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Impacts of Salt Water Intrusion on Maize (*Zea mays)* and Rice (*Oryza sativa*) Production under Climate Change Scenarios in Bagamoyo District-Tanzania

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Abstract Salt water intrusion is a challenge on production of human staple foods *Zea mays* and *Oryza sativa* in the changing climate, along the global coastal zones. Information on how salinity affects these crops is essential in developing scientific mitigations for sustainable food production. This study was conducted to investigate salt water intrusion and its impacts on *Zea mays* and *Oryza sativa* production in Bagamoyo District, Tanzania. Soil and water samples were collected along 14 km of Wami River for determination of NaCl and pH. Direct observations, surveys and questionnaire protocols were used to collect socio-economic data. Along 14 km, soil pH average was 6.5 (acidic) while that of water was 8 (basic). Salinity was high within 5 km and then declined towards 14 km away. *Zea mays* and *Oryza sativa* declined from averages of 18 to 8bags/acre/crop season. The impacts of salinity were clear on farms within 5 km from the Ocean than at 14 km. Salt intrusion is associated with climate change along the Tanzania coastal zone. Agriculturists, environmentalists and policy makers must work jointly to mitigate SWI impacts in Changing Climate. These efforts will help to improve crop production and ensure food security and income of the people along the coastal zones.

Keywords Climate Change, Coastal Zone, Salinity, Salt Water Intrusion, Wami River, Salinity Impacts

1. Introduction

Climate change has been the major environmental challenge that the world is addressing because it has been changing strenuously with variable environmental and socio-economic impacts [1]. Documentation by [2] and [3] show that African continent has experienced a warming of 0.7°C during the 20th century with a decadal temperature increase of 0.05°C due to climatic changes. Again projection by [2] show that Sahara and semi-arid parts of southern Africa warming will reach up to 1.6°C and for equatorial African countries up to 1.4°C rate by 2050. By the same year, it is anticipated that the increase in temperature will increase up to the rate of 0.2°C in East African countries [2] where Tanzania is among the countries to face the impacts of warming increment.These warming figures are threatening because African countries are vulnerable to the impacts of climate change [1]. Widespread poverty, human diseases and high population density make African countries vulnerable to negative impacts of climate change [1].

Coastal zone ecosystems in many parts of the global are vulnerable to the impacts of climate change because of their long history of being stressed by human being activities and natural factors [4]. The coastal zone of Tanzania in particular, like many other global coastal areas are affected by anthropological variables and climate change [5]. The coastal effects of climate change include sea level rise, intense storm events, Ocean acidification, and warmer sea temperatures [6]. Climate change contributes to depletion of freshwater resources [7], [1] and is one the factors influencing water availability to society and ecosystems [8]. Sea level rise as a result of climate change cause salt water intrusion (SWI) into coastal aquifer [9], which results into the aquifers contamination and therefore reducing the available water for human consumption and agriculture[10], [11], [12],[13].High levels of salinity affects plant growth during all developmental stages [14], therefore salt is a major threat to crop productivity. Salt water intrusion, which affects water quality in the context of salinity and pH [6] towards inland, automatically affects farming activities and crop production [15].Salinity imposes detrimental effects on plant growth through low osmotic potential in soil solution and nutritional imbalance [16]. Salt ions prevent water absorption by roots, thus plants are subjected to water deficit [17], and the effects results into reduced or total loss in yield. These effects put crop-agriculture production in difficulty and when agriculture sector is affected, the economy, social and ecological health of coastal communities are threatened [6], [9]. If not addressed, the problem of SWI will continue to affect nearly three-quarters of Tanzania industries and over a quarter of the country's population [18], [19].

Existing studies for example those listed by [4] show that SWI affects coastal water supplies and coastal rivers, yet documentation about SWI impacts on *Zea mays* and *Oryza sativa* production particularly along coastal areas of Tanzania is lacking. This lack of information threats the production of these two crops and the sustainability of the coastal community. Therefore, this study was carried out to explore how SWI have affected *Zea mays* and *Oryza sativa* production and, how farmers have changed crop production and farming systems to cope with SWI in changing climate. This study employed a quantitative dominated approach supported by qualitative data to study the impacts of SWI using *Zea mays* and *Oryza sativa*. This kind of study is recently imperatives as it sets basic opportunities for monitoring SWI and impacts on crops and food security in SWI affected coastal zones. This investigation sets a baseline for monitoring mitigation strategies to deal with SWI by farmers and crop-agriculture practitioners along the coastal zones. Also, this work provide basic information to other coastal regions facing SWI problems hence finding concerted efforts to address climate change, SWI and crop production at large.

2. Materials and Methods

2.1. Location of the Study

This study was conducted in Bagamoyo District (See Figure 1), which lies between latitude 38° – 39° south and longitude 6° – 7° east, located in the Pwani Region in Tanzania. The District shares borders with Indian Ocean Coastal Belt in the East, Kinondoni Municipal Council in the Southern part and Kibaha District in South, Morogoro in the West, Pangani and Handeni in the North [19]. The District covers an area of 9 842 km² of which 855 km² are covered by water (Ocean and Rivers) while the rest is dry land.

2.2. Climatic Condition of the Study Area

Bagamoyo District has a humid tropical climate with seasonal average temperature ranging from 13^0C-30^0C. Normally, this District experiences an average annual rainfall of 800 mm as minimum and 1 200 mm as maximum per year. Before the complications, which are a result of climate change, heavy rainfall usually occurred between March and June every year. The light rainfall usually used to be from October to December each year. According to agronomic factors, the heavy rainfalls are used for *Zea mays* and *Oryza sativa* production while short rainfall mainly used by smallholder-farmers to cultivate pulses and vegetables [19].

2.3. Socio-economic Activities

The economy of Bagamoyo District is predominantly based on subsistence farming. Cash crops in the District are Coconuts (*Cocos nucifera*), Cashew nuts (*Anacardium occidentale L.*), Sesame (*Sesamum indicum*) and Cotton (*Gossypium hirsutum*) while food crops include *Zea mays*, Paddy *(Oryza sativa)*, Sorghum *(Sorghum spp.)*, Cassava (*Manihot esculenta)* and Sweet potatoes (*Ipomoea batatas*) whereby *Zea mays* and *Oryza sativa* form the staple food crops. The arable land in Bagamoyo is 836 579 hectors by which 56 119 ha only are under crop production [19].About 70% of the population is agriculture based while the remaining percent depend on fishery industry i.e. fishing and fish selling for livelihood sustenance.

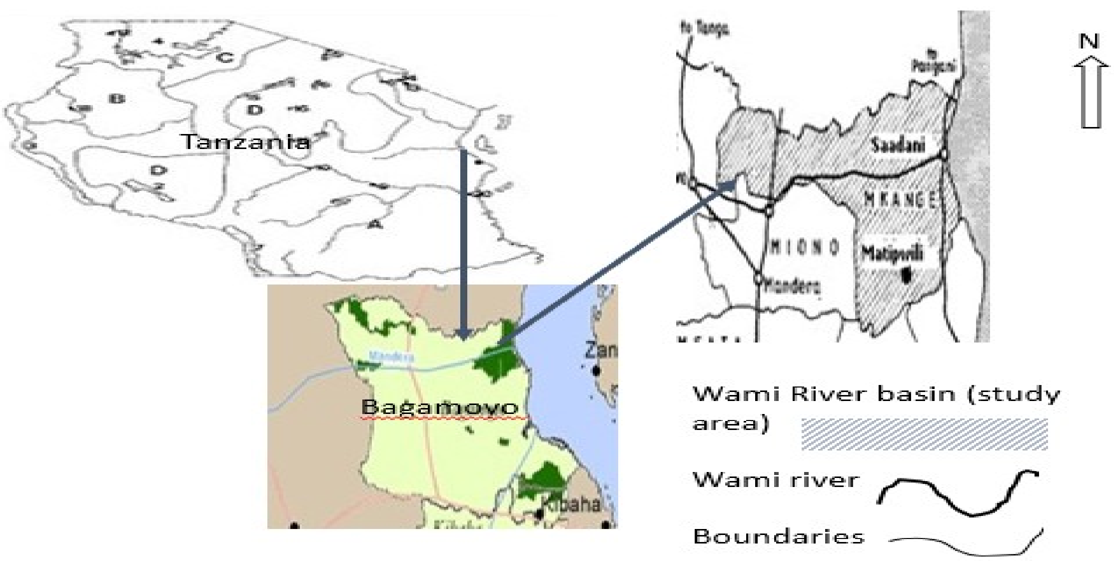

Figure 1. A map of the the study area

2.4. Data Collection

Field data collection was preceded by a thorough desk review of secondary information about climate change, SWI and crop production. Purposive sampling approach was used to select the study area covering a distance of 14 km along the Wami River. Households were randomly selected from a list provided by village leaders. Simple random sampling technique was used to get sample units whereby every household had an equal chance of being selected [20]. Fifty (50) out of four hundred ninety seven (497) households, equalled to ten percent (10%) of households were randomly selected.

2.5. Methods Used for Data Collection

2.5.1. Collection of Socio-economic Data

Questionnaire protocol consisting both open and closed ended questions were used to collect data on household's characteristics, perceptions about climate change and variability, SWI phenomenon and effects. A semi-structured checklist was used to conduct in-depth surveys to key informant interviews. Through surveys, data and information were collected to understand about land use, cropping, farming systems and climate variability history. Elders, extension and agricultural officers formed a key informant category. Famers who lived in Bagamoyo for more than twenty years and had more than twenty years of experience in crop production formed the focus groups. Direct field observations, note taking and photographing were used to capture biophysical variables. Systematic walks with key informants were carried out through the study area for crosschecking the information obtained from the questionnaire and surveys. Discussions from spoken interviews were recorded by using audio tape recorders followed by transcription and production of memos. Memos to summarise the experience about SWI and impacts on *Zea mays* and *Oryza sativa* production, climate change, and adaptation strategies were developed and compared across all the responses to support quantitative (biophysical) results.

2.5.2. Biophysical Data Collection

Although four types of cations prevail in saline water i.e. Sodium (Na^{+}), Potassium (K^{+}), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) and 4 anions (Chloride (Cl^{-}), Carbonate (CO^{-3}) or Bi-Carbonate (HCO^{-3}) and Sulphate (SO^{-4}), in this study only NaCl was measured because it is the most common and plentiful in ions present in saline water [21]. Sampling bottles were used to collect water samples from a depth of twenty centimetres and against the direction of the river [22]. Twenty eight sampling points were established for collection of water samples. Samples were collected at 500 mitres intervals within14 km total distances. Fifty six sampling plots were established to collect soil samples within 10 km width from the river banks and along 14 km distance. Soil samples were collected at 30 cm depth from each sampling sites. For convenient references, the river banks were assigned number 1 and 2 to stand for left and right side banks respectively from Wami River mouth (at the Indian Ocean) to towards inland direction.

2.6. Socio-economic Data Analysis

Socio-economic data were analysed by using Statical Package for Social Science and Microsoft excel programmes. Themes and memo from qualitative information obtained from key informants and focus groups discussions were developed and used to support quantitative data. Results were presented in tables, graphs and histograms for easy interpretations.

2.7. Biophysical Data Analysis

Biophysical samples (soils and water) were preliminary prepared and processed at the field for soils by making composites, proper bagging, and storing water in air tight bottles, labelling and transporting them. All samples were taken to the University of Dar es Salaam Chemistry laboratory for analysis. Quantitatively water pH was determined by using pH meter and Sodium Chloride (NaCl) by Electrical Conductivity method. Results from the analysis were summarised and presented in forms of graphs, tables and figures for easy interpretation.

3. Results

In this study, presentation of the outcomes from household's surveys, focus group discussions and key informant interviews are presented to support biophysical data. Since climate change and impacts of SWI overlap in some cases, it has been difficult to segregate different stakeholders' views and biophysical outputs and hence views from surveys are not presented separately.

3.1. Demographic Data

This study found that, many respondents were in the age between 60 years and above. Females dominated the study at 62 % compared to males who were 28%. Majority of the respondents (82%) were born in Bagamoyo hence expected to give data and information about SWI from their long term experience. About 78 % of the respondents attained primary/ basic education, while 16% had no formal education, and only 6 attained a tertiary level. Crop agriculture (70%) and fishery activities (fishing and selling) 20% were the major occupational activities followed by only 10% doing business (See Table 1).

Table 1. Demographic data

Respondents' demographic variables	Percentage (N=50)
Age (years)	
60 and above years old	34.00
50-59 years old	32.00
40-49 years old	19.00
30-39 years old	10.00
20-29 years old	5.00
Below 20 years old	0.00
Sex	
Male	38.00
Female	62.00
Originality	
Born in Bagamoyo	82.00
Immigrated individuals	18.00
Education	
No formal education	16.00
Basic primary school	78.00
Tertiary level	6.00
Occupation	
Crop agriculture	70.00
Fishery industry activities	20.00
Business	10.00

3.2. Climate Change Understanding

Results from the survey showed that majority of respondents understand climate change with respect to rainfall (84%) and temperature (76%), and about 50% are aware about climate change based on drought, floods and wind patterns. Also, respondents reported the following trends: delayed rainfall onset in different seasons (78%), increase of temperature (66%), decrease of rainfall (64%), decrease of crop productivity (60%) and outbreak of unknown crop insect-pests and diseases (46%) (See Figure 2).

3.2.1. Rainfall Trend

The results in section 3.1 indicate that farmers are aware about changes in rainfall. The reported information is supported by National Centers for Environment Prediction (NCEP): http://globalweather.tamu.edu/home (See Figure. 3). From this figure, the annual rainfall shows to have fluctuated about a mean of 1000 mm from year 1979-2014. It is clearly noted that as from 1979 to 2014, rainfall has been decreasing over time.

3.2.2. Temperature Trend

The annual average temperature shows an average increasing trend with time. Data show that the District experienced the annual increase of average temperature from 1979 to 2014 (See Figure.4).This observation was also supported by local and experienced community in Bagamoyo.

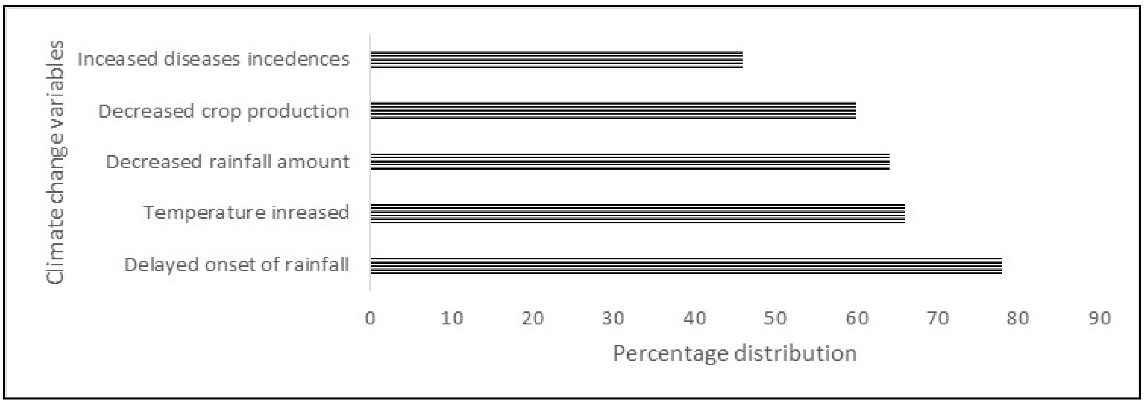

Figure 2. Awareness and resoponces on indicators for climate change

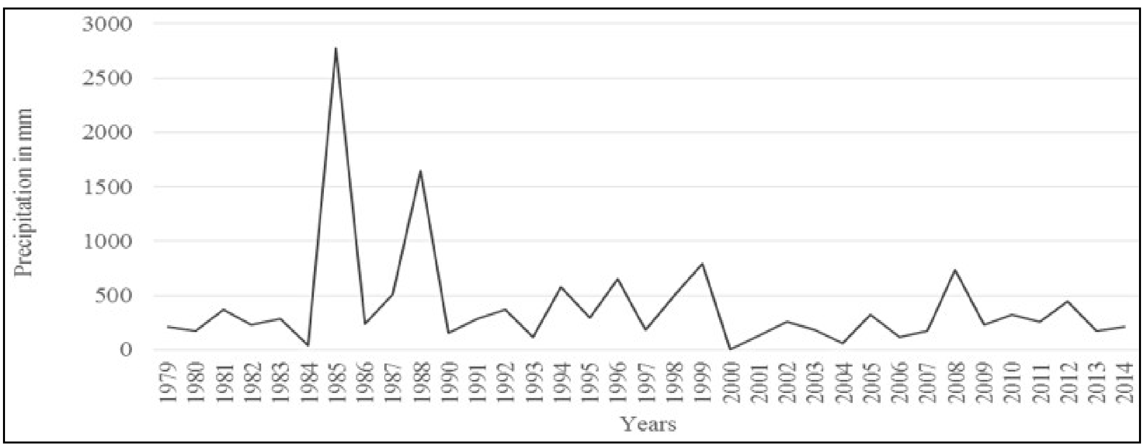

Figure 3. Annual rainfall variability for Bagamoyo 1979-2014

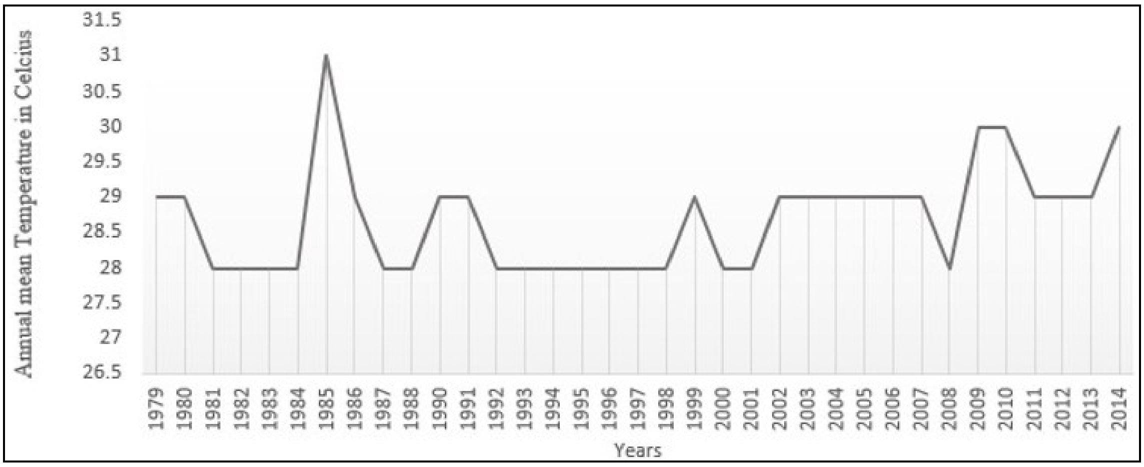

Figure 4. Annual mean temperature trend in Celcius (1979-2014)

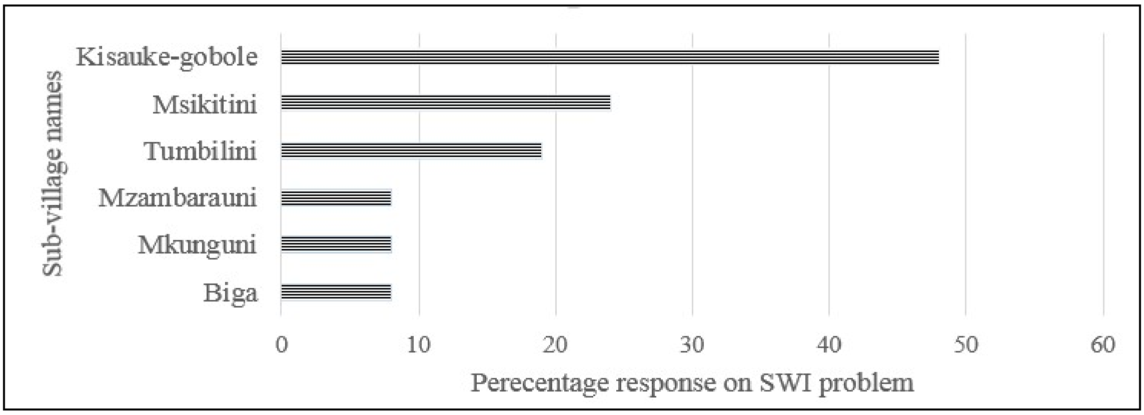

Figure 5. Farmer's response about SWI problem

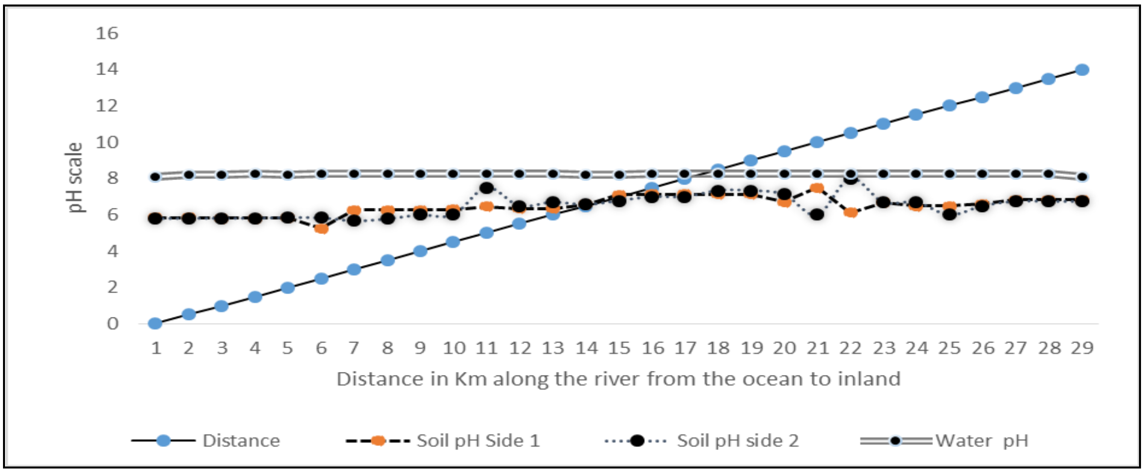

Figure 6. Water and soil pH against distance in km.

3.3. The Extent of Salt Water Intrusion

About (48%) of respondents from Kisauke- gobole, (24%) in Msikitini and (19%) of Tumbilini sub-villages (See Figure 5) showed that their farms are affected by SWI. Eight six percent (86%) of the famers whose farms were affected by SWI explained that this problem usually happens during rainy season particularly accompanied by tides and flooding.

3.4. Water and Soil pH Levels

The average pH level in water was around 8.24, while that of soil increased with increasing distance away from the Indian Ocean and then started to fall down. Soil pH average was 6.48 and 6.50 units of scale for river sides 1 and 2 respectively (See Figure 6).

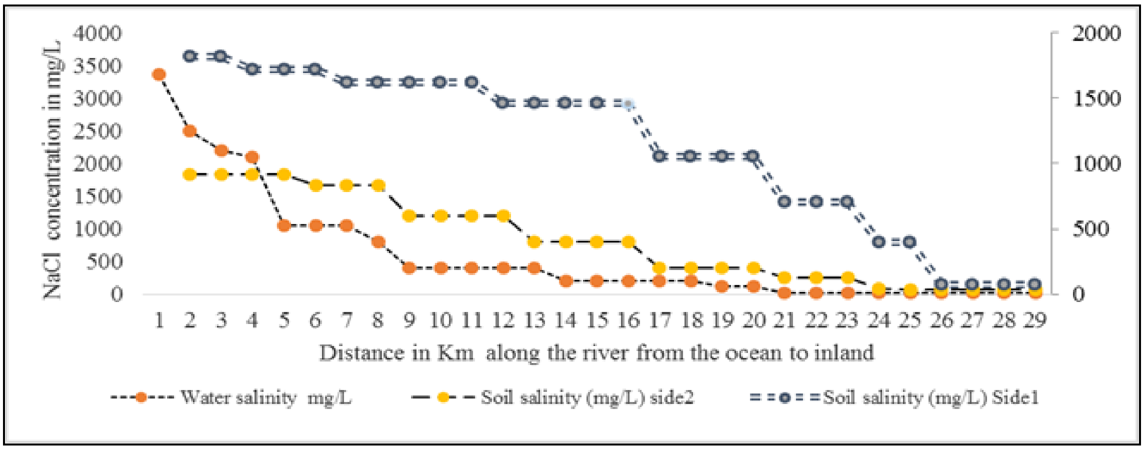

Figure 7. NaCl concentration in water and soil along 14 km distance from the India Ocean

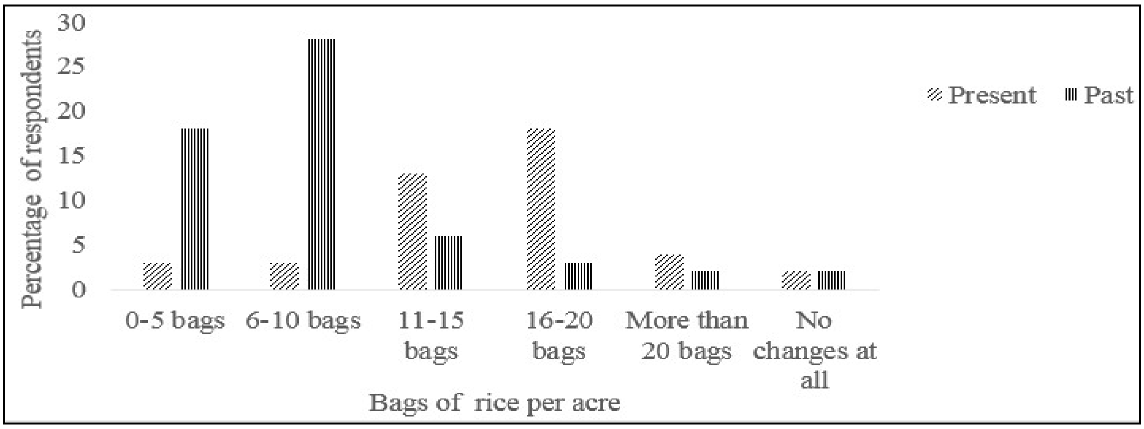

Figure 8. *Oryza sativa* production in the past and the present years

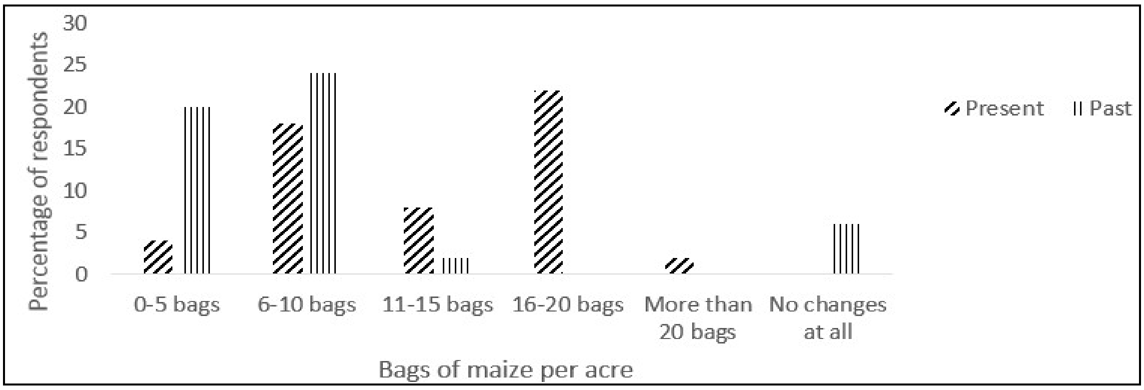

Figure 9. *Zea mays* production in the past and the present

3.5. Sodium Chloride (NaCl) Levels in Water and Soil

Sodium Chloride in soil and water showed a declining trend from Indian Ocean towards 14 km distance. The trend of decline was clearly seen at different levels on each sampling unit (See Figure 7).

3.6. Effects of SWI on *Oryza sativa* Production

Results showed that households experienced a decline of *Oryza sativa* production from a range of 16 to 30 bags[1] per acre per crop season to 6 or 10 bags per the same production unit and time (See Figure 8).These change were clearly stated by farmers, livestock officer and village leaders.

3.7. Effects of SWI on *Zea Mays* Production

In this study it was found that *Zea mays* yield ranged on

1 One bag of Rice equals to 120 Kg

the average of between16-20 bags[2] per acre/crop season in the past ten years, but has fallen to 6-10 bags/acres/crop season recently (See Figure.9).

3.8. Coping and Adaptation Strategies to SWI

During focus group discussion and household surveys, it was found that about 30% of respondents are puzzled by salt water problem and have no alternative solution to deal with it. Six (6%) of the farmers opted to grow crops during dry seasons. Part of the community (2%) have decided to open new farms in other places, and very low percentage (1%) of farmers changed crop types while one percent (1%) reported the occurrence of the problem to the village extension officer for further investigations and technical advice.

4. Discussion

4.1. Demographic and Socio-economic Characteristic

Majority of the respondents were born in Bagamoyo and lived here for more than 60 years (See Table 1).This age category is the key player of crop producers in this District. Like in many parts of the country, agriculture is characteristically dominated by farmers with advanced age (60 and above) mainly women. About 70% of people are engaged in agriculture as reported in this study and this figure is within the range documented by [23].Therefore, this group formed the major component to study about SWI and climate change. Experience in crop production along Wami River is an asset towards understanding SWI and climate change effects. Elders explained well about what is happening recently and they were able to compare the current and past environmental changes. Because of their ages and long term accumulated experience, it was possible to discover the existing SWI in relationships to climate change and impacts. Although the number of immigrants, were small (See Table 1) yet this groups also showed to understand climate change and associated impacts on crop production. Immigrants' understanding on impacts of climate change is associated with the fact that they moved from other districts and regions of the country already affected by climate change to Bagamoyo with a hope of doing farming and fishing activities here. Therefore anything affecting crop and agriculture puts an alarming situation and jeopardize the livelihood of them. Immigrants and natives pointed out that SWI is threatening crop production beyond their expectations. The current discovered farmers' ability to relate SWI to climate change is something contrary to a notice made by [23] especially in Sub-Saharan African countries. This controversy can is partially explained that farmer's awareness on issues related to climate change especially on crop production is improving in the society.

Local people in the study area attained formal and informal education (See Table 1). The number of individuals with basic education is promising and has been a useful tool to understand an occurrence of SWI and climate change although not using scientific measures. The role of education in gauging SWI and climate change was evidenced during focus group discussions where all members actively showed to have mastered their environment including changes occurring in on the environmental and community responses. In regards to climate change and impacts, it was revealed that, formal education had a little contribution when compared to informal system. Through social groups and daily life crop agriculture and fishing activities, majority of the locals learn some abnormal occurrence and create awareness among themselves. This information sharing and practice showed that it as useful methodology when the problem of SWI and climate change is discussed. All participants were able and clearly explained about climate change, and mirrored the impacts over different periods of crop production. With clear examples and references on their farms, majority of respondents showed that there is crop loss associated with climate change and mainly salt water effects in recent years. Therefore in this study it is feasible to establish that both (basic education and experience) are the main useful systems to share information concerning SWI, climate change and crop agriculture.

4.2. Climate Change Understanding

High percentage response on temperature and rainfall show that changes in these variables are evident and are used as major indicators of climate change in Bagamoyo like in other parts of Tanzania [24]. It is obvious that respondents are aware of changes on temperature and rainfall like many other people in the country [25] Key informants emphasised that the two major rain seasons i.e. short season (*Vuli*) from October-November and long rains (*Masika*) between February and April are not predictable any more. From climate change, farming calendar and activities are negatively affected. Recently famers are unable to timely plan for farming activities in relation to rainfall availability. Such impacts do not only affect farmers and food security [26], but also the entire social economic settings of the coastal community [27].Clearly, farmers use changes in rainfall and temperature to explain about climate change. Their explanation can be supported by literature that over the past 35 years, the annual rainfall fluctuated below the mean of 1000 mm (See Figure 2). Temperature is another climate variable used to describe climate change. From respondents and records it shows clearly that temperature has increased in recent years and the average is recently above the mean (28.5^{0}C). This rise is within the range of 1.5°C-2°C anticipated by [8]. It is obvious that the combined effects of SWI and reduced precipitation [4], and increased temperature scale affect crop production beyond farmers'

2 One bag of Maize equal to 100 Kg

control.

4.3. Salt Water Intrusion Local Community Understanding

According to the information obtained from focus group discussion and household surveys, and those supplemented from quantitative data, it was found that among the six sub villages, Kisauke-gobole was highly affected by SWI. This sub-village is nearby to the shore compared to other sub-villages. It shows that, SWI intensity is a function of the distance from the Ocean. This trend tallies well with the location of the most affected sub-villages' distances from the Ocean i.e. the closer the sub-village to the Ocean, the higher the SWI intensity and impacts on *Zea mays* and *Oryza sativa* production. From these results, farmers clearly stated that SWI is a problem occurring recently than in the previous years. It is obvious that farmers and agriculture practitioners clearly associates SWI with climate change and impacts on *Zea mays* and *Oryza sativa* production.

Focus group discussions showed that floods are more frequent in the recent years compared to ten years ago. Information from fishermen supported focus group discussions, that they also experience high tides in recent years than in the past. One of them stated that during high tides, the Ocean water extends up to 5 km upstream as wasn't the case in the past. According to key informants, water from the Ocean has been extending inland over the recent years causing severe impact on agriculture through flooding. Individual respondents and focus groups indicated clearly that high tides and flooding are connected to mangrove loss along the Indian Ocean Coastal belt. The ongoing mangrove deforestation and farming along the river banks cause the Ocean water to extend beyond 5 km and further the coastal rivers. Salt water intrusion, which is occurring along the coastal zone, is also documented by [4]. To support that there is SWI towards Wami River, fishermen affirmed that certain types of fish, which were known as salt dominant have moved towards the river to a distance of 14 km away from the Ocean. These salt water fishes included (local names in brackets): giant catfish (Hongwe), picnic sea bream (Kungu), cock grunter (Kara mamba) and sharks (Papa). However, the justification of fish movement and availability towards the river upstream opens another area for further study beyond the scope of this work.

4.4. Water and Soil pH Levels

The term pH refers to the measure of hydrogen ion concentration in a solution and it is defined as the negative logarithm of hydrogen ion concentration [28], [29]. In this case pH in water and soil was determined and showed changes with differences in distances from the Ocean towards the river in landwards (Figure 6). The levels of pH in water showed a steady trend with increase of distance from the Ocean upstream Wami River. This value was a little above seven (7) hence indicating the basic nature of water. However, results showed that soil pH gradually increased with increasing distance from the Ocean and then started to fall as approaching about 14 km away from the real coastal zone. The average soil pH was 6.5, which is a little below 7 at the scale hence termed acidic. This implies that there was more concentration of salt in soils closer to the Ocean than further upstream.

4.5. Sodium Chloride Levels in Water and Soil

Regarding water salinity, there was high content of NaCl (ranging between 1500 and 3300 mg/L) below 5 km from the Ocean and then fall to below 500gm/L and kept on a steady trend with increasing distance away to 14 km from the coastal zone near the Ocean. Soil salinity was high in concentration about (1500-2000 gm/L) at points around 5 km from the Ocean and declined at around 8 km away from the Ocean with constant trend until a drastic drop at 14 km (See Figure 7). Generally, salt in water was lower than that in soils. Low concentration of salt in water is a function of water having a high capacity of buffering salts and so there is a continuous dilution by incoming fresh water [30]. In this case salinity in Wami River is diluted by fresh water along 14 km distances. Soils contained higher amount of salts than water because after flooding and evaporation, the land is left with salt accumulation. Towards 14 km there was a drastic declining in concentration of salt in soils because water become fresh and more diluted towards upstream. Flooded water at a point towards 14 km has low salt content hence less amount of salt left after flooding and evaporation on both sides (1 and 2) of the river.

4.6. Impacts of SWI on *Zea mays* and *Oryza sativa* Production

Crop agriculture is among the main socio economic activities in along the coastal zone of Tanzania. That is why about 70% of the population depends on it. Crop production is the main source of food and income earning. It means that any decline in crop yield put the community in food insecurity risk and combating poverty in difficulty. Apart from recurrent droughts and damage from wild animals, SWI was reported as a serious problem on *Zea mays* and *Oryza sativa* production in Bagamoyo District (See Figures 8 & 9). The findings in this study establish the relationship of SWI and climate change impacts of crops as supported by [31] that "salinity is among the factors affecting agriculture sector in Tanzania".

4.6.1. Effects of SWI on *Oryza Sativa* Production

Crop producers and agriculture officers who participated in this study, associate *Oryza sativa* declined in recent years to salinity increase and climate change. It is evident that what is happening in this district conform to [32], that NaCl affects *Oryza sativa* production. Although *Oryza sativa* is reported to be more tolerant to salt stress during germination and grain filling, yet it is susceptible especially during early seedling growth and reproductive stages [33]. It was discovered that over the past five years the problem of salt has been recurrent and one of the factors causing loss in *Oryza sativa* yield (See Figure 8). The impacts of salinity on *Oryza sativa* production is supported by [17]. Thus, the determined amount of salt concentration between 1500 to 3300 mg/L in Figure 7, contribute to the loss in *Oryza sativa* production. This amount is enough to cause combined effects of high osmotic potential and specific ion toxicity in cereals [32], [34], [35]. That is why NaCl is affecting farms in the study area particularly those located close to the Ocean and recently the problem is expanding towards the inland along the Wami River. If the problem remains unsolved, salinity problem will continue to limit *Oryza sativa* production [35], [36] hence affecting food stability in the area and other areas depending on *Oryza sativa* produced in Bagamoyo. Therefore it is urgently needed to conduct researches like that conducted by [36], [36] to asses growth, nutrient accumulation and yield of different *Oryza sativa* genotypes in the coastal areas against SWI in changing climate. Such investigations will automatically contribute to find *Oryza sativa*-salt tolerant varieties, which if adopted and produced will function as mitigation strategy.

4.6.2. Effects of SWI on *Zea mays* Production

Zea mays is mentioned as one of the major cereal crops most salt-sensitive compared to other cereals [37]. Salinity is documented by [35] to cause oxidative stress in white corn plants just as an example. It is obvious that salinity is affecting *Zea mays* production in Bagamoyo as it was clearly reported by farmers (See Figure 9). *Zea mays* is sensitively affected by salinity [38], because salt reduces available water in the soil for the plant uptake and blocks the permeability of its root cortex hence death of the crop. This implies that, if no proper measurements taken immediately to overcome this problem, then there will be a huge *Zea mays* loss in Bagamoyo and other coastal zones with SWI effects.

4.7. Coping and Adaptation Strategies to SWI

Based on direct field observation and information from group discussions, it was found that within the last ten years, farmers with farms at the downstream (Mzambarauni and Mkunguni sub-villages) have extended their farms towards the river floodplains. This is used as strategy to maximize available soil moisture and ensure crop production during prolonged dry seasons. These activities affect the river banks and vegetation. The impacts of degrading river bank system results into flooding during rain seasons. Instead of mitigating SWI problem, farmers create more effects from water logging and salts left after evaporation.

Working on salt mines as alternative livelihood activity serves as the coping mechanism when the production of crops is low. Money obtained from salt mining is used to buy food and seeds for the next seasons. But this approach has nothing to do with SWI mitigation measure and so the problem will continue to affect crops production. Fishery business has been the last resort to some families to get some cash for buying food. Yet this mechanism is not tied to solve SWI problem and fishing cannot replace crop production in the area. Also, it was found that farmers are trying to look and use cultivars that can do well in salt affected lands, yet this option is limited. Therefore, there is an opportunity for other researches to come up with inter-cultivar genetic variation for salt tolerance [34] possible to solve SWI in changing climate. With climate change and increased impacts of SWI, growers of *Oryza sativa* and *Zea mays* must take the advantage of different cultivars with different salt tolerance [37], [14], [14], [33]. This approach will function if crop scientists work to develop new cultivars with salt tolerance or avoidance ability, otherwise the current coping and adaptation strategies are weak and probably not functional in the near future as also warned by [23].

5. Conclusions

Climate change and SWI is an incidence which is well understood by people in Bagamoyo. In the past twenty years, there has been a decrease of annual rainfall amounts and increase in temperature. Although rainfall has been dwindling, yet there come erratic rains which are of short time and this cause flooding defined by high tides of the Ocean. These two processes results into expanded salt water along and widely hence increasing salinity at Wami River and its two sides. The occurrence of SWI is a function of distance from the Ocean i.e. the shorter the distance, the higher the concertation of salt. Concentration versus distances explains the reasons for some villages in Bagamoyo such as Kisauke-gobole and sub-villages being affected seriously than others. Mangrove harvesting and farming along Wami River banks contribute to flooding intensities on the sides (1 and 2) of the river hence increasing salt intrusion widely and along Wami. Salt water intrusion has shown a negative impact on crop production near Wami estuary and the problem is expanding towards 14 km. There has been reduction on *Zea mays* and *Oryza sativa* production for the past ten years, the trend pointed by farmers and agriculture experts as results from climate change and SWI in Bagamoyo. Although farmers have their own ways of coping with SWI problems, yet some of their strategies such as farming within 100m of the river banks, creates prone and susceptible environment to flooding and SWI, and it is against the Tanzania environmental management act and regulations. While farmers try to give ways to climate change and SWI problems, they must comply with Environmental Management Act (2004) which prevents carrying any kind of anthropogenic activities within 60 meters. This study establish that climate change and the impacts of SWI on *Zea mays* and *Oryza sativa* is reported and sets a base upon policy makers, crop scientists, environmentalists, ecologists and farmers to work collaboratively in order that the problem is full addressed. Joint efforts are needed to come up with solutions to deal with SWI and its impacts for sustainable food crops production in the coastal communities of Tanzania particularly in Bagamoyo and other coastal zones suffering from SWI in changing climate globally.

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