VULNERABILITY OF CLOVE FARMERS TO IMPACTS OF
CLIMATE CHANGE AND VARIABILITY IN PEMBA ISLAND

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REG: 2013/02/000022/SUZA

A THESIS SUBMITTED TO THE SCHOOL OF NATURAL AND
SOCIAL SCIENCES OF THE STATE UNIVERSITY OF
ZANZIBAR IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE MASTER OF
ENVIRONMENTAL SCIENCE DEGREE

JANUARY 2017
DECLARATION

I, Salim Masoud Msabah do hereby declare to the Senate of State University of Zanzibar (SUZA) that this thesis is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

………………………………                                      ……………………………
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REG: 2013/02/000022/SUZA

Supervisor:

I as supervisor confirm that the work reported in this thesis was carried out by the candidate under my supervision.

………………………………                                      ……………………………
Signature                                      Date

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Department Natural and Social Sciences of the State University of Zanzibar, Tanzania
DEDICATION

This work is dedicated to my parents Mr. Masoud Msabah Ali and Mrs. Sabah Salim Rashid whose efforts laid the foundation of my education.
ACKNOWLEDGEMENT

In the course of undertaking this study, I have received support from many people and organizations to which I wish to register my appreciations. Firstly, I thank God from the bottom of my heart, for giving me the courage to invest time in this study. It is He who made it possible for things to happen. Secondly, I would like to register my sincere appreciation to my supervisor, Prof. M.A. Sheikh, for his guidance during the proposal development to the thesis write-up. To him, I would like to express my sincere feelings and the greatest from his tolerance, painstaking, tireless efforts, vision and willingness to offer constructive criticism and encouragement throughout the whole period of preparation and execution of the research to the write-up of this Thesis. Thirdly, I would like to take this opportunity to express my sincere appreciation to Dr. Aley Soud Nassor of the faculty of social science (SUZA), Mr. Hamad Maalim Sharif of the Department of Education Zanzibar for their valuable contribution in this study. I also extend my thanks to the local communities to the villages visited and those who have contributed information in one way or another for their valuable cooperation, without which this study would have remained a day dream. Special thanks are due to Mr. Said Khamis Faki of Benjamen Willim Mkapa of Teachers Training College, who worked with me during the field survey in a spirit of generosity and commitment. I owe the greatest debt to my sincere friends Mr. Salim Amour Rashid and Abdullah Ali Yussof for their moral support, unremitting encouragement, indispensable prayers and tolerance throughout my absence to accomplish this study. They have demonstrated extraordinary courage and made difficult sacrifices. Neither words nor complex mathematical equations can fully articulate their roles in making this work a reality. This work would not have been
possible without moral and the financial support offered by my beloved father and mother, who enabled my field work and financing of other study logistics. Deep thanks are extended to my lovely wife Ms. Saada Hamoud Ahmed with my lovely children Amira Salim Masoud and Sabah Salim Masoud for their constant encouragement and personal sacrifice during the difficult times of this study. Lastly, I am very grateful to my sister Salama Masoud Msabah and my brother in law Mr. Ali Salim Khalifan who made themselves available and provided assistance throughout the research period.
TABLE OF CONTENT

DECLARATION........................................................................................................ii
DEDICATION...........................................................................................................iii
ACKNOWLEDGEMENT..............................................................................................iv
TABLE OF CONTENT...............................................................................................vi
LIST OF FIGURES....................................................................................................x
LIST OF TABLES......................................................................................................xi
LIST OF PLATES.....................................................................................................xii
LIST OF ABBREVIATIONS AND ACRONYMS......................................................xiii
LIST OF APPENDIXES.............................................................................................xv
COPYRIGHT.............................................................................................................xvi
ABSTRACT..............................................................................................................xvii
CHAPTER ONE.......................................................................................................1
INTRODUCTION......................................................................................................1

1.1 Background ......................................................................................................1

1.1.1 Concept of social vulnerability .................................................................1

1.1.2 Vulnerability of small Islands to climate change and variability ............1

1.1.3 Agriculture and climate change .................................................................3

1.1.4 Contribution of agriculture to Zanzibar economy .................................4

1.2 Statement of the problem. ..............................................................................5

1.3 Objective of the study......................................................................................6

1.3.1 General objective .......................................................................................6

1.3.2 Specific objectives of the study .................................................................6

1.4 Research questions .........................................................................................7
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.12 Impact of climate change and variability on agriculture</td>
<td>36</td>
</tr>
<tr>
<td>2.12.1 Climate change, vulnerability on crop production</td>
<td>36</td>
</tr>
<tr>
<td>2.13 The Livelihood vulnerability index</td>
<td>37</td>
</tr>
<tr>
<td>METHODOLOGY</td>
<td>38</td>
</tr>
<tr>
<td>3.0 Description of study area</td>
<td>38</td>
</tr>
<tr>
<td>3.1.1 Geographical location</td>
<td>38</td>
</tr>
<tr>
<td>3.2 Biophysical characteristics of the study area</td>
<td>39</td>
</tr>
<tr>
<td>3.2.1 Vegetation</td>
<td>39</td>
</tr>
<tr>
<td>3.2.2 Soil and topography</td>
<td>40</td>
</tr>
<tr>
<td>3.2.3 Climate</td>
<td>40</td>
</tr>
<tr>
<td>3.3 Socio-economic characteristics of the study area</td>
<td>41</td>
</tr>
<tr>
<td>3.3.1 Population</td>
<td>41</td>
</tr>
<tr>
<td>3.3.2 Economic activities</td>
<td>41</td>
</tr>
<tr>
<td>3.3.3 Methodology sampling procedures and sample size</td>
<td>41</td>
</tr>
<tr>
<td>3.3.4 Reconnaissance survey</td>
<td>43</td>
</tr>
<tr>
<td>3.3.5 Research design</td>
<td>44</td>
</tr>
<tr>
<td>3.4 Data collection methods</td>
<td>44</td>
</tr>
<tr>
<td>3.4.1 Primary data</td>
<td>44</td>
</tr>
<tr>
<td>3.4.2 Secondary data</td>
<td>45</td>
</tr>
<tr>
<td>3.4.3 Data Analysis</td>
<td>46</td>
</tr>
<tr>
<td>CHAPTER FOUR</td>
<td>50</td>
</tr>
<tr>
<td>RESULTS AND DISCUSSION</td>
<td>50</td>
</tr>
<tr>
<td>4.0 Introduction</td>
<td>50</td>
</tr>
<tr>
<td>4.1 Respondents socio-economic characteristics</td>
<td>50</td>
</tr>
</tbody>
</table>
4.1.1 Age of farmers ................................................................. 51
4.1.2 Gender of farmer ............................................................. 52
4.1.4 Marital status ................................................................. 54
4.1.5 Level of education of farmers .......................................... 54
4.2.1 Relationship between the clove yield and weather parameters .......... 55
4.2.2 Correlation Analysis .......................................................... 57
4.3 The general results of LVI and LVI-IPCC districts ........................ 60
4.4.1 Social demographic Profile (SDP) .................................... 62
4.4.2 Livelihood strategies (LS) .................................................. 63
4.4.3 Social network (SN) ........................................................ 64
4.4.4 Accessibility of health services and health assessment .............. 65
4.4.5 Food .............................................................................. 66
4.4.6 Water resources (WR) ...................................................... 67
4.4.7 Natural Disasters and Climate Variability (NDCV) ................. 67
4.4.8. Energy Resources (ER) .................................................. 69
4.4.9 LVI–IPCC contributing factors ......................................... 70
CHAPTER FIVE ............................................................................ 73
RECOMMENDATIONS AND CONCLUSIONS ............................. 73

5.0 Recommendations .............................................................. 73
5.1 Conclusions ......................................................................... 74
References ................................................................................ 75
Appendixes ............................................................................... 85
LIST OF FIGURES

Figure 1: Average monthly maximum temperatures in pemba (source:tma, 2015)...........26

Figure 2: Rainfall patterns from 1974-2012 in pemba island.................................... 27

Figure 3: Clove production trends ............................................................................. 35

Figure 4: Variation of clove production in pemba districts......................................... 35

Figure 5: Sampling areas of pemba districts and villages.......................................... 39

Figure 6: The graph of rainfall and clove yield ........................................................... 55

Figure 7: The graph of maximum temperature and clove yield .................................. 56

Figure 8: The graph of minimum temperature and clove yield .................................. 56

Figure 9: The graph of relative humidity at 0600z and clove yield............................ 57

Figure 10: The graph of relative humidity at 1200z and clove yield........................... 57

Figure 11: Vulnerability spider diagram .................................................................... 62

Figure 12: Overall lvi in districts................................................................................. 69

Figure 13: Triangle diagram of exposure, adaptive and sensitivity............................. 71
**LIST OF TABLES**

**Table 1:** The trend of clove production one decayed in tons.......................... 35

**Table 2:** The selected districts, village and number of respondents.................. 42

**Table 3:** Social demographic characteristics of the farmers............................51

**Table 4:** Years of experience farming by the farmers..................................55

**Table 5:** Correlation coefficients for lag zero........................................58

**Table 6:** Correlation coefficients for lag one........................................59

**Table 7:** Correlation coefficients for lag two........................................59

**Table 8:** Categorization of major components into contributing factors............60

**Table 9:** Index of sub-components and major components..........................61

**Table 10:** Overall lvi index for four main districts.....................................69

**Table 11:** LVI - IPCC contributing factors calculations for Micheweni, Wete, Chake Chake and Mkoani districts in pemba island.................................71
LIST OF PLATES

Plate 1: The picture showing the clove seed…………………………………………………………29
Plate 2: The picture showing young clove trees…………………………………………………30
Plate 3: The picture showing the flower clove…………………………………………………31
Plate 4: The picture showing the Health clove trees…………………………………………33
Plate 5: The photo showing the effected clove trees…………………………………………34
## LIST OF ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>CGA</td>
<td>Clove Grower Association</td>
</tr>
<tr>
<td>DALDO</td>
<td>District Agricultural and Livestock Office</td>
</tr>
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<td>FEWS</td>
<td>Famine Early Warning System</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHG</td>
<td>Green House Gas</td>
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<td>ISDR</td>
<td>International strategy for disaster reduction</td>
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<td>IPCC</td>
<td>Intergovernmental Panel for Climate Change</td>
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<td>LVI</td>
<td>Livelihood Vulnerability Index</td>
</tr>
<tr>
<td>LVI-IPC</td>
<td>Livelihood Vulnerability Index – Intergovernmental Panel for Climate</td>
</tr>
<tr>
<td>MALE</td>
<td>Ministry of Agriculture, Livestock and Environment</td>
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<tr>
<td>NBS</td>
<td>National Bureau of Statistics</td>
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<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
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<tr>
<td>OCGS</td>
<td>Office of the Chief Government Statistician</td>
</tr>
<tr>
<td>SACCOS</td>
<td>Savings and Credit Cooperative Societies</td>
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<tr>
<td>SLA</td>
<td>Sustainable Livelihoods Approach</td>
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<td>SMOLE</td>
<td>Sustainable Management of Lands and Environment</td>
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<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
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<tr>
<td>SUZA</td>
<td>State University of Zanzibar</td>
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<tr>
<td>TMA</td>
<td>Tanzania Metrological Agency</td>
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<tr>
<td>TAR</td>
<td>Third Assessment Report</td>
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<tr>
<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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<td>UNEP</td>
<td>United Nations Environmental Program</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>URT</td>
<td>United Republic of Tanzania</td>
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<td>UNGA</td>
<td>United Nations General Assembly</td>
</tr>
<tr>
<td>USD</td>
<td>United State Dollars</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nation Development Programs</td>
</tr>
<tr>
<td>USAID</td>
<td>United State Agency for International Development</td>
</tr>
<tr>
<td>USA</td>
<td>United State of America</td>
</tr>
<tr>
<td>WMO</td>
<td>World Meteorological Organization</td>
</tr>
<tr>
<td>WFP</td>
<td>World Food Program</td>
</tr>
<tr>
<td>ZSTC</td>
<td>Zanzibar State Trade Cooperation</td>
</tr>
</tbody>
</table>
LIST OF APPENDIXES

Appendix 1  Questionnaire for Vulnerability of clove farmers to impacts of Climate Change and Variability, A Case of Pemba Island’ Districts........................................................................................................................................85

Appendix 2  Checklist for key informants for Agriculture Offices........................................90

Appendix 3  Checklist for Focus Group Discussion.................................................................92

Appendix 4  Calculating LVI of district..................................................................................95

Appendix 5  Livelihood Vulnerability Index sub-component and major components values .................................................................................................................................98

Appendix 6  Mean monthly Maximum temperature (°C) at Pemba Islands ..............99

Appendix 7  Mean monthly temperature at Pemba Island....................................................101

Appendix 8  Monthly Rainfall (in millimeters) of Pemba Islands.................................102
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No part of this dissertation may be reproduced, stored in any retrieval system or transmitted in any form or by any means without prior permission of the author or The State University of Zanzibar (SUZA).
Clove industry supports significantly Zanzibar economy and leading sector for foreign exchange earning in Zanzibar. Clove plantation like other crops are vulnerable to climate change stresses such as higher temperatures, floods, etc. The objective of this study was to examine vulnerability (exposure, sensitivity, and adaptive capacity) of the clove farmers in Pemba Island to the impacts of climate change and variability. The sampling covered four districts of Pemba Island (Mkoani, Chake chake, Wete and Micheweni). The livelihood vulnerability index (LVI) and LVI-IPCC scores were calculated to assess components of vulnerability of the households. Ninety households were surveyed in each district to collect data on socio-demographics profile, livelihoods strategies, social networks, health, food and water security, natural disasters and climate variability and energy resources. In addition, secondary data from meteorological data were used to analyze long-term variation of temperature and rainfall. The result showed that the sources of vulnerability differed within and between the four districts. The overall livelihood vulnerability index (LVI) for Mkoani, Micheweni, Wete and Chake chake were 0.5261, 0.5148, 0.5061, and 0.5016 respectively. Likewise, LVI-IPCC scores were 0.0770, 0.0729, 0.0602 and 0.0269 for Micheweni, Mkoani, Chake Chake and Wete districts respectively. The overall LVI-IPCC scores indicate that the level of vulnerability varies the sampled districts based on the degree of the dependence of clove industry for their socioeconomic activities.
CHAPTER ONE
INTRODUCTION

1.1 Background

1.1.1 Concept of social vulnerability

The concept of social vulnerability to climate change can be defined as the susceptibility of a given population to harm from exposure to a hazard, directly affecting its ability to prepare for, adapt to, and resilient (IPCC, 2000). Social vulnerability is a function of diverse demographic and socioeconomic factors that influence a community’s sensitivity to climate change (UNEP, 2004). Social demographic profile, livelihood strategies; social network, health, food, and water are among important indicator of individual vulnerability to climate change. It can be directly also related to marginalization and lack of access to resources which are critical when faced with the risk and hazards of climate change and the resultant stress on livelihoods (Hahn et al., 2009).

The basis for any assessment of social vulnerability to climate change is an understanding of the human use of surrounding resources. The extent to which individuals, groups or communities are ‘entitled’ to make use of resources determines the ability of that particular population to cope with and adapt to climate stress (Adger & Kelly, 1999).

1.1.2 Vulnerability of small Islands to climate change and variability

Small Island states increasing vulnerability to the impacts of climate change and variability. These decreasing their physical land size due to the fact that they are surrounded by large expanses of ocean as result encroach the coastal area, limited
natural resources, proneness to natural disasters and extreme events relative isolation; extreme openness of their economies, which are highly sensitive to external shocks, large populations with high growth rates and densities, poorly developed infrastructure, and limited funds, human resources, and skills. These characteristics limit the capacity of small island states to mitigate and adapt to future climate and sea-level change (Cutter 2009).

The most significant and immediate consequences for small Island states are likely to be related to changes in sea levels, rain fall regimes, soil moisture budgets, and prevailing winds (speed and direction) and short-term variations in regional and local patterns of wave action. Owing to their coastal location, the majority of socioeconomic activities and infrastructure and the population are likely to be highly vulnerable to the impacts of climate change and sea-level rise. Review of past and present trends of climate and climate variability indicates that temperatures have been increasing by as much as 0.1°C per decade, and sea level has risen by 2 mm a year in regions in which small island states are located (Cutter 2009).

The trend Analysis of observational data for these regions suggests that increase in surface air temperatures have been greater than global rates of warming (e.g., in the Pacific Ocean and the Caribbean Sea regions). Observational evidence also suggests that much of the variability in the rainfall record of Caribbean and Pacific islands appears to be closely related to the onset of El Niño- Southern Oscillation (ENSO). However, part of the variability in these areas also may be attributable to the influence of the Inter-Tropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ). It is acknowledged however, that for some small islands it is difficult to establish clear trends of sea-level change because of limitations of
observational records, especially geodetic-controlled tide gauge records (Cutter 2009).

Zanzibar as part of Small Island in western Indian Ocean that face number of climate related challenge. It experiences frequent natural disasters that cause loss of life, damage to Infrastructures and economic assets, and adversely impact on lives and livelihoods especially of poor and marginal households (Sheikh et al., 2013).

1.1.3 Agriculture and climate change

Agriculture is a complex system relate very closely with climate factors through the direct effects of temperature, precipitation, sunlight, and atmospheric composition on plant growth and yield, as well as livestock production (Dominati et al., 2010). The soil and water resources of agricultural landscapes are linked with the same environmental factors. As the effects of climate change on soil, water, and environmental goods and services are examined, it becomes apparent that aggregate effects of climate transcend effects on individual agro ecosystem components (Walthall et al., 2012.) For example, precipitation affects the potential amount of water available, however the actual amount of available water depends upon soil type, soil water holding capacity, and infiltration rate, such that the aggregate effect is not directly determined by precipitation amount. In facts climate is key determinate of plant growth and production.. (Dominati et al., 2010).

In the context of agricultural-dependent societies, understanding the potential impacts of climate change and society’s capacity to adapt changes requires analysis on combination of conditions (economic, environmental and social). That contributes to vulnerability, and characterizing locations and segments of society that are most vulnerable (Hahn et al., 2006).
1.1.4 Contribution of agriculture to Zanzibar economy

Zanzibar, Agriculture accounts for about 40% of the gross domestic product (GDP), provides 70 percent of all exports and saves as a livelihood to over 70 percent of the total population. The country depends on limited agricultural commodities such as spices, seaweed and cloves for export (ZRA, 2015).

Clove industry is the major source of foreign exchange in Zanzibar. It contributes over $11 million annually to Zanzibar’s economy (ZSTC, 2011). In the past four-decade, Clove production has been a steady decline since 1970s. The data are shown that 16,000 tons in 1970’s to about 3500 tons in the 2010s (Ali et al., 2011). Diseases and climate change and variability are considered as major sources of clove production decline in Zanzibar (Dabek and Martin, 1987). Climate change poses a major threat to sustainable development because adverse effects are likely to be directed particularly at poor population (Sheikh et al., 2013). The impact of climate change such as heat waves, floods and drought, increased surface temperatures may have potential consequences on agricultural production such as clove plantation ecosystems (Olesen and Bindi, 2002). There are also concerns that flooding, drought and environmental degradation associated with climate change May lead to famers’ displacement and abundant their crops (Haines et al., 2006). Related damage and Risk of climate change may be reduced damage and risk brought about by climate change through tactical responses to these changes (Hassan and Nhachena, 2008).

The study was mainly focus on how clove growers, government, researchers, donors, and policy makers and those consider policy actions at different spatial and temporal scales to reduce different aspects of the vulnerability of clove famers to key impacts of climate change on clove production.
1.2 Statement of the problem.

Small Island States are vulnerable to the impacts of climate change and variability. The most significant and immediate consequences for small Island States are likely to be related to changes in sea levels, rain fall regimes, temperature increasing, soil moisture budgets, decreases in socioeconomic activities and prevailing winds (Cutter, 2009). Zanzibar like others Small Islands has climate dependent economy. It experiences frequent natural disasters that cause losses of life and properties, damage to infrastructures and economic assets, which lead adversely impact on livelihoods especially for poor and marginal households (Sheikh et al., 2013). The previous studies demonstrated the climate change Vulnerability using Livelihood Index (LVI) and IPCC Vulnerability Index (IPCC-VI). For example Kumar, 2010 reported livelihood vulnerability index of climate change in human capital in Chekampar, Nepal. The findings showed the moderate vulnerable situation of the community to the adverse of climate change i.e financial assets (0.7) natural assets (0.557). In Mozambique, there was a low vulnerability in climate change, LVI ranged between 0.005 and 0.074 on socio-demographics, livelihoods, social networks, health, food and water security and natural disasters (Hahn et al., 2008). Assessment of livelihood vulnerability for paddy production in Zanzibar showed relatively high vulnerability where LVI-IPCC ranged 0.47 and 0.080 (Moyo, 2013). Cumulative vulnerability of coastal communities of Zanzibar showed slightly moderate vulnerability to climatic change ranged from 0.29 to 0.31 (Cinner et al., 2012).

Agriculture is the backbone of Zanzibar economy. It accounts for about 40% of the gross domestic product (GDP), provides 70 % of all exports and saves as a
livelihood to over 70% of the total population (ZRA, 2015). Clove industry is the major source of foreign exchange to the Island economy (ZSTC, 2011). Zanzibar was leading in global clove producer for over 90% (Woody Biomass Survey, 2013). Nevertheless, recently they have been a steady decline in clove production from 16,000 tons in 1970’s to about 3500 tons in the 2010s (Ali et al., 2011). Clove plantation has been significantly decreasing from 5,833,100 in 1997 to 4,131,783 in 2013 (Woody Biomass Survey, 2013).

A few studies have investigated the reason of clove production decreasing in Zanzibar. For example Dabek and Martin (1987) found that diseases and climate change and variability are considered as major sources of clove production decline in Zanzibar. However, the extent of social vulnerability of Climate change to clove farmers is not known in the Islands. The objective of this study was to investigate vulnerability of clove farmers to the impacts of climate change and variability on clove production in Pemba Island.

1.3 Objective of the study

1.3.1 General objective

The general objective of the study was to examine vulnerability of clove famers to the key impacts of climate change and variability.

1.3.2 Specific objectives of the study

i To determine the Clove farmers households' vulnerability to the effect of climate change and variability.

ii To assess the variations of the vulnerability in the studied districts.
1.4 **Research questions**

i. What is vulnerability of clove famers to the effect of climate change and variability?

ii. What is variation of the vulnerability in the studied districts?

1.5 **Significance of the study**

The study has attempted to determine the vulnerability of the clove farmers prone to disaster caused by, drought and floods. The assessment of vulnerability can help to reduce the susceptibility of the area with regard to recovery from external shock and future losses. A comprehensive LVI assessment of all areas, thus, can be prepared to identify and access vulnerability of all households, and accordingly, provision for basic amenities and access to resources to strengthen the capacity of households to overcome challenges posed by livelihood bases, multiple options of livelihood and income earning may be created to suit people’s specific requirements. The findings of the study are pertinent to government and non-governmental organizations who are actively involved in flood and drought control program. By using LVI analysis, government can identify the areas where clove farmers were most vulnerable, and thus, can provide basic amenities and access to resources in accordance with their needs as a mitigation strategy, to ensure improved capacity of households in responding to drought. Furthermore, by addressing the basic needs of households and by making provision for better health and sanitation facilities, government can decrease their susceptibility and improve their pace of resilience. Government can further focus on diversification of livelihoods to ensure households’ accessibility to multiple options of livelihood and income during the period the area is inundated, which can be more than 3 months? To determine the interconnection between
vulnerability and resilience, the LVI was used with livelihood strategy components removed from it. Moreover, the study generated the information about vulnerability and impacts of climate change and variability on clove farmers that are helpful to the government, public and clove growers. Thus all were informed as to what extent the climate change has created negative effect to the clove farmers. In addition to that, the study helped the interested group to know level of vulnerability. Finally, government, public and clove growers were provided with adaptation alternative procedure measurement to overcome the impacts of climate change in order to maximize Clove production.

1.6 Scope of the study
This research studied 383 among 9200 clove farmers from four Pemba Island districts. The assessment of vulnerability was conducted at household level in depth to identify the vulnerability level of the clove farmers. The large portion of sample was covered by marginalized clove grower of the districts of the Pemba Island, who are continuously suffering from deprivation on their traditional livelihood assets and strategies due to the adverse environmental situations. Vulnerability assessment to climate change is new issue of concern in Pemba Island as only very few researches have been conducted on this matter quantitatively and in-depth with the approach of sustainable livelihood. This research includes the wide ranges of livelihood aspects and their inter link with the bio-physical environment. Extensive community participation was ensured to generate the indicators of livelihood aspects required to assess their vulnerability to climate change impacts. Likewise, livelihood vulnerability index (LVI) was also calculated on the basis of calculated indices of all indicators of sustainable livelihood. The indicators were also categorized in IPCC’s
dimensions of vulnerability to climate change i.e. exposure, adaptive capacity, and sensitivity to calculate with the LVI-IPC help of following formula. LVI-IPCC = (exposure index-adaptive capacity index) × sensitivity index. The findings of this research not only focused on clove growers but also can be used as a model for other farmers. The indicators used to calculate LVI and LVI-IPCC in this research are very specific to the research site.

1.7 Limitations of the study

The sub-components and major components used to construct the LVI were selected based on a review of available data for this particular study site and consultation with local people which may not apply to other populations. This study was intended to introduce the LVI concept and demonstrate a particular application especially in Pemba Island climate change scenario. Other sub-components could be used to quantify the major components and other weighting schemes can be used to reflect local farmer’s priorities. It is also important to note that this study standardized the subcomponents using maximum and minimum values for specific study population of the study area. As noted by Vincent (2007), this means that LVI estimates in this study are not comparable with future studies unless these are conducted following the same methods (like scaling and weighting schemes). Because LVI is designed in this study for districts level assessment, it cannot be merged with climate projections from low resolution GCMs which, some may argue, would extend the vulnerability analysis further into the future than the LVI allows. Limitations of the overall LVI approach include those associated with the use of indicators and indices, namely that these oversimplify a complex reality and there is inherently no straightforward way to validate indices comprised of disparate indicators (Vincent, 2007). Because sub-
components were averaged into one major component score, the indexing approach did not incorporate variance between study populations. Further, the selection of subcomponents and the assignment of directionality from less to more vulnerable involve normative judgment (Vincent, 2007). Some may debate, for example, whether a larger fraction of female-headed households increases or decreases a community.
CHAPTER TWO

LITERATURE REVIEW

This chapter presents wide range of ideas and discussion of the key concept presented by various scholars and practitioners with regard to climate change impacts and vulnerability in small Island ecosystem. The chapter presents two categories of viewpoints; the theoretical and empirical perspectives. The theoretical perspective of academic reports is presented by various authors, while empirical sides perspectives encloses case studies presented by various practitioners across the globe as related to Climate change, vulnerability and clove production.

2.0 Key definition

2.1 Climate – Climate, in a broad scope, is always outlined as the “mean weather” and on its father meaning, it is the statistical description in terms of the average and variability of relevant quantities of elements of climate over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO, 2007). The relevant quantities are most often surface variables such as temperature, precipitation, dampness into atmosphere humidity sunshine and wind. In a wider sense climate is the state, including a statistical description, of the climate system. The ecosystems, agriculture, livelihoods and settlements of a region are very dependent on its climate. Climate change means the change of frequency and intensity pattern among the climatic factors such as precipitation, temperature, sunlight, wind etc. More precisely, the weather changes collectively make up the climate change (IPCC, 2000).
Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).

In 2006, the United Nations Framework Convention on Climate Change described the climate as the changes due to natural internal processes or external forces or to persistent anthropogenic changes in the composition of the atmosphere or in land use. It defined climate change as “…a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable period of time.” The UNFCCC thus makes a distinction between “climate change” attributable to human activities altering the atmospheric composition, and “climate variability” attributable to natural causes.

Climate variability on the other hand refers to deviations in the mean state and other statistics (standard deviation, occurrence of extreme events) of climate on all time scales beyond that of individual weather events.

Intergovernmental panel on climate change defines Climate variability as variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC, 2000).

2.2 Causes of climate change

Due to increasing world population and industrial development, there is an increased emission of GHGs, deforestation, burning of fossil fuels, construction activities and
decay of biomass, etc., that leads to higher concentration of CO$_2$ in atmosphere which currently is around 388 ppm and predicted to increase to approximately 470 – 570 ppm until year 2050 (IPCC, 2007).

The level of absorption, scattering and emission of radiation with in the atmosphere, ocean and on the earth surface are highly affected by the amount of concentration of atmospheric GHGs, aerosols, soli type and moisture, vegetation and land cover, solar radiation etc. This is true for the fore mentioned entities that are a cause for alteration of energy balance (positive or negative change) within the climate system and are driver of climate change (IPCC, 2000).

2.3 Concept of vulnerability

Vulnerability refer to the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate. Hence, a highly vulnerable system is one that is highly sensitive to modest changes in climate and one for which the ability to adapt is severely constrained (IPCC, 2000).

2.4 Vulnerability to climate change

The third assessment report (TAR) of the (IPCC, 2000) defines vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (Adger, 2006). The climate change vulnerability is due to the exposure, sensitivity and adaptive capacity which may be defined as follows:
Exposure is the character, magnitude and rate of climate change and variation.

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).”

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Adger, 2006).

Vulnerability to climate change depends not only on physical and biological responses but also on socio economic characteristics. Low- income population especially those who cultivate crops under rain fed and non- irrigated agriculture systems in dry lands, arid and semi-arid areas highly affected by severe hard ship due to climate change (Grasty, 1999).

2.5 Climate change vulnerability assessment

Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine interactions between humans and their physical and social surroundings (Hahn et al., 2009). Vulnerability assessments have been used in a variety of contexts including the USAID Famine Early Warning System (FEWS) (USAID, 2007), the World Food Programme’s Vulnerability Analysis and Mapping tool for targeting food aid World Food Program (WFP, 2007), and a variety of geographic analyses combining data on poverty, health status, biodiversity, and globalization ( UNEP, 2004).
The need of vulnerability assessment in grassroots level has become very essential. Large numbers of adaptation programs have turned failed simply because they were not able to properly identify the major aspects and magnitude of vulnerability of the community where projects were to be launched (USAID, 2007). A common thread is an attempt to quantify multidimensional issues using indicators as proxies. These are often combined into a composite index allowing diverse variables to be integrated (Hahn et al., 2009). The Human Development Index, for example, incorporates life expectancy, health, education, and standard of living these are indicators for an overall picture of national well-being (UNDP, 2007). Several methods have been used to combine indicators. The gap method (Gillis et al., 1987) was used by Sullivan (2002) to assess how much water provision and use deviates from a predetermined standard for the Water Poverty Index. Hahn et al. (2009) suggested that both Human Development Index and the Water Poverty Index are examples of composite indices calculated using weighted averages of individual indicators.

2.6 Climate change and Agriculture

Agriculture contributes to climate GHGs emission and highly affected by change in climate parameters. In an intensive farming, we expect high greenhouse gases emission because of using high amount of inputs and chemicals, due to these changes of human activity natural divers and climate change impacts varies accordingly in different part of the world advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.

On other hand Agriculture is a complex system relate very closely with climate factors through the direct effects of temperature, precipitation, sunlight, and atmospheric composition on plant growth and yield, as well as livestock production.
The soil and water resources of agricultural landscapes are linked with the same environmental factors. As the effects of climate change on soil, water, and environmental goods and services are examined, it becomes apparent that aggregate effects of climate transcend effects on individual agro ecosystem components. For example, precipitation affects the potential amount of water available, however the actual amount of available water depends upon soil type, soil water holding capacity, and infiltration rate, such that the aggregate effect is not directly determined by precipitation amount. In facts climate is key determinate of plant growth and production. Actual climate change effects will thus depend on the cumulative effects of climate change factors on resources that are of key importance to agriculture, such as soil and water. Many of these effects are described by the following sections. (Dominati et al. 2010), Walthall et al., 2012 stated that, “Plants response to climate factors and very sensitive to complex set of interactions to CO₂, temperature, sun light, wind and precipitation”. In fact, each crop species has a specific condition of weather and given set of temperature thresholds that control the growth and reproduction, along with optimum temperatures for each developmental phase. Plants are currently grown in areas in which they are exposed to temperatures that match their threshold values. As temperatures increase over the next century, shifts may occur in crop production areas because temperatures will no longer occur within the optimum range, one critical period of exposure to temperatures is the pollination stage, when pollen is released to fertilize the plant and trigger development of reproductive organs, for fruit, grain, or fiber. Such thresholds are typically cooler for each crop than the thresholds and optima for growth. Pollination is one of the most sensitive stages to temperatures, and exposure to high temperatures during this
period can greatly reduce crop yields and increase the risk of total crop failure. Plants exposed to warm nighttime temperatures during grain, fiber, or fruit production also experience lower productivity and reduced quality. Increasing temperatures cause plants to mature and complete their stages of development faster, which may alter the feasibility and profitability of regional crop rotations and field management options, including double-cropping and use of cover crops. Faster growth may create smaller plants, because soil may not be able to supply water or nutrients at required rates, thereby reducing grain, forage, fruit, or fiber production. Increasing temperatures also increase the rate of water use by plants, causing more water stress in areas with variable precipitation. Estimated reductions in solar radiation in agricultural areas over the last 60 years are projected to continue due to increased cloud cover and radioactive scattering caused by atmospheric aerosols. Such reductions may partially offset the temperature-induced acceleration of plant growth. For vegetables, exposure to temperatures in the range of 1°C to 4°C above optimal for biomass growth moderately reduces yield, and exposure to temperatures more than 5°C to 7°C above optimal often leads to severe, if not total, production losses. While many agricultural enterprises have the option to respond to climate changes by shifting crop selection, development of new cultivars in perennial specialty crops commonly requires 15 to 30 or more years, greatly limiting that sector’s opportunity to adapt by shifting cultivars unless cultivars can be introduced from other areas. An increase in winter temperatures also affects perennial cropping systems through interactions with plant chilling requirements. All perennial specialty crops have a winter chilling requirement (typically expressed as hours below 10°C and above 0°C) ranging from 200 to 2,000 cumulative hours. Yields will decline if the chilling requirement is not
completely satisfied because flower emergence and viability will be low. Projected air temperature increases for California, discovered that increased or decreased temperature, may prevent the chilling requirements for fruit and nut trees by the middle to the end of the 21st century. In the Northeast United States, perennial crops with a lower 400-hour chilling requirement will continue to be met for most of the Northeast during this century, but crops with prolonged cold requirements (1,000 or more hours) could demonstrate reduced yields, particularly in southern sections of the Northeast. This is sufficient evidence to show that Climate change affects winter temperature variability, as well; mid-winter warming can lead to early bud-burst or bloom of some perennial plants, resulting in frost damage when cold winter temperatures return. Increasing carbon dioxide (CO₂) in the atmosphere is a positive for plant growth, and controlled experiments have documented that elevated CO₂ concentrations can increase plant growth while decreasing soil water-use rates. The effects of elevated CO₂ on grain and fruit yield and quality, however, are mixed; reduced nitrogen and protein content observed in some nitrogen-fixing plants causes a reduction in grain and forage quality. This effect reduces the ability of pasture and rangeland to support grazing livestock. The magnitude of the growth stimulation effect of elevated CO₂ concentrations under field conditions, in conjunction with changing water and nutrient constraints, is uncertain. Because elevated CO₂ concentrations disproportionately stimulate growth of weed species, they are likely to contribute to increased risk of crop loss from weed pressure.

The effects of elevated CO₂ on water-use efficiency may be an advantage for areas with limited precipitation. Other changing climate conditions may either offset or complement such effects. Warming temperatures, for instance, will act to increase
crop water demand, increasing the rate of water use by crops. Crops grown on soils with a limiting soil water-holding capacity are likely to experience an increased risk of drought and potential crop failure as a result of temperature-induced increase in crop water demand, even with improved water-use efficiencies. Conversely, declining trends of near-surface winds over the last several decades and projections for future declines of winds may decrease evapotranspiration of cropping regions.

Crops and forage plants will continue to be subjected to increasing temperatures, increasing CO₂, and more variable water availability caused by changing precipitation patterns. These factors interact in their effect on plant growth and yield. A balanced understanding of the consequences of management actions and genetic responses to these factors will form the basis for more resilient production systems to climate change.

“Risk” is used here to designate the potential of shocks and stresses to affect, in different ways, the state of systems, communities, households or individuals. Probability, uncertainty (when probabilities of occurrence or even nature of impacts are unknown), severity, economic scale, time scales and direct and indirect costs should be taken into account.

Walthall et al. (2012) stated that “Resilience” is the ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation.

Walthall et al. (2012) also defined Adaptive capacity as the ability of a system to adjust to climate change including climate variability and extremes to moderate
potential damages, to take advantage of opportunities, or to cope with the consequences.

Coping capacity refers to the ability of a system to deal with the impacts of present-day weather extremes or climate variability (Lures and Moser, 2006).

Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become well understood. Careful monitoring of these outcomes both climate change is a threat to the livelihood and development of most African countries because it brings about decrease in agricultural production and drop in farm revenue. The negative effects are apparent on limited resource among residents in rural areas whose livelihoods depend entirely on agriculture. This study was conducted to investigate the impact of climate change on crop production and development of Muyuka subdivision. Simple random sampling technique was used where by 30 farmers were selected from each of the five communities (Mautu, Owe, Bafia, Ikata and Muyenge). Data collected on social characteristics of the respondents, impact of climate change on production and development were analyzed using descriptive statistics. The Results indicated that most farmers who were aged between 40-49 years, had attained primary education, and had been farming for 10-14 years.

On other hand famers aged 25 years and above were farming for both subsistence and commercial purposes. These findings revealed that Farmers had been negatively affected by climate change as it brought about drop in yields of crops like plantain, cocoyam, maize and cocoa which are commonly grown in this subdivision. Climate change affected development through increasingly poverty, hunger and hence
21
deterioration of living standards. The climatic event which affected farmers most was
the increase in sunshine intensity which caused drying of plants and ripening of
cocoa pods before maturity. Adaptation is therefore necessary to reduce negative
impact and ensure comfortable livelihood of farmers (Defang et al., 2014).
Among the strategies recommended by the study is smallholder irrigation
development. The study showed that the performance of smallholder irrigation
schemes in terms of improved water management, food security and income is
encouraging; with net earnings ranging between USD 200 and 1200 per month for
single-crop enterprise in Kenya. Rainwater harvesting complements smallholder
irrigation and enhances farmers’ profitability. Rainwater harvesting for supplemental
irrigation, for example, yielded net profits of USD 150-600 per ha in Burkina Faso
and USD 110-500 in Kenya. But despite evidence of good returns on investment,
large-scale national programs on water management have not been realized (Stephen,
2009).

2.7 Effects of climate change on ecosystems and ecosystem services
An ecosystem is a dynamic complex system of plant, animal, and microorganism
communities and the non-living environment interacting with each other as a
functional unit. Ecosystem services are the benefits that people get from ecosystems,
like food, forest products, water quality and quantity, soil conservation, biodiversity,
recreation of what and other cultural values. In order to get good ecosystem services
for human wellbeing there should be a mechanism, which maintain the nutrient
cycles, production, soil formation, etc. in a good state, furthermore enhancing
sustainability and conservation of natural as well as human made ecosystems is
important. Any disruption or loss of natural ecosystems leads to breakdown of
ecosystem functioning and causes loss of ecosystem services. Because of climate change (increased extreme events, e.g. drought and forest fire) large proportion of species are at risk of distinction. Here we can include the water purification by wetlands provided by forest, the protection of coastal areas from storm surges by mangroves and coral reefs, the regulation of pests and diseases and the recycling of waste nutrients, the removal of carbon from the atmosphere (Warren, 2011).

A fundamental difference between global ecosystems of the past and in the future is the dominating influence of human activity and intervention in natural environment, in addition, deforestation, agriculture and over grazing can fasten the processes of desertification especially in sub tropics and semiarid lands (Bolin et al., 1989). If we observe the function of natural ecosystems and take few example in USA, at least half of the medicines used today derive from natural source. Between 1998 and 2002, one hundred sixteen out of 158 new medicine drugs licensed obtained from natural origin and only one percent of known plants analyzed for their potential of use in medicine (Warren, 2011).

Ecosystems and ecosystem services affected by global climate change, both directly and indirectly. Many studies particularly on agricultural crops and forest shows that the enhanced atmospheric CO$_2$ directly increase productivity, because higher ambient CO$_2$ concentration stimulates net photosynthetic activity which have been called 'CO$_2$-fertilization' effect. Transpiration decreases through a partial stomata closure resulting in increased water use efficiency of plants at least at a leaf scale; nevertheless, there are considerable differences between different species regarding their response. Some species in terrestrial ecosystems may in the long-term indirectly react negatively, perhaps fatal, to increased CO$_2$ concentration. The indirect
responses of ecosystems are due to the effect of elevated CO$_2$ concentration is through effect on climate, such as change in temperature or radiation, humidity, precipitation or other climate variables. In most cases, this situation (the change in climate variables) can cause an impact on ecosystems (Bolin et al., 1989). As environmental exploitations by humans are increased, the global environmental change (GEC) (increasing atmospheric CO$_2$ levels and associated climate changes fragmentation and loss of natural habitats) will also increase, which leads to rapid change on ecosystems in the world. Despite the large body of research showing effects of GEC on population abundances, Community composition, and organism physiology, GEC may cause less obvious alterations to the networks of interactions among species. Yet complex networks of biotic interactions such as predation, parasitism and pollination play an important role in the maintenance of biodiversity, mediation of ecosystem responses to GEC, and the stability (resistance or resilience) of those ecosystem services on which human well-being is dependent (Tylianakis et al., 2008). The uptake of minerals, nutrient and water, canopy exchange of plants, absorption of light energy for the formation of carbohydrate through photosynthesis reactions as well as the breakdown and burning processes of carbohydrate for growth and development of the plant (respiration) is highly dependent on the amount of atmospheric CO$_2$ concentration and ambient Temperature. The processes of transpiration (affected by the opening and closure of stomata), and evaporation from surface of plants determined by the level of temperature and CO$_2$. Soil biotic processes e.g. decomposition, mineralization, immobilization, and soil a biotic processes such as solute transport, weathering, cat ion exchange, etc. in the soil affected by climate change. As a result, it causes a change in net primary production,
species composition and resource competition; consequently, the general services, which we get from forest ecosystem; such as forest products, biodiversity, species composition, soil and water resources and recreation are affected (Lukac et al., 2010).

2.8 Temperature

The average annual temperature increased by 0.7°C. The analysis of annual average temperature over a period of 20 years 1984-2004 showed an increase on average annual temperature by 0.7 units. Such a change is not surprising but it validate that global warming which can be revealed even at local scales. Yanda et al. (2008) showed that the average annual temperature in Zanzibar and Arusha increased by 1.9°C and by 1.1°C respectively between 1961 and 2005. Fischer et al. (2002) reported that changes in rainfall amount and patterns, in addition to shifts in thermal regimes, influence unbalance or dislocation local seasonal and annual water balances. These in turn affect the distribution of periods during which temperature and moisture conditions permit agricultural crop production. According to IPCC (2007), increase in average temperature will adversely affect crops, especially in semi-arid regions, where already heat is a limiting factor of production. Increased temperature also increase evaporation rates of soil and water bodies as well as evapotranspiration rate of plants, and increase chances of severe drought. It means that with warmer temperatures. Plants require more water.

Local perceptions by farmers with respect to changes in temperature as well as increasing rainfall variability are closed related to empirical analysis of rainfall and temperature trends using the data obtained from meteorological station. Trend analysis of rainfall data indicated that annual rainfall decreased from 1922 to 2007,
more pronounced decrease from 1982 onwards. The observations under similar climatic conditions are in broad agreement with those reported by Yanda et al. (2008).

Generally in the past, rainfall in Manyoni used to start fading away in May. Currently this is not the case as indicated by decreases in rainfall amounts and patterns also shows that the onset of rainfall has shifted from October to November and that the rainy sea (Mary and Majule, 2009).

Warming of the earth do not uniformly distributed over the world; continents show more rapid temperature increase as compared to oceans. Temperature change will have very different impacts on vegetation and ecosystem productivity, structure and composition depending on the 17 actual temperature ranges at the location (Morison & Lawrol, 1999). Global temperature has increased about 0.2°C per decade for the past 30 years and warming is larger in the western equatorial pacific than in the eastern equatorial pacific over the past century (IPCC, 2007). Regional warming predicted to increase with increasing latitude. However, when we see warming in tropics, although relatively small in its magnitude, it is likely to have consequences on ecosystems, because of the warming effect dry ecosystems become drier, since tropical species are relatively sensitive to temperature change as they currently are living very close to their optimal temperature level. These results imply that the greatest extinction risks from global warming may be in tropics, where biological diversity is also greatest (Fussel, 2009).

Temperature can affect photosynthesis through modulation of the rates of activities of Photosynthetic enzymes and the electron transport chain and indirectly through leaf temperatures defining the magnitude of the leaf–to-air vapor pressure difference,
which is a key factor influencing stomata conductance. Unlike the temperature sensitivity of processes like flowering and fruiting many other physiological processes have small genotypic variations, although some genetic adaptation have been observed on enzymes like Rubisco (Lloyd and Farquhar, 2008).

A case of Zanzibar, there is showing that changes of increasing temperatures on both islands, with the strongest increases in the period December – May. The changes between recent decades are shown below (note the time series is shorter for Pemba). While some care must be taken in interpreting these trends, because of decadal variations and the relatively short time periods involved, they do show strong rising trend. In recent years Zanzibar has been subjected to changes of climatic parameter this as demonstrated with Rise of temperature, alteration of precipitation pattern and the strength of winds. These also affect the dampness and humidity into the atmosphere.

Figure 1: Average monthly maximum Temperatures in Pemba (Source: TMA, 2015)

2.9 Precipitation change

Global warming causes higher evaporation rates and therefore, higher precipitation rates, but a large general increase in precipitation is not expected, there will be some
regions on the globe where the precipitation will increase and others where it will decrease. According to IPCC (2007), more rain expected in the equatorial belt (humid tropics) and at higher-latitudes. While less precipitation projected at mid-latitudes, semiarid areas and dry tropics. The spatial extent of severe soil moisture deficits and frequency of short-term drought (due to shortage and absence of expected rain water for a short period of time) is expected to double until late 21st century and long-term drought become three times more common especially in regions with less precipitation (IPCC, 2007). A case of Zanzibar, There is observational changes of pattern of rainfall on both islands, with the heavy rainfall in the period March – May. The changes between recent decades are shown below (note the time series is shorter for Pemba). While some care must be taken in interpreting these trends, because of decadal variations and the relatively short time periods involved, they do show strong rising trend.

![Figure 2: Rainfall patterns from 1974-2012 in Pemba Island](image)

2.10 Description of clove tree

2.10.1 Origin of clove

The word “Clove” is derived from Latin word *clavus* means 'nail shaped', referring to the bud and the botanical name *Syzygium aromaticum*, Eugenia caryophyllus.
Cloves are an early spice and, because of their exceptional aromatic strength, have always been held in high esteem by cooks in Europe, Northern Africa and Asia. The tree is endemic in the North Moluccas (Indonesia). After the end of the Dutch monopoly (18th century), clove trees were introduced to other countries. Clove, *Syzygium aromaticum*, is a monoecious (both male and female flowers on the same plant) evergreen tree in the family Myrtaceae grown for its aromatic flowers. The many branches of the tree are semi-erect with smooth oval shaped leaves. The branches end with a 3–4 flowers near the tip with one terminal flower and the others opening below it. The leaves, flowers and bark all have a distinct smell. The clove is the unopened flower buds. The tree grows 10–20 m (36–72ft) tall and can live to be more than 100 years old. The clove tree may also be referred to as tropical myrtle and are native to the Moluccas Islands (Parle and Deepa, 2011).

### 2.10.2 Basic requirements

Clove trees require a warm, tropical climate with an annual rainfall of 1500 mm – 3000mm. Clove trees are very susceptible to stress. Areas that undergo a dry season are good for flowering but the tree must be planted in an area with deep, fertile soil to limit water stress. Clove trees grow optimally at temperatures between 16 and 27°C (65–80°F) in rich loamy, well-draining soil (Parle and Deepa, 2011).

### 2.10.3 Uses of Clove

The vast majority of commercially cultivated cloves are used by the tobacco industry to flavor cigarettes, used as spices; either in their whole form or after first grinding into powder and Clove is also used for medical purposes (Parle and Deepa, 2011).
2.10.4 Propagation of Clove

Clove is commercially propagated from swollen seeds which are planted soon after harvest. Seeds should be collected and extracted from the fruits of healthy mother plants exhibiting desirable characteristics. The seeds are extracted by soaking the fruits in water and peeling the skin from the fruit. The seeds can be planted in prepared nursery beds or polyethylene bags containing a mixture of soil and aged manure and should be planted to a depth of 2 to 5 cm (0.8-2.0 in) and spaced 12 to 15 cm (4.7-5.9 in) apart. Germination usually occurs within 1 to 6 weeks. The seedlings should be shaded to protect them from harsh sunlight. The seedlings should be kept moist through regular watering and can be transplanted when they reach at least 30 cm (11.8 in) in height. The seedlings should be hardened off by exposing them to increasing amounts of sunlight before they are transplanted to the field.

Plate 1: Clove seeds
2.10.5 Transplanting

Young clove trees should be planted in pre-dug pits which are approximately 60 × 60 × 60 cm (24 × 24 × 24 in), or large enough to accommodate the root ball. The recommended spacing for clove trees is 8 m (26 ft) but closer spacing are commonly used. Trees planted in the field should be provided with temporary shading to alleviate stress. Shade can be provided through intercropping with other crops such as banana, cassava or coconut these can be pruned to alter the amount of light reach in the cloves throughout the year.

Plate 2: Young clove trees.

2.10.6 General care and maintenance of new germinated clove plants

Once the temporary shade plants are removed, the plantation should be kept free from weeds by weeding once or twice each year or by applying a layer of mulch around the trees. Mulch helps prevent the roots being damaged by the physical removal of the weeds. Trees may require additional irrigation during dry periods to prevent them becoming stressed which harms their production. The trees should also
be provided with nutrients in the form of fertilizer or manure. The composition and amount of fertilizer required is dependent on the region and soil type.

2.10.7 Harvesting of Clove

The complete inflorescence (flower) should be picked just before the first buds open to ensure maximum size and oil content of the buds. The harvest is often conducted over 3 to 8 pickings during the season as buds mature. After harvesting, the buds are laid out to dry in the sun for several days.

Plate 3: Flower clove.

2.11 Clove Industry in Zanzibar

2.11.1 Historical background of clove farms in Zanzibar

Clove industry in Zanzibar was established in about 1812 by Arab immigrant from Oman. The worldwide increasing demand for this product in different purposes called for special attention to increasing production (Croucher, 2007). The clearing of land for large estate was motivated by cheap labor and slaves services in 1822. High prices and free marketing system led to a rapidly expanding plantation sector during the years 1835 to 1847. From that on ward some Indian and most Zanzibar
indigenous particularly in Pemba Island involved in this business (Shariff, 1987). In 1872 Zanzibar was blown by hurricane where by the large number of clove plantation was destroyed. Due to the importance of clove plantation the colonial government and individual people initiated the special effort to revive the situation. By the 1900's the clove plantation regained its strength where by clove plantation were reestablished to covered most of the Pemba Island and some fertile area in Unguja Islands (Shariff, 1987). During the British protectorate a lamp sum of money was used to support clove growers this made clove enterprise flourish to its maximum height. The reasonable price and freedom of farmers to sell their clove wherever they desired encourage farmers to grow more clove plantation (Shariff, 1987). Many years before Zanzibar revolution clove plantation and production were monitored by local community association called Clove Growers Association (CGA) (ZSTC, 2012). Soon after Zanzibar revolution in 1964 when the then government intended to nationalize all basic economic means the State Trading Corporation (ZSTC) was established being the Government Institution based in Zanzibar. The establishment of ZSTC was under the Public Enterprise Decree No. 39 of 1966 through Zanzibar State Trading Order Section 2(1) of 1968 (ZSTC, 2012). This Corporation was established to replace the functions of the Clove Growers Association (CGA). However, ZSTC was specifically charged with responsibilities of clove development, buying crops from farmers as well as conducting all necessary business in connection with the supply and distribution in external business (ZCST, 2011).

For many decades and until now, Clove industry has been the backbone of the Zanzibar economy and the leading of all agricultural products in country for long
time. It constitute the primary source of economic for the majority of Zanzibar’s and sources of income for many people because it is a major component of development and stability of the country under suspicious of (ZSTC) assistance in Zanzibar. The economy of Zanzibar depends on exploiting clove and it has been a major means of foreign exchange earning in Zanzibar since the last hundred and fifty years (Juma, 2010).

Plate 4: Healthy clove trees

The above photo show the nature of clove trees in its flourish and health state before the affected from deferent factors including the climatic change and variability.
Plate 5: Affected clove trees

This photo above show the effected clove trees due to the influence of climate changes and some them has already die.

2.11.2 Trend of clove production in Zanzibar

In the past years around 1970s the clove production in Zanzibar was very high with estimation of 16000 tons annually. Currently, there has been drastic change of production which has fallen to estimated production of 1500 to 3000 metric tons annually in 2010 (Juma, 2010).
Table 1: Show the trend of production one decayed in tons.

<table>
<thead>
<tr>
<th>Years</th>
<th>Average tons of clove in 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-1980</td>
<td>7586</td>
</tr>
<tr>
<td>1981-1990</td>
<td>6225</td>
</tr>
<tr>
<td>1991-2000</td>
<td>4804</td>
</tr>
<tr>
<td>2001-2010</td>
<td>2920</td>
</tr>
</tbody>
</table>

Figure 3: Clove production trends

Figure 4: Variation of Clove production in Pemba districts
2.12 Impact of climate change and variability on agriculture

According to IPCC (2007) climate variability especially total seasonal precipitation as well as its pattern of variability is affecting agricultural systems especially in developing countries dependent on rain-fed agriculture, where drought is already a limiting factor of production. It is projected that by 2020, yields from rain-fed agriculture could be reduced by up to 50% in some countries (IPCC, 2007). In many African countries it is expected agricultural production, including access to food, will be severely compromised, adversely affecting food security and exacerbate malnutrition. It is further projected that rice production will decrease as temperatures increase in rice-growing areas in Asia (Lobell and Burke, 2008). Climate change may directly affect rice plant growth through changes in air temperature, precipitation, evapo-transpiration, and water temperature. Increased temperature also increases evaporation rates from soil and water bodies as well as evapo-transpiration rate in plants, and increases chances of severe drought as with warmer temperatures crops require more water. Furthermore, increases in temperature may affect crop growth and yield depending on sensitivity of crop growth to temperature changes.

2.12.1 Climate change, vulnerability on crop production

The long-term climate variability influences sowing date, crop duration, crop yield, and the management practices adapted in crop production. Short-term weather episodes can also affect yield by inducing changes in temperature, potential evapo-transpiration, and moisture availability. The degree of vulnerability of crops to climate variability depends mainly on the development stage of the crops at the time of weather aberration. This makes climate variability a threat to food production leading to serious social and economic implications (Hossain, 1997).
2.13 The Livelihood vulnerability index

The Sustainable Livelihoods Approach (SLA) is a useful tool for understanding the socio economic aspects of vulnerability, especially to climate risks, which is an important step in adaptation processes (IFAD, 2009). The Sustainable Livelihoods Approach, that includes five types of household assets natural, social, financial, physical, and human capital (Chambers and Conway, 1992), is an approach used to design development programming at the community level United Nations General Assembly (UNGA, 1997). The approach has proven useful for assessing the ability of households to withstand shocks such as epidemics or civil conflict. Climate change adds complexity to household livelihood security. The Sustainable Livelihoods Approach to a limited extent addresses the issues of sensitivity and adaptive capacity to climate change, but a new approach for vulnerability assessment that integrates climate exposures and accounts for household adaptation practices is needed in order to comprehensively evaluate livelihood risks resulting from climate change (Hahn et al., 2009).
CHAPTER THREE

METHODOLOGY

3.0 Description of study area

3.1.1 Geographical location

The study will be conducted in Pemba Island at Mkoani, Chakechake, Wete and Micheweni. The island of Pemba lies between latitude 4° 80’S and 6° 30’S and longitude 39° 35’ E and 39° 50’E at the distances of 40 km (25 miles) from North of Unguja Island estimated or neared from ras nungwi in Unguja Island to mkumbuu in Pemba Islands. It is separated from the main continent by a channel some 56 km (35 miles) from Tanzania mainland. The four districts are characterized by sharing boundaries to each other. Mkoani is Located on the southern part of Pemba Island where by the main sea port of Pemba is found and also is the administrative Centre of the district. Chake Chake is located at the center of the island on the northern side, about 28 km from Mkoani and a little less than 30 km from Wete. It is the central headquarter of administrative headquarter of the district as well as Pemba South region. In fact, Chake Chake is an unofficial capital of Pemba with having their head offices most of government departments. Wete is the next most important urban center of Pemba that is found in Northern Province about 30 km north of Chakechake. It had offices for some government departments and is the headquarter of the district. Konde located on the northern part of Pemba about 15 km from Wete. It was for a long time an administrative center before shifting to Micheweni in the early 1980, north east of Konde. It is located on the road to Ras Kigomasha, the northern of the Pemba Island. The total land area of Pemba Island is 988 square kilometers or 381 sq. mils.
The study was conducted in selected districts regions (shehia) in four districts of Pemba Island (Mkoani, Chake Chake, Wete and Micheweni) as shown in Figure 5.

![Randomly Selected Shehias for Clove Production in Pemba Island](image)

**Figure 5:** Sampling areas of Pemba districts and villages

### 3.2 Biophysical characteristics of the study area

#### 3.2.1 Vegetation

The study area lies within the tropical rain forest. The most area of the western side of Pemba Island is dominated by clove plant community and the eastern side of the
Pemba Island is semi-arid climate where shrub is common vegetation. The vegetation type has largely been disturbed by man's activities through deforestation, encroachment which change the nature of the land. Tree species found in the forest include mango tree, iron word, clove tree, cinnamon, and others. Also there is an Ngezi forest reserve which is formed by different species of plant community.

3.2.2 Soil and topography

There are two geological formations in the Pemba Island namely; the upland area in western side and lowland area in eastern side of the Pemba Island. The soil in western side is developed from different parent materials and organic matter. Soils developed from granite are deep fertile, well drained and permeable which is extremely good for the cultivation of different crops including banana, cocoyam, maize, cassava, beans, groundnuts, ginger and all kinds of vegetables also plantation of cash crops such as clove tree, citrus, coffee and oil palm. The soils in the eastern side are very shallow, excessively rocky. It is suitable for the cultivation of crops such as millets, cassava, maize, watermelon, and vegetables.

3.2.3 Climate

The study area experiences tropical equatorial conventional climate. It has double rainfall maxima regimes with the major season occurring between March and May (autum). The minor rainfall season occurs between September and November (spring). Average annual rainfall ranges between 1600mm and 2500mm. Relative humidity is about 80-90% during the major rainy season, reaching its peak of 90%. Between June and July experienced coldest seasons (winter). The months December to March are dry and warmest (summer). A maximum temperature of 30ºC is experienced between March and April. Mean monthly temperature is about 27ºC.
3.3 Socio-economic characteristics of the study area

3.3.1 Population

The population of the Pemba Island according to the 2012 population census is 406848. The population of northern region is 211732 comparing 103222 male and 108510 female with household size 5.3. The population of southern region is about 195116 comparing 93871 male and 101245 female with household size 5.4. The district Wete, Chake, Mkoani and Micheweni has population of 107916, 97249, 97867 and 103816 respectively (NBS, 2012).

3.3.2 Economic activities

Agriculture is substantial farming especially food-crop farming is the main economic activity in the study area. Over 65% of the active populations are farmers, 10% are engaged in fishing activities and the rest 25% are the engaged in blue and white color job and trader. This type of agriculture takes place through the traditional system of land use and bush-fallowing, in which the land is over cultivated until he/she reduce its fertility after a period of cultivation. The increased demand for land has led to clearing vegetation and consequently severe degradation of land (NBS, 2012).

3.3.3 Methodology sampling procedures and sample size

Communities in the Districts selects on for the study includes two village from each districts which are the following (Ngwchani and Kengeja) from Mkoani, Ziwani and Wesha from Chake Chake, Pandani and Piki from Wete and Mgogoni and Shumba vyamboni from Micheweni. The reason for selecting these communities is that they have large number of clove growers and their clove plantation communities are found. These communities therefore have one of the largest concentrations of people who primary engage in clove production.
Eight communities in the study area were selected for the entire survey. The communities were selected based on area of concentration where the clove communities are found. Sample were random selected at least forty five clove growers in each village which make three hundred and eighty three clove growers in the study area to serve the need of the study. Again, officers of the Ministry Agriculture, Forestry and from official clove organization and NGO. Five people were interviewed from each district which makes total twenty peoples. This complements three hundred and eighty of total sample of the population. The reason for selecting this sample from population is that population in this study are homogenous and has the same biophysical data. Therefore there is no need to take large sample size just is wastage of time, resource and money and hence below
formula was used to determine the sample size standard. The methodology for the integrated assessment follows the widely accepted definition that is clove farmers vulnerability is a function of exposure to a stressor, in this case climatic; the sensitivity of a clove farmers to the stress associated with that exposure; and the adaptive capacity to recover(resilience) from the impacts of that exposure. Clove producers are exposed equally to a stressor within the same geographical area, but the levels of sensitivity and adaptive capacity vary due to the geographical position and the economic status. The sampling frame will be constructing around Mkoan, Chake chake, Wete and Micheweni districts. From these eight village were random selected which including following (Ngwchani and Kengeja from Mkoani, Ziwani and Wesha from Chake Chake, Pandani and Piki from Wete and Mgogoni and Shumba vyamboni from Micheweni). These were selected because they are large numbers of clove growers and their clove plantation communities are found. These communities therefore have one of the largest concentrations of people who primary engage in clove production. The above sample is obtained by using this formula

\[ n = \frac{N}{1 + N(e)^2} \quad \text{(Israel, 1992)} \]

Where \( n \) is the number of sample size, \( N \) is the number of population and \( e \) is the level of Precision. Therefore \( N = 9200, e = 0.05 \) and \( n = \) Number of sample size

Solution \( n = 9200 \)

\[ 1 + 9200(0.05)^2 = 383. \quad \text{The number of sample size is 383} \]

3.3.4 Reconnaissance survey

Eight days were spent to carry out a reconnaissance survey in the study area by visiting located regions. The procedure of the survey was manifested in four aims:
i. To establish contact with farmers in the villages where the actual survey was taken place.

ii. To identify possible households from which a random sample took place for the actual survey.

iii. To pretest questionnaire to be used in the actual survey.

iv. To rapidly appraise some of the key information and socio-economic features in the area.

The survey was conducted within eight villages whereby the clove plantation community is dominant, Clove growers experienced within and above 40 years were interviewed with the help of the field/technical officers from the Ministry of Agriculture under supervision of local government authority of shehia. A contacted farmer was selected for each community who was given in order to construct a pre-test of a drafted questionnaire for the actual survey.

3.3.5 Research design

A cross-sectional research design was used in this study in which data from respondents were collected at a single point and time. The design is simple and saves time, manpower, and financial resources by allowing the researcher to study a large population at once. Apparently, there are other researches designs such as case study and longitudinal, but the cross- section research design was adopted because the researcher was acquainted with the design and has been widely used in similar studies.

3.4 Data collection methods

3.4.1 Primary data

A quantitative household survey was conducted to assess how climate variability and
change are experienced at the household level directly through household production systems, and indirectly through its impact on the commodity value chain. Two villages were selected at random from each district; from each, 45 households from each village, for a total of 360 households.

**Focus group discussions** (FGDs) was conducted to determine more detailed perceptions of changes in climate stress and the corresponding behavioral responses. The outcome of the focus group discussion helps to explain the patterns that emerge from the quantitative work. In each village, one FGDs was conducted for both, men and women, generating a total of 8 FGDs. Key information (nature of climate, vulnerability index and clove and adaptation) were rapidly appraisal through the use of group discussions, historical time line, resource map and direct observation with local communities, district authorities, officials of relevant NGOs, key community leaders, and grassroots communities in order to extract required information of the study. Through the cheek list that guide the focal group discussion.

**Key informant interviews** were conducted at the national and district levels with government and civil society policymakers, the academic community, and service providers. The goal is to understand the institutional context in which to develop climate change policy and programming

**3.4.2 Secondary data**

Secondary information was obtained from extension reports. The data on annual clove yields were obtained from Zanzibar state trade cooperation (ZSTC) and Ministry of agriculture and natural resources. Climate data, rainfall and temperatures records were obtained from Tanzania Metrology Agencies (TMA) office at Chake Chake airport station in Pemba Island. The rainfall data covered the period between
1983 and 2012, while temperature data was from 1983 to 2012. These data were essential in this study in order to evaluate the effects of climate change and variability clove famers.

3.4.3 Data Analysis

The collected data was systematically analyzed using Statistical Package for the social science Software (SPSS version 21) and excel Program for quantitative data sets. Using social science package software and qualitative data recorded from interviews were transcribed and information was organized according to the study objectives. Furthermore, narrative technique and assessment of the policy was also utilized among others. The qualitative data were analyzed by thematic methods. The information the data analysis was presented using number of methods; these include statistics (averages and median), descriptive approach, paradigm interpretation, graphs, charts, tables and pictorial.

The Livelihood Vulnerability Index (LVI) and LVI-IPCC were used as essential tools to assess components of vulnerability of the households. The components are first broadly categorized under eight (8) different major components which are Socio demographic (DS), livelihood strategies (LS), social network (SN), food (F), health (H), water (W), natural disaster and climate variability (NDCV), and energy resource (ER). There are several sub-components used as indicators under each major component. This explains how each sub-component was quantified, survey questions used and original source of the survey question. The LVI was calculated using a balanced weighted average approach where each sub-component contributes equally to the overall index though each major component is comprised of a different
number of subcomponents. As each sub-component was measured on a different scale, we first standardized each as an index using the following equation:

\[ \text{Index}_{sd} = \frac{s_d - s_{min}}{s_{max} - s_{min}} \]

Where \( s_d \) is the original sub-component for district \( d \), \( s_{min} \) is the minimum value and \( s_{max} \) is the maximum values, for each sub-component determined using data from both districts extracted from survey question.

After each was standardized, the sub-components were averaged using Eq. (2) to calculate the value of each major component:

\[ \text{Md} = \frac{\sum_{i=1}^{n} \text{index}_{sd_i}}{n} \]

where Md = one of the seven major components for district \( d \) [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W), or Natural Disasters and Climate Variability (NDCV) Energy resource (E R)], indexes \( di \) represents the sub-components, indexed by \( i \), that make up each major component, and \( n \) is the number of sub-components in each major component. Once values for each of the seven major components for a district were calculated, they were averaged using Eq. (3) to obtain the district-level LVI.

The livelihood vulnerability (LVI) was calculated using the equation below:

\[ LVI = \frac{\sum_{i=1}^{8} w_{Mi} \cdot M_{di}}{\sum_{i=1}^{8} w_{Mi}} \]

Where,

LVI is the Livelihood Vulnerability Index for household and equals the weighted average of the eight major components; \( W_{Mi} \) are the weights of each major component, determined by the number of sub-components, \( M_{di} \), that make up each
major component were included to ensure that all sub-components contribute equally to the overall LVI (Hahn et al., 2009). It can also be expressed as:

\[ LVI = \frac{W_{sdp}SDP_d + W_{lsLS_d} + W_{snSN_d} + W_{hhH_d} + W_{wwW_d} + W_{fF_d} + W_{nD_d}NDC_d + W_{erER_d}}{W_{sdp} + W_{lsLS} + W_{snSN} + W_{hhH} + W_{wwW} + W_{fF} + W_{nD}NDC + W_{erER}} \]  \hspace{1cm} (3)

(Sullivan, 2002). Pointed out that the LVI is scaled from 0 (least vulnerable) to 0.5 (most vulnerable). On the other hand, the LVI-IPCC was calculated as follows:

\[ CF_s = \frac{\sum_{i=1}^{n} W_{mi} M_{di}}{\sum_{i=1}^{n} W_{mi}} \]  \hspace{1cm} (4)

Where,

CFs is the IPCC-defined contributing factor (exposure, sensitivity, or adaptive capacity) for each district. Md\(d\) are the major components for a districts indexed by i, \(W_{mi}\) is the weight of each major component, and n is the number of major components in each contributing factor. Once exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

\[ LVI-IPCC = (Ex-Ad)*SS \]  \hspace{1cm} (5)

Or

\[ LVI-IPCC = (Exposure – Adaptive capacity)*Sensitivity \]

Where, LVI-IPCCS is the LVI for a districts expressed using the IPCC vulnerability framework. Es, is the calculated exposure score for districts (equivalent to the natural disasters that have occurred in the past 6 years, while climate variability is measured by the average standard deviation of the maximum and minimum monthly temperatures and monthly precipitation over a 6-year period. and energy resources
major components As, is the calculated adaptive capacity score for districts, weighted average of the socio-demographic profile (e.g., percent of female-headed households), livelihood strategies (e.g., predominately agricultural, or also collect natural resources to sell in the market), and social networks major components (e.g., percent of residents assisting neighbors with chores), and SS, Sensitivity score for districts is the calculated weighted average of the heath, food, and water major components. The scale used were the LVI–IPCC from -1 least vulnerable to 1 most vulnerable (Hahn et al., 2009).
CHAPTER FOUR
RESULTS AND DISCUSSION

4.0 Introduction

The overall results of this study are presented in this chapter. The discussion is built on the results and analysis of vulnerability of households who are engaged in clove production. The spatial variation of the districts were also presented and discussed.

4.1 Respondents socio-economic characteristics

Information on respondents’ socio-demographic characteristics, age, marital status, education level, gender and household size are shown in (Table 3).
### Table 3: Social demographic characteristics of the farmers (360)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>MICHEWENI (%)</th>
<th>WETE (%)</th>
<th>CHAKE (%)</th>
<th>MKOANI (%)</th>
<th>ALL DISTRICTS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age of respondents</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 -29</td>
<td>3.30</td>
<td>4.40</td>
<td>6.66</td>
<td>2.20</td>
<td>4.14</td>
</tr>
<tr>
<td>30 – 39</td>
<td>11.10</td>
<td>12.20</td>
<td>15.60</td>
<td>18.90</td>
<td>14.36</td>
</tr>
<tr>
<td>40 - 49</td>
<td>36.70</td>
<td>32.20</td>
<td>34.40</td>
<td>31.10</td>
<td>33.43</td>
</tr>
<tr>
<td>50 – 59</td>
<td>35.50</td>
<td>40.00</td>
<td>36.70</td>
<td>37.80</td>
<td>37.30</td>
</tr>
<tr>
<td>60+</td>
<td>13.30</td>
<td>11.10</td>
<td>6.70</td>
<td>10.00</td>
<td>10.77</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>21.10</td>
<td>17.70</td>
<td>14.40</td>
<td>12.20</td>
<td>16.66</td>
</tr>
<tr>
<td>Married</td>
<td>78.80</td>
<td>81.10</td>
<td>85.50</td>
<td>87.70</td>
<td>83.33</td>
</tr>
<tr>
<td><strong>House holder head</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>81.10</td>
<td>85.50</td>
<td>84.44</td>
<td>90.00</td>
<td>85.27</td>
</tr>
<tr>
<td>Female</td>
<td>17.70</td>
<td>14.40</td>
<td>15.50</td>
<td>10.00</td>
<td>14.72</td>
</tr>
<tr>
<td><strong>Education level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>15.50</td>
<td>10.00</td>
<td>12.20</td>
<td>18.90</td>
<td>14.16</td>
</tr>
<tr>
<td>7</td>
<td>58.90</td>
<td>54.40</td>
<td>51.10</td>
<td>47.70</td>
<td>53.05</td>
</tr>
<tr>
<td>11</td>
<td>17.80</td>
<td>20.00</td>
<td>18.80</td>
<td>18.90</td>
<td>18.33</td>
</tr>
<tr>
<td>16</td>
<td>5.60</td>
<td>8.90</td>
<td>12.20</td>
<td>8.90</td>
<td>8.88</td>
</tr>
<tr>
<td>18+</td>
<td>4.44</td>
<td>6.70</td>
<td>5.55</td>
<td>5.55</td>
<td>5.55</td>
</tr>
<tr>
<td><strong>Size of householder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 – 4</td>
<td>17.80</td>
<td>18.80</td>
<td>12.20</td>
<td>23.30</td>
<td>12.77</td>
</tr>
<tr>
<td>5 – 9</td>
<td>50.00</td>
<td>54.44</td>
<td>61.10</td>
<td>52.20</td>
<td>59.44</td>
</tr>
<tr>
<td>10+</td>
<td>32.20</td>
<td>26.60</td>
<td>26.60</td>
<td>24.40</td>
<td>27.50</td>
</tr>
</tbody>
</table>

#### 4.1.1 Age of farmers

The ages of the farmer’s household ranged from 29 to 60+ years (Table 3). The results show that majority respondents were aged between 30 to 59 years and were
about 80%. Only 5% of the respondents were young age between 20-29 years. It was noted that 90% of the respondents were in the prime of human capital aged between 18-59 years. This is an important observation because these of farmers were appropriate age that able to cope challenge of climate change adaptation. It was also observed that the heads of households who ranged the age between 30-50 years were more crops as compared to those younger households. Although the respondents older than 60 years were relative fewer 10%, they had more experience on a wide range of climate change adaptation or coping strategies. According to Tripp (1993), younger farmers are more likely to adopt new technologies, since they are more educated the older generation or perhaps have been exposed to new ideas as migrant laborers. Older individuals in a society have more experience and have better assess to products than youths and hence a higher probability of. Climate change adapting (Basu, 2012)

4.1.2 Gender of farmer

Eight five percent of the clove growers were males while 15% were females (Table 3). The gender of farmers indicates poor involvement of women in clove production. Many of the clove production activities like planting, weeding, harvesting, draying and selling the commercial crops, which are done manually. Women are mostly having been involved in planting and cultivating food crops to meet household consumption needs rather than commercial crops. According World Bank (1996) female-headed households in rural areas own less land, less livestock and have, on average, less years of schooling and they tend to have a higher dependency. Individuals’ households may have different rights depending on gender. For example some of the African countries women plant and tend fire-wood or fruit trees but do
not have right to harvest fruits or wood (Eckman, 1992). This clove production and climate change adaptation initiatives should consider the role of woman in controlling resources and decision making. Motivation of women in promotional activities has been highlighted by the previous studies for example (Shiva 1988). Women play important roles in clove industry such as fetching the water, firewood, foodstuffs and medicinal herbs and hence have directly implications in environmental degradation.

4.1.3 Household size

Fifty four percent households had between 5-9 members, while 28% had more than 10 members (Table 3). The large family size may be due to other extended family members being catered for. Also, the reasonably high household sizes probably indicate that farmers were youthful and highly reproductive. The large family size of the bulk of farmers 82% could provide labor which is an incentive to for clove farming adoption. However, the consequences of large family size are increased pressure on the ecosystem, land fragmentation and tree ownership problems. According to Akinsami (1988) excessive land fragmentation may leave a farmer several small land holdings scattered over an area, and therefore very difficult and uneconomical for working. According to Kayunze (2000), large family sizes are an important asset in working together to reduce vulnerability to the effects of climate change. Pender (2007) pointed out that, household size is normally seen as equivalent to family lab our endowment, despite the lack of a significant impact of family size on crop production, where most of the household members play very crucial role in production and/or service provision they contribute significantly to the
development of economy of the household. Conversely, having big families is considered to be one of the causes of poverty in Tanzania (URT, 2002).

4.1.4 Marital status

The majority (83%) of respondents was married (Table 3). Marital status influences decision making at the household level. Although the majority of respondents were married, women’s status may not be important in decision making powers, especially in the poor community by (Jan and Akhtar, 2008).

4.1.5 Level of education of farmers

The levels of education among clove farmers were generally high. About fifty four of respondents had basic primary school education 18% had secondary education while 16% had no formal education and only 13% had higher education. The total number of clove growers who were literate constituted 86% . The high level of literacy rate would result in increase of technical efficiency and decreased conservationism among farmers. Education is an important socio-economic variable that may make a farmer more receptive to advice from climate change and more able to deal with technical recommendations that require a certain level of numeracy or literacy (Tripp, 1993). Knowledgeable had a better chance of adopting new technologies in coping with climate change challenges (Abdallah, 2001). In addition, De Jonge (2010) found that farmers who had university education were more likely to respond to climate change than farmers who have primary education.
Table 4: Years of experience farming by the farmers.

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>No. of farmers</th>
<th>(%) of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-19</td>
<td>46</td>
<td>12.78</td>
</tr>
<tr>
<td>20-29</td>
<td>62</td>
<td>17.22</td>
</tr>
<tr>
<td>30-39</td>
<td>123</td>
<td>34.17</td>
</tr>
<tr>
<td>40-49</td>
<td>108</td>
<td>30.00</td>
</tr>
<tr>
<td>50-59</td>
<td>21</td>
<td>5.83</td>
</tr>
<tr>
<td>TOTAL</td>
<td>360</td>
<td>100</td>
</tr>
</tbody>
</table>

The (34%) of farmers interviewed had between (30-39) years of experience in Clove farming while (13%) and (17%) of the farmers had (1-19), (20-29) years of experience respectively. While (30%) had between (40 – 49) years of experience in farming and few (6%) had between (50-59) years of experience as shown in Table 4.

4.2.1 Relationship between the clove yield and weather parameters

The figures below show the statistical relationship between clove production and weather parameters.

![Relationship between clove and rainfall](image)

**Figure 6:** The graph of rainfall and clove yield
Figure 7: The graph of maximum temperature and clove yield

Figure 8: The graph of minimum temperature and clove yield
4.2.2 Correlation Analysis

The correlation analysis was performed between clove yield and weather parameters with three different lag arrangements which are lag zero lag one and lag two. The
95% confidence level interval was used to test the significant of the correlation coefficient. The correlation coefficient values were taken as significant if the t-test (t-calculated) was greater than the t-tabulated. At the degree of freedom \( v = n - 2 \).

**Table 5:** Correlation coefficients for lag zero

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Correl. Coefficient</th>
<th>t-calculated</th>
<th>t-tabulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (mm)</td>
<td>0.409</td>
<td>1.902</td>
<td>2.101</td>
</tr>
<tr>
<td>Maximum temperature (°C)</td>
<td>-0.246</td>
<td>-1.077</td>
<td>2.101</td>
</tr>
<tr>
<td>Minimum temperature (°C)</td>
<td>-0.342</td>
<td>-1.544</td>
<td>2.101</td>
</tr>
<tr>
<td>Relative humidity 06z</td>
<td>0.370</td>
<td>1.689</td>
<td>2.101</td>
</tr>
<tr>
<td>Relative humidity 12z</td>
<td>0.319</td>
<td>1.423</td>
<td>2.101</td>
</tr>
</tbody>
</table>

The table above showed the output correlation coefficient values for the weather parameters and the clove yield at zero lag arrangement. It was found that none of the parameters were significant correlated with the clove yield.

**Table 6:** Correlation coefficients for lag one

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Correl. Coefficient</th>
<th>t-calculated</th>
<th>t-tabulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (mm)</td>
<td>-0.143</td>
<td>-0.596</td>
<td>2.110</td>
</tr>
<tr>
<td>Maximum temperature (°C)</td>
<td>-0.256</td>
<td>-1.092</td>
<td>2.110</td>
</tr>
<tr>
<td>Minimum temperature (°C)</td>
<td>-0.167</td>
<td>-0.698</td>
<td>2.110</td>
</tr>
<tr>
<td>Relative humidity 06z</td>
<td>-0.087</td>
<td>-0.360</td>
<td>2.110</td>
</tr>
<tr>
<td>Relative humidity 12z</td>
<td>-0.302</td>
<td>-1.306</td>
<td>2.110</td>
</tr>
</tbody>
</table>
The table above showed the output correlation coefficient values for the weather parameters and the clove yield at one lag arrangement. It was found that none of the parameters were significant correlated with the clove yield and these coefficients were negative correlated with clove yield. These correlation coefficients above were related to the same statement as from the Peter J. Martin (1988), but not significant correlated.

**Table 7: Correlation coefficients for lag two**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Correl. coefficient</th>
<th>t-calculated</th>
<th>t-tabulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (mm)</td>
<td>-0.467</td>
<td><strong>-2.121</strong></td>
<td>2.120</td>
</tr>
<tr>
<td>Maximum temperature (°C)</td>
<td>0.565</td>
<td><strong>2.739</strong></td>
<td>2.120</td>
</tr>
<tr>
<td>Minimum temperature (°C)</td>
<td>0.136</td>
<td>0.549</td>
<td>2.120</td>
</tr>
<tr>
<td>Relative humidity 06z</td>
<td>0.022</td>
<td>0.088</td>
<td>2.120</td>
</tr>
<tr>
<td>Relative humidity 12z</td>
<td>-0.294</td>
<td>-1.230</td>
<td>2.120</td>
</tr>
</tbody>
</table>

The tables above show the output correlation coefficient values for the weather parameters and the clove yield at two lag arrangement. It was found that rainfall and maximum temperature were significant correlated with the clove yield and the remaining parameters which are minimum temperature, relative humidity at 0600z and relative humidity at 1200z were not significant correlated with clove yield. These correlation coefficients above were related to the same statement as from the Peter J. Martin (1988), and were significant correlated.
4.3 The general results of LVI and LVI-IPCC districts

The results of Livelihood vulnerability index (LVI) and LVI-IPCC in Micheweni, Wete, Chakechake and Mkoani districts are presented and discussed. In this study we have considered eight major components: Social and demographic Profile (SDP), livelihoods strategy (LS), Social network (SN), Health (H), Food (F), Water (W), Energy resources (ER) and natural disaster and climate variability (NDCV). Have been considered in the present study. Each major component has several sub-components, as shown in Table 8.

**Table 8:** Categorization of major components into contributing factors

<table>
<thead>
<tr>
<th>Contributing factors</th>
<th>Major components for district</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive capacity</td>
<td>Socio-demographic profile</td>
</tr>
<tr>
<td></td>
<td>Livelihood strategies</td>
</tr>
<tr>
<td></td>
<td>Social networks</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Health</td>
</tr>
<tr>
<td></td>
<td>Food</td>
</tr>
<tr>
<td></td>
<td>Water</td>
</tr>
<tr>
<td>Exposure</td>
<td>Natural disasters and</td>
</tr>
<tr>
<td></td>
<td>Climate variability</td>
</tr>
<tr>
<td></td>
<td>Energy resources</td>
</tr>
</tbody>
</table>
Table 9: Index of sub-components and major components

<table>
<thead>
<tr>
<th>Sub components</th>
<th>INDEX</th>
<th>Major components</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DM</td>
<td>DW</td>
<td>DC</td>
</tr>
<tr>
<td>Dependents ratio</td>
<td>0.63</td>
<td>0.58</td>
<td>0.58</td>
</tr>
<tr>
<td>Percent of female-headed households</td>
<td>0.20</td>
<td>0.15</td>
<td>0.16</td>
</tr>
<tr>
<td>Average age of female head of household</td>
<td>0.26</td>
<td>0.60</td>
<td>0.56</td>
</tr>
<tr>
<td>Percent of households where head of HH not attended to school</td>
<td>0.16</td>
<td>0.10</td>
<td>0.12</td>
</tr>
<tr>
<td>Average Agricultural Livelihood Diversification Index (range: 0.20–1)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Percent of household depends only in agriculture</td>
<td>0.56</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>Percent of households that have not gone to their local government for assistance in the past 12 months</td>
<td>0.93</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td>Percent of households where not member of SACCOS/VIKOBA</td>
<td>0.37</td>
<td>0.77</td>
<td>0.35</td>
</tr>
<tr>
<td>Percent of households receive support from relative out of Zanzibar</td>
<td>0.24</td>
<td>0.32</td>
<td>0.29</td>
</tr>
<tr>
<td>Percent amount (Tsh.) earned from trades year 2011</td>
<td>0.15</td>
<td>0.22</td>
<td>0.20</td>
</tr>
<tr>
<td>Average distance to health centre</td>
<td>0.67</td>
<td>0.11</td>
<td>0.30</td>
</tr>
<tr>
<td>Percent of households with family member with chronic illness</td>
<td>0.25</td>
<td>0.24</td>
<td>0.20</td>
</tr>
<tr>
<td>Percent of households where a family member had to miss work or school in the last 2 weeks due to illness</td>
<td>0.09</td>
<td>0.02</td>
<td>0.25</td>
</tr>
<tr>
<td>Average malaria exposure*prevention index</td>
<td>0.75</td>
<td>0.83</td>
<td>0.85</td>
</tr>
<tr>
<td>Average number of months households struggle to find food</td>
<td>0.44</td>
<td>0.65</td>
<td>0.43</td>
</tr>
<tr>
<td>Percentage of households that save the money from clove</td>
<td>0.58</td>
<td>0.78</td>
<td>0.62</td>
</tr>
<tr>
<td>Percentage of households that most get money from clove</td>
<td>0.58</td>
<td>0.78</td>
<td>0.62</td>
</tr>
<tr>
<td>Average distance to health centre</td>
<td>0.75</td>
<td>0.57</td>
<td>0.35</td>
</tr>
<tr>
<td>Average number taken to water source</td>
<td>0.40</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Average number of liters of water stored per household</td>
<td>0.05</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Average distance taken to water source</td>
<td>0.17</td>
<td>0.24</td>
<td>0.28</td>
</tr>
<tr>
<td>Percentage of household do not have consistent water supply</td>
<td>0.87</td>
<td>0.14</td>
<td>0.80</td>
</tr>
<tr>
<td>Average number of flood, drought, and events in the past 30 years</td>
<td>0.10</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Average number of flood, drought, and events in the past 30 years</td>
<td>0.10</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Mean standard deviation of daily mean average maximum temperature by month</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Mean standard deviation of daily mean average minimum temperature by month</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Mean standard deviation of daily precipitation by month</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Percent of HHs reporting death during the recent climate disasters</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Percent of HHs reporting land degradation by climate related extremes during past 30 years</td>
<td>0.98</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td>Mean standard deviation of daily mean average maximum temperature by month</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Mean standard deviation of daily mean average minimum temperature by month</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Mean standard deviation of daily precipitation by month</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Percent of HHs using only Forest-based energy for cooking purpose</td>
<td>0.96</td>
<td>0.86</td>
<td>0.79</td>
</tr>
<tr>
<td>Average distance/time to fetch firewood</td>
<td>0.96</td>
<td>0.86</td>
<td>0.79</td>
</tr>
<tr>
<td>Percent of HHs using traditional cooking stoves</td>
<td>0.97</td>
<td>0.91</td>
<td>0.94</td>
</tr>
<tr>
<td>Average distance/time to fetch firewood</td>
<td>0.90</td>
<td>0.75</td>
<td>0.45</td>
</tr>
<tr>
<td>Percent of HHs reporting that firewood is being scarce now in comparison to 30 years back</td>
<td>0.65</td>
<td>0.71</td>
<td>0.83</td>
</tr>
<tr>
<td>Percent of HHs using traditional cooking stoves</td>
<td>0.65</td>
<td>0.71</td>
<td>0.83</td>
</tr>
</tbody>
</table>
The Vulnerability spider diagram below showing the major components of the livelihood vulnerability index for districts (Micheweni, Wete, Chake Chake, and Mkoani).

![Vulnerability spider diagram](image)

**Figure 11**: Vulnerability spider diagram

### 4.4 Results of LVI in Pemba District

#### 4.4.1 Social demographic Profile (SDP)

The results of sub-components and major components are shown in (Table 9) for the SDP index, the result shows Wete district has relatively high vulnerability (0.355) compared to other districts Mkoani (0.351), Chake Chake (0.349) and Micheweni (0.310). On the other hand, the dependency ratio index, results showed Micheweni have a higher ratio (0.63) followed by Wete and Chake Chake which has the same ratio (0.58), while Mkoani has 0.56. Furthermore, the index for female-headed households was lower in Mkoani (0.10) and slightly increased for Wete (0.15), Chake Chake (0.16), and Micheweni (0.20). The literacy level in the household was higher in Micheweni district (0.19) and lower in Wete (0.10), while Chake Chake
Mkoani was 0.12, and 0.16 respectively. This indicates that the household have less vulnerability in term of education. Similarly study conducted by Moyo (2013) in Zanzibar found that Mtetema and Mahonda vulnerability index were 0.05 and 0.22 respectively for rice farmes. In addition, education level considered an important factor for the livelihood to adapt to the climate change variability. The present results showed that household in Mkoani and Micheweni districts were more vulnerable than those in Wete and Chake Chake. The same finding was reported by Mhinte (2000) that education increases working efficiency and productivity and making households with more educated to benefit in terms of food and income.

4.4.2 Livelihood strategies (LS)

The study shows the livelihood strategies for the households vary greatly from place to place due to knowledge and experience adaptation to climate change impacts. The livelihood strategy include growing crops, raising animals, collecting natural resources such as timber and family member(s) migrate to another places. In this study, the result shows the overall livelihood strategies component was high in Micheweni (0.40) or more vulnerable than other districts like Mkoani (0.18), Wete (0.16) and Chake Chake (0.15). Furthermore, many farmers in Micheweni and Mkoani districts depend only on agriculture such as food crops and clove production for their daily livelihood. The agriculture dependency ratio was 0.56, 0.11, 0.08 and 0.06 for Micheweni, Mkoani, Wete and Chake Chake respectively. However, the average overall agricultural livelihood diversification index for both districts was the same 0.25. This indicates both districts were less vulnerability. Compared to Zanzibar, stone town, kizingo and buyu which had adaptive capacity of 0.43, 0.43 and 0.37 respectively (Cinner et al., 2011). The study also found the households
depend on clove production were more effected than those produced food crops they have the extra advantage by earning money from selling other commodities such as coconuts, fruits and vegetables.

4.4.3 Social network (SN)

The result of a SN indicator of the four districts is shown in (Table 9). The vulnerability index for SN was low in Micheweni (0.361) and gradual increased in Mkoani, Chake Chake chake and Wete 0.432, 0.451 and 0.590 respectively. The result also shows that over 90% of the households in all districts have not sought any assistance from their local government in the past 12 months. This indicates that households in all districts were more vulnerable because they have not sought any kind assistance from their local government. Likewise, the study found few households were members of Savings and Credit Cooperative Societies (SACCOS) in Chake Chake, Micheweni, and Mkoani 0.35, 0.37, and 0.38 respectively as compared to Wete which were most vulnerable of Sacco’s members (0.77). Moreover, households in all districts reported to borrow money more frequently and receiving more in-kind assistance from family, friends and other relative from outside Zanzibar. In addition, the study found that households in Wete were slightly better (0.32) than other districts Chake Chake (0.29), Mkoani (0.26), Micheweni (0.24). As explained by Hahn et al. (2008) that the socio-network activities borrowing money and receiving assistance, seeking assistance from government are a good indicator measure of the degree to which households rely on family and friends for financial assistance? Furthermore, the result shows the average amount of income in Wete households earned from other sources were more than other districts.
This might be considered that many households in Wete have other income generating activities such as small-scale industry and small business activities.

4.4.4 Accessibility of health services and health assessment

For the health care’s services, the result shows Micheweni households travel an average of 1.5km (VI= 0.67) to seeking a health service, while Mkoani, Chake Chake, and Wete travel (0.9km (VI=0.40), 0.8km (VI=0.30), 0.2km (VI=0.11) respectively. Likewise, the result shows Micheweni and Wete have higher vulnerability indexes in terms of chronic diseases (0.25) and (0.24) respectively, and slightly lower in Chake Chake (0.16) and Mkoani (0.20). The study found higher vulnerability index for off-sick households in Mkoani (0.27) and Chake Chake (0.25 and relatively low for Wete (0.02) and Micheweni (0.09). These suggest that the households of Chake Chake, and Mkoani were more vulnerable than those of Micheweni and Wete. In addition, the results of malaria exposure show that the vulnerability index was higher in Chake Chake (0.33) followed by Wete (0.27), Mkoani (0.17) and Micheweni (0.02). Also, the results show that the overall health vulnerability score were 0.158, 0.248, 0.254 and 0.345 for Wete, Mkoani, Chake Chake, and Micheweni respectively. These findings suggest that diseases like malaria may have a negative impact on household income. Also, the distance from households to health centre facilities might be important reason. For instance, the higher health vulnerability index for Micheweni is related to long distance covered by households to seek health services. This is concurred with the previous study of Mtei and Borghi (2010) who found that poorest segment of the population receive less health care benefits relative to their need, whereas other population segments receive a greater share of benefit relative to their needs.
4.4.5 Food

The study found that the vulnerability index of households struggle to find adequate food for their families was very high in Chake Chake (0.85) and Mkoani (0.80) compared to Micheweni (0.75) and Wete (0.83). The result also shows that 68% and 65% of the households in Mkoani and Wete respectively save their money from clove and spent food compared to 44% in Micheweni and 43% in Chake Chake. In addition, the percentage of households solely relying on their farm for food consumption were 80% for Mkoani, 75% for Micheweni, 57% for Wete and 35% for Chake Chake. Furthermore, the result indicates that 75% of households in Wete did not get clove seedling from the Government compared to Micheweni (82%), Chake Chake (83%) and Mkoani (80%). The overall food vulnerability score for Mkoani and Wete districts were relatively high (0.642), and (0.615) compared to Micheweni (0.538) and Chake Chake (0.482) respectively. In addition, insufficient rainfall for planting the Clove trees in both districts force people to move from the upland area to the valley in order to follow the water resources and some of them relies on others social economic activities such as agricultural activities like food crops and vegetables production. These were used as mitigating strategies for the effect of climate change and variability. According to Benjamin *et al.* (2012) achieving food security requires that the aggregate availability of physical supplies of food is sufficient, that households have access to those food supplies through their own production. Also, through the markets or through other sources and that the utilization of those food supplies is appropriate to meet the specific dietary needs of individuals in their households.
4.4.6 Water resources (WR)

The result shows that the overall vulnerability scores for water component was low in Wete (0.249) compared to Chake Chake (0.386), Micheweni (0.377) and Mkoani (0.377). Likewise, the result also shows that over 86% of the households surveyed in Wete reported to have a consistent tap water supply. On the other hand, 87% of household in Micheweni, 80% in Chake Chake and 88% in Mkoani had reported inconsistent water supply from the municipality. Most of them reported to get water either from ponds, community pump well or bore well. The study also found for the adaptation strategy, Wete households stored of water on average 155.5 L compared to Chake Chake, Mkoani and Micheweni which were stored on average 148.5L, 132.5L and 113.5L respectively. Similarly, the study found most of the population in the study do have tap in their house. However, significant portion reported to travel long distance to fetch water from public tap or other sources. For instance, household travels an average of 0.9 m and 0.8m for Micheweni and Mkoani respectively, and same distance for Wete and Chake chake (0.7 m). In addition, around 28% of Chake Chake households reported hearing about conflicts related to water in their communities compared to 24% in Wete, 17% in Micheweni and 13% in Mkoani. These results show that both districts have accessibility of tap water. However, the reliability of running tap water is very low.

4.4.7 Natural Disasters and Climate Variability (NDCV)

Natural disaster and climate variability is the major component of vulnerability. This includes several sub-components as shown in Table 9. The result shows that, the percentage of households that did not receive warnings about the pending natural disasters vary greatly from district to district. The same percentage was reported for
Micheweni and Chake Chake (81%). However, lower percentage was reported for Mkoani and Wete, 76% and 46% respectively. In terms of index the values were 0.81, 0.76, 0.81 and 0.46 for Micheweni, Wete, Chake Chake and Mkoani respectively. Moreover, the percent of households reporting a disaster-related injury or death was very low. The same index was obtained for Mkoani and Chake (0.02) and (0.03) Micheweni and Wete in terms of the vulnerability index (VI). According to Hahn et al. (2008) the early warning systems and community preparedness plans may help communities to prepare for extreme weather events. Similarly, seasonal weather forecasts may help farmers to have time their plantings and prevent diversion of scarce water resources for irrigation as well as disaster preparedness (Hahn et al., 2009). The both districts have higher vulnerability index 0.98, 0.98, 0.97 and 0.95 for Micheweni, Mkoani, Chake Chake and Wete respectively. The higher vulnerability may be due to land degradation. According to Mudzonga (2011) if a farmer is exposed to information on climate change, then his/her probability of adaptation to climate change increases by about 44%. This implies that more climate change information dissemination through extension services, weather reports and other channels would increase the likelihood of farmers’ adaptation to climate change (Komba and Muchapondwa, 2009). Likewise, reported by Hassan and Nhemachena (2008) that information on climate change significantly influences farmers’ adaptation choices. The result shows no significant difference in the overall LVI index. The LVI index for Chake Chake, Mkoani, Micheweni and Wete are 0.397, 0.387, 0.380 and 0.351 respectively. This means all districts have relatively high vulnerability to climate change impacts and could source of clove production decline.
Table 10: Overall LVI index for four main districts.

<table>
<thead>
<tr>
<th>District</th>
<th>LVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micheweni</td>
<td>0.5148</td>
</tr>
<tr>
<td>Wete</td>
<td>0.5061</td>
</tr>
<tr>
<td>Chake chake</td>
<td>0.5016</td>
</tr>
<tr>
<td>Mkoani</td>
<td>0.5262</td>
</tr>
</tbody>
</table>

Figure 12: Overall LVI in districts

4.4.8. Energy Resources (ER)

The overall LVI score for the energy resources component is shown in Table 9. The result shows ER for all districts were 0.869, 0.871, 0.810 and 0.759 for Micheweni, Wete, Mkoani and Chake Chake respectively. This has contributed to the fact that all households totally depend on forest-based energy (firewood) as a source of energy for cooking. Mkoani and Micheweni were the highest with 97.3%
and 96% respectively. For Wete and Chake Chake were 85.5% and 78.5% respectively. In addition, the result shows Micheweni and Wete travel long distance to fetch for firewood, an average walk about 2.5 km and 2 km respectively. For Mkoani households travel about 1.5 km and travel 1.4 km for Chake chake. These imply that peoples in Micheweni and Wete were more vulnerable in terms of ER than Mkoani and Chake Chake. Furthermore, the study also found around 95% of households in all districts was using traditional stoves for cooking. However, most of the stoves are inefficient and put more pressure on forest and cutting down more trees for firewood. In the near future, unless the alternative measure is taken, most of forest will be depleted, creating environmental degradation, the acute energy crisis, and hence threatening local community livelihood. The vast majority of rural people in the third world depend on traditional fuel such as wood, dung and crop residues, often using primitive and inefficient technologies (Masekoameng et al., 2005). Hence, while energy is one of the basic requirements for human life, most of the rural people do not have enough access to efficient and affordable energy sources as reported by the (World Energy Council, 1999) and these remain as a main challenge of rural energy poverty in developing countries.

4.4.9 LVI–IPCC contributing factors

The LVI-IPCC scores range between -1 to +1. The -1 score indicated least vulnerable and +1 indicated the most vulnerable (Hahn et al., 2009). In other words, when LVI-IPCC has positive score, it means a household is more exposed to natural disaster and climate variability than the capacity to adapt or overcome these adverse situations. When the score of LVI-IPCC is negative, it means a household is less exposed to natural disaster and climate variability.
Table 11: LVI - IPCC Contributing Factors Calculations for Micheweni, Wete, Chake Chake and Mkoani districts in Pemba Island

<table>
<thead>
<tr>
<th>PCC contributing factors to vulnerability</th>
<th>Pemba Island districts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Micheweni</td>
</tr>
<tr>
<td>Exposure</td>
<td>0.5432</td>
</tr>
<tr>
<td>Adaptive</td>
<td>0.3502</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.3992</td>
</tr>
<tr>
<td>LVI-IPCC</td>
<td>0.0770</td>
</tr>
</tbody>
</table>

The result shows the most vulnerable districts blocks were Micheweni (0.0770) and Mkoani (0.0729) because of more sensitivity and less adaptive capacity, compared to Chake Chake (0.0602) and Wete (0.0269) as shown in (Table11). The overall LVI-IPCC scores indicate that households in Wete were less vulnerable than other blocks because of better adaptive strategy (0.43) and less sensitivity (0.35). Moreover, the
study also found Wete district as the least vulnerable block despite being severely exposed to climate change stress in comparison to other blocks. The other blocks lack basic facilities and thus why were more vulnerable because they have less capability to recover. However, in all the blocks have comparable exposure; most of the households still depend on natural capital for their livelihood. It means that the livelihood of households living below the poverty line is controlled and regulated by the whims of nature. Infertility and dispossession of land as well as dependency on rain fed agriculture have made the situation to be worse. Furthermore, unskilled labors are left with no opportunities to earn, and hence, migrate to other areas. The outmigration of people in order to earn a wage helps them to sustain their livelihood. Social ties facilitate the process of migration (Bird and Deshingkar, 2006) but for the poor it is difficult to migrate without any network or support. Social capital plays an important role in migration and features in all blocks, which helps in recovery of households.
CHAPTER FIVE
RECOMMENDATIONS AND CONCLUSIONS

5.0 Recommendations

Based on the key finding, Following are the recommendations engendered on the basis of this entire study.

i. Due to the meteorological data gap weather stations should be installing each district of Zanzibar.

ii. Urgent intervention in Pemba Island is necessary to enhance livelihood strategies and social network. Along this, simultaneous intervention is required to enhance social economic acclivities.

iii. A community financial co-operative can be established in order to promote saving and investment of that money to compensate the climate change impact.

iv. Horticulture crops such as water melon, tomato, spinach etc should be promoted to farm commercially which is wildly feasible in Pemba can significantly contribute to enhance people's financial capitals.

v. Disaster and vulnerability monitoring strategies should be established

vi. Promotion of informal and non-formal education using information vocational training centre(s) and classes for adults should be enhanced.

vii. Social services such as health, water and infrastructure should be strengthened and make necessary arrangements to provide regular and reliable health services to the local people.

viii. Green energy should be introduced to the community level in order rescue the coral forestry.
ix. The rain fed dependent for Clove farming households should be more sensitized about climate change and variability, their effects, solutions and appropriate adaptation measures.

5.1 Conclusions

The impacts of climate change have been destabilizing the human living systems. This study has carefully assessed the magnitude of social vulnerability due to climate change with the main focus on clove farmers in Pemba who significantly contribute to Zanzibar foreign currency income. The study findings have been analyzed and discussed and final concluding remarks are as follows;

- The social vulnerability contributed by broad number of factors such as social demographic profile, health, water, social network, energy resources, and livelihood strategies etc.
- The Clove farmers are generally moderately vulnerable to the impacts of climate change compared to other Indian Ocean Islands e.g. Madagascar Island.
- The social vulnerability showed clear clusters with Pemba Island and districts i.e Chake Chake, Wete, Mkoani and Micheweni. The trend of vulnerability shows as Mkoani > Micheweni > Wete > Chake Chake.
- The magnitude of vulnerability mainly connected to the degree of dependence of the clove industry compared to alternative activities such as business, horticulture etc.
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Appendixes

Appendix 1. Questionnaire  vulnerability of clove famers to impacts of climate change and its variability.

Household Survey Form

Dear participants,

This research intends to assess vulnerability of clove famers to key impacts of climate change and its variability. The results obtained from this study will be used to improve the clove production in Zanzibar.

I appreciate your kind participation in this study. It is important to note that the information that you will provide will be used for research purpose. It will not be used in a manner which allows identification of your individual responses.

Questionnaire administrator…………………………………………

Questionnaire completed by…………………………………………

Location………………………………………………………………….

House number address………………………………………………

1) Identification and characterization of stakeholder.

a) Social Demographic

1) Age     20-29 = 1, 30-39 = 2, 40-49 = 3, 50-59 = 4, 60+ = 5

2) Sex     Male = 1, Female = 2

3) Years of experience in farming 10-19 = 1, 20-29 = 2, 30-39 = 3, 40-49 = 4, 50-59 = 5.
4) Education level Illiterate = 1, Basic/Elementary = 2, Secondary = 3, Tertiary = 5, Vocational/Technical = 4.

5) Marital status Single = 1, Married = 2, Divorced = 3, Widow = 4

6) Household size. Small size (1 – 4) = 1, Medium size (5 – 10) = 2 and Larger size (11+) = 3

7) How many years have you lived in Pemba 10-19 = 1, 20-29 = 2, 30-39 = 3, 40-49 = 4 and 60+ = 5.

b) Livelihood Strategies

8) Have you given any support to neighbor in past one year?
   Yes = 1, No = 2

9) If yes, what kind of support?.................Food = 1, Cash = 2, Clothes = 3
   Others = 4

10) Have you received any kind of support from neighbor in the past one year?
    Yes = 1, No =

11) If yes, what kind of support?.......... Food = 1, Cash = 2, Clothes = 3
    Others = 4

12) Have you approach any government’s official for assistance during the past year?
    Yes = 1, No = 2

13) If yes, for what purpose?............................................

14) Are you a member of any NGO? Yes = 1, No = 2

15) If yes, why did you join to any NGO?.................................
16) Are you a member of a SACCO’s group? Yes = 1, No = 2

17) Have you ever received a support from relatives outside of Zanzibar?

   Yes = 1, No = 2

c) Health

18) How long does it take to reach nearest health centre from your house?

   <1km = 1, 1km = 2, 2km = 3, Above 2km = 4

19) Is anybody in your family chronically ill? Yes = 1, No = 2

20) Has anyone in your family been so sick in the past one month that they had to miss work or school? Yes = 1, No = 2

21) Has anyone in your family had malaria in past 3months? Yes = 1, No = 2

22) Do you have mosquito net? Yes = 1, No = 2
d) Food and Nutrition

23) Where does your family get most of its food?

   Own farm = 1, Market = 2, Others = 3

24) Are you get the most money from the clove?

   Yes = 1, No = 2

25) Are you save the money from clove?

   Yes = 1, No = 2

26) Does your family have adequate food the whole year?

   Yes = 1, No = 2

27) Are there times during the year that you do not have enough food?

   Yes = 1, No = 2
28) If yes how many months in a year do you get trouble of enough food?

3 months = 1, 4 months = 2, 5 months = 3, 6 months = 4

29) Are you use the money you get from clove to buy food?

Yes = 1, No = 2

e) Water


31) How long (in km) does it take to get your water source?

<1km = 1, 1.5km = 2, >1.5km = 3

32) Is this water available every day?. Yes = 1, No = 2

33) What containers do you usually store water in? (Observation)?

34) How many containers?.................................

35) How many liters are they in each container?.................................

36) During the past year, have you seen any conflicts over water in your community? 1:Yes 2:No.

f) Natural Disaster and Climate Variability

37) What climate related disasters and extremes have affected your land?......................

38) How have these affected the land and clove production? .........................................................

39) How many times has this area been affected by a flood/drought in ten years?
Non = 1, Once = 2, Twice = 3, Three times = 4

40) Did you receive a warning about the flood/drought before it happened?

Yes = 1, No = 2

41) Was anyone in your family injured in the flood/drought? Yes = 1, No = 2

42) Did anyone in your family die during the flood/drought? Yes = 1, No = 2

43) What type of fertilizer do you use?

Organic = 1, Inorganic = 2, Non of above = 3

**g) Energy Resources**

44) What is the major source of energy for cooking/heating purpose in your household?

Firewood = 1, Charcoal = 2, Gas = 3, Electricity = 4, Solar = 5

45) How long does it take to fetch firewood for your family?

0.5 km = 1, 1km = 2, 1.5km = 3, 2km = 4, More than 2km = 5

46) What is the situation of availability of firewood in comparison to 30 years back?

More than before = 1, Less than before = 2, Same as before = 3

47) What kind of Cooking stove (observation)?

Traditional = 1, Improved = 2
Appendix 2. Checklist for key informants for agriculture offices.

1. Name of Officer……………………………….

2. Designation/Title……………………………..

3. What do you understand about climate change and variability?

4. When the climate change and variability start in Pemba Island?

5. What is the trend of climate change and variability for past 30 years?

6. What is the effect of climate change and variability on the clove production?

7. What is the average rainfall and temperature in every year?

8. Do you think the climate change and variability has a significant contribution to vulnerability and resilience to clove farming to livelihoods?

9. What kind of assistance do you provide to the households in help them in managing their clove plantation estate?

10. What are the main problems facing the government due to climate variability?

11. How these problems affect the sector of Agriculture?

12. What adaptation strategies are applied to deal climate change and variability effects?

13. How effective are these strategies?

14. What are principal interventions that could be implemented to reduce risks and negative impacts associated with climate change?

15. What are major constraints or barriers to implementing recommended interventions?
16. What are potential actions that could facilitate and support local level adaptations to climate change?

17. What are the challenges facing the livelihoods involves on Clove production?
Appendix 3. Checklist for focus group discussions.

1) What are the livelihood resources’ which available from your village?
2) What kinds of crops did you cultivate?
3) What is the previous and current climatic hazard faced by the village?
4) What are the impacts of the previously mentioned climatic hazard on the livelihood resources?
5) What are the impacts of the previously mentioned climatic hazard on crops?
6) What are the impacts of climate change on clove production?
7) What are the coping strategies for those impacts?
8) Which social groups do you think are vulnerable to the climatic change and variability?
9) Why do you think the above mentioned social groups are more vulnerable to climate change and variability?
10) What organization/institutions were available in your area to assist you during climatic hazards occurring?

Checklist (area of observation).

a) Local awareness and perception of climate variability and trends related to climate change and associated impacts on clove production.
   - Changes in rainfall seasonality, abundance.
   - Observed changes and trends in temperature.
   - Cyclones – frequency and severity.
   - Floods – frequency and severity.
   - Droughts – frequency and severity.
b) Impacts of climate change on clove production in Zanzibar.

- Clove – changes in quantity.
- Clove – changes the quality
- Forest – changes in extent.
- Soil fertility, extent of erosion, run of

C) Consequences and impacts of climate related changes and trends, with particular attention to clove industry in Zanzibar.

- Changes in principal sources of income, livelihoods.
- Changes in crop yields, productivity of rural production systems.
- Changes in food security.
- Changes in land use mix changes in labor/time devoted to secure water supply.
- Changes in availability of fodder, fuel-wood, non-timber forest product.

D) Observations on responses and adaptation.

- Local initiatives and adaptations adopted in terms of mix of crops planted for shading.
- Adoption of soil/water conservation practices.
- Other measures taken to intensify clove production.
- Other major changes in use of natural resources or shifts in relative importance of local.
- Livelihoods.
e) Observations about barriers or principal constraints to adaptation to climate change and implementation of interventions to reduce vulnerability.

- Principal interventions that could be implemented to reduce risks and negative impacts.
- Associated with climate change.
- Major constraints or barriers to implementing recommended interventions.
- Potential actions that could facilitate and support local level adaptations to climate change.
Appendix 4.Calculating the food major component for the LVI for Micheweni districts and contributing factors.

<table>
<thead>
<tr>
<th>Major components</th>
<th>Sub components</th>
<th>Units</th>
<th>Sd</th>
<th>Min val</th>
<th>Max val</th>
<th>Index</th>
<th>Md</th>
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</thead>
<tbody>
<tr>
<td>Socio-demographic profile</td>
<td>Dependents ratio</td>
<td>Ratio</td>
<td>0.63</td>
<td>0</td>
<td>1</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent of female-headed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>households</td>
<td>Percent</td>
<td>19.50</td>
<td>0</td>
<td>100</td>
<td>0.20</td>
<td></td>
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<tr>
<td></td>
<td>Average age of female head</td>
<td>Average</td>
<td>45.80</td>
<td>39</td>
<td>65</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of household</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent of households where</td>
<td>Percent</td>
<td>15.5</td>
<td>0</td>
<td>100</td>
<td>0.16</td>
<td>0.31038</td>
</tr>
<tr>
<td></td>
<td>head of HH not attended to school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 1 (repeat for all sub-component indicators): index social demographic profile of Micheweni:-
Index SDP Micheweni = \frac{S_d - S_{min}}{S_{man} - S_{min}} = \frac{19.5 - 0}{100 - 0} = 0.20

Step 2 (repeat for all major components): social demographic profile of Micheweni:

\sum_{i=1}^{n} \frac{F_{1}^{Micheweni} + F_{2}^{Micheweni} + F_{3}^{Micheweni} + F_{4}^{Micheweni}}{n} = \frac{0.63 + 0.20 + 0.26 + 0.16}{4} = 0.310

Step 3 (repeat for all study areas): LVI Micheweni:

\sum_{l=1}^{n} \frac{W_{mi}M_{dl}}{\sum_{l=1}^{n} W_{mi}} = \frac{(4)(0.31) + (2)(0.403) + (4)(0.254) + (5)(0.488) + (5)(0.377) + (8)(0.38) + (4)(0.869)}{4+2+5+4+5+4+8} = 0.515

Step 1 (calculate indexed sub-component indicators and major components as shown in Appendix A, taking the inverse of the adaptive capacity sub-component indicators: Socio-demographic Profile, Livelihood Strategies, and Social Networks).

Step 2 (repeat for all contributing factors: exposure, sensitivity, and adaptive capacity):

Exposure of Micheweni: \frac{\sum_{l=1}^{n} W_{mi}M_{dl}}{\sum_{l=1}^{n} W_{mi}} = \frac{(8)(0.38) + (4)(0.869)}{8+4} = 0.5431

Step 3 (repeat for all study areas): LVI IPCC Micheweni = (eM - aM) * sM = (0.54316976 - 0.350231)*0.39922917 = 0.077027.
<table>
<thead>
<tr>
<th>Contributing factors</th>
<th>Major components for district</th>
<th>Major Components value for Micheweni</th>
<th>Number of sub-components per Major component</th>
<th>Contributing factors Values</th>
<th>LVI - IPCC value for Micheweni.</th>
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</thead>
<tbody>
<tr>
<td>Adaptive capacity</td>
<td>Socio-demographic Profile.</td>
<td>0.31</td>
<td>4</td>
<td>0.3502</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Livelihood strategic</td>
<td>0.403</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social networks</td>
<td>0.244</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.07702</strong></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Health</td>
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<td>4</td>
<td>0.3992</td>
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</tr>
<tr>
<td></td>
<td>Food</td>
<td>0.488</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>0.377</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure</td>
<td>Natural disasters and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Climate variability</td>
<td>0.38</td>
<td>8</td>
<td>0.5431</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy resources</td>
<td>0.869</td>
<td>4</td>
<td></td>
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</table>
### Appendix 5: Index of sub-components and major components

<table>
<thead>
<tr>
<th>Sub components</th>
<th>INDEX</th>
<th>Major components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DM</td>
<td>DW</td>
</tr>
<tr>
<td>Dependants ratio</td>
<td>0.63</td>
<td>0.58</td>
</tr>
<tr>
<td>Percent of female-headed households</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>Average age of female head of household</td>
<td>0.26</td>
<td>0.60</td>
</tr>
<tr>
<td>Percent of households where head of HH not attended to school</td>
<td>0.16</td>
<td>0.10</td>
</tr>
<tr>
<td>Average Agricultural Livelihood Diversification Index (range: 0.20–1)a</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Percent of household depends only in agriculture</td>
<td>0.56</td>
<td>0.08</td>
</tr>
<tr>
<td>Percent of households that have not gone to their local government for assistance in the past 12 months</td>
<td>0.93</td>
<td>0.97</td>
</tr>
<tr>
<td>Percent of households where not member of SACCOS/VIKOBA</td>
<td>0.37</td>
<td>0.77</td>
</tr>
<tr>
<td>Percent of households receive support from relative out of Zanzibar</td>
<td>0.24</td>
<td>0.32</td>
</tr>
<tr>
<td>Percent amount (Tsh.) earned from trades year 2011</td>
<td>0.13</td>
<td>0.68</td>
</tr>
<tr>
<td>Percent amount (Tsh.) earned from other sources year 2011</td>
<td>0.15</td>
<td>0.22</td>
</tr>
<tr>
<td>Average distance to health centre</td>
<td>0.67</td>
<td>0.11</td>
</tr>
<tr>
<td>Percent of households with family member with chronic illness</td>
<td>0.25</td>
<td>0.24</td>
</tr>
<tr>
<td>Percent of households where a family member had to miss work or school in the last 2 weeks due to illness</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>Average malaria exposure*prevention index</td>
<td>0.02</td>
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</tr>
<tr>
<td>Average number of months households struggle to find food</td>
<td>0.75</td>
<td>0.83</td>
</tr>
<tr>
<td>Percentage of households who save the money from clove</td>
<td>0.44</td>
<td>0.65</td>
</tr>
<tr>
<td>percentage of households that most get money from clove</td>
<td>0.58</td>
<td>0.78</td>
</tr>
<tr>
<td>Percentage of households that most get seed from government</td>
<td>0.18</td>
<td>0.25</td>
</tr>
<tr>
<td>Percentage of family get most of its food from its own farm</td>
<td>0.75</td>
<td>0.57</td>
</tr>
<tr>
<td>Average distance taken to water source</td>
<td>0.40</td>
<td>0.20</td>
</tr>
<tr>
<td>Average number of liters of water stored per household</td>
<td>0.40</td>
<td>0.66</td>
</tr>
<tr>
<td>Percentage of household do not have consistent water supply</td>
<td>0.87</td>
<td>0.14</td>
</tr>
<tr>
<td>Percent of HHs that collect water directly from river, pond and streams</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Percent of households reporting water conflicts</td>
<td>0.17</td>
<td>0.24</td>
</tr>
<tr>
<td>Average number of flood, drought, and events in the past 30 years</td>
<td>0.30</td>
<td>0.43</td>
</tr>
<tr>
<td>Percent of households that did not receive a warning about the pending natural disasters</td>
<td>0.81</td>
<td>0.46</td>
</tr>
<tr>
<td>Percent of households injured during the recent climate disasters</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Percent of households reporting death during the recent climate disasters</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Percent of HHs reporting land degradation by climate related extremes during past 30 years</td>
<td>0.98</td>
<td>0.95</td>
</tr>
<tr>
<td>Mean standard deviation of daily mean average maximum temperature by month</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Mean standard deviation of daily mean minimum temperature by month</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Mean standard deviation of daily precipitation by month</td>
<td>0.49</td>
<td>0.49</td>
</tr>
<tr>
<td>Percent of HHs using only Forest-based energy for cooking purpose</td>
<td>0.06</td>
<td>0.86</td>
</tr>
<tr>
<td>Average distance/time to fetch firewood</td>
<td>0.09</td>
<td>0.75</td>
</tr>
<tr>
<td>Percent of HHs reporting that firewood is being scarce now in comparison to 30 years back</td>
<td>0.05</td>
<td>0.71</td>
</tr>
<tr>
<td>Percent of HHs using traditional cooking stoves</td>
<td>0.97</td>
<td>0.91</td>
</tr>
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</table>
Appendix 6: Mean monthly maximum temperature (°C) at Pemba as observed at Pemba meteorological station from January 1983 to December 2012.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
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<th>OCT</th>
<th>NOV</th>
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<td>31.7</td>
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<td>29.0</td>
<td>28.6</td>
<td>28.2</td>
<td>29.2</td>
<td>29.9</td>
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<td>32.1</td>
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<td>27.6</td>
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<td>27.3</td>
<td>27.5</td>
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