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2 **Assessment of Climate Change Adaptation**

3 **Options and their Implications on Mangrove**

4 **Resources in Bagamoyo District, Tanzania**

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13 **ABSTRACT**

The study assessed climate change adaptation options and their implications on mangrove resources in Bagamoyo District. A total of three villages and 158 respondents were involved. Close and open-ended questions and FGDs were used to collect quantitative and qualitative data. Descriptive and content analysis was used for qualitative data while SPSS (Version 20) and Microsoft excel were used for quantitative data analysis. Results indicated that, majority of respondents (>80 %) were aware of the climate changes and majority perceived rainfall (Kaole 72.7 %, Kondo 70 % and Mbegani 43.9 %) as a major climate change indicator. Analysis of the empirical data from TMA showed a decline of rainfall ( $y = -3.8748x + 978.1$ ) and an increase of earth's surface temperature of an average of 0.8 °C ( $y = 0.4142x + 21.655$ ) from 1985-2015. Unpredictable and shortage of rainfall and increased earth's surface temperature in combination acted to reduce agricultural yields and fish catch in the surveyed villages. Different climate change adaptation strategies were identified in the surveyed villages including; expansion of farms, modifying fishing activities and engagement into different income generating activities such as casual labour, and petty businesses. The identified adaptation options in Kaole seemed to have positive implications on mangroves resources i.e. effective mangrove restoration programmes while those identified in Mbegani and Kondo i.e. weak mangrove restoration programmes, commercial firewood and charcoal making were unsustainable and had negative implications on mangroves resources. Further studies on climate change adaptation, awareness raising and scientific studies on mangroves species composition, richness and restoration in a changing climate are recommended to enhance coastal community adaptive capacity and effective management of coastal resources.

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16 *Keywords: Climate change; climate change adaptation; mangroves; Terebralia palustris*

17 *Bagamoyo District; Kaole; Mbegani; Kondo.*

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## 1. INTRODUCTION

There is a merit that, anthropogenic emissions of Carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and other greenhouse gases from industrial and land-use activities is the root of climate change whereby the global temperature has increased to an average of 0.76 °C [1]. The increase of global temperature is projected to continue to an average of 1.1 °C to 6.4 °C over the next century (ibid). The Africa continent as part of the world is not shielded from climate change. Across the 20<sup>th</sup> century most of the African continent has experiencing warming trend of an average of 0.7 °C [2]. However, climate change has been manifested in different forms in different parts of the continent including, decadal warming rates of 0.29 °C in the tropical forest and 0.1 °C to 0.3 °C in South Africa (Ibid).

Climate change has caused different impacts on both human and natural system [3]. Change of precipitation and melting of ice or snow exacerbated by climate change has changed the hydrological system that has been affecting water resources both in term of quality and quantity as also crop yield being negatively impacted. Climate change has changed the seasonal activities, migration patterns, geographic ranges, species interactions and abundances of both terrestrial and marine organisms [3]. Africa is likely to be negatively impacted by climate change because most of her people depend on direct rain-fed agriculture and low adaptive capacity [4], whereby the direct impacts of climate change will vary across the continent [2]. In Tanzania, impacts of climate change which have occurred include, an increase in weather extremes (floods and drought), melting of ice sheet on Mount Kilimanjaro, occurrence and persistence of pest and vector borne diseases such as Malaria in highland areas, submergence of Maziwe Island in Pangani, intrusion of salt water into fresh water wells along the coast of Bagamoyo town and decline of agricultural and fishing products [5,6].

Adaptation to impacts of climate change involves changes in practices, processes and structures so as to moderate potential damages or to explore benefits from opportunities associated with climate change [7]. Adaptation to climate change impacts is location based and time dependent; there have been different studies conducted in Bagamoyo District on adaptation to climate change impacts. A study conducted by [8], proposed different adaptation measures to be undertaken by the village and District authorities such as rain water harvesting and storage, energy efficient technology which will reduce deforestation, planting mangrove, resistant shrubs and grasses to reduce coastal erosion and applying good practice in crop cultivation including planting of drought resistant crops. [9] conducted a study and indicated that farmers adapt to a changing climate through; change of planting dates, use of fertilizer, mixed farming and cropping, and participation in non-farm activities. A study by [6] identified some of climate change adaptation options such as; livelihood activity diversification, rain water harvesting, adoption of irrigation agriculture, cultivating drought resistant crops such cassava and migration of people from one village to another in search for agriculture activities.

However, mangroves are plants found in tropical and sub-tropical latitudes, along shorelines where freshwater from rivers flow or rainfall enters the ocean [10]. Mangrove forests provide different ecosystem services such as, timber for construction of houses, traditional boats, fishing stakes, source of fuel either as firewood or charcoal, food and traditional medicine. It provides suitable environments for breeding, spawning, hatching and nursery habitat for different animal species including fish, mollusks, crustaceans, birds, insects, monkeys, and

71 reptiles [11] and acts as significant carbon sinks [12]. Mangroves have the ability of filtering,  
72 trapping pollutants and reducing the action of tropical storms, hurricanes and oceanic waves  
73 which cause shoreline erosion and flooding [13]. Distribution of Mangrove forest around the  
74 globe varies in density and coverage. In regions, such as the Middle East, much of Australia,  
75 and East Africa, mangrove forest occurs in discontinuous sparse clusters and formations  
76 and the total mangrove species according to global assessment considers the presence of  
77 73 species [10]. The Coastal zone of East Africa is said to have eight different species of  
78 mangrove including; *Sonneratia alba*, *Rhizophora mucronata*, *Brugiera gymnorhiza*, *Ceriops*  
79 *tagal*, *Xylocarpus granatum*, *Avicennia marina*, *Lumnitzera racemosa*, *Xylocarpus*  
80 *moluccens* and *Heritiera littoralis* which some consider as a mangrove associate (Semesi,  
81 1998). Globally, it is estimated that mangroves cover an area of about 150,000 km<sup>2</sup> [14], but  
82 according to [15], it is estimated that global mangrove area was once more than 200,000  
83 km<sup>2</sup>. The coastline of Tanzania is about 1,424 km long with a total coverage of mangrove of  
84 about 135,500 hectares [16].

85 Community adaptation options to impacts exacerbated by climate change have both positive  
86 and negative implication on mangrove forest use and management because it may involve  
87 enhancing mangrove forest resilience to the impacts of climate change while mal-adaptation  
88 options are likely to compromise the resilience of both coastal community and mangrove  
89 ecosystem [17-19]. Restoration of mangroves as climate change adaptation strategy in  
90 Nijhum Dwip Island in Bangladesh and Panay Island in Philippines was emphasized to  
91 protect the community against natural disasters including storms which are exacerbated by  
92 climate change [20,21]. Coastal erosion is a problem that is said to be associated with rise of  
93 sea level. An analysis conducted in Martinique and West Indies beaches suggested the  
94 rehabilitation of mangrove forest to reduce the rate of coastal erosion exacerbated by strong  
95 waves as one of the climate change adaptation strategy [22]. However, [23] conducted a  
96 study on Zanzibar beaches and concluded that beach erosion is due to absence of  
97 indigenous vegetation including mangrove. Construction of seawalls adjacent to mangrove  
98 landward edge to reduce coastal erosion exacerbated by sea level rise has been an  
99 important factor in reducing the resilience of mangrove forests, since they cause erosion and  
100 scouring of the mangrove immediately fronting and down-current from the structure [24].  
101 Moreover, construction of storm water drainage systems to reduce flooding in coastal upland  
102 areas and diverting surface water from entering mangrove forests lead to reduction of  
103 mangrove productivity because it affects the nutrient budget of mangrove sediments [19].  
104

105 Degradation of mangrove forests in different ways through conversion to agriculture,  
106 aquaculture, tourism, urban development, hydrological alterations, over-exploitation and  
107 climate change have been addressed [10,14,15,19,25-27]. It is estimated that more than 50  
108 % of the total original cover of the world mangrove forests including Tanzania coast zone  
109 have declined [14,28] while the remaining proportion is in degraded condition [29]. Mangrove  
110 forests degradation because of anthropogenic factors in the last three decades, have  
111 increased significantly [15] and mangrove of East Africa are among the most threatened  
112 coastal forest due to an increase of anthropogenic activities exacerbated by a changing  
113 climate [18]. This rate of degradation is bound to compromise the ecosystem services  
114 provided by mangrove forests, and will affect the livelihood of coastal communities including  
115 those found in Bagamoyo District. Communities found in Southern part of Sahara are more  
116 vulnerable to impacts of climate change due to low adaptive capacity [1]. Adaptation to  
117 impacts of climate change involves diversification of livelihood activities influenced by  
118 different factors including availability of natural resources such as mangroves. There is a  
119 need for intervention but information is needed on the extent of the problem among  
120 mangroves of Bagamoyo District. None of the anthropogenic factors for mangrove  
121 degradation discussed the implications of community climate change adaptation mechanism  
122 on mangrove uses and management. Therefore, climate change adaptation options and

123 their implications on mangrove forest use and management are not well documented in all  
 124 coastal areas of Tanzania. In light of the above situation, a better understanding on the  
 125 community adaptation options to the impacts of climate change and their implications on  
 126 mangrove forest use and management is necessary for proper use and management of  
 127 mangrove forest for sustainable development and ecosystem integrity.

128

## 129 2. MATERIAL AND METHODS

130

### 131 2.1 Description of the study area

132

133 This study was conducted in Kaole, Mbegani and Kondo villages of Bagamoyo District  
 134 (Figure 1). Bagamoyo District is found in Coast Region of Tanzania. It is bordered to the  
 135 North by Tanga Region, to the West by the Morogoro Region, to the East by the Indian  
 136 Ocean and to the South by Kinondoni and Kibaha Districts [30] (URT, 2006). It lies between  
 137 37<sup>o</sup> and 39<sup>o</sup> East; and between 6<sup>o</sup> and 7<sup>o</sup> South of the Equator. The district covers an area of  
 138 9,842 km<sup>2</sup>, where 855 km<sup>2</sup> is covered by water (Indian Ocean as well as Ruvu, Wami River  
 139 and their tributaries). According to the 2012 Tanzania National Census, the population of the  
 140 Bagamoyo district was 311,740; comprising of 154,198 males and 157,542 females [31].

141

142 The study sites were selected because they have been experiencing some impacts of  
 143 climate change. Secondly, although there have been several studies conducted in these  
 144 areas on the impacts of climate change, adaptation and vulnerability, there is limited  
 145 knowledge on implications of climate change adaptation options on mangrove resources use  
 146 and management.

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149

150 **Figure 1:** Location of Bagamoyo District and the study sites

151

### 152 2.2 Sampling procedure and sample sizes

153 Stratified sampling was used according to [32]. This was conducted by purposively forming  
 154 strata, on the basis of age of the participants (aged more than 20 years) from a population  
 155 frame; respondents were randomly selected from the formulated strata. Sample size was  
 156 determined by using 10 % of sampling frame [32], whereby 77, 41 and 40 respondents from

157 Kaole, Mbegani and Kondo respectively were used for questionnaires. The respondents  
158 included village elders, village executive officers and ordinary villagers.

159

## 160 **2.3 Methods of data collection**

161 The study used both primary and secondary data. Primary data was collected through,  
162 questionnaire, focused group discussion and field observation. Secondary data was  
163 obtained through detailed review of various publications including journal papers, books and  
164 book chapters as well as collection of rainfall and temperature data of Bagamoyo district  
165 from TMA for the past 30 years (1985-2015).

166

### 167 **2.3.1 Questionnaire**

168 Both close and open-ended questions were used. These questions were formulated on the  
169 basis that, close-ended question enabled the researcher to collect standardized information  
170 (quantitative data) while open-ended questions were included to allow the respondents to air  
171 their understanding on basis of study theme (qualitative data).

### 172 **2.3.2 Focused group discussion**

173 Focused group discussions were used to collect information around the theme of the study  
174 purposely for triangulation of issues raised in questionnaire. Different questions were  
175 introduced into the group for discussion whereby; sound recorder and note book were used  
176 to collect the output of discussions from respondents. Each focused group discussion in  
177 surveyed villages constituted 12 respondents. The nature of the group used was  
178 heterogeneous and cut across a diverse sample based on age, livelihood activities, gender  
179 and experiences as to make it representative and minimizing bias.

180

### 181 **2.3.3 Field Observation**

182

183 Field observation involved transect walk with villages executive officers to different area of  
184 mangrove forests, observing, asking and listening to the explanations based on the theme of  
185 the study. Photographs were taken using a digital camera to record the state of mangrove  
186 forests. This method was used as check and to validate the information obtained from  
187 questionnaire and focused group discussion.

188

## 189 **2.4 Secondary data collection**

190 Collection of secondary data involved review of different published and unpublished reports  
191 and documents which are relevant to the theme of the study. Climatic data of annual rainfall  
192 and temperature for the past 30 years (1985-2015) was collected from Tanzania  
193 Metrological Agency Headquarter (TMA) to study their trends and to confirm the perceptions  
194 of respondents on the trend of rainfall and temperature to the study sites. Annual rainfall and  
195 temperature was retrieved from Bagamoyo and Kibaha meteorological station respectively.  
196 This was because, Bagamoyo meteorological station records only rainfall data and it was  
197 suggested by TMA technical staff (Headquarter) responsible for data that, to use  
198 temperature data from the nearest station which was Kibaha meteorological station.

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203 **2.5 Data analyses and presentation**

204 Data was analysed both quantitatively and qualitatively. Qualitative data from focus group  
 205 discussion and open-ended questions was analysed by descriptive and content analysis in  
 206 which the information was divided into smallest meaningful units of themes and summarized  
 207 to supplement important information with respect to the objectives of the study.

208  
 209 Data from closed-ended questionnaire was analysed quantitatively using Statistical Package  
 210 for Social Science software (SPSS) version 20 and Microsoft Excel. Temperature and rainfall  
 211 data from TMA was analysed using Microsoft Excel.

212  
 213 Information from observation was used to describe the nature of problem concerning climate  
 214 change adaptation options on mangrove resources especially on extent of forest degradation  
 215 and management. To supplement the data which was collected, photographs taken from the  
 216 study area were used to illustrate the nature and extent concerning the theme of the study.  
 217 The information gathered from data analysis were summarized and presented in term of  
 218 tables and figures organized around major study theme.

219  
 220 **3. RESULTS AND DISCUSSION**

221  
 222 **3.1 Typology of sample population**

223 **3.1.2 Age and origin**

224 Age was an important variable in this study, because different age groups have different  
 225 perceptions regarding climate change impacts on different livelihood activities. An analysis of  
 226 age distribution of the sample population in Kaole, Mbegani and Kondo village ranged  
 227 between 20 and 60+ years (Table 1). The population was dominated by youths and the  
 228 middle-aged class of respondents who are the most active working population and few  
 229 elders. Age structure has an implication on different natural resources management and  
 230 utilization including mangroves. The study of [33] revealed that, due to poor crop production  
 231 and unreliable rainfall, most of productive youths in the coastal communities in Bagamoyo  
 232 District had employed themselves in unsustainable harvesting of forest products such as  
 233 selling poles and making charcoal.

234 The current study revealed that, 82.5 % of respondents in Kondo, 61 % in Kaole, and 34.1 %  
 235 in Mbegani were the original inhabitants of the areas. The remaining 65.9 % in Mbegani, 39  
 236 % in Kaole, and 17.5 % in Kondo were migrants from other villages and parts of the country.  
 237 The main reasons given for immigration included; access to land for agriculture, fishing and  
 238 employment from government or private sectors such as Fisheries Education and Training  
 239 Agency (FETA) in Mbegani.

240 **Table 1:** Age distribution of the respondents (%)

Age (years)	Village		
	Kaole	Mbegani	Kondo
20-30	14.3	12.2	2.5
30-40	19.5	24.4	10.0
40-50	22.0	34.1	25.0
50-60	20.8	22.0	22.5
60+	23.4	7.3	40.0
<b>Total</b>	100	100	100

241

242 Distribution of duration of stay in the village in the interviewed sample population revealed  
 243 that, 79.2 % of respondents in Kaole, 56.1 % in Mbegani and 97.5 % in Kondo had stayed in  
 244 their villages for more than 20 years, while the remaining 20.8 % of respondents in Kaole,  
 245 43.9 % in Mbegani and 2.5 % in Kondo had lived for less than 20 years (Table 2). A twenty-  
 246 year time-frame has been adopted for other studies in Uganda [34] and Ethiopia [35].

247 Information on place of origin and time spent by respondents in the study sites was  
 248 important because it indicates the degree of familiarity with various issues concerning the  
 249 theme of the study. For example, the study conducted by [35], in South Ethiopia revealed  
 250 that those respondents (96%) who had lived for twenty years in the study sites were more  
 251 familiar with issues of climate change on their localities. Therefore, having stayed in the area  
 252 for a considerable time makes respondents more knowledgeable in providing reliable  
 253 information on the concerns of the study.

254 **Table 2:** Average years lived by respondents in surveyed villages (%)

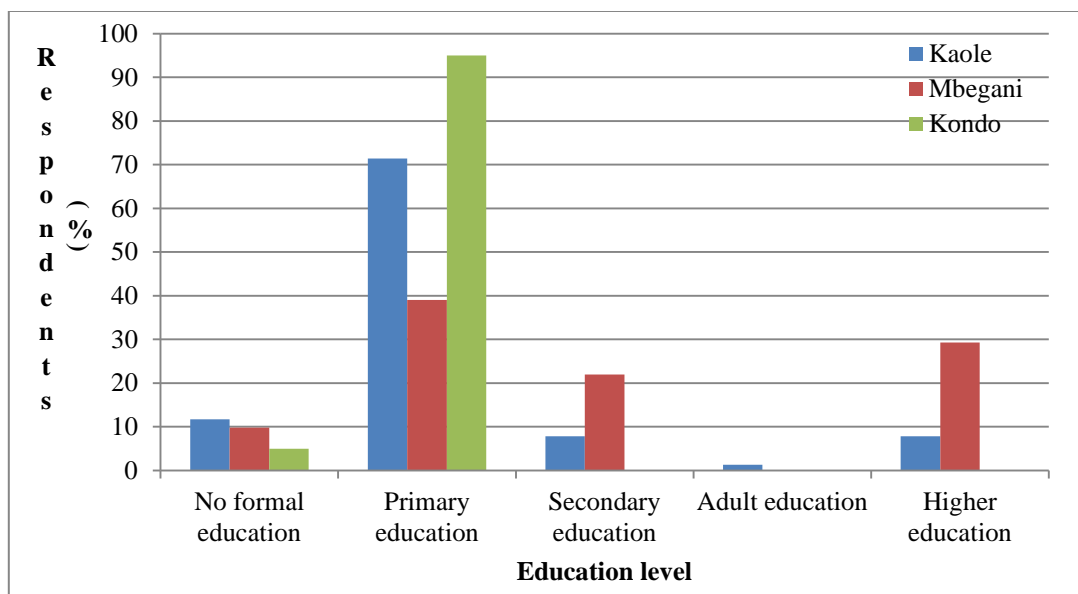
Duration of stay in the village	Village		
	Kaole	Mbegani	Kondo
More than 20 years	79.2	56.1	97.5
Less than 20 years	20.8	43.9	2.5
<b>Total</b>	100	100	100

255

256 **3.1.3 Education level of the respondents**

257 Information collected on education using questionnaires revealed that, education level  
 258 among the respondents varied ranging from no formal education to college level education  
 259 termed as higher education level (Figure 2). Majority of respondents in both surveyed  
 260 villages had completed the primary education. Respondents from Mbegani have higher  
 261 education level because most of them were trainers at FETA. Information on an individual  
 262 level of education was important in this study, because in most cases better education level  
 263 can enhance one's capacity to critically analyse and deal with environmental issues  
 264 including climate change and its related impacts [36].

265 The number of years spent in schools is often associated with acquisition of knowledge and  
 266 skills whereas insufficient education is highly correlated with individual's lack of skills and  
 267 ignorance. The study of [37], revealed that individuals with low level of education especially  
 268 those who have no education at all or who have not completed primary school have low per  
 269 capital expenditure hence more vulnerable to climate change impacts. This implies that,  
 270 education is the most important tools for liberation of people from poverty and enhancing  
 271 adaptive capacities for socio-economic and sustainability of natural resources in a changing  
 272 climate.



273

274 **Figure 2:** Education level of respondents

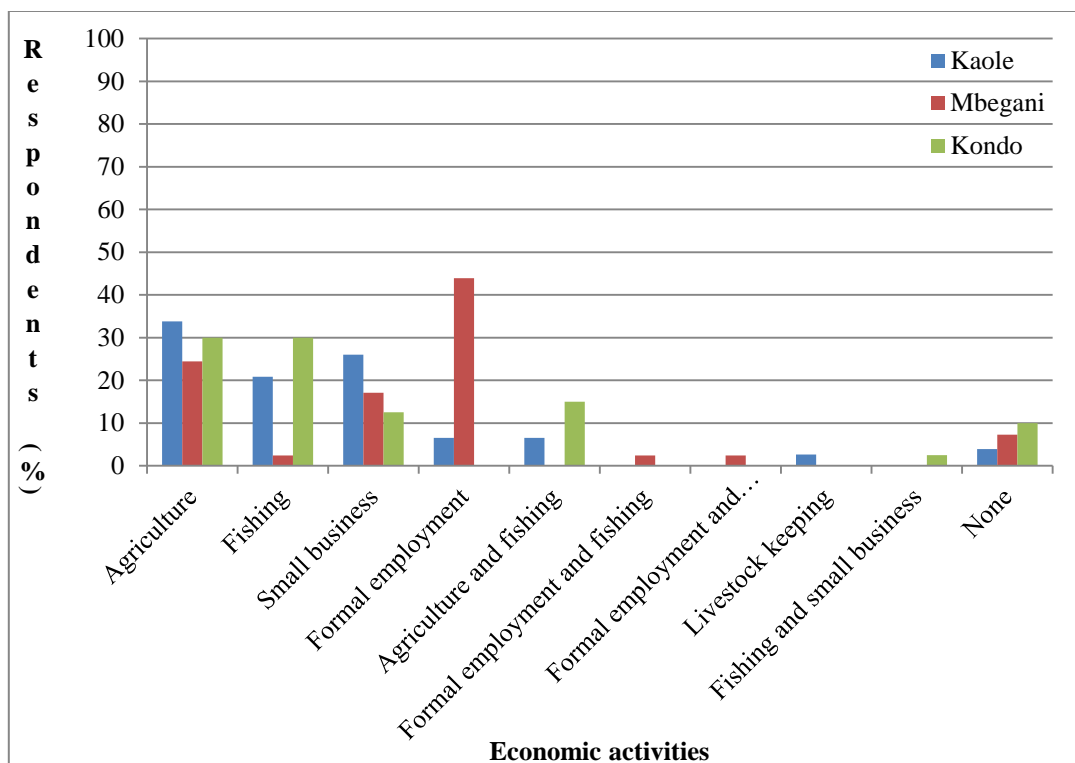
275 The implication of the reportedly low education level among respondents (especially  
 276 Mbegani and Kondo) is that, higher proportion of them may not be engaged in formal  
 277 employment, hence increasing their dependence on climate sensitive livelihood activities  
 278 such as rain-fed agriculture where they become more vulnerable to climate change.

279 **3.1.4 Economic activities**

280 Economic activities as sources of generating income are crucial in understanding level of  
 281 community dependence on natural resources and management practices. Crop cultivation  
 282 and fishing were the most dominant economic activities in the surveyed villages (Figure 3).  
 283 However, the type of the identified economic activities varied significantly from one village to  
 284 another. It was revealed that, the residents of Kaole depends more on crops cultivation (33.8  
 285 %) and less on livestock keeping (2.6 %), as well as formal employment (6.5%) while the  
 286 residents of Mbegani depends more on formal employment (43.9 %), at Fisheries Education  
 287 and Training Agency (FETA, Mbegani) and less on practicing both formal employment and  
 288 livestock keeping (2.4 %). Inhabitants of Kondo village depends more on agriculture (30.0 %)  
 289 and fishing (30.0 %) and less on practicing both fishing and small business (2.5 %). It was  
 290 identified that, some of the community members were engaged in more than one economic  
 291 activity for their survival. The study revealed that, 3.9 % of respondents in Kaole, 7.3 % in  
 292 Mbegani and 10.0 % in Kondo were not engaging themselves in any economic activities  
 293 because they were old aged above 75 years.

294 The variation in the levels of dependence on identified livelihood activities among residents  
 295 of these villages are influenced by number of factors, including; proximity to ocean and town,  
 296 presence of arable land and level of education. This imply that, large number of residents in  
 297 surveyed villages still depend directly on climate sensitive livelihood activities including  
 298 agriculture and fishing that position them to be more vulnerable to a changing climate. The  
 299 majority of people in most part of Africa are still depending on climate sensitive livelihood  
 300 activities as revealed in different studies of [9, 38-41].





301

302 **Figure 3:** Economic activities of the respondents

303 **3.2 Perception of local community on climate change**

304

305 Information on respondent's perception on indicators and impacts of climate change was  
 306 important as it influences the way community members respond to climate change impacts.  
 307 Based on these grounds, an inquiry was made on how the local community members in  
 308 Kaole, Mbegani and Kondo perceived climate change.

309 To establish this, respondents were asked to state a number of variables which are  
 310 associated with climate change. The findings revealed that, majority of respondents in Kaole  
 311 (85.7 %); Mbegani (97.6 %) and Kondo (100 %) had sufficient knowledge and awareness  
 312 concerning climate change (Table 3). Studies on local people's perceptions and awareness  
 313 on climate change and its associated impacts have been conducted in different countries  
 314 including Bangladesh [42], Wales [43], Ethiopia [35], Zambia [44], and Tanzania [33,38-39]  
 315 and it was revealed that higher proportion of the respondents were aware of climate change  
 316 issues.

317 **Table 3:** Respondents' awareness on climate change (%)

Respondents' awareness	Village		
	Kaole	Mbegani	Kondo
<b>Changing</b>	85.7	97.6	100
<b>Not changing</b>	14.3	2.4	-
<b>Total</b>	100	100	100

318

319 Further probe into major contributor of climate change revealed that, the majority of  
320 respondents from Kaole (72.7 %), Kondo (70 %) and Mbegani (43.9 %), ranked rainfall as  
321 the major indicator of climate change. The remainder of respondents in both villages termed  
322 climate change indicator(s) as an increase of earth's surface temperature, outbreak of  
323 diseases, and increase in extreme climatic related events or combination of all or among  
324 identified variables. Different responses among respondents on the possible indicator of  
325 climate change have been highlighted in different studies. The climate change survey in  
326 Bangladesh conducted by [42] revealed that 42 % of the respondents perceived climate  
327 change as flood, while 37 % stated that it meant storm or cyclone and 22 % stated drought  
328 as signifying climate change.

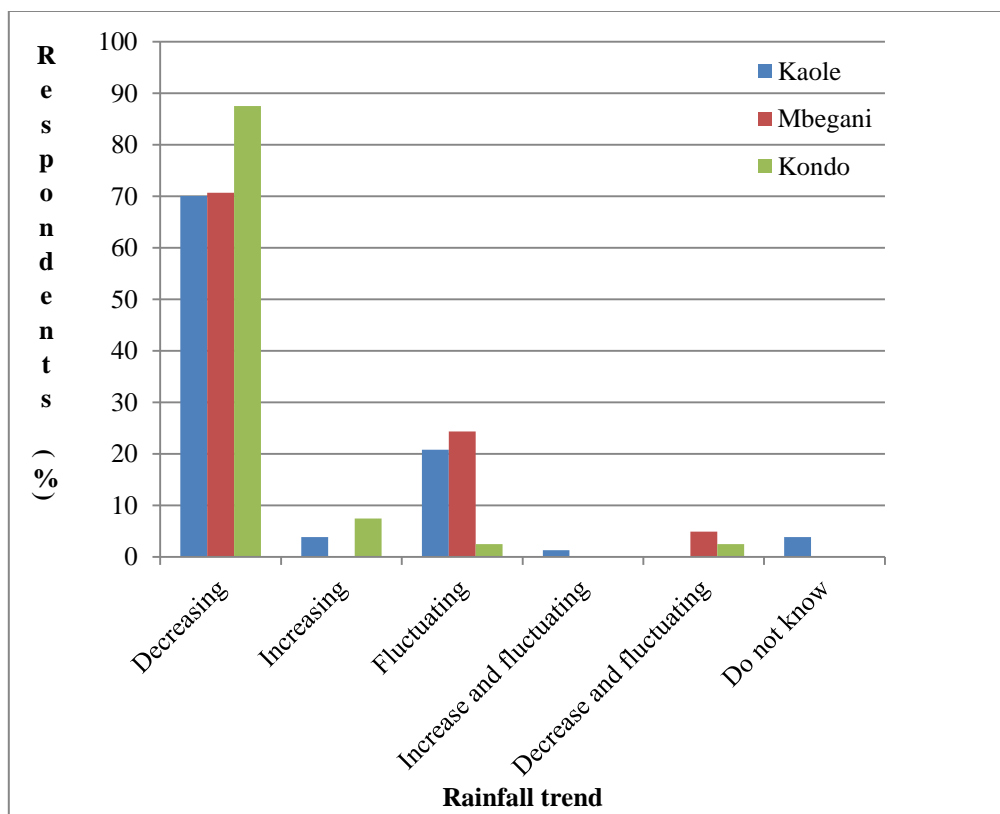
329 Moreover, the findings of [36] in Bangladesh, revealed that 53.9 % of the respondents  
330 perceived climate change as a change in the pattern of rainfall, while 43.2 % stated it as an  
331 occurrence of colder winter than the usual cold, and 36.5 % attributed climate change with  
332 higher incidence of cyclones or tidal waves. Also, the study of [9] in selected coastal  
333 communities of Bagamoyo (Mlingotini, Pande and Kondo), revealed that 87.5 %, 93.3 %,  
334 74.1 % and 55.8 % of respondents perceived climate change as unusual rainfall, drought,  
335 floods and increased incidence of pest and diseases respectively.

336 In addition to that, the study of [33] in the coastal communities of Bagamoyo (Pande,  
337 Kidomole, Saadani and Matipwili) revealed that large proportion of the interviewed  
338 respondents perceived rainfall as indicator of climate change. This variations among  
339 community's perception on climate change is explained on the basis of the major climatic  
340 element(s) which have an influence on the livelihood of the respective community (Lyimo et  
341 al., 2013).

342 However, despite the high number of residents in the current study sites seeming to be  
343 aware on issues concerning climate change; further efforts on disseminating education on  
344 environmental issues and climate change is needed to enhance understanding that will  
345 advance their adaptive capacity.

### 346 **3.3 Rainfall and temperature trend since 1980's**

347  
348 Information from local community perceptions on rainfall and temperature trend was  
349 important to establish the basis of climate change impacts and adaptations options in the  
350 surveyed villages. This study revealed that 70.1 % of the respondents in Kaole, 70.7 % in  
351 Mbegani and 87.5 % in Kondo reported a relative decrease of precipitation, while the  
352 remaining percent reported that rainfall has either been increasing, fluctuating or some of  
353 them did not know the trend of rainfall (Figure 4).



354

355 **Figure 4:** Local community perceptions on rainfall trend

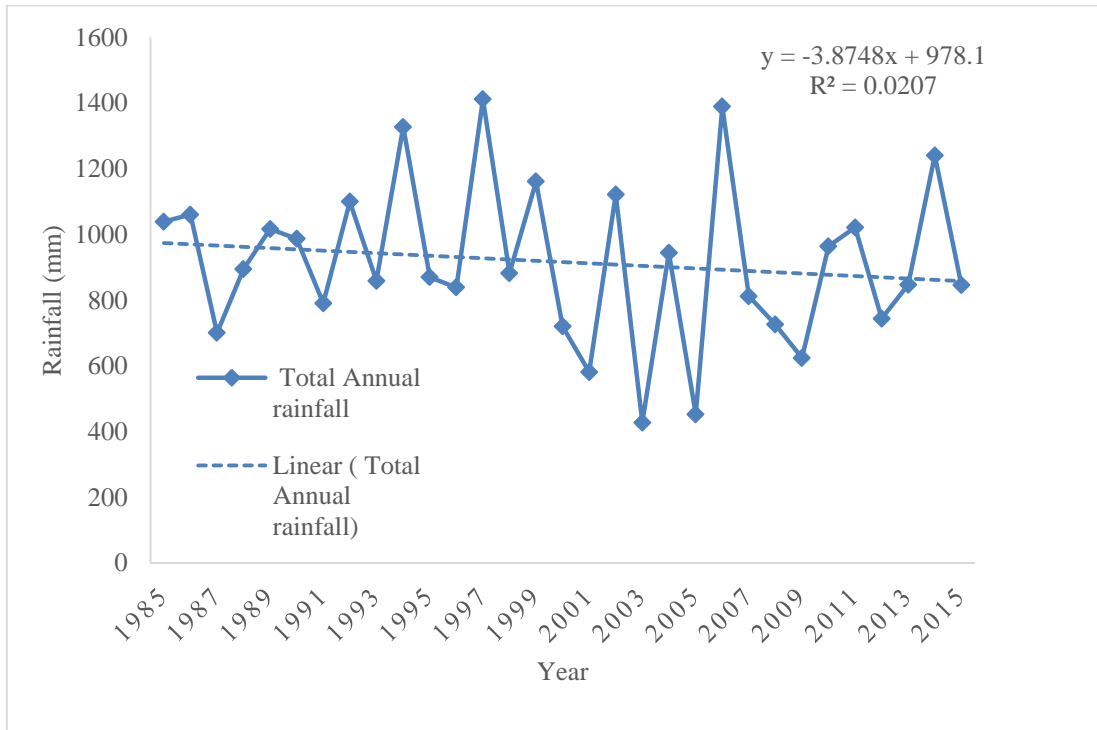
356 These responses correlate with rainfall statistical findings from Bagamoyo meteorological  
 357 station (Figure 5) and data on the rainfall trend in the study area show high variability and  
 358 this trend is supported by different studies. For example, the findings of [45] in semi-arid  
 359 areas (Tabora Urban and Uyui Districts) revealed that the majority of the interviewed  
 360 respondents (97 % farmers and 100 % research and extension officers) agreed on the  
 361 decline of rainfall on their areas for the past ten years and pointed out that the bad years  
 362 were becoming more frequent than before which is supported by the meteorological data  
 363 (1973-2008).

364 The study of [33] in the coastal communities in Bagamoyo District, revealed the positive  
 365 correlation between respondent's perception on rainfall trend and meteorological data  
 366 whereby the area is subjected to high rainfall variability in term of spatial and temporal  
 367 distribution. Another study of [46] in coastal forest dependent communities pointed out the  
 368 strong decadal variability with decreasing trend and total number of seasonal rain days  
 369 which confirmed the community's perception on rainfall trend.

370 Moreover, according to [47] on regional climate projections stated that the region of East  
 371 Africa including the coastal areas would experience an increase in annual mean rainfall.  
 372 However, the study of [48] revealed that coastal areas of Tanzania has been facing a decline  
 373 in annual mean rainfall for the past half century which correlated to the community's  
 374 perceptions and metrological data of this study.

375 On the basis of these supporting findings, the coastal and other parts of Tanzania are  
 376 experiencing the great decline in spatial and temporal rainfall distribution which has  
 377 compromised the rainfall dependent livelihood activities including agriculture.

378



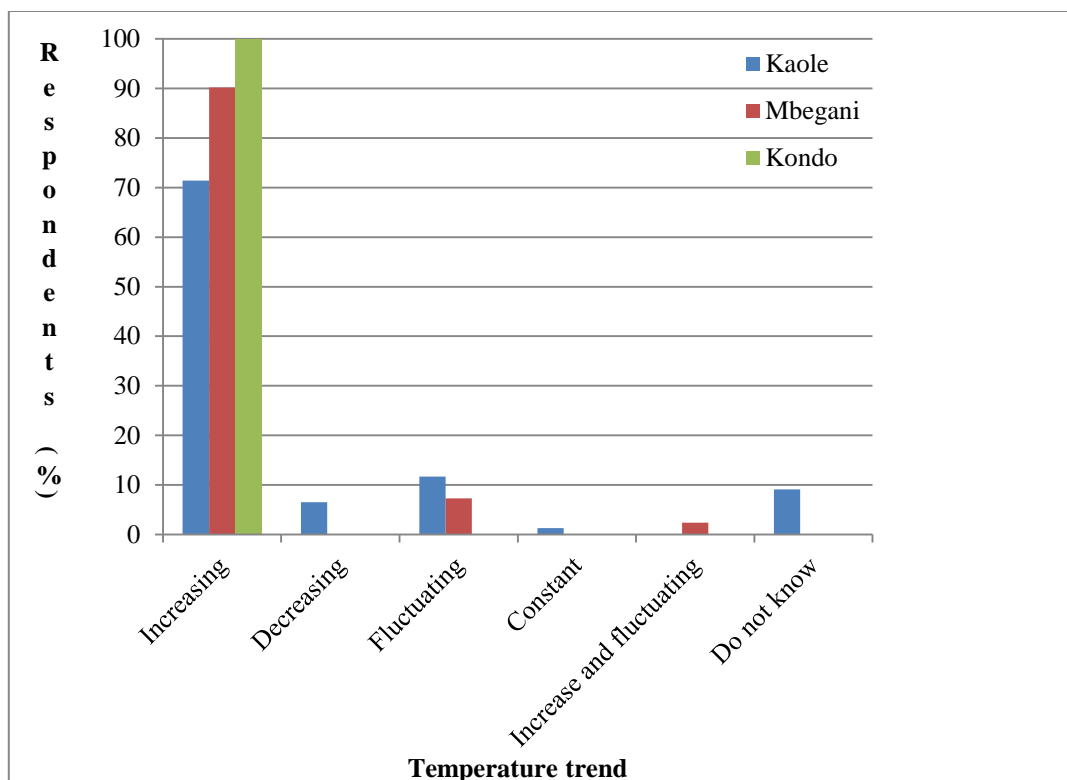
379

380 **Figure 5:** TMA documented annual rainfall trend in Bagamoyo District 1985-2015

381 Moreover, the majority of respondents in the surveyed villages were reported that earth's  
 382 surface temperature has been increasing. As shown in (Figure 6) findings of this study  
 383 revealed that, 71.4 % of respondents in Kaole, 90.2 % in Mbegani and 100 % in Kondo  
 384 reported a relative increase of earth's surface temperature. The remaining percentage of  
 385 respondents stated that it was decreasing, fluctuating or a combination of the two  
 386 parameters while others did not know anything.

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390 **Figure 6:** Local community perceptions on temperature trend

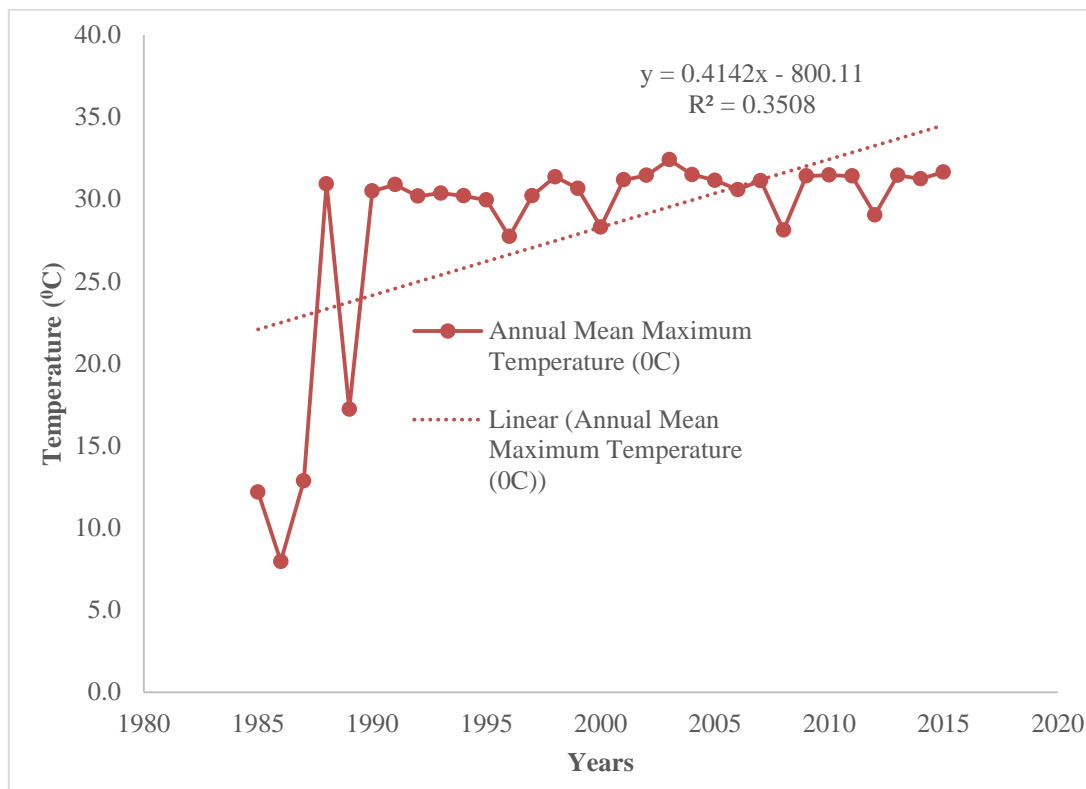
391 These responses correlate to meteorological statistical data from Kibaha station as indicated  
 392 in figure 7, whereby the earth's surface temperature recorded from 1988 to 2015 show an  
 393 average increase of  $0.8^{\circ}\text{C}$  ( $y = 0.4142x + 21.655$ ).

394 This average increase in surface temperature in the study area is also supported by the [3]  
 395 report on global surface temperature, which reported that the total combined land and ocean  
 396 temperature have increased by an average of  $0.85^{\circ}\text{C}$  from 1880-2012. According to [49] the  
 397 warming has been greater over land than ocean since 1901's and the global surface  
 398 temperature have increased from 1970's whereby on the last three decades there has been  
 399 a significant warming of the earth's surface than all preceding decades since 1850.

400 Moreover, different studies have indicated an increase of surface temperature in Africa. The  
 401 study of [50] revealed an increase in average surface temperature of  $+0.76^{\circ}\text{C}$  from 1971 to  
 402 2010 in the semiarid zone of north-eastern Nigeria. Another study by [51] in North Central  
 403 Nigeria revealed that there was a positive correlation on respondent's perception on  
 404 temperature trend (71.9 %) and data from meteorological station which showed a maximum  
 405 increase of  $0.49^{\circ}\text{C}$  for the past 30 years (1980-2009).

406 The possible factor for an increase in minimum mean surface temperature along the coast of  
 407 Tanzania have been described [52] pointed out that the warming period of the past 50-years  
 408 oscillation events (ENSO and IOD) and increase in cloudy cover for the past half century  
 409 have exacerbated an increase of surface temperature along the coastal of Tanzania in view  
 410 of climate change scenario.

411 Therefore, despite of meteorological data being collected from different geographical area,  
 412 there is an increase in the average earth's surface temperature as stated by respondents in  
 413 this study.



414

415 **Figure 7:** TMA documented trend in annual mean maximum temperature 1985-2015

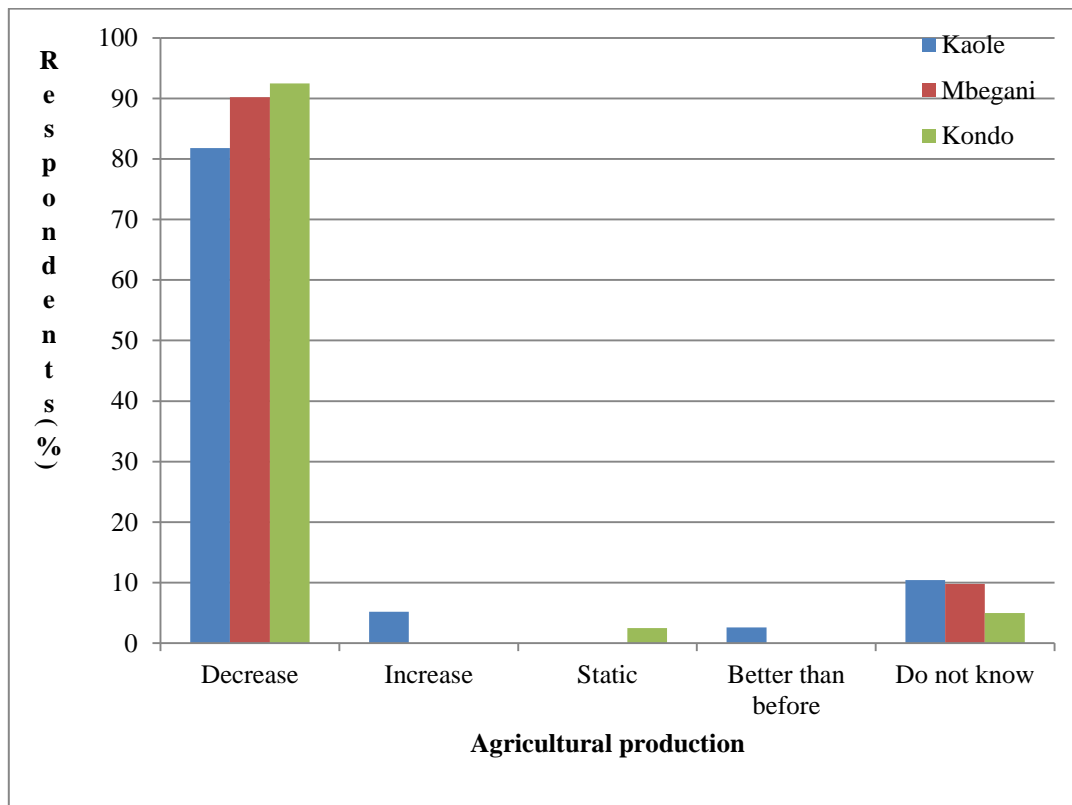
416 This result implies that; local people are able to predict the climate change and variability in  
 417 their area which is a basic precondition for climate change adaptation. Therefore, the finding  
 418 on rainfall and temperature trend in this study reflects that, community member(s) who  
 419 depends heavily on climate sensitive livelihood activities are likely to be vulnerable to climate  
 420 change impacts including persistent drought and other effects of increased earth's surface  
 421 temperature such as plant pest and diseases.

422 **3.4 Agriculture and Fishing activities in a changing climate**

423 **3.4.1 Agriculture**

424 Agriculture was one of the economic activities carried out by residents of the surveyed  
 425 villages. Findings of this study revealed that, 81.8 % of respondents in Kaole, 90.2 % in  
 426 Mbegani and 92.5 % in Kondo reported a decrease in agricultural production especially  
 427 cassava and rice which are the most commonly planted crops and the conditions were  
 428 becoming worse (Figure 8). Moreover, the study revealed that, 64.9 % of respondents in  
 429 Kaole, 53.7 % in Mbegani and 90.0 % in Kondo associated the decline of agricultural  
 430 production with shortage and unpredictable rainfall. Different studies reported that the  
 431 decline of agricultural production conducted in Ethiopia [35] and Tanzania [6,9,33,38,45,46]  
 432 was perceived by majority of respondents to be caused by shortage and unpredictable  
 433 rainfall. However, [53] had pointed out that the decline of soil fertility and inadequate fertilizer

434 inputs were the causes of decline of agricultural production in Africa including Tanzania.  
 435 Furthermore, this study revealed that, the surveyed community still depended on rain fed  
 436 agriculture. If there will be no any interventions to put in place to advance agricultural  
 437 techniques such as irrigation, these surveyed villages will face food insecurity. Eventually  
 438 this would compromise their socio-economic development and extreme use of available  
 439 resources including mangroves to sustain their livelihood as an adaptation option.



440

441 **Figure 8:** Respondents perceptions on agriculture production

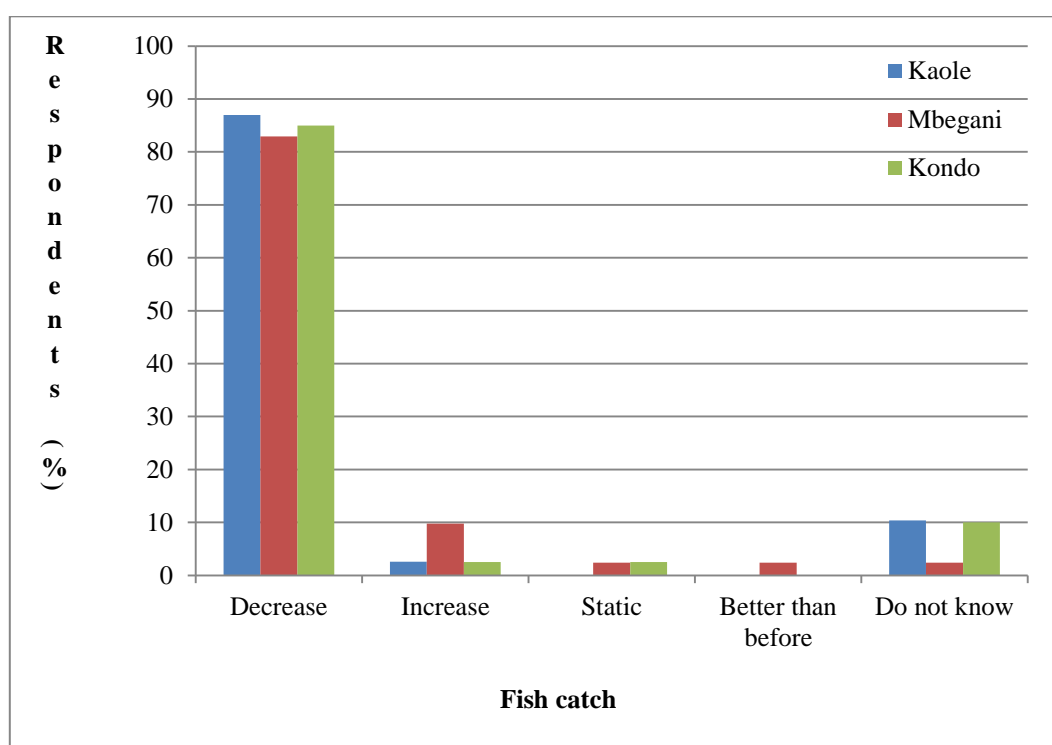
442 **3.4.2 Fishing**

443 Most of the Coastal communities depend on fishing activities for income generation to  
 444 sustain their livelihood needs [41]. In this study, it was revealed that, 87.0 % of respondents  
 445 in Kaole, 82.9 % in Mbegani and 85.0 % in Kondo reported the shortage of fish catch in  
 446 ocean in comparison to the past 20 years. It was also revealed that, 53.2 % of respondents  
 447 in Kaole, 12.2 % in Mbegani and 25.0 % in Kondo did not know the cause for decline of fish  
 448 catch. It was revealed that, 39.0 % of respondents in Mbegani and 22.5 % in Kondo  
 449 associated the decrease in fish catch with an increase of illegal fishing techniques, including  
 450 the use of dynamite bombs, small sized fishing net and poison from "*utupa*" *Tephrosia spp*"  
 451 (Figure 9). However, during FGDs in both villages it was reported that, an increase in sea  
 452 water temperature was another factor implicated for decline in fish catch because fish have  
 453 to migrate in deeper water where it is still cool. The study of [9] had revealed the possible  
 454 non-climatic factors for decline of fish catch from the respondents to be; use of poison in  
 455 fishing, natural variability and seasonality of fish catch, increase in fishing activities and use  
 456 of dynamite. In addition to that, [9] reported that, respondents in the selected villages of  
 457 Bagamoyo Coast could not associate climate change impacts with declining fish catch. The  
 458 study of [33] had revealed that over fishing and climate change was implicated with the

459 decline of fish catch in Bagamoyo. Furthermore, the findings stated that, changing in climatic  
 460 factors especially rainfall patterns and wind velocity was mentioned by respondents as a  
 461 possible driver for decline of fish catch. During the season of adequate rainfall, fish catch  
 462 increased because of high accumulation of fish-feeding material deposited by inland run-off  
 463 to the ocean (Ibid).

464 In addition to that, [41] reviewed a number of studies related to the fishing industry in a  
 465 changing climate in coastal areas and revealed that, climate change can affect biological  
 466 and ecological parameters of fisheries through; change of wave action and wind velocity,  
 467 change of water temperature, coral reef bleaching and sea level rise.

468 Therefore, the findings of this study reflect the need for an extra effort from government and  
 469 other stakeholders to provide enough education on the possible causes for decline of fish  
 470 catch and to empower fishermen to conduct their fishing activities using sustainable methods  
 471 to improve their socio-economic development and to enhance sustainable natural resources  
 472 use and management for livelihood improvement and stability of coastal biodiversity.



473  
 474 **Figure 9:** Respondents perceptions on status of fish catch

475 **3.5 Climate change adaptation options identified in the surveyed villages**

476 Adaptation to climate change can contribute to the well-being of people as well as the  
 477 maintenance of biodiversity for ecosystem services now and in the future while the mal-  
 478 adaptation will compromise their integrity [3].

479 This study revealed different climate change adaptation strategies conducted by member(s)  
 480 of the community. Findings obtained through questionnaires revealed that, 40.3 % of the  
 481 respondents in Kaole and 34.1 % in Mbegani engaged in different casual labour including;  
 482 driving of motorcycles “*bodaboda*”, small business of petty shops and frying chips, temporary



483 migration to nearby towns, working in construction sites either within or outside their villages,  
484 engaging in temporary works in farms, vegetables growing for selling as well as an increase  
485 of collection and selling of the brackish-water snail *Terebralia palustris* "tondo" which  
486 fishermen use as fishing baits.

487 Also, the study revealed that, 22.1 % of the respondents in Kaole, 26.8 % in Mbegani and  
488 12.5 % in Kondo adapted to shortage of fish catch by modifying their fishing activities.  
489 Modification of fishing activities included; increase in use of high powered motors in their  
490 fishing boats, fishing in groups in deeper sea, use of modern lighting torches and special  
491 bulb that is inserted in water for attracting fish "*uvuvi wa birubiru*" and increased use of spear  
492 fishing technique. The study of [33] revealed increasing frequency of fishing (twice per day),  
493 use of improved motorized boats and fishing nets as adaptation mechanism in Pande and  
494 Matwipili villages in Bagamoyo District.

495 As stated by one member of FGD in Mbegani village:

496 *"We are now using a new special bulb that is able to produce enough light when inserted in*  
497 *water, in trying to attract and increase fish catch in addition practicing spear fishing method*  
498 *because we use any means to get fish"*

499 Also, as stated by one member of FGD in Kaole village:

500 *"For the recent years, we have been experiencing decline in fish catch compared to the past*  
501 *twenty years that forced fishermen (in groups) to stay in the ocean even for more than three*  
502 *days consecutively aimed at catching reasonable amount of fish"*

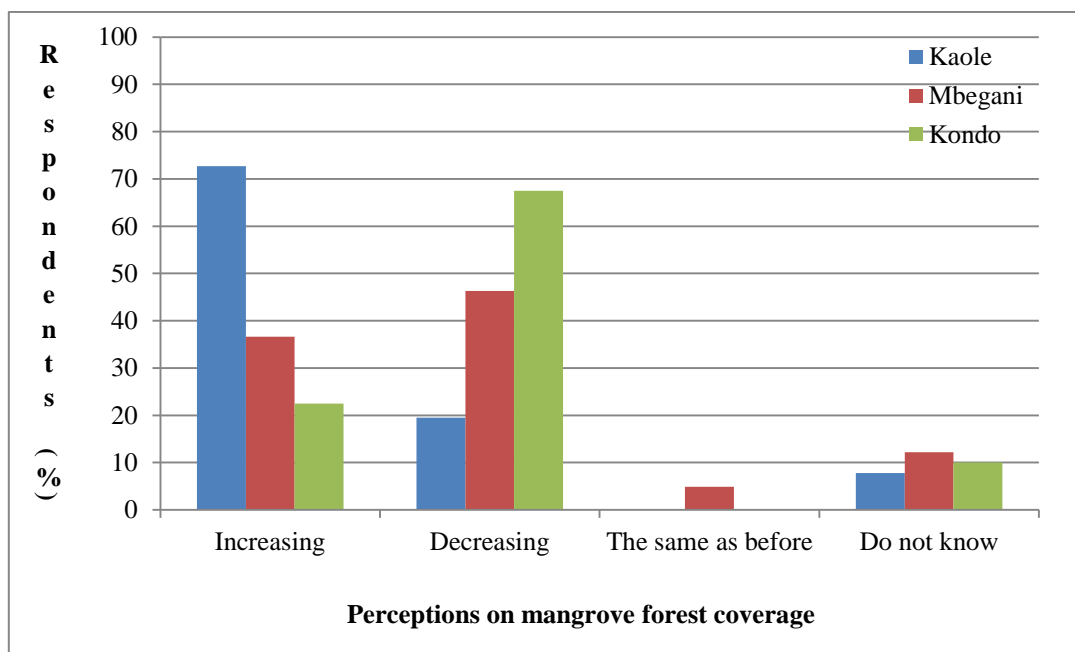
503 The, findings of this study revealed that, 19.5 % of respondents in Kaole, 7.3 % in Mbegani  
504 and 10.0 % in Kondo adapted towards decline of agricultural production by increasing  
505 acreage for maximization of crops production. However, it was reported during FDGs in both  
506 villages that, using this kind of adaptation strategy is no longer preferred by farmers since  
507 the land of coastal areas of Bagamoyo is becoming un-accessible for agriculture because  
508 there are too many socio-economic investments initiatives such as the proposed Mbegani  
509 port, EPZ and rich people who buy and hold large areas of which during the past year the  
510 land was mostly for agriculture use and local settlement. The remaining percentage of  
511 respondents asserted to adapting by using industrial fertilizer, pesticides, and planting early  
512 maturing and drought resistant crops such as cassava, sorghum and some local varieties of  
513 rice. Also, this study revealed that 45% of respondents in Kondo did not know whether they  
514 were adapting to impacts of climate change or not.

515 According to [3], adaptation is context-specific and place based. From this basis, there are a  
516 number of studies which have identified different adaptation options carried out by different  
517 communities. For example, the study of [45] in semi-arid of Tanzania, revealed different local  
518 climate change adaptation options such as livelihood diversification including charcoal and  
519 brick making, cultivation of alternative crops, expansion of area for cultivation, planting of  
520 drought resistance crops such as cassava and sorghum. [54] conducted a review of  
521 different studies concerning farmers' perceptions and adaptations to climate change in sub-  
522 Sahara Africa. The study revealed that farmers including those found in Southern and East  
523 Africa have developed water conservation methods such as water harvesting, waste water  
524 re-use in agriculture and crop irrigation. However in the study sites of this study none of  
525 them was (were) not observed but small scale for homestead irrigation was reported by  
526 Mkama et al. (2013) in Kiharaka and Pande village of Bagamoyo district.

527 Therefore, these findings indicate that despite of agriculture and fishing being major  
 528 economic activities in the surveyed villages, there is reasonable number of residents who  
 529 employed themselves in casual activities to sustain their lives. For that reason, it is high time  
 530 for the government and other stakeholders to empower these residents with both material  
 531 and non-material support to improve socio-economic and sustainable use and management  
 532 of the available natural resources. This will enhance their adaptive capacity and  
 533 improvement of human-environmental resilience to impacts of climate change.

534 **3.6 Current status of mangrove forest coverage**

535  
 536 Information from local residents on mangroves was important to establish the current status  
 537 of mangrove forest coverage because documented data on mangrove forest coverage from  
 538 department of forestry in Bagamoyo District was limited as explained by district forestry  
 539 officer. However, because of financial constraints it was not possible to supplement the  
 540 information collected from respondents by using Landsat map as it was used in the study of  
 541 [55,56]. Therefore, in this study, mangrove forest coverage refers to an increase or decrease  
 542 in size of mangrove forest. The study revealed that, 72.7 % of respondents in Kaole reported  
 543 an increase in mangrove forest coverage; while the remaining percent of respondents (19.5  
 544 %) reported a decrease and others (7.8 %) did not know the status of mangrove forest. It  
 545 was also revealed that, 46.3 % of respondents in Mbegani and 67.5 % in Kondo reported a  
 546 decrease in mangrove forest coverage, while 36.6 % of respondents in Mbegani and 22.5 %  
 547 in Kondo reported an increase of mangrove forest coverage (Figure 10). This result, point  
 548 out an overall increase of mangrove forest coverage in Kaole but a decrease of mangrove  
 549 forest coverage in Mbegani and Kondo.  
 550



551  
 552 **Figure 10:** Local people perceptions on current status of mangrove forest coverage  
 553  
 554

555  
 556  
 557

558 **3.6.1 Implications of climate change adaptation options on the current mangroves**  
 559 **status in Kaole village**

560

561 Information concerning the current status of mangrove forest in Kaole village was collected  
 562 from local resident's perceptions, and it was reported that coverage of mangrove forest has  
 563 increased (Figure 10), and different factors in relation to climate change adaptation options  
 564 were identified.

565 The study revealed that, 40.3 % of the interviewed respondents in Kaole village has  
 566 engaged in different livelihood activities (section 3.5). These activities are mostly carried out  
 567 by youths and middle aged people who conduct these activities either within or near village  
 568 and town centers including Bagamoyo town. According to [6], areas with different alternative  
 569 livelihood sources which are non-climate change sensitive are characterized with high  
 570 adaptive capacity and natural resource management. Therefore, the identified adaptation  
 571 activities in Kaole has relatively reduced over dependence on mangroves for charcoal  
 572 making and firewood business as an alternative source of income and the surveyed forest  
 573 was found to be less disturbed (Plate 1).



574

575 **Plate 1:** Photograph showing part of Kaole mangrove forest

576

577

578 The study revealed again the role of community member(s) who participate in collection of  
 579 the brackish-water snail *Terebralia palustris* "tondo". It was reported that, there has been an  
 580 increase in number of residents whom previously were farmers and fishermen but now were  
 581 collecting "tondo". *Terebralia palustris* is collected from sediments of mangrove forest and  
 582 those who collect have been involved in protection of mangrove forest from illegal  
 583 exploitation because they spent most of their day time in the mangroves.

584

585 As stated by one member of FGD:

586 "Fish catching and agricultural production have been decreasing year after another, life has  
 587 become worse and we have opted to engage in collection and selling of "tondo" to sustain  
 588 our daily needs; and for that reason, we protect our mangrove forest because without it, we  
 589 will not be able even to buy exercise books for our children"

590 Another possible reason for mangrove forest of Kaole village to be relatively less degraded  
591 was the role played by environmental and mangroves management committee of Kaole in  
592 collaboration with Bagamoyo district department of forestry. The study revealed the  
593 existence of relatively regular patrols in mangroves forest, conducted by members of  
594 mangrove management and environmental committee. It was reported in this study that, in  
595 recent years (5 years back) there has been an emphasis through environmental education  
596 provided to the community on the importance of mangroves conservations and each of  
597 residents to be a watch man for one another aimed to reduce and even cut-off illegal  
598 utilization of mangroves. The collaboration between environmental and mangrove  
599 management committee in Kaole and district forestry department has progressed because of  
600 close cooperation between Kaole and the forestry department in addition to accountability  
601 among leaders of mangroves conservation committee. Close cooperation and accountability  
602 was revealed to be initiated by neighborhood of Kaole village and Bagamoyo district forestry  
603 department. The inter-comparison of village adaptive capacity conducted by [6] pointed out  
604 that, for those villages situated near Bagamoyo town (Dunda, Pande and Makurunge) they  
605 had higher adaptive capacity (fairly strong leadership and highest in natural resource  
606 management) compared to those allocated far away from the town (Kondo and Kiharaka).

607

608 Moreover, the study also revealed the presence of mangroves restoration program in Kaole.  
609 It was reported that, environmental and mangroves management committee, BMU and  
610 residents, collaborates in planting mangroves during winter season “*masika*” when there is  
611 enough deposition of sediments. This activity has contributed to relative increase of  
612 mangrove forest coverage in this study site. Significant increase of mangroves population  
613 through mangrove restoration programmes have been appreciated in different countries  
614 such as, Vietnam [57,58], West Indies [22], Bangladesh [20] and Philippines [21].

615

616 On the other hand, restoration of mangroves has encountered challenges including dying of  
617 a large number of planted mangroves seedlings. During FGD it was reported that, the major  
618 causes for loss of planted mangroves seedlings was the increase in strength of ocean wave  
619 action that swept away the planted seedling and unpredictable rainfall that changed the rate  
620 of deposition of sediments ready for mangrove seedlings to be planted. The study of [59]  
621 revealed that, shortage of precipitation may lead to the decrease of nutrient-inputs in  
622 mangroves sediment from terrestrial runoff and increase salinity of shoreline sea water that  
623 can influence poor growth rate and development of mangroves. Moreover, the study of [60]  
624 revealed that, the large die-off of planted mangrove seedling can be due to poor knowledge  
625 on the influence of mangrove species zonation, because each mangrove species has  
626 different tolerance to environmental factors such as salinity, elevation of the land and tidal  
627 flooding.

628

### 629 **3.6.2 Implications of climate change adaptation options on current mangrove status in** 630 **Mbegani and Kondo villages**

631

632 The study revealed the decline in mangrove forest coverage (as per community member  
633 perception) at Mbegani and Kondo village (figure 10), and different possible factors were  
634 identified. It was reported in this study that, there was an increase of illegal harvesting of  
635 mangroves in Mbegani and Kondo villages for commercial fire wood. [25] revealed that, most  
636 of the coastal communities use small quantities of mangrove resources for local use  
637 although, at commercial level there is as an over exploitation of mangrove resources.  
638 However, this study revealed that, there has been an increase of exploiting mangroves for  
639 firewood “*vibare*”, on large scale which were shipped to Unguja where there is large firewood  
640 market. It was also noted that, this kind of business as an alternative source of income has  
641 been increasing since 1990s when agriculture production and fish catch as major livelihood  
activities started to decline.



642

643 In addition to that, it has been revealed that large-scale clearing of mangrove forests has  
644 negative implications on natural regeneration of mangrove resources [25].

645 There has been an exploitation of mangroves for charcoal making. This was reported in  
646 Kondo and during transect walk along mangrove forest, the forest was dominated by  
647 juvenile, stunted mangroves and many mangrove stumps (Plate 2). Human pressure on the  
648 identified characteristic of the mangroves in the field was also reported by the study of [14].

649

650 Livelihood diversification by the community to cope with impacts of a changing climate was  
651 revealed to be a key reason behind charcoal making as one of alternative sources of income  
652 for sustainability of their lives. Livelihood diversification (as climate change adaptation  
653 mechanism) and its implications on forest use is supported by the study of [46], which  
654 revealed an increased rate of coastal forest degradation of Pugu and Kazimzumbwi forest  
655 reserve.

656



657

658

659 **Plate 2:** Photograph showing part of stunted, juvenile and mangrove stumps in Kondo

660

661 Moreover, the study revealed the role played by mangroves in houses construction. An  
662 increase of birth rate and immigration of people has triggered the need for housing  
663 especially simple local houses. Information collected from questionnaire and FGDs revealed  
664 that, mangroves are still used by the majority of Mbegani and Kondo community for houses  
665 construction. Decrease in agriculture productions and fish catch exacerbated by climate  
666 change has hindered some local residents (poverty exacerbated by changing climate) from  
667 purchasing constructing materials including cement-bricks. Report of [61] in Uganda  
668 revealed that, increase of unpredictable weather conditions has led to poor agricultural yield  
669 and reduced household incomes leading to poverty. The observed high poverty level among  
670 coastal communities of Bagamoyo in the study of [33], revealed the inability of households to  
671 even purchase agricultural inputs. In addition to that, [3] reported an increased rate of  
672 poverty among coastal communities in low latitude countries including Tanzania because of  
673 climate change related impacts in fishing activities. Therefore, poverty exacerbated by a  
674 changing climate together with an increase in demands of local houses construction it

675 accelerates the community to utilize the available mangroves forest for local house  
676 construction.

677

678 Another, reason for a reported degradation of mangroves in study sites is an increase in  
679 exploitation of fishing baits "*Kuchimba daa*" using hand hoes in mangroves sediments. There  
680 has been an increase in fishing activities as means of livelihood diversification in coping with  
681 climate change impacts. The mode of finding fishing baits is not sustainable for mangroves  
682 growth since it involves excavating mangrove sediments leading to cutting-off of mangrove  
683 roots that cause up-rooting, stunted growth and even death of the mangroves. Despite the  
684 government provisioning a special powder as an alternative for easy collection of fishing  
685 baits, the responses of majority to using this powder seemed to be poor. Therefore, there is  
686 a need of providing educations to fishermen on the best techniques to use in finding and  
687 collection of fishing baits without affecting the growth and stability of mangrove forests for  
688 the benefit of coastal biodiversity.

689

690 Moreover, it was revealed that, weak initiatives in mangroves restoration and management  
691 have contributed to the decrease of mangrove forests coverage in Mbegani and Kondo. It  
692 was reported from questionnaires and FGDs that, mangroves restoration program has been  
693 conducted by members of BMU and few community members in unsatisfactory remarks,  
694 whereby lack of enough education on importance of mangrove restoration to community was  
695 spotted as a challenge.

696

697 Furthermore, the study revealed the weakness in protecting mangroves including lack of  
698 regular patrol and establishment of written beacons with an order of offence when found  
699 guilty of an illegal exploitation of mangroves as a way to raise awareness compared to that  
700 seen around Kaole mangrove forest (Plate 3). This finding is in agreement with the study of  
701 [60], which revealed that the level of co-operation between local community and their leaders  
702 have great influence on the structure and function of mangrove resources found in the  
703 respective area. The study of [6] on adaptive capacity among selected coastal villages of  
704 Bagamoyo revealed that, those villages found far away from Bagamoyo town (in terms of  
705 administrative services) scored low in adaptive capacity and natural resource management  
706 below the district average. From this basis, geographical location (in terms of distance) of  
707 Mbegani and Kondo villages from forestry department of Bagamoyo district may have an  
708 influence on weak co-operation among local community and respective leaders at the village  
709 and district level on mangrove resources management.

710



711  
712

713 **Plate 3:** Photograph showing a post with warning words in Kaole mangrove forest

714

#### 715 **4. CONCLUSION**

716

717 Local perceptions and empirical climate data revealed that, climate change in the study sites  
718 are in form of increased annual average temperature and decline of annual average rainfall  
719 since 1980's. Increase of temperature and decline of rainfall for the past 30 years has  
720 contributed for decline of agricultural production and fish catch in surveyed study sites.

721

722 Adaptation to climate change impacts is time specific and location-based and is influenced  
723 by a number of factors including socio-economic status of an individual or community. The  
724 most local adaptive strategies noted included engagement in different casual labour,  
725 expanding farms, use of pesticides and fertilizer as well as modifying fishing activities such  
726 as deep water fishing, use of modern sport light illuminators and special bulb able to produce  
727 light when plunged in water.

728

729 Implications of climate change adaptation option of the community member(s) on mangrove  
730 resources varied from one study site to another. It was reported that mangrove forest in  
731 Kaole seemed to be on an increase compared to the past 20 years. Different possible  
732 adaptation options identified to contribute to the increase of mangrove forest coverage  
733 included; majority engaged in different non-mangrove destructive options e.g. casual labour,  
734 role and commitment of the environmental and management committee, role of some of  
735 community member who engaged in collection of *Terebralia palustris* "tondo" and presence  
736 of mangrove restoration program. However, it was reported that, mangrove forest coverage  
737 has decreased in Mbegani and Kondo whereby the following possible climate change  
738 adaptation were pointed included; illegal harvesting of mangroves for firewood and charcoal  
739 for commercial, over dependence of mangroves for domestic houses construction, increase  
740 of unsustainable exploitation of fishing baits and weak initiative in mangrove management  
741 such as restoration and regular patrol.

742

743 Therefore, it is concluded that most of surveyed community member(s) depends on climate  
744 sensitive livelihood activities and local adaptation strategies used seemed to be  
745 unsustainable for socio-economic and natural resource management (especially in Mbegani  
746 and Kondo) including mangroves. It is high time for the government and other stakeholders  
747 to enhance adaptive capacity of these communities through different climate change related  
748 initiatives for improvement of their socio-economic status and natural resources  
749 management in a world of a changing climate.

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#### ABBREVIATIONS AND ACRONYMS

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IPCC: Intergovernmental panel on climate change; URT: United Republic of Tanzania;  
 UNEP-WCMC: United Nations Environment Programme's World Conservation Monitoring  
 Centre; FAO: Food and Agriculture Organization; FGD: Focused Group Discussion; BMU:  
 Beach Management Unit; FETA: Fisheries Education and Training Agency; ENSO: El Niño  
 Southern Oscillation; IOD: Indian Ocean Dipole; TMA: Tanzania Meteorological Agency