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Climate Change and Adaptation in Pemba Island, Zanzibar: Environmental History – Pre-colonial Period to 1840

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Abstract

Despite vast research on climate change and adaptation in Pemba Island, and Zanzibar at large, little is still known about past climate changes and community adaptation to the ensuing hazards. Existing scholarship on climate change and community adaptation have generally focused on the most recent changes and adaptations. This paper intends to provide a historical understanding of past climate changes and community adaptation to contribute to the current scholarship. It relied on archival data, archaeological and historical reports, observation of existing sucked sites and existing oral traditions to reconstruct climate change adaptation history in the Island. The study found that climate changes have been happening in the Island since time immemorial. The Island experienced fluctuating rainfalls and temperatures that generated long- and short-term changes from wet to dry climatic conditions. The study further found that, for centuries, local communities in the Island suffered the impacts of climate change and innovated varied adaptations to survive. The strategies ranged from prayers to small-scale irrigation. It is argued that although the mechanism driving global climate change today are different from those in the past, the understanding of past adaptations to climate change offers some valuable insights into dealing with current and anticipated future climate changes.

Keywords: *climate change, adaptation, local knowledge, Pemba Island, pre-colonial period*

1. Introduction

In the context of growing concerns on global and regional climate change and adaptation, this paper explores past climate changes and adaptations in Pemba Island (hence, the Island), in Zanzibar. Although climate change was first recognized by climate scientists as a global problem in the late 1980s, it is not a new phenomenon in the East African coast, islands and the world at large (Adger et al*.,* 2003; Chami, 2003). Available literatures show that predictable and unpredictable climatic changes have been there since time immemorial (Adger et al*.,* 2003; Chami, 2003; Hassan, 1997). In the future, it is predicted that

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human societies across the globe will experience increasing climate change, which will have dramatic impacts to their livelihood systems, and undermine their adaptive capacities (Brooks, 2010; Adger et al., 2003; Oba, 2014). Small island developing states (SIDSs) of the world, including Pemba Island and Zanzibar, are expected to suffer most from increases in temperature, reduced precipitation and sea level rise due to their high vulnerability caused by their sensitive ecological and economic systems and other interacting stressors (Mangora et al., 2015; Bakari, 2015; Hassan et al., 2014; Makame, 2013). This will result to potential adverse impacts on traditional economies, including rural agriculture, fishing and seaweed farming (ibid.).

Despite vast research on climate change and adaptation in the Island, and Zanzibar at large, information on past climate changes and adaptation responses is still meagre. Existing literatures have mostly focused on current climate changes and adaptations in the Island (Mangora et al., 2015; Bakari, 2015; Hassan et al., 2014; Makame, 2013; Hassan, 2010). Yet, little is known on past climate changes and adaptations as seen from the perspectives of the early communities in the Island. This paper addresses the lacuna of knowledge about past climate changes and adaptations through the use of environmental history framework as suggested by environmental and social historians (Oba, 2014; Tiki, 2010; Brooks, 2010). This is due to the fact that past climate changes and adaptations by communities were in terms of intricate relationships between human communities and the environment in the course of interacting for livelihood activities. The paper attempts to answer the question of whether past adaptations to climate and environmental changes could offer valuable insights on how to deal with anticipated future changes.

The past informs how local societies developed from simple to complex modes of life (Mkumbukwa, 2014; Oba, 2014; Tiki, 2010; Walshaw, 2005; 2010; Chami, 2003; Msemwa, 1994; Hamilton, 1982). The shift from hunting and gathering to crop farming, livestock keeping, fishing and trading during the pre-colonial period demanded fundamental changes in human strategies to address environ-climatic dynamics and food availability (ibid.). For instance, the increase in aridity made local communities in the Island demand for more reliable food sources, which they found through the innovation of various strategies, including domesticating the animals and plants they had hunted and gathered in the past; as well as trading with local and distant communities (ibid.). Ultimately, these strategies allowed the communities to develop complex modes of living; and strategies became fundamental for adjusting to the environ-climatic dynamics (ibid.). Through centuries of adaptation, communities in the Island have accumulated enormous environmental knowledge (Mkumbukwa, 2014, Oba, 2014; Chami, 2003, Hassan, 2010). The local environmental knowledge is a unique body of knowledge, practices, and

beliefs evolving by adaptive processes, and have been handled down through generations (Seme, 2006; Tiki, 2010; Masebo, 2010; Oba, 2014). As the world—and the Island in particular—confronts the realities of climate variability, historical studies are becoming more relevant.

2. Context and Methods

2.1 Study Area: Location and Justification

Pemba Island is one among the two main Islands of Zanzibar, Tanzania. The other main island is Unguja; and the two islands—together with several small islands—make up Zanzibar. The Island is located in the western parts of the Indian Ocean between 4 to 6 latitudes south of the Equator, and 39 and 40 longitudes east of Greenwich; and lies between 40km and 60km off the coast of East Africa.

Figure 1: Map of Zanzibar Showing Pemba Island, the Study Area
Source: Adopted from Mkumbukwa, 2014

The main traditional activities are crop farming, livestock keeping, fishing, and trade: which are all climate-sensitive. Pemba—nicknamed by one Arab writer as Green Island—was for many years a supplier of agricultural produce—including rice, other grains and cereals—to Malindi and Mombasa (Walsh,

2009; Pollard, 2009; Walshaw, 2005; 2010). By 1819 the Island was known to be the granary of East Africa and Arabia states (Sheriff, 1991). However, this was not without challenges, including fluctuating climate, of which the communities had to adapt to survive and thrive. In its eastern belt, the Island is characterized by a semi-arid zone that has been experiencing high weather uncertainties, particularly unreliable and varied rainfall, associated with prolonged droughts and localized food shortages (Bakari, 2015; Hassan et al, 2014; Walshaw, 2005, 2010; Sheriff & Ho, 2014; La Violette & Fleisher, 2013).

The Periplus of the Earythrean Sea, a document written probably in the first or second millennium AD by an anonymous writer, shows that Pemba has been experiencing periods of highly variable rainfalls, temperatures and intense storms, which have been threatening different economic activities, including crop farming, fishing, livestock keeping and trade (Sheriff & Ho, 2014). In the course of interacting with their environments, communities in the Island had to adjust to the changes to make progress. However, little is documented on the communities' experiences and adaptation strategies to the changes. Thus, the Pemba Island is purposely selected to address the lacunae of such knowledge.

2.2 Environmental History and the Annalles Frameworks

Environmental history is the history of interaction of human communities with their natural environment (Maddox, 2006; Hughes, 2001). Since human-nature interaction is intricate, this study required a historical research approach to understand the dynamics of the relationship, and to provide a frame of references for examining patterns and processes over time. Thus, the environmental history and *Annalles* frameworks investigate long-term climate changes and adaptations in the Pemba Island.

The *Annalles* framework, in this context the pre-colonial period up to 1840—referred as *la long durée* by French historians of the *Annalles* school—is useful to understand the dynamics of human-environment relationship from the rise of complex societies up to 1840 (Oba, 2014; Sheriff & Ho, 2014; Tiki, 2010). The temporal framework is also useful to understand how societies adjusted to the frequencies and onset of climate changes over time through the use of long-time evidences (Adria, 2008; Fleisher, 2009; Pollard, 2000).

2.3 Data Collection

Environmental historians have suggested the use of sources from historical, archaeological, anthropological and linguistic evidences to collect long-term data on climate changes and adaptations (Tiki, 2010; Oba, 2014). They also suggest that the use of oral traditions, corroborated with available archival sources, are relevant in reconstructing the climate change and adaptation history of a community since society and environment are intricately linked systems.

The reviewed reports include archaeological, historical and linguistic evidences that provided data on climate change trends and adaptations through different indicators, including proxy data[1], dietary and technological shifts, standing monuments, storage facilities and linguistic indicators. The histories of standing evidences such as early prayer sites, irrigation structures, early trade sites, migration and settlements; as well as linguistic, cultural and environment changes also shed light on climate changes and adaptations over time in the Island. The few available archival sources reviewed in the Zanzibar National Archive (ZNA) in Unguja and subsection in Pemba also helped shed light on the geography, weather and climate, traditional activities, and community responses to the changes.

The fieldwork of this study—conducted in 2015 and 2017 in Pemba—worked on oral traditions, linguistic evidences, and observation of standing monuments and existing cultures that shed light on climate change and centuries of adaptation. Purposeful sampling was used to identify key informants: time-reckoning experts, including elders, who had retained memories or inherited information from their grandparents on seasonality and the seasonality changes, weather forecasting, disasters (including droughts and famines) and responses to the impacts. The identification of the key informants was done through the help of local administrative officers (*shehas)*, and field assistants from the study areas who were native to the Island. Snowball sampling was used to locate more relevant informants and experts as the study progressed.

2.4 Data Sorting and Analysis

Primary and secondary data were evaluated and processed through qualitative methods of analysis. The qualitative information was thematically arranged based on the objectives and guiding questions used to administer interviews. In the whole, the qualitative data were evaluated and processed for analysis and presentation. The quantitative data—i.e., climate trends—were presented through tables. Since in most cases the qualitative sources reflect on the perspectives of those who produced them, they were interpreted as complementary evidences to enable their evaluation against each other to get valid information.

3. Results and Discussion

3.1 Climate Trend and Patterns in Pemba Island to the 1840s

Proxy data evidences—particularly the analysis of sediment cores of the highland lakes from archaeological reports—reveal the climate trends in the Island. The study of this proxy data, as compiled by Walshaw (2005; 2010), shows that the Holocene climate[2] in the Island—and other islands of Eastern

[1]Proxy data are data used by pale climatologists (who study past climate) to gather climate records from natural recorders of climate variability. Examples of proxy data are tree rings, ice cores, fossil pollen, and historical data.

[2]Holocene climatic pattern is generally referred to a gradual shift from conditions prevailing during the last glacial maximum (18 ka. B.P.), to a global thermal maximum (6 ka B.P.), to the prevailing climate

Africa—was characterized by severe droughts between 8700–8500 cal BP. The same data shows that a series of droughts also occurred in 4100 cal BP, 2000 cal BP, and 1500 cal BP, and were widespread in all eastern African areas, including Pemba Islands, between 750 cal BP and 950 cal BP (ibid.). Other proxy data used were Low Nile floods in Ethiopia, low lake levels, and high-pressure systems of the Indian Ocean: all of which indicated periods of droughts and great famines between AD 1822 and AD 1830. Archaeologists who have studied this data have interpreted these years as a period of international famine that spread in the East African lowland coastal areas, including Pemba Island (Oba, 2014; Chami, 2003). This data has also revealed a series of famines in the periods between AD 1835 and AD 1840s, which led to food shortages, diseases and deaths (Oba, 2014; Walshaw, 2010). Using the proxy data of Nile flood discharges, which are determined by rainfall in East Africa and Ethiopia, archaeologists and historians (Chami, 2003; Walshaw, 2005, 2010; Oba, 2014; La Violette & Fleisher, 2003; 2013) have presented climate trends and patterns of the coasts and islands of East Africa. Table 1 summarizes the climate trends in the islands of Tanzania, including Pemba, and the coast of East that can be inferred from proxy archaeological data.

Table 1: Climate Trends in Islands of Pemba and Coast of East Africa up to 1840

AD 1835 and 1840s	Series of droughts and famines in East African lowland areas: Pemba
AD 1820 and 1830	Decade of severe drought associated with food shortages in the Island
AD 1650 and 1800	Dry periods associated with food shortages
AD 1500–AD 1650	Wetter Climate with alternating dry spells
AD 1250 and 1500	Drier climate with alternating wet periods
AD 900–AD1250	Wetter Climate
AD 600 and 900	Drier Climate with food shortages
100 BC-AD 600	Wetter Climate
3000 BC-100BC	Drier climate in East African coast and Islands
5000 BC -3000BC	Climate fluctuation began in East African Coasts and Islands

Source: ZNA/AA21/15, Chami (2003: 13); Walshaw (2005, 2010); Oba (2014); La Violette and Fleisher (2003: 38); Fleisher and La Violette (2013: 1163–1164).

Reading Table 1 from bottom upwards, the trends show dry and wet period associated with drought and famine events as highlighted by archaeological proxy data and archival information. Table 1 also indicates that the region of East Africa, including Pemba, experienced drier climates between 3000 BC and 100BC; and wetter climates between 100BC and 600 AD. These drier and wetter climatic conditions repeated between AD 600 and AD 900, and AD 900 and 1250, respectively. It is also evident in this data that the period between AD 1250 and AD 1500 experienced drier climates, while the period between AD 1500 and AD 1650 experienced wetter climatic conditions (Chami, 2003: 13).

of today (Walshaw, 2005: 39–40). The Holocene epochs were characterized by frequent and extended drought events lasting for centuries, and were associated with famine incidences in different parts of the globe (Hassan, 2009; Grau-Satorras, 2016; Walshaw, 2005)

3.2 *Climate Change and Adaptation: Proxy Data Informs of Dietary Shift Indicators*

Changing climate had important implications on changing dietary tendencies of the people of Pemba and other areas of East African coast. Dietary changes, revealed from archaeological excavations done in different sites in Pemba Island, forms one of the important indicators of climate fluctuations and community adaptation to these fluctuations by modifying their dietary behaviours accordingly. Table 2 (reading from bottom upwards) shows climate changes and shifts in food pattern as communities adjusted to droughts and famines before the 18th century.

Table 2: Climate Change Trends and Community Responses

Cultural Tradition	Date Range	Climate Record	Dietary Shift Evidence
Post Swahili-Phase 1 (PS)	AD 1500–1650	Wetter	Fewer bones of marine and terrestrial mammals observed. Cultivated food dominated the diet: rice, coconut and millet, indicating a resume of wet climate
Neck Punctuating Swahili (NPW)	AD 1250–1500	Drier	Hunting and fishing as well as shellfish collection re-emerge again as observed in recovered materials in the sites. Recovered materials have found to have larger quantity of shellfish and land snails (*Gastropod*) remains. Farming : pearl millet and sorghum dominates, indicating drier climate
Plain Ware (PW)	AD 900–AD 1250	Wetter	Hunting, fishing and shell collection disappear during this period. Cultivated foods re appears: rice and pearl millet predominated. Wet rice and millets implies that climate was fluctuating between wetter and dry climatic conditions.
Triangular Incised Ware (TIW)	AD 600–AD 900	Drier	Abundance of shells and bones of marine and terrestrial mammals were observed in excavated materials. Pearl millet appears implying drier climate dominated. All indicated dry climate.
Early Iron Working (EIW)	AD100 BC–AD 600	Wetter	Few bones of shellfish, other marine and wild mammals appear indicating fishing, hunting and shell collection was not main activities but cultivation and iron smelting dominated. Rice and coconut were introduced in AD 200 but did not dominate due to low population and thus low labour. Introduction of rice indicated a wet climate
Late Stone Age (LSA)	3000 BC–100 BC	Drier	Abundance of bones of fishes, shell fish and land snails (*Gastropod*), which constituted the main diet, hunting of variety of wild animals: wild pigs, Zanzibar rock hyrax (*procavia capensis*), wild fruits also dominated.

Source: Adapted and Modified from Chami (2003: 13); ZNA/AA21/28; Walshaw (2005, 2010); La Violette and Fleisher (2003: 38); Fleisher and La Violette (2013: 1163)

Table 2 shows the climate fluctuations indicators and community adaptation mechanisms, both evidenced by proxy data in the form of dietary change tendencies recovered by archaeologists in household deposits at sites in north-east Pemba, including Chwaka-Tumbe sites at Micheweni. The evidences of dietary changes show that the earliest period of the late Stone Age—from 3000 BC to 100 BC—was characterized by dry climatic conditions. Archaeological excavations have shown that people relied on hunting wild animals, gathering wild fruits or vegetables, and fishing for food. Climate conditions changed during the period from 100 BC to around 600 AD, which was characterized largely by wet climatic conditions. One of the major indicators of wet climate was the beginning of rice growing, which could only thrive in wet conditions. During this period, very few bones of shellfish, marine organisms and wild animals appear in the households' deposits, indicating they were not the main forms of diet for many households.

Table 2 further shows that the period from around 600 AD to around 900 AD was characterized by dry climatic conditions. An abundance of shells and bones of marine and terrestrial mammals were found in archaeological materials excavated in the Island. Pearl millet—a drought resistant crop—appears and dominated this period, which implies a drier climate. The peal millet was a new innovation by the communities as they responded to the dry condition. The period from 900 AD to 1250 AD seems to have been characterized by climate fluctuations between wet and dry conditions. As Table 2 shows, the diet of the local communities was dominated by rice, which is usually grown in wet climatic conditions; and millet, which is a drought-resistant crop. Evidences for fishing, hunting and collecting wild foods are fewer than in the previous dry period, while evidences of crop cultivation of rice and millet are more common. The changing dietary tendencies suggest fluctuations between wet and dry climatic conditions during this period.

The period from 1250 AD to around 1500 AD appears to have been dominated by dry climatic conditions. Hunting and fishing, as well as shellfish collection, re-emerged again as observed in the recovered archaeological materials in the sites. Recovered materials were found to have larger quantities of shellfish and land snail (*Gastropod*) remains. Also, the farming of pearl millet and sorghum dominated, indicating the existence of a drier climate. People adapted to the dry climatic conditions by resorting to growing drought-resistant crops. The periods after 1500 AD to around the 1650s, and after, were characterized by wet climatic conditions. Archaeological evidences in these periods reveal fewer bones of marine and terrestrial mammals. Notable in the evidence is the growing tendencies towards cultivated food crops, especially rice, coconut and millets, among others; which were indications of recourses to wet climates.

Generally, Table 2 reveals that the climate of the coastal islands, such as Pemba, had been changing and fluctuating between dry and wet climate periods; and communities responded to these changes by undertaking economic activities that responded well to the respective climatic conditions. The observed major food shift patterns implies that the communities were adapting to the impacts of climate change by ensuring food security to survive. For instance, according to Chami (2003: 11–13), the activity of marine shell collection and hunting of terrestrial mammals, as well as wild fruits, are conducted by various communities during times of food stresses. Msemwa (1994: 311) has also pointed out that "… shellfish exploitation is a strategy to minimize risks due to poor agricultural yield caused by drought or shortage of the preferable food resources." Therefore, it is during times of stress that agricultural people subsidize their diet with hunted wild animals, and shellfish collections as Table 2 has shown.

This culture persisted to the 19th and 20th centuries. The reviewed archival documents from the annual reports of the Department of Agriculture inform that, up to the colonial government,[3] fishes and various other marine and terrestrial resources, which formed the base of animal protein in the Island, were also used as supplements by peasant communities during times of food stress. The documents also show the important contribution of livestock in the provision of food to households, especially during times of food stress—either through direct consumption, or through selling of livestock products like meat, milk and eggs—to secure money to buy important foodstuffs that the communities lacked (ibid.). Additionally, the reviewed archival documents also highlight that animals—such as goats and cows—were used as special sacrificial offerings to appease the deities during rain-making ceremonies performed especially during drought periods. "The livestock in these communities were given high value; sometimes the communities offered them in their traditional rituals."[4] These evidences are also supported by archaeologists La Violette and Fleisher (2003: 38), who highlighted that until the 8th century AD, when the climate was drier (see Table 2), the earlier Swahili communities were mostly reliant on local marine resources such as fishes, shellfishes, and sea turtles; as well as wild animals (such as pigs) and domesticated mammals—including goats, cattle and chickens—as observed in excavated materials.

Fleisher and La Violette's faunal analysis (2013: 1163) of more than 1500 bone fragments recovered from the Tumbe site in Micheweni shows that about 50 per cent was of cattle; and others were of fish, ovicaprine and chicken, as well as of wild species such as birds, sea turtles and land tortoise that were consumed during drier periods. Similar archaeological observations were given by Chami (2003: 11–13) who pointed out that the people of the Late Stone Age

[3] (ZNA/AA21/28Agricultural Department: Departmental Bulletin March. 1942–December, 1948.
[4] ZNA/AA21/28, Bulletin of the Department of Agriculture for the two quarters ending 31st March,1948

tradition (3000–100BC), which was characterized by drier climates (see Table 2), consumed a lot of shellfish, land snails and fishes. Therefore, the consumption of marine resources, as well as wild and domesticated fruits and mammals, is an indication of the communities' adaptive mechanism to adjust to food shortages resulting from prevailing drier climatic conditions.

The use of marine and terrestrial resources to adapt to climate change is a culture that has continued to be practiced in the Island to date. This is evident from the responses by time-reckoning experts at Micheweni.[5] They highlighted that marine and terrestrial resources always served their communities during times of food crisis. During famine people survived by eating fishes, shellfish and wild plants (ibid.). The study by Mkumbukwa (2014) and Walsh (2009) have also showed that the culture has persisted in the Island till now. The studies underscore the fact that marine resources were used as an important alternative and compliment for the people to seek socio-economic refuge in whenever there were increased pressure on terrestrial resources or during drier periods. Therefore, the appearance of a large accumulation of marine and terrestrial remains during these drier periods (3000–100 BC; AD 600– AD 900, and AD 1250–AD 1500) in the East African coast—and Pemba Islands, in particular—as indicated by proxy data evidences, implies that those times were difficult periods when communities experienced drier climatic conditions.

The decline of shellfish and other marine and terrestrial resources during wetter periods, as indicated in Table 2, suggests that the climate was shifting from a dry to a wet period. The interpretations by archaeologists such as Chami (2003: 13) and Msemwa (1994: 311) indicate that wetter climates were not conducive for shellfish growth because mangrove forests, where shellfish bred and grew, became less saline; and therefore shellfish exploitation disappeared during those times. The implication is that the decline of shellfish and terrestrial mammal remains during 100 BC–600 AD; AD 900–1250 and AD 1500–1650 periods, as seen in Table 2, suggests that those periods were characterized by wet climatic conditions when communities consumed cultivated foods, including rice, as their main diet.

3.*3 Growing of Drought Resistant Crops*

Growing of drought-resistant crops to adapt to drought conditions is an old phenomenon in the Island as indicated in Table 2. Proxy data from archaeological reports indicate that planting of drought-resistant crops was one of the earliest and most important strategies that local communities devised to adapt to evolving dry climatic conditions (Walshaw, 2005, 2010). Archaeologists have recovered botanical evidence showing changing crops that resonated with either dry or wet conditions (Walshaw, 2005, 2010; Fleisher and La Viollete,

[5] Interview with time reckoning experts across the sites in Micheweni Pemba: Juma Mshindo Dawa, Ali Mohamed Sudi, Khadija Hassan Mzee, Mafunda Khamis Omar Suleiman Juma in September, 2017.

2013). Notable in the archaeological data is that dry climatic conditions coincided with the dominance of African grain crops such as pearl millet (*Pennisetum glaucum (L*), finger millet (*Eleusine coracana ssp. L.*), sorghum (*Sorghum bicolor (L.)* and wheat. The study found that growing and consuming of drought-resistant and shallow-rooted grains were efforts by local communities to adapt to drought conditions and ensure food security. This is also evident with the presence of grinding stones in the recovered fragments of house deposits in Tumbe and Chwaka old stone towns in Micheweni, which included hand grinders, small basins, and wheat stones (Fleisher & La Viollete 2013: 1162). Fleisher and La Viollete (ibid.) underlined that "In each house there seems to have a set of grinding stones that may have been used for grinding cereals." Additionally, local cooking and backing stoves and ovens, locally known as *mafa,* were recovered in house deposits in the areas, which imply that they were used for cooking and for baking breads (Fleisher & La Viollete, 2013: 1162).

Discussions with descendants of councils of elders revealed the persistence of drought-resistance crops when they underscored that millets and wheat in Micheweni have endured for a long time "… since the time of our grandparents who always cultivate it to overcome drought conditions in our areas."[6] *Sheha* Juma Dawa pointed that their grandparents, who were among the *wakuu wa mji*, were weather experts; and so guided the community on what to be planted in a dry or wet period (ibid.). The use of drought-resistant crops, therefore, is interpreted as the communities' mechanism to adapt to drier climates (ibid.). The innovation has persisted to date in the Island, especially in drought-prone zones in the east coast of the Island where varieties of drought-resistance crops are widespread as indicated in Photos 1a and 1b.

Photo 1a: Sorghum Crop at Kiuyu (Source: Author, 2017)

Photo 1b: Peal millet Crop at Kiuyu (Source: Author, 2017)

[6] Interview with *Sheha* Juma Dawa Mshindo and *Mzee* Mkasha Mbwana and Bw. Abdallah Hamadi Omar conducted in Micheweni in September 2017.

3.4 Rice Cultivation during the Wet Climate

Rice cultivation was an old innovation to adjusting to wet climate and population growth in the Island, adopted from Asia as a result of monsoon exchanges. Walshaw (2010: 142) has reported that early trade exchanges from Asia to the Island brought Asian rice (*oryza sativa L)* and coconut (*cocos nucifera L*) by the second century AD during wet climatic conditions in the Island. Asian rice was introduced in Pemba through trade exchange across the Red Sea (ibid: 148). The wet climate, coupled with an increasing population, necessitated the intensification of rice production to meet the food demands of the growing population in the stone towns (Walshaw, 2005). In the archae-botanical records, rice dominated the grain elements in the area during this period, leading into rice gaining the status of being the staple food in the Island (ibid.) (Photo 2).

Photo 2: Rice Crop at Micheweni
Source: Author, 2017

Ultimately, rice and other cereals cultivation expanded, and Pemba became a granary of East Africa and other international markets since rice was highly demanded internally and externally (La Violette & Fleisher, 2009: 435; Martin, 1978: 26–27). The rice-growing culture in the Island during wet seasons have persisted to date despite the challenge of increasing impacts of climate variability.

3.5 Local Meteorology Knowledge and Maritime Trade

Local communities in the Island utilized their long-accumulated knowledge on meteorology to adapt to climatic changes in the Island. The knowledge on marine technology and monsoon wind systems were found to be vital adaptation mechanisms to the impacts of climate change. The local communities' observations and interpretations of meteorological phenomenon guided their seasonal and inter-annual activities for millennia not only to

survive from its impacts, but also to benefit from the opportunities it offered (Sheriff & Ho, 2014: 18; Mjema, 2014). *The Periplus of the Erythrean Sea* recorded the long-lasting coastal communities' knowledge and awareness on climatology (ibid.). The document highlights that coastal long-distance trade networks were made possible mostly by the development of the communities' technology on marine engineering, and harnessing of the monsoon wind systems (Sheriff & Ho, 2014: 18; Sheriff, 1987). The knowledge and cultural practices continued to be useful up to the 19th and 20th centuries among fishers, farmers, traders and seaweed farmers. Interviews with fishers and traders at Tumbe and Shumba Mjini, where long-standing local ports are found, have highlighted that monsoon winds *(kusi* and *kaskazi)* have for long guided trade with Mombasa, Tanga and Bagamoyo; the knowledge of which was inherited from forefathers.[7] Thus, coastal communities, guided by their local patrons, exploited opportunities provided by the monsoon wind patterns to use maritime trade links to increase their resilience, and enhance food security in terms of varieties and abundance.

The local knowledge of marine sciences and the impetus to share scarce commodities, together with fluctuating climatic conditions, enabled communities to develop local and long-distance maritime trade along the coastal line: within Pemba, Unguja, Mombasa, Pangani-Tanga, northern highland areas, and as far as India and China (Mjema, 2014; Kimambo, 1996; Sheriff & Ho: 2014). Sheriff and Ho (2014: 14) have shown that people in the Indian Ocean rim—including the Pemba Island—had for millennia increased the abundance and variety of food by exploiting opportunities provided by the land and sea environments, through what is commonly known as monsoon exchanges. The need to survive fluctuating climatic conditions made maritime trade a vital mechanism to ensure resilience and food security of the trade partners vis-à-vis the vagaries of climate fluctuations. This is supported by Fuller (2003, quoted in Walshaw, 2010: 140), who argues that the early global interactions on the coast of East Africa had close relations with the food grown with the trading partners, and the climatic conditions from the source and destinations. For instance, the African grains pearl millet, finger millet and sorghum, as well as ideas on how to cultivate and use them from the coast of East Africa, were exported to India where it is reported that the grains were found in domesticated forms by the beginning of the second millennium BC (ibid.). This implies that both the East African coastal communities—including Pemba communities—and Indians were experiencing droughts, and thus adjusted by cultivating drought-resistant crops; and by sharing crops and ideas through inter-continental trade exchange and migration.

[7]Interviews with Bw. Omar Muhamed Saleh of Tumbe, Bw. Khamis Shoka Pandu of Kiuyu, Bw. Musa Mustafa of Shumba ya Mjini, *Sheha* Juma Dawa Mshindo of Micheweni conducted across the sites in September, 2017.

3.6 Seasonal Out-migration

The rural communities also developed a culture of seasonal out-migration from the east to the west belt, and from the west to east, locally known as *dago* (Walshaw, 2005; Fleisher & La Viollete, 2013). This culture started as a group cooperation among communities sharing labour and resources, as well as mitigating food shortages due to differences in weather and environmental conditions between the east and west belts, and as far as other parts of East Africa (ibid.). Interestingly, this study has found that the observed drought and food shortage trends for the East African coast and Pemba Island indicated in Table 1, also coincided with increasing seasonal out-migration to the western belt. For instance, the migration to the west—especially to the early Swahili cities in Pemba Island, such as the early stone town cities of Tumbe—were frequent between AD 700 and AD 1000; and later to Chwaka between 11th and 13th centuries (Fleisher, 2003: 138–142).

This study is of the view that the emerging cities played the role of mitigating food shortages resulting from climatic fluctuations, among other factors. The cities formed one among the earliest market places where people exchanged their products to mitigate food shortages resulting from climate fluctuations and other interacting stressors (Fleisher, 2003: 138–142). The movement to the west was a community response to dry conditions that were was more acute in east than the west due to different soil and weather characteristics. This interpretation is supported by other historians and archaeologists who report that there were movements of people from the north-east coast of the Island to the western rainfall areas to cultivate food crops like rice for survival, for feeding the growing population in towns, as well as for sale elsewhere (Walsh, 2009: 3). Fleisher (2003) and Walshaw (2010), for instance, report that there was a depopulation of people in the countryside, especially in the north-east coast of the Island; and that such people migrated to the stone towns in the west to find refuge against famine and food shortages. Thus, out-migration (*dago)*, a culture observed to date in the Island, has a long history in Pemba, and Zanzibar Island at large. The linguistic indicators through the word *dago* and the culture is still in use to date among farmers, fishers and seaweed farmers in the Island.

3.7 Small-scale Irrigation

Small scale irrigation was equally an important adaptation strategy that local communities developed to adapt to climatic fluctuations. Available evidences in the Island, especially in the north-east area—a semi-arid climate and drought-prone belt—show that irrigation farming was another old cultural mechanism that communities adapted to survive climatic fluctuations. This study observed long-standing local irrigation structures—including local dug-wells and natural caves—which were used for irrigation farming long before the nineteenth century (see Photos 3a and 3b). This culture, which has persisted to date, was among the

community strategies to adjust from drought conditions in the eastern belt. A discussion with the head of the Department of Irrigation in North Region, Pemba, Mr. Mbarouk Ali Mgau, underlined that irrigation in the Island is a culture that has endured for centuries as seen from the standing irrigation structures in the east-coast of the Island.[8] Kjekshus (1977: viii), Kimambo (1996), and Seme (2006) also support this finding: that irrigation agriculture was one of the oldest indigenous innovations in African agriculture, documented from about 3000 BC in Egypt in the Nile Valley. In Tanzania, studies have documented that indigenous irrigation technology can be traced from the first millennium AD in Engaruka, which is the earliest known site (ibid.). This technology spread from Engaruka to other parts of East Africa. Photos 3a and 3b are long-standing irrigation structures at Kiuyu and Maziwang'ombe areas.

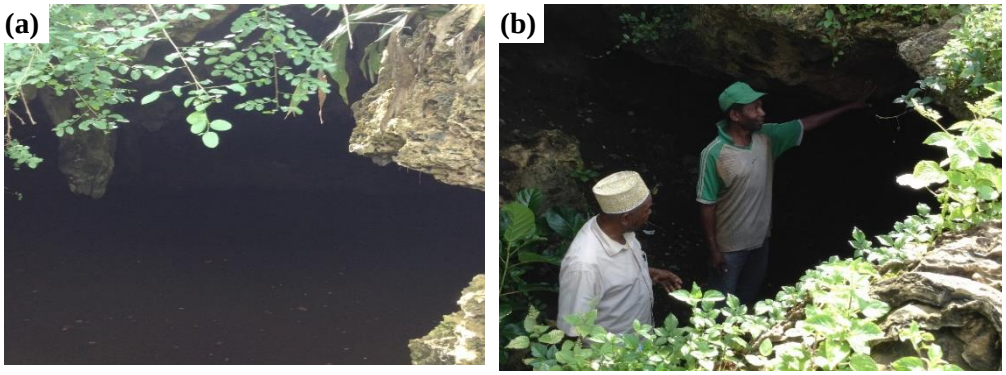

Plate 3: Water Cave at (a) Maziwang'ombe; and (b) Kiuyu
Source: Author, 2015 and 2017

3.8 Lessons from History

This study basically sought to answer the key question of whether past adaptations to the impacts of climate change by rural communities in Pemba Island could improve our understanding of anticipated future changes. The study has presented an environmental-historical analysis of the adaptations through the use of long-term evidences, in an attempt to answer the key question. The use of Pemba rural communities to illustrate past adaptation successes has helped us to appreciate the value of history in understanding the evolution of adaptations to climate changes in the Island. The adaptation strategies were never through trial-and-error, but evolved through curiosity and deliberate experimentation by the communities to adjust to the challenges brought by environ-climate changes. The adaptation strategies have always been dynamics as the communities learnt to innovate new strategies to the emerging new challenges, and abandoned dysfunctional ones.

[8] Key Informant Interview with the Head of Department of Irrigation Mr. Mbarouk Ali Mgau conducted at Pemba, Northern Region in July and September 2015 and 2017 respectively.

Thus, there is a need to look back into history to acknowledge past experiences, and understand the current and the future. While it is obvious that the adaptation to current and future changes due to climate change will be different from the past because of the different drivers that triggered the changes, and the socio-economic and political transformations now taking place in the Island, yet the study suggests that the past provides a knowledge base useful in understanding current, and anticipating future, adaptations.

This environmental-historical study has covered a long period of time, and has been able to document past rural community adaptive strategies. It has shown that despite of the challenges brought by the impacts of climate change to their livelihoods during pre-colonial period, rural communities in the Island maintained their resilience. It has clearly demonstrated that the rural communities continued to modify and innovate new adaptation strategies, and were able to make progress. The communities adopted new plants that survived the prevailing and fluctuating climatic conditions. They combined crop farming, livestock keeping, as well as participating in local and long-distance trade to diversify their livelihoods. They also practiced seasonal migration to survive from climate changes and other stressors. In the participation in global trade exchanges, the monsoon exchange was one of the remarkable adaptation responses by the community to survive adverse climate impacts. The communities also innovated new technologies, and improved their old ones, to survive from new emerging challenges. The resilience of the local communities in the Island, and their historical capacity to innovate new adaptation strategies, have provided insight and confidence that they have survived and continued to be productive. Therefore, despite challenges facing the community adaption strategies, their adaptation history of past and current innovations should not be ignored. The local environmental history should be fundamental in understanding how to sustainably manage environmental impacts brought by natural factors and human agencies.

4. Conclusion

Climate changes during the pre-historic period were driven by global climatic events as opposed to the current climate variabilities that are due to anthropogenic factors, such as emissions of greenhouse gases (GHSs), which has resulted to global warming. However, climate scientists should not focus only on the current and future climates, and ignore the past. There is a danger if we do not learn from past experiences of adaptation by thinking that current and future climate conditions will not be as chaotic as the past, or vice versa. The lack of an appreciation of lessons from history creates a tendency of devaluing the past and its usefulness in understanding the current, and predicting the future. Thus, this study concludes that a successful adaptation

to current and anticipated climate changes requires climate science to accommodate past experiences of adaptation to deal with the current and anticipated future changes due to climate and other interacting stressors.

Additionally, contemporary challenges facing rural communities are numerous, including inappropriate policies, population increase, diminishing resources and climate variability, among others, which have challenged rural communities' adaptive capacities. While the study has clearly demonstrated experiences with past adaptations to climate change, yet the sustainability of rural communities in Africa and elsewhere would require actions not only related to climate change adaptation and mitigation, but also improvement of governance and policies that would reduce the vulnerability of rural communities.

Future predictions have clearly underlined that human societies across the globe—Zanzibar not an exception—are expected to suffer dramatic changes of their livelihoods and reduced adaptive capacities due to climate variability and other interacting stressors. While the persistent desire for economic growth by industrialized countries, ever since the genesis of the industrial revolutions, has hindered attempts towards the reduction of GHS emissions, and the fact that the impacts of climate variability and other associated stressors know no boundaries, the need to reduce the vulnerability of rural communities in developing countries, and enhancing resilience of coastal communities in particular, is not only important, but crucial.

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