cotton board, agricultural consultants and extension officers, export and import processors were consulted so as to acquire the necessary information regarding delivery of necessary information on how cotton seeds can easily reach cotton growers. The rationale behind choosing this study population is related to the homogenous nature of problem which is the delay of information about cotton seeds to the cotton growers.

Sample Size

Sample Size Selection

In conducting a study, it is not possible, practical and sometimes expensive to collect data by taking into account the whole population. Thus, a sample was chosen to represent the relevant attributes of the whole of the units (Resnik, 2011).

According to Nsimbila, Nylandsted, & Kimeme, (2014) presented that the entire Western Cotton Growing Area in 2012 covered more than 50 competing ginneries and had 350,000 registered smallholders. Therefore, target population was 350,000 which used in the determination of true sample.

Saunders (2011) proposed a use of infinite formula in order to select sample for the study. Thus, this study adopted the following formula to calculate the sample size.

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

Where

n = Sample size

N= Targeted Population (350,000)

e = The precision level (error of estimations) (5%) i.e. 95% Confidence interval

Thus

$$n = \frac{350,000}{1+350,000(0.05)^2}$$

n = 400

Based on this formula the sample size that used for this study were 400 cotton farmers based in Mwanza region covering only Sengerema.

Study Procedures

Based on this nature of the study, the data were collected from both small scale and large-scale farmers. Due to the nature of the study only simple random sampling technique were used to collect information, meaning that every individual had equal chance to provide information so as to fulfill the demand of the study. The purpose of employing this method in gathering information is to ensure the sample selected have true representative to the true population that they are cotton farmers and the same time they had convenient time to participate in answering the questions for the study as proposed by (Saunders (2011).

The kind of information gathered should reflect on how mobile phone is useful at receiving and transmitting information relating to cotton seed in both availability of cotton seeds and payments through mobile phones.

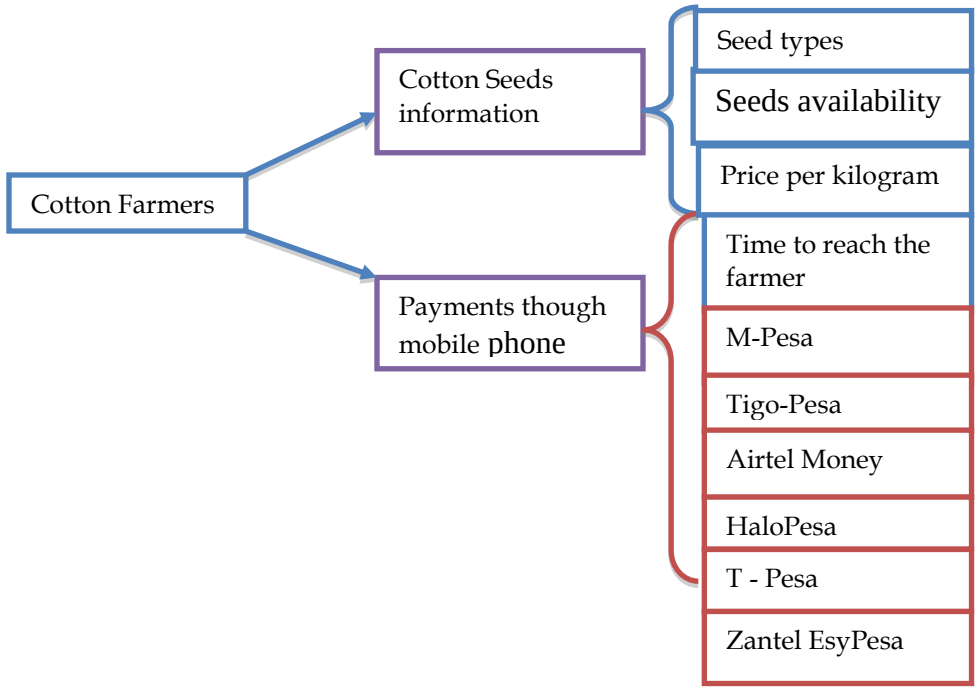

Figure 2: The diagram above depicts the information relations as demanded by farmers so as to fasten farming process

Methods of data collection and study tools

This research used both primary and secondary data because the interest of the study is to determine the contribution of mobile phones at speeding up the rate of information delivery about cotton seeds to the cotton farmers. For example, manures can easily be accessed through mobile phones *150*53# for YARA TANZANIA, where the study has suggested to be the same even for cotton seeds. Primary data will involve the collection of data from respondents by the use of a questionnaire, focus group discussion, interview guide and the information from respective cotton bodies. The use of the questionnaire was justified because it is an effective way of collecting information from a large literate sample in a short period of time and at a reduced cost than other methods.

Additionally, questionnaires facilitate easier coding and analysis of data collected (Resnik, 2011). The questionnaires were important tool in assessing

whether the model is effective in facilitating best farming cotton practices. Focus group discussion and interviews were engaged to collect information which were not readily available from the prepared data collection tools. The communication process through mobile phones in farming process has enabled cotton farmers to ask and receive cotton farming information easily which resulted to the increased cotton productivity and the welfare of all cotton farmers. The process become softer due to vital information gathered from cotton farmers in solving the problem of information delay as demanded by cotton growers.

Data Analysis Methods

The researcher applied both qualitative and quantitative methods of data analysis in order to provide the reliable results or findings to the research study. Data collected through questionnaire especially closed ended questions were analyzed using Statistical Package for Social Sciences (SPSS). Descriptive analysis in the form of percentages and univariate measures such as mean were used to analyze the data and were presented in form of tables. The data collected through personal interview and documentary review were analyzed using content analysis.

Ethical Considerations

Ethical considerations form a major element in research. Ethical research principals: honesty, objectivity, integrity, carefulness, openness, respect for intellectual property, confidentiality, competence and legality are important to follow (Resnik, 2011). Thus, the study carried out considering a range of ethical principles such as Obligations to Subjects in terms of avoiding undue intrusion, obtaining and adjusting informed consent, protecting the interests of subjects, enabling participation, maintaining confidentiality of records, preventing disclosure of identities. Obligations to Colleagues in terms of maintaining confidence in research, exposing and reviewing their methods and findings, ensuring safety and minimizing risk of harm to field researchers and referencing texts that belong to other authors in APA style.

Results and Discussion

The findings were based on the commonalities between the needful information by both cotton farmers and dealers or agents of cotton seeds. The important issue in this aspect is to measure the speed of information delivery and associated payments with the aid of mobile phone. Moreover, is to assess on the interaction between cotton seeds agents and the cotton farmers. Finally, is to measure the potentiality of mobile phone in strengthening cotton farming process.

Results

The systematic literature review has tried to explore the cotton productivity in the lake zone regions, from the year 2008/2009 to 2012/2013 indicating the production trend in tones from each mentioned region and zone as indicate in Figure 1. However, the Cotton Board report does not state anything on how mobile phones had been potential at transferring information related to cotton farming.

Hereunder is the needful information by the cotton farmers and dealers/agents percentage-wise as rated by the respondents;

Table 2: Cotton seeds information

S/N	Needful information	Frequency of information in %
1	Information about availability of cotton seeds	52
2	Information about types of seeds	43
3	Information about price per kilogram	71
4	Information about time frame to reach the farmers	16
5	Information about cultivation seasons	32

Table 3: Mode of payments

S/N	Needful information	Frequency of payments (%)
1	Payment through bank account	19
2	Payment through debit or credit cards (Visa & MasterCard)	2
3	Payment through M-pesa	81
4	Payment through Tigo pesa	78
5	Payment through Airtel Money	59
6	Payment through HaloPesa	9
	Payment through T - Pesa	0
	Payment through Zantel EsyPesa	0

Discussion of findings as per study objectives

Both systematic literature review and random sampling reflected that the application of mobile phones in cotton farming is being practiced; however, is not so active for early delivery of some farming vital information. Information provided in Table 2 and 3 rated in percentages tries to provide an overview about the application of mobile phones in speeding up the cotton farming process. The information is categorized into two important aspects, which are general cotton seeds and mode of payment information which are the most important in strengthening quality, quantity, accessibility of cotton farming information and products at an affordable cost to all stakeholders

The crucial cotton farming information for both cotton farmers and seeds agents/dealers.

Cotton farming information is power to cotton stakeholders in Tanzania, because help to create awareness on situations regarding cotton

productivity, market availability, availability of cotton seeds, cotton market price, harvesting time, and the cultivation seasons (Nsimbila, Larsen, & Kimeme, 2014). The researchers have made thorough analysis of the information gathered from the respondents as they rated the identified crucial information as indicated below:

(i) Information about availability of cotton seeds

The cultivation of quality cotton seeds in a well-controlled environment, usually results into good yields during harvesting period. This information reaches customers (cotton farmers) for an average of 52%, which is very low speed depending on the potentiality of the information. Therefore, there is a need to stimulate the spread of such information up to about 90% - 99% so as to increase sales on cotton seeds agents and increase of production of quality cotton and its products at appropriate time.

(ii) Information about types of seeds

Type of seeds is very important because farmers sometimes they cultivate basing on the nature of the environment (climatic condition) therefore could be in need of specific species. Despite of these information to be readily available, but mobile phone usage at spreading such information is not sufficient and constitute about 43% which should be increased to manageable level so as to sophisticate the process.

(iii) Information about price per kilogram

Price per kilogram is very important to be aware by the cotton farmers at appropriate time and can help farmers to budget appropriately. A reasonable average of 71% of reach ability of information through mobile phones to the customers about the pricing models of cottons seeds helped to make decision at right time.

(iv) Information about time frame to reach the farmers

Distance from the agents of cotton seeds and to the farmers matters a lot to determine the time frame at which when demanded can arrive to the farmers at right time. Respondents (cotton farmers) responded that, the information regarding cotton farming practices are disseminated to all stakeholders, however at a lower speed as rated by 16%. Thus, the study has suggested using mobile phones in disseminating information at high priority to simplify the ordering and delivery process of cotton seeds, manure and to the market as demanded by users.

(v) Information about cultivation seasons

32% of the respondents agreed that, mobile phones rarely help to share some information rapidly about the cultivation seasons; however, some of

them are less concerned with it, because they are aware with cotton cultivation seasons and amount of rainfall supporting the farming practices. Respondents further clarified that, amount of rainfall is not stable since fluctuates seasons to season or year to year which sometimes making them to depend on the information from weather forecasting agents for cultivation implementation.

Shimamoto, Yamada, & Gummert, (2015) and Saidu, et al., (2017). Emphasize that, mobile phones are vital at speeding up information of any nature (text messages, calls or social networks) and that if used properly in agriculture, brings greater impacts which can be quantified into outputs. Thus, the study has created awareness to cotton growers to adopt new means of disseminating information through mobile phones.

The cotton farmers and seeds middlemen interact each other through mobile phones when transacting cotton seeds

Shimamoto, Yamada, & Gummert, (2015) and Saidu, et al., (2017) asserts that, before realization of mobile phones as vital tool for disseminating agricultural information, cotton farmers used internet to communicate through emails, however was not popular because few classes of farmers had Information Technology (IT) skills. Nsimbila, Larsen, & Kimeme, (2014) points out that, the adaptability of cotton growers to dissemination of information through mobile phones is growing gradually and possibly to be high in recent years after emphasis by many researched publications. The respondents argued that, mobile phones despite of not being adopted by many farmers with reasons like unable to use, illiteracy, and difficulties to accept such technology, but it is health to persuade them because is useful in speedy dissemination of information as well as escaping the possible intermediary costs.

The potentials of mobile phones in strengthening information flow and mobile money transaction between cotton farmers and cotton seeds agents/dealers in Sengerema

Mobile phones play vital role of completing payments instantly at any time so long there is network Mahant et al. (2012). Payments through mobile phones is easy and accessible more than banks with the reason that, banks have limited operation time, while mobiles phones have no limited time and money can be retrieved from bank account to mobile phone, then payments can be made as per requirements. Respondents have valued the payment modalities as per their views as listed below:

(i) Payment through bank account

Banks are very scattered, commonly are located in towns and some famous areas basically a place with specific economic activities like mining, large industry like that of Dangote in Mtwara – Mikindani. There banks are not sufficient tool for completing payments because farmers basically are situated in rural areas. Therefore, this kind of payment modality does not favor majority as rated very low for about 19% of total respondents. However, a number of Bank agents have started opening-up much closer to people in both rural and urban areas so there could be some improvement in this payment mode in near future.

(ii) Payment through debit or credit cards

Debit or Credit cards are not popular payment method for Tanzanians. Debit or Credit cards are commonly used for foreigners especially who come to visit Tanzania National Parks where they do not accept cash payments rather through these cards. Only 2% of total respondents are able to use debit or credit cards, that is to say this payment modality for cotton farmers is not common and is totally disparaged instead they need to use payment system which is user friend and readily available to most of farmers.

(iii) Payment through M-pesa

M-Pesa is one of the most commonly payment modality which is rated by good number of respondents for 81%, that is to say is the most preferred by the good number of cotton growers and dealers around the lake zone. The underlying assumption on this aspect is that Vodacom has more customers around Lake Zone as compared to other networks.

(iv) Payment through Tigo - pesa

78% of the respondents have been paying and still suggesting the payments to be made through Tigo – pesa.

(v) Payment through Airtel Money

59% of the respondents have been paying and still suggesting the payments to be made through *Airtel Money*

(vi) Payment through HaloPesa

9% of the respondents have been paying and still suggesting the payments to be made through Hallo – pesa. However, this is not popular because the mobile network is very new in the market since it was introduced in Tanzania late 2016. Therefore, has very few customers and yet not adopted to use Hallo – pesa in cotton seeds payments to cotton dealers.

(vii) Payment through T-Pesa and Zantel Easy-pesa

In Sengerema District of which the study was conducted, no any cotton stakeholder among the sampled respondents used in making payments through mobile phones by TTCL (T- pesa) or Zantel (EsyPesa). Mobile phone payments is increasing gradually and counting an average of 56.7% which is above the average of other payment modalities by 43.3%. Misaki, Apiola, Gaiani, and Tedre (2018), Mbatia et al. (2013) & Mwangulumba & Kalidushi, (2012). Encorages cotton growers to devote on mobile phones payments and dissemination of cotton farming information to speed up farming practices with the possible minimum costs.

Recommendations

Mobile phones are common and superior in transferring information from one point to another in recent years as compared to the previous years where we had only internet and e-mails. Through introduction of mobile phones particularly smartphones have termed as universal due to the fact that have covered all the areas of communication like, internet (emails), social networks and ordinary messages. Moreover, mobile phones have facilitated rapid flow of information in different forms like audio, video, text/files, pictures, and others at right time. Mobile phone has helped much on strengthening the link between cotton seeds' agents and farmers on timely delivery of related information such as general seeds information and payment modalities.

Each payment modality is sufficient depending to the user of the mobile network, however debit or credit cards are not popular to both sides (cotton seeds agents, farmers and other stakeholders), and therefore through observation is suggested to be ignored and adopt to bank and mobile payments because they are secured, easy to transact, easy to realize payments, and services are abundant especially when considering that rural electrification has covered much more villages and more banking services are increasingly brought closer to people in urban and rural areas through their agents.

Since the interaction between cotton farmers and cotton seeds' agents is not significant yet, therefore it is recommended to be increased so as to make all the necessary information readily available to all respective categories.
It is also recommended to government as policy maker to include and formalize payments through mobile phones and to enforce all the cotton stakeholders to adopt for their own future benefits.

Conclusion

In recent years, most of Tanzanians are good users of mobile phones. However, they are mostly using for normal communication and rarely for agricultural information transmission and associated payments.

The study found that, cotton farmers sometimes disseminate information related to cotton farming and in any other business categories through mobile phones.

The study's focus was on contribution of mobile phones in communication of information between cotton farmers and seeds' agents/middlemen which has been in average; therefore, this study has suggested to activate the flow of information so as significantly can increase productivity and cost-effectiveness for coming out with quality and quantity of cotton outputs. The study has observed that, there is insufficient utilization of mobile phones particularly for farming; therefore, it suggested to be utilized vigorously so as to make cotton farming practices much better and raising productivity to the reasonable level.

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Financial Inclusion and Cluster-Based Industrialization

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Abstract: *There are two related lines of arguments which forms twin objectives for this study. The first is to assess how financial inclusion may spur industrilization in Africa, and the second is to assess how industrialization may prosper where there is clustering of SMEs/industrial activities in Africa. The study employs a quantitative approach where regression analysis is used employing secondary data from the World Bank Development Indicators for Seven African economies. The study found that clustering promotes industrial growth. It has also found lack of evidence for the role of financial inclusion in promoting industrial growth. It also did not find statistical evidence for joint effects of these factors on industrialization. It calls for policy dressing and specific researches in the areas of clustering properties and financial inclusion and their effects on industrial growth.*

Key words: financial inclusion, clustering, industrialization, industrial growth

Introduction

Developing countries, particularly in Africa have looked at small industries with hopeful stances, waiting to see how they could contribute to industrialization process. Evidences have been established that point to the crucial roles that clustering played in promoting industrial growth in China (e.g. Long & Zhang, 2011; Zhou *et al*., 2019; Zhu *et al*., 2019) and in Africa as well (e.g. McCormick, 1999). Some of the notable contribution of clustering to industrial growth are the breeding of collective efficiency, encouraging growth in small steps and swiftness in responding to opportunities and crises, promoting start-ups, labor/skills pooling and boosting export performance. (McCormick, 1999; Long & Zhang, 2011). Clustering is expected to easy and or solve some of the challenges that face Africa in the industrialization process (McCormick, 1999).

The African industrial cluster experiences can be summarized based on the work of McCormick (1999). He studied six cases from Ghana, Kenya, and South Africa and found that the African clusters were characterized by a combination of some of the following features; high heterogeneity, less connectivity, weak bilateral/multilateral links, weak technology spillovers, good/bad horizontal/vertical cooperation and good/bad market access.

Conversely, an important feature of the Asian industrialization experience is marked by the presence of indutrial clusters that are highly inter-related, cross-linked, densely connected and enjoying collective efficiency (Zhu *et al.*, 2019). These clusters are characterized by closer interactions within same regions, high complementarities in both real and financial resources, skill sharing possibilities and an intergrated structure of dissaggregated small steps production that are performed by a large number of firms (Long & Zhang, 2011). This feature has ushered in the contributions of clusters to economic growth in a much shorter decade-period of time in Asia particularly China than the century- length of time that Europe and America took to accomplish the same. In the context of industrial clusters, based on Cluster theory, industries have been able to reap immense benefits from symbiotic relationships such as; sharing of labour, capital, technologies and other transfarable inputs which led to industrial growth. Further evidences indicate that, clustring brings about skills sharing, builds credit trust, and an efficient way for financial institutions to facilitate firms financial inclusion and reap the benefits thereof (Long & Zhang, 2011).

Clusters present a new thinking about state, nation and local economies. They reshape roles of companies/SMEs, government and institutions in competition. Clusters are structural agglomerations of linked suppliers, service providers, firms in related industries, and allied institutions. A cluster acts as an entity for competitive exploration along with a specific firm and industrial cluster (Porter, 2000). On the other hand, developing a financial system that leads to more financial inclusion is a pre-cursor to SMEs/industrial development (Long & Zhang, 2011).

One important stakeholder in the industrial cluster framework are the financial services providers. They are able to offer credits at lower rates due to familiarity and trust built within the industrial clusters to which they are connected. The question which one raises is that, how financial inclusion within this context is able to lead cluster-based SMEs/industrial growth. In Asia, particularly China, industrialization took a few decades, whereas in Europe and America it took more than two centuries. How can Africa learn from China and possible replication within its context is the focus of this research?

This work addressed the following specific objectives as stated below:

1. To assess the effects of firms clustering on industrial growth in Africa
2. To assess the effects of financial inclusion on industrial growth in Africa
3. To assess the interaction of financial inclusion and financial inclusion size on industrial growth in Africa
4. To assess the interaction of financial inclusion and firm clustering on industrial growth in Africa

The article is organized as follows; after the introduction, the second major part contains a review of literature detailing; clustered industries and cluster theory, emperical evidence for cluster-based industrial growth, and financial inclusion in cluster-based industrial growth. The third major part contains the methods section describing the data source, variable measurements and models assessed, and the fourth section include a presentation and discussion on findings and last section presents both conclusions and recommendations.

Literature Review

Clustered Industries and Cluster Theory

Michael Porter in 1990 put forward what is popularly known as the Cluster theory (Porter, 1990), which he further explains in the context of industrial clusters (Porter, 2000). It is a micro-economically based theory of national, state and local competitiveness. The theory proposes a prominent role played by clusters in the economy. The theory envisages clusters covering not only firms of the same kind. Firms in a cluster may include agglomerations of firms across firms of a similar nature that share complementarities and or compete in the same level. They may include firms on a vertical level, such as the supplier's chain or customer's line.

They include an array of industries and entities crucial to competition. The interaction that make up a cluster span from functional forms that offer skills, informational, knowledge, research, technology, resources, product, infrastructure, to institutional and forms that share, compete and complement various listed resource types (Porter, 2000). "Drawing cluster boundaries often is a matter of degree and involves a creative process informed by understanding the linkages and complementarities across industries and institutions that are most important to competition in a particular field" (Porter, 2000: 3). The importance of the cluster "spillover" effects and their significance to productivity, innovation and industrial growth are cluster-boundaries determining factors.

For the sake of disambiguation and clarity, clusters may or may not correspond directly to aggregate industries such as manufacturing firms or beverage firms, etc. in this case the connections between firms may be weak and miss the whole idea of a cluster (Porter, 2000). Clusters occurs in many varied contexts; national, local, cities and in developed as well as developing countries. Clusters are more advanced in developed countries than in less developed countries. It is worth noting that cluster boundaries rarely conform to standard industrial classifications systems that fail to capture the acts in competition and linkages across industries in a cluster (Porter, 2000; Shakya, 2009).

The appropriate characterization of a cluster can vary in diverse locations, conditional on the segments in which the member companies compete and the strategies they employ. The theory indicate that boundaries of a cluster may evolve as new firms emerge, shrink, decline or change, new linkages may emerge or shift. Clusters are not viewed through traditional lenses of grouping firms, such as company types, sectors, industries or Standard Industrial Classification (SIC) codes, because clusters are aligned with the nature of competition and the role of governments (Porter, 2000; Zeng, 2012; World Bank, 2009).

Based on cluster theory, clusters in a micro-economic sense usher in a novel intelligence for local economies that aspires for industrialization. They restructure roles of participants in the economy (Porter, 2000; Zeng, 2012). "Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (Potter, 2000: 1) and consequently contribute to industrial growth. Clusters reveals the microeconomics of competitions. They suggest that a whole lot of competitive advantages lie outside a company and even outside its industry but within a cluster or between several clusters. Theoretically, a cluster acts as a unit of competition along with the firm and its industry. Thus, clusters are a driving force for exports and attracting new and foreign investments, which in turn drives industrial growth. Stated otherwise, a cluster is "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster relates to the distance over which informational, transactional, incentive, and other efficiencies occur" (Porter, 2000: 2), thus the degree to which there is effectiveness and efficinecy in these afore mentioned properties have a hypothetical positive effect on industrial growth.

Zhou *et al*. (2019) note that the formation of industrial clusters requires the following conditions; location agglomeration, complete independent industrial chain, industrial networks through widening of the vertical and horizontal production value chain. Further development of industrial clusters is achieved through specialization in production, markets and development of specialized support services and professional skills essential for further refinement of the production process (Porter, 2000). Cluster development increase in linkage with rural industrialization, urbanization, development of small towns/cities and industrial park formation which in turn create market and sources of materials. A large population propels growth of clusters by harnessing cheap labor from it which is easily pooled into these industrial clusters.

Ray (2019) posits that the development of industrial clusters takes either of two routes: spontaneous or policy driven. Spontaneous route follows the natural factors selection, for instance some clusters in the Chinese experience for example in Zhejiang, Guangdong, Fujian, Shandong provinces did emerge from this route, while policy driven route is set by government actions for instance the famous Silicon Valley cluster in the USA.

Empirical Evidence for Cluster-Based Industrial Growth

Evidently, entrepreneurial activities play crucial role in promoting cluster formation, size and strength. (Zhu *et al*., 2019). In their study, they indicate that entrepreneurial activities such as number of private firms, nascent and private and small firms; contribute significantly to industrial clusters formation, size and strength. They point out other significant determinants of cluster formation as being; geography, natural advantages, and agglomeration aspects such as localization, urbanization and population density. The concept of clustering can be captured in different ways depending on the focus of the study. For instance; to capture the concept of clustering, McCormick (1999) considers physical conglomeration in locations for the industries in terms of numbers. Conversely, Long and Zhang (2011) use a clustering algorithm that captures the idea of industry proximity based on sharing of resources such as asset, labor or outputs in terms of how industries interact one and another in terms of these resources. Despite the difference, the thrust of this review is to look at how clusters play a role into industrial growth process.

Industrialization entails building an economy's capacity to transform raw materials into new products and enabling the production system to function (McCormick,1999). There are two ways to look at industrialization and industrial growth; focusing on manufacturing value addition and focusing on firm performance per se. Long and Zhang (2011) find positive relationship between clustering and firm performance. Clustering boost competition making firms more productive, contributing to industrial growth. A developed financial system is a pre-cursor to industrial development. They note that, as late as 1970 China's financial system was still underdeveloped, evidenced rapid industrialization in China seems to have defied this pre-cursor within the same past three decades stretch. Despite the missing developed financial system, China's industries were able to complement its credits requirements cheaply within industrial clusters financial services members and firms in clusters (Zhou *et al*., 2019). Credits and trade credits could be obtained due to built trust and familiarity conditions that existed within the industrial clusters. Conversely, the same industrialization effects took more than two centuries in Europe, which China had achieved within three decades (Long & Zhang, 2011).

Long and Zhang (2011) findings suggest that increased clustering marked China's industrializtion. Based on firm level data, they find that firms in more clustered regions have high export value and total factor productivity with positive implications to industrial growth. To the contrary, they indicate that this effect is abscent in state owned non-clustered firms. They established positive causal relationships between clustering, firm financing and firms performance leading to industrial growth. Even after controlling for firm characteristics, Long and Zhang (2011) find positive and significant effect of clustering on firm performance leading to industrial growth. Their findings were robust in that all clustering measures used established positive effects on both export and total factor productivity leading to industrial growth, and the effects were economically large. They also found that firms in clusters are more productive and more competitive in the international market which consequently leads to local industrial growth and expansion. Conversely, they found that clustering is active in stimulating export leading to industrial growth. And to the contrary they show that the level of financial development has little to do with firm export performance leading to industrial growth. In constrast, Ray (2019) found negative relationship between cluster and firm performance leading to industrial growth. His further qualitative inquiry equivocally account for this apparent contradiction to the proximity of production units with other processing units which leads to cost efficiency and sales at competitive prices.

The replication of China's industrialization process through clustering needs to consider at least two aspects. Labor-intensive production technologies in line with the country's population comparative advantage (Long & Zhang, 2011; Zeng, 2012). Secondly, institutional arrangements and policies in concerned countries need to foster clustering (Mohan, 2006), following a policy driven route documented by Ray (2019), where the necessary institutional arrangements are planned and implemented to create industrial clusters. Under fiscal decentralization, local governments in China are fostering clustering the same could be emulated in Africa and elsewhere. In China for instance (Zeng, 2012), various specific economic zones and industrial clusters which came after the country's reforms are credited for China's remarkable industrial development. It is expected that this will plays a crucial part in promoting regional competitiveness (Juan 2019) and industrial growth. On a corroborative axiom, Zhou *et al*. (2019) found that massive economic development is characterized by thriving small and medium businesses and the dominance of industrial clusters. Industrial clusters are dominant in early stage of massive economy development, which progresses through transformation and ultimately leads to creation of industrialized massive economies.

Several emperically verified industrial growth related advantages of clustering are eminent in
the literature (e.g. McCormick, 1999; Long & Zhang, 2011; Zhou *et al*., 2019). They include better access to market and suppliers, labour pooling, easy flow of technology, rise of collective effiency (McCormick, 1999) and, although less discussed, helping firms alleviate financial contraints (Zhu *et al*., 2019).

Financial Inclusion in Cluster-based Industrial Growth

A key feature of clusturing in connection to financing benefits is that a whole production process is broken down into small steps up the production ladder which are done by many small firms. This allows the disaggregation of production through clustering which disaggregate the investment cost required in industrial production among many small firms in a narrowly clustered geographic area. Which in turn allow retail financing to be possible in a credit crunched context. Conducted over time, this builds up trust in the cluster which in turn lower transaction costs of extending and receiving credits/finance thereby reluxing working capital financing burdern (Long & Zhang, 2011).

In the framework of cluster theory, oftern included are various stakeholders, one group of special consideration is financial providers. Industrial clusters and financial providers within the same context normally enjoy economic and financial benefits of location-specific externalities and synergies (Shakya, 2009). Specifically, Barkley and Henry (2001) indicate that clustering strengthens economies of localization by saving cost through financial markets familiarity with the industrial clusters. Long and Zhang (2011) found that clustering relates more to the use of trade credits among firms, this in turn reduces reliance on external financing for working capital. Dev (2006) conceives financial inclusion as delivery of banking services at an affordable cost to the economy or part of an interested section of the economy for instance industrial clusters. Though credit is a notable part of financial inclusion, it includes other services such as saving insurance, payments, and remittance facilities (Dev, 2006). Traditionally, financal inclusion aims at drawing the unbanked into the formal financial system. Financial inclusion on a policy level represent a broader consesus on the positive role it plays on economic development and poverty reduction. It represent one of the outcomes of financial sector policies in developing counries. The evolution of such policies have gone through at least three phases: state-led agricultural and industrial development via direct credits; makert-led development through liberalization and deregulation; and, institutional building that balances government and market failures (Hannig & Jansen, 2010).

A comprehensive financial development mirrors financial inclusion. The primary function of a financial system is to facilitate the allocation and deployment of economic resources both across borders and across time (Levine, 2005). Different functions of financial system includes settling payment to facilitate exchange of goods, services and assets, pooling of resources and subdividing shares, transferring of economic resources, managing risks through elaborate financial securities through private sector and government intermediaries, providing information on shares and various securities traded in the market and dealing with incentive problem (Levine, 2005). While all financial systems provide these functions, there are large differences in how well a financial system provides these functions. It has been evidenced that, financial system integration does not automatically lead to higher financial development in developing economies (Trabelsi & Cherif, 2016), as such macroeconomic figures may not readily translate to microeconomic situations such as in the context of industrial clusters. Thus studying the role of financial system from a financial inclusion vantage gives more microeconomically visible effects on industrial growth within the context of industrial clusters. It has been well document that, financial system influence industrial growth (Beck *et al*., 2006). Financial intermediaries such as banks, and other financial institutions play financial inclusion roles from the supply side. Thus, financial intermediaries and markets, play a role in the effects of financial system on economic/industrial growth (Levine, 2005) in a microeconomical level.

Allen et al (2014) indicate that African economies have lower levels of financial development and inclusion compared to the rest of world. However, Kalunda (2014) shows that the advent of mobile money forms has considerably increased the level of financial inclusion in Africa in recent decades. Particularly, Efobi *et al*. (2014) show that ICT inclination of individuals and other variables such as age and income levels have effects on access and use of financial services leading to financial inclusion. The development of financial inclusion in economic growth agenda is an imperative strategy that need to be considered. It fosters financial deepening which in turn improve economic development in terms of industrial growth. One of the major thrusts now has been on how to mainstream rural credit from institutional sources to a wider coverage in the economy through IT-enabled forms (Mohan, 2006), this thrust is expected to contribute positively to financial inclusion. Agbenyo *et al*. (2019) argue that finance has an imperative role in economic growth. Access and usage of finance is critical for growth of an economy as it provides capital necessary to finance growth in both the agricultural and production sectors. Kalunda (2014) contends that financial inclusion avails a range of financial services at affordable prices in the right place, in a convenient form and at the opportune time.

The role of financial inclusion to economic development and industrial growth is well documented (e.g. Allen *et al*., 2014; Beck *et al*., 2006; Agarwal, 2010). They found that financial inclusion impact both industrial and economic growth.

Emperical results from industrial clusters in China suggest that both financial inclusion and clustering contribute to the emergence of new firms. The two processes reinforce each others in the firms breeding process (Long & Zhang, 2011). Financial inclusion in industrial cluster context provides firms with affordable credits and enabling less costly credit flows among firms. Clustering engages more enterpreneurs into industrial production through lowering of capital barriers and easing firms' working capital constraints through possible trade credits. Clustering easy credit constraints due to good famiriality and trust conditions in industrial clusters thereby improving firm performance leading to industrial growth (Zeng, 2012).

Increasing credit related interactions among other types of interactions between industries within regions' clusters directed China's industrialization. Evidence shows that firms grow faster in clustered regions where they are able to enjoy fair credit benefits among other advantages coming from industrial clusters. With lower constrained capitals, smaller entrepreneurs can start small businesses in the industrial cluster context. Therefore, arguably, financial system development is important, but clustering is the second-best solution in credit-constrained environments (Long & Zhang, 2011).

There are mutual effects between industrial growth and financial system development. The former creates demand for financial services particularly credits while the later mobilize and allocate financial resources to the former (Shahbaz *et al*., 2017). Several issues propel financial development. For instance, it has been argued that, developing countries have poorly developed financial systems, one remedy suggested is for them to open up their economies to the rest of the world (Levine, 2005; Shahbaz *et al*., 2017). Financial reforms and development have had positive impacts in China and India in the time of their implementations. The reforms increased participation of banks. A strong financial infrastructure is possible only if an economy is open to local participants and rest of the world in terms of finance and trade (Shahbaz *et al*., 2017).

New firms are always established using funds from either banking sector or stock markets. These sources of capital are in turn influenced by other sufficiently large sources of funds, particularly international capital markets.

When a country's capital market is restricted, by for instance cross-border flows of capital, the number of new industrial establishments that are financed will be limited in a consequence. Thus, liberalization in capital accounts increases the capital pool exposed to entrepreneurs (Vlachos & Waldenström, 2002). Thus, measure geared toward increasing financial inclusion at all national level, local level and industrial cluster context will lead to more access to financing and boost industrial growth. Liberalization of financial markets at an industrial level may leads to increased financial inclusion. It kick-starts firm creation. This reduces the cost of finding financiers to entrepreneurs and firms (Vlachos & Waldenström, 2002). Clustering facilitates trade credits from upstream industry (Long & Zhang, 2011; Zeng, 2012) such that if there is more financial inclusion that means there is a possibility of mutual reinforcement of both towards industrial growth among the networked clusters. Particularly, Zeng (2012) cites Wenzhou cluster among others in China where the trust built within clusters have significantly reduced transaction costs, often times firms operate on borrowed funds from other firms in industrial clusters they belong to or on trade credits through downstream and upstream firms.

From the preceding review the current study seeks to test the following hypotheses:

H1: *Firms clustering promote industrial growth in Africa*
H2: *Financial inclusion promote industrial growth in Africa*

H3: *Interaction of financial inclusion and financial inclusion size promote industrial growth in Africa*

H4: *Interaction of financial inclusion and firm clustering promote industrial growth in Africa*

Methods

The study follows a quantitative research method. It uses ordinary least squares estimator. The regression forms use to analyze the data are listed in Models 1, 2, and 3. Models diagnostic issues such as multicollinearity and endogeneity problems posed no threats to the analysis (the results not included). The study used real annual sales growth (%) from manufacturing industries as indicator for industrial growth (I_GROWTH) within manufacturing industries sub-groups as a dependent variable. The independent variables were namely; Financial inclusion (F_INCL) measured by percentage of firms with bank loans/line of credit, this is a reasonable measure for financial inclusion because it shows how each firm beneficially use the financial system from a capital leverage point of view for the

purpose of industrial growth (e.g. Kalunda, 2014). Cluster size (C_SIZE) was measured as a total number of industries in each manufacturing sub-group.

The method also controlled for age of industries (I_AGE) and financial inclusion size (F_SIZE). Lastly, it includes interaction variables to test moderations (F_SIZE*F_INCL and C_SIZE*F_INCL). Chart to depict trends are used to show the growth of the variables over time (these were used trend data over the indicated respective years in the charts). Regression analysis is used to assess effects of coefficients. Model 1 represents the basic regression without interaction variables, while model 2 and model 3 have added the two interaction terms to capture interaction effects for financial inclusion as defined before. The regression models are:

$$I_{GROWTH} = \alpha + C_{SIZE}B_1 + F_{SIZE}B_2 + F_{INCL}B_3 + I_{AGE}B_4 + e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$I_{GROWTH} = \alpha + C_{SIZE}B_1 + F_{SIZE}B_2 + F_{INCL}B_3 + I_{AGE}B_4 + (F_{SIZE} * F_{INCL})B_5 + e \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$I_{GROWTH} = \alpha + C_{SIZE}B_1 + F_{SIZE}B_2 + F_{INCL}B_3 + I_{AGE}B_4 + (C_{SIZE} * F_{INCL})B_6 + e \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The study draws data from the World Bank Development Indicators (WBI) averages for manufacturing clusters from seven countries survey, namely Egypt, Ethiopia, DRC, Nigeria, Tanzania, Kenya and South Africa. These countries were selected randomly to represent Africa as the case of developing countries that are on the process of promoting industrialization in their economies. It pooled industrial averages in manufacturing sub-groups from each country making a total of 54 observations per country-survey-variable, which make a total of 324 country-survey observations from six variables listed above.

Findings and Dicussion

In this first part, the study presents both manufacturing value added and domestic credit to private manufacturing sector for the seven countries (namely Egypt, Ethiopia, DRC, Nigeria, Tanzania, Kenya and South Africa) to compare both the level of industrial growth and financial inclusion for the private sector over years, respectively.

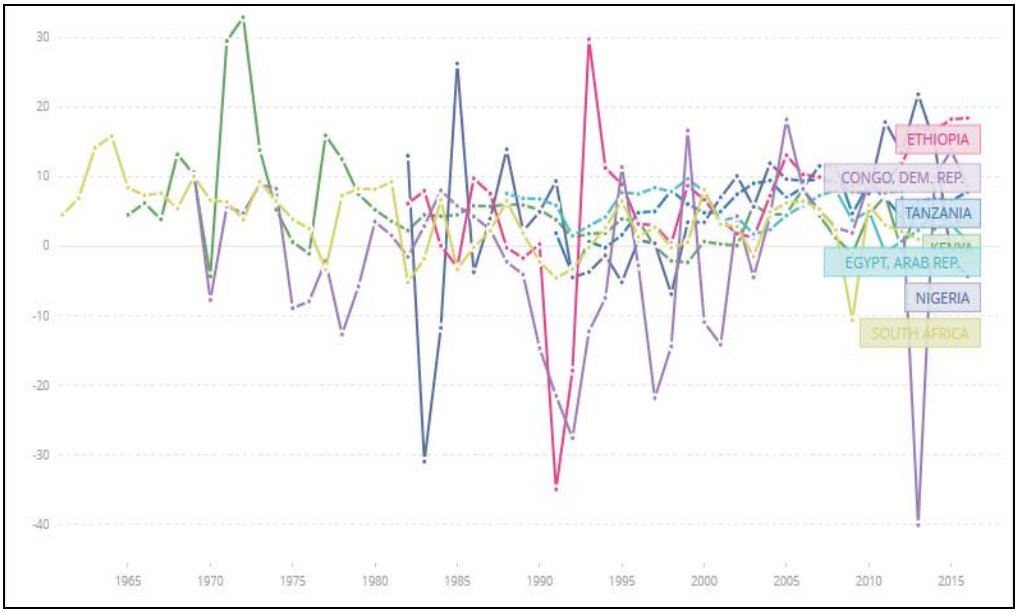

Figure 1: Manufacturing value added (Annual % Growth)

Manufacturing value added in terms of percentage of annual growth depicts (Figure 1) a cyclical trend over time for all seven economies. This indicate a prolonged (1960s to 2016) period of cyclical rising and falling of manufacturing value added. This shows instability on the growth of the manufacturing sector which is a basic indicator for industrial growth and therefore industrialization. The process of industrialization as indicated by data shows lack of stability over time, there is lack of definite breakthrough overtime.

Domestic credit to private manufacturing sector is a good indicator for financial inclusion for the manufacturing industries. Credits to this sector shows a growing trend over time with few falls especially for South Africa, Egypt and Ethipia. The rest of the countries (Nigeria, DRC, Tanzania and Kenya) show a prolonged lack of growth in domestic credits to manufacturing in the private sector (see Figure 2).

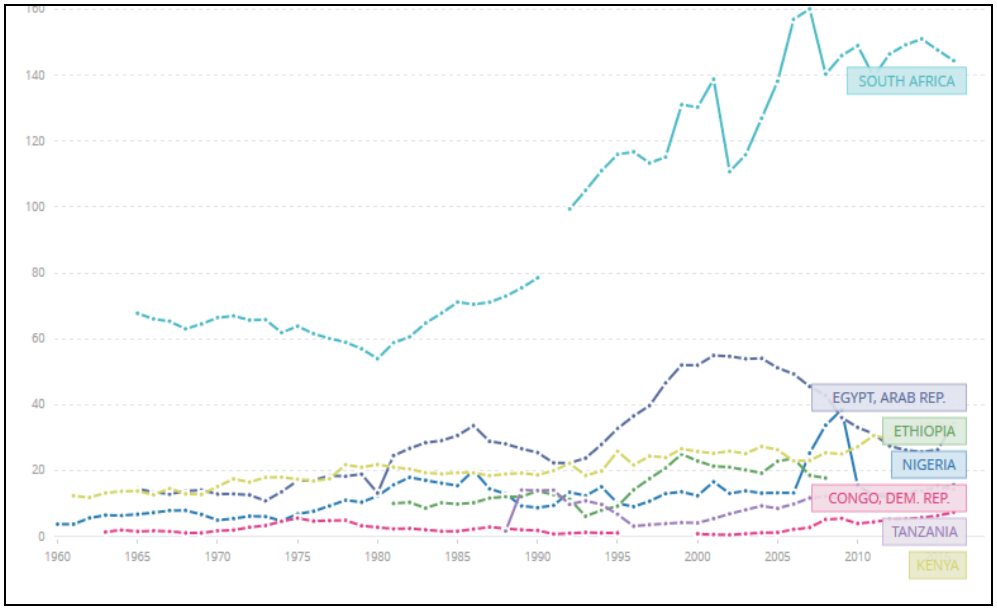

Figure 2: Dometic credits to private sector (% of GDP)

In this second part the study presents the empirical regression result to reflect the main findings of the article. The regression analysis finding indicates that cluster size promotes industrial growth. The more industries are in clusters they tend to grow. Therefore, this result indicates that industries that are in clusters especially large clusters produce more and growth more than otherwise (Table 1). The result in the analysis is not only statistically significant at 0.01 level but also economically large (+2.751). This finding is consistent to Long and Zhang (2011) who also found that clustering lead to higher industrial performance, increased export, and the breeding of new industries within the clusters. The financial inclusion size was negatively related to industrial growth, the results were statistically significant at 0.05 level and economically (-2.587) large as well.

Table 1: Regression Analysis

Model	**(1)**	**(2)**	**(3)**
Dependent variable	I_GROWTH	I_GROWTH	I_GROWTH
C_SIZE	2.493**	2.533**	2.751**
F_SIZE	-2.528*	-2.221*	-2.587*
F_INCL	0.484	1.334	1.033
I_AGE	0.301	0.557	0.459
c.F_SIZE#c.F_INCL		-0.004	
c.C_SIZE#c.F_INCL			-0.003
N	270	324	324
r2	0.657	0.703	0.680
r2_a	0.243	0.315	0.263
rmse	11.33	10.78	11.18
F	1.588	1.814	1.631
	Standardized beta coefficients, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.		

Therefore, financial inclusion size determines industrial growth negatively. This hints to the possible impact of inefficient financial system with less financial inclusion size due to high interest rates in these economies that might not be beneficial to industrial growth. On the other hand, financial inclusion variable though statistically significant at 0.1 level, it is economically large (+1.033) implying that the more industries are involved in using the financial system the more likely economies would realize the hope of industrial growth. This later finding supports evidence from other studies such as Levine (2005) and Long and Zhang (2011) who found that financial system and inclusion promoted economic growth and industrial growth process respectively.

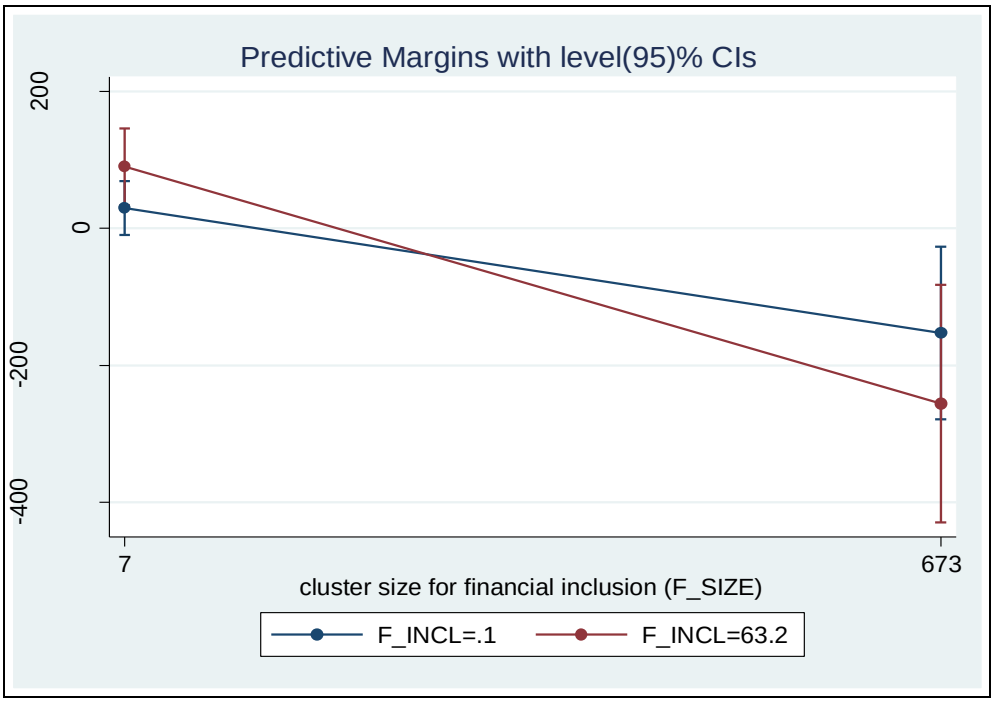

Figure 3: High-Low Graphs for F_INCL and F_SIZEInteraction Effects.

Age of industries (proxying experience) positively affect industrial growth, the results were not statistically significant. Nevertheless, the positive relationship hint to the fact that the older the cluster is the more industrial growth is to be expected. The interaction/moderation effect (c.F_SIZE#c.F_INCL), between financial inclusion (F_INCL) and clustering (F_SIZE) indicates a negative effect on industrial growth, the result was statistically significant at 0.1 level. Because c.F_SIZE#c.F_INCL is negative, then the more negative financial inclusion clustering (F_SIZE) is, the more negative the effect of financial inclusion (F_INCL) on industrial growth becomes and vice versa (see Figure 3; a high-low graph).

Alternatively, F_SIZE exacerbate the negative effects of F_INCL on industrial growth (I_GROWTH) statistically significant at 0.1 level. This help to point to the fact that, when the financial system is not rightly tuned to benefits industrial growth, it will in turn harm it, one reason could be high interest rates that are above returns on investments done by these industries.

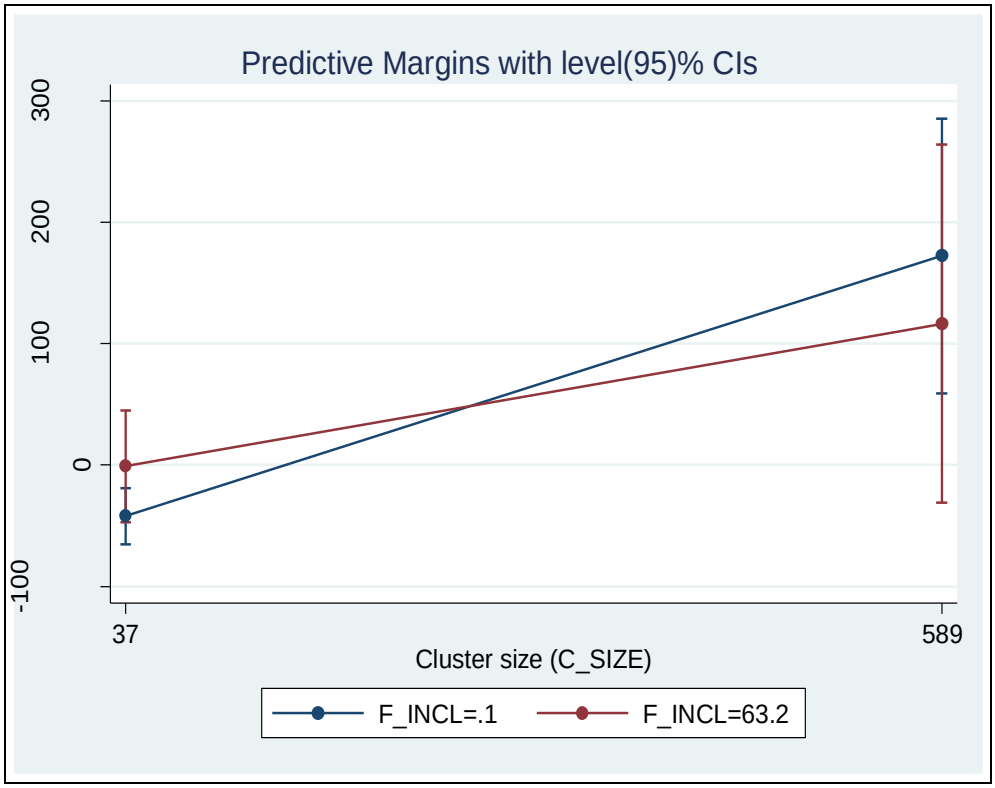

Figure 4: High-Low Graphs for F_INCL and C_SIZE Interaction Effects.

Conversely, in the same vein, interaction/moderation effect (c.C_SIZE#c.F_INCL), between financial inclusion (F_INCL) and clustering (C_SIZE) indicates a negative effect on industrial growth and was statistically significant at 0.1 level. Because c.C_SIZE#c.F_INCL is negative, therefore the more negative clustering size (C_SIZE) is, the more positive the effect of financial inclusion (F_INCL) on industrial growth becomes and vice versa (see Figure 4; a high-low graph). Alternatively, C_SIZE exacerbate the positive effects of F_INCL on industrial growth (I_GROWTH). This help to point to the fact that, when the financial system is more open to firms, the larger the clusters, it benefits industrial growth.

At least 68% of the effects on industrialization is explained by these factors, especially the significant ones.

This is a big proportion indicating that these factors, particularly industrial clustering, financial inclusion and industrial experiences (I_AGE) are important if these economies are to succeed in propelling industrialization process.

The hypothesis test results were as follows;
H1: *Firms clustering promote industrial growth in Africa (confirmed)*
H2: *Financial inclusion promote industrial growth in Africa (not confirmed)*
H3: *Interaction of financial inclusion and financial inclusion size promote industrial growth in Africa*

H4: Interaction of financial inclusion and firm clustering promote industrial growth in Africa (not confirmed)

Conlusions and Recommendations
Government and particularly local governments need to consider effects of business clustering on industrial growth; policies need to be in place to address and plan how best to cluster industries for mutual benefits so that they grow together. More policy dressing needs to be done on how clustering and financial inclusion could reinforce each other. Long and Zhang (2011) study found that clustering and financial development reinforce each other in promoting industrial growth. But, the current study's finding indicates that the African economies are just not yet there, either the financial system or clustering or both are not righly tuned. The businesses do not collaborate in a symbiotic mutual benefits for industial growth.

Further research needs to look at how the different aspect of industrial clustering such as, size, proximity, type and shape may foster industrial growth. These may be studied and assessed for effects on industrial growth.

The size of financial inclusion is negatively affecting industrial growth, more research needs to probe into the problem and explore this type of effect, or some explanatory study design to explain this type of effect. More need to be researched on how best clustering in connection with financial inclusion could be tuned for a better industrialization experience. The factors studied in the current research accounts for a large contribution to industrial growth (r2 = 68%), policy research need to look at these factors more closely in search for how best to manipulate these factors for successful industrialization.

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Challenges Encountered by Agricultural Science Student Teachers During Teaching Practice in Kwara State, Nigeria

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Abstract: *Teaching practice is a vital aspect of teacher training programme which is usually undergone by students with varied experiences and challenges. The study examined teaching practice experience of agricultural science student teachers in the Faculty of Education at the University of Ilorin and Kwara State College of Education, Ilorin in 2018. The study adopted a survey research design. The population for this study was all the 400 level Agricultural Science student teachers of University of Ilorin and NCE III students of Kwara State College of Education, Ilorin. Sixty students comprising of thirty students each from both, the University and the College of Education who were in the penultimate years of graduation made the sample for the study. Six research questions were raised to guide the study. Based on the findings of this study, some of the problems militating against agricultural education student teachers during teaching practice include pedagogical problems, cooperating school related issues, learners related problems, personal problems and institution based problems. Based on the findings, the study recommended frequent trainings and seminars for the stake-holders of teaching practice, budgeting of enough time for teaching practice exercise, provision of relevant instructional materials in schools and provision of stipends as incentive to agricultural science student teachers after the teaching practice exercise.*

Key words: Teaching practice, cooperating schools, student teachers, cooperating teachers, agricultural science student teachers

Introduction

The Federal Government of Nigeria stated the purpose of teacher education in the National Policy on Education to be able to produce highly effective teachers for all levels of Nigeria educational system. Teachers must be exposed to both theoretical and practical aspects of teaching for them to be able to teach effectively. Teaching is very vital to the society.

Teaching is the practice by which a teacher makes use of various knowledge domains which include knowledge of learners, knowledge of subject matter and knowledge of methodology to assist learner to learn (National Policy on Education - FRN, 2013).
Teaching is said to be a complex problem-solving activity that involves generating meaningful and relevant knowledge, values and skills between at least two people, the teacher and the learner. Teaching revolves around teachers, learners, subject matter, instructional objectives and delivery method. The teaching process takes place in all fields of human learning which include; science, fine art, humanities, vocational and educational technology. Effective teaching could be done by those who have undergone training in teaching and internalized effective teaching practices. Generally, such training involves learning basic principles in classroom situations and undergoing specific period of teaching practice exercises in actual classroom teaching and engaging in other school activities. Besides, teaching student teachers are sometimes obliged to engage in administrative and management activities.

Teaching practice is a period that a student teacher spends in teaching at a school as part of his or her training. It is an integral part of teacher education which constitutes a practical phase of its own kind. Stones and Morris, (1977) explain that teaching practice has three major process of practicing teaching skills and exposure to practicing a variety of other non-teaching roles or responsibilities. Teaching practice sessions enable the 'teachers to be' to undergo a range of experiences that they might have otherwise only studied through related teaching theories and pedagogical models. Anyone undergoing such student teachers' exercises is regarded as student teacher who Adelowokan and Makinde, (2011) describe as a college, university or graduate student who is teaching under the supervision of a certified teacher in order to qualify for a degree, diploma or certificate in an education programme.

Arguably, the most important component of a teacher education programme in Career, Technical, and Agricultural Education (CTAE) is the student teaching field experiences. Researchers have argued that the student teaching 'experience' plays a significant role in the formation of attitudes and perceptions of pre-service teachers regarding their roles and responsibilities as future practitioners (Harlin, Edwards & Briers, 2002). Teaching Practice (TP) is an important component of becoming an effective teacher. It grants student teachers experiences in actual teaching and learning environments (Ngidi & Sibaya, 2003; Marais & Meier, 2004; Perry, 2004).

Teaching practice affords the student teachers the avenue to experiment the act of teaching before entering into the actual teaching profession. Teaching practice is seen as the hub of preparation processes in the teaching profession; it forms the link between the period of studentship and bonafide membership of the teaching profession. As a result, teaching practice creates a mixture of anticipation, anxiety, excitement and apprehension in the student teachers as they commence the exercise (Mani- on *et al*., 2003; Perry, 2004).

During the teaching practice exercises, the student teacher is expected to fulfill all the responsibilities of a teacher which, according to Perry (2004), is exciting but also challenging. Perry further pointed out that, on the one hand, student teachers should experience the excitement of being a part of a real classroom setting, getting to know learners, planning and organizing classroom tasks and activities. On the other hand, student teachers could have doubts about their ability to cope with the exercise because of their concerns about their strengths to manage unfamiliar situations, controlling and managing learners or establishing a working relationship with their mentors or supervisors. TP may generate mixed feelings that contribute to the making of an effective or ineffective student teacher.

The value of teaching practice lies in providing the teacher-trainees the initial exposure to the realities of teaching through a broad range of activities. Successful participation in TP is a compulsory requirement for the completion of any certificate, diploma or degree in Teacher Education Programme in Nigeria. The basic assumption is that since most of the teacher-trainees have never taught formally before TP attempts, it is rational to include TP in their professional training programmes so as to provide them with unique experiences and opportunities to learn by doing and being.

In Nigeria, teaching practice exercise is usually done by student in teacher training institutions which are Colleges of Education which awards Nigeria Certificates in Education (NCE) and Faculty of Education in universities which awards Bachelors in Education (B.Ed.) in different subject areas.

The scheduling and timing of teaching practice exercise in teacher training institutions is done in such a way that students must have been exposed to all the pedagogical knowledge which they would need to practice as teachers. Before students are sent for teaching practice, they must have been taught the different methodologies of teaching as well as the principles and practice of class management. Apart from this, students should have been exposed to small scale teaching experience in the school, which is usually referred to as micro or peer teaching.

This is an arrangement which allows student to prepare for lessons and teach their colleagues in the presence of their teachers or supervisors. All these initial trainings are geared towards making the pre-service teachers conversant with what is obtainable in real classroom situations before they are sent out on teaching practice.

As good as all these preparations may be, student teachers are faced with a lot of challenges, prospects and experiences which they may never have been taught during their college/university studies. These experiences present themselves in diverse forms to student teachers. These could be challenges or opportunities relating with students, school head teachers, cooperating teachers, or even their own colleagues. Sometimes it could be in form of lack or over confidence in lesson preparation and delivery. It could be even be personality issues which strain or enhance relationships with other co-workers or students.

In some cases, student teachers record varied experiences with their supervisors. All these occurrence/situations present potent experience which could create a lasting impression on the life of the student- teachers throughout their teaching career or other aspect of life. Hence, the need to investigate and document these teaching practice experiences with the intention of using them to improve upon future teaching practice exercises.

In some schools where teachers are lacking, student teachers are often used as permanent teachers to do all sorts of works. This would also create a sort of experience which the student teachers may or may not enjoy. This study is considered necessary due to the peculiar case of agricultural science teacher. An agricultural science teacher is peculiar because, the practical aspect of their course which requires them to take students to the farm to acquire some agricultural skills in farming could generate both positive and most often negative experiences from the students, fellow teachers or school principals. An agricultural student teacher may experience, support, cooperation as well as opposition or rejection from students, parents, fellow teachers or school heads. Furthermore, in a school where school farm and other agricultural instructional resources are lacking, an agricultural student teacher may go through hard experience sourcing or improvising for these resources.

Agricultural science student teachers are expected to have a deep understanding in curriculum development, learning styles, technical areas, teaching methods and techniques.

Joerger (2002) categorizes professional teaching competencies needed for success and survival as classroom management, leadership and Students Agricultural Education (SAE) development, technical agriculture, and program design and maintenance. These are the competencies that agricultural education student teachers are expected to acquire during teaching practice.

(i) Thus, the different experiences, opportunities and challenges, that an agriculture student teacher go through during their teaching practice exercise are worth researching into so as to serve as a knowledge base for teacher educators in preparing aspiring student teachers as well as providing a content for orientation of student teachers. The inability to fully realize the objectives of teaching practice or the inability of student teachers to perform to expectation can be attributed to certain challenges or inadequacies of the programme. The challenges that face student teachers during teaching practice is what necessitates the need for the study and hence they constitute the problem of the study. The study had four objectives including to identify the pedagogical challenges that Agricultural Science students-teachers face during teaching practice sessions; to find out the challenges encountered by Agricultural Science student teachers when working with cooperating schools during teaching practice sessions; examine the challenges encountered by Agricultural Science student-teachers when working with learners during teaching practice sessions; to find out the student-teachers' personal challenges affecting Agricultural Science student- teachers during teaching practice sessions; and to examine the institutional related challenges that student-teachers encounter during teaching practice sessions and identify the strategies that can be used to improve undergraduate teaching practices for Agricultural Science students. In order to achieve the above objectives, the research questions that were answered in the course of the study include: What pedagogical challenges do Agricultural Science students-teachers face during teaching practice sessions? What are the challenges encountered by Agricultural Science student teachers when working with cooperating schools during teaching practice sessions? What are the challenges encountered by Agricultural Science student-teachers when–working with learners during teaching practice sessions? What are the student-teachers' personal challenges affecting Agricultural Science students during teaching practice sessions? What institutional related challenges do student teachers encounter during teaching practice sessions? and What strategies can be used to improve undergraduate teaching practices for Agricultural Science students?

Methodology

This study engaged a descriptive survey research design. The population for this study was all year 2018, 400 Agricultural Science Student Teachers at the University of Ilorin and Kwara State College of Education, Ilorin, Kwara State. A simple random sampling technique was adopted to obtain 60 Agricultural science students who had completed their teaching practice exercise at the two institutions A well structured questionnaire that consisted of two sections was used to obtain relevant information from the respondents. Section A of the questionnaire dealt with students' demographic information; which included respondents' age and gender while section B dealt with the challenges encountered by agricultural science student-teachers during their teaching practice sessions. A 4 points Likert scale response option of; strongly Agree (SA), Agree (A), Strongly Disagree (SD), and Disagree (D) was adopted for the questionnaire.

The instruments were validated for face and content validity by three experts in Agriculture and Science Education in the Department of Science Education, University of Ilorin. Modifications were made based on the corrections and suggestions which were reflected in the final instrument used for this study. Data analysis was carried out with the use of Statistic Package of Social Science (SPSS) version 21. The research questions raised in the study were analyzed using percentages and means. All the data collected from the questionnaire were systematically presented and interpreted.

Research Results

The Pedagogical Challenges faced by Agricultural Science Students while on Teaching Practice

Table 1 shows the pedagogical problems faced by Agricultural Science Students during teaching practice.

Data revealed that unconducive classroom environments, teachers' difficulties in designing lesson plans, inability to break topics into teaching units, limited choice of appropriate teaching methods, and non availability of teaching aids and problem of choice of appropriate teaching aids were pedagogical problems facing Agricultural Science students on teaching practice. The mean value of 3.78, 3.65, 3.58, 3.58, 3.45 and 3.41 were derived and ranked respectively from first to sixth levels. This implied that pedagogical challenges are part of the problems facing Agricultural Science students during teaching practice sessions.

Table 1: Pedagogical Problems Faced by Agricultural Science Students - Teachers

S/N	Items	Mean ($\bar{x}$)	Standard Deviation	Rank
1.	Non availability of teaching aids	3.45	0.76	5th
2.	Limited choice of appropriate teaching methods	3.58	0.49	4th
3.	Unconducive classroom environment	3.78	0.52	1st
4.	Teachers' difficulties in designing lesson plans	3.65	0.66	2nd
5.	Inability to break topics into teaching units	3.58	0.62	3rd
6.	Problem of choice of appropriate teaching aids	3.41	0.62	6th

Source: Field Survey, 2018. **Mean ≥2.5 = Agreed, Mean < 2.5 = Disagreed*

Cooperating School related Challenges encountered by Agricultural Science student teachers during teaching practice

Table 2 shows the cooperating school related problems faced by Agricultural Science student-teachers during teaching practice. It was shown that inadequate time allocation, absence of school farms, overcrowded classrooms, old farm tools and equipment, underequipped laboratories and unsupportive attitudes of some cooperating teachers in charge of student teachers and lack of instructional materials in the cooperating school constituted teaching practice school related problems facing Agricultural Science students on teaching practice and was ranked from 1st to 6th in accordance with mean values of 3.46, 3.36, 3.35, 3.35, 3.25, 3.20 and 3.03 respectively. This implies that the cooperating schools create some challenges for Agricultural Science students' teachers on teaching practice.

Table 2: School Teaching Practice Related Problems Faced by Agricultural Science Students-Teachers during Teaching Practice

S/N	Items	Mean ($\bar{x}$)	Rank
1.	Unsupportive attitude of cooperating teacher in charge of student teachers	3.20	6th
2.	Inadequate time allocation	3.46	1st
3.	Underequipped laboratories	3.25	5th
4.	Overcrowded classroom	3.35	3rd
5.	Absence of farm problem for practical	3.36	2nd
6.	Lack of instructional materials in the school	3.03	7th

7. Old farm tools and equipment	3.35	3rd
8. Rejection of pre-service teachers by some co-operating school	2.60	8th

Source: Field Survey, 2018. **Mean ≥ 2.5 = Agreed, Mean < 2.5 = Disagreed*

Learners related challenges faced by Agricultural Science Students teachers during teaching practice

Table 3 shows that learners at cooperating schools posed some challenges to Agricultural Science student during teaching practice exercises. Data revealed that learners' unwillingness to learn (3.65), indiscipline among some of the learners (3.33), underrating student-teachers' teaching capacity (3.31), lack of seriousness among students (3.26) and lack of respect for the student-teachers (3.18) were learners' related challenges encountered by Agricultural Science Student during teaching practice. The questionnaire targeting this item was composed of items was ranked from Ist to 5th accordingly. This implies that Agricultural Science learners for the 2018 cohorts at the selected institutions posed some challenges to Agricultural Science students during teaching practice.

Table 3: Learners Related Problems Faced by Agricultural Science Students on Teaching Practice

S/N	Items	Mean ($\bar{x}$)	Standard Deviation	Rank
1.	Lack of respect for the student teachers	3.18	0.85	5th
2.	Underrating student- teachers' teaching capacity	3.31	0.85	3rd
3.	Indiscipline among some of the learners	3.33	0.75	2nd
4.	Learners' unwillingness to learn	3.65	0.63	1st
5.	Lack of seriousness among students	3.26	0.71	4th

Source: Field Survey, 2018. **Mean ≥2.5 = Agreed, Mean< 2.5 =Disagreed*

Student-teachers personal problems affecting Agricultural Science students during teaching practice

Table 4 shows student-teachers' personal problems confronting Agricultural Science Student during teaching practice. Field results showed that lack of understanding of some subject content among the student-teachers, long distance to primary place of the teaching assignment, student teachers' shyness before students and financial constraints during the teaching practice exercise were some of the student-teachers' personal challenges facing Agricultural Science student on teaching practice. Item of the questionnaire was ranked respectively from 1st to 4th in accordance with the mean value of 3.48, 3.46, 3.43 and 3.17 respectively. This implies that student teachers' personal problems constituted challenges encountered by Agricultural Science student-teachers during teaching practice.

Table 4: Student teachers personal problems affecting Agricultural Science students on teaching practice

S/N	Items	Mean ($\bar{X}$)	Rank
1.	Long distance to primary place of assignment	3.46	2nd
2.	Lack of understanding of some subject content by student teachers	3.48	1st
3.	There are financial constraints during the teaching practice exercise	3.17	4th
4.	Student- teacher lack of confidence in facing students in class room	3.43	3rd

Source: Field Survey, 2018. **Mean ≥2.5 = Agreed, Mean< 2.5 =Disagreed*

Student teacher's institutional related challenges affecting Agricultural Science students during teaching practice

Table 5 shows student teachers' institutional related challenges confronting Agricultural Science student-teachers on teaching practice. Information from the field showed that inadequate orientation before teaching practice, academic strike, short duration of teaching practice exercise, insufficient peer teaching experience and problem of interruption between the co-operating school calendar and the University or College of Education calendar are student teachers institutional problems affecting Agricultural Science students on teaching practice and was ranked from 1st to 5th items respectively with a mean value of 3.33, 3.31, 3.30, 3.18 and 3.17 respectively. This implies that factors related to student teachers institution constituted challenges to Agricultural Science students during teaching practice.

Table 5: Student Teachers Institutional Related Problems Affecting Agricultural Science Students on Teaching Practice

S/N	Items	Mean ($\bar{X}$)	Rank
1.	Insufficient peer teaching experience	3.18	4th
2.	Academic strike	3.31	2nd
3.	The problem of interruption between the co-operating school calendar and the institutional calendar	3.17	5th
4.	Duration of teaching practice exercise is short	3.30	3rd
5.	Inadequate orientation on teaching practice	3.33	1st

Source: Field Survey, 2018. **Mean ≥2.5 = Agreed, Mean< 2.5 =Disagreed*

Strategies for improving undergraduate teaching practice

Table 6 shows some strategies for improving agricultural education undergraduates' teaching practices. Based on the analysis of data, the Nigerian government should encourage both private and public schools to accept pre –service student teachers for their teaching practice exercise ($\bar{X}$ = 3.77); frequent training and seminars should be offered to teachers to

improve their professional practices ($\bar{X}$ = 3.67); enough time should be provided for the teaching practice exercise ($\bar{X}$ = 3.47); and the government should pay the teachers as at when due in order to solve the problem of unpredicted calendar ($\bar{X}$ = 3.47), instructional materials should be provided at schools where TP is conducted ($\bar{X}$ = 3.33). Generally, the agricultural science students have positive views about solutions to be proffered to improve the quality of teaching practice as revealed in the average mean of their responses which stood at 3.54, and greater than the benchmark of 2.50.

Table 6: Strategies for Improving Undergraduate Teaching Practice

S/N	Items	Mean ($\bar{X}$)	Rank
1.	Instructional materials should be provided at the schools where TP is conducted	3.33	5th
2.	The government should pay the teachers as at when due in order to solve the problem of unpredictable calendar	3.47	3rd
3.	Frequent training and seminars should be offered to teachers to enhance professional practices	3.67	2nd
4.	Enough time should be provided for the teaching practice exercise	3.47	3rd
5.	Government should encourage both private and public schools to accept pre-service teachers' student- teachers for their teaching practice exercise	3.77	1st

Discussion of the Findings

Findings from the study revealed that pedagogical challenges were part of the problems faced by Agricultural Science student-teachers during teaching practice. It was found that unconducive classroom environments, difficulty in designing lesson plans, inability to break topics into teaching units, choice of appropriate teaching methods, non-availability of teaching aids and problems of choices of appropriate teaching aids were pedagogical problems facing Agricultural Science students during teaching practices. The pedagogical challenges highlighted by the respondents have been a general problem affecting beginning teachers in their early years in teaching profession. Beginning teachers often find lesson planning to be difficult. This difficulty often stems from the inability of the teachers to delineate appropriate contents that should be adequate for a single period of lesson. Also, the beginning teachers often find it difficult to break the array of contents they have been taught at higher institutions into understandable units for the secondary school learners as well as think up of the appropriate methods to deliver the lesson to be understood by the learners. Fritz and Miller (2003) found that first- and second-year agricultural education teachers experienced challenges with classroom instruction. This condition, imply that pedagogical challenges were common problems confronting early career teachers (novice).

The cooperating schools also created some challenges for the Agricultural Science students' teachers during teaching practice. It was found that inadequate time allocation, absence of school farm, overcrowded classroom, old farm tools and equipment, underequipped laboratories and unsupportive attitude of some cooperating teachers in charge of student teachers and lack of instructional materials in the cooperating school constitutes teaching practice school related problems facing Agricultural Science student-teachers on teaching practice. These institutional problems are more prominent in public schools and some upcoming private schools.

These problems usually arise from lack of funds to acquire the needed facilities for effective teaching and learning in the school. In most cases these schools are not adequately funded by the government. Therefore, the classes and laboratories (where they are even available) are overstretched and most times permanent teachers compete for space or time to deliver their lessons. Therefore, when student-teachers are posted to such schools, they are treated as second class teachers who can only have space and time to teach their lessons when the permanent teachers have fully taken their turn. This is similar to the study conducted by Kabugi's (2013) at Kakuyuni Division, Kangundo District, Machakos County in Kenya on the challenges to teaching and learning of agriculture in secondary schools where he also found inadequate resources for teaching and learning Agriculture in schools as one of the institutional-based challenges facing the teaching and learning of agriculture. This implies that the problem of inadequate resources or facilities in the teaching of agriculture is not only peculiar to the study area but to most underdeveloped nations.

Msangya, Mkoma and Yihuan (2016) recorded similar experiences showing that teaching practice students in Tanzania are faced with the problem of negative attitude among in-service teachers in local schools. This shows that inadequate teaching resources are peculiar issue that characterizes teaching practice in schools, hence the need for pre-service teachers to be competent in the act of improvisation.

Moreover, the learners posed challenges to the Agricultural Science student-teachers during teaching practice. It was revealed that unwillingness of students to learn, indiscipline, underrating student-teachers, lack of seriousness and respect among students constituted learners related problems encountered by Agricultural Science student-teachers on teaching practice. Secondary school student being in their adolescents' stage often constitute some challenge to the practice of teaching by student-teachers.

Some secondary school learners often regard the students-teachers as inferior to their permanent teachers thereby exhibiting some in disciplinary

acts during teaching. Some even intentionally challenge the intellectual capacity of the student teachers to test if they are competent enough to teach them or not. While some learners are naturally trouble makers / extrovert. All these categories of learners often stressed the patience or confidence of the student-teachers thereby posing a constraint to the smooth running of their teaching practice exercise. Msangya, Mkoma and Yihuan (2016) affirmed this situation by stating that even secondary school students were considered a challenge to student-teachers during teaching practice in Tanzania. Fritz and Miller (2003) observed that novice teachers faced challenges with classroom management, student discipline and safety. Mundt and Connors (1999) reported that the main challenges faced by novice teachers were classroom management and student discipline. Hence, the issue of student indiscipline is assuming a worldwide phenomenon and will always constitute a serious challenge to novice and pre-service teachers.

Furthermore, student-teacher's personal problems were part of the challenges affecting Agricultural Science student-teachers on teaching practice. Findings revealed that lack of understanding of some subject content among student teachers, long distance to places of primary assignment, student teachers shyness before students and financial constraints during the teaching practice exercise were student-teachers personal problems affecting Agricultural Science students during teaching practice. Since there can be no perfect situation or perfect individual, the personal problems of student- teachers most often at times result into major challenges inhibiting the smooth running of teaching practice for the student teachers. Some student-teachers are naturally below average in their performance, while some that are even brilliant may be shy when facing large group of students. Both factors may result into fear or stage fright in the course performing their teaching practice exercise in addition, financial challenges or distance from place of teaching practice may result into perpetual lateness of student teachers to school. This may bring the student teacher at logger-heads with the school principal thereby affecting the relationship between such student-teacher and the school management. Msangya, Mkoma and Yihuan (2016) observed similar experience that teaching practice students in Tanzania faced lack of financial and materials support while Mundt (cited in Fritz and Miller, 2003) remarked that pre-service teachers being faced with teaching challenges could lead to a lack of self-confidence, confusion, frustration, and isolation among student teachers. Further findings from respondents also reveals that inadequate orientation before teaching practice, academic strike, and insufficient peer teaching

experience and problem of interruption between the co-operating school calendar and the tertiary institutions calendar were institutional problems affecting Agricultural Science students-teachers during their teaching practice sessions.

The government lackadaisical attitude to the welfare of teachers at both pre-university and university levels in Nigeria has not only affected the performance of learners in Nigeria, but has succeeded in truncating the academic calendar of both secondary and tertiary institutions, thus affecting everyone that has anything to do with the academic sector of Nigeria. The incessant strike actions usually affect university calendar to the extent that students that were supposed to be mobilized for teaching practice were left unattended to until the secondary schools have closed for the session. Therefore, in other to make-up for the lost time in most cases, student-teachers are rushed through the teaching practice exercise thereby creating undue stress for the student teachers .Furthermore, some institutions in bid to maintain an uninterrupted academic calendar create less period for student to actually undertake peer teaching/micro teaching which the sole purpose is to help students to practice teaching among their peers to assist them in learning the act of teaching as well as gain confidence in teaching. Thus, students- teachers were sent on teaching practice exercise ill prepared for the exercise.

Similar findings were recorded by Msangya, Mkoma and Yihuan (2016) who observed that there was insufficient time for teaching practice and that students in Tanzania are faced with mismatch of TP with the secondary schools' calendars. It is worth noting that these challenges usually arise from inevitable strike actions that are sometimes embarked upon by higher institutions in Nigeria. Strike actions often disrupt scheduled teaching practice periods leading to shorter period for accomplishing TP targets that are set to meet intended learning outputs and outcomes for school-based students, student-teachers and institutional goals.

Recommendations

Based on the findings and discussions presented in preceding narrative of this study the following recommendations have been made: There is a need for strengthened collaboration between teacher training institutions (Universities and Colleges of Education) with cooperating schools before commencement of teaching practice exercises. Such collaboration will help to reduce critical challenges that limit attainment of teaching practice goals and outcomes in the study area. The duration of the teaching practice exercise in teacher training institutions should be increased to provide ample time for the practice of professional activities associated with teaching and learning of the trainees. While the teacher training institutions should endeavour to distribute student- teachers for teaching practice

exercise to cooperating schools early enough so that they can get involved in preparatory school activities before schools resume.

The Nigerian government should develop an enabling policy through National Policy on Education (NPE) for both private and public teacher training institutions to accept pre –service teachers for the teaching practice exercise. Also, teachers teaching in teachers' training institutions should be motivated through regular payment of salaries and allowances to reduce problem of interruption in school calendar as a result of industrial action by the teachers. In addition, stipends should be provided as incentive to agricultural science student teachers after the teaching practice exercise. Adequate instructional materials and relevant school resources should be provided in cooperating schools by the government or school proprietors to improve the effectiveness of teaching and learning for student-teachers.

Conclusion

The study has affirmed that agricultural science student-teachers encountered a lot of challenges during their teaching practice exercises. These challenges emanated from various sources such as pedagogical issues, cooperating school, learners at cooperating school, the student-teachers themselves, teacher education institutions and other related factors. All these factors constituted a potential challenge to the successful acquisition of teaching skills by the agricultural science student-teachers. However, students have also suggested some measures which they think, if adopted, could serve to ameliorate the challenges encountered.

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Mathematics Performance across Gender and Who Owns a School

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Abstract: *Mathematics performance has always been low in Tanzania among primary school learners. The low performance is contributed by multiple factors most of which emanate from the investment and usage of resources. Some schools especially the public ones are in most cases low resourced when compared with their counterpart private schools. The study compared results in mathematics at Primary School Leaving Examination (PSLE) between public and private schools and between boys and girls. The National Primary School Leaving Examination results of 2016 of twenty schools were analysed. Private schools were found to do better than public schools. Boys were found to do better than girls in general and in public schools. The study adds to the existing discussion about gender parity in mathematics performance. Recommendations made suggest more investment in resources and effective use of the same should be done especially in public schools. Suggestions are further made on addressing both school-based factors and how schools relate to the immediate surrounding society.*

Key Terms: mathematics performance, primary schools, gender, public, and private-owned schools

Introduction

Mathematics is one of the key subjects in the school curriculum in Tanzania primary and secondary education. The subject addresses logical mental growth, analytical skills and communicates multiple meanings in other subjects (Uwezo, 2011). The subject is very important in science and technology-related subjects all over the world (Sa'ad, Adamu & Sadiq, 2014; Shao, 2014) as its theories are highly applicable among them and in nearly all disciplines (Shao, 2014). Bhalalusesa, Westbrook, and Lussier (2011) advocate that the importance of mathematics is also for future educational endeavors. In the era of rapid scientific and technological development and a wish for underdeveloped countries to industrialize, mathematics is one of the vital study areas necessary to foster development.

Such a situation has made Tanzania to place the subject at the centre of the school curriculum by making it compulsory to both primary and ordinary secondary education (Kisakali & Kuznetsov, 2015; Uwezo, 2011).

To achieve the long-term educational aims learners may need to learn effectively the subject and perform well when it comes to examinations. Good performance of the subjects at lower levels of education motivates students and makes them to like the subject and builds up learners' self-esteem on their mathematical ability (Calder & Campbell, 2016). Furthermore, good performance enables learners to qualify or be selected to pursue mathematics and other subjects that apply mathematical knowledge base in higher levels of education. With specificity to primary education and mathematics, the Primary School Leaving Examination (PSLE) determines pupils who will proceed to secondary education (Kabote, Niboye & Nombo, 2014) and mathematics is one of the major areas contributing to their required cut-off point.

Despite the known importance of mathematics and the emphasis shown in policies and school curriculum, the performance of the subject among learners has always been very low (Kisakali & Kuznetsov, 2015; Mabula, 2015; UNESCO, 2011; Kabote, Niboye & Nombo, 2014). Zilimu (2014) in his doctoral study found out that the low performance of pupils in mathematics is also horrendous at a lower level such as in standard three.

The performance of mathematics may be subject to multiple factors. There is no singled-out factor solely responsible for the ill-performance of mathematics. Factors leading to poor performance of mathematics include among others: a shortage of mathematics teachers, shortage of mathematics textbooks, incompetence among mathematics teachers, negative altitude among teachers and learners, and unfriendly environment (Kabote, Niboye, & Nombo, 2014). Most of the factors listed above reflect challenges in resource investment. Quality and use of effective feedback in mathematics may also improve students' performance (Kyaruzi *et al*., 2019). In the schools where such challenges are addressed, performance is likely to be improved.

Most of the Tanzania primary schools of which the majority are public owned schools are low resourced. Yusta *et al*. (2016) support the view that there is an appalling shortage of teaching and learning resources especially audio-visual resources which accordingly affect pupils learning of mathematics. The schools are marked with high enrollment rates (Developing Countries Strategies Group, 2009). Schools face shortages of classrooms and desks for learners to sit on (HakiElimu, 2014).

However, there are, though few in number, private-owned schools many of which are well resourced. Private owned schools are also not congested with multitudes of students, the situation which reduces resource competitions in the schools. HakiElimu (2014) contends that public and private schools operate in two quite different education milieus.

Boys and girls' study in the same schools and the factors mentioned earlier are gender insensitive. However, Kabote, Niboye and Nombo (2014) and Jones and Smart (1995) contend that girls' performance in almost all schools was below that of boys. Kabote, Niboye, and Nombo (2014) argue that in general boys performed better in mathematics than girls with a few exceptions. Furthermore, in other parts of the world, there is a belief that mathematics is a male domain (Brandell & Staberg, 2008; Jones & Smart, 1995). Unlike Kabote, Niboye and Nombo (2014) whose findings address the comparison between urban and rural-based schools, this paper explores the same issues but across ownership in urban-based schools. Specifically, the paper looks at the extent to which gender is likely to have been addressed even in good performing schools. While the difference in performance between private and public schools seems to be obvious, the gender aspect seems to have been given less attention (Ngware *et al*., 2012). Therefore, this paper attempts to analyze the differences in mathematics performance between the public and private-owned primary schools but with a critical look at gender differences. As such it also tackles the analysis of the performance of mathematics across gender. The study presupposed that there was no difference in mathematics performance at PSLE between public and private-owned schools. It also presupposes that there was no difference in mathematics performance at PSLE between boys and girls.

Methodology

The study was designed to compare PSLE mathematics results between public and private schools as well as between boys and girls. The study used the 2016 PSLE mathematics grades. There were no manipulations of the subjects. The study analysed results from twenty primary schools all of which are located in the urban Ilala district in Dar es Salaam region of Tanzania Mainland. In total, the schools had 2,355 (1,170 (49.7%) boys and 1,185 (50.3%) girls) whereby 1,208 (561 boys and 647 girls) of the pupils came from public schools and 1,147 (609 boys and 538 girls) pupils came from private schools. The district was chosen as its demography is relatively uniform by having all schools located in the centre of Dar es Salaam city.

The district also had a relatively high number of private schools, the factor which made it possible to select ten private and ten public schools with a reasonable number of learners. There were 108 schools in the district. Multistage sampling was used to obtain the schools. First, 80 schools that had forty or more pupils were identified for the study. Two strata were then

formed: 64 public and 16 private schools. Ten schools were randomly selected from each stratum. Their mathematics results were obtained from the National Examination Council of Tanzania (NECTA) and were analysed with the help of the SPSS version 20. A comparison between the performance of public and private schools and between boys and girls was calculated and the level of significance was established by the Chi-Square test of independence.

Findings

The NECTA pupils' grades in mathematics were recorded A, B, C, D and E. The grades were fed into the SPSS as A = 5, B = 4, C = 3, D = 2 and E = 1 for both public and private schools. Public schools had 135As, 221Bs, 374Cs, 412Ds, and 66Es, while private schools had 362As, 302Bs, 329Cs, 146Ds, and 8Es. This information was put in a line graph below.

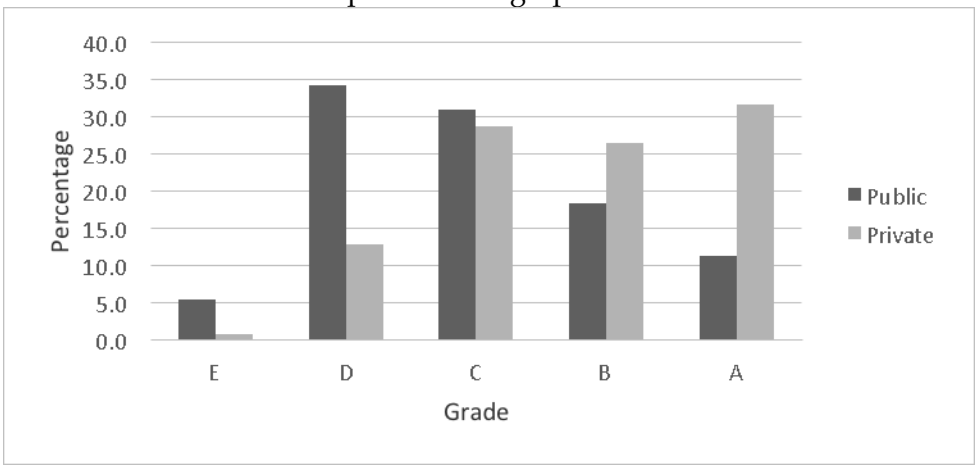

Figure 1: Performance in mathematics for public and private schools

The difference in performance of mathematics in public and private schools was run through the Chi-Square test of independence to determine its significance. The test showed that Chi-Square; $X^2(4, N = 2355) = 289.982$, $p < .05$. This means that there is actually a significant difference in the performance of mathematics between pupils from public and private schools.

First, the comparison was made by comparing the performance of boys and girls from all the twenty schools. Second, the comparison was made within the categories as either public or private. In the first case, there were 1 170 boys and 1 185 girls. It was found out that there were 289As, 261Bs, 325Cs, 265Ds, and 30Es for the boys, 208As, 262Bs, 378Cs, 293Ds, and 44Es for the girls. The general performance between boys and girls was descriptively put in a line graph as seen hereafter.

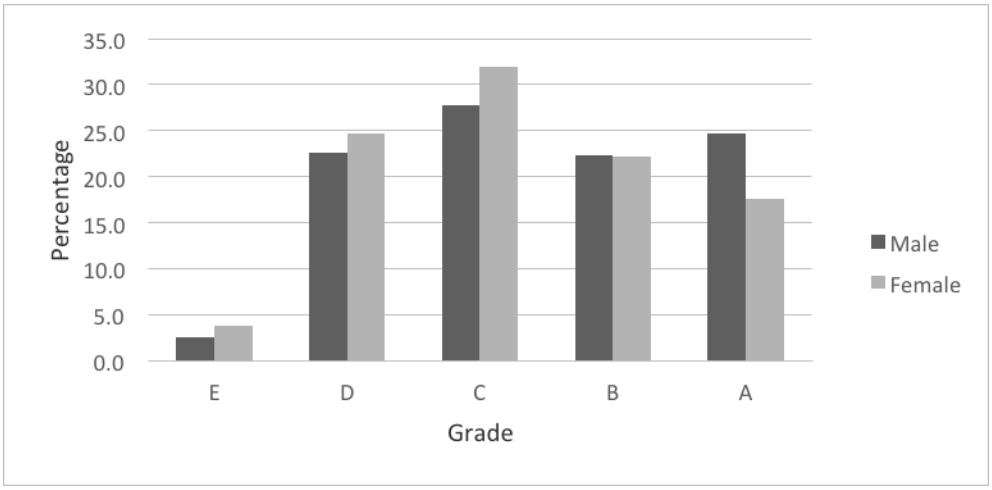

Figure 2: Performance in mathematics for boys and girls in primary schools

This difference was again put into the Chi-Square test of independence to determine if the difference was statistically significant. The test showed that Chi-Square $X^2(4, N = 2355) = 21.158$, $p < .05$. Thus, the difference in the performance of mathematics between boys and girls was statistically significant.

Further comparisons were done to check if the difference in mathematics performance between boys and girls is significant within the two categories of schools. In public schools, the boys had 82As, 93Bs, 165Cs, 193Ds, and 28Es while girls had 53As, 128Bs, 209Cs, 219Ds, and 38Es. The test showed that Chi-Square $X^2(4, N = 2355) = 14.054$, $p < 0.05$. This difference is statistically significant. In private schools, the boys had 207As, 168Bs, 160Cs, 72Ds, and 2Es and girls had 155As, 134Bs, 169Cs, 74Ds, and 6Es. The test showed that Chi-Square $X^2(4, N = 2355) = 9.211$, $p > 0.05$. Unlike in the case of public schools, in private schools, the difference in performance between boys and girls is not statistically significant. Graphically this information can be seen as in the following figures.

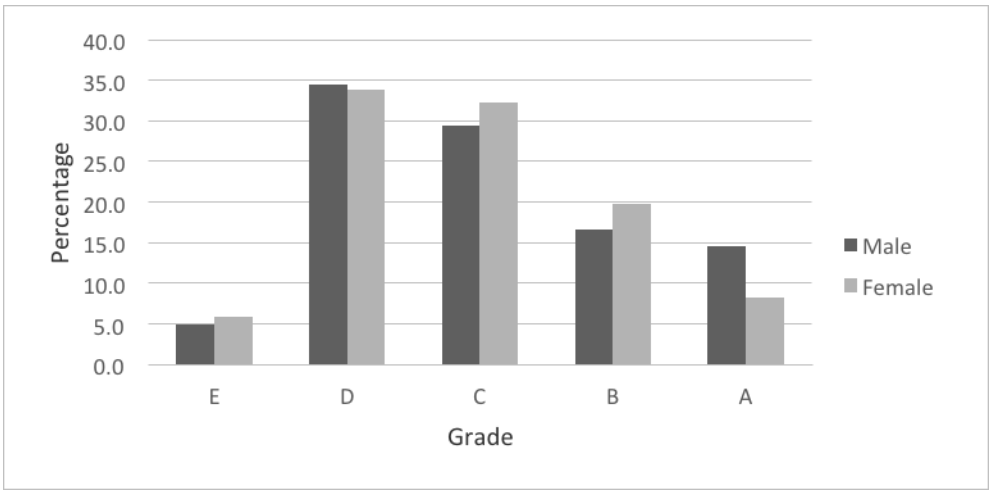

Figure 3: Performance in mathematics for boys and girls in public schools

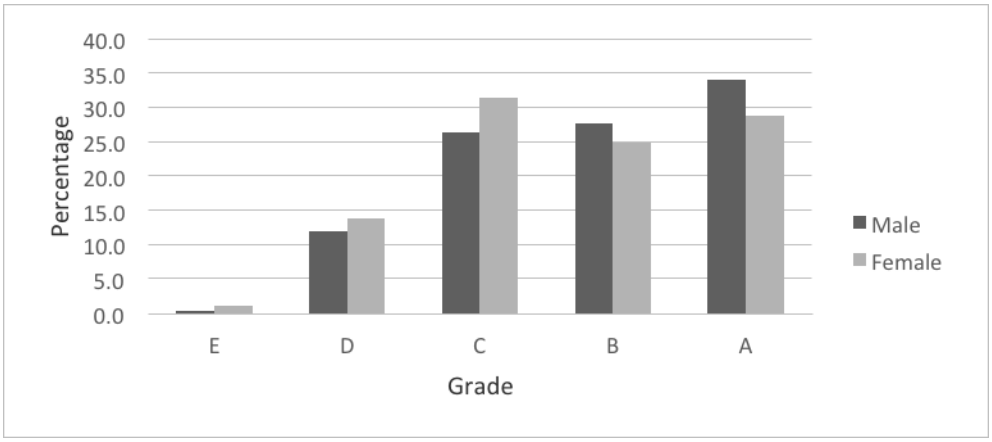

Figure 4: Performance in mathematics for boys and girls in private schools

Discussion

The study investigated the difference in mathematics performance between public and private-owned schools as well as across gender. The study found out that there is a significant difference in the performance of mathematics between public and private schools. While other studies such as that of Kabote, Niboye and Nombo, (2014) show differences in mathematics performance between rural and urban primary schools, in this paper such differences have been explained to exist between private and public primary schools in an urban area. As the performance is assumed to be affected by multiple factors, specific factors are yet to be explored that account for differences in mathematics performance between public and private primary schools. In order to improve performance in public primary schools at least to the same level as private-owned primary schools, the public sector has to learn from its counterpart private sector.

Furthermore, as the criterion to study mathematics and other related subjects and disciplines is doing well in mathematics (Ngware *et al*., 2012), then it can be implied that pupils who come from private schools are more likely to advance in mathematics and related fields than those in public schools. This suggests that by virtue of being in a public school one is likely to be disadvantaged when it comes to advancing in mathematics. While the public sector is hereby called upon to improve the learning process and consequently performance in mathematics, the ministry and other stakeholder organizations should consider learners' backgrounds based on the type of school ownership when it comes to selections.

Public schools provide education relatively free while private schools levy a reasonably high amount of money, which common people who are the majority of Tanzanians find it difficult to pay. As a result, private schools accommodate children from families, which are well-off economically while public schools accommodate children from families which are not well-off economically. In this case, the difference in mathematics performance between public and private schools may actually be the difference in mathematics performance between the rich and the poor. Also, as noted earlier that mathematics performance in lower levels of education affect motives and chances to proceed in the same and related fields, those who cannot afford to study in private schools are less likely to perform better in mathematics and as a result, may become disadvantaged when competing for opportunities of higher levels of education.

Gender issues were also examined from the mathematics performance viewpoint. This was important since most literature in Africa and Tanzania, in particular, discusses gender parity in terms of enrolment (Ngware *et al*., 2012). This leaves a gap in explaining the outcome of such enrolment especially when it comes to achievement. In this study generally, boys were seen to do better in mathematics than girls. These findings are supported by Kabote, Niboye, and Nombo (2014). The difference was also significant within the public schools' category. However, in private owned schools the difference in mathematics performance between boys and girls was statistically non-significant. This raises the discussion as to whether gender gaps truly exist in a well-established school (Ngware *et al*., 2012). Using similar data from standardized mathematics tests from the US, Hyde *et al*. (2008) dismiss the view that there is a gender gap in mathematics. The study did not address gender issues leading to the differences in mathematics performance but it identified that there are differences in the performance and therefore there may be school-based factors that affect mathematics performance across gender.

Additionally, the differences in mathematics performance between girls and boys may not be the result of school-based interaction alone but the general

social life of the pupils (Guiso *et al*., 2008). In fact, countries where boys seem to do better than girls in mathematics, Tanzania inclusive, have been reported to have the lowest gender-related development index (UNDP, 2005). Therefore, the education stakeholders need to investigate the gender issues surrounding primary school children which affect their mathematics performance be it school or out of school factors. Addressing such hindrance factors among girls and society at large may increase the number of girls doing better in mathematics and who may advance in mathematics and the related fields to higher levels.

Limitation of the study

The study was delimited to standardized mathematics primary school leaving examination performance data. As such the discussion was limited to this data and further research is needed in order to explore the various factors that affect mathematics performance and lead to differences in gender parity especially for public schools. Furthermore, gender parity seems to be a societal phenomenon that is not limited to the school environment alone. Therefore, future research may explore how private and public schools situate themselves within society.

Conclusion

The study was done to compare the mathematics performance between public and private schools as well as between boys and girls. There were notable differences in mathematics performance between public and private schools as well as between boys and girls. Pupils in private schools were found to perform better than those in public schools. Also, boys were found to perform better than girls in public primary schools. This suggested that public schools may not equitably be providing the required learning interaction milieu to boys and girls. Furthermore, the difference in mathematics performance between boys and girls may be attributed to other factors beyond the school environment that are still worth addressing. Unless these causative challenges are identified and addressed, public schools where the majority of children who come from poor families are found to obtain their education will continue to underperform. Also, unless gender issues are well addressed, girls will continue to be left behind despite individual efforts they may make especially in public-owned schools.

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Alignment to Climate Compatible Development: A Content Analysis of the Tanzania National Energy Policy

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Abstract: *This paper examines the extent to which the Tanzania Energy Policy 2015 aligns to Climate Development pillars. The study adopts an exploratory researchl design where the Tanzania National Energy policy of year 2015 is a major source of data. Content analysis is undertaken using an analytical framework developed after literature review. Findings indicate that the Tanzania national energy policy of year 2015 aligns partially to Climate Compatible Development pillars. The paper therefore calls upon a policy review to attain high alignment to Climate Compatible Development pillars.*

Key words: Climate compatible development, energy policy, renewable energy resources, adaptation, mitigation and development

Introduction

Production and use of energy, especially which comes from fossil fuels contributes significantly to climate change. The burning of coal, natural gas, and oil for electricity and heat is the largest single source of global greenhouse gas emission accounting to up to 25% of the total greenhouse gas emission globally (IPCC 2018). The industrial sector contributes to up to 30% of the total greenhouse gas produced annually at global level excluding emissions from industrial electricity use (Fischedick *et al*, 2014 and IPPC 2018). Production and use of energy from fossil fuels accounts for more than 84% of U.S. greenhouse gas emissions (EPA 2019 and IPPC 2018).

Production and use of energy is one of the key issues featuring in Tanzania as far as climate change is concerned especially because the country aims to become a semi-industrialized country by 2025 (URT 2011). The contribution of manufacturing to the national economy is targeted to reach a minimum of 40% of the GDP by 2025 (URT 2011). The country however faces serious challenges regarding energy production and power supply which is necessary for industrial development. Energy production rate and power supply seems not catching up with the growth of power demand and is virtually threatening industrial activity in the country (URT 2011). Not only that but also power shortage and frequent outage for civilian life is more

serious in the country (Chandra et al., 2008; and Ebinger and Vergan 2011). Alam (2013), however, noted that increases in the incidence of power outages reduce the output and profits of some electricity-intensive industries.

For many years Tanzania has been relaying much on hydro power as the major source of energy. The country, however, like many other countries in the world, is experiencing climate change (IPPC 2018; Mwiturubani 2019; and Matata *et al.,* 2019). Climate change has already negatively impacted most developmental sectors in the country including the energy sector (Ebinger and Vergan 2011; URT 2011; and URT 2015). Repeating prolonged severe droughts, for example, have been a major cause for reduced water for hydroelectricity production in the country (Ebinger and Vergan 2011; and URT 2015); as a result, power cuts have been common in the country. Power cuts however have negative connotation on industrialization as warned by Alam (2013). This is especially because in the manufacturing sector electricity for energy and power is important for machines running. The literature elsewhere shows that the impacts of power outage goes beyond the industrial sector; services in such important sectors as health and education may be severely hampered from unreliable electricity supply (Franco *et al.,* 2017; Chawla, *et al.,* 2018 and Oum, 2019). Franco *et al.,* (2017) and Chawla, *et al.,* (2018), for example, share the view that, energy is an important variable when it comes to delivering and improving healthcare services and life-saving interventions especially among developing countries.

Oum (2019) on the other hand noted that in Nigeria, energy poverty negatively impacts education levels attainments and health status in the country. Tourism is also likely to be affected since most hospitality services are highly facilitated by electricity as Moutinho *et al.,* (2015) explains. Businesses as supermarkets which hugely use refrigerators are also vulnerable to power outage as the experience from Chile presented by Moreno and Shaw, (2019) demonstrates. Experiences from Chile shows that domestic activities also get affected by power cuts (Moreno and Shaw, 2019). Agriculture might also suffer from power cuts where irrigation and processing industries may be negatively affected, although, as Ali *et al.,* (2019) explains, electrification of agriculture can be detrimental to the environment, hence energy intensification in agriculture should embrace clean energy resources. Basing on the literature one my conclude that the combination of all the effects of power outages in the different sectors would generally hamper the overall socio-economic development of any country.

The government of Tanzania has embarked on several projects to ensure power supply to support industrial growth as well as to ensure power supply for civilian life (URT 2011; URT 2014; and URT 2015). One of such government efforts has been exploration and tapping of gas and oil resources as well as development of the Stigler's gorge project. Gas and oil are two important emerging energy resources in Tanzania. The two resources, if well harnessed, are likely to boost significantly the economy of the country (URT 2014). In the years between 2010 and 2013, relatively large gas discoveries were made (URT 2014). Natural gas discoveries totaling about 8 trillion cubic feet (TCF) were discovered from the onshore gas fields at Songosongo, Mnazi Bay, Mkuranga, Kiliwani North and Ntorya. As of June, 2013 natural gas discoveries of about 42.7 TCF (7.5 billion barrels of oil equivalent – BoE) were made from both on- and off-shore basins (URT 2013). The deep sea gas discoveries have brought about new exploration targets for hydrocarbons in Tanzania. These discoveries may result in large revenues and form a major source of income for the nation. There is therefore a huge potential for growth in the energy sector in Tanzania following the discovery of oil and gas in Songosongo and Mtwara as well as the development of the Stigler's gorge project. While production and consumption of gas from Songosongo is already taking place, in Mtwara preparations for production of gas and oil are underway where already the government is fixing the infrastructure for the same. The Stigler's gorge project is expected to boost the total power production for the country by about 145% (https://www.esi-africa.com/regional-news/east-africa/tanzania-continues-stieglers-gorge-hydroelectric-project/).

There is however a more recent paradigm pertaining addressing climate change impacts on development known as 'Climate Compatible Development (CCD)' paradigm (OECD 2015). CCD refers to '...development that minimizes the harm caused by climate impacts, while maximizing the many human developmental opportunities presented by a low emission, and creating a more resilient future" (Mitchell and Maxwell 2010 pg 1). With climate change policies need to be crafted in a way that enables societies to develop socially and economically but at the same time sustain such development (OECD 2015). Developing such policies need a critical analysis of the multiple threats and uncertainties created by climate change. But also, policies need to promote reduction of Green House Gases to the minimum level possible (Kaur and Ayers 2010). In tackling the challenges, CCD moves beyond the traditional separation of adaptation, mitigation and development strategies. Instead it emphasizes the integration of threats and opportunities of a changing climate into developmental goals and strategies.

With CCD, communities are expected to leap development in different developmental dimensions without been affected by climate change and also without aggravating climate change and its impacts, this is called

climate resilient and low emissions development' (Mitchell and Maxwell 2010). In simple terms climate compatible development encourages policies that can simultaneously promote low emissions, resilience and development (Kaur and Ayers 2010). Climate compatible development, therefore, advocates for developmental projects that are non-climate change vulnerable but at the same time same they are pro low emissions.

Climate compatible development is, however, as said earlier, a relatively new paradigm in climate change and development sphere of knowledge. As a result the literature is almost silent on case studies explaining the extent to which developmental policies have so far bought and taken aboard the paradigm especially in Tanzania. This study, therefore, explores the extent to which developmental policies in Tanzania incorporates the concept climate compatible development with reference to the national energy policy. The study specifically examines the extent to which the Tanzania national energy policy aligns with the three CCD pillars namely adaptation, mitigation and development.

Methodology

The study adopted an exploratory research design since scant literature is available as far as policy assessment on alignment to CCD is concerned. The study adopted qualitative document analysis (QDA) approach in line with Bowen (2009) to analyze the extent to which the Tanzania national energy policy aligns to the CCD pillars namely adaptation, mitigation and development. The energy sector was selected due to the fact that the sector is climate change sensitive in that it contributes to GHG emissions which lead to global warming but also it is vulnerable to climate change through among others, reduction of water resources which are important resources in power generation in the country. Not only that but also since the country is aiming to leap forward in industrialization by year 2025, it will obviously require a huge development in the energy sector; for that matter it was thought important to examine the way CCD is framed within the policy sector. It is acknowledged however that there are other many climate sensitive sectors in the country including agriculture, water, forest and tourism, yet it was important to draw a manageable boundary around the study, so other climate change sensitive sectors were purposively omitted as they are less directly linked to industrialization-GHG emission as the case is for the energy sector. To be precise, those "other" sectors are largely GHG emitters via industrialization-energy relationship. However, these other sectors will definitely form important areas of further research following findings from this study.

The study abided to the eight steps pertaining QDA as defined by O'Leary (2014). The first step was gathering relevant texts. During this stage, the

Tanzania National Energy policy of year 2015 was identified as the current energy policy for the country hence identified to be the right document for the analysis. But also, literature pertaining climate compatible development was identified, this was important for developing the CCD pillars. The second step was developing an organization and management scheme. Since the focus was on the Tanzania energy policy only as opposed to analysis of multiple policies the document was easily managed as there was minimal distraction from contents of unrelated policy documents. It was during this stage where the CCD pillars as well as the scoring criteria were developed (Tables 1and 2). The third step was assessing the authenticity of the document; the research ensured that the document was gathered from the relevant ministry. The next steps were to explore the document's agenda and purpose. Here the researcher scrutinized the document and ensured that it was the policy document for the energy sector in Tanzania. Questions as who produced the document, why, when and type of data to be found in the document were delineated prior to the analysis of the document contents. In exploring the actual content of the policy document in question, the study abided to the interview technique as prescribed by O'Leary (2014) where "the researcher treats the document like a respondent or informant that provides the researcher with relevant information" (O'Leary, 2014). The researcher "asks" questions then highlights the answer within the text. Meaning and implications of texts within the document was key to the analysis, rather than simply the presence of keywords. The policy document was thoroughly read to identify evidence in support of CCD as outlined in Table 1. Finally, the information was organized into what is "related to the central questions of the research" (Bowen, 2009, p. 32). Quotes from the policy are presented for almost each alignment assessment purposely to allow inspection of the assessment.

Table 1: Description of Climate Compatible Development Alignment Pillars

Pillars	Indicators	Description
Adaptation	Access to energy	Access to energy can alleviate supply constraints
	Energy diversification	Energy diversification eliminates reliance on one single generation source to enhance security of supply.
	Energy efficiency and demandresponse-side management	Energy efficiency and demand response-side management can alleviate supply constraints.

	Smoothing the demand curve for energy	Smoothing the demand curve for energy over the day and the year, can lower overall required energy capacity.
	Distributed as opposed to centralized energy systems	Distributed as opposed to centralized energy systems can increase resilience
Mitigation	De-carbonization of energy.	De-carbonization of energy can be met through use of renewable energy, use of nuclear power, or the use of carbon capture and storage (CCS) technology, all the options can significantly reduce amount of GHGs in the atmosphere although there are challenges attached to each option that countries need to address them to achieve de-carbonization
	Improvement of energy efficiency	This level of assessment is for checking the efficiency aspect of products and systems. Energy should be used in the most efficient way to achieve the greatest output. Energy efficiency has been improving worldwide, but the speed of improvement should be even faster if the world was to minimize the impact of climate change. In some sectors, energy efficiency at the product level is satisfactory, but not at the system or community levels. Hence, various levels of energy efficiency need to be assessed. Some policies to promote energy-efficient products do not always lead to overall emission reduction because they may stimulate increased consumption of products and energy at community level.
	Minimizing demand for energy service	While energy efficiency needs to be further improved, the best approach is to eliminate any need for energy. For instance, improvement of energy efficiency in automobiles is important, but people can use other means of transportation such as bicycles and public transportation while enjoying the same level of mobility. Energy demand management is another approach to reduce the pressure on insufficient electricity supply, rather than increasing the supply by burning more fossil fuels to meet the requirements.

	land use, land-use change and forestry (LULUCF)	LULUCF refers to reducing GHG emissions through: conservation and protection; efficiency improvements; and fossil fuel substitution.
	Sequestering of carbon	Increased forest area; increased vegetation cover; increased carbon storage in soils; and conversion of biomass to long-term products.
Development	Promotion of social-economic development	The policy need to promote social-economic development since the two can in turn capacitate communities to sustainably adapt to climate change

Source: Modified from Antwi-Agyei (2013)

Table 2: Scoring criteria for alignment of the sector policy documents with key pillars of CCD

Type of alignment	Description of alignment	Score
High alignment	The sector policy aligns strongly with the indicators of triple wins (adaptation, mitigation and development (A/M/D). Policy devotes attention to the particular building block and includes specific activities for achieving the particular block.	3
Partial alignment	Although the policy supports the various indicators of A/M/D, it is less clear and less distinct in terms of how the indicators and each particular building block could be achieved. There is limited evidence present of how the specific indicators as well as the building blocks could be achieved in practice	2
Limited alignment	The sector policy supports a particular indicator of the A/M/D building block but there is a lack of evidence to support alignment with it.	1
No alignment	There is no evidence in the document to suggest that the sector policy supports the implementation of the building block or even encourages it.	0

Source: Gouais and Wach (2013)

Findings

Policy Alignment to Adaptation Pillar

Improving access to energy in rural areas

Improving access to energy in rural areas is one of the main indicators that a given energy policy aligns to the adaptation CCD alignment pillar. It is believed that rural electrification reduces vulnerability to climate variability and change especially among rural dwellers and particularly in developing countries (Stuwart 2017). The Tanzania energy policy (2015) aligns implicitly with this adaptation indicator. The policy first defines clearly why rural electrification is an issue. It identifies the magnitude of the problem to be serious since the largest population in Tanzania (70%) depends on wood

fuel, and it is so because majority of such population reside in rural areas where other sources of energy are not yet available (URT 2015). Hence most operations in institutions including domestic operations such as cooking, as well as industrial operations such as the processing industries depends on wood fuel for energy (URT 2015). For sure such heavy reliance on wood fuel is contrary to the millennium developmental goal that propounds for cutting down emission of CO_2 and other GHGs in order to save the environment. After defining the problem and its magnitude the policy states its objective as "To accelerate rural electrification to foster socio-economic transformation" (URT 2015 pg 16). The actions to address the objective are also clearly stated as follows: that the government shall i)Facilitate private sector participation including community groups and financial institutions in provision of modern energy services; ii) Facilitate local capacity building for manufacturing, installation, maintenance and operation of rural energy systems; and iii) Strengthen institutional capacity for effective coordination, administration, implementation and monitoring of rural energy projects.

The policy concern, however, sounds to be primarily facilitation of social economic development in rural areas vs. cutting down GHGs emissions. But social economic development may mean more production activities including industrial activities especially agro-processing industrial activities, as well as farm expansion through land clearance; such activities are highly advocated under the current paradigm namely 'value adding in the chain of production' as demonstrated in Ali *et al.,* (2019). *Ali et al*., (2019) argued for example that, electrification of agriculture can enhance food production hence contribute to social-economic development but at the same time can be detrimental to the environment unless electricity is made from non fossil fuel. For that case, objectives targeting at lowering levels of GHGs emissions must state categorically the focus on cutting down emission instead of having an implied objective. Clear objectives help in identifying areas of collaboration with other relevant sectors in attaining the intended objective, which for this case would be cutting down GHG to the minimum level possible. With unfocussed objectives there tend to be greater chances for ending up with sectoral operations instead of having greater connection among sectors; such sectoral approach however in most cases fail to resolve tensions and trade-offs between sectors and stakeholders (Amani and Mkumbo 2012). Therefore, one may conclude that although social economic transformation is good as it may mean poverty reduction yet focusing at social economic transformation may disorient the whole intention of saving the environment to social economic development, which may not necessarily address the issue of sustainable environmental management unless the concept of sustainable development is taken

onboard. The building block score 2 points meaning that it partially aligns to CCD.

Energy diversification

Diversification is an indicator for adaptation to climate change in the energy sector. In principal, energy diversification eliminates reliance on one single generation source which in turn enhances security of supply Stuwart (2017). With ensured supply chances for turning to environment unfriendly sources of energy such as wood fuel tends to be minimized. One of the Tanzania energy policy objectives provides for energy diversification as it intends " To enhance utilisation of renewable energy resources so as to increase its contribution in diversifying resources for electricity generation" The government intends to scale up utilization of renewable energy resources through: (i) promoting renewable energy sources and sustainable use of biomass for power generation; (ii) facilitation of integration of renewable energy technologies in buildings and industrial designs; (iii) establishment of feed in tariffs for renewable energy technologies; (iv) establishing framew orks for renewable energy integration into the national and isolated grids; and (v) promoting sustainable biofuel production and usage.

In principal Tanzania depends much on hydroelectric power, therefore utilization of renewable resources is an important move towards adaptation to climate change in the sector especially because water resources is one of the most vulnerable resources to climate change. Investing in solar, wind, biomass, and geo-thermal is important for diversification from energy from fossil fuel, as well as from hydroelectric which is vulnerable to climate change hence less reliable especially during prolonged drought a phenomenon that has become common nowadays partly due to climate change. The policy however presented a number of challenges, which for a long time have hindered harnessing such renewable resources as solar, wind, biomass, and geo-thermal. One would, therefore, expect the policy to present policy statements, which are directed towards addressing such challenges so that harnessing of renewable resources is made possible.

Unfortunately, the policy fails to provide a clear picture as to how the identified challenges which for many years made harnessing of such alternative sources of energy source not possible. For example, as far as utilization of solar power is concerned the policy states that "solar utilization is constrained by high initial cost; poor after sales service; insufficient awareness on the potential and economic benefits offered by solar technologies, and appropriate credit and financing mechanisms" (URT 2015 pg16). If this is the problem then one may ask, which policy statement of the five statements provided is intended to address it? How promotion of renewable energy resources will be done without first addressing the issues raised as constraints to harnessing renewable resources? Where will the

resources to meet the allegedly high initial coasts come from, what strategies are in place to handle that challenge, will establishment of feed in tariffs for renewable energy technologies suffice to handle the high initial coasts and to what extent? What about the challenges related to poor after sales service? What about appropriate credit and financing mechanisms? One may note that it is difficult to answer these questions basing on the information provided by the policy. Ross (2014) for example noted that initial costs for solar projects is a real challenge facing transformation in the energy sector; he therefore, implicitly, advocates that policies should demonstrate strategies which guarantees that renewable energy resources can sustainably compete with fossil fuel energy resources. Ross (2014) provides an example from Asia where doubling cumulative installation capacity of photovoltaics was a strategy used to reduce solar energy price allowing solar energy to compete with energy from fossil fuels sustainably (Ross 2014). Therefore, it would be important for the 2015 Tanzania National Energy Policy document to demonstrate how it takes on board strategies for ensuring that all stabling blocks towards transformation in the sector are eliminated.

For biomass, the policy states that "Challenges associated with biomass include: low conversion and end-use efficiency deforestation; indoor emissions; inadequate legal and institutional framework to support sustainable production, distribution, supply and use of wood fuel"(URT 2015 pg 17). One may note that there are about four barriers hindering the taping of biomass for energy. Surprisingly there is only one generic policy statement for biomass i.e. promoting sustainable bio fuel production and usage. Yes, but how? How will the issue of low conversion be handled? How will the issue of end-use efficiency be addressed, and what about indoor emissions? All has been wrapped up in one phrase - '...sustainable bio fuel production and usage..' It would have been more helpful if objectives could be self explanatory and reflecting specific problems to be resolved. To minimize deforestation Ross (2014) advocates for roof-top solar installations against solar farming which usually lead to land to facilitate installation and native vegetation is cut or removed to avoid shading.

OECD (2015) noted that energy policies need to demonstrate strategies towards ensuring sustainable land-management practices which will assist reducing deforestation, restoring degraded land, foster low-carbon agricultural practices and strategies for increased carbon sequestration in soils and forests. England *et al.,* (2018) noted that policy approaches that advocate promotion and expansion of renewable energy sources (such as solar, wind, biomass, geothermal) score highly as far as alignment to CCD owing to their support for reducing CO2emissions. However, the analysis

by England *et al.,* (2018) did not show how problems, objectives and action statements were assessed to determine achievability of the objectives and statements as opposed to the analysis in this study.

For wind power, the identified problems by the policy document are wind regime data; high investment costs; integration and compatibility to the grid system and distance from grid and load centers. For geo-thermal the problems identified include high investment costs; high exploration risks; inadequate data, human and capital resource required to undertake necessary studies; remote location of geothermal fields and undeveloped infrastructures (URT 2015 pg18). Again, there is a very weak link between the identified problems for both wind and geo-thermal power and the prescribed policy action statements, which are to: (i) promote renewable energy sources and sustainable use of biomass for power generation; (ii) facilitate integration of renewable energy technologies in buildings and industrial designs; iii) establish Feed-in- Tariffs for renewable energy technologies; iv) establish frameworks for renewable energy integration into the national and isolated grids; and v) promote sustainable bio-fuel production and usage. As Walker (2000) put it, "...a policy is a set of actions taken to solve a problem. The policymaker has certain objectives that, if met, would 'solve' the problem" (Walker 2000). This means, for any given policy, there need to be a clear link between policy action statements and the policy problem (policy issue) stated in order to achieve the intended objectives; this is what is lacking here as far as the policy under scrutiny is concerned.

Generally, the policy issue and the objective indicate some alignment with the adaptation indicator in question, the major problem is that the policy statements are weakly connected to the existing hindrances towards harnessing renewable energy resources. As a result, although the policy statements sound good in the sense that they seem to focus at promotion of renewable energy resources, yet in real sense they may not change the situation since they fail to beam out any indicator that they can resolve the existing barriers towards promoting such renewable energy resources.

Good policy statements could come up with clear variables to be worked upon to resolve specific issues. It would have been of help if there could be objectives and action statements for each renewable energy category. Therefore, the analysis here concludes that the policy scores 1 point meaning limited alignment with the energy diversification indicator since it fails to provide policy action statements clear enough to demonstrate that once such actions taken the existing barriers towards harnessing of the resources in question will be removed hence the intended objective will be attained. A study by Antwi-Agyei *et al.,* (2017) indicated that stakeholders in

Ghana were not happy with their National Energy Policy partly because it lacked specificity on who should do what to achieve prescribed objectives.

Energy efficiency and demand response - side management

Energy efficiency, water efficiency and demand—side management alleviate supply constraints. The Tanzania National Energy policy, however, does not seem to address clearly the concept 'energy efficiency and demand response - side management'. Of course the policy does explain ways to handle issues of energy efficiency and demand but in a separate manner that the nexus between them does not feature out clearly. One of the relevant policy objectives to energy efficiency is "to promote energy efficiency and conservation in all sectors of the economy" (URT 2015 pg21). The action statements to meet the objective are somewhat troublesome though, they are six of them as follows: i) facilitate establishment of standards and code of practice for energy management; (ii) ensure energy uses are benchmarked to industry prudent practices; (iii) facilitate efficient biomass conversion and end-use technologies; (iv)ensure integration of energy efficiency aspects in housing policies and building codes; (v) Enhance fuel switch from wood fuel to modern energy; and (vi)Facilitate adoption of appropriate cooking appliances to promote alternatives to wood fuel. Both the policy objective and the policy action statements clearly reflects the government vision towards enhancing energy efficiency. With reference to URT (2015), one may note that the six statements largely address the identified challenges pertaining promotion of energy efficiency despite language being generic. The prescribed policy statements clearly matches proposed policies for reducing GHG emission in Maxwell (2016). However the generic language is not encouraged since if not handled with care it may cause leakage of actions during policy implementation. Due to such generic language, for example, there are some challenges which can be perceived to have been left hanging. For example, energy inefficiency use in industries is associated with old and sub-standard equipments as well as outdated technologies (Maxwell 2016).

There is no policy objective to address demand response rather there is an objective to address issues of supply which states as follows: "To mainstream sectoral plans into Energy Sector planning". This objective emanates from the problem of poor planning on the side of the energy sector; this means, the energy sector admits that it is not well informed on who needs how much energy and at what time, hence the energy sector is calling upon an integrated plan that well take care of the issue of proper energy supply at a particular time. The policy action statements on planning are presented in the next section where the paper discusses in details the 'smoothing the demand curve for energy' adaptation indicator.

Looking both the policy objective and the respective policy action statements one would note that the policy does not indicate any aspiration to make the demand side accountable for the energy used so that the demand side can use energy sensibly. The policy could indicate for example that it intends to impose extra charges to users who would need supply at times when energy is not that much necessary basing on their nature of operations, that would likely lead to careful use of energy and eventually demand would be regulated to balance the need, the coast and the supply as it is proposed in NAPEE (2010). The policy could also impose positive incentives packages to user who happen to use energy wisely. Such that they generate more energy in store for other users especially during peak hours. If for example domestic users can be encouraged to use cold preserving cabinets during peak hours instead of having refrigerators on throughout. Such practices can create an opportunity for energy serving during peak hours hence balancing the demand and supply without necessarily affecting quality of service.

Energy efficiency and demand response management when properly handled reduces the pace for expansion of energy production, which is desirable for adaptation to climate change. The current option in the demand side suggests a likelihood of expansion in energy production to meet the demand; this is contrary to the adaptation and mitigation requirements. Expansion of energy production means more emission of the GHG and therefore more global warming. Box 1 presents a description of energy efficiency and demand response nexus. Failure to clearly show the demand response measure to be taken by the energy sector leads to rating this indicator as no alignment (0) since there is no evidence in the document to suggest that the sector policy supports the implementation of the building block i.e. energy efficiency and demand response side management.

Box 1

Energy efficiency - demand response nexus

Energy efficiency refers to using less energy to provide the same or improved level of service to the energy consumer in an economically efficient way; it includes using less energy at any time, including during peak periods. In contrast, demand response entails customers changing their normal consumption patterns in response to changes in the price of energy over time or to incentive payments designed to induce lower electricity use when prices are high or system reliability is in jeopardy. Better coordination of energy efficiency and demand response programs at the provider level could bring about cost efficiencies and more rational allocation of resources for both program providers and customers. Coordination could help customers, as most customers do not understand or care about the difference between energy efficiency and demand response and would be receptive to an integrated, packaged approach to managing their energy usage. Greater customer willingness could also increase demand response market penetration and capture energy savings and customer bill-reduction opportunities that might otherwise be lost. Over the long term, customer and utility smart grid investments in communications, monitoring, analytics, and control technologies will blur many of the distinctions between energy efficiency and demand response and help realize the benefits of this integration (NAPEE 2010pg.1-2)

Smoothing the demand curve for energy

Smoothing the demand curve for energy over the day and the year, will lower overall required energy capacity; this can be attained through reducing and shifting energy demand away from peak hours (National Action Plan for Energy Efficiency 2010; and REN21. 2019). The problem is implied under the description of the planning problem in the electricity sub-sector. The sector describes the problem pertaining planning for the electricity subsector as follows: "Inadequate planning has led to conflicting and competing interests among various sub-sectors of the economy with regard to the development and utilization of energy resources; occasional shortages or disruptions in supply of fossil fuels; power rationing as well as frequent power interruptions" (URT 2015 pg 44). Hence the policy advocates for mainstreaming sectoral plans into the energy sector planning (ibid pg 44) which will lead into having a robust integrated plan that takes on board the needs of government actors, regional and international energy trends.

In that regards, the government is committed to: (i)promote inter-sectoral and cross-sectoral energy planning; and (ii)facilitate development of energy master plans, programmes and projects as these are its prescribed objectives specific to solve the problem of poor planning which has caused poor energy demand curve due to conflicting and competing interests across sectors. Likewise, the petroleum subsector advocates for proper management of energy through an integrated plan that considers all energy users in a manner that energy demand and supply are determined in advance thus reducing burning more fossil fuels to facilitate high energy demand. The objective and associated action statement to resolve the planning problem in the electricity sub-sector; also, the objectives and action statements to resolve the problem of proper management in the petroleum sub-sector; may definitely address the issue of smoothing the demand curve. However, the implications of the given actions towards ensuring a smooth demand curve might be detrimental if production of energy can be expended unless such expansion is taken care with alternative sources of energy, which are less detrimental to the environment. The policy fails to control the demand response, which could otherwise assist in ensuring a smooth demand curve without necessarily calling upon expansion of energy production, which is costly and may not be environmentally friendly. This building block is rated partial alignment (2) for its problem definition is just by implications and also action statements do not clearly reflect on environmental conservation agenda.

Distributed as opposed to centralized energy systems

Distributed as opposed to centralized energy systems is another important climate change adaptation indicator in the energy sector. Distributed energy system can increase resilience (National Action Plan for Energy Efficiency 2010; and Avila et al., 2017). With distributed generation energy is produced next to its point of use. Renewable energy-based generation can enhance resilience due to its modular nature, ability to operate in severe weather when designed to do so, and lack of fossil fuel requirements (REN21. 2019). According to Stout et al., (2018) policies for distributed energy for climate change resilience need to observe commitment to spatial diversification, micro-grids installations, addressing the water-energy nexus, and redundancy.

Spatial diversification -The modular nature of renewable energy technologies, such as wind turbines and solar photovoltaics, allows greater spatial diversification of energy supplies compared to conventional power generation systems, which deliver power from a concentrated point or central location (Avila et al., 2017; and REN21. 2019). This increased spatial diversification reduces the vulnerability of the energy supply to cause damage from a single event or a single critical location, which increases overall energy system resilience (National Action Plan for Energy Efficiency 2010; and Avila et al., 2017). The Tanzania National Energy Policy a sound objective regarding spatial diversification of energy production, which states as follows: " To enhance utilization of renewable energy resources so as to increase its contribution in diversifying resources for electricity generation (URT 2015 pg 18)". The policy provides the following action statements to attain the objective are attainable. Such action statements are presented as follows: (i) Promoterenewable energy sources and sustainable use of biomass for power generation; (ii) Facilitate integrationof renewable energy technologies in buildings and industrial designs; (iii) Establish Feed-in- Tariffs for renewable energy technologies; (iv) Establish frameworks for renewable energy integration into the national and isolated grids; and (v) Promote sustainable biofuel production and usage(ibid pg 19). But as presented earlier these objectives do not reflect on the problem, which hinders development of the specific renewable energy sources i.e. solar, biomass, liquid fuels, wind, small scale-hydro, and geothermal presented on pg 17-18 of the 2015 Tanzania National Energy Policy document (URT 2015). It may not be very realistic to throw one generic objective with a focus to address issues from different types of sources of energy with different kinds of challenges towards exploitation of such resources. Hence there is partial alignment to CCD as far as this aspect is concerned and therefore the sub building block scores 2 points.

Microgrids installations - Microgrids capable of islanding based on distributed energy systems can disconnect from the central grid during a major climate event to allow energy to be diverted to critical loads (Stout et al., 2018). This allows utilities flexibility in restoring generation stations, responding to critical

outages, and shutting down systems before a major event to prevent damage (ibid). Islanded energy systems, therefore, ensure consumers have access to power during long-term power outages that severely impact central grid systems, which can occur after major natural disasters (ibid). The Tanzania National Energy policy commits the government to this requirement as one of its objects focuses at "Enhancing power reliability and coverage of transmission and distribution networks" (URT 2015 pg 15). More efficient energy use is one of the main options for achieving global sustainable development in the 21st century; support interconnection with neighboring countries. The action statement which goes as follows: i) Ensure timely investment in construction, rehabilitation and expansion of the transmission and distribution infrastructure; ii)Ensure establishment of appropriate legal and regulatory framework for an Independent System Operator and Independent Market Operator; iii)Ensure reduction of power losses in transmission and distribution networks; and iv)Establish a framework to allow open access to distribution networks (ibd pg 15), well links up with the challenges identified regarding achieving reliable transmission and distribution which include aged infrastructure, high power technical losses, lack of proper rehabilitation and maintenance and system overload; vandalism of transmission network; land and way-leaves acquisition, dilapidated networks, outages as well as technical and non-technical losses. The policy therefore is highly aligned to this sub-building block scoring 3 points.

Water and energy: The water-energy nexus is a critical factor in resilience. Water is used for energy generation in hydro-electric plants and in cooling systems for nuclear plants. Simultaneously, energy is used for treating and pumping water supplies. Technical solutions ranging from making power-generation plants more efficient, to using clean-energy technologies, and designing systems to utilize gravity-fed options can enhance resilience of both energy and water systems. The Tanzania National Energy Policy, however presents that Tanzania has considerable potential of small hydro, the problem is that the proven sites have not been fully exploited due to lack of funds to develop the sites and restrictions on water rights (URT 2015 pg 18). The policy however does not provide clear policy action statements to resolve the problem related to lack of funding although it intends to promote renewable energy sources, promotion of renewable energy sources however definitely need funding. Hence there is less commitment to this requirement since and the sub building block is rated partial alignment scoring 2points.

Redundancy - Redundancy may be explained as the extent to which multiple power lines are committed into energy supply to a given entity (community, industry, etc). Communities served by only one power line or water supply have limited resilience. Increasing supplies, routes, or incorporating

redundancy to overall systems will reduce the risks of those systems (Stout et al., 2018). The Tanzania National Energy policy intends to "Establish frameworks for renewable energy integration into the national and isolated grids" (ibid pg 19), which in a way may improve redundancy. For this case the policy is fully aligned to this requirement scoring (3). For this building block therefore the policy scores an average of 2.5 therefore rounded to 3 and hence it is voted for full alignment score**.**

Policy Alignment to Mitigation Pillar
De-carbonization of energy
All countries, in one way or another, should reduce consumption of fossil fuel. As an alternative, countries can increase the use of renewable energy, the use of nuclear power, or the use of carbon capture and storage (CCS) technology. While all these options are effective in reducing CO2 emissions, the latter two face other issues. These options could be considered as intermediary solutions until renewable energy is widely diffused. The use of renewable energy is far more supported by the people than the other two options. However, some voices emphasize economic and technical concerns related to renewable energies. These are the challenges that need to be overcome for a wide diffusion of renewable energy technologies.

There is much evidence that the policy is aligned to the de-carbonization of energy requirement as it advocates for promotion of use of renewable energy resources. The policy identifies such sources as wind, solar, biomass, small-scale hydro, geothermal, tidal, waves, and ocean thermal conversion. The specific objective on use of renewable energy resources is "to enhance utilization of renewable energy resources so as to increase its contribution in diversifyingresources for electricity generation." The government is committe d to (i) Promote renewable energy sources and sustainable use of biomass for power generation (ii) Facilitate integration of renewable energy technologies in buildings and industrial designs (iii) Establish Feed-in- Tariffs for renewable energy technologies iv) Establish frameworks for renewable energy integration into the national and isolated grids; and (v) Promote sustainable biofuel production and usage (URT 2015pg 9). Implicitly, the objective is set to address one of the key drivers for the formulation of the policy, which is "promoting compliance with environmental, health and safety standards in the Energy Sector" (ibid pg 9). Likewise the policy statements indicate that activities related to electricity generation will encourage de-carbonization in the energy sector. Promotion of renewable energy resources and suitable use of biomass power generation for example would mean more investments in wind, solar, geothermal and other sources of renewable energy; and that will mean increase in electricity from such non-fossil fuel, as a result electricity from fossil fuel will be produced minimally and that will mean energy used in the country will be non Co_2 generator.

Likewise, facilitating integration of renewable energy technologies in buildings and industrial designs means ensuring infrastructure that is friendly to renewable resources based energy. That enables use of energy that is based on non renewable resources, that way, use of energy from fossil fuels will be reduced and that will transform into de-carbonization of energy. When the government establishes Feed-in- Tariffs for renewable energy technologies it actually encourages importation of relevant materials for renewable resources energy taping, distributing and use since all such materials will be available at a relatively affordable price. Frameworks for renewable energy integration into the national and isolated grids are important for smooth operations. Promotion of sustainable biofuel production and usage means ensuring that production and usage of biofuel does not compromise other relevant parameters of human life including environmental conservation. Hence, implicitly the government is committed to ensuring more forests conservation, more tree planting campaigns, use of improved stoves that consumes less wood etc. This is another action that will improve de-carbonization in the energy sector.

However, as pointed out in the previous sections, the policy identified challenges which constrains the harnessing of the different renewable energy sources but its policy action statements hardly connects to such problems. This creates a gap between the existing hindering factors regarding promotion of renewable resources and actions to be taken. It would have been better if policy actions would have been set specifically to address specific challenge facing a specific resource rather than having generic action statements which reflects on a single generic objective. This is a pitfall on the side of the policy since one may not clearly anticipate changes in the shortcoming. This building block score partial alignment (2) since the action statements fail to prove how they will address the existing challenges facing harnessing specific renewable resources.

Improvement of energy efficiency

Energy should be used in the most efficient way to achieve the greatest output. Energy efficiency has been improving worldwide, but the speed of improvement should be even faster if we were to minimize the impact of climate change. In some sectors, energy efficiency at the product level is satisfactory, but not at the system or community levels. Hence, various levels of energy efficiency need to be assessed. Some policies to promote energy-efficient products do not always lead to overall emission reduction because they may stimulate increased consumption of products and energy at community level. However, this goal only intends to assess the efficiency aspect of products and systems.

URT (2015) defines energy efficiency and conservation as measures aimed at reducing energy consumption without sacrificing productivity, level of service or increasing costs. This definition clearly addresses efficiency at consumption level. Likewise, the general objective for energy efficiency in the Tanzania National Energy policy of 2015 which states "To promote energy efficiency and conservation in all sectors of the economy" (URT 2015pg 21) is well focused to ensuring efficiency in the energy policy. The four policy statements, which are important for action, prescribe action to be taken by the government for just some of the issues raised as stabling blocks for ensuring efficiency in the sector. The statements are as follows: (i) Facilitate establishment of standards and code of practice for energy management; (ii) Ensure energy uses are benchmarked to industry prudent practices; (iii) Facilitate efficient biomass conversion and end- use technologies; and (iv) Ensure integration of energy efficiency aspects in housing policies and building codes (ibid pg 21).

The issue of awareness rising and capacity building does not appear to be addressed by the prescribed action statements despite the fact that the policy recognizes the importance of awareness rising as an approach towards enhancing energy efficiency as in URT (2015 pg 20). Also, issues surrounding transport are not well addressed by the action statements; for example, one may wonder how the issues of driving behavior, poor transport infrastructure and traffic congestion will be addressed with the prescribed action statements.

Furthermore, a more thorough analysis is required for the transport sector, marine, air, and inland transport system need specified analysis rather than just generic analysis as presented in URT 2015 pg 20 where there is no where such transport segments are been specifically addressed. This sub building block is therefore rated partial alignment (2) since although the policy presents an objective which clearly supports the energy efficiency mitigation indicator, it is less clear and less distinct in terms of ways in which each particular stabling block will be addressed to affect the indicator and ultimately achieve the prescribed objective.

Minimizing demand for energy service

While energy efficiency needs to be further improved, the best approach is to eliminate any need for energy. For instance, improvement of energy efficiency in automobiles is important, but people can use other means of transportation such as bicycles and public transportation while enjoying the same level of mobility. Energy demand management is another approach to reduce the pressure on insufficient electricity supply, rather than increasing the supply by burning more fossil fuels to meet the requirements. It is becoming more important to reduce unnecessary demand for energy and products to reach the climate mitigation goal.

The Tanzania energy policy advocated for an integrated planning for energy management to smooth the demand curve as explained early; the policy, however, falls short in terms of promoting use of non-automobiles such as use of bicycles for transport as opposed to use of automobiles. The policy, for example, identifies the transport sector to be one of the major consumer of fossil fuels in the country particularly petroleum yet its measures to address emissions from the transport sector focuses only at dealing with such issues as driving behaviors, standard of vehicles and age, quality of transport systems and the mode of transport (refereeing to use of public transport over private transport). The policy also observes that poor transport infrastructure causes traffic congestions, which result in high fuel consumption and air pollution (URT 2015). The policy observes that exploration of possibilities for fuel switch to other forms of energy such as electricity, ethanol and compressed natural gas to the best options for addressing emissions in the transport sector. Although ethanol cuts GHG emissions from petrol by more than half, yet use of non automobiles need to be priorities number one as they cut GHS emissions in the transport sector by almost 100% (not counting emissions related to production of such non automobiles means of transport such as bicycles). This sub building block is therefore rated limited alignment (2) since there are no much evidence as to how energy demand services will be significantly minimized.

Land use, land-cover change and forestry (LULUCF)and sequestration:
Another indicator for aligning to mitigation pillar is promotion of proper land use and forestry conservation for minimizing Green House Gases (GHG) emission. In this regards the energy policy need to stipulate specific objectives as well as policy statements that indicate government commitment to forestry conservation and sustainable land use. Standards, regulations, and subsidies for conservation of forests; promotion of wise-use of wood products; projects that may lead to minimization of land-use change from forests to other non-vegetative land use/cover are highly recommendable. One of the key drivers for the development of the 2015 Tanzania National Energy Policy is "Promoting compliance with environmental, health and safety standards in the Energy Sector" (URT 2015 pg 9). The energy sector for that matter is expected to promote -conservation and protection of forestry resources through financing research and community based conservation activities including awareness building. The sector also is expected to promote efficiency improvements in bio related fuel production and energy use.

Moreover, promotion of carbon sequestration related activities such as those focusing at increasing forest area, increasing vegetation cover, increasing carbon storage in soils and conversion of biomass to long-term products would be highly recommended for any energy policy. The policy provides a

clear description of the environmental problems associated to production of energy resources including implied deforestation. The policy also provides a clear objective, which aspires to abide to environmental standards. Likewise the policy provides three action statements that clearly indicate that the policy can attain the intended objective, these are (i) Enforce environmental, health and safety standards and laws governing the Energy Sector; (ii) Ensure that contractors in the energy sector establish a decommissioning fund for environmental restoration where appropriate; and (ii) Strengthen institutional capacity in monitoring and enforcement of laws and regulations on safety, occupational health and environmental management (URT 2015 pg48). This sub building block is therefore rated high alignment (3) since the problem is well defined, the objectives reflects the need to address the problem and action statements are practical enough to attain the intended objective.
Overall, mitigation building block, therefore, scores 2.25 points meaning that the building block partially aligns to CCD.

Policy Alignment to Development Pillar
Social economic development

Socio-economic development is key to CCD. Poor people are more vulnerable to the impacts of climate change but at the same time such people are more likely to degrade the environment due to limited adaptation options (Climate Change and Poverty Conference 2015). Therefore socio-economic development is an important CCD building block. The socio-economic development indicator, however, is weakly handled in the policy under scrutiny. The policy recognizes the importance of local communities in development of the petroleum subsector and it sets an objective to attain as "To optimize benefits of petroleum industry for social and economic development (URT 2015 PG37). The policy also sets action statements to attain the prescribed objective as to (i)Ensure available opportunities in petroleum industry are utilized by communities; (ii) Strengthen coordination of local content issues and petroleum industry; and (iii) Ensure oil and gas players support Tanzanian communities in their economic activities in order to effectively participate in the petroleum value chain (ibid). The problem here is that the policy fails to explain why social economic development is a policy issue. What are the issues surrounding the Tanzanian community which if not sorted may hinder the development of the petroleum sub-sector? Also what are the available opportunities in the subsector for socio-economic development of the Tanzanian community? Answering these questions could provide a good answer as to why socio-economic development is a policy issue and there after assessing whether policy action statement are objective or not could be easy. As for now it may not be easy to assess the objectiveness of the policy action statements since the question why socio-economic development is an issue is not fairly delineated.

Furthermore, Despite the fact that the policy recognizes the important entities for social and economic development yet it provides no clear definition of the issues surrounding such entities; it therefore does not provide any objectives specifically to address such issues hence forth there is no specific policy statements for promoting social economic development in the Tanzanian community. Some of the social economic development entities that the policy recognizes include the private sector, academia and research institutions, Non Governmental Organizations (NGOs), media, and the community. The policy for example recognizes that "Private sector including Independent Power Producers (IPPs), Oil Marketing Companies (OMCs) and Oil and gas companies play important role in providing substantial capital investment and technologies needed in theenergy sector.

The policy therefore states that the government will continue to work with the private sector to promote, build capacity and facilitate PPP projects or other arrangements in the energy sector. The private sector is expected to implement credible local content programmes" (URT 2015pg 86). Though the policy indicates some commitments to promote developmental activities through corporation with the private sector yet there was a need to define issues surrounding the private sector in the country and thereby pin down areas, which the energy sector could provide a helping hand for enhancing development. The way it is at the moment it is as if all is well with the private sector, which is not true. Relevant and areas of priority need to be stipulated rather than having such generic statements as 'the government will continue to work with the private sector to promote, build capacity and facilitate PPP projects or other arrangements in the energy sector' Such kind of statement does not give clue on the kind of projects to be promoted by the energy sector. The private sector for example faces challenges related to capital; one would ask which kind of projects are likely to be supported in terms of capital by the energy sector is important to be described. Same applies to NGOs; the policy need to outline the nature of NGOs that could be supported by the energy sector; are those that working towards environmental conservation? is it those NGOs working to promote education? What Kind of support such NGOs should expect from the energy sector? These are some of the questions that need some clarifications.
The policy recognizes that the role of the media in providing balanced public information on the Energy Sector activities is important. In this regard, the media need to strengthen their capacity in understanding Energy Sector activities to ensure delivery of information accurately and timely. This will increase public awareness, enhance transparency and ensure accountability on Energy Sector. But there is nowhere in the policy document that indicates commitment of the government to support the media in its undertakings to support the energy sector and thereby stimulate social economic development.

The policy also recognizes the importance of the local community in that, local communities are important entities in safeguarding the integrity of the infrastructure in the energy sector. The policy therefore outlines that, because such local communities benefit from the infrastructure they therefore have the responsibility to maintain security and safety of such infrastructure for sustainability purposes. Of course the local communities benefits either directly or indirectly from the use of the infrastructure related to the energy sector, however, that alone is not enough in promoting social economic development in the local communities. The energy policy need to define clearly all major social and economic issues surrounding local communities in Tanzania and identify priority areas for the energy sector. Education for this matter could be one of the priority areas for the energy sector in that with education community can stand a better chance to protect the energy infrastructure. The policy promotes education, training and research in the energy sector through working close with academic and research institutions. This implicitly means that the policy is committing the government to support education higher levels.

However, promotion of primary and secondary education would be the most important thing since majority of the population in Tanzania fall at that level of education. Other social services as water, health, transport and communication are issues surrounding local communities in the country. It would have been better if the policy could direct investors to prioritize development of such services to communities surrounding respective projects. Furthermore, poverty is rampant in rural areas where most energy related projects are located. Poverty alleviation to communities surrounding such projects need to be a policy issue and be articulated more clearer than the case is at the moment.

The policy indentifies gender issues as one of its priority areas. The policy clearly shows its commitment in areas of employment and training as well as on preventive, curative and education on HIV & AIDS. Unfortunately the policy does not clearly articulate its promotion of training in such important aspects as training on use of non wood sources of fuel as well as fuel effective stoves.

The socio-economic development building block is rated limited alignment (1) due to the fact that, the policy seem to appreciate that development is one of the important aspects to be considered in the energy sector. However, there is no clear description of the social and economic problems in the policy as a result there is no clear focus on what the policy intend to achieve as far as social economic development is concerned.

Table 3: Policy alignment Score to CCD

CCD building block	Indicator	Evidence of alignment	Score
Adaptation	Improving access to energy in rural areas	The sub-building block is rated partial alignment (2) since the policy aligns with the adaptation indicator just by implications, it does not state categorically that improvement of access for rural electrification is for ensuring reduction of GHGs emission for environmental conservation and not otherwise. There is no any strategies identified to overcome the identified challenges regarding rural electrification, that raises questions on whether the objective can be attained.	1.5points
	Energy diversification	There is a clearly defined problem and objectives but the action statements fails to link up with the identified problems as a result there is no clear evidence that during implementation the stabling blocks towards attaining the objective will be overcome. Therefore, the score is limited alignments (1)	
	Energy efficiency and demand response-side management	There is literary no definition of energy efficiency and demand response - side management as a policy issue, objective as well as action statements. The score therefore is no alignment (0) since there are no aspects that indicates that the policy acknowledges efficiency and demand response side management s important for CCD.	
	Smoothing the demand curve for energy	The problem is implied under the description of the planning problem. The objective and associated action statements to resolve the planning problem may indirectly address the issue of smoothing the demand curve. However, the implications on actions towards ensuring a smooth demand curve might be detrimental if production of energy can be expended unless such expansion is taken care with alternative sources of energy which are less detrimental to the environment. This building block is rated partial alignment (2) for its action statements are controversial as far as environmental conservation is concerned.	

	Distributed as opposed to centralized energy systems	The policy scores an average of 2.5 from the three aspects for this building block hence rated as having partial alignment to CCD.	
Mitigation	De-carbonization of energy	This building block score partial alignment (2) since the action statements fail to prove how they will address the existing challenges facing harnessing specific renewable resources.	2.25
	Improvement of energy efficiency	Partial alignment (2) since although the policy presents an objective which clearly supports the energy efficiency mitigation indicator, it is less clear and less distinct in terms of ways in which each particular stabling block will be addressed to affect the indicator and ultimately achieve the prescribed objective.	
	Minimizing demand for energy service	This sub building block is rated limited alignment (2) since there are no much evidence as to how energy demand services will be significantly minimized	
	Land use, land-cover change and forestry (LULUCF)	This sub building block is rated high alignment (3) since the problem is well defined, the objectives reflects the need to address the problem and action statements are practical enough to attain the intended objective.	
Development	Social and economic development	The socio-economic development building block is rated limited alignment (1) due to the fact that, the policy seems to appreciate that development is one of the important aspects to be considered in the energy sector. However, there is no clear description as to why social-economic development is a policy issue hence the policy fails to pin down burning issues which could otherwise target to sort them out, as a result the policy provides a generic objective and action statements where it may be difficult to determine their objectivity.	1
Average score			1.58

Having computed scores from the three CCD alignment pillars the policy scores an average of 1.58points which means the policy alignment to CCD is limited.

Discussion

The analysis indicates that overall the energy policy has limited alignment to CCD. The policy scored significantly low in terms of adaptation (1.5points) and also in terms of Development (1point). The policy however scored better in terms of mitigation (2.25points). This is to say the policy is skewed towards climate change mitigation hence failing to meet the CCD requirements. Most alignment pillars are implied in the policy document.

What falls the policy is the weak link between defined policy issues and action statements. In some cases, the policy defines clearly policy issues but policy statements fail to reflect likely actions to be taken to address the identified challenges so as to meet the prescribed objectives. In other cases, the policy issues fail to come out clear such that one find it difficult to assess the objectivity of the accompanying policy action statements even though such statements may seem to be sound. In Antwi-Agyei *et al.,* (2017) the Ghana energy policy scored zero (0) on adaptation alignment pillar since it failed to demonstrate clearly ways in which objectives and actions could be met. As the case is in this study, the Ghana policy scored highest in terms of mitigation (Antwi-Agyei *et al.,* 2017). Having a policy which leans towards mitigation may not be welcoming news especially for developing countries where technology and capital to ensure de-carbonization of energy, improving efficiency and minimizing the demand for energy service (as in defined in NAPEE 2010) is a problem. Although CCD is arguably best policy approach for now yet when things are tough at least developing countries are expected to focus on adaptation (IPPC 2014). In South Africa the energy policy scored least in alignment to CCD pillars as it offered minimal strategies which demonstrated a possibility for achieving objectives and statements (England *et al.,* 2018).

Alignment to the 'development' pillar is not well prescribed in the policy. It would be interesting to see how opportunities brought by the new discoveries on oil and gas can be used in a manner that maximizes promotion of the climate compatible development including investing more in low carbon emission projects such as supporting woodlot for carbon sequestration projects, wood fuel effective stoves, etc. These kinds of investment would not only promote reduction in GHG emission but will also create employment opportunities among local communities ultimately reducing poverty as proposed in Jain *et al,* (2009). Investors in the energy sector and other beneficiaries would be made not to concentrate only on what they get from the sector, but also support the sector in the fight against the impact of climate change. There could be a policy statement that could, for example, specifically focus on reinvesting the profit generated from oil and gas in renewable energy such as solar energy. Although already the policy shows government commitment to the use of energy from renewable energy resources yet it could be important to stress the point of reinvesting the gains from the sector to more use of such renewable energy resources with a view to sideline use of fossil fuel completely in future as suggested in NAPEE (2010). Already studies indicate that the use of renewable energy technologies such as solar systems has helped to facilitate sufficiently appropriate and cost effective energy supply in rural areas where there is no national grid and now people enjoy modern communication by charging their mobile phones with the aid of solar electricity" (Mnzava A 2011).

Reinvesting in such renewable energy resources could enable harness more energy enough to run all domestic operations as well as small industries; once this is achieved there would be a significant cut of GHG emission from the sector. The policy needs to clearly indicate strategies for improving technology in view to improve infrastructure for renewable energy. So far there are no clear goals for revamping renewable energy technologies as interventions to the energy policy.

The legal and regulatory framework is another area that needs to be improved for proper implementation of the policy actions. The policy document indicates that some laws and regulations are still drafts and they are yet to be enacted, this leads to a lack of legal support for the operations in the sector; this has serious implications when it comes to implementation of the policy. Gao (2013) argued that lack of strategic implementation plan as well as measurable indicators on policy implementation; and finally lack of awareness at local level are all pitfall for the success of the policy objectives all of which have implications on alignment to CCD.

Conclusions and recommendations

The Tanzania national energy policy of 2015 has limited allignment to CCD pillars as far as the analysis in this study is concerned. This has implications on the fight against climate change and its associated impacts. Ultimately this also has implications for sustainable development especially because although reliable energy is essential for socio-economic development yet processes leading to energy generation and use make up a significant portion of global greenhouse gas (GHG) emissions contributing to climate change (IPCC, 2014). Climate change also impacts seriously even ecosystems which are important sources of energy resources. This symbiotic relationship presents both near-term and chronic challenges in providing reliable, affordable, equitable, and sustainable energy services. This is why reviewing the policy to ensure that it highly aligns to the CCD pillars is important.

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Children's Perception of the Teacher-Child Relationship in Tanzania: (Dis)Similarities among Children with Internalizing Versus Externalizing Behavior

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Abstract: *In this study we examined the perception of young children with internalizing and externalizing behavior of their relationship with their teacher and their (di)similarities of their perception. The relationship with the teacher focused on warmth, conflict and autonomy support. Ninety-two (92) respondents, 40 children with internalizing behavior and 52 children with externalizing behavior, participated in the study. A series of two-way MANOVA's was used to analyze the data. Overall, findings revealed that children from both groups roughly reported to experience disharmonious and conflitual relationships with their teachers and a more directive instruction from the teachers. Furthermore, children with internalizing behavior perceived more warmth in their relationship with teachers than children with externalizing behavior. These findings highlighted the difficulties experienced by both groups in their relationship with their teachers. We propose that teachers should be trained to identify and help children with internalizing and externalizing behavior.*

Key words: children's perception, externalizing behavior, internalizing behavior, teacher-child relationship, Y-Cats measure

Introduction

Every child who joins pre-primary school experiences a transition from home to school. In schools, children experience daily interactions with a teacher that form part of their relationship. In their relationship with the teacher, children display behavior, which differs partly due to different rearing styles and partly to their temperament tendencies (see also Shavega, Brugman, & Van Tuijl, 2014). On the other side, a teacher in the school context is a role model to the child and has a significant effect on the formation of behavior, attitudes and future education (Douglas & Skipper, 2015).

The teacher-child relationship takes place in the school context, and can be regarded as a secondary relationship to the child. Although the teacher-child relationship is a more formal relationship, from an attachment perspective and especially for young children, this relationship with the

teacher is a significant one. Before children enroll in pre-primary schools, they have experienced different rearing style at home and possibly received different orientations from a wider community (Shavega *et al*., 2014; 2015). In addition, children's temperaments differ from one another. The orientations that a child experiences before joining pre-primary schools may influence the child's expectations from his/her teachers. For instance, a child may perceive school as an exciting new environment or as an unwelcome or overwhelming new environment, and encounter the teachers and fellow children who are new to her/him with curiosity, shyness or boldness. This might have implications for their relationship with their teachers. Furthermore, teachers interact with children of diverse behavior such as prosocial, internalizing or externalizing behavior. The reactions children receive from the teacher in response to their behavior also may have implications for children's perception of their relationship with the teachers. Studies reveal that the ways children perceive their daily relationship with their teachers guide their social behavior and behavior adaptations. For example, the perception of less supportive relations worsens the behavior of young children (Laibe *et al*., 2004). Arsenio and Lemerise (2004) assume that the way children understand and interpret social behavior and motives of others may play a fundamental role in children's immediate and long-term behavior. For many studies the teacher has been the main reporter of the teacher-child relationship. However, it is important to know how children perceive this relationship, especially when children show 'difficult' behavior. This study therefore, examined the perception of the teacher-child relationship of children with internalizing and externalizing behavior.

Attachment Theory

In the school context, the relationship between a teacher and a child can be viewed as an attachment. According to Bowlby (1980), children construct the so-called internal working models out of their relationships with caregivers, which influence the way children respond to new social partners. The construction is based on previous experiences. Therefore, if the child has negative experience, s/he may even view a friendly teacher initially as unsupportive. A secure attachment is related to positive social development, whereas children with insecure attachment are at risk for lower social competence and self esteem (O'Connor & McCartney, 2006). For example, Bowbly (1980) points out that, a child with a secure attachment experience will construct a social model of the teacher as lovable and will therefore respond to a teacher as a safe attachment figure. For a child who experienced insecure attachment will construct a social model of the teacher as unfriendly and may respond to the teacher as not a safe attachment figure. However, in the long run positive experiences with the teacher can alter the child's negative history. Koepkes and Harkins (2008) postulate that

the internal working model based on the teacher-child experiences allows children to construct generalized expectations of this relationship. According to Koepkes and Harkins (2008), the teacher-child relationship supplements the maternal attachment as a contributing factor to children's social development.

Based on internal working model, children are more likely to display friendly behavior when they view teachers as supportive. If a teacher shows authoritarian behavior (e.g., gives a lot of commands and is not supportive), a child is more likely to construct a working model as unfriendly. The child may tend to fear the teacher, which implies internalizing behavior, or the child may in turn respond in a conflictual way, which implies externalizing behavior. Attachment theory therefore, guides the explanation of a relationship between a teacher and a child in a school context.

Many studies have addressed the quality of teacher-child relationships. The key informant in the case of young children reporting the quality of the dyadic and class relationship has been the teacher (Baker *et al*., 2008; Pianta & Stuhlman, 2004; Shavega *et al*., 2014, 2015). However, the perspective of the child about his/her relationship with the teacher especially for children with internalizing and children with externalizing behaviors is under-researched. Although literature is lacking about children's perception on the relationship, still children judge and take actions, which have implications for their relationship with their teachers and their behavior adjustment in school. As pointed out by Mclaughlin, Aspden, and McLachlan (2015) children learn from their relationship and interactions with significant people in the school context, i.e. the teacher. This study took a lead to examine this aspect.

Teacher-Child Relationship

The teacher-child relationship is regarded as an integral part of the quality of children's experience and adaptations in schools (Dobbs & Arnold, 2009), since it nurtures the development of the child in different aspects. Furthermore, the research postulates that the quality of the teacher-child relationship is a central factor for child adjustment and adaptation in pre-schools (Dobbs & Arnold, 2009; Shavega *et al*., 2015). The research provides evidence that the teacher-child relationship actively shapes children's capacity for self-regulation and behavior through teaching and feedback, which both have implications for short term and long-term benefits (Baker, Grant & Morlock, 2014; Jerome, Hamre & Pianta, 2009). The importance of the teacher-child relationship for children's development underscores the need for research to better understand the experience of each part (i.e. teacher and child) within the interpersonal exchanges that comprise the relationship. Children's perspectives on this relationship are often not addressed, in part because they are assumed to be less reliable and valid.

Recent research however shows that in the case of young children, reliable information on their perception of the teacher-child relationship is possible (Mantzicopoulos & Neuharth-Pretchett, 2003).

The teacher-child relationship is viewed as a complex phenomenon since it involves two parties: a teacher on one hand and a child on the other (Smith, Lewis & Stromont, 2011). In this relationship, each part has its own expectations (Smith *et al*., 2011). A child constructs knowledge out of the relationship, while on the other hand, a teacher expects a child to behave in an acceptable manner (Smith *et al*., 2011). This may imply that in schools teachers set standards of behavior expected from the child and a child should adhere to the standards set; on the other hand a child perceives whether the relationship is friendly or not. In addition, a young child views a teacher as the most significant person to her/him, who executes teaching as well as parenting roles in the school context. This means the teacher models desirable behavior and buffers and corrects unaccepted behavior of the child (Laibe *et al*., 2004).

During the teacher-child interaction, especially in the dyadic relationship, children learn and teachers support the relationship that has been developed between them (McLaughlin, Aspeden & McLachlan, 2015). In a Tanzanian context, studies show that teachers are reported to stress on obedience as important characteristics for the child's adjustment (Shavega *et al*., 2014). In this relationship, each member (teacher and child) may perceive the relationship differently, either favorable or unfavorable.

Furthermore, Garner and Waajid (2008) state that to understand the relationship between a teacher and a child, we need to address teachers and children's perceptions towards one another and their behavior. Although a common assumption is that teachers influence the behavior of children more than the vice versa, according to Taylor and Carr (1992), children's behavior strongly influences the way teachers behave towards them, especially for young children. Negative reactions of teachers then may evoke a reciprocal process of negative exchanges. This argument is in line with the observation by Dobbs, Arnold and Doctoroff (2004) that pre-school children, who misbehave frequently, have received more commands from their teachers. If the commands are frequently used, the children are more likely to develop or display externalizing behavior such as aggressive and/ or internalizing behavior such as reticent, anxiety or fear. The question was whether children's perception of the teacher-child relationship offers a way to explain their behavior towards the teacher. This study therefore examined the perception of children with internalizing behavior and

children with externalizing behavior of their relationship with their teachers in pre-primary schools.

Children's Perception of the Teacher-Child Relationship

Papadopoulou and Gregoriadis (2017) in their study examined children's perception about their quality of their interaction. They studied children's perception of the quality of the teacher-child interaction among the normal children with average age of 5 years and found that, in general, children perceived positive interactions with their teachers. Skipper and Douglas (2015) examined the influence of teachers' feedback on children's perception of the teacher-child relationship. The sample consisted normal children aged between 7 and 11 years. The findings revealed that children reported a negative perception on their relationship with their teachers after the feedback of failure, but reported a positive relationship following feedback on success. Some studies focused on children's perception on their drawings (Arslan Cansever, 2017; Furman & Buhrmester, 1985; Kesicioglu & Deniz, 2014). For example, Cansever (2017) conducted a study to examine the perception of children of the teacher among normal children aged between 66 and 68 months and found that young children in primary schools were able to explain their perception towards their relationship with their teachers through drawings. Other studies evaluated children's perception with tools adapted to a particular cultural context (Longobardi *et al*., 2016; Spilt, Koomen & Mantzicopolous, 2010). Ghysens (2009) focuses on children's perception of involvement in relation to children's learning and found a positive perception of the parent-child relationship.

Studies on the perception of children with internalizing behavior and children with externalizing behavior on their relationship with their teachers are to a great extent missing. Since teachers are role models for children and fulfill roles in the formation of children's behavior and attitudes of which perception is a crucial part, the importance of children's perceptions towards their relationship with their teachers cannot be overlooked (see also Skipper & Douglas, 2015). For example, Van Orden (2011) did a study to children with internalizing behavior and externalizing behavior and the findings revealed that behaviors were associated with an unfriendly teacher-child relationship with their teachers as reported by the children. This experience of relationship is more likely to instill negative perceptions in children towards their teachers. Since children with internalizing or externalizing behavior have been reported by their teachers to be the source of a disharmonious relationship in pre-primary schools (Hamre & Pianta, 2001; Longobardi *et al*., 2016; van Orden, 2011), it is important to explore the children's views on their relationship with their teachers. In this study, we establish that children are important stakeholders in their relationship with the teachers in school since they have great influence on the relationship. Exploration from the children perspective

may help to have a more profound understanding of the relationship and how to help children with problem behavior in a positive way.

Internalizing and Externalizing Behavior

Internalizing behavior involves behavior in which feelings or emotions are directed towards oneself, such as depression, fearfulness, reticent or withdrawn behavior, feeling isolated and anxious to mention a few (Koledin, 2005; Skipper & Douglas, 2015; Van Orden, 2011; Volckaert & Noel, 2016). Externalizing behavior is disruptive behavior directed towards others, which can involve aggressive behavior such as hitting, bullying and beating other children. Research indicates that during early childhood, non-compliance, temper, tantrums, and aggression are regarded as normative since they are common to many children. As children grow older, they become more able to understand, memorize and comply with rules and routines. Non- compliant behavior may stop at a certain age, but for some children it may persist over time and develop into maladaptive behavior (Smith, Cowie & Blades, 2011; Wakschlag *et al*., 2007). Pre-school children exhibiting early externalizing behavior are at risk of developing anti-social problem behavior in the long run (Calkins & Keane, 2009) whereas pre-school children with internalizing behavior are at risk for developing emotional problems. A positive teacher-child relationship may help children to adjust in schools, including buffering problem behavior (O'Connor, Dearing & Collins, 2011), whereas a negative teacher-child relationship may exacerbate of even be the source of problem behavior in children, especially if children perceive the dyadic relationship as disharmonious. If teachers are not warm or friendly during their interactions with children, children are more likely to afraid of the teachers, hence become reticent, or behave in an unfriendly way.

Perceptions of children of their relationships with the teachers are more likely to guide their behavior than perceptions of the teachers. For example, Liu *et al*. (2011) report that children aged four to ten years drew upon their perception to guide their social interactions. Moreover, children who experienced unfriendly relationships in other settings, like home, are more likely to maintain their perceptions of adults as unfriendly and of relationships as conflictual. These perceptions can become self-fulfilling prophecies, leading to more conflict (see also Calkins & Keane, 2009), especially for a teacher who lacks the skills in handling children with internalizing behavior or externalizing behavior. In this study, we assume that children with internalizing behavior and children with externalizing behavior might face problems during interaction with their teachers, and that their perception of the relationship with teachers plays a crucial role in the maintenance of problem behavior or their adjustment to the school setting.

In most studies, teachers have been the main informants of their relationship with young children (Baker, 2006; O'Connor *et al*., 2011; Shavega *et al*., 2015; Waas, 2008). This study adds to this body of knowledge by exploring the children's perspective on the teacher-child relationship as a factor in the maintenance of problem behavior. Internalizing behavior and externalizing behavior have been chosen since children experience from an early stage and they tend to continue over time if there is no intervention (O'Connor *et al*., 2011).

The Role of Gender

The role of gender in both problem behavior and the teacher-child relationship has been investigated and confirmed: Boys display more externalizing behavior problems than girls and also experience higher levels of conflict with their teacher as reported by their teachers (Jerome *et al*., 2009; Koepkes & Harkins, 2008; Liu *et al*., 2011; O'Connor *et al*., 2011). Liu *et al*. (2011) further comment that males who are reported to have externalizing problems display poorer relationships with teachers. Girls show more internalizing behavior problems than boys and a more favorable relationship with their teachers (Hendrickson & Rydell's, 2004; Jerome *et al*., 2009; Liu *et al*., 2011; Mullola *et al*., 2012). Therefore, we expect gender differences for children with internalizing or externalizing behavior in the child's perception of the teacher-child relationship. In this study, we aimed to establish whether there is an interaction effect between gender and behavior on the perception of the teacher-child relationship.

Pre-Primary Schools in the Tanzanian Context

Tanzania is located in the Eastern part of Africa with a total area of 945,089 square kilometers. About 80% of its people are local farmers engaged in agricultural sector. About two decades ago, in Tanzania there were no programs to prepare children for school before they joined primary education (Grade 1) at age 7. In 1995, Tanzania established the Education and Training Policy through the Ministry of Education and Culture (1995), which focused on preparing children aged 5 to 6 years for primary education. According to the policy, it was mandatory that every child aged 5 to 6 years should attend a pre-primary class before joining primary education. To implement this policy each primary school was supposed to have a pre-primary class on its premises. Another Education and Training Policy was developed in 2014 (URT, 2014). Education structure in this policy is 1-6-4-2-3+; one year for pre-primary education, 6 years for primary education, 4 years for ordinary secondary education, 2 years for advanced secondary education and 3+ years for tertiary education. In this education structure implementation was done for pre-primary school where a child should attend one year, but for 6 years for primary education is yet to be accommodated. The rest education levels have remained the same.

Pre-primary education' is the official term for early childhood education in Tanzania. The term has been adapted in this study to refer to all children who are being prepared to join primary education (standard one). In 1995, pre-primary education became part of the formal education system. In public pre-primary schools, children spend five hours a day from 7.30 am to 12.30 pm, whereas in private schools they spend longer hours, and some children are in boarding schools (see also Shavega *et al*., 2014). In Tanzania, a public pre-primary class has only one teacher (see also Shavega *et al*., 2014). The language of instruction in public schools is Kiswahili (national language), whereas, in private schools it is English. The government is responsible to train pre-primary teachers (Tanzania Institute of Education, 2009) as well as private sectors. Teachers attend short courses on early childhood education. These short courses are sometimes organized by the government in teachers colleges and sometimes by private sectors such as Plan International (see also Shavega *et al*., 2014). In the Tanzania cultural context, people are increasingly becoming aware of the importance of pre-primary classes for children before they join primary education.

The Present Study

The purpose of this study was to examine the perception of two groups of children (i.e., children with internalizing behavior and children with externalizing behavior) of their relationship with their teachers in pre-primary schools. Specifically, the study aimed at addressing two key questions. First, how do children with internalizing behavior and children with externalizing behavior perceive their relationship with their teachers? And, does the perception of the teacher-child relationship differ between children with internalizing behavior and children with externalizing behavior? Second, does the type of behavior (internalizing vs externalizing) interact with gender? The research indicates that, the way children perceive their relationships with their teachers shapes their behavior trajectory either towards a positive or a negative direction (Douglas & Skipper, 2915; Jellesman & Koomen, 2011). In addition, the research indicates that perceptions guide children's behavior trajectory (Van Orden, 2011). Furthermore, Henricsson and Rydell (2004) found that internalizing behaviors are often characterized by negative expectations, which may lead to poor social skills and finally affecting the relationship with other people. Exploring children's perceptions from the perspective of children with internalizing and children with externalizing behavior may help us to understand children's personal experience in their daily lives with their teachers.

Internalizing and externalizing behavior were chosen since these types of behavior have been reported to affect children from early stage and tend to

continue over time if not intervened. For example, a child experiencing anxiety, withdrawal, and fear is more likely to display such behavior in the future if not supported by significant people including teachers. Likewise, a child displaying disruptive behavior can persist with such behavior if not supported and this behavior may become serious in the future if it becomes stable over time (Bub, McCartney & Willet, 2007). Specifically, this study was guided by the following objectives: To explore the perception of children with two types of behavior problems of their relationship with their teacher, especially to examine whether there is a difference in perception of the teacher-child relationship (on conflict, warmth and autonomy) between children who display internalizing behavior and those who display externalizing behavior; and to explore whether gender affects the perception of children with internalizing or externalizing behavior of their teacher-child relationship.

Methods

Participants

This study was done in Ilala municipality, Dar es Salaam region, in Tanzania. Participants were pre-primary children who displayed internalizing behavior and children with externalizing behavior as nominated by peers as well as rated by the teachers. This group involved a total of 92 children, 47 (51.1%) males and 45 (48.9% females) from 16 schools. Class size ranged between 24 and 98 children. Only children aged 5 years and above participated because they were assumed to have the capabilities to respond to the interview. Each child in the class was interviewed and participated in nominating children who display internalizing behavior and children who display externalizing behavior.

Procedures used to obtain children with internalizing and externalizing behavior

Two procedures were used to obtain children with internalizing behavior and children with externalizing behavior. The first step comprised of peer rating. All 384 children from 10 pre-primary classes who were present during the interview period were contacted and were first asked to nominate children displaying internalizing behavior followed with children who display externalizing behavior. This procedure was much similar to that of Shavega, Van Tuijl and Brugman (2016). For internalizing behavior, we selected a few indicators, which are common to children aged 3 to 6 years such as loneliness, fearfulness, reticent and withdrawn behaviors. For example, a child was asked to mention a child who is always lonely, quiet and does not like to join other children during play. For externalizing behavior, we asked every child to mention children who frequently bully,

pinch and beat other children in the class and during playtime outside the classroom. An example of an item is: "*Tell me names of children who frequently bully other children in the class and during play time*. During the interview we stressed that for a child to be considered as displaying internalizing behavior or externalizing behavior, the behavior should occur repeatedly.

Each interview with a child lasted between six and eight minutes. Children who were able to mention both groups (children who display internalizing behavior and children who display externalizing behavior) were allowed to continue in the nomination process. Children who were not able to mention children with such behaviors were not included in the study. Of 384 children, 290 were eligible to continue with the nomination process. The participation rate among classes ranged between 60% and 85%.

There was no overlap between the group with internalizing and externalizing behaviors. After this nomination process, a researcher established tallies for each child who was mentioned to display internalizing behavior or externalizing behavior. Children who scored many tallies (by at least 1/3 of all children in the class) in one of the groups were labeled as displaying either internalizing behavior or externalizing behavior. Tallies for children nominated as displaying internalizing behavior ranged between 8 and 15 and for children nominated as displaying externalizing behavior ranged between 10 and 32.

The second step involved asking each class teacher to report children who displayed internalizing behavior and children who displayed externalizing behavior. Teachers filled in the Children Behavior Checklist (CBCL) (Achenbach, 1991) for younger children version for children who were nominated both by pees and the teacher. Of this questionnaire, two scales were used: internalizing behavior and externalizing behavior (both five items for indicators). We prepared a list of children who were nominated by the children and those who were not nominated. Every teacher reported on every child on the list whether the child was displaying internalizing behavior or externalizing behavior. Since teachers were not involved during the peer rating they were therefore blind to children's nomination.

In the third step the researcher crosschecked the names. A child who was frequently rated by peers as displaying internalizing behavior or externalizing behavior and reported by the teacher as displaying the same behavior respectively, was included in the study to report their relationship with their teachers. Based on this criterion, two groups nominated by peers and reported by teachers were selected. 40 children displaying internalizing behavior and 52 children displaying externalizing behavior from ten classes

participated in this study. The interview with the selected children was arranged after class hours to avoid interruption of class timetable. The focus in the interview was on the children's perception of their relationship with their teachers, using the Y-CAT tool (Mantzicopoulos & Neuharth-Pretchett, 2003). The author interviewed the children and coded all the responses from each child. The interview was done in Kiswahili, which is the national language and lasted between 15 and 20 minutes. Since children do not concentrate on one thing for long time, during interview we asked a child to break for 1 or 2 minutes so as to persist with interview after 15 minutes.

Measure

Two measures were used in this study. First, we used Children Behavior Checklist (CBL) for selection procedure (Achenbach, 1991) for children aged 4 to 18 ages. The checklist has three Likert Scale which are Not true = 0, Sometimes true = 1 and often true =2.

Second, we used the Young Children's Appraisals of Teacher Support (Y-CATS, Mantzicopoulos & Neuharth-Pretchett, 2003). This instrument aims to assess child's perceptions of his/her relationship with his/her teacher. The measure consists of 31 items from three sub-scales, namely warmth, conflict and teacher support for autonomy. Warmth refers to whether a child feels that a teacher likes him/her, says nice things/words about the child, and feels loved, such as "*my teacher likes me*". Conflict refers to behavior which shows a disharmonious relationship with the teacher. Examples of items are "*the teacher gets angry with me*", "*the teacher tells me that I don't listen*". Autonomy support refers to whether a teacher offers help to a child or the teacher's ability to stimulate the child's autonomy in the class, for example "*My teacher lets me do different activities*". The researchers have adapted this tool in their cultural context (e.g., Longobardi *et al*., 2016; Spilt, 2010). Cronbach's Alpha in the previous studies were acceptable; for example Mantzicopoulos and Neuharth-Pretchett (2003) reported a Cronbach's Alpha coefficient of .75 for warmth, .78 for conflict and .70 for teacher's autonomy support. Spilt (2010) reported a Cronbach's Alpha of .65 for warmth, .72 for conflict and .61 for teachers' autonomy support and the mean age of children was 69.5 months.

Previous studies used dichotomous responses of Yes/No; *true*/untrue; true or yes for agreement and *untrue* or no for disagreement (Longobardi *et al*., 2016; Mantzicopoulos & Neuharth-Pretchett, 2003; Spilt, 2010). Because the Tanzanian context could differ from a more western context, especially with regard to autonomy support, a pilot study was conducted with 25 normal pre-school children. The pilot study showed that children used to respond "yes", "no" and "sometimes". Therefore, we opted a three point Likert scale; Not at all = 1; sometimes = 2; and always = 3. Not at all refers to disagreement, sometimes refers to partially agreement and always refers to

agreement. The number of respondents determined the agreement or disagreement. With regard to autonomy support, the results from all respondents indicated that autonomy support for children was practiced in a limited number of situations. For example, in the classroom children were allowed to choose a study corner they were interested in, especially during the recess period. Autonomy support was practiced also outside the classroom during playtime; children were allowed to choose the type of play they were interested in. Therefore, under these conditions the autonomy support subscale was adapted in the context of this study. Cronbach's alpha was .73 (10 items) for warmth, .65 (7 items) for conflict, and .71 (5 items) for autonomy, which are acceptable. Items which were not culturally relevant in the Tanzanian context such as "*my teacher remembers my day for me*" were deleted. Also, items with a very low correlation if item deleted were deleted, for example "*my teacher is mean"*.

Data analysis

Items were subjected to factor analysis to obtain variables. During analysis, we first used descriptive statistics to present the general picture of the perception of children with internalizing behavior and externalizing behavior. Second, two-way multivariate analysis of variance (Two-way MANOVA) was performed to examine whether children with internalizing behavior versus externalizing behavior differ in their perception of their relationship with their teachers using the Y-CATS measure. Furthermore, we aimed to find out whether there was an interaction between children's behavior (internalizing/externalizing) and child's gender (male/female) on their perception of the teacher-child relationship. We used the Statistical Package for Social Sciences (SPSS) 21 version to analyze the data.

Results

Table 1: Children's responses on their perception of their relationship with their teachers (percentages and frequencies)

Child teacher relationship items	Internalizing behavior			Externalizing behavior		
	Response			Response		
1. Variable: Warmth	Not at all % (N)	Sometimes % (N)	Always % (N)	Not at all % (N)	Sometimes % (N)	Always % (N)
1. My teacher is my friend	50 (20)	50 (20)	00	84.6 (44)	15.4 98)	00
2. My teacher likes my family	60 (24)	40 (16)	00	88.5 (46)	11.5 (6)	00
3. My teacher says nice things about my work	57.5 (23)	42.5 (17)	00	76.9 (40)	23.1 912)	00
4. My teacher tells me I'm smart	60 (24)	40 (16)	00	84.6 (44)	15.4 (8)	00
5. My teacher likes me	65.5 (27)	30 (1)	2.5 (1)	82.7 (43)	17.3 (9)	00
6. My teacher smiles a lot	40 (16)	57.5 (23)	2.5 (1)	51.9 (27)	48.1 (25)	00
7. My teacher helps me when I don't understand	55 (22)	43 (18)	00	57.7 (30)	48.1 (25)	00
8. My teacher tells me good stories	35 (14)	65 (26)	00	50 (26)	50 (26)	00
9. My teacher answers my questions	52.5 (21)	47.5 (9)	00	44.2 (23)	55.8 (29)	00
10. My teacher makes fun in class	25 (10)	75 (30)	00	44.2 (23)	55.8 (29)	00
2. Variable: Conflict						
1. My teacher tells me I'm doing wrong	00	32.5 (13)	67.5(27)	00	23.1 (12)	76.9(40)
2. My teacher gets angry with me	00	30 (12)	70 (28)	00	21.2(11)	78.8(41)
3. My teacher tells me I don't try hard enough	2.5 (1)	47.5 (19)	50 (20)	00	51.9 (27)	48.1(25)
4. My teacher tells me I don't listen	00	60(24)	40 (16)	00	50 (26)	50(26)
5. My teacher tells me I will be in trouble	00	27.5(11)	72.5(29)	00	21.2(11)	78.8(41)
6. My teacher has too many rules for us	2.5(1)	62.5(25)	35(14)	00	61.5(32)	38.5(20)
7. My teacher shouts at me	2.5 (1)	25 (10)	72.5(29)	00	17.3(9)	82.7(43)
3.Variable: Autonomy support						
1. My teacher lets me choose what I want to do	65 (26)	35 (14)	00	82.7(43)	17.3(9)	00
2. My teacher lets me do activities I want to do	75 (30)	25 (10)	00	82.7(43)	17.3(9)	00
3. My teacher lets me do different activities	65 (26)	35(14)	00	76.9(40)	17.1(12)	00
4. My teacher does activities with me	67.5 (27)	32.5(13)	00	82.7(43)	17.3(9)	00
5. My teacher lets me choose where to sit	77.5 (31)	22.5(9)	00	76.9(40)	23.1(12)	00

From Table 1 it shows that both groups reported to experience conflict with their teachers but in a differing degree. For example, low scores on warmth for children with internalizing behavior ranged between 0 and 2.5%. Moderate scores ranged between 25% and 62.5% and higher scores ranged between 35% and 72.5%. For conflict moderate scores ranged between 17% and 61.5% and higher response ranged between 38.5%and 82.7%. Higher scores on conflict means children perceived higher conflict with teachers.

Responses about whether children receive autonomy support from the teachers revealed a high score from both groups but with a differing degree. For example, for children with internalizing behavior higher scores on disagreement ranged between 65% and 77.5%. Moderate scores (partial agreement) ranged between 22.5% and 35% and there was no response on agreement. For children with externalizing behavior higher scores on disagreement ranged between 76.9% and 82.7%. Partial agreement ranged between 17.1% and 23.1% and there was no response on agreement.

Table 2: Descriptive statistics of Y-CATS variables including age, warmth, conflict and autonomy and Pearson correlation (N = 92)

Variables	N items	Min	Max	Mean	S D	α	Warmth	Conflict	Autonomy
Age		5.00	6.00	5.50	.62				
Warmth	10	2.32	2.73	2.56	2.57	.79		-.12	.28**
Conflict	7	1.27	1.65	1.42	1.88	.74			-.25*
Autonomy	5	2.64	2.76	2.71	1.45	.81			

Note,*p<.05; **p< .01

Table 3: Descriptive statistics of warmth, conflict and autonomy by children with internalizing behavior and children with externalizing behavior

TCR	Group					
	Internalizing			Externalizing		
	M	*SD*	*n*	*M*	*SD*	*n*
Warmth	2.45	2.22	40	1.03	1.70	52
Conflict	6.45	1.71	40	6.75	.83	52
Autonomy	.47	1.37	40	.11	.37	52

Children's perception regarding their relationship with their teachers on warmth, conflict and autonomy support

A two-way multivariate analysis of variance (Two-way MANOVA) was performed to examine whether children with internalizing behavior and externalizing behavior differ in their perception of the relationship with their teacher and also whether there was an interaction between the type of

children's behavior and child's gender on perception. The independent variables were type of children's behavior (internalizing behavior and externalizing behavior) and child's gender. In order to perform a two-way MANOVA, several assumptions should be met**.** Preliminary, assumptions for normality, linearity, univariate and multivariate outliers, homogeneity of variance –covariance matrices and multicollinearity were tested. No violation of assumptions was noted.
To reduce Type 1 error and to achieve a better result, we set a higher alpha value and we applied a Bonferroni adjustment. We divided the p-value (.05) by 3 (i.e., the number of dependent variables), which gave us a new alpha value of .017 (Field, 2009). Therefore, a variable with a *p*-value < .017 was considered as significant. In our findings, only one dependent variable (warmth) recorded a significant value less than this cut-off, $F(1,88) = 7.09$, $p = .009$.

We examined whether the effect of type of children's behavior on the perception of the relationship with their teacher was dependent on the gender of the child. The result from the two-way MANOVA revealed that there was no statistically significant interaction effect between type of child behavior (internalizing behavior and externalizing behavior) and gender on the combined dependent variables; $F(3, 86) = 539$, $p = .66$, Wilk's, Lambda = .982.

Results from the main effects two-way Manova revealed a statistically significant difference between children with internalizing behavior *versus* those with externalizing behavior on the combined variables $F(3,86) = 2.677$, $p < .05$; Wilks Lambda = .85; partial eta .085, which indicates a medium effect. When the results for the independent variables were considered separately, the only difference to reach statistically significance, using a Bonferroni adjusted alpha level of .017 (Field, 2009), was on perceived warmth, $F(1, 88) = 7.09$, $p = .009$, partial eta squared = .09 which indicate a medium effect. The remaining two dependent variables, conflict and autonomy support, revealed non-statistically significant differences. Mean scores indicated that children with internalizing behavior reported rather lower score on warmth ($M = 15.02$; $SD = 2.74$) than children with externalizing behavior ($M = 13.35$; $SD = 2.19$).

Results on main effect about whether females perceived higher or lower on the perception of teacher-child relationship revealed a non-statistical significant difference on all variables: warmth ($F(1,88) = .010$, $p = .92$), conflict ($F(1, 88) = 1.869$, $p = .17$) and autonomy support ($F(1, 88) = .653$, $p = .42$), indicating that there was no interaction effect.

Discussion

The purpose of this study was to explore perception of children with internalizing and externalizing behavior about their relationship with their teachers regarding warmth, conflict and autonomy support from their teachers. It also aimed to examine whether children with internalizing behavior differ from children with externalizing behavior in perception regarding their relationship with their teachers using a Y-CATS measure as well as possible interactions between type of behavior and children's gender on warmth, conflict and autonomy support.

Responses on perception on their relationship regarding warmth, conflict, and autonomy support for children with internalizing behavior and children with externalizing behavior roughly indicated the same direction for both groups. For example, both groups rated higher on disagreement about warmth and lower on autonomy support. This indicates that many children perceive teacher as unfriendly in the school context. In addition, both groups recorded high on a conflictual relationship with teachers, which indicate that many children regardless of displaying internalizing or externalizing behavior experienced a disharmonious relationship with their teachers. This implies that the quality of the teacher-child relationship as perceived by the children from both groups is of poor quality. The findings are contrary to that of Papadopoulou and Gregariadis (2017) who state that children perceive a positive interaction with their teachers. This difference might be attributed to the sample of this study, which used only children with extreme behavior problems. In addition, these studies are done in different contexts where the teacher-child relationships may differ as due to cultural orientations. Children adapt their behavior to adults such as parents and teachers, as was pointed out by Mclauglin, Aspdem and Mclach (2015) that children learn from their relationships and interactions with significant people in the home and school context. If a teacher is not friendly during interactions with a child, the child may develop a negative perception on the relationship with the teacher. This may happen especially when a teacher views a child as problematic and lacks skills of helping a child with internalizing and or with externalizing behavior. In this context each child may perceive the relationship as not friendly.

We examined whether there were differences in the perception on the teacher-child relationship between children with internalizing behavior and children with externalizing behavior. The results partially supported our hypotheses. We found a statistically significant difference in the perceived warmth between children with internalizing behavior and externalizing behavior.

Children with internalizing behavior reported rather higher on warmth indicating that they partially experience less relational difficulties as compared to children with externalizing behavior. These findings are contrary to that of Henricsson and Rydell (2004) who found that children with internalizing behavior had more negative interaction with teachers. The findings are also contrary to the findings from studies which report that for children with internalizing behavior, negative perceptions matter more than positive perceptions (Jellesman, Zee & Koomen, 2015). However, this might be attributed by the nature of children with internalizing behavior as they are not readily visible and can't be easily recognized. Furthermore, since these children are so silent, it is difficult for other people including teachers and peers to help them (see also Stephens, 2016).

We also found out that both groups reported to experience a conflictual relationship with their teachers and a lack of autonomy support from the teachers. This generally implied that both, children with internalizing behavior and children with externalizing behavior experience misunderstanding during their interaction with their teachers. In addition, both groups do not receive autonomy support from the teachers. The findings are in line with that of Baker, Grant and Marlock (2018) who argue that children with internalizing and children with externalizing behavior are at risk for relational difficulties and poor adjustment at school. Teachers tend to dislike children who display unacceptable behaviors and it is difficult for them to maintain a positive quality of the relationship because if a child feels disliked s/he will perceive the relationship as unfriendly (see also Fumo & Hargreaves, 2003; Rudasilli & Rim-Kaufman, 2009; Silva *et al*., 2010). In Tanzania, obedience is encouraged in children, a disobedient child may elicit anger in a teacher and a teacher may respond in an unfriendly way to the child. This may lead to a vicious circle of conflictual relationship. For example, it may lead into a trajectory path of problem behavior and finally develop into difficult behavior in future hence difficult to maintain relationship with other people in different context.

The responses on all variables from both groups roughly indicate the same direction but with a varying degree. Both groups indicated higher on disagreement and very low on agreement about warmth and autonomy support from teachers. In contrast, in both groups, responses on conflict indicated higher agreement and no responses on disagreement indicating that conflict relational was high to both groups.

Conclusion

This study highlighted the perception of children with internalizing behavior and children with externalizing behavior on their relationship with

their teachers and whether the perception differ between them or not. The study further examined whether there is an interaction effect between gender and child behavior. The findings revealed that both groups rated higher disagreement and lower on warmth and autonomy support and higher agreement on conflict. This indicates that both groups; children displaying internalizing behavior and children displaying externalizing behavior perceive a disharmonious relationship with their teachers and that teachers are not supportive to these children. Two-way MANOVA revealed that children with internalizing behavior and children with externalizing behavior view their teacher as not friendly, not supportive and that they experience a conflictual relationship; a situation which puts children at risk of developing a trajectory of problem behavior in their school career. Teachers' reports are in line with this assertion as they report difficulties to relate to a child who persistently shows negative behavior (Fumo, Hargreaves & Maxwell, 2003); however, they view this as indication of teacher failure. Generally, the findings imply that children who display internalizing behavior and children who display externalizing behaviors are not treated in a friendly manner as a result lead into a negative perception into children which may lead a vicious circle of these behavior and relational trajectory.

Strengths and Limitation

This is the first study to explore perceptions of children with internalizing and children externalizing behavior about their relationship with their teachers. We used peer rating and teachers report to obtain children who display internalizing behavior and children who display externalizing behavior; this leads to methodological strength as two types of informants were involved. Furthermore, the study highlighted the relational problems facing children with internalizing behavior and externalizing behavior that may inform teachers on how to manage these behaviors in pre-primary schools. However, this study has limitations. First, only children with internalizing behavior and children with externalizing behavior reported on their relationship with their teachers. In the future, to bring a clear picture about the quality of child interactions with the teacher in pre-primary schools normal children should be included in the sample study to report their relationship with teachers. This may serve the purpose of comparison between normal children and children with internalizing behavior and those with externalizing behavior. In addition, children displaying these behaviors should report their relationship with other people who are significant to them such as parents and siblings. This shall reveal the relationship of the child with other people in home and school settings. Furthermore, in the future parents should be involved to report whether the

child displays internalizing behavior or externalizing behavior; this can reveal a real picture of child development at home and at school and may help teachers to handle their dyadic relationship with these children from the beginning a child starts a school.

Implications for Practice

The study highlighted the perceptions of teacher-child relations from the child's perspective of children with internalizing behavior or and children with externalizing behavior. The study suggests that in pre-primary schools children with internalizing behavior and children with externalizing behavior perceived a disharmonious relationship with their teacher, more directives from the teachers as well as more conflict. Literature suggests that perceptions on these behaviors may become stable and the children are more likely to experience more relational difficulties with their teachers, and finally poor adjustment in the school context. This informs teachers that they have roles to help these children to develop a positive relationship.

According to Baker *et al*. (2018) teachers have a role of scaffolding the development of behavior competence and self-regulation in children. In addition, teachers have a role of protecting children against developing further internalizing or externalizing behavior; they should help children to develop beliefs and positive attitude towards behavior competency. In this study we suggest that pre-primary teachers should be trained to identify children with internalizing and children with externalizing behavior in pre-primary schools. Furthermore, teachers should be equipped with skills which will help them in identifying children with indicators of internalizing behavior and children with externalizing behavior so as to help these children to establish positive perception on the dyadic relationship with teachers. From the time children start pre-primary schools should be screened to identify children with internalizing behavior or externalizing behavior for the purposes of helping them. In addition, studies should be done to identify several behaviors in children, which may affect relationship with teachers in schools and prevent young children from developing circles of relational difficulties. Since children come from different home background with differing rearing styles; their behavior differs; in this situation, a pre-primary teacher should act as a buffering factor of internalizing and externalizing behavior in children. This will make teacher-child relationship in school an integral part of children's behavior regulation.

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Assessing Tanzanian English as a Foreign Language: Teachers and Students' Preference of Written Corrective Feedback

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Abstract: *The current study was an assessment of the opinions and preferences of Tanzania English as a foreign language (EFL) students and their teachers with regard to Written Corrective Feedback (WCF). It focused on Respondents feelings on errors, their preference on actors of error correction, immediacy of error correction and social company during error correction and whether there are differences between teachers' and students' opinions and preferences. The study involved 20 English language teachers, 10 from public schools and 10 from private secondary schools. Composition of the participants considered gender balance; hence ten females and 10 males were purposively selected. Participants also involved 60 secondary school students from the same schools where the teachers were drawn. Data were gathered through written questionnaire to elicit both teachers and students' opinions about their perceived preference on actors and correct time for WCF and the social group involved. The resultant data were handled both quantitatively and qualitatively. The findings have revealed that over half of the students and a grand majority of their teachers felt that it is the teacher who ought to correct the errors. Furthermore, the majority of both students and their teachers opined that errors should be corrected every time it is committed and a significant number felt that their errors should be handled by their social group rather than the teachers. It was concluded that, in handling learners' errors their feelings and perceptions should be taken into account. This can be through classroom observation or carrying out classroom based attitudinal study.*

Key words: Language Errors, Learners, Teachers

Introduction

From the 1950s, after major criticisms by innatists and cognitivists against behaviorist approach to language acquisition, linguists and scholars in language in education have realised that to acquire and develop linguistic system, a child makes hypotheses, tests them, and gradually acquires the correct language forms. They have noted the same case in the learning of a second language where the child's acquisition of its first language (L1) has contributed in changing this view concerning language two (L2) learning. Just like a child at the beginning of its L1 acquisition, the L2 learner has his own limitations along the learning process and s most likely to make errors

that reflect the hypotheses that the child keeps making during all its language learning process to finally gain proficiency. Errors, whether intralinguistic or interlinguistic, have thus become necessary and an important step in the learning process of any L2 learner. Errors have not only become important for the learner but also for the teacher and the linguist. Errors enable the teacher to know their learners level of acquisition and thus be in a better situation to design remedial activities for them. Errors also help the researcher to understand the psycholinguistic process of a learner acquiring a second language.

However, research reports that the teacher's feedback may have three different effects on the learners. The feedback may interrupt the learners' L2 acquisition progress, confuse them and consequently, inhibiting their learning; alternatively, it may help them to notice the gap between their performance and the target language or it may simply have no effect on them. In spite of its usefulness, teacher's feedback may have undesirable effects, and that is why the appropriate feedback should be selected for the appropriate error and appropriate learner and in appropriate time.

Theoretical Base of the Study

Many researchers such as Lightbown and Spada (1999) and Long (1996) share the idea that input alone is not sufficient to reach a high level of proficiency in any L2 learning. According to them, the learner should be active in his learning process and this is by producing his output and being able to compare it with the given input so as to identify the difference and make his own self-correction, which is proved to be very effective in the L2 learning process. In addition to self-correction, research referring to peer-correction has been an efficient method that should be given a certain priority in second language acquisition (SLA) classes.

Various studies, e.g., those by Carroll and Swain (1993), Iwashita, (2003) and Sheen (2004), have indicated that, in general, teachers' corrective feedback is inconsistent, ambiguous, arbitrary, and idiosyncratic. As a result, studies in this area are rarely viewed positively because, as Han (2002: 569) contends "in real classrooms, students rarely get much, if any, individualized attention, and corrective feedback, if provided, it is usually given ad hoc, [attention generally] covering a wide range of inter-language constructions". Given limited time in language classes, it is virtually impossible for the teacher to address each error that occurs. Thus, errors are selectively corrected. Consequently, classroom interaction often does not address individual needs of language learners. Several studies, however, have found that developmental readiness (Mackey & Philp, 1998), attention,

motivation, language background (Han & Selinker, 1999), education level (Bigelow et al., 2006) and proficiency level (Lyster, 2004), all influence a learner's processing of corrective feedback.

There have been a few studies on perceptions on corrective feedback. In fact, Amrhein (n.d.) noted that there has been a renewed interest into how students and teachers perceive the usefulness of corrective feedback, notably the written ones. Such studies, she observes, are on students' preferences. She cites some studies on students' opinions and preferences for certain types and amounts of WCF which affect their use of this type of feedback for learning such as McCargar (1993) and Schulz (2001) both of whom conclude that if a student prefers or believes that one type of WCF is more useful, then he or she may be more likely to pay more attention to the correction and use it for learning than if he or she does not believe in its effects. Furthermore, students' preferences for WCF are not homogenous.

In a survey of 59 English as second language (ESL) class, students' attitudes towards feedback on their written work, Radecki and Swales (1988) concluded that ESL teachers might lose their credibility among their students if they do not correct all surface errors, since findings revealed that students expressed their need for written corrective feedback. Hence, they expect correction of all errors.

In Africa most studies are in the realm of error analysis. For example, in South Africa a study by Nzama (n.d,) of both rural and urban schools revealed that all grades committed the following errors: incorrect use of auxiliaries, tenses, concords, articles, prepositions, pronouns, plurals, mother tongue interferences, infinitives and auxiliary with past tense.

A study conducted by Eyengho and Fawole (2013) in Nigeria assessed error-correction techniques used in correcting students' essays in English language in the South Western parts of Nigeria. The results showed that indirect approach to … was the most effective means of … as indicated in the results of (x=11.88) compared to the use of direct metalinguistic technique (x=11.53) and the use of conventional method (x=10.4).

In Tanzania, Msanjila's (2005) study sought to identify and discuss writing problems in Kiswahili in secondary schools. The study revealed six glaring writing problems, namely: capitalization and punctuation problems, inexplicitness or fuzziness, poor organization or illogical sequencing, spelling problems and grammatical errors. Other scholars within this area who have examined writing problems in Kiswahili essays in some Teacher Training Colleges and the University of Dar es Salaam, are Mkude (1980), Qorro (1988) and Msanjila (1990), all of these scholars noted with great

concern that students have writing problems in expressing themselves systematically and logically. Sebonde and Biseko (2013) examined morpho-syntactic errors among secondary school students in Tanzanian English Language Classrooms focusing on corrective feedback techniques that teachers used to handle their students' morpho-syntactic errors (both written and spoken errors). The data revealed that a total of four corrective feedback techniques are commonly used in Tanzanian English language classrooms. These are focused Corrective Feedback, direct Corrective Feedback, indirect Corrective Feedback and metalinguistic Corrective Feedback. It was also discovered that teachers preferred the use of indirect Corrective Feedback when they mark written assignments while explicit and recast are the most applied techniques in handling students' oral errors.

On the basis of the literature surveyed and the researchers' experience and interest, the current study sought to assess the opinions and preferences of Tanzania EFL students and their teachers with regard to WCF. Its foci were what opinions and preferences of Tanzania EFL students and their teachers with regard to Written Corrective Feedback (WCF) and whether there are differences between teachers' and students' opinions and preferences towards WCF.

Methodology

The study involved a total of 20 English language teachers, 10 from public schools 5 males and 5 female participants, and the 10 participants were drawn from both private and public secondary schools. These were purposively selected following gender and work experience as major criteria. It also involved 60 secondary school students form the same schools from which the teachers were drawn but their attributes were as follows: from each school there were 6 students (3 pursuing Arts subjects and 3 pursuing Science sub-streams). Half of each sub stream was boys and the other half girls. These were randomly selected from each sub stream to ensure representativeness.

The proposed study used a written questionnaire to elicit both EFL O'Level teachers and students' participants' opinions about their perceived usefulness of the frequency of using WCF in their English language classes. The resulting data were handled both quantitatively and qualitatively.

The questionnaire responses were recorded in an excel spread sheet and then imported to SPSS 15.0 for statistical analysis. For the quantitative data, the frequencies of responses on the questionnaires were calculated and then compared. Qualitative analysis was conducted on the participants' explanatory responses and were summarized and categorized according to common themes and then compared between teachers and students.

Findings

The findings are organized into five subthemes, namely respondents' feelings on errors, their preference on actors of error correction, time of error correction, immediacy of error correction, and social company during error correction.

Respondents' Feelings on Errors

The respondents were asked to indicate their feelings on seeing their written work corrected by their teachers (for students) or seeing their errors in their students' assignments (for teachers). Their responses are as summarized in table 1.

Table 1: Respondents' Feelings on Errors

	When Students are corrected		When Teachers notice errors	
	Frequency	Percent	Frequency	Percentage
Embarrassed	11	18.3	8	40.0
Annoyed	5	8.3	10	50.0
Confused	5	8.3	2	10.0
Reassured	5	8.3	20	100.0
Fine	34	56.7	8	40.0
Total	60	100.0	10	50.0

The majority of the learners (34, which is 56.7%) indicated that whenever they saw their written assignment marked, with errors indicated or corrected, they felt fine. Feeling fine here, means not being emotionally evoked by the errors the teachers had indicated or corrected. The same kind of feeling was shared by 8% of the teachers.

A half of teachers (10, which is equal to 50%) and a fairly small number of students (5 which is only 8.3%) indicated that they felt annoyed when viewing errors in students' scripts. This is a group which feels annoyed at seeing students' errors in teachers' feedback; this kind of feeling is what scholars like Pishghadam and Alchondpoor (2011) refers to as perfectionists, a people who strive to meet very high standards in everything they do and they strongly believe that mistakes are evidence of an individual's unworthiness characteristic. In their study Aregersen and Howitz (2002) noted that anxious learners reported, inter alia, a higher level of concern over their own errors, something that has, according to Mehrabizadeh (2003), a debilitating effect. Other forms of reactions which share similar emotive reactions are feeling of embarrassment (by 90% of teachers and 18.3% of students) and confusion (by 10% of teachers and 8.3% of students).

Preference on Actors of Error Correction

The respondents were asked to identify the person who is the one they prefer to correct errors. The responses by both the students and their teachers are summarized in Table 2 below.

Table 2: Preference of who should Correct students' Errors

	Students		Teachers	
	Frequency	Percent	Frequency	Percent
by a classmate	22	36.7	2	10.0
by the teacher	34	56.7	18	90.0
not indicated	4	6.7	0.0	0.0
Total	60	100.0	20	100.0

Table 2 summarizes the comparative responses of students and their teachers on their preferences of who should correct the errors. The findings indicated that over half (56.7%) of the students and a grand majority (90%) of their teachers felt that it is the teacher who ought to correct the errors. This is a solid belief on teachers as the 'know all' person and the authority when it comes to language corrective feedback. Given such belief, Oladejo (1993) opines that teachers must be willing to change their attitude towards errors as well as realize that language teaching is a process of an intervention to quicken the language learning process.

This is also in agreement with earlier recommendations by Corder (1973) and Allwright (1975) who argue that the teacher should be primarily responsible for correcting learners' errors. However, a significant number of students (22 out of 60, which is equivalent to 36.7%) indicated that peer/classmates should be primarily responsible to correction of their classmates' errors. This position was also shared by 2 out of 20 teachers (10%). This viewpoint is congruent to Raven (1973) and Cohen (1975) who recommended that peer correction is a welcome attempt to complement the teacher's role in error correction.

Time of Error Correction

The respondents were further asked to show preferred time for error correction. Their responses are as summarized in Table 3.

Table 3: Preference of when Errors are Corrected

	Students		Teachers	
	Frequency	Percent	Frequency	Percent
Every time you make a mistake	32	53.3	14	70.0
Only when the mistake is important	17	28.3	4	20.0

Never, errors should not be corrected at all	11	18.3	2	10.0
Total	**60**	**100.0**	**20**	**100.0**

Another vexing issue in this area is the correct time for error correction. There have been vehement contentions amongst scholars in this area. Table 3 indicates the students and teachers' varied preferences with regard to time of error correction, with the majority of both students (53.3%) and their teachers (70%) opting for every time an error is committed. In other words, all instances of errors, even if they all point to non-mastery of one or specific rule of grammar or language use, should be corrected. In a study by Kavaliquskiene and Anusience (2012) it was noted that 64% of all their respondents concurred with the assertion that teachers should correct every error. This was also in line with Lim's (1990) respondents the majority of whom also indicated grammatical errors to deserve correction always they occur.

Immediacy of Error Correction

Related to the aspect of time of error correction is the notion of how immediate error correction should be affected. Table 4 summarizes the students and their teachers' preferences in this aspect.

Table 4: Preference of Immediacy of Error Correction

	Students		**Teachers**	
	Frequency	**Percent**	**Frequency**	**Percent**
Immediately	31	51.6	8	40.0
After class	24	40.0	10	50.0
Not indicated	5	8.3	2	10.0
Total	60	100.0	20	100.0

The findings suggest that while 51.6% of students would prefer the errors they made to be corrected immediately, 40% of their teachers share the same preference. However, 50% of the teachers and 40% of their students indicated their preference for delayed (after class) treatment of errors, agreeing with Amara's (2015) assertion that, for communicative purposes, delayed correction is usually preferred because … In smith's (2000) study, it was noted that delayed corrective feedback was so unpopular among students respondents that only 2 out of 50 (4%) indicated preference for delayed correction of errors.

Social Company during Error Correction

We were interested to find out learners and their teachers' preferences as to whether they preferred to be corrected individually or as a group while they corrected errors. Table 5 summarizes their responses.

Table 5: Preference of the Social Company during Error Correction

	Students		Teachers	
	Frequency	**Percent**	**Frequency**	**Percent**
Individually	30	50.0	7	35.0
As a Group	27	45.0	9	45.0
Not Indicated	3	5.0	4	20.0
Total	**60**	**100.0**	**20**	**100.0**

The findings indicated that half of the participating students favoured being corrected individually as contrasted with the teachers 35% favouring correcting their learners' errors individually. While, as indicated earlier, the students earlier, the students might be concerned with social image, their teacher's preference of handling their learners individually may be due to pedagogical efficiency of such technique. Of Kavaliauskene and Anusiene's (2012) study, over 95% of students respondents agreed with an assertion that individual correction of mistakes in writing is useful, attributing its utilitarian value to facilitative role in personalized learning of language. This individual error correction had earlier been proposed by Fregeau (1999), Koshik (2002) and Lewis (2002) in what they called "individual conference" during which the teacher meets learners individually, to assist those that have difficulties with correcting particular errors.

However, a significant number 45% for both students and teachers favoured group error correction over individual consultation with the teacher. This kind of error correction is labeled by Harmer (1991) an error illustration "during which the teacher uses learners" common errors as instances for class explanations.

4. Pedagogical Implications of the Findings

As can be seen from the analysis, corrective feedback is an important part of the foreign language learning, since it considerably increases the accuracy of learner output. The opinion and preferences of corrective feedback should be adapted to the objective of the lesson, the activity and the needs of learners. If the objective is to develop accuracy, then, of course, corrective feedback is necessary. In this case, teachers are to follow such an imperative: allow the students to correct themselves first, then in the case when it does not work, the teacher may allow for the correction from peers, and finally, if

no one knows how to repair the erroneous form; the teacher can intervene by giving the right correction. This may seem tedious and time-consuming at first sight. Nonetheless, it helps to reduce reliance on the teacher and at the same time, increase student autonomy and confidence. If the activity focuses on fluency, correction is not as frequent as in the case of the activities developing accuracy, since constant interruption of students' utterances may be perceived as disruptive or even irritating, especially when errors do not hamper the meaning of communication.

When it comes to the time of providing corrective feedback, EFL teachers may think that it is better not to correct immediately and frequently, but students may assume that their teacher is not qualified enough to correct errors or that teachers do not want or care giving feedback to their students. What is more, EFL teachers may prefer to provide delayed correction, which unfortunately has some drawbacks. Although it is less disruptive and irritating than immediate correction, it is more effective to give corrective feedback after erroneous forms have been identified, because the processing mechanisms of students are then more likely to be activated.

In order to rectify both teachers and students' opposing expectations involving the correction of errors, mistakes and attempts to …?, one should correct them in a positive and friendly manner, assuring that any kind of error is an inevitable part of foreign language learning. Positive attitude towards students' errors and mistakes makes them feel more comfortable and confident that they will manage to reduce their erroneous forms of the language in the processes of language learning.

Conclusions

Learning a language involves testing out hypotheses about the learning system. As a result, some of the attempts might be erroneous. Since erroneous forms of language are inevitable parts of language learning, there might be various views concerning them. Some teachers regard errors as failures in teaching particular in language aspects and students perceive them as failures to gain what they are supposed to learn and know. However, errors might also be accepted as indication of the learning taking place within a learner. The researcher has been especially interested in investigating the distinctions in opinions between teachers and students, and also in comparing their views as stated in this study's questionnaire items.

The quantitative and qualitative analysis demonstrated that speaking in the classroom is perceived as the opportunity to make errors, that is why so many students hesitate from taking part in language learning communicative activities. The study has made it clear that corrective

feedback is considered a crucial part in language learning processes, and it is even expected by most students and teachers.

Although peer correction and self-correction have many benefits and the majority of teachers declare to promote these types of correction in the classroom, the students seem not to appreciate them and they expect their teachers to rectify what they do not know. It has also been proved that contrary to immediate correction, which is usually regarded as disruptive or even irritating, delayed correction is most frequently used by teacher, in spite of the fact that it is not as beneficial as it might be considered since learners' cognitive processing mechanisms are less likely to be activated. The study demonstrates that students might react to corrective feedback in a number of ways. However, the findings have revealed that learners usually feel contented when they receive corrective feedback, which prevents them from committing the same errors in future language practices.

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Vegetable Pest Management and Pesticide use in Kigoma, Tanzania: Challenges and way Forward

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Abstract: *This study assessed farmers' knowledge and practices regarding pesticide use and pest management in vegetables and implications for human health and the environment. Participatory approaches including focus group discussions, individual farmer interviews and observations were held. The study revealed that most of the farmers are relatively new to vegetable production and use synthetic pesticides as the major strategy for controlling pests and diseases. The farmers lack access to information on proper management of pest and safe use of pesticides, and most often depend on informal advice, notably from pesticide retailers. Consequently, the majority of farmers apply pesticides haphazardly without correctly identifying diseases and pests on their crops. The anomaly is attributed to the lack of knowledge on pesticide use and related hazards, lack of alternatives to synthetic pesticides, stringent market requirements for unblemished crops, and the unwillingness of farmers to accept the risk of crop loss. The indiscriminate application of pesticides, if it remains unchecked, will have adverse effect on the environment, health of farmers and consumers of vegetables. The challenges faced by these farmers in their attempt to manage vegetable pests and possible strategies for intervention are discussed.*

Keywords: Pesticide use, Risk exposure, Farmer awareness, Tanzania

Introduction

Pesticides are the major components of the modern agricultural production because of their high capability and reliability for crop protection against pests and assurance of high crop yields (Schreinemachers *et al*., 2017). In this respect, high input intensive agricultural production systems which involve greater and widespread use of pesticides in managing pests have now become a dominant feature (Abhilash and Singh, 2009; Gautam *et al*., 2017; Jallow *et al*., 2017). Unfortunately, this trend has made farmers in low income countries to become overly reliant on synthetic pesticides in managing crop pests and diseases (Gautam *et al*., 2017). However, reliance on pesticides is difficult to sustain because of the risks, which are associated with misuse of pesticides, and which can cause harm to humans and to the environment. These risks include pesticide poisoning; acetylcholinesterase depression; increased health burden; and adverse effects on animals and

fishes, birds, and honey bees (see Abhilash and Singh, 2009; Damalas and Koutroubas, 2016; Gangemi *et al*., 2016; Kiwango *et al*., 2018; Mahugija *et al*., 2018).

Human exposure to pesticides can occur indirectly from environmental contamination (dietary intake or atmospheric contamination) or directly from occupational, agricultural, and household use. In this regard, farm workers are more likely to be exposed both directly and indirectly, which puts them at higher risks of both acute intoxication and long-term adverse health effects (Gangemi *et al*., 2016; Lehmann, *et al*., 2017). Scholars (e.g. Gangemi *et al*., 2016; Mrema *et al*., 2017) provide comprehensive reviews of the impact of pesticides on human health, particularly as regards to the development of chronic diseases.

Many of the adverse effects of pesticides are a direct result of the overuse and misuse of pesticides. These include deviation from the recommended application procedures and dosages; the use of obsolete and banned pesticides; and improper storage, handling, and disposal of pesticides (Damalas *et al*., 2006; Ngowi and Semali, 2011; Damalas and Koutroubas, 2016; Jallow *et al*., 2017; Kiwango *et al*., 2018). Additionally, harvesting of treated fruits and vegetables without following the correct withholding period/pre-harvest interval leads to unacceptable levels of pesticide residues and poisoning to the consumers as observed by Kiwango *et al*. (2018).

Over the years, there has been a substantial increase of pesticide usage trend in agriculture and public health in Tanzania, making pesticide poisoning and contamination of consumer products a major public health concern (see Ngowi *et al*., 2007; Ngowi and Semali, 2011; Kiwango *et al*., 2018). This scenario was envisaged in the villages along the Eastern shores of Lake Tanganyika by the "Tuungane" project. The Tuungane project was introduced in year 2012 as a partnership of the District governments, Pathfinder International, and The Nature Conservancy, to protect the health and well-being of the natural environment and people living in the Greater Mahale Ecosystem (GME) in western Tanzania. The main occupation of the people in the GME is agriculture, followed by fishing and livestock (Hess *et al*. 2016). Owing to an increase in vegetable cultivation and pesticide usage in the villages along the shoreline of Lake Tanganyika, there was a strong need to assess farmers' pest management practices and pesticide use.

Several studies on knowledge, attitude, and behaviour among smallholders' farmers in their handling of pesticides have shown that unsafe use of pesticides is common in Tanzania and other developing countries (Ngowi

and Semali, 2011; Kiwango *et al*., 2018), Ethiopia (Mengistie *et al*., 2017), Iran (Rezaei *et al*., 2018), Nepal (Bhandari *et al*., 2018b) and Bangladesh (Gautam *et al*., 2017; Akter *et al*., 2018). The anomaly is linked to the lack of education and training in pesticide use, lack of alternatives to pesticides, inadequate information on related hazards, stringent market requirements for crop aesthetic perfection, and unwillingness of farmers to accept the risk of crop loss (Damalas and Koutroubas, 2016; Jallow *et al*., 2017; Bhandari *et al*., 2018).

The lack of knowledge among farmers on safer pesticides handling (application, storage, and disposal) has also been reported in Tanzania (see Ngowi and Semali, 2011; Lekei *et al*., 2014; Elibariki and Maguta, 2017; Lekei *et al*., 2017; Ngowi *et al*., 2017; Kiwango *et al*., 2018). This calls for a critical consideration of agricultural technologies and identification of best practices of reducing the negative effects of pesticides on human health and the environment for promoting sustainability of agricultural production (Jallow *et al*., 2017; Mengistie *et al*., 2017). The identification of factors that contribute to unsafe behaviours and practices is a prerequisite for the development of appropriate preventive interventions in reducing occupational risks and health problems among vegetable farmers and consumers.

The current study was carried out to (i) assess pest management and pesticide use practices, among vegetable farmers with a special focus on tomato and cabbage, (ii) identify farmers' pesticide use practices that risk the environment and human health (iii) determine the challenges faced by these farmers in their attempt of managing vegetable pests, and (iv) recommend possible alternative strategies for managing pests that will reduce synthetics pesticide use and promote safer pesticide use.

Materials and Methods

Description of the study area

The research was carried out from August to September, 2016. The study area was confined to 16 villages located in Buhingu and Kalya zone along the eastern shores of Lake Tanganyika in Uvinza District of Kigoma region. The villages in Buhingu zone were; Mgambo, Buhingu, Katumbi, Nkokwa, Rukoma, Igalula, Kaparamsenga, Herembe, Kanyase, Mgambazi, Kabusemele, and the villages in Kalya zone were Sibwesa, Kalya, Tambusha, Kashagulu and Lufubu (Figure 1). The 16 villages were purposively included in this study as they were constituent villages of the Tuungane project.

The villages in the Kalya zone, in the southern part of the study area are not easily accessible by roads. Kigoma region has a tropical climate with a long wet rainy season running from October to May, with a short dry spell of 2-3

weeks in January or February followed by a prolonged dry season. The months of January to May receive more precipitation than the months of October to December. The average temperature in Kigoma is 23.2°C while the average rainfall is 1033 mm.

There is a marked difference in soil fertility in the villages. A study by Wickama (2016), revealed that the twelve villages in the Buhingu zone have clay loam soils of better fertility conditions compared to the sandy soils of the four villages in the Kalya zone. All the villages have serious limitations in zinc and all major plant nutrients except calcium. The common soil amendments in vegetables include application of farm yard manure and inorganic fertilizers such as Urea, CAN and a form of Minjingu Phosphate Rock called Minjingu Mazao. However, the manures and fertilizers are applied at less than a quarter of the recommended rates.

This study focused on tomato and cabbage as they are the most cultivated crops in the study area. The crops are susceptible to many arthropod pests and diseases, while consumers prefer unblemished pest-free vegetables. As such, pesticide use is particularly high for these two crops.

Figure 1. Map showing location of most of the villages included in the study. Adopted from Hess *et al.* (2017)

Sampling

For Participatory Rural Appraisal (PRA), the representative farmers were selected by the Tuungane project staff and local village leadership based on a simple random sampling method.

Farmers invited for Focus Group Discussions (FGDs) related to vegetables, were chosen by simple random sampling among the list of known vegetable farmers in each village. Respondents for key informant interviews were selected by both convenience sampling technique (Pesticide retailers and farmer leaders) and purposively by selecting all resident Extension Officers.

Data collection
Data collection methods
Desk/ literature review: A review of literature and various reports concerning vegetable growers and their farming practices in the study area, and important crops pests and diseases as well as methods of control was done. The risks associated with environmental hazards for each of the pesticides already in use was established based on Food and Agriculture Organisation of the United nations (FAO) classification of pesticide toxicity. The relative appropriateness of pesticides used was also assessed in respect to effectiveness, human health and environmental risks.

Focus group discussions: At the beginning of the study, FGDs were held in each of the 16 villages, to establish crop produced and major pest problems encountered. Thereafter, additional six FGDs were held in the villages where vegetable production was deemed important. Each FGD consisted of eight to fourteen representative individuals. Discussions were tape recorded.

Key informant interviews: The informants included; all four resident Agricultural Extension staff, all three Pesticide retailers at Mwanga market area in Kigoma town and the two retailers at Kalya. Additionally, Village leaders, selected vegetable Farmers' group leaders, Tuungane field staff and officials from Uvinza District Headquarters, were interviewed. A checklist of questions was used to guide discussions with key informants as described in section 2.3.2.

On the spot observations: Participatory observations were carried out to complement information obtained from interviews and FGDs. A checklist for different types of observations was used. Key pesticides and their application methods were identified based on the description given by farmers and photo documentation. In addition, the two Agrovet shops located in one village (Kalya) and the three shops at Mwanga area in Kigoma town were visited to identify and get more information about the pesticides currently in demand or commonly used by the vegetable growers. The interaction of customers and pesticide shop keepers as well as handling of pesticides was also observed in each shop. The focus here was to assess whether (i) Shop keepers have adequate knowledge about the different pesticides in their stores (ii) Shopkeepers adhere to safety

precaution while handling pesticides and (iii) Farmers have adequate knowledge to allow them to choose a pesticide that is appropriate to their pest problem**.**

Checklist for interviews

The FGD with vegetable farmers used an interview guide that probed information on (i) the type of vegetables grown, (ii) the type of pests/diseases and methods of control, (iii) the type of pesticides used and their methods of application, (iv) farmers' knowledge about pesticide use (selecting, storing, and applying pesticides), (v) adherence to safety precaution when using pesticides, (vi) perceptions of the consequences of their behaviour, in other words, farmers' awareness on the effect of pesticides on health and environment (vii) the challenges vegetable growers face in managing pests and diseases. During interviews, self-perceived pesticide poisoning symptoms were also recorded. A similar checklist was used for Key informant interviews where the interviewees also helped to clarify issues that were not clear from the discussions with farmers.

Data analysis

Data analysis was done immediately after the field visit. Data from interviews and FGDs were transcribed from tape recordings and later typed using MS Microsoft Word immediately after fieldwork. Content and thematic analyses were done by first ordering the narratives in relation to the interview checklist topics and specific objectives of the study. The information gathered was then summarized as major qualitative results in separate sections of the findings, following the objectives that guided the collection of the particular data.

Limitation of the study

The study was carried out during off season. Usually, there are more pests and disease incidences and high disease severity during the rainy season. Vegetable crops observed in the field included tomato, cabbage, Chinese cabbage, collard, Amaranthus, watermelon and cucumber. Hence, the identification of some of the pests and diseases which could not be seen relied mostly on the descriptions obtained from farmers. However, despite these limitations, it is envisaged that the data collected and the results of the study are a true representation of the situation existing in the study area.

Results

Type of vegetables grown

A wide range of vegetable crops are cultivated mostly on small plots of less than 0.25Ha. Only watermelons (*Citrullus lanatus*) are grown on large plots of about 0.5Ha. The most cultivated vegetables in the order of importance, are tomato (*Lycopersicon esculentum*) and cabbage (*Brassica oleracea* var.

capitata). Other vegetables include Chinese cabbage (*Brassica rapa* subsp. *pekinensis*), watermelon, cucumber (*Cucumis sativus*), collard greens (*Brassica oleracea* var. *acephala*), Amaranthus (*Amaranthus* spp.), onion (*Allium cepa*) and the African eggplant (*Solanum aethiopicum*). The most important vegetable producing villages were Katumbi, Mgambo, Buhingu, Magambazi, Lagosa, Herembe and Kalya. The major field crops grown are rice, cassava, maize, common bean (*Phaseolus vulgaris*) and oil palm. Other field crops grown include banana, sweet potato, coconut and groundnut.

Major crop pests and Pest management strategies

The major pests and diseases for tomato and cabbage are listed in Tables 1 and 2.

Table 9. Important Pests and Diseases Of Tomato

SN	Tomato Pests	Tomato Diseases
1	Fruit borers (*Helicoverpa* spp., *Spodoptera* spp.)	Late blight (*Phytophthora infestans*)
2	Cutworm (*Agrotis* spp.)	Tomato yellow leaf curl virus
3	Leaf miner (*Liriomyza* spp.)	Fusarium wilt (*Fusarium oxysporum* f. sp *lycopersici*)
4	Root knot nematode (*Meloidogyne* spp.)	Blossom end rot of fruits (Physiological problem)
5	Aphids (*Aphis gossypii, Myzus persicae*)	Stem canker (*Didymella lycopersici*)
6	Loppers (*Trichoplusia* spp.)	
7	Spider mite (*Tetranychus* spp.)	

In tomato, fruit borers and leaf miners were reported as the most troublesome insects, whereas late blight was singled out as the major disease. In cabbage, the diamondback moth and black rot were the most important constraints. Farmers during FGDs reported that synthetic pesticides are by far the commonest crop protection technology used to control arthropod pests and diseases. However, other discussions and field observations revealed an increase in cultivation of disease resistant varieties. A very popular, but disease susceptible tomato variety Marglobe was largely being phased out by farmers in favour of a variety Tengeru 97, which is fairly resistant to a number of diseases, and has a long post-harvest shelf life. For cabbage, field observation showed several fields planted with

variety Gloria F1 which is less susceptible to black rot as opposed to open pollinated varieties.

Table 10. Important Pests and Diseases of Cabbage

SN	Cabbage Pests	Cabbage Diseases
1	Diamondback moth (*Plutella xylostella*)	Black rot (*Xanthomonas campestris* pv. *campestris*)
2	Aphids (*Brevicoryne brassicae, Lipaphis erysimi, Myzus persicae*)	Bacterial soft rot (*Erwinia carotovora* var. *carotovora*)
3	Cutworms (*Agrotis* spp.)	
4	Cabbage looper (*Trichoplusia* spp)	
5	Green grasshoppers	

In Katumbi village, one farmer complemented insecticide spraying by hand picking and destroying tomato leaf miners. Some good agricultural practices such as field sanitation, tomato staking, and correct crop spacing were being implemented by farmers. Unfortunately, farmers do not bother with removing and destroying crop residues immediately after harvest.

Type and source of pesticides used

Type of pesticides used

Thirty-two different pesticides were reported by farmers or were observed during field visits (Tables 3 and 4). Their formulations were predominantly emulsifiable concentrates (EC) for insecticides or wettable powders (WP) for fungicides. Insecticides accounted for 56% of the pesticides followed by fungicides, while herbicides were not used in the study area (Tables 3 and 4). The commonly used insecticides included Organophosphates (50%), mostly comprising Chlorpyrifos 400EC and Profenofos 720EC, Pyrethroids with or without Neonicotinoids (39%), and Biopesticide Abamectin. It is worth noting that organochlorines, such as the banned Endosulfan, were neither stocked in the pesticide retailer shops nor used by farmers. The most popular fungicides were Mancozeb with or without Metalaxyl and Chlorothalonil. A few farmers reported of having tried or having heard about spraying with botanical concoctions prepared from chillies and tobacco.

Table 11. List of Crop Insecticides used by Farmers and Sold at Kalya/Kigoma Pesticide Retailer Shops

SN	Chemical group[11]	Common name (Active ingredient)	Trade name(s)[12]	WHO class[13]
1	BP	Abamectin	Bimectin 3.6 EC; Dudu-Acelamectin	II
2	NC	Imidacloprid 20%	Metro 200 SC*	II
3	NC, PY	Acetamiprid 3% + Lambda-cyhalothrin 3.0%	Blasto 60 EC	II, II
4	NC, PY	Imidacloprid 20% + Cypermethrin 14.4%	Attakan C344 SE	II, II
5	OP	Chlorpyrifos 400 EC	Ascoris 48 EC*; DASBA 40 EC; Farmrifos 48 EC; Twigaphos 48EC*	II
6	OP	Fenitrothion	Sumithion	II
7	OP	Profenofos 720 g/l	Mocron 720 EC; Profit 720 EC*; Selecron 720 EC*; Wilcron 720 EC	II
8	PY	Cypermethrin 10% EC	FA Supa*	II
9	PY	Lambda-cyhalothrin	CS-Calates 5EC*; Su Karatii 5EC	II
10	PY, NC	Lambda-cyhalothrin + Imidacloprid	Perfecto	II, II

[11] Chemical group: BP = Biopesticide, NC=Neonicotinoids, OP Organophosphate and PY=Pyrethroids

[12] Trade names with an asterisk had labels with instructions in Kiswahili

[13] WHO class: Ia=Extremely hazardous, Ib = Highly hazardous, II=Moderately hazardous, III = Slightly hazardous, and U = Unlikely to present acute hazard

Table 12: List of Crop Fungicides used by Farmers and Sold at Kalya/Kigoma Pesticide Retailer Shops

SN	Common name (Active ingredient)	Trade name[14]	Target/Use	WHO class[15]
1	Chlorothalonil 500 SC	Banko 500 SC*; Linkonil; Twigathalonil 500*	Contact broad spectrum	U
2	Chlorothalonil 720 SC	Asconil 720 EC; Odeon 720 SC	Contact broad spectrum	U
3	Fosetyl-al 20% + Mancozeb 30%	SuperKinga*	Contact Broad spectrum	U
4	Hexaconazole 5 EC	Xantho*	Powdery mildew, Rusts	III
5	Mancozeb 640 + Metalaxyl 80	Eureka 72 WP*; Supalaxyl 72 WP*	Broad spectrum Systemic & Contact	U, II
6	Mancozeb 800	Farmerzeb 80WP; Supazeb 80 WP	Broad spectrum, contact & preventive	U
7	Mancozeb	Dithane M45	Broad spectrum, contact & preventive	U
8	Metalaxyl 80g+Mancozeb 640g	Ivory M 72 WP; Linkmil 72 WP	Protective and curative broad spectrum	II, U

Source of pesticides used

Pesticides were mainly obtained from pesticide shops located in Kigoma town. There were no pesticide retailer shops in all the villages except in Kalya. In some villages, notably Mgambo, Buhingu, and Rukoma, some

[14]Trade names with an asterisk had labels with instructions in Kiswahili

[15] Who class: Ia=Extremely hazardous, Ib = Highly hazardous, II=Moderately hazardous, III = Slightly hazardous, and U = Unlikely to present acute hazard

individuals sell a few pesticides in shops not meant for agricultural inputs. Farmers also buy pesticides from crop buyers and other individuals who re-pack pesticides and sell them in smaller quantities in unlabelled containers. A few banned substances and products that are not registered in the country were reported by farmers. These include a banned Endosulfan insecticide called "Teretere", which used to be imported in yesteryears from Burundi, and an Abamectin insecticide named "Dudu-Acelamectin", which is apparently illegally imported with label/language suggesting that Uganda was the country of origin.

Risky practices associated with pesticides use

Farmers' perception of pesticide toxicity

Farmers and retailers are aware that pesticides are toxic but they seem to be less worried by fungicides as compared to insecticides. As such, fungicides are facetiously referred to, in the local Kiswahili language, as "dawa" (medicine) while insecticides are called "sumu" (toxin/poison) basing on their perceived curative and lethal effects on diseases and insects, respectively.

Farmers' knowledge of pesticides: choice and application rates

Farmers in the study area most often depend on informal advice for information on pesticide selection, dosage, and application. The advice is sought mostly from pesticide retailers, neighbouring farmers, and very occasionally from extension staff. Many farmers are relatively new to vegetable production; and despite the fact that resident Extension Officers are available in the four villages, farmers do not usually consult them. In Kalya village, the Extension Officer, who also serves as a Village Administrative Officer, reported to have been frequently consulted by farmers. Furthermore, observations and discussions with pesticide retailers revealed that retailers are not familiar with the use of most of the products stoked in their stores.

The majority of the vegetable farmers were noted to apply pesticides haphazardly and sometimes routinely, without correctly identifying the diseases and pests on their crops. Hence, often farmers use pesticides which are not appropriate in addressing the problem in the field. Fungicides are routinely and frequently applied for up to two times a week as a protective measure against late blight in tomato fields. Whereas, insecticides are applied weekly once leaf miners and Diamondback moth damage are sighted in tomato and cabbage fields, respectively. When a pesticide is not effective, it is often replaced by a more toxic and potent alternative or higher dose or a combination of pesticides is applied, and sometimes the frequency of application is increased. Cases of crop injury due to excessive use of

pesticides were noted in tomato fields at Mgambazi and Katumbi villages. Studies elsewhere have shown that higher than the recommended dosage of pesticides are applied under the misconception that a higher dose means better eradication of pests (Mengistie *et al*., 2017).

Pesticide packaging and labelling

The pesticides were commonly sold in containers ranging from 0.25 to 5 L or in packets ranging from 0.25 to 25 Kg. Most of the pesticide retailers stocked small package size (<0.75 L) because they are affordable to most farmers. However, small packages have little room for adequate display of instructions, requiring a magnifying glass to read some of the instructions in the containers of less than 250mL. Surprisingly, most of the pesticides (59%) lacked instructions in Kiswahili (Tables 3 and 4). On the contrary, a few pesticides, notably Selecron 720 EC (Profenofos), included an easy to read, detachable folded leaflets with detailed information.

In the remote area of Kalya, one of the pesticide retailers was re-packing and selling fungicides, particularly Mancozeb (Dithane M45), that were originally packed by manufacturers in large packages (>5Kg), into small (<1Kg) unlabelled packages. Incidentally, the practice is commonly used for pesticides used against store pests such as Pirimiphos-methyl (Actellic EC), originally packed in one litre bottles, and Aluminium phosphide (Quickphos/Phostoxin) tablets.

Several pesticides of the same common name, such as Mancozeb 80 % WP and Insecticides Profenofos 720 g/L and Chlorpyrifos 400 EC are sold by different manufactures using different trade names (Tables 3 and 4), and hence add more confusion to farmers during the selection of pesticide for purchasing or applying them in the field. Furthermore, some insecticides such as Blasto 60EC, Attakan C344 SE and Perfecto are blends of two different active ingredients (Table 3).

Many farmers in the study area neither understand nor rely on the information on pesticide packages. The communication barrier is attributable to having labels in English language, having some users who are illiterate or labels being illegible due to font type and small font size used or the use of signs and symbols in the labels which are not comprehensible to farmers. Similar observations were previously made in Tanzania and elsewhere by other scholars (e.g. Ngowi *et al*., 2007; Damalas and khan, 2016; Mengistie *et al*., 2017).

Pesticides application technique

The majority of farmers in the study area apply pesticides using 15-20L Lever Operated Knapsack (LOK) sprayers and occasionally using small hand-held sprayers of <2.0L. Pesticides are applied while diluted with water as high-volume sprays. The LOKs sprayers are fitted with hollow cone spray nozzles, which as correctly noted by Sibanda *et al*. (2000), are in principle quite appropriate for vegetable spraying. They produce a relatively fine spray at low pressures and disperse the spray droplets quite effectively. However, most of the LOKs used by farmers were of poor design/construct, and did not have the desired safety, durability, comfort, or efficiency, which is considered essential for smooth functioning of the equipment. Accordingly, many of the LOKs were either leaking or having problems with their nozzles as a result of wear, damage, and poor maintenance. Similar observations were made by Sibanda *et al*. (2000) in Zimbabwe.

Most of the farmers spray their crops in the morning or late in the afternoon and avoid the hot hours of the day. Incidences of spray drift were occasionally observed in the fields because sometimes farmers directed the spray into the wind or advancing through the crop in a downwind direction thus moving into contaminated vegetation. This was partly due to limitations posed by crop rows as is the case with staked tomato.

The tank mixing of pesticides

Mixing of different types of pesticides in one spray tank was a very common practice in the study area. Up to four different types of pesticides may be mixed in one spray tank as a strategy of controlling multiple pests or diseases. Sometimes the same chemical ingredient from different products is mixed and sprayed leading to overdose and plant injury.

Use of personal protective equipment

Farmers in all villages and all pesticide retailers visited did not comply with the use of personal protective equipment (PPE). As a result, contact with pesticides is a common feature during handling or spraying of pesticides. Besides, after field sprays, contaminated work clothes are not washed daily. The PPEs were not used by farmers because they were deemed (i) expensive (ii) uncomfortable during application and (iii) unavailable. Additionally, some farmers reported to have not been aware of the adverse effects of handling pesticides without PPEs. Consequently, several pesticides, notably fungicide Chlorothalonil 720 SCR have commonly been reported to have caused discomfort during and after spraying. This fungicide irritates the eyes, the nose and the throat. Pesticide contamination of the ground may lead to contamination of water points.

Pesticide poisoning and safety harvest period
Farmers do not stick to the recommended safety harvest period before the sale or consumption of the produce. For instance, it is a common practice for fungicides to be sprayed on ripe harvested tomatoes, which are destined for the markets, because farmers and even crop buyers believe that spraying the tomatoes prior to harvesting helps to prolong the shelf life of the fruits.

Most farmers reported to have experienced a range of pesticide poisoning symptoms after spraying. Commonly self-reported toxicity symptoms were headache, dizziness, itching/skin irritation, and general body weakness. Pesticide poisoning symptoms were more common with insecticides than was the case with fungicides.

All farmers declared to have been washing their hands with soap immediately after handling pesticides. Body washing is done at the homesteads or at the edge of the fields or right in the water streams. The equipment used in the fields is washed at the edges of the fields or along the stream banks but reportedly not in the stream. These practices obviously lead to contamination of water sources.

Pesticides storage and disposal of used containers
Pesticide packages were reportedly to have been stored in areas beyond easy reach of children. The practices mentioned include hanging on walls, hiding under the bed, placement in designated storage room as well as hiding pesticide containers in the concealed places outside the house or in the field. Farmers seemed to have been aware that used containers need to be properly disposed of. They reportedly dispose the containers in the waste (dump) areas, pit latrines, or burn, or bury them in the soil or throw them in their fields. Incidentally, large (ca. One litre) plastic containers are occasionally used for keeping kerosene or collecting water from the streams for spot irrigation or for filling the sprayers. However, observation in some of the vegetable fields revealed that used plastic pesticide containers are placed on top of staking sticks in the tomato fields or are just thrown haphazardly.

Discussion
Challenges faced by farmers
The following are some of the challenges which farmers face in managing pests in vegetables.

Farmer reliance on synthetic pesticides

The high dependence on pesticides by vegetable farmers noted in this study has earlier been observed in other parts of Tanzania (see Ngowi *et al*., 2007), Ethiopia (see Mengistie *et al*., 2017), Zimbabwe (see Sibanda *et al*., 2000) and elsewhere (see Abhilash and Singh, 2009). Synthetic pesticides are advantageous because they are reasonably acting fast and have a relatively broad spectrum of activity, hence they can deal with a range of pests or diseases at the same time. Heavy dependence on pesticides is catalysed by the fear among farmers of economic loss resulting from crop damage by pests. The dependence is also catalysed by the requirement of high-quality standards demanded by the market (Damalas and Koutroubas, 2016; Jallow *et al*., 2017). Additionally, low knowledge on beneficial and harmful insects was also associated with more pesticide use (Schreinemachers *et al*., 2017). However, this reliance implies that farmers may not be aware of other pest management strategies that are effective, inexpensive, and friendly to the environment (Ngowi *et al*., 2007; Mengistie *et al*., 2017).

Risky practices associated with the use of pesticides

Farmers' perception of pesticide toxicity

Farmers' knowledge and perceptions about pesticide risks play an important role in determining the extent of their exposure to pesticides. Despite the fact that farmers have limited control over the toxicity of a pesticide, significant control over risks that are associated with the use of this pesticide can be expected (Damalas and Koutroubas, 2016). The misconception noted in this study about pesticide toxicity, has also been reported in other countries (see Mengistie *et al*., 2017; Bhandari *et al*., 2018) and seem to influence the way farmer handle pesticides. Nevertheless, Ngowi *et al*. (2007) cautioned that serious and acute damage to farmer's health may occur following long-term exposure to fungicides.

Farmers' knowledge of pesticides: choice and application rates

The majority of the vegetable farmers were noted to apply pesticides haphazardly and sometimes routinely without proper identification of the pest problem. Similar observations were also reported in other parts of Tanzania (see Ngowi *et al*., 2007; Victoria *et al*., 2017; Kiwango *et al*., 2018) and elsewhere (see Sibanda *et al*., 2000; Abhilash and Singh, 2009; Mengistie *et al*., 2017; Akter *et al*., 2018; Bhandari *et al*., 2018). In most cases, the noted anomalies were attributed to farmers' inadequate knowledge of pesticides and safe pesticide handling practices (Damalas and Koutroubas, 2016; Sharma and Peshin, 2016; Mrema *et al*., 2017; Bhandari *et al*., 2018).

This study noted that pesticide retailers play an important role in the pesticide supply chain in Tanzania. The overt farmers'reliance on advice

from pesticide retailers noted in this study is common in Tanzania and in several other developing countries (Sibanda *et al*., 2000; Ngowi *et al*., 2007; Ngowi and Semali, 2011; Jallow *et al*., 2017; Sharma and Peshin, 2016; Mengistie *et al*., 2017; Ngowi *et al*., 2017; Schreinemachers *et al*., 2017). According to Jallow *et al*. (2017), this tendency may be driven by the desire among the retailers of making super profit from the sales of more pesticides, which in turn promote aggressive use of the pesticides. Unfortunately, as Jallow *et al*. (2017) and Ngowi *et al*. (2017) correctly put it, the retailers are also known to practice unsafe behaviours; such as selling unregistered, prohibited, or expired pesticides; mixing, reweighing and repacking pesticides; and trading on the open market.

It was also noted that farmers are vulnerable to pesticides which are brought to local retailers in Tanzania from unauthorised, sometimes illicit, sources and illegal trading. Informal cross border movement of pesticides is a problem that has been reported in other countries such as Ethiopia (see Mengistie *et al*., 2017) and Nepal (see Bhandari *et al*., 2018).

Pesticide packaging and labelling

Farmers in the study area face a lot of difficulties in understanding information on pesticide containers. The problem seems to be aggravated by packaging pesticides in small packages, which were incidentally very popular among farmers. Consequently, most farmers do not read labels instead they rely on advice from pesticide dealers, extension workers, and neighbours. Inadequate or illegible information provided on the labels and package leaflets was considered to be the main barriers against good safety behaviour practices in Pakistan (Damalas and Khan, 2016) and Nepal (Bhandari *et al*., 2018). According to Stadlinger *et al*. (2011), this is a challenge which pesticide manufacturers need to overcome by producing smaller packages that meet the needs of the end-users. Additionally, the selling of pesticides belonging to the same common name using different trade names confuses farmers (Mengistie *et al*. 2017).

Pesticides application technique

Pesticides are typically applied by using the Lever Operated Knapsack (LOK) sprayers. However, most of the LOKs had some problems related to their design/manufacturing and poor maintenance but farmers obstinately continued to use them. In Ethiopia, Mengistie *et al*. (2017) noted that about 50% of the sprayers examined during their study were leaking. The leaks either came from the trigger valve or from the pipe union with the tank. Incidentally, farmers in Sri Lanka continued to use faulty sprayers even when they were trained to avoid using leaking LOK sprayers. Furthermore, Abhilash and Singh (2009) correctly observed that despite the use of modern

pesticides in India, the technology used for their application has not been upgraded resulting in a waste of pesticides and unnecessary environmental contamination. According to the authors, a change of the design of the nozzles of LOK sprayers could have saved up to 70% of pesticides as opposed to the farmers' previous practice.

Spray drift due to a change in wind speed or direction was another challenge observed in this study. Spray drift should be a major concern because it diverts the pesticides from the intended target, reduces efficacy, and deposits pesticide where it is not needed or wanted causing environmental and health hazards (Abhilash and Singh, 2009; Delcour *et al*., 2015). Experience in Ghana has shown that pesticide applied to a watermelon farm can drift and accumulate in significant levels in the neighbouring non-target okra crop (Elibariki and Maguta, 2017).

The tank mixing of pesticides

The mixing of more than one pesticide in a spray tank was common in the study area and in other parts of Tanzania and elsewhere (see Ngowi *et al*., 2007; Ngowi and Semali, 2011; Mengistie *et al*., 2015; Damalas and Khan, 2016; Bhandari *et al*., 2018). For example, Ngowi and Semali (2011) noted that onion farmers in Northern Tanzania sprayed a cocktail of up to five insecticides that incidentally included three Prefenofos insecticides. Whereas, in Cambodia applicators mixed an average of 3.7 pesticides together in a single spray (Schreinemachers *et al*., 2017).

The practice of tank-mixing pesticides is carried out to save time, labour cost, and with the anticipation of high efficacy in pests and diseases control (Ngowi *et al*., 2007; Mengistie *et al*., 2017). Nevertheless, label instructions do not cover mixtures of three or more pesticides and give no information on the compatibility of inert ingredients such as emulsifiers and wetting agents (Mengistie *et al*., 2017). An interaction between fungicides, insecticides, and water mineral content that influences the efficacy of individual pesticide against fungal pathogens and insect mortality has been reported elsewhere (see Smit *et al*., 2002; Ngowi *et al*., 2007). In the study of Ngowi *et al.* (2007), some of the tank mixtures induced phytotoxicity on tomato. Similarly, this study observed several tomato plots, which were abandoned due to pesticide phytotoxicity associated with failed attempts of controlling leaf miners and or late blight. Furthermore, it is on record that mixtures of insecticides generally result in the simultaneous development of insect resistance (Ngowi *et al*., 2007).

The tank mixing malpractice is generally attributed to lack of basic knowledge of pesticides application among farmers. However, studies in Kuwait and Sri Lanka show that the practice of mixing pesticide may

continue even after farmers are trained on pesticide application (Jayasooriya and Aheeyar, 2016; Jallow *et al*., 2017).

Use of personal protective equipment

Vegetable farmers in the study area are at a high risk of pesticide exposure because they hardly use any Personal Protective Equipment (PPEs). Similar observations have been noted in other parts of the country (see Ngowi *et al*., 2001, 2007; Victoria *et al*., 2017). A study by Lekei *et al*. (2014) in Tanzania noted that over 60% of PPEs used by farmers were damaged or extremely contaminated by pesticides. The correct use of personal protective equipment has always been considered fundamental for the safety of workers (Gangemi *et al*., 2016). Usually, the risks (hazards) from a specific pesticide depend on the toxicity of the specific product used and the amount and form of exposure (Damalas and Koutroubas, 2016). Often, occupational exposure to pesticides is associated with the mixing of these substances, transportation, application on crops, and cleaning of the equipment. When PPEs are not used, the dermal and inhalation routes of entry are the most common routes of farmers' exposure to pesticides (Damalas and Abdollahzadeh, 2016; Damalas and Koutroubas, 2016).

Dermal exposure can be limited by wearing the most common types of PPEs such as gloves, boots, hats, long sleeve shirts, and chemical-resistant coveralls (Damalas and Koutroubas, 2016). In their excellent review on farmers' exposure to pesticides, Damalas and Koutroubas (2016) cautioned that personal protection can be low because the PPE is unsuitable, incorrectly fitted, and improperly maintained and used. Additionally, experience elsewhere has shown that farmers may not use PPEs due to unavailability of the equipment or lack of awareness and economic burden or time limitation resulting from performing the work or discomfort resulting from heat stress and dampness experienced in the field (Ngowi *et al*., 2001, 2007; Mengistie *et al*., 2017; Akter *et al*., 2018; Bhandari *et al*., 2018). Similar observations were reported by Sharma and Peshin (2016) in India, Yassin *et al*. (2002) in Gaza strip, and by Schreinemachers *et al*. (2017) in Cambodia and Laos.

The protection offered by common protective clothing against exposure to pesticides vary according to the fabric type, including thickness and weight. For instance, a greater protection in terms of decreasing dermal exposure occurs when waterproof polypropylene fabrics are worn as opposed to cotton garments (Damalas and Koutroubas, 2016). It is further cautioned that the safety behaviour depends on the perceived susceptibility, the severity of the risks and the benefits as well as the current inhibiting factors

to adopting good safety behaviours (Akter *et al*., 2018; Bhandari *et al*., 2018; Bondori *et al*., 2018).

Safety harvest period and pesticide poisoning

The non-adherence to safety harvest period noted in the study area implies that, the consumption of vegetables with pesticide residues cannot be ruled out. This anomaly cuts across the food chain as almost each household regularly consumes tomato and other vegetables. In other parts of Tanzania, tomato farmers were reportedly applying Lambda cyhalothrin (Karate EC) every seven days instead of fourteen days and one day instead of seven days before harvesting (Victoria *et al*., 2017). Similarly, in Nepal, researchers discovered that farmers apply pesticides to vegetable crops at rates nearly four times higher than the recommended (Bhandari *et al*., 2018). Regrettably, this indiscriminate use of pesticides does not translate into increasing crop yields for the farmers, but rather increasing the potential of adversely affecting human health and the environment. Incidences of pesticide residues, above the maximum residual limits, have been reported in various vegetables grown in Tanzania (see Victoria *et al*., 2017; Kiwango *et al*., 2018).

Unfortunately, the monitoring of pesticide residues in vegetables is not a common practice in Tanzania (Kiwango *et al*., 2018). In Kuwait, the presence of chlorinated pesticides in the breast milk of lactating women has raised even greater concerns over the possible health risks of breastfed infants (Jallow *et al*., 2017). The common incidences of pesticide poisoning symptoms reported by farmers imply that pesticides are not correctly handled and farmers are at a great risk of pesticide poisoning.

Pesticides storage and disposal of used containers

Throwing of empty pesticide containers was a common practice in the study area despite the fact that farmers seemed to be aware of the malpractice. This anomaly has previously been noted in other parts of the country (see Lekei *et al*., 2014; Nonga *et al*., 2017). In other studies, empty pesticide containers have been reused mostly by women, for domestic purposes such as storing food items and kerosene (see Remoundou *et al*., 2014; Ngowi *et al*., 2017). Empty containers always have residues and are a source of exposure that can cause harmful effects to users (Ngowi *et al*., 2017). Incidentally, even the recommended practices of burning or burying these empty packages are also potentially hazardous to human health and the environment (Mengistie *et al*., 2017). Recently, Bolivia successfully implemented a responsible management plan for empty plastic pesticide containers (Skovgaard *et al*., 2017). The programme entailed training of farmers to practice triple rinsing and puncturing of the containers, followed by disposal of containers in designated collection points for further processing and recycling by plastic manufacturing companies.

Lack of access to alternative pest management technologies

Host plant resistance: Host plant resistance remains the most feasible strategy for managing important diseases in Tanzania and other developing countries where vegetables are largely produced by smallholder farmers. Promising varieties with resistance to major diseases of cabbage and tomato are shown in Table 5. However, most of the varieties are not available to farmers.

Safer pesticides and biological control: Viable alternative to synthetic methods of pest control include biopesticides, biological control and pheromone-based pest management (Jallow *et al*., 2017). Isman (2017) underscored the existence of a very large "inventory" of plant extracts or compounds therefrom arising from scholarly researches in contrast to the very few investigations on (i) methods of extraction on an industrial scale, (ii) formulation of plant extracts or oils into consistent, concentrated products, and (iii) best practices for the use of such products. Thus, the author called for more emphasis on technology transfer end in order to push the products to farmers.

These observations are reflected in a recent review of Moshi and Matoju (2017), that indicated the status of application of biopesticides in Tanzania and challenges that need to be addressed in order to exploit their inherent potential. Up to now, a few bio pesticides have provisional or full registration in the country. The few commercially available bio-pesticides are mainly used for mosquito control e.g. *Bacillus bassiana* strain GHA (Bio-bassiana), *B. thurugiensis* var. (BN3WP), *B. sphaericus* (Griselesf) and Neemray super (Azadirachtin) for control of cotton bollworms (Moshi and Matoju, 2017). Examples of interventions that can help the farmers to manage pests are shown in Table 5. Regrettably, botanical pesticides, such as neem products, have not been very popular because of variability between batches of formulation leading to variable efficacy, short shelf life and the difficulty of preparing sufficient quantities for medium scale cropping systems. Possible mammalian toxicity is an issue which has been largely neglected. Furthermore, some of these botanical products are not officially registered and have, therefore, not usually undergone systematic toxicological testing (Sibanda *et al*., 2000).

Pesticide registration and monitoring system: According to Moshi and Matoju (2017), the legal framework in Tanzania is seen as one of the limiting factors against registration and commercialization of biopesticides. The authors cautioned that pesticide registration procedures are unnecessarily costly and bureaucratic, and are four times higher than those in Kenya. This

could be one of the reasons for increased illegal trading of pesticides in the country.

Lack of information on pest management and proper use of pesticides

The incorrect pesticide uses and heavy reliance on pesticides noted in the study area are attributable to farmers' social and farming characteristics, increased pest incidences, lack of access to extension support, lack of access to non-synthetic methods of pest control, and farmers' perception of yield loss due to pests. As Jallow *et al*. (2017) observed, farmers who had access to extension support were more knowledgeable about pesticides and alternative methods of pest control, and thus were less receptive to using pesticides. Recently, Bondori *et al*. (2018) noted that farmers' knowledge of pesticide hazards, attitudes towards pesticides, past experience of pesticide poisoning, and the use of information sources are important variables that can shape farmers' behavior towards safety. However, in the absence of effective extension services and training in the country (Ngowi *et al*., 2007), other intuitive training approaches need to be developed and tailored to the needs of smallholder farmers. In India, Sharma and Peshin (2016) emphasised the need for refocusing extension services to traders/retailers dealing with pesticides, with training on safe handling, storage, and correct pesticide usage. In another study done in Southeast Asia, Schreinemachers *et al*. (2017) observed that raising awareness about pesticide health risks was not enough to reduce the actual use, although higher awareness was associated with fewer self-reported poisoning symptoms as it may induce farmers to protect themselves better. Similarly, Remoundou *et al*. (2014) attributed the risk-related behaviours to other factors such as economic and employment pressures and peer group related influences.

Conclusion

This study sought to reveal pest management strategies and pesticide use among vegetable farmers in a remote district of Uvinza, Tanzania and the challenges faced by these farmers in managing vegetable pests. The study has shown the plight of farmers who embark on small scale vegetable production, whilst they have limited knowledge on pest management and on correct use of pesticides. This scenario has long been observed in Tanzania and other developing countries where an increase of the demand for vegetables encourages farmers to venture into vegetable production (Massomo *et al*., 2005). There are so many risks posed to humans and the environment from indiscriminate use of pesticide in vegetable farming. The adverse effects are more acute in Tanzania and other developing countries where farmers lack training and access to awareness programs on proper management of pest and safe use of pesticides.

The heavy dependence on pesticide as well as pesticide poisoning may be reduced through better farmers' education, training in Integrated Pest

Management (IPM) and improved safe use and handling practices on pesticides, and improved access to extension support. Efforts should be

made to develop and promote alternative methods of pest control such as host plant resistance to common diseases and non-synthetic pesticides in the context of IPM. It is envisaged that with climate change, increase in temperatures and changes in precipitation patterns will be the main determinants of pests and pathogen infection. This may lead to an increased pesticide use in terms of high amounts, doses, frequencies, and differences in varieties or types of products applied if the situation is not addressed. Excessive and haphazard use of pesticides is detrimental because it leads into contamination of our ecological systems including soil, sediments, and waterways (that adversely impact the wildlife) and through transfer of residues across the food chain.

Way forward

This study therefore recommends three strategies for reducing synthetic pesticide use, improving pesticide use and handling practices among smallholder farmers in developing countries. These strategies are; (i) Enhancement of farmers' awareness (ii) Development and use of alternative pest management methods, and (iii) Enforcement of laws and regulations on pesticides use and handling.

Enhancement of farmers awareness

(i) It is important to raise awareness among farmers about good safety behaviours and long-term consequences of pesticide use. This may be achieved through development of more educational programs, such as documentaries and talk shows as well as information dissemination through radio, television, and any other possible means.

(ii) Mobile software applications should be developed by researchers in order to assist farmers in the identification of pest problems and the potential strategies for control. This is encouraged by good cell phone coverage and increased affordability and possession of cell phones by farmers in developing countries and in the study area as well.

(iii) Stakeholders, notably pesticide manufacturers, should be encouraged to facilitate the development of simple informative crop specific posters/flyers/booklets with coloured images of pests/diseases for ultimate sale to farmers. These would assist farmers to choose appropriate types of intervention(s) according to the problem in question. An example of excellent and concise poster on tomato pests and diseases was developed by ICIPE and Biovision and appears at http://www.biovision.ch/fileadmin/pdf/e/projects/tomato_6-02-08.pdf (Last visited in February, 2019).

(iv) The available crop specific technical guidelines, such as the one by Massawe *et al*. (2010) on integrated tomato production in northern Tanzania, should be translated in the local language (i.e. Kiswahili) and sold to farmers.

(v) Local government authorities should strive to re-train, motivate, and guide resident extension workers so as to improve farmers'

(vi) knowledge, especially on IPM. This can be done in villages that have resident extension workers including; Mgambo, Mgambazi, Rukoma and Kalya. This is crucial because many government extension programmes in African countries have been encouraging the use of pesticides (Abate *et al*., 2000), but they seem to have been insensitive to the impact of pesticides on health and the environment (Ngowi and Semali, 2011).

(vii) Pesticide retailers should be trained on pesticide use/misuse, its storage, safe handling and application, so that they can effectively disseminate accurate and reliable information on these aspects to farmers (Jallow *et al*., 2017; Mengistie *et al*., 2017). For instance, they could promote low-cost improvements to spraying equipment, such as the use of smaller nozzles and adaptations such as the V-lance and training on their use in order to reduce dosage and frequency of pesticide application (Sibanda *et al*., 2000; Schreinemachers *et al*., 2017).

(viii) Interventions such as farmer field schools and farmer exchange visits that allow for local knowledge sharing in pest management, need to be promoted. This would encourage farmers to seek advice from friends and neighbours instead of pesticide retailers who are known to encourage much more pesticides use for selfishness (Schreinemachers *et al*., 2017).

(ix) Empowering communities to monitor the impact of pesticides and making decisions that might reduce the risks to themselves and to their environment, as recommended by Ngowi and Semali (2011) need to be explored.

Use of alternative pest management methods

Farmers are understandably reluctant to adopt new pest management strategies which are not familiar to them, and will need to see convincing on-farm results before shifting from chemical-based pest control strategies to non-chemical alternatives (Jallow *et al*., 2017). However, the development and promotion of alternative pest control methods are important components of broader efforts of reducing pesticide risk and promoting a more sustainable form of vegetable production.

The alternative pest management strategies are usually packaged in the form of integrated pest management (IPM), which aim at a more rational deployment of a variety of pest control methods designed to complement, reduce, or replace the application of synthetic pesticides, as discussed below.

IPM training and IPM promotion

Several studies have indicated that training in vegetable IPM methods improve farmers' knowledge and attitudes in pest management, lead to safer use of pesticides, and reduce the number of pesticide sprays (see Ngowi and Semali, 2011; Musebe *et al*., 2014; Jayasooriya and Aheeyar, 2016; Sharma and Peshin, 2016; Gautam *et al*., 2017). The IPM methods typically involve regular scouting of plants for pests and action is taken only when an economic threshold is reached. The IPM includes such measures as; healthy seeds, the use of non-chemical preventive methods, biopesticides, biocontrol agents, and resistant varieties as well as judicious use of synthetic pesticides. Furthermore, several cultural practices can be promoted to make the environment less attractive and less favourable for the survival, dispersal, growth and reproduction, of pests and disease-causing organisms, and hence reduce the prevalence of unwanted pests and diseases. These practices include the use of proper crop rotation, good agricultural practices (GAP) including optimization of other inputs and field sanitation. Incidentally, some interventions such as crop rotation can be limited by shortage of irrigable land. The reduction of pesticide use was reported in Burkina Faso when tomato plants were planted in combination with onions (Diakalia, 2018).

However, it should be cautioned that IPM is not a straight forward concept for application, and it requires farmers training and a supportive environment that make knowledge and inputs available to farmers (Williamson *et al*., 2008; Ngowi and Semali, 2011; Gautam *et al*., 2017). For instance, a study in India on IPM training in cauliflower, cabbage and okra, did not find a significant adoption of non-chemical practices other than pheromone traps which are used by okra growers (Sharma and Peshin, 2016). Whereas, in Sri Lanka Jayasooriya and Aheeyar (2016) identified several major constraints in promoting IPM among vegetable farmers. These included weaknesses in the national level policies for IPM promotion, poor attitudes among farmers and Extension Officers, insufficient human resource in the extension system, lack of capacity on IPM among Extension Officers, and lack of resources and institutional support for IPM promotion. Thus, for a widespread adoption of IPM components, it is important for researchers to focus on the development of IPM methods that reduce costs and increase profits (Sharma and Peshin, 2016). The IPM training also needs

to be gender-sensitive to be more effective (Remoundou *et al*., 2014; Jallow *et al*., 2017; Schreinemachers *et al*., 2017).

Host plant resistance

Improved levels of resistance could increase yields by reducing crop losses and expenditure on pesticides. Several tomato varieties with tolerance to major diseases are available in Tanzania (Table 5). Whereas in cabbage, management of black rot can be achieved by introduction and growing of esistant hybrid cultivars (Massomo *et al*., 2004; Jensen *et al*., 2005). Effort should be made to avail and promote these varieties to farmers.

Safer pesticides and biological control

Effort should be made to develop and promote non-synthetic products that can be used by farmers. Application of alternative strains of *B. thuringiensis* (BT), have successfully been used in Arusha-Tanzania to control the Diamondback moth in cabbage. The BT pesticides can also control a number of lepidopteran pests such as *Helicoverpa* spp. in other vegetables. Different plant extracts can significantly reduce pest populations in various vegetable crops (see Table 5), especially if used in combination with other biopesticides as recently shown by Jallow *et al.* (2018). In their study, the efficacy of biopesticides against the leaf miner (*T. absoluta*), was enhanced when a combination of *Azadirachtin* + *B. thuringiensis* or *Azadirachtin* + *Beauveria bassiana* were applied as compared to individual treatments. Pheromone insecticide baited traps, also need to be explored and promoted to vegetable farmers. Such traps have widely been adopted by watermelon and cucumber farmers in Tanzania for use against the melon fly (*Bactrocera* spp.).

Table 13. Potential Strategies for Managing Pests and Diseases of Cabbage and Tomato without using Synthetic Pesticides

Crop [16]	Intervention	Target pest	Reference
	Resistant varieties		
1	Several resistant varieties	Black rot	Massomo *et al*., 2004 ; Jensen *et al*., 2005
2	Tengeru 97	Late blight, Fusarium Wilt (FW), Tomato Mosaic Virus (TMV), Tomato Yellow Leaf Curl Virus and Root-knot nematodes (RKN)	Musebe *et al*., 2014
2	Meru	Late blight, TMV and RKN	ICIPE & Biovision (undated)
2	Roma VF	FW and verticillium wilt	Musebe *et al*., 2014
2	Kentom variety	Bacterial wilt, RKN and TMV	Musebe *et al*., 2014
2	Roma VFN	FW and verticillium wilt, RKN and red spider mites	Musebe *et al*., 2014
2	Rio Grande	FW, Early and Late blight	Musebe *et al*., 2014
	Botanicals		
1,2	Neem seed (*Azadirachta indica*)	Tomato leaf miner *(Tuta absoluta*) *and* other insects	Jallow *et al*., 2018 ; Musebe *et al*., 2014 ; Moshi & Matoju, 2017
1,2	*Tephrosia* leaf extract	Leafhopper, Thrips, Fruit borers, Cabbage Aphid and others	Musebe *et al*., 2014 ; Kerebba *et al*., 2019
	Biological		
1	*Bacillus subtilis*	Black rot	Massomo *et al*, 2004
1	*Diadegma semiclausum*	Diamondback moth	Nyambo and Löhr., 2005; Macharia *et al*., 2005
1,2	*B. thuringiensis*	Diamondback moth	Massomo *et al*., 2005
1,2	Nuclear Polyhedrosis Virus	Diamondback moth Other lepidopteran insects	Sibanda *et al*., 2000 ; Grzywacz *et al*., 2008
2	Spinosad (*Saccharopolyspora spinose*)	Thrips, leaf miners (including *T. absoluta*), spider mites, mosquitoes, ants, fruit flies and others	El-Aassar et al., 2015
2	*Beauveria bassiana*	*Tuta absoluta*	Jallow *et al*., 2018
2	*Aspergillus oryzae*	*Tuta absoluta*	Mbega *et al.,* 2019

Enforcement of laws and regulations on pesticides

Despite the existence of several laws and regulations governing pesticide handling and management in Tanzania (see Ngowi *et al*., 2007; Moshi and

[16] Crop 1= Cabbage and 2= Tomato

Matoju, 2017; Kiwango *et al*., 2018), their enforcement is in most cases inadequate due to lack of capacity (human and equipment) among other reasons (see Ngowi and Semali, 2011; Moshi and Matoju, 2017; Kiwango *et al*., 2018). Nevertheless, efforts should be made to address the following aspects;

(i) There should be emphasis on improvement in pesticide labelling and packaging. A standard format of labelling pesticide containers should be adhered to. Manufacturers should be encouraged to include information in the local language (Kiswahili) and provide separate legible leaflets especially in cases of small packages. Pesticide manufacturers should be encouraged to visibly display the pesticide common names on the packages at the expense of their trade names.

(ii) The regulatory framework for pesticide evaluation and registration need to be reviewed to reduce the unnecessary bureaucratic processes and costs which are involved in the registration process. Furthermore, the registration phase for restricted use of pesticides need to be harmonised with those in other countries in the region as recommended by Moshi and Matoju (2017). Ease of regulation and active promotion of biopesticides and other IPM component technologies can drastically reduce chemical pesticide use (Schreinemachers *et al*., 2017).

(iii) Effort should be made to strengthen monitoring mechanisms to reduce illegal import and use of unregistered or banned pesticides as well as expired products. Where possible local communities should be empowered and involved to assist in this task.

(iv) Deliberate efforts should be made to promote and make protective safety devices more accessible and modify them to reflect local needs. As a compromise, farmers in the warm climate areas, such as Tanzania, ought to be encouraged to wear at least long sleeve dust coats and use gloves and boots. The last two are considered to be the minimum PPEs for most pesticide products (Damalas and Koutroubas, 2016).

(v) Efforts should be made to encourage the use of new pesticides such as Spinosad that have novel modes of action and improved safety profiles (see El-Aassar *et al*., 2015). Moreover, manufacturers need to be encouraged to improve the existing pesticide formulations towards safer formulations (e.g., microcapsule suspensions) that could reduce the adverse effects of farming and particularly the toxic effects of pesticides.

(vi) There is a need to explore the potential uses of nano-technology in integrated pest management as recently outlined by Kumar *et al*. (2018). The nano-technology offer controlled delivery of Active

Ingredients with enhanced activity at low drug concentration and efficient monitoring of pesticide interactions with the environment.

(vii) Regular monitoring of environmental pollution and pesticide residues in vegetables should be done in order to analyse the risk of exposure among consumers.

Disclosure of interest

The author reports no conflict of interest in this study.

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