

# Adaptation on Climate Change Impact on Variability of Rainfall to Banana Farming in Zanzibar

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**Abstract:** *Banana is very popular crop in the world but mostly considered as tropical crop due the uniform warm and rainy climate throughout the year. The study was conducted at Makunduchi, Kinyasini and Kizimbani from three different regions of Zanzibar Island... Survey method was employed to examine climate change on rainfall impacts and adaptation measures to banana farmers in the selected sites. The SPSS computer program was used to obtain descriptive statistics of surveyed data and Microsoft excel was used to analyze climate data using one sample t-test method. The result shows that banana farming suffer from insufficient rainfall and high dry spells as annual monthly rainfall is (p- value 0.03948) which means that there is a significant difference from the base line of 60 mm per month. It is concluded that adaptation to reduce rainfall impacts is necessary to improve production, as observed at Makunduchi where technical and institutional changes maintained to manage a good farming practice especially irrigation enabled farmers to increase production, while inadequate water supply is unable to manage sustainable increased banana production mostly at Kinyasini and Kizimbani. Overall water infrastructure should be improved to promote high production of banana so as to maintain livelihood and enough food supply.*

**Keywords—** adaptation, climate change, banana production, rainfall variability

## 1. INTRODUCTION

Climate change adaptation aims to mitigate and develop appropriate coping measures to address the negative impacts of climate change on agriculture [1] The policy debates has increasing focus on adaptation to climate change, thus referred differently in articles by UNFCCC and the Kyoto protocol [2]. The altered climate condition forces farmers to adopt new farming practices in response to climate's direct impacts to livelihood [3]. Adaptation measures help to reduce negative climate change impacts to agriculture which is highly vulnerable due to decreasing of rainfall and rising of temperature, apparently destroying farming communities around the world ([4]; [5]; [6]. Technical, institutional and educational changes are crucial for stimulating agricultural development in maintaining livelihood and food security which continue to deteriorate in Sub Saharan Africa where the number of people living in poverty has increased in the last decade [7]; [8]; [6]. Therefore adaptation is among focal area of the special work programmed assist to Least Developed countries supported by Least Developed Countries Fund from Global Environmental Fund [2].

Banana in Tanzania considered as a valuable food and cash crop [9]. It takes up to 60% of the daily per capita calorie intake in the most productive regions of Western Tanzania [10]. It is also considered to be the second important food crop to 35.2% of farmers from all districts in Zanzibar compared to cassava (43.1%). Banana is also considered an

important cash crop (15.5%), the third to cassava (18.9%) and vegetables (16.4%) [11].

In-adequate rainfall and change regularity of the seasons are the main threatening aspects of climate change in Zanzibar which are all extremely detrimental to the survival of agricultural success on the island [12]. It is noted that seasons are getting less and less predictable. Example rainfall during Masika and Vuli has shifted intensity and in some places in the island, the Vuli season has completely disappeared [13] and [14]. The scarcity of rainfall leading to water stress due to prolonged droughts results into higher wilt incidences causing banana plants more vulnerable to banana *Xanthomonas* wilt diseases infection during and after inoculation periods [15]. This relatively leads to decreases in yield of banana in Zanzibar (UKAID and Global Climate Adaptation Partnership 2012b).

For banana, climate change and variability of rainfall may alter both yield as well as vulnerability to diseases affecting farm output, which consequently threaten livelihood of farmers ([16]; and [17]. Some indicative studies estimate up to 10% reduction in suitability, as well as loss in soil fertility for banana in the regions [12] This condition endangers the livelihood of Zanzibaris, therefore, adaptation to climate change and variability of rainfall is required to reduce vulnerability to banana farming so as to sustain livelihood and prevent extreme poverty of Zanzibaris [18].

**2.0 MATERIALS AND METHODS**

**A. The study area**

The study was done in three regions of Unguja Island, North, Urban-West and South regions. Selection of the study areas was based on the high intensity of banana crop plantation where these regions import much banana to the market areas and the significant difference in rainfall pattern experienced. In addition, these are the areas which exhibit the presence of meteorological stations which helped to observe the rainfall for the study. The study was conducted at Kinyasini area (North region), Kizimbani area (Urban- West region) and Makunduchi area (South region) (as shown in figure 2.1). The areas are characterized with high rainfall (Kinyasini), moderate rainfall (Kizimbani) and low rainfall (Makunduchi).

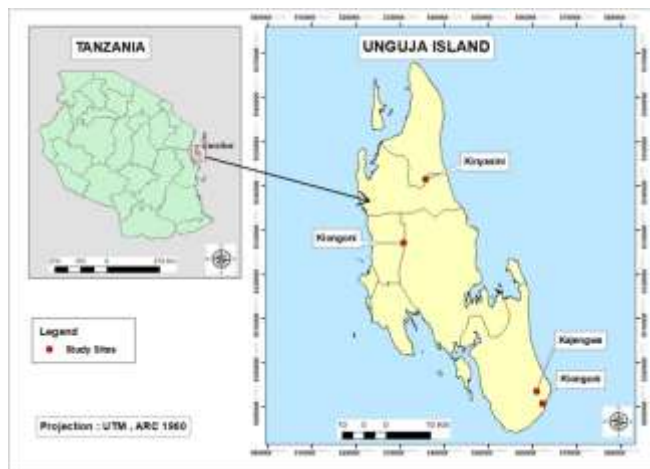


Figure 2.1: Map of Unguja Island in Zanzibar showing the study area

**B. Data collection and sampling procedure**

Non probability sampling was made by using semi structured questionnaires by using purposive sampling techniques to the banana farmers so as obtain the target population which the banana farmers from each village. Because the random sampling procedure would provide the respondents which are not farmers. And in depth interview to key skilled informants to attain factual and detailed information at the Institute of Agriculture, the questionnaire and interview focused on the climate change variability, adaptation measures and attainable yields. To achieve the goals the formula below was used to determine a sample size.

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

Where n=sample size; N=sample frame; and e=error significant level [19] In this study N=5121 and e = 0.10. by substituting these figures into the above formula the sample size (n) of 98 is obtained, and therefore sample for each village is also obtained (14 banana farmers from Kizimbani, 31 from Kinyasini and 53 at Makunduchi from the most two productive shehias, (34 from Kajengwa and 19 from Kiongoni shehias) were selected and 13 district officers including 3 District Agricultural Development Officers

(DADO) 4 Block Extension Officers (BEO), 3 Agricultural Services Support Program (ASSP)-Program District Officers 3 (PDO) were selected at each region. The climate data used in this study were collected from TMA Zanzibar office were collected. The data range is 30 years from 1985 to 2014 for Zanzibar rainfall, and 7 years rainfall for the study sites per month.

Data collected were summarized, coded and analyzed using Statistical Packages for Social Sciences (SPSS) Computer programs to calculate frequencies, means, percentage and correlation coefficients so as to make task easy for inferences. Microsoft excel computer program was used to convert 30 years climate data from monthly to annual average, compute climate data using one sample t-test method to obtain their difference from the base line from alpha 0.05 and to plot graph. R. statistical software was used for analysis of correlation between climate change factor and banana yield.

**3.0 RESULTS**

**A: Variability of rainfall in Zanzibar**

In Zanzibar, the average annual rainfall is 1623 mm/year. The results from Tanzania Meteorological Agency, Zanzibar office shows that there are fluctuations in rainfall in Zanzibar where the highest rainfall was 2459.7mm in 1997 and the lowest rainfall was about 704 mm in 2004 as shown in figure 3.2.

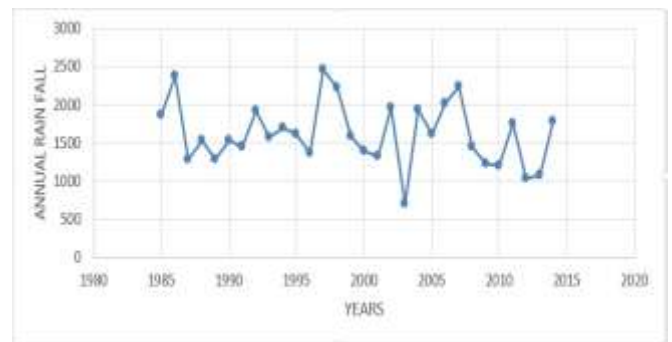


Figure 3.2: Annual rainfall in Zanzibar 1985-2014

While the average monthly rainfall ranges between 28 mm to 382 mm as shown in figure 3.3



Figure 3.3 Annual Monthly Average rainfall for Zanzibar 1985-2015

In the months of January, March to April and October to December there is higher rainfall which range between 73.44 mm to 382 mm. However, in the month of February and June to September there is low rainfall which range from 28 mm to 54.92 mm is experience during the months of February and June to September. Low amounts of rainfall lead to stunting growth of banana plants.

The analysis of a sample t-test shows that the p-value for annual rainfall in Zanzibar is 0.1909, which means that there is no significant difference from the base line of 1500 mm this means that the average annual rainfall is enough to support banana production, with a slight challenge on rainfall pattern where maximum rainfall rains only during Masika.

One sample t-test result for average monthly rainfall shows p-value of 0.03948, which is significant from the base line of 60mm per month. This suggests that banana production suffer from inadequate rainfall. Banana production requires at least 60mm per month for better growth, a month below 60mm is considered dry month for banana production and production is almost impossible with three consecutive dry months without irrigation [20]

With few fluctuations in 1987 and 1999, the annual rainfall was between 1450mm and above which is good for banana farming. However, from 2008 the rainfall started to have a higher fluctuation which goes below the average (1500mm) for more than 3 years, which is not promising for banana farming. The previous study suggests that to attain a better yield banana plants need at least a minimum of 1500 mm throughout the year, while above 1500mm per year are more favorable [20]. Thus the annual average rainfall is enough to support banana production and the problem is on rainfall pattern where maximum rainfall rained only during Masika. However there are high intensity during high rainy season and low frequency of rainfall during rainy seasons [12] restrict well growing of banana plants due to rotten and falling.

The monthly average rainfall pattern is enough only during high rainy season March-May for banana farming. However, the time period of farming ranges around one year. Therefore, depending on the rainfall patterns for this farming

will not be profitable; therefore having adaptive measures is required for the better profit in farming of banana crop. Banana production requires 60 mm per month for better growth, a month below this content considered as dry month for banana production and three dry months for banana growth is impossible without irrigation [20]. The average monthly rainfall to support banana production indicates that, Zanzibar experience long dry season below the 60 mm between February and June – September. The correlation between annual rainfall in Zanzibar and banana production from 2010 to 2014 is negative and not significant, which means that production increase as rainfall decreases as shown in table 3.1

Table 3.1 relationship between annual rainfall and banana yield

Variables	Years					P-value	Correlation
	2010	2011	2012	2013	2014		
Banana yield (tones)	15047	15044	13492	13230	10778		
Rainfall (mm)	1207	1749	1030	1082	1784	0.6513	-0.277469

This result lined with respondent’s responses that high rainfall causes a lot of impact include falling of banana plants almighty after long dry period weakened the banana plants.

**B. Variability impact of rainfall in the study areas.**

The annual rainfall pattern shows variability in all study areas in general (figure 3.4),

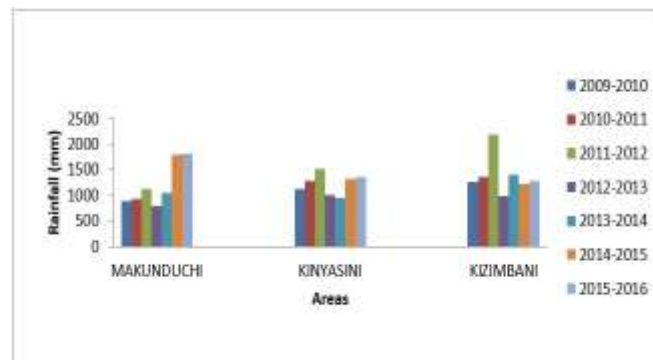


Figure 3.4 Annual rainfall in the study areas 2009-2015

It shows fluctuation from year to year and from one place to another. At Makunduchi the result indicates that, the years with high rainfall above 1500 mm for good harvest of banana is only 2014 and 2015 but most of the years they lack enough rainfall for cultivation. Kizimbani and Kinyasini 2011 is only year with enough rainfall to support production and the remaining years rainfall is less than 1500 mm. The one t- test results from the annual rainfall from TMA data shows that Kinyasini area exhibits significant difference from the alpha p- values of 0.05 to 0.012 compared to Makunduchi with a p- value of 0.113. Kizimbani has the greatest p-value of 0.4449. From the results Kinyasini is the only area with significant difference from the base line,

meaning that production of banana is impossible without irrigation interventions, while Makunduchi and Kizimbani might be able to produce some yield even at a very small amount. The rainfall pattern results in the study areas aligned with the [21] said that 2011 is year with extreme event as indicated by 3- and 12-months Standardized Precipitation Index for Zanzibar.

The annual monthly rainfall results from TMA in the figure 6, 7 and 8 indicate that at Makunduchi and Kizimbani January – February and July to October are the dry months for banana production. At Kinyasini January - February and July to September

The variation in rainfall pattern in the study areas is a result of difference in a geographic features, examples Kizimbani is the areas surrounded by vegetation cover includes timber forests and spice farms, with high coverage of wet land areas, which facilitate availability rainfall while Kinyasini is the areas covered by scattered trees and wet land areas and Makunduchi is the coral rag region and scattered vegetation without wet land areas causing more declining of rainfall. However the year with enough rainfall unable to increase production due to falling and rotten of banana corm, as rainfall rained with high intensity in a few days. Generally the annual average rainfall in the study areas is not enough for good harvest since few years reach the average rainfall. This results support the result of [20] state that, rainfall below 1500 mm banana growth reduced depend on the length of dry month. While Zanzibar the strong rainfall is only between March - May. The annual average monthly rainfall suggests long term dry period affects the banana growth, since 4-5months are dry for banana growth in all regions because rainfall is below 60 mm as indicated in figures 6-8. As well, January -February are dry months. Three months rainfall shortages linked to yield reduction to more than 35% [22]. Hence farmers use irrigation measures and changing planting pattern from short rain season to long rain season for good growth of banana. This has improved banana production at Makunduchi which is the most areas with low rainfall however their production are good due to using of irrigation measures, while Kinyasini the situation are worse due to low rainfall and inadequate water supply for irrigation and Kizimbani they have their production is at maximum as rainfall nearly to the approximation level. The combinations of dry month and rain fall below the 1500 mm indicate the prevalence of leaf diseases [20] It is observed that prolonged water stress leads to higher wilt incidence [15].Therefore adaptation measure like irrigation and mulching are the most important to cope with long dry spells in all banana farming areas so as to conserve soil moisture and minimize water shortages [22]. As observed that banana plants recover its growth during rainy season and weakened during dry spells.

The variability of rainfall showed various impacts on banana farming like diseases and pests include Black Sigatoka and panama which is common at Kizimbani especially for mtwike varieties evidenced by [23] that Zanzibar Islands is

among the coastal areas of Tanzania mainly affected by Black Sigatoka diseases that possible to reduce yield up to 30-40%. Presence of white fliers at the leave canopy in all study areas, bites of banana bunch, these effects are common during hot periods. At Makunduchi about 64.2 %,Kinyasini 74.2% and 71.4% at Kizimbani responds from farmer's interview. This diseases infection is an implication of scarcity rainfall and long dry spells. .Since the epidemiology of sigatoka widely occurs during the dry season when humidity is the limiting factor [24]. This case observed at Kizimbani where sigatoka mostly cover after rainy season. Generally diseases infections are the main effects of climate change causing other effects include banana plant break and plants to stunt its growing which highly influenced by water shortages. These impacts related to each other in its impacts to plant growth. Since the plants affected with diseases stunt it growing, then falls as affected by wind blow or high rainfall due to water logging. In agreement with [25] these effects associates with scars water supply due to prolonged dry periods which decrease water content, results to the declining of growth attributes includes salicylic acid which considered as the most potential growth regulator for improving plant growth.

{26} State that banana production is unable to reduce levels of poverty and combat food insecurity under the negative climate change scenario. Though, it's among the important value chains for food security, nutrition and income, when the climate impacts are controlled. However, Makunduchi is highly depending on banana production for income generation due to availability of water services for irrigation as observed in this study, of which about 94.3% of respondent confessed to have applied irrigation measure in their farming. These changes affect household income positively and make the crop to be the main source of income in the families. At the same time, income from the crop income has gone down at Kizimbani and Kinyasini due to low productivity resulted from poor access of farming facilities including water for irrigation.

### *C. Adopted measures towards climate change impacts observed to banana production*

To cope with climate change impacts hitting in the study areas, respondent have adopted various measures like irrigation techniques, mulching, cover cropping, replanting, fertilization, change of planting pattern, use of short season varieties, use of drought resistant varieties, mixed farming, pot holing, and increase plant spacing.

Apart from those identified adaptation option suggested by [18], other adopted measures noted the study areas include paring and hot water treatment to avoid diseases infection, reducing banana suckers to prevent over absorption of soil nutrients, cutting of female bud for better banana bunch and polling of banana plants to avoid breakage of plants.



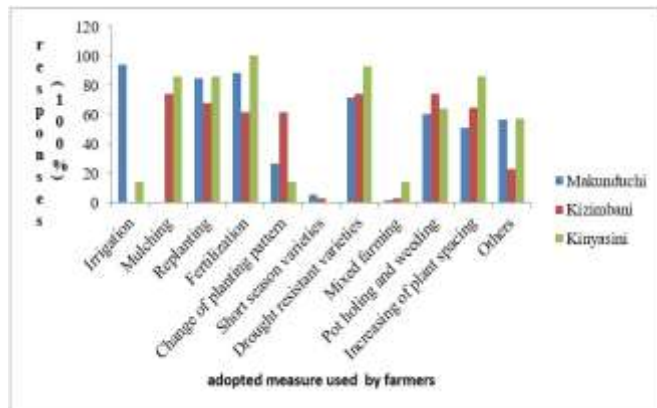


Figure 3.5 Adaptation measures agreed by farmers

The respondents in all regions perceive differently on various useful adopted measures in their application and from observations. They perceive that irrigation, fertilization, mulching, pot holing and weeding, replanting and the use of drought resistant varieties are the most effective adoptive measures for improving production while the change of planting pattern is the most effective method for those who are not using irrigation measure.

It observed that lack of efficient on the use of adoptive measure is reason for ineffective of adaptation measures to high production, as explained by interviewers that they have inadequate water supply, and low income to buy fertilizer and banana suckers. This result compared to result of [6] that implementation and effectiveness of adaptation measures is limits with a range of barriers. [27] Identified the facilities mentioned above as a barrier, since are not easily accessed without financial capacity.

Production has improved in Makunduchi due to an increased number of farmers applying improved banana production techniques motivated by high income return. Contrary to Kizimbani, production is moderate, while the situation at Kinyasini is not good. They experience low productivity at Kinyasini to the extent that farmers are opting out of the business while those still engaged in farming are for family consumption.

Generally, most respondents are aware on the importance of application of adaptation measures in their farming practices though unable to apply them. This situation is caused by lack of capital needed to invest in farming technologies including water facilities, fertilizer and availability of quality suckers. Example the used varieties by farmers include *Yagambi km5*, *pelipeterYangambi*, *pelipita* and *kachako*, are among the 14 new registered East African high land banana hybrids introduced by International Institute of Tropical Agriculture that have led to higher yields [23]. According to [28] access to credit determines the use of agricultural technologies to adopt the climate change risks. Therefore, banana farmers are unable to effectively apply adaptation measures due to lack of access to credits. Alternatively, they concentrate on the use of mulching to preserve moisture, manure and

compost as a means of fertilizing the farms. Even they believed that irrigation techniques are the main reason for improved production as observed at Makunduchi area.

#### D. Policy implication to adopted measures

Farmers cooperate with agricultural institution through Agricultural Services Support Program (ASSP) from all districts in the all regions, they give them a training on better farming practice through Season Long Farmer Fields Schools (SLFFS) to the group of twenty peoples giving them loans by coordinating to the fund for self-reliance from Ministry of Labor, Empowerment, Elders, Youth, Women and Children and incentives. And Institute of Research of Kizimbani at Kizimbani by gives them a good banana suckers. For those who get support they are achieved by increasing production after managing good farming practice. Therefore there suggestion to the government and other stake holders is to provide them with incentives like farming tools, improve water services for irrigation, and give loans with low interest for fund. Their views also supported by DADO and BEO from the study areas and add their views on improvement of tissue culture experiments by providing laboratory equipments and chemicals in order to produce a good banana suckers. These implied to the role of government in promote adaptation measures appropriate for particular circumstances and agro ecological zone [29]. The main challenges of the policy implication to adopted measure includes farming infrastructure are not well improved especially Kinyasini and Kizimbani, water services are poor, and they have low income to invest on farming for buying fertilizer and good banana suckers results to negative response on effectiveness of adoptive measure . This result is similar to the studies of [29] that lack of farming input including (seeds, and chemical fertilizer), lack of money, and water are main constraints to adaptation on climate change. This is due to the facts that banana production are worse without adoptive measures as explained by interviewee from district agricultural development officers (DADO) and Block Extension Officers (BEO) in all regions. Thus poor farming infrastructure are the main challenge of implementing adoptive measures in all selected regions.

#### 4.0 Summary of findings and conclusions

Rainfall was found as the major constraints affecting banana production leads to decline of production. It is the main sources of climate change impacts observed in this study to banana growing. Banana growths are in harsh condition due to low rainfall with a long dry spells. Therefore adaptation measures especially irrigation to manage water stress and mulching to preserve soil moisture are crucial to the farmers so as to sustain banana growing and slow incidence of diseases increased during dry period, as directly observed at Makunduchi through which dependency of banana production for income generation frequently has been increased due to improved water infrastructure for irrigation and reduce prevalence of diseases, while Kizimbani and

Kinyasini were only able to sustain meals of their family due to low production and high incidence of diseases due to poor water infrastructure for irrigation as a result fail to cope with long dry spells affecting production. Stakeholders aim to improve banana production through education and fund should pay more special attention to preserve the role of banana production in serving the communities to secure food security and income generation to the family as tourism activities grow correspond to the establishment of traditional food festival unities, mostly in enabling them to invest in water facilities which are the main obstacle due to poor financial support to the farmers to solve this problem. This implied to the means of implementation of adaptation policy in Zanzibar. Indeed, extension services and incentives are the most crucial inputs play a greater role to assist farmers on the use of adoptive measures, as it enable farmers to identify, mobilize and use right knowledge on adaptation measures [30]; [31]; [32]. Therefore, could solve farmer's constraints to the application of adaptation measures.

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