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WATER DYNAMICS IN THE UMBA RIVER SUB-CATCHMENT OF TANZANIA: WATER RESOURCE ALLOCATION FOR LIVELIHOODS

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A Thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy.

Supervisors: **Professor Christopher Curtis**
&
Dr. Melanie Samson

September 2019

DECLARATION

I declare that I composed exclusively this thesis and that it is not submitted for any other degree or professional qualification at any other learning institution. It is being presented for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg.



(Candidate's Signature)

19th day of September, 2019

ABSTRACT

This study seeks to answer the question: how do changes in biophysical environment and social dynamics that include institutions affects water resource availability and allocation for livelihoods in the Umba River sub-catchment? I combined qualitative and quantitative methods within a single investigation whereby: quantitative methods traced and assessed land use and cover changes from 1975-2015 as well as tracing rainfall trends and extremes events since the 1960s across the study villages to understand how these changes affect water resource availability and livelihoods. Qualitative methods were used to gather information on livelihood capital, histories and how policies have been changing, especially the villagisation programme, as well as communities' perceptions on water scarcity and how they react and adjust to those changes. I argue that mixed methods increase opportunities for data triangulation and corroboration of results to understand contemporary water related challenges in the global south.

The conceptual framework combined the concepts of resilience, hydrosocial territories and waterscapes to demonstrate how human-environmental interactions and related changes that include power relations are linked to water access and allocation challenges and how these shape livelihood pathways in the Umba area. This approach revealed how changes in both biophysical environment (including land use and climate) and social dynamics that include institutions together have affected water resources availability, access and allocation and that in turn have affected water dependent livelihoods and related trajectories in the Umba area. Hydrosocial and waterscapes lenses revealed that available legal institutions have challenges and are influenced by politics and interference from government officers with interest in water and that the situation has caused some water infrastructures and water access to be allocated for some groups and places while denying other groups within the same sub-catchment. This has led to contestations and conflicts among water users themselves and institutions. I argue that the availability of water resources for livelihoods is complex and uncertain due to changes in biophysical environment, social dimensions, institutions and power relations which are interlinked and cannot be understood using a single based discipline and approach.

Results demonstrate that the study area has experienced significant changes in land use and climate over the last 40 years. Settlement and scattered cultivation have increased by 1761% and 395% respectively. Linked to that, natural forests have decreased by 48%, bushland decreased by 28% and grassland by 55%. Trends in annual mean rainfall appear to be declining but the Mann-Kendall test

did not detect any statistically significant trend ($P > 0.05$). However, extreme events assessed using the SPI for 55 and 33 years at two weather station locations indicated that the Umba area is experiencing increasing droughts events compared to wet events and the trend test has proved to be statistically significant ($P < 0.05$). Also, the seasonal analysis indicates interannual and interseasonal rainfall variabilities in terms of amount, onset, cessation and length of the season.

Water access for livelihood is shaped by how it is allocated. Due to skewed power relationships within formal institutions, water is allocated in such a way that some groups within the catchment have water access while others not. Also, in the sub-catchment some locations such as midstream and downstream have water infrastructures while those in off-stream and upstream areas have limited infrastructure rights. This has led to contestation and conflicts. In the Umba area, there are six types of water related conflicts which include; farmers versus pastoralists; farmers versus formal institutions; community versus conservationists; upstream versus downstream; irrigators versus other water users; and farmer (s) versus farmers. Therefore, rather than simply being the effect of changes in land use and climate, changes in water availability in the sub-catchment are due to a combination of variations in rainfall, changes in land use and land cover, and the politics and practice of allocation of water via complex hydrosocial waterscapes. Over time, this combination of forces has affected availability and access to water leading to struggle, contestations and conflicts between people living in different locations along the river, and within each area.

DEDICATION

I dedicate this PhD Thesis to my wonderful parents, my beloved wife Lilian and our cherished children: Faith, Mark and Ryan. I love you so much!

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ACRONYMS

ERDAS	-	Earth Resources Data Analysis System
CAN TZ	-	Climate Action Network Tanzania
CSOs	-	Civil Society Organisations
FAO	-	Food and Agriculture Organisation of the United Nations
FGD	-	Focus Group Discussion
GIS	-	Geographical Information System
GWP	-	Global Water Partnership
HHS	-	Household Survey
IPCC	-	Intergovernmental Panel on Climate Change
ISODATA	-	Iterative Self-Organizing Data Analysis Techniques
IUCN	-	International Union for Conservation of Nature
JFM	-	Joint Forest Management
KII	-	Key Informant Interviews
LGA	-	Local Government Authority
LEDAPS	-	Landsat Ecosystem Disturbance Adaptive Processing System
LULCC	-	Land Use and Land Cover Change
MAM	-	March, April and May
NAWAPO	-	National Water Policy
OND	-	October, November and December
PCA	-	Participatory Community Analysis
SACCOS	-	Savings and Credit Cooperative Organization
SLF	-	Sustainable Livelihood Framework
SPI	-	Standardised Precipitation Index
SPSS	-	Statistical Package for the Social Sciences
TMA	-	Tanzania Meteorological Agency
UNEP	-	United Nations Environmental Programme
URT	-	United Republic of Tanzania
UWABU	-	Umoja wa Watumiaji Maji Mto Umba
VICOBA	-	Village Community Bank
WRM	-	Water Resource Management Act No 11 of 2009
WUA	-	Water Users Association

CHAPTER 1
INTRODUCTION

1.1 Context of the study

The availability, allocation and access of freshwater resources is a major challenge facing the Sub-Saharan African countries, and Tanzania in particular (Kusiluka et al., 2005; Rodina, 2018; Oates et al., 2017). Some of the factors for water-related challenges include rapidly growing population, poor farming methods, woeful governance and management structures, unimproved infrastructure, deficiency of scientific and technical capabilities, destruction of water sources, and changing lifestyles (UNEP and WRC-South Africa, 2008; Falkenmark, 2017; Nair and Howlett, 2015). Studies affirm that land use pressure and unsustainable utilization of natural resources have jeopardised both biological and physical structures that support water sources in rural areas (Folke et al., 2016;URT, 2014; Kelly et al., 2015). Climate change impacts are adding more stresses especially through prolonged droughts and unreliable rainfall (IPCC, 2014; McCartney and King, 2011; Natkhin et al., 2015). Kangalawe (2016) asserts that in Tanzania, increased hydrological variability has negative effects on all dimensions of water use, allocation and management. Kangalawe adds that, the livelihoods of rural communities are the most vulnerable to water resource challenges.

On the other hand, studies carried out to investigate river basins and catchments have concluded that communities living in, and depending on those areas for their livelihoods are facing increase in poverty, contestations and conflicts that are linked to inadequate water allocation and access (Merrey and Cook, 2012; Franks et al., 2013). According to Merrey and Cook (2012), this situation is exacerbated by either changes in land use and climate or illness and incapability of formal institutions to transform and address those challenges. Sakketa, (2018) and Merrey and Cook, (2012) argue that inequalities to water access, exposure to extreme events such as droughts or floods, limited livelihood choices and or diversifications that lead to contestations, conflicts and negative livelihood trajectories of individuals and or households in most cases are mediated, reshaped and reproduced through complex legal, political and institution systems (Cleaver, 2012; Swyngedouew, 2006; Kelly et al., 2015; Quandt, 2016; Merrey and Cook, 2012). It is therefore vital to have an understanding of the role and effectiveness of policies and institutions governing availability and allocation of common natural capital like water in a way that enhances resilience of target communities to the impacts of either degradation or climate variability/ or change in the sub-catchment (Kelly et al., 2015; Brockington and Wilkie, 2015; Quandt, 2016; Merrey and Cook, 2012). This thesis seeks to assess and understand

changes in biophysical environment and social dynamics that include institutions and how these changes affects water resource availability and livelihood trajectories.

Studies have been carried out Tanzania on water availability, access and how that influce rural livelihoods results show that water resources is well linked to rural human livelivelihoods including irrigation farming, livestock keeping and maintaining ecological ecosystems (Perez-Foguet and Garriga, 2011; URT, 2012; Soltani et al., 2015; Smiley, 2016). However, most of these studies have been focusing on the major nine water basins that include Pangani, Ruaha, Rufiji, Ruvu/Wami, Lake Victoria and Lake Tanganyika (Kashaigili et al., 2007; Walsh, 2012; Swallow et al., 2009; Komakech, 2013). Less attention has been paid to sub-catchments of the main basins, thus emerging and long-term challenges of water resources use,allocation and management have remained unaddressed (Kangalawe, 2016; Natklin et al., 2015; Komakech, 2010). Yet, most of the sub-catchments are very important to rural communities of Tanzania. In recent years, these sub-catchments have been considered as new areas for agriculture expansion, water sources for households, pasture, sand and mining extractions, hydropower, settlements and tourism attractions. This situation has resulted in a decreasing flow of water in the rivers and hence seasonal water scarceness (Howard et al., 2016; Kohlitz et al., 2017; Kohlitz et al., 2019). Long term droughts also add a threat to the sub-catchments (Sawa and Adebayo, 2011; Franks et al., 2013; Anderson and Bolling, 2016). This has, in turn, caused resource competions, contestations, conflicts among stakeholders; hydropower versus irrigation sectors, farmers versus national parks/game reserves, irrigators versus pastoralists and upstream versus downstream (Damonte and Boelens, 2019; Seemann, 2016; Mbonile, 2005; Burgoyne and Kelso, 2014: Swatuk et al., 2015; de Bont et al., 2015). Poor management and unharmonized policies are the other challenges that face the water sector in Tanzania . For the case of water resource allocation and management in Tanzania, the hindrance factors include poor planning, weak formal institutions, unharmonized policies and legal frameworks (Rajabu and Mahoo, 2008; Fundi and Kinemo, 2018). Other factors that hinder water allocation include inadequate data, poor infrastructure, poor monitoring capabilities, and monetary constraints (Jiménez and Pérez-Foguet, 2011). Moreover, due to limited financial resources invested in the water sector, there has been limited technologies to harness and store water that could be used during extreme dry seasons at sub-catchment levels (Fundi and Kinemo, 2018).

The water in most of the rivers in rural Tanzania and in the Umba River sub-ctchment found in the northeastern part of the country and west Usambara mountains, in particular, is an important resource that supports livelihoods of communities that include offering water for irrigation farming, domestic water supply and ecosystem services (Falkenmark, 2017; Fundi and Kinemo, 2018). Other activities supported by this sub-catchment are conservation the of rich biodiversity of Umba Game Reserve , Mkomazi National Park and Shagayu forest. In recent decades, Umba River has experienced natural resources degradation and a decrease in water volume threatening water supply for human activities and ecosystems (Ngana and Madoffe, 2011; IUCN, 2009). The causes of water scarcity can be environmental or socio-economic or both (Brockington and Homewood, 2001; Swyngedouw, 1999). Policy failures and weak institutions may add threats to water availability and access in the Umba River sub-catchment (Rugemalila and Gibbs, 2015). Water scarcity has been associated with water users' conflicts between big versus small, upstream versus downstream, pastorals v/s farmers v/s fishermen (URT, 2012; Ngana and Madoffe, 2011). Furthermore, some ecosystems in the catchment are reported to be in danger due to a combination of population growth, changes in land use and land cover, overgrazing, sand extraction, obstructing and unsustainable utilization of water resources (Ngana and Madoffe, 2011; IUCN, 2009; Kashaigili et al., 2005). These circumstances have motivated this study which investigates changes that affect water resource and water allocation challenges and how both shape households and communities livelihoods in the Umba River sub-catchment of Tanzania.

1.2 Statement of the Problem

The Umba River sub-catchment is considered to be a strategic area as it provides water to diversified stakeholders and provides habitats for a multi-diversity of ecosystems (Ngana and Madoffe, 2011). It also supports about 200 villages both in Tanzania and Kenya by providing water for both irrigation farming and domestic use. The area is also regarded as the Tanga region bread basket for both vegetables and rice (Lushoto District Council, 2016). While irrigation activities are the main issues of concern to both upstream and downstream, other important concerns are reported to be related to biodiversity and environmental conservation, domestic water supply and pasture (Ndesanjo, 2017).

Umba River sub-catchment is considered to be a water scarce area that experiences various emerging conflicts among water stakeholders (IUCN, 2009; Mbonile, 2005;Komakech, 2013; Ngana and Madoffe, 2011). Studies have shown that due to severe land shortage, overgrazing and deforestation (Songoro, 2014; Swatuk et al., 2015; Kangalawe, 2016), some streams and river valleys within the Umba sub-catchment have been converted into farms and settlements. There are cases where some

streams are reported to have disappeared completely (Mwanga, 2013; Kangalawe, 2016). Population increase upstream is considered to have led to an expansion of settlements along the stream, specifically near water sources and thereby increasing risks associated with degradation and floods (UNEP and WRC-South Africa, 2008; Guillaume, 2009; Kelly et al., 2015). Although relevant policies, legislations and formal institutions have been established, the day to day management of the Umba River ecosystem seems to be weak and challenging (Kohlitz et al., 2019; Katomero and Georgiadou, 2018). The sub-catchment is also reported to increasingly suffer from environmental challenges such as climate change (associated with prolonged droughts or sometimes heavy rains), over-dependence on nature, land degradation, soil erosion and deforestation that in turn affect water availability for both ecosystems and human beings. Brown, (2009) argue that freshwater resources are declining and if trends in water demand and allocation challenges remain unaltered, the opportunity to conserve and allocate much of the remaining water resource will be more complicated and challenging and may promote more natural resource conflicts. This argument calls for active attention to the relationship between current water demand for human development and future sustainability.

Even though there is an increased interest in the Umba River sub-catchment, few studies have been carried out analysing the inter-linkages between household livelihood activities and water allocation processes. The few pieces of research conducted, such as Songoro (2014), put weight on land shortage, rural livelihoods and forest management in the West Usambara mountain and do not touch Umba River water resources. Conte (1999) examined the early colonial debates over environmental degradation and its remedies in some villages found near the Umba uplands of the West Usambara Mountains. This is a 16-year-old study and is out of date as both environmental and socio-economic challenges have since emerged that require special attention. Temu and Hella (2014) looked at the impact of sustainable land-use practices on food security, with no focus on river catchment management nor water allocation. Ngana and Madoffe (2011) looked at trans boundary water resources management in the Umba River sub-catchment. Although this study paid attention to water resources, challenges and prospects, it did not establish the inter-linkages and challenges between household livelihood resilience, water allocation and power issues. Therefore, as water has continued to play a great role in promoting livelihoods in rural areas of Tanzania, more changes in land use and climate are reported to have increased, affecting water access and allocation. This situation has led to increasing conflicts and contestations from communities and othe water users that instititutions are not playing their role to address water challenges (Hakansson, 2019). This findings call for more

studies that intend to understand water related complexities and changes both in biophyscial environment and social dynamics and changes and how these are linked to water access and livelihoods (Merrey and Cook, 2012; Quandt, 2016). More special attentions are needed to the sub-catchment levels as they support a large number of rural communities by providing water both for irrigation and domestic purposes. It is in in this regard that, this study on the Umba River sub-catchment was thought to be important so as to recommend how best the water challenges in the sub-catchment can be addressed to promote rural sustainability.

An integrated approach to water resource management and allocation is considered instrumental for dealing with water issues in a cost-effective and sustainable way at catchment and sub-catchment levels (Quandt, 2016; Hommes et al., 2019; Kohlitz et al., 2019; Swatuk et al., 2015; IPCC, 2014). However, Kabogo et al. (2017), Karpouzoglou and Vij, (2017), Boelens et al. (2016) and van Koppen et al., (2016) emphasize that integrated approaches to water resource management must go beyond water to include land and ecological aspects. Issues related to socio-economic systems, stakeholders, power relations, water uses and cultural aspects have to be considered and change with time (Brown, 2011; Kabogo et al., 2017; Swyngedouw and Boelens, 2018). In so doing, there was a need to pay attention to the role of local institutions through which the whole process of access, participation, allocation and regulation of natural resources is embended (Strauch and Almedom, 2011; Swyngedouw and Boelens, 2018). There was also a need to look at the main livelihood courses of the households for at least 30 years between the 1980s up to 2015, to have a clear understanding of how households' livelihood have been transforming with time .

Consequently, the existing scenario in the Umba River sub-catchment on water demands and competition from livelihood activties such as irrigation farming and pasture demands and water allocation challenges necessitated a research study that aimed at exploring how water availability, dynamics and contestations are linked to livelihoods and relevant individuals trajectories. The Intergovernmental Panel on Climate Change (IPCC) Assessment Report Five (2014) insists that climate change and non-climaatic factors will affect African Rivers and water bodies in terms of volume and flow conditions such as timing and quantity of flow. Kangalawe, (2012), insisted that the challenges of water resource's development in Tanzania will have serious implications on socio-economic development (URT, 2012). Therefore, all these need to be assessed and analysed together if we are to ensure livelihood resilience.

1.3 Research aim

In view of the above discussion, this study attempts to understand how human-environmental interactions lead to changes in water resource availability and contestations over water allocation and access, and how these in turn affect/shape livelihoods in the Umba sub-catchment of Tanzania. I approaches this task by combining three concepts: resilience, waterscapes and hydroscial territory (Kelly et al., 2015; Folke et al., 2016; Quandt, 2016;2018; Kliskey et al., 2019; Jackson and Barber, 2016; Boelens et al., 2016; Hommes et al., 2019).

In this study I have combined the concept of resilience with origin in ecological sciences and hydrosocial territories and waterscapes (political ecology) with origin in cultural ecology and political economy (Quandt, 2016) to understand how human-environmental interactions and related changes as well as power relations are linked to water access and allocation challenges and how these shape livelihood pathways in the Umba. Using resilience, I assessed the history and up to date status of biophysical environmental changes (from 1975-2015) which was dominated by land use changes due settlement expansion, decrease of natural forest and expansion of scattered cultivation in the water sources and forests overtime. It was also possible to trace and assess the riparian zones within 60 m from the river bank for the last 40 years up to 2015. In general, it was learnt that, in the off stream and upstream villages, land has decreased forcing people to expand farms encroaching water sources. Also, across villages the settlement area has increased by 1761% since 1975 up to 2015, interfering with areas which used to be water sources. This led to significant land degradation and has affected water availability in the Umba. The resilience thinking also traced the climate (rainfall variations) and how these changes are shaping the status of water and livelihood in the Umba. SPI indicated increase of extreme events since 1990s but the worse scenario was in 2012-2015 where the area was dry for 3 years consecutively.

On the other hand, hydrosocial territory and waterscapes assessed social dynamics and the role of institutions (formal and informal), their politics and how they are perceived by local communities in the Umba. Results showed how politics play role in creating territories of those with water access rights and those who have no rights or losers. These territories are developed either through project design or by diverting project targets during implementation through top -down order approaches. This has increased tension, contestations and water access related struggles which cannot be addressed by formal institution alone. The six types of conflicts were reported which include: farmers versus

pastoralists; farmers versus formal institutions; community versus conservationists; upstream versus downstream; irrigators versus other water users; and farmer (s) versus farmers. Also, hydrosocial territories showed how people across the sub-catchment are respecting and trusting informal institution when comes to water source management, allocation and solving related conflicts. Informal institutions are well established at the grass roots with respected elderly people with power and wisdoms which lead to conflict resolution. I argue that in the Umba, water resources and livelihoods are experiencing complexities and uncertainties in terms of biophysical environment, social dimensions, institutions and power relations which are interlinked and cannot be understood using single based discipline and approach.

The methodology employed combined qualitative and quantitative methods and data within a single investigation and interpretation to develop a broader, complete and synergistic understanding of biophysical and social cultural changes, dynamics and challenges in relation to water and livelihoods in the Umba. Quantitative methods such as Geographical Information System and remote sensing traced and showed the percentages of land use and cover changes since 1975-2015. The most dominant land use changes are decrease of natural forests, increase of scattered cultivation, settlement area expansion and decrease of swamp. On climate; trends in annual mean rainfall-appeared to be declining but the Mann-Kendall test did not depict any statistically significant trend ($P > 0.05$). However, extreme events assessed using Standardized Precipitation Index (SPI) depicted that the Umba River sub-catchment is increasingly experiencing more droughts events compared to wet events and the trend test has proved to be statistically significant and P- value < 0.05. Qualitative methods (e.g. household surveys, key informant interviews, participatory community analysis and group discussions) gathered information on histories and how policies have been changing especially the villagisation programme which forced people to leave their ancestor land and shifted to establish new settlement in the Umba which contributed to natural resource degradation especially water sources, land and forests. Qualitative methods traced histories of grown crops and those which have been abandoned such as yams; gave perceptions on rainfall which corroborated well with meteorological data, and existing institutions that both formal and informal institutions exist but the informal institutions are more respected, trusted, well rooted into communities and are helpful in water management and allocation at local scale. I argue that, mixed methods help the researcher to investigate further and go beyond combined methods to integrate all elements of the study and philosophical underpinnings.

1.4 Research questions

The overarching question for this study is: how do changes in biophysical environment and social dynamics that include institutions affects water resource availability and allocation for livelihoods in the Umba River sub-catchment? To answer the overarching question the following sub-questions have been considered:

i. What is the physical evidence for changing pressures on water resources from land use and climate change?
ii. What are the factors underpinning water resource allocation in the Umba River sub-catchment in relation to livelihood activities?
iii. How are decisions on water resource allocation reached, by whom and at which scales?
iv. How can households' livelihood pathways/trajectories in the Umba River sub-catchment be conceptualized and interpreted?

1.5 Structure of this thesis

The thesis consists of eight chapters (Figure 1). This first chapter presents the context of the study, problem statement, research aim followed by research questions. Therefore, chapter one lays a foundation on which other chapters are shaped and developed.

The second chapter reviews and analyses relevant work on resilience and livelihood resilience, livelihood assets and strategies, institutions, waterscape and hydrosocial territory to grasp key relevant gaps and debates. The first part gives a picture of resilience and livelihood resilience, and their relation to water resources, institutions and power relations in the context of rural settings. The second part uses those bodies of literature in developing the conceptual framework that guides this study. It is important to note that, in this study, literature is engaged across the thesis and in all chapters. Therefore, chapter two is relatively short to explain relevant concepts and the conceptual framework, but other literature is introduced in relevant sections throughout.

The third chapter outlines and explains the rationale for selecting the study site, as well as the methodology and methods for collecting and analyzing data underpinning this study. The chapter explains the relevance of mixed method approaches in expanding an understanding of the complexity, changes, contestations, institutions and power relations in the Umba River sub-catchment. More

importantly, the chapter reflects on how mixed methods are able to integrate both qualitative and quantitative approaches, using data triangulation. The approach allowed me to reflect on the complexity and contested interests that are entrenched in the research setting and processes.

The fourth chapter analyses and presents land use and cover changes as well as changes in climate in the study area to define how the two have been changing over time and their contribution and or limitation to water resource availability. I apply Geographical Information Systems (GIS) and Remote Sensing as well as climate trend and extreme weather events analysis techniques and tools to assess relevant changes that have happened. In doing so, I document and analyze the role played by impacts of those extremes and changes and how they shape water sources and resources in the study villages and contribute to vulnerability, waterscape and contestations.

The fifth chapter gives an understanding of the Umba River sub-catchment and other selected off-stream villages by assessing the socio-economic profile, land and water tenure systems, forms of existing livelihood assets and water resource demands and use in different villages included in the study. Also, some relevant policies and history are given in this chapter. Since water resources play a great role in shaping socio-economic and ecological landscapes of the study area, I use the concept of livelihood resilience (Kelly et al., 2015; Quandt, 2018; Fang et al., 2018; Li et al., 2019) as a working lens through which forms of livelihood capitals and households' livelihoods activities are analysed and discussed. The chapter provides fundamental information and context that are crucial for thorough analytical work and discussion of other empirical chapters, especially chapters 6 and 7.

The sixth chapter takes the discussion further into households and community perceptions on water scarcity and effects of water scarcity on households' livelihoods. The chapter also assesses and documents the existing water resource contestations and conflicts as well as how they happen in different river courses within the Umba River sub-catchment and in two villages that are off-stream. I also document how those conflicts are managed. Furthermore, the chapter assesses and discusses the role played by both formal and informal institutions in ensuring water allocation and existing power relations. To have a better undertanding and analysis of this chapter I combine the concept of livelihood resilience, the concept of waterscapes (Karpouzoglou and Vij, 2017; Kliskey et al., 2019) and the concept of hydrosocial territory (Boelens et al., 2016; Lopez et al., 2019)to describe and analyse livelihoods, water resource allocation, institutions and constestation in the study area.

The seventh chapter takes the waterscape discussion and links it with households' livelihood trajectories/pathways. In this chapter, I apply the concept of livelihood resilience combined the concept of hydrosocial territory as an important lens useful to explore the main livelihood courses of selected households embraced for 35 years. I go further to assess the general environment and magnitude which govern the routes of variation and the possessions that have been useful to the community. Through embracing different stories from selected household's life histories I capture and document their local settings, livelihood pathways, challenges and helpful institutions. I put more attention in the role of water resources in stimulating households' livelihoods, related dynamics and contestations with time. It further uses the livelihood resilience lens in analysing the socioeconomic and institutions that are linked to livelihood activities and related outcomes.

The eighth chapter summarizes the key findings of the thesis, provides some conclusions and thesis contributions.

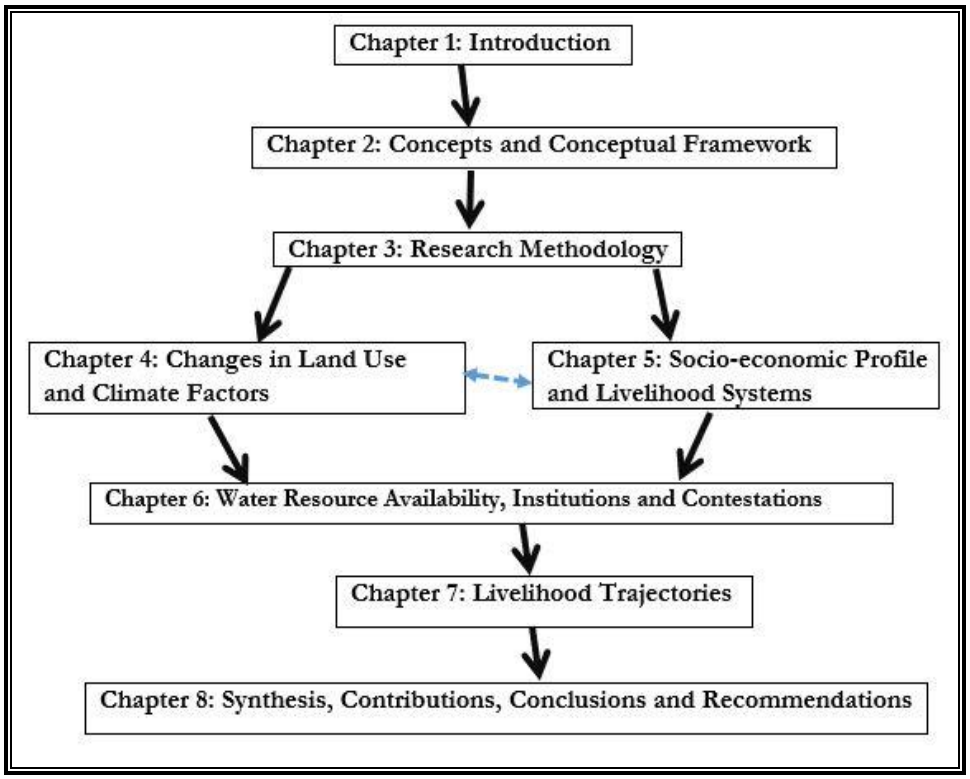

Figure 1: Structure of the thesis

CHAPTER 2
CONCEPTS AND CONCEPTUAL FRAMEWORK

2.1 Chapter introduction

This chapter explores the concepts underpinning livelihood resilience, hydrosocial territories and waterscapes and develops a comprehensive conceptual framework to guide this study that will provide a better understanding of climate-human-ecosystems interactions and changes in social dimensions, power and power relations, institutions and contestations, and how these shape water allocation processes and livelihood trajectories in the Umba. The chapter begins by examining literature relevant to livelihood resilience, water resilience and rural livelihood activities. It then moves on to step by step navigating literature helpful for developing the potential approaches and concepts that could guide this piece of work. After identifying strengths and weaknesses of each concept, the chapter develops a guiding conceptual framework for the study. The chapter concludes with a short summary.

2.2 Resilience and Livelihood Resilience

2.2.1 Resilience

The concept of resilience has continued to play an important role in environmental research due to its ability to focus on complex and dynamic issues which pose important challenges on social-ecological systems (Fang et al., 2018; Sharma and Goyal, 2018; Rodina, 2018; Mao et al., 2017; Folke, 2016; Tanner et al., 2015). In recent decades, both resilience as a concept and as a thinking have emerged to be a lens of enquiry that create a platform for interdisciplinary discussion, a key concept for assessing the continuity and sustainability of Socio-Ecological Systems (SES) (Sarkki et al., 2016; Folke, 2016) and how to successfully deal with environmental and socio-economic changes (Tanner et al., 2015; Folke, 2016). SES are interlinked and complex systems of which people are considered part and parcel of nature (Berkes and Folke, 1998)

Holling, (1973) observed that ecological systems have an ability to return to a normal situation after experiencing shocks, now this concept has been developed as an approach for understanding complex environmental and emerging socio-economic issues (Tanner et al., 2015; Folke et al., 2016; Rodina, 2018; Folke, 2016). The concept of resilience has several definitions as it is used in several fields and contexts (Mao et al., 2017; Brown, 2016; Reyers et al., 2018). My focus is to conceptualize how resilience is interpreted and how it can be used to guide this study especially on water and rural livelihood resilience. In the fields of physics and engineering where resilience originates it has been

used to refer to the ability of systems to bounce back after disturbance to resume their original state (Li et al., 2019). In other arenas, the concept is linked to capacity to adapt and or cope with changes. Folke (2016) and Reyers et al. (2018), critique this thinking as it focuses on resisting changes and making everything possible to maintain stability. The meaning of resilience should be richer to include complex, dynamic systems and uncertainty and should be able to persist and perform some key functions in a changing environment (Folke, 2016; Ayeb-Karlsson et al., 2015). Resilience in the context of environmental and natural resource governance is linked with a move from governing for efficacy and optimization to empowering and nurturing the capacity of systems to reorganize and accept changes (Rodina, 2019; Folke, 2016) Therefore, resilience is the ability of a system (social, environmental or economic), household or community to withstand and or accommodate slow or fast tremors, risks, trends and or disturbances (which could be climate change impacts, land degradation, water scarcity, socio-economic changes, or resource exhaustion) while continuing to perform key functions, learning and transformation (Ayeb-Karlsson et al., 2015; Rodina, 2018; Folke, 2016). In most cases it is a combination of two or more circumstances such as environmental degradation and change, poverty, conflicts and or prolonged legacies of past shocks or events which increase the magnitude of the disaster and cause the system to respond (Wilson et al., 2018).

Apart from engineering the concept of resilience is widely used within the ecological sciences with the intention to understand and clarify different trajectories of ecological and social systems and how they maintain equilibrium (Alexander, 2013; Nguyen and James, 2013). In the recent decade the concept of resilience is widely applied in understanding complex dynamics and changes linked to social-ecological systems and their ability to respond to disturbance and embrace transformation with changes (Folke et al., 2016; Rodina, 2018; Wilson et al., 2018; Tanner et al., 2015). Resilience thinking need to be forward looking and rethinking on how slow and fast changes interact and how individuals, households, community and culture adapt and or transform into new pathways in the face of changes (Folke, 2016; Reyers et al., 2018; Folke et al., 2016).

Recent advancements of the resilience approach have focused on integrating resilience of social-ecological systems, people and institutions to govern social-ecological dynamics as a way to improve human well-being across scales (Ayeb-Karlsson et al., 2016; Reyers et al., 2018). Folke (2016) argues that social-ecological systems are interconnected systems of human beings and nature and are entrenched in the biosphere. The biosphere connection is central in resilience and work with social

ecological systems to govern complex social-ecological dynamics to ensure sustainability (Folke et al. 2016; Anderies et al., 2013).

Scholars like Tanner and colleagues have insisted that the lens of resilience requires more consideration of human livelihoods if it is to address the limits of adaptation strategies and the development needs of the local poor and most vulnerable people (Tanner et al., 2015:23). Therefore, resilience thinking should be a dynamic concept which can navigate complexities and uncertainties and understand human adaptation and actions that support current and future trajectories. It should reflect the ability of households and communities to be able to continue living and developing in an ever-changing environment (Folke, 2016).

2.2.2 Livelihood Resilience

2.2.2.1. Livelihood

The thinking and conceptualisation of the term livelihood has shifted to focus on society development and sustainability instead of capital accumulation alone (Habtemarian et al., 2018; Scoones, 2015). Some scholars (Wang, 2018; Tuyen, 2013) see livelihood linked to Robert Chambers' work back in the mid-1980s. However, Scoones, (2009) and Ashley and Carney, (1999), assert that the history of livelihood perspectives can even be traced back to another five or more decades where the perspective was influencing rural development practices and thinking. During that period anthropologists, ecologists and economists worked together, finding possible solutions on changes in the rural syststems which were taking place during that period (Fardon, 1990; Scoones, 2009). It was after robust lobbying and advocacy in the 1990s, first by Chambers and Carney, (1992) and later by Scoones (1998) and Ashley and Carney (1999), that the term livelihood was linked to sustainable then "sustainable livelihood", which was adopted by development partners and used in their development programmes and approaches. The UK Department for International Development (DFID) is acknowledged to have contributed both in financial resource and funding projects on the ground that are guided by Sustainable livelihood approaches (Krantz, 2001; Wang, 2018).

Generally, livelihood refers to various activities and resources supportive to human being. The term "livelihood" has been defined by several schoolers. Influenced by Chambers and Conway, (1992) work:

> "a livelihood comprises the capabilities, assets or capital (natural, human, social, and financial) and relevant activities and acesses (as influenced by institutions and social connections) needed for a means of living and absence which may lead to vulnerability of individual or household." (Hebtemarian et al., 2018).

Later in this chapter, chapter 5 and 7 these elements of livelihood assets will be defined and framed in relation to water resources and household's livelihood.

Also Chambers and Conway give a definition on the concept of " sustainable livelihood". That;

> "a livelihood is sustainable if can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for next generation and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (Chambers and Conway, (1992:6).

Also, Scoones, (1998) gave a modified definition that;

> "A livelihood contains capabilities, assets (materials and social resources) including important activities useful for making living possible. For a livelihood to be sustainable should be able to cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, and should not undermining the natural resource base" (Scoones, 1998: 5).

It is insisted that people need to have ability to access livelihood assets, both in the form of tangible and intangible (Scoones, 1998; Carney, 1998). As I will show in the subsequent sub-sections, it can be established that, the concept of sustainable livelihood is close to the concept of livelihood resilience given by Tanner (2015).

2.2.3 Livelihood Resilience

Environmental and socio-economic changes have proven to affect water resources access for human livelihoods in the global south (Tanner et al., 2015; Ayeb-Karlsson et al., 2016; Quandt, 2018) by increasing rate of degradation and deforestation, abnormal droughts and precipitation and resource scarcity and conflicts. This calls for an approach that will understand how to build resilience against these effects in a holistic manner. To achieve this the lens of livelihood resilience is useful to assess and understand how people and households withstand complexities linked to environmental and socio-economic dynamics (Tanner et al., 2015; Ayeb-Karlsson et al., 2015; Jones and Tanner, 2015; Ayeb-Karlsson et al., 2016). Resilience has become a key concept used for analyzing human-nature

interactions in social–ecological systems (SES) and trying to have a better understanding on how to successfully deal with climatic and socio- economic changes (Speranza et al., 2014). Scholars such as Tanner and colleagues have had the most cited definition that; livelihood resilience refers to "the capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances" (Tanner et al. 2015: 53). Based on this definition, a livelihood approach expands the meaning of resilience to include and acknowledge human situations, socio-economic factors, values, perceptions and how these affects human ability to adapt (Tanner et al. 2015). Ngigi et al., (2015) and Quandt (2018) assert that when livelihood resilience is built it means livelihood strategies for a given household are better prepared to cope and adapt to changing conditions. According to Olsson et al., (2015) and Quandt, (2018), resilience building has two main aims: first, to make sure the system is prevented from moving in an undesired direction in the face of change; second is to nurture and embrace the components of the system that build resilience and allow the system to renew and reorganize after a disturbance. In order to successfully build resilience, it is essential for one to ask questions of: "resilience of what", "resilience to what", and "resilience for whom" (Brown 2014; Bruijn et al., 2017). Generally, the resilience approach is a promising tool as it creates an opportunity for exploring adaptive changes by individuals, household and or communities toward sustainability and gives a way for analyzing how to maintain stability in the face of change (Biggs et al. 2015; Folke, 2016).

Livelihood resilience is closely linked and draws from the sustainable livelihood approach in a sense that livelihood sustainability strives to understand how to keep a system functioning and livelihood resilience gives more emphasis on the ability of the system to bounce back after a certain disturbance (Fang et al., 2018; Thulstrup, 2015; Hebtemarian et al., 2018; Folke, 2016). The Sustaible Livelihood Approach (Schoones 1998) is a tool designed to conceptualise rural households' livelihood systems in an inclusive way and by apprehending existing challenges and opportunities that are linked to their livelihoods (Thulstrup, 2015; Quandt et al., 2017). The approach helps to understand the ways households interact with the external environment such as livelihood capitals, insitutions and policies (DFID, 2000). It also seeks to understand changing combinations of livelihood activities in a dynamic and historical context (Serrat, 2010). The approach considers five key components for analysis: (i) context, environments and trends, (ii) livelihood capitals, (iii) institutional process and governance structures, (iv) livelihood strategies and (v) livelihood outcomes. In this case, the approach takes into account the fact that livelihoods are not neutral but are largely subjective to different settings including

micro and macro environments (Scoones, 1998). It further considers the role of physical and socio-economic settings existing across levels (Songoro, 2014, Katikiro, 2014). According to Scoones, (1998) the sustainable livelihood approach is useful at different scales and levels – from individual, to household, to groups of households, to village, region or even nation. The approach gives an opportunity to local people in rural settings to engage and participate in the planning process whereby their views are taken into account. Despite the fact that the approach puts people at the center, it also acknowledges the vulnerability context which affects the access to livelihood assets (Jonnson, 2017).

Despite the strengths of the sustainable livelihood approach, it is criticized as it fails to consider dynamics and relations and accounting for power relationships and politics which are important for approaching complex socio-environmental governance (Katikiro, 2014; Quandt, 2018). The approach has also been criticised for paying too much attention to formal institutional factors as the central drivers of livelihood capitals, while forgetting to consider and appreciate the role of traditional and informal institutions in the framework (Scoones, 2009; Krantz, 2001). It lacks rigorous attempts to deal with long-term changes (Quandt, 2018; Scoones, 2009), and is expert-driven (Jones and Tanner, 2015). On this, Scoones (2009) contends that despite the fact that livelihood analysis is able to identify and analyze different future pathways, livelihood approaches have little to offer on understanding transformation and the longer term change. There is need to enhance livelihood thinking in relation to sustainability that incorporates resilience (Speranza et al., 2014; Tanner et al., 2015). On this Speranza and colleagues suggest examining the trade-offs between vulnerability and resilience in livelihood theory which will enrich the scholarship in the this field (Speranza et al., 2014: 111).

In the past two decades, there has been a number of studies shifting from use of the sustainable development approach to livelihood resilience the at community level in relation to natural asset endowment and or degradation (Thulstrup, 2015; Walters, 2015; Kelly et al., 2016;Wilson et al., 2018), disaster risk reduction (Rapaport et al., 2018; Coaffee and Lee, 2016; Ayeb-Karlsson et al., 2016; Szoenyi et al., 2016), water resources (Rodina, 2018;2019; Falkenmark, 2017) and livelihood functions (Otsuki et al., 2017; Speranza et al., 2014). The reviewed studies show the importance of evaluating forms of livelihood assets as articulated in the sustainable development field and linking them to livelihood strategies and livelihood resilience at community levels (Kelly et al., 2016; Rudiarto et al., 2019). The choice of the household livelihood resilience approach is not arbitrary. Households have essential components of the water resource systems and activities that are in continuous interaction

with the environment (ecological, economic, social, institutional, technological, physical etc.; Dhraief et al., 2019; Jonsson, 2017). Nonetheless, many efforts to use the five forms of livelihood assets to understand livelihood resilience have been paying much attention to the community scale as compared to household scale (Berkes and Ross, 2013; Quandt, 2018). I argue that, in measuring livelihood resilience, it is imperative to focus on household and not an aggregation of households known as 'community'. This is due to the fact that understanding households or groups with a minimum level of livelihood resilience will inform institutions and policy makers to take informed interventions as way of building resilience. This is because it is households or groups of people in a certain area who are able to access and control livelihood assets and are the ones who may either be vulnerable and or marginalized in the community and hence need to be assisted by building their resilience (Quandt, 2018).

Therefore, resilience of a human system is thought to comprise a range of different components and capacities to; absorb change, preparedness and contingency, innovation and learning as well as renewal, reorganizing and transformation (Folke, 2016). For the case of water resources challenges and insecurity, households work and make decisions to improve their resilience by reorganising the functioning of the water systems. So, the question of whether the water system resilience will be sustainable or not is dependent on how decision makers and institutions consider the feedback from the households and incorporate feedback into their intervention actions.

Like any other approaches, livelihood resilience has attracted criticism from different scholars that it has paid less attention to power relations and social or politics of social-ecological systems (Wilson, 2017; Quandt et al., 2017; Cooper and Wheeler, 2015; Brown, 2014; Folke, 2016). Martin et al., (2018) argue that apparent failure of resilience to address the distributive and power dimensions of environmental and development problems indicates a serious limitation of the concept. The issue of conflicts on resources is overlooked in the process (Quandt et al; 2017). Another area which has attracted criticism is institutions (both formal and informal) that are not given the required attention despite the fact that both have capacities to influence access to livelihood assets, practices and management (Brown, 2014). In order to address these criticisms, this study will assess and analyse the livelihood resilience of Umba River sub-catchment by using both qualitative and quantitative methods while referring to several natural and anthropogenic historical trend and or disturbances, including climate and land use change as well as forms of livelihood assets. The use of the concepts of

waterscapes and hydrosocial territories intend to address all criticisms on social vulnerability, power relations and institutions.

2.2.4 Understanding water resilience

Water is part and parcel of the Earth, resilience and sustainable development (Falkenmark et al., 2019). It is through water the capacity of social-ecological systems to deal with disturbances, adapting to changing environments and transforming in situations of crisis are possible (Wurl et al., 2018; Wilson et al., 2013; Kelly et al., 2016; Rodina, 2019). In this regard, the function of water includes; regulating the climate, ensuring water availability and supply to households and communities (Falkenmark et al., 2019). However, these functions are decreasing due to natural and human interferences such as climate forcing, water overuse and unsustainable irrigation, and land-use changes have significantly disturbed these water functions and induced regime shifts in social-ecological systems (Falkenmark et al., 2019). This has called for research emphasizing the need to understand the history, trends and interactions between humans and water resources though the lens of livelihood resilience (Johannessen and Wamsler, 2017). This will provide understanding of how households are building livelihood resilience in the complex and changing environment.

It is in the last two decades that the concept of resilience got much attention and use in the context of water resources such as hydrological resilience, socio-hydrological resilience, community and urban resilience to water related disasters and hazards (Mao et al., 2017; Reyhani et al., 2017; Wurl et al., 2018; Rodina, 2019). Hitherto, the application of the resilience concept has not paid the required attention to the essence of socio-hydrological dynamics and changes in the human-water context (Maoetal, 2017; Eslamian et al., 2019; Rodina, 2018). From a water perspective, resilience refers to the capacity of the system to cope and adapt to changes, and transform into a new state following a regime shift (Folke et al., 2010; Rodina, 2019). Water resilience refers to the role water plays in preserving and sustaining a certain wanted state of a social-ecological system, ranging from sustaining the ecosystems and biomes, to the stability of local and regional weather and climate systems, and the ability to sustain water supply for households and or communities and that of the Earth system (Falkenmark et al., 2019). Therefore, water resilience can be defined as the capacity of water systems in generating critical ecosystem functions and services and in building households or communities' ability to cope and adapt to changes in biophysical and hydrological systems and beyond that to continue to develop with a changing environment.

The use or application of water resilience in both academic studies and public policy with attention to human–water interactions is increasingly evident ranging from aquatic ecosystem conservation (Khamis et al., 2013) to hydrological risk management (Johannessen and Wamsler, 2017; Hallegatte et al., 2013) sustainable water use and development (Brown, 2016; Habtemariam et al., 2018; Falkenmark et al., 2019) and polycentric governance of water (Ostrom, 2014; Baldwin et al., 2018; Aubin et al., 2019; Kellner et al., 2019). According to Falkenmark et al., (2019), there are three roles of water in the system resilience: first, as control variable, water is considered to be the "source" of resilience or one of the key components in sustaining all life on the earth. Second, as state variable, here water becomes vulnerable to several external changes that include extreme weather events, deforestation, encroachment of water sources and land use and land cover change. Third, as driving variable whereby water becomes the agent of disturbances that affect resilience to both human and ecosystems in terms of floods and or droughts which lead to scarcity of water.

Despite the fact that the literature on water resilience remains rather fragmented (Rodina, 2019), there has been an increasing and considerable body of work that focuses on assessing and integrating water resilience as an approach in water studies. However, more work still needs to be done to have a better understanding of the role of water resilience to household livelihood and how these could be planned and mainstreamed into policies and local institutions.

2.3 Key Factors Affecting Livelihood Resilience

Studies have highlighted that, in order to have a better understanding of households' resilience it is a prerequisite to understand the complex interplay of different domains that are linked to social-ecological systems (SES) (Tanner et al., 2015; Kelly et al., 2015). Several scholars have concluded that it is difficult to directly measure livelihood resilience and instead they use surrogates and or indicators such as household wealth, access to improved water resources, well-built infrastructure, access to financial resources, membership to social groups and access to water for irrigation and irrigation schemes (Kelly et al., 2015; Quandt et al., 2017; Thulstrup, 2015). However, there is no one strong and self-complete procedure that can be applied to determine resilience indicators. This study builds on the conceptual framework as outlined by Speranza et al. (2014), Quandt et al. (2017), Wilson et al., (2018) and Kelly et al., (2015) which also draws from the sustainable livelihood approach (Thulstrup, 2015) and suggests that communities and households become and remain resilient when forms of livelihood assets such as social, financial, physical and natural or environmental resources are in good

state (Table 1). This is a comprehensive and innovative approach that ensures that all major social and ecological aspects of resilience are included and used in the study protocol (Thulstrup, 2015; Quandt et al., 2017). Natural assets include access to lands, forests, wildlife and environmental services. Social assets include access to associations, networks, formal and informal groups, relationships with neighbours, taboos, trust and reciprocity (Thulstrup, 2015). Physical assets involve access to necessary infrastructures such as all-weather roads, markets, water systems and electricity. Financial assets refer to access to financial institutions, credits, savings and remittance. Human assets involve knowledge and skills, health, education level of household head, and access to trained labour force. As stated above, all five forms of livelihood assets are important in building livelihood resilience and vice versa. Quandt et al., (2017) assert that, by evaluating forms of livelihood assets one is able to determine the level of household livelihood resilience, and that it is an effective and innovative way to embrace nonmonetary measures in resilience. Adaptation of strategies which are influenced by livelihood assets help to maintain the diversity of livelihood options and these lead to building livelihood resilience of the given household and or community (Quandt et al., 2017).

As stated by Quandt et al., (2017) and Kelly et al., (2015) livelihood resilience approaches have emphasize on people's access to livelihood assets (e.g. natural capitals, physical capitals, human capitals, financial and social capitals) and ways in which these assets are combined by to create livelihood and how institutions are able to facilitate more access to livelihood assets. These capital assets are more interlinked and need to be well developed if they are to contribute significantly to building livelihood resilience (Thulstrup, 2015; Speranza et al., 2014; Wilson et al., 2018). The five forms of livelihood assets provide the basis for the structure of analysis in this thesis and ensure a wide diversity of indicators are included in livelihood resilience (Quandt et al., 2017). A household or community where one or more livelihood assets are not developed will be considered vulnerable. Vulnerability is the opposite of livelihood resilience (see section 2.6 for details).

Table 1: Forms of household livelihood resilience indicators

Forms of Livelihood assets	Description
Natural	Access to natural resource stocks and services such as fertile land, forests, freshwater, wildlife, aquatic species and clean air (EEA, 2015; Wilson et al., 2018).
Physical	Access to basic infrastructure helpful for timely movement of other capitals e.g. markets, electricity, roads, postharvest infrastructure, water systems, housing and communication systems (Speranza et al., 2014).
Social	Access to connections and networks of social relationships that influence and affect people livelihoods, also including political influence/power (DFID, 1999; Katikiro, 2014). Informal groups/institutions have norms and beliefs for management and sharing of common resources such water, land and forests (Lal, 2012).
Financial	Access to wealth resources (cash, savings, salaried job, business, technologies, remittance, etc.) important for people in pursuing livelihood objectives (Quandt et al., 2017; Berge et al., 2011)
Human	Access to education, access to knowledgeable and trained labour force (Diebolt et al., 2014), health facilities. Used to stimulate other capitals through adding value and making them useful to household livelihoods resilience.

Source: Adopted and modified from Thulstrup (2015) and Quandt (2018)

To advance this, Speranza et al., (2014) argue that the resilience concept can help understanding of important factors necessary either for households and or other stakeholders to protect their livelihoods from disturbances and shocks. The authors have suggested three indicators to measure resilience: First, buffer capacity – the ability of the system to absorb disturbances and still continue functioning (encompassing livelihood assets-human, financial, social, physical and natural). Second, self-organization - spontaneous reaction of social system based on both top-down and bottom-up processes without being influenced by the external system. It includes the roles of institutions (formal and informal) with policies, norms, rules and capacity to implement them. It also encompasses cooperation and network, structure of the network and ability to use their own resources. Lastly is the ability of the SES to learn from the previous experiences and inform the new actions. It encompasses the ability to obtain knowledge and sharing, transfer and feedback mechanisms to ensure

transformation in the changing environment. These are considered in the analysis of livelihood trajectory/pathway in this thesis especially in chapter 7.

2.4 Institutions, policies and governance

The concept of institution is defined differently depending on the field and need of the author. Some have defined institution as a structure with aim and capacity to influence rules and social interactions (Marquis and Reynard, 2015). Scoones (1998: 12) citing Giddens (1979), defined 'institutions' as

'... regularized practices (or patterns of behaviour) designed by rules and norms of society'.

According to Fuest et al. (2005), institutions could include written and unwritten rules or principles that manage and control behaviour and facilitate what people will do while giving orientation and security to their socio-economic undertakings.

Institution therefore, refers to accepted complex and dynamic systems that comprises rules, norms and behaviours that exist to guide and regulate human and nature multi-level interactions. At a point when there is no, or insufficient, rules and institutions, human-nature interactions can lead to conflict and or degradation of natural resources and this may lead to stakeholder vulnerability (Rahman et al. 2017)

Cleaver (2002) and Rahman et al. (2017) assert that there are two types of institutions involved in natural resource management: 'formal' and 'informal'. Formal institutions have hierarchical organizational structures, contracts and other codified norms of behavior. On the other hand, informal institutions are based on norms, habitual, customary rules, culture and day to day practices. In most cases both formal and informal institutions exist in one environment or place and sometimes it might be difficult to distinguish and separate them. In some circumstances the differences can challenges collaborative interactions of the two types of institutions. Still, scholars show for the importance of such interactions in promoting livelihood resilience and sustainable natural resource management and use (Pike et al., 2015; Rahman et al., 2017).

Building livelihood resilience depends on how households and or communities are able to interact, access and use livelihood assets and how institutional set up allows that to happen (Quandt, 2018; Beunen and Patterson, 2019; Cleaver and de Koning, 2015). Also, it depends on the history and

current context of the given area, conditions, trends, and institutions that shape individual and household interactions with livelihood assets to build resilience livelihood strategies, or not.

As argued by Cleaver and de Koning, (2015), it is important to place local institutional arrangements in the wider context of governance (the political ecology and political economy) to better shape resource allocation, adaptation and negotiated solutions. Indeed, the outcome of any intervention designed to improve livelihood resilience is dependent on the existing institution structure and governance through which the intended intervention is delivered (Aubin et al., 2019; Quandt, 2018; Wang, 2018; Cleaver and de Koning, 2015). It is within institutions that governance, policies, legislations, power relations and norms are developed and enforment is done, which in turn shape and transform livelihood resilience across levels and scales (Beunen et al., 2017; Speranza et al., 2014). Hobley and Shields, (2000) assert that institutional structures influence the governance arrangement and determine the power relationship between state and citizens. They further add that institutions have power in terms of equity sharing among local people and have direct and indirect impacts on livelihood resilience. It is within this understanding the assessment of the role of institutions should include how they are cultivating capacity of people and or communities to live, sustain and develop in the face of change and be able to navigate complexity, uncertainty, and dynamics across level and scales (Beunen et al., 2017: 1).The institutions structures and governance have power to determine access to livelihood assets and livelihood strategies (Cleaver and de Koning, 2015; Speranza et al., 2014; Ostrom, 2014). However, this should be explained and done in a way that people are democratically given spaces to be involved in decision making.

Institutions must guide how people, acting individually or collectively are able to sustainably interact with their environment to utilize livelihood assets to sustain their well-being and pursue development. This attracts attention to the assessment of how power works to shape participation, access and outcomes (Cleaver and de Koning, 2015). The power relations embedded within institutions over time make contestations that again continuously shape institutional practices (Scoones, 1998). It is in that regard that institutions continue being dynamic, shaped and reshaped with time. These institutions can be public (for instance Local Government Authorities - LGAs) or private (Non-Governmental Organizations; Rakodi, 2002). They can also be formal and or informal institutions. In the context of rural Tanzania, the government administration in most cases may include formal and informal institutions at the same time.

Relevant institutions need to be strengthened and be effective accompanied with relevant policies that are democratically enforced on the ground to transform rural communities in a positive way (Herrera and Post, 2014). Baird et al. (2013) and Karpouzoglou and Vij (2017), assert that the institutions should strive to ensure inclusive participation in policy formulation, decision-making processes, increase transparency and accountability and at the same time uplift the voice of the poor by empowering them. They should facilitate the interaction between ecological and social systems; the diversity of livelihoods, resources and uses; the variability of actors and their practices within heterogeneous communities; multiple and overlapping scales, domains and timescales of interaction; and monitor the variability of outcomes produced (Cleaver and de Koning, 2015). In the process of addressing these, institutions must be strategically positioned to deal with complexity, uncertainty and dynamics in relation to a multiplicity of factors. Still, it is through institutions with influence over political capital and capabilities of people, that access to assets and resources are always reproduced, redefined, changed, renegotiated and redistributed (Bebbington, 1999; Rakodi, 2002).

In the Umba River sub-catchment context, both formal and informal institutions are thought to have the power to influence the use of and access to the water resources. Therefore, it is imperative to assess and understand how the collaborative interaction of these institutions plays a role in facilitating and or limiting the use of livelihood assets and how that leads into livelihood resilience or vulnerability in an ever-changing environment. It is also imperative to understand the ways in which these institutions exercise power and how different stakeholders respond to the power dynamics in a complex and ever-changing environment and context.

2.5 Livelihood strategies and outcomes

This refers to a combination of diverse portfolio of activities chosen by individuals and or households with an intention to achieve certain livelihood objectives (Martin and Lorenzen, 2016; Walelign and Jiao, 2017; Manlosa et al., 2019). Livelihood strategies are dynamic and might change with time, climate trend, circumstance, geographical location, livelihood capitals endowment and access, and wealth levels (Wang, 2018; Gautam and Andersen, 2016; King, 2011). It is important to always consider institutions and policies that control and govern the way livelihood assets are accessed and used, as they have the power to embrace and or hinder the success of livelihood strategies (Beunen et al., 2017; Guillaume, 2009). Yang et al., (2018) assert that in a rural context people have three broad types of livelihood strategies, which are intensification and or extension of agricultural activities,

livelihood diversification and migration. On intensification; people will either gain livelihood more from agriculture where it could include rearing livestock, apiculture, forestry, aquaculture and others through use of more inputs and labour, or put more land under cultivation. On livelihood diversification; some people may decide to diversify to non-farming activities that lead to earning income. Lastly on migration, here some people tend to move away to find livelihood in other places which could be temporary or permanent. However, some people who are well off tend to pursue a combination of strategies (Rakodi, 2002; Scoones, 2009; Tesfaye, et al., 2011) and this could lead into results that are more tangible and resilient in terms of livelihood strategies.

Studies have documented evidence of changing livelihood strategies in several places; for instance, due to denial to natural resource access by formal institutions (King, 2011), decreased land and productivity (Tesfaye et al., 2011; Jiao et al., 2017; Masunungure and Shackleton, 2018) and due to climate change (Kangalawe, 2016; Mngumi, 2016; Pauline, 2015). Most of the livelihood strategies included embracing non-farming activities or a combination. The analyses of the literature show that households' livelihood strategies are dynamic and keep on changing with climate trends, land history and status, livelihood assets, national and local policies and institutions (Yang et al., 2018). Livelihood assets play a central role in the transformation of livelihood strategies. With this background, it is recommended to use the livelihood assets indicator as an independent variable and the type of livelihood strategy as a dependent variable to understand factors that influence households in choosing their livelihood strategies in the study area (Yang et al., 2018).

On the other hand, it is important to understand the outcome of households' livelihood strategies. Livelihood outcomes refer to what people achieve through their livelihood strategies which can be measured, such as river rejuvenation and hence water availability, food security and income increase (Manlosa et al. 2017; Yang et al., 2018). The outcomes and set indicators can give a clear understanding of the output and the stakeholders' motivation for behaviour change (Kollmair and Gamper, 2002), and whether that will be sustainable or short term (Tuyen, 2013).

Kollmair and Gamper (2002) argue that livelihood outcomes have direct influence on livelihood capitals and keep on changing, offering other new livelihood strategies and corresponding outcomes. The livelihood outcomes need to be sustainable instead of creating another loophole for vulnerability by leading to unstainable land use or land cover changes, degradation of water resources and air

pollution which in turn lead to environmental change and challenges such as climate change impacts (Daregot et al., 2015; Blaikie and Coppard, 1998).

2.6 Vulnerability context

Water resource availability and use are becoming key factors determining the resilience and vulnerability of households and communities in the East Africa region (Winowiecki et al., 2015). Factors linked to human-nature interactions and linked to climate and land use changes, deforestation alongside ill enforcement of policies coupled with weak institutions, are considered to construct the history of water availability challenges in the East Africa region (Wickama et al., 2014; Winowiecki et al., 2015; Ngana and Madoffe, 2011). Both resilience and vulnerability provide a useful conceptual framework for understanding how households and or communities respond and adapt to social and environmental changes (Wilson, 2012). While resilience is more associated with 'positive' changes (ability to absorb disturbances and reorganizing into a fully functioning system), vulnerability is associated with 'negative' changes (describing human exposure and sensitivity to disturbances) (Wilson, 2012).

The vulnerability context refers to the external and sometimes uncontrollable seasonality, trends and shocks that affect people, their assets and livelihood options (Wilson, 2012; Bhattach et al., 2018; Kollmair and Gamper, 2002; Kasie, 2017). In other words, vulnerability context encompasses the insecurity of people and their assets and livelihood opportunities, due to changes in the external environment. Local people and especially the poor households cannot control factors and events that lead to vulnerability, so it is important to minimize their negative impacts by building strong resilience (Tittonell, 2013; Etzold et al., 2014; Huai, 2016) while strengthening security to livelihood and relevant assets. Poor rural households and or communities have limited assets and strong social support to respond to seasonality, events and trends as compared to their rich counterparts (DFID, 2000).

Available literature indicates that the factors that are increasing household vulnerability in the Umba River sub-catchment and Lushoto district in general include demographic trends which are increasing, diseases (malaria and sexually transmitted diseases including HIV/AIDS), changing natural resource trends (due to land use change and land degradation) as well as unpredictable climate and seasonality trends (frequent prolonged and sometimes abnormal heavy rains) (Lushoto District Council, 2016; Songoro, 2014; Winowiecki et al., 2015; Ngana and Madoffe, 2011). The Usambara mountains where

the Umba is found, face complex environmental challenges linked to over-cultivation, soil erosion, and limited land with fertile soil (Wickama et al., 2014; Songoro, 2014; Winowiecki et al., 2015; Ngana and Madoffe, 2011), coupled with low crop productivity and erratic weather patterns (Lyamchai et al., 2011; Msita, 2013; Kimaro et al., 2014). All these challenges increase vulnerabilities of smallholders' farmers living in the district. It is argued that efforts to understand the vulnerability of household livelihood systems in the context of wider transformational shifts (political and power relations, social and biophysical) must be given high priority (Tanner et al., 2015; Quandt, 2016).

In relation to water scarcity and vulnerability, studies from the region indicate that changes in land use and climate are among the factors that increases water resource vulnerability at sub-catchment levels (Jimenez Cisneros et al., 2014; Kelly et al., 2016). Tanner et al. (2015) assert that the impact of climate change and land use change fall disproportionately on the livelihood systems of poor households, undermining their capacity to build livelihood resilience and forcing them into vulnerability. On climate, most of the changes impacting on water resources in the sub-catchments of East Africa are reported to be highly dependent on decreases in rainfall (Adhikari et al., 2015; Ashton and Haasbroek, 2002). Astrom (2014) and Merrey and Cook (2012) insist on considering relevant institutions and policies while assessing the impacts of climate change at sub-catchment levels, as the two can increase or reduce vulnerability context. Yet, while assessing vulnerability context, especially those caused by climate change and or variability, some regional scholars (Pauline et al., 2017; Kangalawe, 2016; Ndaki, 2014; Mwanga, 2013; Yanda and Mubaya, 2011) have tended to overlook related institutions and consider trends, seasonality and shocks (DFID, 2000). However, institutions and policies are very important as they have the power to influence how long it will take for people to achieve a normal situation, after having experienced impacts from those trends, seasonality and shocks. They do so by limiting one group and favoring another to access resources needed for minimizing vulnerability. This might lead to access imbalance and hence contestations, conflicts and increased vulnerability. They can also cause the unfavoured group to react in a way that might lead to more degradation of the resources and physical violence and conflicts (Mussa et al., 2019). Scholars argue that, frequently, communities who are neglected in terms of resource access may disobey rules, start rioting and even some times deliberately degrade the water resources (Sadoff et al., 2015).

Literature has suggested methods for assessing climate trends and land use change and resilience to detect the level of vulnerability (DFID, 2000; Kasie, 2017; Ayeb-Karlsson et al., 2016; Duraisamy et

al., 2018; Masek et al., 2013; Tilumanywa, 2013; Kelly et al., 2016; Quandt et al., 2017). For example, on trends, rainfall and temperature trends use historical meteorological data, while for degradation and land use, trends could include the assessment the natural resource stocks or could use satellite imagery. Historical occurrence of floods, droughts and environmental trends also can be obtained through discussions with the community and interviews with key informants. To understand household and community resilience and vulnerability levels, here I use household surveys, key informant interviews and group discussions.

2.7 The Concept of Waterscape

In recent decades, different scholars (Loftus and Lumsden, 2008; Tagseth, 2010; Jackson and Barber, 2016; Perreault et al., 2012) have used the concept of 'waterscape' to ensure a better understanding of the interactions between society, water, environment and related contestations that emerge as a result of such interactions (Jackson and Barber, 2016). Waterscape refers to water of a particular geographical area and related interconnectedness with other environmental, physical, and biotic elements and human activities (Karpouzoglou and Vij, 2017). Waterscape encompases socio-economic and political processes through which the water resource is conceived and manipulated by society (Irvine et al., 2016). Some scholars consider waterscapes as landscapes which are observed through lenses and from different angles of their water resources, whereby any action taken or inaction shall affect both ecosystems and human livelihood activities (Swyngedouw 1999, Tegseth, 2010).

The waterscape concept helps to explore ways in which flows of power, water and capital congregate to produce socio-ecological arrangements over space and time (Budds and Hinojosa, 2012). Scholars such as Swyngedouw (1999) and Hundley (1987) have challenged the conventional way of conceptualising water as a natural resource which is separate and free from political interference or interests. On this, Karpouzoglou and Vij (2017) and Swyngedouw (1999) argue that the waterscape perspective, with its origin in political ecology, recognises that nature and society are always intertwined to produce hybrid socio-natures. Scholars insist on the importance of diagnosing water in a form of hybrid socio-nature, which at any one point is naturally and socially produced, and embodies and reproduces social power (Loftus and Lumsden, 2008; Swyngedouw et al., 2002). They further establish that a waterscape is neither purely natural nor social, but rather modified by human activities through a historical process. Swyngedouw (1999) considers this as "hybrid socio-nature". It is through combining natural and societal, that the complex products of the whole interaction such as human

actions and social struggle can be understood (Karpouzoglou and Vij, 2017). In recent years, the application of the waterscape concept is motivated by the fact that water resources are increasingly facing complex challenges which are linked to limited access, population growth, changes in land use and climate, as well as increasing demands to meet competing interestsamong stakeholders (Kliskey et al., 2019).

A recent study by Kliskey and collegues on planning for Idaho's waterscapes, demonstrates how biophysical drivers of climate and surface runoff together with human drivers (i.e land use change, hydrologic engineering and policies) have affected water availability and increased tension. As water resources become scarce due to nature and social interactions, uneven power relations emerge and manifest themselves in a form of who has rights to water access, first use, quantity and flow as well as quality (Perreault et al., 2012). These competing social constructions of nature are organised by different groups in order to achieve their interests including imposing ways in which nature and water resources are managed (Boelens et al., 2016).

The concept of waterscape gives wider freedom to the researcher to undertake a broad analysis of existing relationships between water and society within a socio-spatial context (Perreault et al., 2012). The waterscape concept is not antithetical to sub-catchments but instead considers sub catchments-both hydrological entities and administrative units to be central in understanding a given waterscape (Budds and Hinojosa, 2012). As such, a waterscape should be treated as a sociospatial conformation which constitutes the interrelationships between social and geo-ecological processes and mostly extends beyond that given sub-catchment (Cohen and Davidson, 2011). Budds and Hinojosa (2012) and Perreault et al. (2012) assert that a waterscape might involve far away social or natural processes, institutions, artefacts or social relations and institutions not physically close to the sub-catchment or place under investigation. It is by converging multiple dimensions of water-society interactions, that waterscapes can be extensively defined from local sub-catchment/watersheds to river basins or states (Kliskey et al., 2019) to countries (Swyngedouw, 1999). Waterscapes can also emphasise historical trajectories (Kliskey et al., 2019; Jackson and Barber, 2016).

Being insipired by the work of Kliskey et al. (2019) that understands waterscape by analysing changes in land use and climate, population growth, institutionsand policies in Idaho state, I apply the waterscape concept to analyse and present water dynamics and ways they affect water availablity for

livelihoods in the Umba River sub-catchment. I also use the concept to enhance and complement the concept of livelihood resilience especially for understanding institutions, social vulnerability and conflicts.

In this thesis, the waterscapes concept has been used as an aid that is intended to assist in thinking about water issues at household and community levels. Therefore, the concept in this thesis is considered loose to the extent that it allows multi-interpretation; its strength is that it gives an opportunity for this study to tackle water issues based on different perspectives related to water use, challenges and governance in the Umba. To avoid bias and capitalizing on the strength of the concept, in this thesis, I approach the Umba River waterscape neither as pure nature or morphology, nor as a pure social construction (Tegsth, 2010). I seek to analyse and integrate the Umba sub-catchment waterscape through three aspects, namely 'resource/assets', 'situation', and 'institution.'

Like any other concepts and approaches, the concept of waterscape has a criticism, in this case that most of the literature focuses mainly on the hegemonic structures and discourses that drive (and follow from) socio-natural reconfiguration (Swyngedouw and Boelens, 2018:129). In this thesis this criticism is addressed by the concept of hydrosocial territory which innovatively stresses the resulting diversity in terms of overlapping, simultaneously existing hydro territorial regimes and imaginaries (in one and the same geo-political location, and with unequal power) (Swyngedouw and Boelens, 2018: 130).

2.8 The concept of hydrosocial territories

Tanzania has continued to experience increasing water challenges due to scarcity leading to competition and conflicts (among farmers versus pastoralists, government versus local water users, and irrigators versus conservationists) and these have increased complexities in water resource governance. Water resource allocation seems to be dynamic and driven by politics and hence being contested and contestable (Seemann, 2016). The dynamics can be narrated through the way in which power relationships decide and allocate water and (re)configure the territory (Budds and Hinojosa, 2012; Hommes et al., 2016; Lopez et al., 2019). This thesis uses the concept of hydrosocial territories to complement the waterscapes concept by ensuring multidimensional analysis of the relationships between territorial and social transformations (Hommes et al., 2016; Damonte and Boelens, 2019; Karpouzoglou and Vij, 2017). The concept of hydrosocial territories concerns the multiscale nature of hydrosocial relations and their politics (Karpouzoglou and Vij,, 2017; Boelens et al., 2016).

Boelens and colleagues conceptualize a 'hydrosocial territory' as:

> "the contested imaginary and socio-environmental materialization of a spatially bound multi-scalar network in which humans, water flows, ecological relations, hydraulic infrastructure, financial means, legal-administrative arrangements and cultural institutions and practices are interactively defined, aligned and mobilized through epistemological belief systems, political hierarchies and naturalizing discourses" (Boelens et al., 2016: 2)

The use of the hydrosocial territory at the level of water users allows for a better understanding of who, how, and with what interests some go against and demand for changes in the sub-catchment (Lopez et al., 2019). Water resources have continued to be a political resource which is disputed through power and authority relationships (Vos and Boelens, 2014; Lopez et al., 2019). In this regard, water flows are organised and directed in such as way that political power relations influence access and exclusion of some actors (Lopez et al., 2019). As a result, they immediately produce the physical –geographical, social-cultural and emblematic landscape (Budds and Hinojosa, 2012; Hommes et al., 2016; Hoogesteger et al., 2016). It can be argued that both construction of water infrastructure and water allocation processes lead to access to, and exclusion from, water flows, establishing control by one group over another and reinforcing or challenging established power structures (Meehan, 2013; Hommes and Boelens, 2017). Hoogesteger et al. (2016) argue that water allocation and irrigation projects are grounds for resistance and social struggle among actors.

According to Boelens et al. (2016), reasons and strategies for making a territory greatly differ amongst actors, as do the produced territories. In this regard, efforts by local communities that strive to configure and protect their water-based territories such as sub-catchments, watersheds and water for domestic use systems are always dynamic and complex (Boelens et al., 2016; Hoogesteger et al., 2016). The challenges and threats are likely to come from both powerful water users (which could be government institutions, big farmers etc) or from internal or small water users such as households and or smallholder irrigators. However, at a point of defending their hydrosocial territory, local water users need to put aside their internal differences/conflicts to mobilise themselves and collectively defend to control their main territories (Boelens et al., 2016). This may also involve grassroots forming alliances with other external powerful actors or groups against other powerful actors on territorial claims and water rights. As reported by Hoogesteger and Verzijl (2015) local/grassroots territorialization is a struggled process that shapes and re-creates togetherness through cooperation towards a common

resource control objective. To analyse and understand these, the concept of hydrosocial territory therefore, helps in creating better understanding of how relations (re)created through interactions amongst human practices, water flows, hydraulic technologies, biophysical elements, socio-economic structures and cultural-political institutions becomes suitable and relevant (Boelens et al., 2016; Lopenz et al., 2019). Boelens and colleagues assert that hydrosocial territory (imagined, planned and materialized) helps in creating better understanding of how the relations between society, nature, territory and governance play out specifically in the water domain (Boelens et al., 2016: 1)

The concept of hydrosocial territory is suitable and powerful for multidimensional analysis of the relationship between territorial and social transformations (Damonte and Boelens, 2019: 210). It gives attention to actor-oriented approaches and interface concepts. This is far beyond, the concept of waterscapes which focuses particularly on the hegemonic structures and discourses that drive socio-natural reconfiguration' (Swyngedouw and Boelens, 2018: 129). Furthermore, the hydrosocial territories concept clearly deals with modernist territorial recognition politics:

> "the tactics of "recognizing" and "incorporating" local territorialities (integrating local norms, practices, and discourses into mainstream government rationality and its spatial/political organization) make state/formal and local/vernacular modes of territorial ordering depend on each other in complicated (and often confrontational) ways" (Swyngedouw & Boelens, 2018:130).

In this thesis, the concept of hydrosocial territories is used to describe and analyze the challenges and contestations of water in the Umba sub-catchment and two off-sub catchment villages. The concept intends to help in analysing water users, their territories and power and institutional relationships in the whole process of water availability, allocation and access. The study will take a critical look at the diverse geographical location and how this influences hydrosocial relations, equity and sustainability in the exploitation of water sources for household livelihoods (Seemann, 2016). Here the understanding is that households and communities in the study villages have distinct actors, influences and interests which may lead to competition and contestations on water resource access (Hoogendam, 2016; Boelens et al., 2016). On this, Boelens et al. (2016) argue that territorial struggles go beyond fights over natural resources to include struggles over meaning, norms, knowledge, identity, authority and discourses.

2.9 Conceptual Framework

The preceding sections and discussion in this chapter intended to build a base from which a relevant conceptual framework for this study could be built. The main argument is that water resources in rural East Africa are dynamic and face multiple challenges, from those related to human-nature (social-ecological systems) interactions to those related to changes in the biosphere. However, water plays an imperative role in enhancing households and community livelihood resilience. To have a better understanding of this 'hybrid' research work which involves social, natural resource and environmental changes, needs a capable and integrative conceptual framework. The framework should ensure a better understanding of livelihoods and water dynamics, contestations, weather extremes and trend uncertainties that affect household livelihood assets (especially water), water allocation processes, shape power relations, institutions, trajectories and vulnerability in the Umba. In this regard, three conceptual frameworks currently appraised by researchers are the concept of livelihood resilience, waterscapes and hydrosocial territories which are combined and used in this study. The combination of the three concepts in this conceptual framework makes it stronger and suitable for the analysis of complex and multi-scalar interplays between society and the environment and the way these interactions produce particular livelihood trajectories and outcomes (Seemann, 2016; Quandt, 2016; Swyngedouw & Boelens, 2018; Kliskey et al., 2019; Folke, 2016; King et al., 2019; Ayeb-Karlsson et al., 2016; Kelly et al., 2016; Quandt et al., 2017). Instead of treating this study through a single and prescriptive approach, this framework supports pluralist perspectives and encourages debate on socio-hydrology and its interrelations with livelihood resilience (Mao et al., 2017:3656).

The concept of livelihood resilience allows a thorough examination and understanding of inseparable interactions of human and natural systems and transformation aspects towards sustainability (Folke et al., 2016). The concept helps this research to understand how households and communities at large access and use different livelihood assets and strategies that are important for reducing impacts of stress, shocks and vulnerability (King et al., 2019; Quandt et al., 2017) to increase sustainability. The questions of resilience of what and resilience for whom can be answered by focusing on the resilience of people's livelihood strategies (Quandt, 2018).

The concepts of waterscapes and hydrosocial territory complement each other to allow this study to investigate ways through which social interactions (i.e. power relations, political struggles, institutions, discursive strategies) contribute to shape the ecological milieu (Guillaume, 2009; Boelens et al., 2016;

King et al., 2019). The concept of waterscapes helps to analyse natural and societal interaction and the complex products of the whole interaction beyond the study villages (Karpouzoglou and Vij, 2017) and quantifying historical trajectories or pathways. On the other hand, the concept of hydrosocial territory is a powerful tool for complex and multidimensional analysis of the relationship between territorial and social transformations. The reasons for combining the three concepts are that; the resilience concept is able to allow for complexities of human-nature interactions and how they lead to sustainability and or vulnerability. The concept is also able to trace the livelihood either at household or community level. On the other hand, waterscape takes into consideration the question of power and power relations and how they shape access or exclusion from water resources. The concept of hydrosocial territory goes into details by understanding how both formal and informal power relations interplay for social transformation. The main intention is to make sure that the gaps in one conceptual and or methodological approach is filled by the other conceptual approach. This kind of study is complex and hence needs a framework that links social and environmental concepts and approaches together. I argue that one concept alone cannot explore and comprehend all the research questions and concepts in studies that try to understand human-nature interactions and related outcomes, livelihood assets, power and power relations, institutions and livelihood trajectories.

While waterscape and hydrosocial territory have the same origin in Political Ecology and in this study are supplementing each other, the concept of livelihood resilience originates from a different field of physics/engineering and ecology. However, the three concepts have similarities and commonalities as all address the complexity of society-environmental interactions and related outcomes. Also, all concepts put human beings at the centre of the analysis. These make this combination suitable for exploring and fruitful analysis of water challenges, contestations and governance in the Umba. Still, some conceptual differences exist. For instance, while livelihood resilience puts less attention to power relations and institutional issues, the waterscapes and hydrosocial territory concepts give high priority to institutions and how they can lead to social struggle and resource conflicts. As such this combination gives a more comprehensive approach to investigate the multidimensional complexity of water, livelihoods and social-environmental changes in the Umba.

2.10 Chapter summary

The chapter has explored and discussed concepts that are relevant to livelihood resilience, vulnerability, institutions, waterscapes and hydrosocial territory. Before developing a conceptual

framework to guide this study, I spent time assessing the relevant existing conceptual approaches. Results have shown that each conceptual framework has its strengths and weaknesses. Still, no single conceptual framework is suitable or strong enough to guide this complex and multi-faceted piece of work. I argue that dealing with socio-environmental (society-nature) interactions and changes and related water politics, contestations and institutions needs a comprehensive conceptual framework capable to pull them all together. Therefore, I have brought together/combined the concepts of livelihood resilience, waterscapes and hydrosocial territory. This conceptual framework guided this study in understanding livelihood issues, resource degradation, resource allocation and access, power relations, contestation conflicts and mediation strategies, institutions as well as livelihood trajectories and household resilience or vulnerabilities.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Chapter introduction

I started knowing and interacting with communities in the Umba River sub-catchment back in 2013. By then I had just finished my Master's thesis, and I was assisting the late Professor James Ngana (University of Dar es Salaam) on assessing key issues affecting the socio-ecological setting of the Umba River sub-catchment in order to recommend intervention measures that can ensure sustainable water resources use within the sub-catchment.

During this work, both literature and field observation showed to me that the Umba River sub-catchment was facing environmental and water resources management related challenges and that more comprehensive study was needed. However, this study was impossible, as I had no financial resources. In 2014, my organization-Climate Action Network Tanzania (CAN TZ), got funding to strengthen Local Governments and Civil Society Organizations (CSOs) in selected districts of Tanzania. One of the selection criteria of the districts and CSOs was that they should be located in areas where there are environmental, climate change and/or natural resource issues/ challenges that threaten community prospects. Having some background on the situation in Lushoto District (home of the Umba River) I suggested and presented shreds of evidence for being included in the project and was accepted by Bread for the World who was funding the project.

Being responsible of the project and with prior information to the water and environmental challenges in the Umba River sub-catchment, my first activity brought together CSOs and local government authorities to debate on the environmental and water challenges in the Umba River. Yes, during our discussions different issues were raised including water allocation challenges that are connected to conflicting political interests, power dynamics and human-related environmental degradation. It was further mentioned that climate change and poor farming were contributing to water resources challenges in the sub-catchment. During those discussions, I found out that there were different views among participants depending on where they are located in the sub-catchment. Those from upstream saw water challenges related to the introduction of eucalyptus trees, poor farming among farmers due to land shortage and low investments from the government. However, downstream representatives were concerned on how the upstream were misusing and denying the downstream rights to access

water resources, especially during the dry periods. They also mentioned how water-related conflicts were increasing among farmers and other stakeholders.

To me the whole process and presentations showed a need for a detailed study that could explore the linkage between water resource availability and households' livelihoods. Certainly, the PhD was the best option for me. After one and half years of resource mobilisation, I was able to secure funding and the journey started. Gathering information from 8 villages for this study was extensive work and I would like to thank again my officemates Kelvin Shirima and Msololo Onditi for assisting me in interviewing 331 households.

Therefore, this chapter gives details of the study area that covers population, climate and/or physical features. The subsection also covers natural resource endowments, including the Umba River sub-catchment, Shagayu forest and their pivotal role in supporting households' livelihoods. The chapter further establishes factors that underpin the selection of the study area. The explanation of the study area is followed by the research design that provides a specific direction for procedures in a study. Sampling strategy also has been introduced and discussed. Methods for data collection that include mixed methods are discussed in detail in this chapter. Different methods for data analysis for both qualitative and quantitative data are discussed followed by the chapter summary.

3.2 Location of the Study Area

Lushoto District Council (the home of the Umba River sub-catchment) is within 4° 25' – 4° 55' latitude south of the Equator and 30 ° 10' – 38 ° 35' Longitude East of Greenwich (URT, 2013). Administratively, Lushoto has 5 divisions (Lushoto, Mlola, Mtae, Mlalo, and Umba) and 33 wards with a total number of 125 villages and 1,040 hamlets (Lushoto District Council, 2016). This study was done in villages found in the six wards of Rangwi, Hemtoye, Mwangoi, Dule M, Mng'aro and Lunguza (Figure 2). The council headquarters is allocated at Lushoto town.

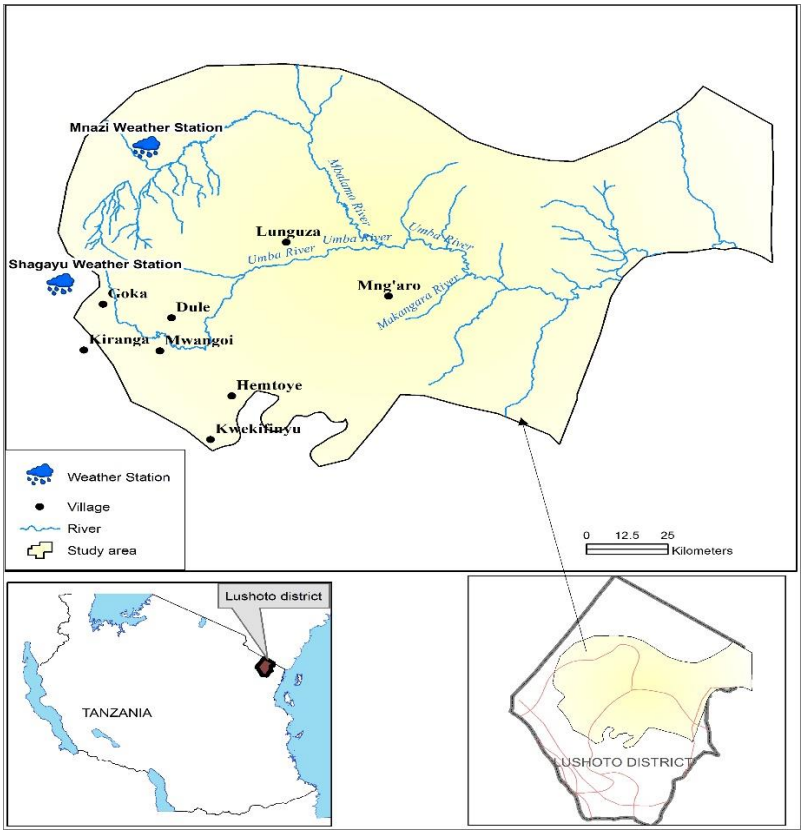

Figure 2: Study villages and location of the weather stations

Source: Developed by a researcher at GIS Lab, University of Dar es Salaam, 2017

3.2.1 Population

According to the URT (2013), the district population has been increasing in size since 2002 from 279,096 to 332,436 in 2012 of which about 96% lived in rural areas, with an average household size of 4.7. The population density is 144.54 per square kilometer, the second most densely populated district in Tanga Region after Tanga city (Lushoto District Council, 2016). The population profile is young, with 48% aged under 14 (URT, 2013). The population density is attributed to the topography (that includes mountains, hills, gentle and steep slopes, springs), natural increase, and limited fertile agricultural land for cash and food crops production. The largest (81.3%) ethnic group is the Wasambaa and the second is the Wapare (14%) while the 6 % is divided among the Wambugu, Masai who are the pastoral-groups and minority groups (Lushoto District Council, 2016). The pastoral-group in the study areas are social-economic group of people whose ways of life depend on raising and keeping animals especially cattle and goats (Schiling et al., 2012). They are nomadic and some come from Kenya and the central part of Tanzania. While the Wasambaa are considered to have been in the

Lushoto mountains for centuries, the Pare seems to have shifted to the area due to prolonged droughts in the East Africa region between 1885-1900 (Conte, 2004; Huijzendveld, 2008). At the moment, the two tribes are intermarried and are living together. Farming activities by small holder farmers are the main stay of the majority of households, and they grow vegetables, Irish potatoes, beans, sweet potatoes fruits and cassava (Huijzendveld, 2008). Paddy farms are found in *vitivo* (sing. *kitivo*) which are found downstream of the sub-catchment (Mascarenhas, 2000). *Vitivo are* relatively flat fertile areas, with productive soil deposited from floods upstream (Conte, 2004; Huijzendveld, 2008).

3.2.2 Climate / Physical features

Lushoto district including the Umba sub-catchment has a bimodal rainfall pattern, whereby short rains are from October to December and long rains from March to June (Lushoto District Council, 2016; Mahoo et al., 2015). According to Lushoto District Council (2016), the highlands get an average of 800 – 2000mm rainfall per annum and get about 500-800 mm per year from October to December and long rains from March to June. The average annual rainfall is 1,092.2 (Mahoo et al., 2015) and the long rains were expected to be reliable. However, the emerging global climate change has changed the rain pattern considerably (URT, 2012; Mngumi, 2016). Nowadays rains come either too early or too late with undetermined intensities (Mahoo et al., 2015; Mngumi, 2016). Within the long rains period, April of each year is considered to experience the heaviest rain events. On the other hand, the short rains are normally not reliable although are they important for supporting crops like maize and beans.

According to Lushoto District Council, (2016), the mountainous areas of Lushoto are less humid and are cooler. The high temperatures are experienced in the periods of October to February and lowest temperatures occur in the period of June to August (Lushoto District Council, 2016). The average annual temperature is 17.3^{o} centigrade. In general, the Agro-ecological zones described in Table 2 have different temperature and rainfall patterns.

Table 2: Agro-ecological zones in Lushoto District

Zone	Altitude (Masl)	Rainfall (mm)	Temperature (^{0}C)	Areas	*Crops*
Dry hot	300-600	400-600	30	Umba	Rice, cocoyam, cotton, Sisal, watermelon, Cassava
Humid cold	800-1500	600-1200	22	Lushoto	Coffee, Vegetables, Bananas, Potatoes, Fruits
Dry warm	800-1800	500-800	20	Mlola,	Maize, Beans, Cassava, Vegetables
Dry cold	1700-2100	500-800	16	Mtae, Upper Mlalo	Vegetables, Fruits, Irish potatoes

Source: Lushoto District Council, 2016

3.3 Umba River sub-catchment and Shagayu Forest Reserve

The Umba River sub-catchment covers an area of 8,070 km^2 and is shared between Tanzania and Kenya (IUCN, 2003). The River originates from the Usambara Mountains in Lushoto district, Tanga region in Tanzania and flows to the Indian Ocean (Lerise, 2005). Shagayu forest reserve (388 18' E, 48 30' S) acts as a source area of the Umba River sub-catchment (Figure 3). The forest has an area of 7,830 ha and is considered to be an old natural forest, which was gazetted as a reserve in 1908. It provides ecosystem services to about 13 villages. Although it was managed by the central government, since 2002 the forest is under Joint Forest Management (JFM) between surrounding villages and Lushoto District Council. Mainly the forest management objective under JFM in Shagayu forest is to focus and ensure the sustainability of biodiversity, and provision of water resources for villages (Mbwambo et al., 2012). Apart from biodiversity value, Shagayu forest is the chief source of 4 main tributaries namely the Umba, Muinga, Baghai, and Mbaramo Rivers all draining towards the eastern part of the forest and the Mbalamo tributary draining the western and later towards the eastern part to join the Umba main system (see Figure 3). These tributaries provide water to about 200 villages (Lushoto District Council, 2016; URT, 2014). Nevertheless, most of the present and proposed small irrigation schemes in the Tanga Region are situated along the Umba River and its tributaries. Because of high-water demand for different economic activities, including irrigation and impacts of climate variability or change on the catchment, conflicts already exist between water users (Ngana and Madoffe, 2011).

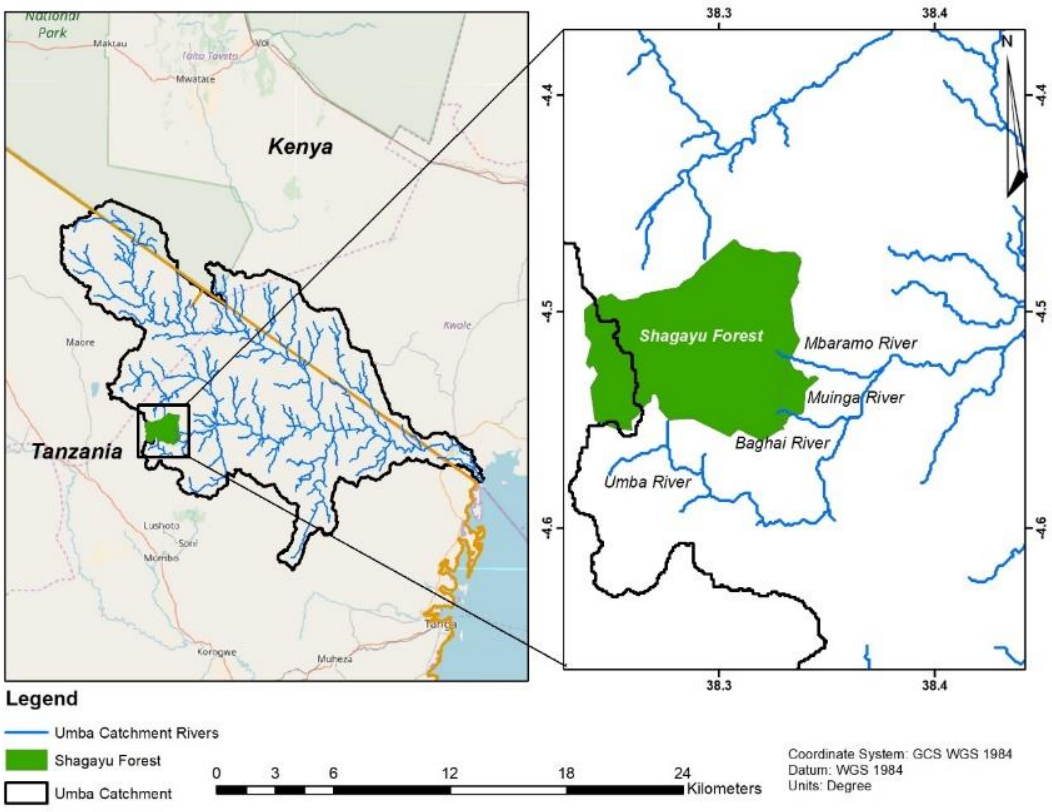

Figure 3: Umba River tributaries around Shagayu forest reserve
Source: Developed by a researcher at GIS Lab, University of Dar es Salaam, 2017

This district and in particular the Umba River sub-catchment were identified as suitable for conducting this research as other studies such as Mbonile (2005) and IUCN (2009) argue that the majority of households found in and near the sub-catchment rely heavily on small scale irrigation to enhance their subsistence farming. As in other small scale irrigation farming in Tanzania, many households in the study area are using destructive farming and irrigation methods for cultivating around water sources (URT, 2014). Likewise, in many cases, water for irrigation is obtained through local surface/gravity irrigation and some apply unsustainable types of pumping irrigation methods without appropriate irrigation mechanisms (Huijzendveld, 2008; IUCN, 2009).

3.4 Selection of the study area

The available literature (Songoro, 2014; Ngana and Madoffe, 2011; German et al., 2012; Mascarenhas, 2000) has shown that for over the past 120 years the West-Usambara and Lushoto, in particular, have been experiencing environmental and agricultural changes. The changes have been connected to population increase, with increased pressure on land and forests resources (Huijzendveld, 2008). As a

result, for decades now, most of the villages have experienced soil erosion, reduction of soil fertility, deforestation, encroachment of water sources and hence repeated water scarcity (Mbonile, 2005; Songoro, 2014; Mngumi, 2016). Water and land scarcity have great impacts on the household's livelihood activities in the study area of which most are farming activities. However, the intensity of these impacts differs depending on where the village and household are located within the Umba River course. Likewise, the water available for households' livelihood activities tends to vary depending on the number of dependants, location, and nature of activities practised as well as conservation initiatives (King, 2011). Despite the fact that the government and development partners have been introducing different initiatives to address both soil erosion and water challenges, recent studies (such as Ngana and Madofe, 2011; Tenge et al., 2011) have clearly indicated that the issue of water scarcity still persists, affecting many household's livelihood activities. Some of these initiatives include; the Mlalo Basin Rehabilitation Scheme of the 1930s, the Soil Erosion Control and Agroforestry Project (SECAP) (1981–1999) (Mascarenhas, 2000) and afforestation programs to reduce deforestaions and forest demands that have been implementend since the 1950s (German et al., 2012).

To get an understanding of water challenges at households' levels in the Umba River sub-catchment, eight villages were identified and studied (Figure 4). The villages under study represent upstream, middle stream and downstream. Another two villages were selected from off-stream. The rationale for selecting the villages was based on the facts that I had some prior information which I got through having worked with the local government authorities in Lushoto and respective communities for about two years. I also had a preliminary field work to equip myself well with the current situations before the final selection of the study villages. During preliminary fieldwork, I had the opportunity to meet village and Umba River Water Association leaders who gave me the details on villages to consider. In the selection process the following factors were considered:

i. Location of the village in the sub-catchment and river course; this was an important criterion that was motivated by the understanding that under an ideal situation, the village located upstream has different experiences and perceptions on water challenges (in terms of quality, quantity and related conflicts) which might not be similar to middle stream or downstream villages.

ii. Villages which depend on traditional irrigation methods; with reference to the objective of this study the village in which households' livelihood activities depended on traditional irrigation was included. A village that was practising farming but with no water for irrigation was also included for representation and comparison purposes.

iii. Villages which were mentioned during preliminary field work to experience water resource-related conflicts were considered with the aim to get a clear understanding of how they have managed to solve or live with them.

To achieve the main aim of this study, and have efficient and representative samples, the studied villages were selected to epitomise upstream (Goka and Kiranga villages), middle stream (Mwangoi and Dule M villages) and downstream/Umba plains (Mng'aro and Lunguza villages). Furthermore, two off-stream villages (Hemtoye and Kwekifinyu), which are far away by 10 -28 kilometres from the main Umba River at the outer edge of the sub-catchment and depend on rain-fed agriculture, were selected and visited to facilitate comparison with villages using water for irrigation. Another reason for selecting the villages far away from the river was to have a comprehensive district representative study.

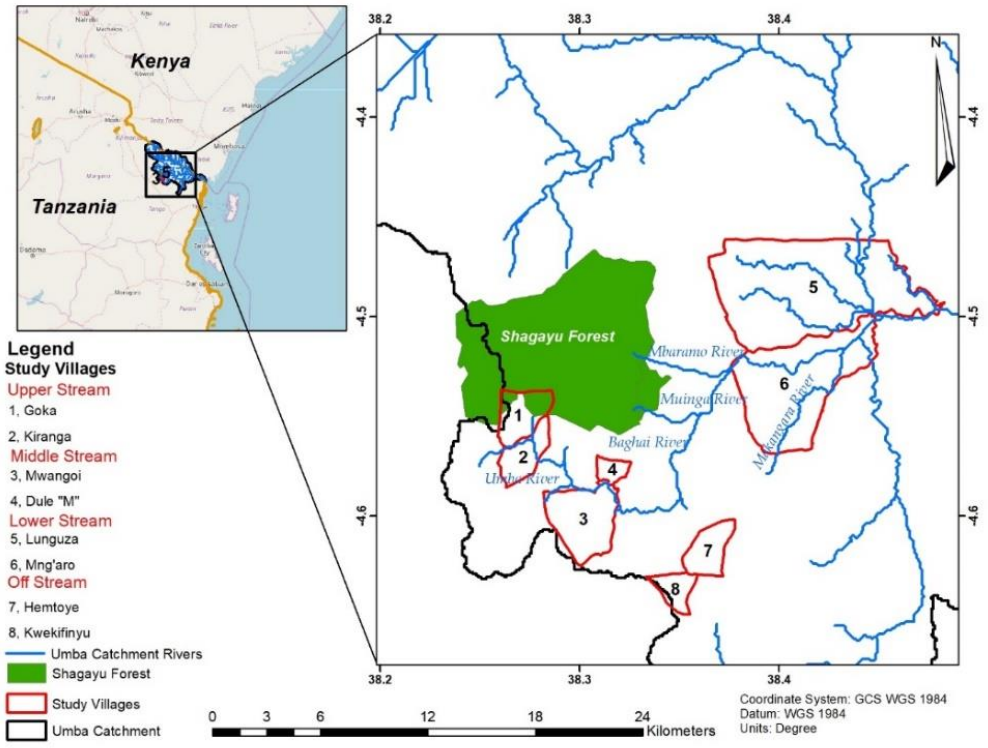

Figure 4: Study villages and forest reserve in West Usambara
Source: Developed by a researcher at GIS Lab, University of Dar es Salaam, 2017

3.5 Research design

Since this study aims to expand an understanding about the complexity of changes that affect water availability and contestations on water resources allocation and how these shape livelihoods, adoption of a mixed methods design is appropriate for this study. A mixed research design, gives a wider spectrum through which both quantitative and qualitative approaches are able to yield important details useful for understanding complex issues, which touch human- environment interactions (Terrell, 2011; Creswell, 2014). A mixed-methods approach was chosen for collecting, analysing, interpreting, and validating results. The application of a mixed methods design for this study intended to allow triangulation of data from both qualitative and quantitative methods to address research questions by gaining a broader perspective and understanding. In triangulation, I was able to use two or more research methods to reduce the weaknesses of an individual method and strengthen the outcome of the study (Fusch et al., 2018; Abdalla et al., 2018; Weber, 2019). The design also intended to ensure that statistical data on climate, land use and livelihoods are gathered, analysed and results are represented in a numerical data while giving an opportunity for community voices to be heard, analysed and interpreted. Triangulation of mixed methods helped me in this study to combine strength of each method to improve arguments and results (McKim, 2017). Borrowing insights from Carter et al. (2014) and Fusch et al. (2018) I was able to compare qualitative data gathered through focus group discussions, key informants and secondary data on livelihood activities and water scarcity in the Umba. I compared quantitative data (gathered through remote sensing and GIS) and those from key informant interviews to assess the challenge of land cover change and how this has affected water resources availability in the Umba. In the same way, information from climate data analysis was triangulated with information from focus group discussions, household surveys and key informant interviews to reduce bias from any single method. According to Carter et al., (2014) and Fusch et al. (2018) data triangulation strengthens the reliability and validity of collected data and broadens understanding of the topic under study.

3.6 Sampling Strategy

Sampling refers to the process whereby a portion of the populace, in the study area, is selected for representation purposes (Kumar, 2011). It is the sample that represents the population under study (Kumar, 2011). This study has used both probability and non-probability sampling techniques. In probability sampling, this study intended to give an equal opportunity to water stakeholders in the sub-catchment of being included in the sample. It is important to give everyone an equal chance of

being selected as it eliminates the danger of a researcher biasing the selection process because of their own opinions or desires (Latham, 2007; Frey et al., 2000; Singleton and Strans, 2005). Non-probability sampling procedures involve the selection of elements based on assumptions regarding the population of interest. The advantage of non-probability sampling is that it provides a convenient way for a researcher to assemble a sample with little or no cost and/or for those research studies that do not require representativeness of the population (Babbie 1990; Latham, 2007). In this study, non-probability sampling, - purposive sampling was used to determine a sample for in-depth key informant interviews and focus group discussions (FGDs). Thus, the use of both probability and non-probability sampling in this study was intended to allow each strategy to complement the weakness of the other.

The study population consists of selected: heads or representatives of households, water resource officers, district natural resource officers, land and agricultural officers, extension workers, village leaders, community development officers and selectedwater users association memberswithin the area of study (Umba River sub-catchment and off) who are above 18 years old.

The sample size chosen (Table 3) from village households was obtained with the assistance from respective village governments. To determine the sufficiency of sample size, Bartlett et al. (2001) suggest that for a mixed methods approach, even a 5% sample from each study locality could be sufficient. Therefore, the household's sample size for the study was obtained through the following procedures.

First, village leaders were requested to provide government village resident registers so that the study population could be established. In this regard, the village resident register served as a sampling frame.

Second, I used the village resident registers to establish the study sample for the household survey. At first, the heads of households (as identified by village authorities and included women or men in the household) were targeted to provide household information and in some cases where heads were not available, anyone aged above 18 years represented a household. In this thesis, the definition of the head of household has been adopted from Buldlender (1997) to refer to someone who is adult, female or male, in the household who provides economic support for the household unit, is important in the decision-making process and is considered by other members as the head.

I tried to organize such that individuals in the sampling units are categorized into youngsters (18 – 30 years), adults (31– 50 years) and elders (51 years and above). This aimed at ensuring all categories of the study population are represented in the study sample (Borg and Gall, 1983). Nevertheless, in consultation with village leaders and/or district leaders/officers, key interviewees and individuals for participating in Key Informant Interviews and FGDs were chosen based on their experiences, gender and expertise.

At a village level, a sample size of 331 households (equivalent to 7.3%) out of 4,531 households was selected from these villages for more investigation (Table 3). Such respondents were selected from six villages, which are found in the Umba River sub-catchment and two villages, which are in the outer part of the sub-catchment and depend solely on rainwater. For sampling purposes participants for household surveys were randomly selected to ensure each houshold has an equal chance of being included in the study. For the purpose of focus group discussions and Participatory Community Analysis (PCA), the selection process was that; village leaders used age, wealth category, gender, education level and location in relation to water source to select participants. Key informants were selected purposely for in-depth discussion based on their experiences and expertise. On gender, I was well informed in advance that men and women plays different duties in water use and management, therefore, the reasercher made efforts to ensure women are represented in all data collection processes. Studies have continuously raised concerns on the imbalance in representation of women in research studies as compared to men (Bendels et al., 2018). In this study 37% (122) of all participants were women while men were 63% (209). The low number of women in this study was influenced by the fact that, most households in the study area are headed by men.

Table 3: Villages Selected and number of Respondents

Village	Location in the river course	No of Households	No of Respondents	% of respondents
Mwangoi	Middle stream	550	40	12
Dule M	Middle stream	452	33	10
Goka	Upstream	433	32	10
Kiranga	Upstream	207	15	5
Hemtoye	Off stream	777	57	17
	Kwekifinyu	495	36	11
Mng'aro	Downstream	602	44	13
Lunguza	Downstream	1015	74	22
	Total	**4,531**	**331**	**100**

Source: Fieldwork, 2016

3.7 Methods of data collection

Mixed methods (quantitative and qualitative) were used to collect information and validate different sources of information collected (Table 4). The data were obtained from both primary and secondary sources. As Dresse et al. (2016) observe, for research related to environmental concerns a multidisciplinary approach is needed to link an individual's values and attitudes to environmental concerns. This observation convinced me to apply mixed methods. In all methods used to gather data, more weights were given to livelihood strategies that mainly depend on natural resources such as water, land and forests since in the Umba River sub-catchment, a majority of people are still relying mostly on agriculture and natural resources for their livelihoods.

Primary data collection was carried out through the use of a questionnaire, Focus Group Discussion (FGDs), Key Informant Interviews (KIIs), Participatory Community Analysis (PCA), transect walk and field observation and household surveys (Table 4). Secondary data came from research relevant institutions, both at national, international levels, and relevant journal papers and books. Furthermore, interpretation of satellite imagery (Geographical Information System (GIS) and remote sensing were applied, please see details in section 3.6.6). Last was the stakeholders' validation workshop, an interactive workshop where stakeholders had the opportunity to validate information and add inputs to chapters 5, 6 and 7 before they become public.

Table 4: Data collection strategy

Methods	**Data/information collected**	**Source of data**
Participatory community analysis	Local conditions, natural resources use and degradation, livelihoods, and social formations, historical process	Mixed participants from different groups
Household survey	Household socioeconomic features; livelihood activities and water constraints; perceptions and reactions	Heads of households or anyone above 18 years old
Key informant interviews	Local knowledge, view and opinions on water allocation decisions, other livelihood activities and threats; degradation of water sources; power relations, gender and ethnicity issues, historical processes of resource use and allocation and involvements	Officials from water, land, natural resources district departments; village officials; ward councillors, NGOs and local community members
Focus group discussions	Different perspectives on livelihood assets and reasons for water allocation; structure and power relations, water allocation processes and challenges; wealth ranking; risks and reaction	Discussions with local people in each study village
Participatory validation workshop	Adding inputs to the report, scenario planning exercise for future of water allocation and livelihoods	Selected from diverse backgrounds (active district and community members)

Source: Field survey, 2016

3.7.1 Participatory Community Analysis (PCA)

PCA techniques helped to create an open dialogue and mutual sharing of information among research participants at each village level (Machumu and Yakupitiyage, 2013). Village leaders helped to identify and select PCA participants based on their location in relation to village natural resources especially water, age whereby the more elderly were over 55 and women representatives. In each study village participants were asked to be in group of 4-7 people and together discussed and gave information about water resources, rainfall and land conditions, historical changes and reasons for changes. This method empowered participants in groups to discuss, agree and rank answers in a harmonised way. PCA also gave an opportunity to women in groups to speak, as they were encouraged to do so. PCA gave opportunities for each community to identify and rank significant challenges and opportunities to their livelihoods (Lunt et al., 2018). In this thesis, PCA was convenient in the process of identifying and ranking livelihood strategies and how they have been evolving with time in villages under study. This was possible because participants were few and knowledgeable compared to the number in FDGs. The method was able to provide additional information to focus group discussions, household surveys and key informant interviews. PCA has the limitation that some groups, especially women, were not talking much in front of elderly men, a situation which needed the researcher to keep on motivating them to speak. It also takes time to build trust and empower participants to share their perceptions in a group.



Figure 5: Data collection at Kiranga village
Source: Field survey, 2016

3.7.2 Household Surveys

These are among the major tools in this study and were carried out using questionnaires, and collected information on water allocation challenges, livelihoods and the rest of the relevant data needed (see Appendix 2A). In addition, HHS provided spaces to collect information tied to livelihood assets/capital. In relation to natural capital, data gathered included forests, land and soil as well as water resources. On human capital, attention was given to the availability of skilled labour by considering the level of education attained at the household level, entrepreneurial skills and ability to connect livelihood activities and markets. Regarding financial capital, the attention was on sources of income, petty business, village community banks, financial institutions and access for finance. On social capital, data gathered included human connections, exchange and sharing of information as well as informal and religious institutions. Regarding physical capital, the emphasis was on the availability of improved infrastructure such as roads that could facilitate transport, availability of markets, schools and irrigation schemes. Moreover, questions related to water resource access and allocation in relation to livelihood activities were covered during the household survey. However, Parker and Kozel (2007) recommend that household surveys alone are not sufficient to provide all required information for livelihoods and vulnerability. Therefore, the household survey was used to complement other data collection tools such as FGDs, PCA and key informant interviews.

3.7.3 Key Informant Interviews

This tool was used to collect in-depth information from people with understanding of the study area including aspects of livelihood activities, environment and politics (Morse, 1998; Perecman and Curran, 2006). The key informant interviews served the purpose by gathering data from stakeholders such as community and district leaders (water managers, agricultural extension workers, livestock officers, land experts, natural resource officers and community development officers). Key information was provided on changes in livelihood activities, conditions of natural resources especially water, land and forests and challenges facing communities in different parts of the river course. They were also asked to provide more details on climate change and how this has shaped and or affected village livelihood activities. This was regarded as a tool that could provide well-informed and in-depth information after household surveys.

In order to interview key informants, I obtained permission from the heads of relevant departments and organizations. At the district level, one or two experts, mostly the seniors and experienced, who

have worked and stayed in the district for at least five and above years, representing each department were interviewed. However, at the ward, village leadership, religious institutions, and Water Users Association levels; the number of people to be interviewed depended on skills and time available for them. In that regard, some institutions two or more people were interviewed (Table 5). These people with sound expertise, knowledge and understanding, provided a clear insight into the nature of water challenges within the sub-catchment and gave recommendations for solutions.

Table 5: Key Informant Interviews Conducted with different Respondents

Level of interview	**Position of the respondent**	**Number of representatives**
District	Water engineer	1
	Livestock officer	2
	Natural resource officer	1
	Senior agriculture officers	2
	Planning officer	1
	Environmental officer	2
	Community development officer	1
Within Umba	Upstream local water officer	1
	Downstream local water officer	1
	Middle stream local water officer	1
Ward	Ward officers (from upstream, off stream, downstream)	4
	Ward extension workers (from Mwangoi and Lunguza wards)	2
Village	Village chairpersons from all village offices under this study	8
Households	Heads of households	47
Total		**74**

Source: Researcher's own, 2016

Additionally, key informant interviews were also conducted with 47 heads of households who were identified during the household surveys (Appendix 1A and 2B). During household surveys, village leaders assisted to pinpoint household heads whom we found to have deep understanding and experiences on water and life issues in their villages. After household surveys, potential key informants were asked if they were interested and happy to spare time to give some details on the water situation in their locality. After agreeing, the appointment was set and mostly was on the next day or during the weekend, depending on interviewee conveniences. In most cases, during key informant interviews which mostly took place at the home of the households, other family members could come and listen to the discussion. Sometimes they could give their comments on what was mentioned by the respondent and even open for discussion among them before they could agree.

3.7.4 Focus Group Discussions

A focus group discussion (FGD) is intended to ensure active participation and discussion with small numbers of participants of 7 to 12 per group (Morgan, 1996). In this study, FGDs were employed to gather quick, relevant data and enrich the knowledge shared by individuals. FGD was a useful tool in collecting participants' perspectives on livelihood assets and reasons for water allocation, structure and power relations, water allocation processes and challenges, wealth status, risks and reaction within the study villages (Figure 6).



Figure 6: Key informants meeting at Hemtoye village
Source: Field Survey, 2016

The method was facilitated using a guide with questions and issues related to the research topic; ranking of water-related problems and the main causes were discussed. The process to identify and select participants was done with strong help from local and village leaders. Village leaders were informed first by the researcher on what the focus group discussion was intending to achieve during this study. Then the village leaders proposed names of participants whom they knew are knowledgeable and are able to stimulate the discussion. After proposing the names, the contacts were given to the researcher to plan and meet them and give them details followed by invitations. The interviewer was able to ask probing questions for the added details (e.g., 'Who?', 'Where?', 'When?', 'Why' and 'How?') based on respondents' answers and conversation flow. The method provided speedy results and information on how people from the study areas think, perceive and react on water resource challenges. It also gave an opportunity to participants to reflect and think about what could be practical solutions for addressing water challenges in their localities. Within the discussion, it was

possible for the participants to share their water challenges and experiences even beyond 30 years ago. The discussion stimulated collective thinking about the topic not only to give answers to the researcher but for their livelihood activities. Elderly people were able to even tell stories to the group on how water has been changing with time in terms of quantity and quality. This was very important as it gave an opportunity to the researcher to experience and really feel the situation as presented by the participants. A total of seven discussion meetings were held in the villages as follows; 2 meetings upstream, 2 meetings middle stream, 2 meetings downstream and 1 meeting off stream of the Umba River sub-catchment (Appendix 3A).

3.7.5 Transect walk and field observation

The transect walk is regarded as a participatory approach that facilitates gathering of data (Lorenzo and Motau, 2014). The transect walk is usually led by a group of knowledgeable local people and visiting professionals tend to be followers (Van Staden et al, 2006). The transect walks and field observations were organized across all study sites. These tools aimed at gaining hands-on experience at a community level during which attention was specifically paid to people, activities, water and other natural resources. Through these walks and observations, information provided during the focus group discussion, interviews and household surveys were verified. Through field observation, I had an opportunity to ask for clarification on some issues observed in the field such as why someone decided to build a house near a public water source. The transect walks focused on environmental and agricultural features (such as cultivated land, forests, streams, bodies of water and types of crops. The walks were organized for a small group, to maximise the interactions. The participants in the transect walk involved farmers and village leaders who were prepared to walk. Since most villages are so mountainous, it was not easy to involve elderly people in the walk. However, it was important to ask them some clarifications after the walk. The walk was taken across the river where most of the farms are found. The intention was to observe - farming practices such as encroachments on water sources, irrigation infrastructures, farm sizes, soil erosion and crops grown. It also included observing non-farming activities such as brick making, sand extraction and areas which were near forests where it was possible to witness beekeeping activities.

3.7.6 Remote Sensing and Geographical Information Systems

Relevant studies (Rawat and Kumar, 2015; Carocci et al., 2009; Foley et al. 2005; Tilumanywa, 2013) have shown that land use and cover change analysis has the capacity to identify many influences in natural phenomena and ecological processes such as runoff, soil erosion and deforestation.

Furthermore, land use and land cover change analysis can show how droughts have affected water sources and rivers as well as how farmers could have changed the direction of the river to favour irrigation in their farms. In the study areas, previous studies (e.g. Songoro, 2014; Ngana and Madoffe, 2011; Mascarenhas, 2000; URT, 2012, IUCN, 2003; Tenge, 2005) concluded that there is substantial soil erosion in the upstream of the Umba River sub-catchment due to unharmonised and intensive land-use changes for farming, settlement and grazing.

The changes have been associated with an interactive process of over-exploitation of natural resources, deforestation, land degradation and erosion, as a result affecting households' livelihoods (Ngana and Madoffe, 2011; Rawat et al., 2013). Like in other parts of East Africa, in the Umba sub-catchment land use and cover changes are linked to agricultural expansion and other human activities (Mascarenhas, 2000). It is important to remember that in most cases, land use is a product of interactions between society and state as they strive to meet their physical needs from land potentials or other natural resources (Bashir, 2012). The use of remote sensing and GIS in detecting land use/cover changes has great potential for improving understanding of how landscape dynamics that would have changed with time and space (Zubair, 2006). It helps to trace the impacts of human activities such as farming fields, grazing, charcoal burning, mining, sand extractions and settlement's expansions. Thus, GIS and remote sensing were used as tools that could help to detect such changes. It was also important to undertake an analysis of land-use changes to understand the causes, changes and their subsequent impacts on water resources and households' livelihoods.

Therefore, two reasons necessitated the use of GIS in this study: first, to detect and assess the extent of land use and cover change and how these could be contributing to water challenges in the Umba River sub-catchment. Second, the Umba River sub-catchment is big (8,070 km2) for field observation and has several springs, water sources and tributaries of which some are in Shagayu forest. Therefore, use of GIS and especially Landsat images covering the period of 1975-2015 was the most efficient approach based on time and financial resources available.

Since the Umba was found to be generally, affected by cloud cover especially in the months of October-December and March to early June, efforts were made to make sure that images were not obtained in those months to limit interferences from clouds and rain and hence ensure that good

quality images were obtained (Tilumanywa, 2013). All images were obtained during the months of July-September which is a dry period with cloud free sky.

3.6.7.1 Land cover change assessment methodology

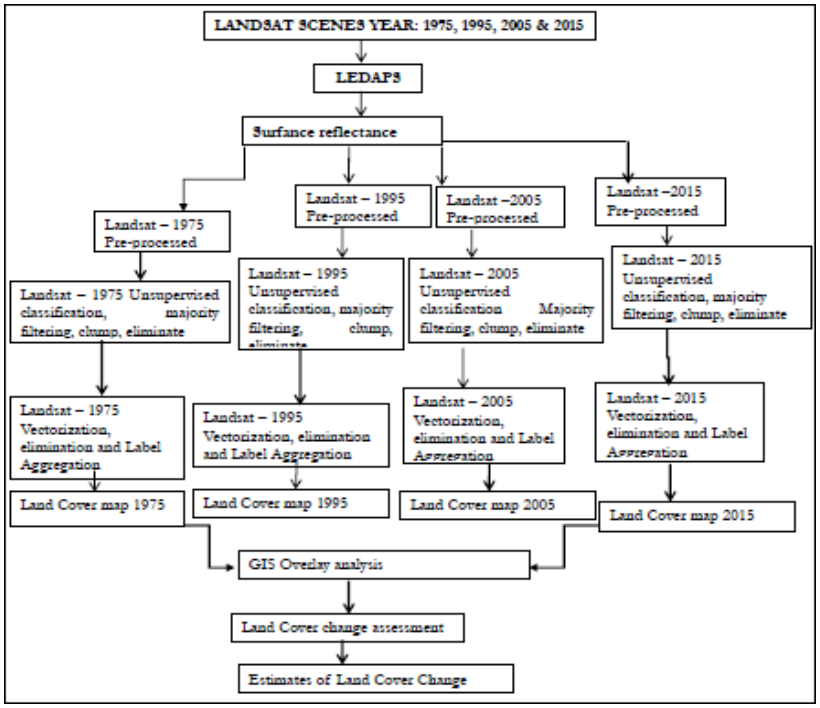

Figure 7: The flow chart employed in the land cover change assessment
Source: Modified from Tilumanywa, 2013

Images were pre-processed and then classified (Masek et al., 2013). Unsupervised classification was applied to create a thematic raster layer. This allowed the user to specify parameters that the computer used as guidelines to uncover statistical patterns in the data. ERDAS IMAGES 2014 software has been used in this research study. For running the classification, the ISODATA algorithm was selected as it was able to use minimum spectrum in forming clusters. Unsupervised image classification led to datasets containing pixels which are classified and with several classes of land cover. This was followed by the application of a filter to remove residues in the image that is already classified. Then small polygons were eliminated using ArcGIS 10 software after vectorization of the classified image. Lastly, classes were assigned to one of the 9 classes identified (see chapter 4).

3.7.7 Precipitation data

Long-term rainfall data for this study were provided by the Tanzania Meteorological Agency (TMA). The obtained rainfall data were relevant to the Umba River sub-catchment and covered a period of 55 years (1960-2015) at Shagayu weather station and 33 years (1967-2000) at Mnazi weather station.

3.8 Data analysis methods

3.8.1 Qualitative data analysis

All information which was obtained in Swahili was transcribed and translated into English. Qualitative data from focus group discussions, key informant interviews, PCA, field observations and household surveys were coded and analysed. The analysed qualitative data were presented in the forms of tables, texts and quotes. Some descriptive passages from opinions expressed by respondents were used to make comparisons and interpretations on climate and resource trends and changes as well as livelihood activities and water availability in different parts of the river course. All qualitative data were categorised into the smallest units of themes for easy inclusion in discussions (Songoro, 2014; Katani, 2010). Quotes were used to strengthen the discussion and analysis and for supporting quantitative data. In order to check the validity of the qualitative data, quantitative data were used through triangulation (Mngumi, 2016)

3.8.2 Quantitative data analysis

3.8.2.1 Structured questionnaire survey data

Quantitative data gathered from key informant interviews and household surveys (including age, sex, size of household, income sources, education level, land owned, number of labour force, livelihood activities, information on climate change and water scarcity incidences), were analysed using Statistical Package for Social Sciences (SPSS) software version 20. SPSS was a powerful data analysis tool which provided many quick ways to examine data (Mngumi, 2016). It was used to produce descriptive statistics such as frequencies, time series and multi variate analysis on droughts and heavy rains (Songoro, 2014). Descriptive statistics were run to generate frequencies and percentages. Results are presented using frequencies, percentage distributions, tables and graphs. Percentages generated for different variables in different villages and locations under study were compared between downstream, up stream, middle stream and off-stream areas.

3.8.2.2 Rainfall data

Assessing the impacts of variability and /or changing climate and uncertainty of rainfall to the Umba River sub-catchment cannot be ignored. It is possible that the area was experiencing warmer, increasing drought periods, late and/or early start of the season and decreasing length of the rainfall seasons (URT, 2014; Stern and Cooper, 2011). Those changes could have led to diminishing water quantity and flow in the sub-catchment and hence affected other socio-economic and livelihood activities (IPCC, 2014).

Given the possible effects associated with climate variability and change, the Instant Statistical programme developed by the University of Reading was used for analyzing rainfall data to determine the onset and cessation of the rainfall season as well as length of rainfall seasons (Stern et al., 2003; University of Reading, 2008; Moyo et al., 2017). According to the available rainfall data at meteorological weather stations, for Shagayu weather station the analysis covered a period of 55 years (1960-2015) and for Mnazi weather station, the analysis covered only 33 years (1967-2000).

All rainfall data from both stations were examined and missing values were identified. The missing data were estimated and filled by using methods suggested by Lo Presti et al. (2010)and Asfaw et al. (2018). Rainfall data from the closest (within 30 kilometers from the study area) weather stations were used to estimate and fill the missing values (Tabios and Salas 1985; Chow et al., 1988).

3.8.2.3 Intra-Seasonal Rainfall Characteristics

Both Shagayu and Mnazi weather stations were used to determine the intra-seasonal rainfall characteristics: onset, cessation and length of rain seasons. Understanding the intra-seasonal rainfall behavior was vital for determining water resource availability and for planning purposes in a given period (Stern et al., 2003). Several studies (Asfaw et al., 2018; Stern et al., 1982; Bosire et al., 2019; Pauline et al.,, 2017; Mugalavai et al., 2008; Kijazi and Reason, 2011; Moyo et al., 2017; Mupangwa et al., 2011) have examined and defined onset and cessations of the rain season to mean start and end of the rainfall season. In this thesis, I used the definitions of Asfaw et al., (2018) and Stern et al., (1982) as described in the following subsections.

i. Onset of the rain season

In this thesis, the onset of the rains season is defined by modifying the definitions provided by Moyo et al. (2017) and Stern et al., (2003). Therefore, the start of the rains is defined as the first day of rain event that accumulates to 20 mm or more in 2 days after 1st March for March, April, May (MAM) rain season and 1st October for October, November and December (OND) season with no 10 consecutive dry days within the following 30 days.

ii. Cessation of the rain season

Cessation of the rain season is defined as the possible date where the water balance in the soil falls to zero while the evaporation is also reduced to 5 mm. With the application of INSTANT software, which is based on water balance, cessation of the rain is considered to be different from the end of

the season (Amukono, 2016; Pauline, 2015). In this thesis, the cessation of rains for OND is the 20th December and for MAM is the 21st May. Therefore, the end of the rain season refers to that day whereby water balance falls to zero after what is considered to be the last day of rains.

iii. Length of the rain season

The length of the rain season was obtained based on the method applied by Mugalavai et al., (2008) and Amukono (2016) in which the length of the rain season is obtained by calculating the difference between the end and start of the rain season. This is presented in equation 1.

Length of the rain season = end of rain season - start of rain season ……. (1)

iv. Climate Variability

In order to examine and quantify the reliability and variability of seasonal and annual rainfall data, the coefficient of variation (CV) was computed (see equation 2). The classification of CV values are; < 20 % as low variability, 20-30% as moderate variability, and > 30% as high variability (Bosire et al., 2019; Araya and Stroosnijder, 2011).

$$\text{Coefficient of Variation} = \frac{\textit{Standard Deviation}}{\textit{Mean}} * 100 \qquad \text{……..(2)}$$

v. Determining dry and wet occasions using the Standardized Precipitation Index (SPI)

The healthiness of rivers and sub-catchments depends on meteorological events, especially droughts and wetness. In the future, meteorological and hydrological events, especially in terms of droughts and floods are projected to increase threats to water resources and other climate dependent livelihood activities such as small-scale farming and pastoralism (Easterling, 2011; Asfaw et al., 2018; Zhao et al., 2018). The standardized precipitation index (SPI) (McKee et al. 1993, 1995) is extensively used to determine years of meteorological and hydrological droughts and wet periods/events. It is a helpful tool in estimating intensity and frequencies of wet and drought years (Silva et al., 2007; Sebenik et al., 2017; Zhang et al., 2009; Ahmad et al., 2015). Pauline (2015, 2017) and Ndesanjo (2017) used SPI to analyse dry and wet years in Tanzania, while Rouault and Richard (2003) used SPI to analyse spatial extension and intensity of droughts in South Africa since 1921.

In this study, SPI was applied for determining dry and wet years and their frequencies in the Umba River sub-catchment. SPI was chosen because it is able to define the probability of dry and wet events

within a range of time scales (such as 3 months to 2 years mean rainfall) and results can be comparable (Hayes et al., 1999). It has an advantage that it needs only precipitation data to get the results. Based on McKee et al., (1993) the classification scale is normalized in order to make sure that dry and wet can represent the same SPI values (Table 6). Pauline (2015) indicates that SPI is the standardisation of time series; Y, as Y1, Y2, Yn.

Therefore,

$$SPI = \frac{(Y - Yi)}{\sigma} \quad \ldots\ldots\ldots\

misunderstandings by the researcher (Sitko, 2013). Financial resources were provided by Bread for the World, who was funding my PhD studies. The validation workshops were attended by representatives from studied villages, Lushoto District Council, extension workers, Tanga region environmental officers, local researchers and representatives from Umba Water Users Association, civil society organisations and media (Figure 8 and Figure 9). These respondents' workshops are also in line with the observation by Ndaki (2014) that stakeholders' validation workshops give opportunities to respondents and study populations to validate data collected from different localities, villages, local leaders, experts and elders.



Figure 8: Photo during feedback presentation
Source: Field survey, 2017



Figure 9: Workshop participants group photo
Source: Field survey, 2017

3.9 Ethical aspects

As a requirement of the University of Witwatersrand, I firstly applied for and received an ethics certificate from the responsible Ethics Committee (Appendix 4). I used my ethics certificate and an introduction letter from my employer-CAN TZ to introduce myself to the Tanga Regional Administrative Secretary who also introduced me to Lushoto District (Appendix 5), and finally, I was introduced to all ward and village leaders where this study was planned to be conducted (Appendix 6). Being introduced by the Regional Administrative Secretary is a very important step in Tanzania for research on the ground despite the fact that I had a long-term working relationship with all villages. At each village, I had a research introduction meeting to village committees responsible for development, water, natural resources and agriculture. I informed them of the aim of the study, how the study will be conducted and for how long. This introduction meeting to each village had the intention of getting local consent before the actual study commenced.

Before starting any interview, I made sure that each participant was given a participant information sheet and consent which were translated into Swahili which is a local language for easy understanding. The participant consent had information on the main goal of the study, participant freedom to refrain from the study discussion any time as there is no penalty, and assuring a participant that information given will remain anonymous and no name shall be used in writing the thesis.

3.10 Limitations of the study

In the course of data collection and writing this PhD thesis, I encountered some challenges.

The first challenge that was encountered in this study was logistical and transportation difficulties. The nature of the terrain in the study area is very hilly associated with steep slopes and unimproved roads. The most available transportation system for the researcher was the motorbike locally known as *bodaboda* that are expensive during the rain seasons and most roads and walkways are too slippy. The researcher had to postpone the fieldwork for four weeks as big stone had fallen and destroyed the route to the field sites and roads were heavily affected during the long rain seasons of 2017. Most of the challenges were in the villages of Goka, Kiranga, Kwekifinyu and Hemtoye. To address this challenge, it was important to set appointments before the long rains especially with village leaders and using a person from the village to negotiate and bargain the price in advance with *bodaboda* drivers.

There was also a challenge of household heads not being able to recall the years when incidences of heavy and limited rains, floods and water challenges occurred. To reduce the risks of being given

unrealistic data the researcher opted to spend more time with household heads so that they can remember, and sometimes they could call and ask other old people.

I encountered a challenge of having less women and youth in the study. Women were not ready to participate as most of the time they wanted to be represented by their husbands who are considered to be spokespersons and heads of the households. To address this, I worked with village leaders to raise the participation of women to 37%. Youth were always not available as most are in Lushoto, Tanga and Dar es Salaam town doing non-farming activities. Those who were available wanted to be paid to provide information but also had limited knowledge to link water resources, climate and village livelihood activities. This may be linked to the fact that most of youth are engaged in transportation activities and not farming.

Another potential limitation of this study was the difficulty to differentiate if water challenges in the study area were due to climate change impacts or non-climatic factors such as population growth, unsustainable farming methods, land use/cover change and encroachment to water sources. To address this, the researcher had to perform land use/cover change analysis and rainfall trend/extremes analysis to aid in understanding the main causes of water challenges in the study area.

Lastly, there was a challenge of getting similar temporal coverage of meteorological data from different weather stations. However, Shagayu station had rainfall data for 55 years (1960-2015) while Mnazi had only 33 years (1967-2000). In this situation, only 1967-2000 were used for comparison purposes. There was no water flow data (Tesfamariam, 2018) and therefore the water flow changes and its impacts were not able to be covered in chapter 4.

3.11 Chapter summary

This chapter presented the study area which is Lushoto District, but the focus was on some selected villages in the Umba River sub-catchment. The climate of the study area is considered bimodal but with high temperature between October-February. According to previous studies, the Umba River sub-catchment and Shagayu forest reserve play pivotal role in supporting household's livelihood activities.

The chapter has established the factors that have been used to select the study villages, whereby six villages were selected from within the sub-catchment but located in different courses of the river, so that challenges from all river courses are presented and interpreted. The other two villages of Hemtoye and Kwekifinyu were selected far away from the central sub-catchment so that data from villages with no access to the river can be compared with those having access.

This study has applied a mixed -methods approach, so that the researcher can gain both qualitative and quantitative information. Therefore, the sampling strategy used by this study includes both probability and non-probability sampling. For data collection, mixed methods were used. Questionnaires, FGDs, KIIs, field observation, household surveys as well as GIS and remote sensing have been used. Finally, this chapter presents data analysis methods for both qualitative and quantitative data, including spatial data analysis.

CHAPTER 4
LAND USE AND CLIMATIC FACTORS AS DETERMINANTS OF WATER RESOURCE AVAILABILITY

4.1 Chapter introduction

This chapter explores the impacts of changes in land use and climate on water resources availability in the Umba sub-catchment and two selected off-stream villages. The chapter has analysed changes in both land use and climate in the sub-catchment to define their contribution and impacts on water resource availability and hence livelihoods in the Umba River sub-catchment. Analyses of water flow and temperature were not possible due to lack of long-term data in the study area and nearby stations. The chapter starts by providing information on land use and land cover changes (LULCC) and their potential impacts on water sources and resources in the study villages. Furthermore, the chapter assesses the role of climate variability/change and related impacts on water resource availability in the study villages. Finally, the chapter gives a short summary of the whole work and the findings.

4.2 Spatial Land Use and Land Cover Change in the Umba River Sub-Catchment

An increasing human-caused LULCC is documented to be one of the major causes of freshwater and other natural resource depletion (Roy and Srivastava, 2012). In developing countries, most of land use practices aim at meeting and satisfying short-term needs of the population. In most cases, land use practices pay less attention to the long-term loss of ecosystem services and the loss of natural resources (Duraisamy et al., 2018). In this section, GIS and remote sensing tools are employed to detect land cover changes and related impacts to water resource availability. The analysis of land use change is intended to measure the rate and possible contribution to water resource changes.

The identified changes in land use and land cover in the sub-catchment area for 1975, 1995, 2005 and 2015 are shown in Figures 10 to 13 respectively. The percentages of LULCC for the same period are shown in Table 7. The shape of the map (polygon) is influenced by administrative boundaries, location of the villages under study and the nature of the sub-catchment.

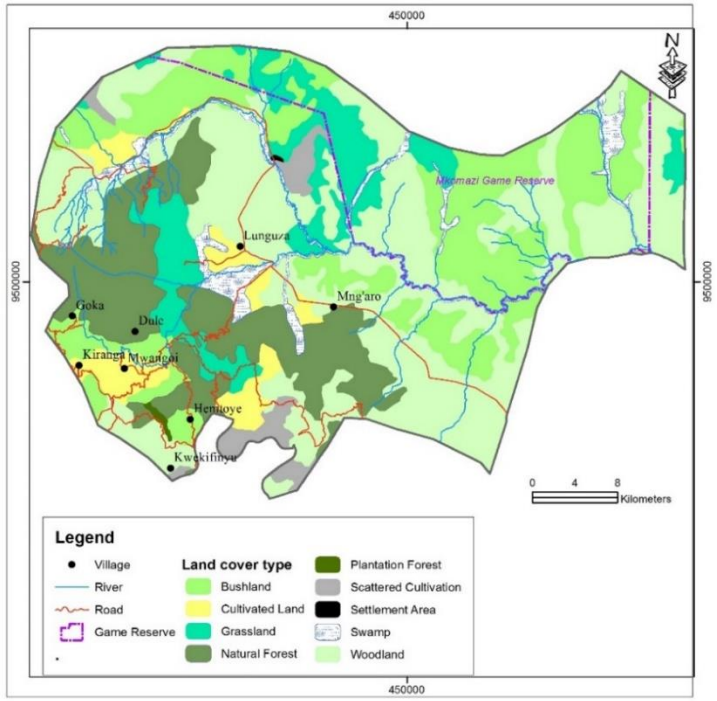

Figure 10: Map-land cover/use categories for the year 1975

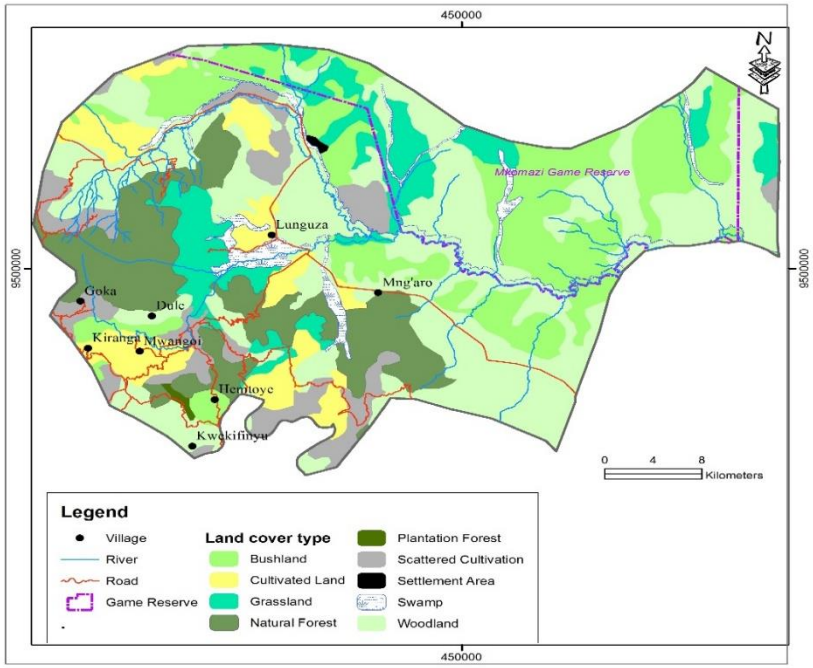

Figure 11: Map-land cover/use categories for the year 1995

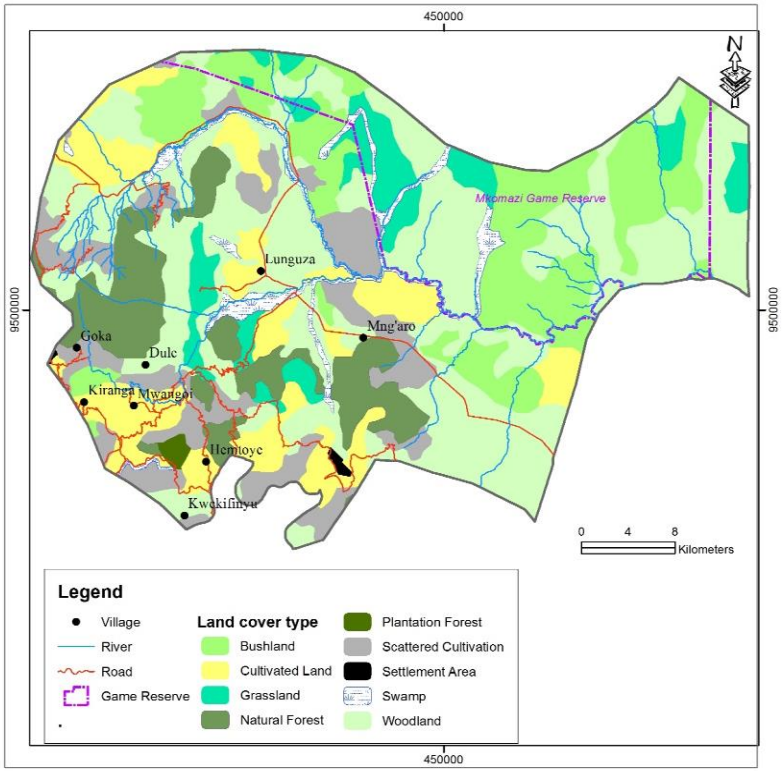

Figure 12: Map-land cover/use categories for the year 2005

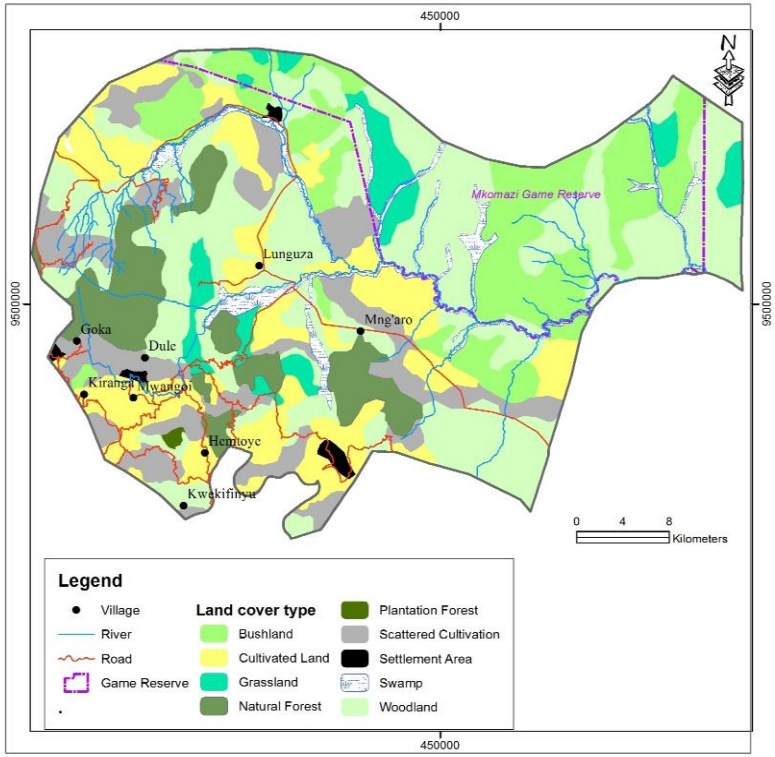

Figure 13: Map-land use cover/use categories for the year 2015

The general observation from the analysis of maps indicated that, in the study villages, natural forests are sparsely distributed and have been decreasing with time. These forests include Shagayu and Mkomazi Game Reserve. The two forests are protected whereby Shagayu forest is under Joint Forest Management headed by the Lushoto District Council and Mkomazi Game Reserve is under the Tanzania National Parks Authority. The two forest reserves were established before the 1970s (Mwangi et al., 2017). The area also has some sparsely distributed planted forests which are found in many places but which have changed little over time. On the water category, most rivers and streams are originating from hills and natural forests, especially Shagayu forest but some seem to disappear near settlements and farms. Furthermore, the cultivated land is widely distributed and found in all villages, including near water sources. The scattered cultivated land and settlement areas show a considerable increase for the period of 1975 to 2015.

4.2.1 LULCC detection and analysis in the sub- catchment

A change matrix (Table 7) shows LULCC classes and percentages of change for the 40 years (1975-2015) in the study area.

Table 7: The matrix showing changes in LULC in Umba River Sub catchment, 1975-2015

Land use/cover type	Coverage								Land Cover Change							
	1975		1995		2005		2015		1975-1995		1995-2005		2005-2015		1975-2015	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Bushland	39,283	23	36,274	21	30,989	18	28,259	16	-3,009	-2	-5,285	-3	-2,730	-2	-11,024	-7
Cultivated Land	8,547	5	13,543	8	22,107	13	28,556	17	4,996	3	8,564	5	6,449	4	20,009	12
Grassland	18,220	11	16,215	9	11,983	7	8,970	5	-2,005	-1	-4,232	-2	-3,013	-2	-9,250	-6
Natural Forest	27,545	16	23,015	13	16,745	10	14,343	8	-4,530	-3	-6,270	-4	-2,402	-1	-13,202	-8
Plantation Forest	261	0	283	0	547	0	235	0	22	0	264	0	-312	0	-26	0
Scattered Cultivation	4,529	3	14,148	8	19,148	11	22,423	13	9,619	6	5,000	3	3,275	2	17,894	11
Settlement Area	54	0	157	0	269	0	1,005	1	103	0	112	0	736	0	951	1
Swamp	7,361	5	5,093	3	5,473	3	6,758	4	-2,268	-2	380	0	1,285	1	-603	-1
Woodland	66,598	39	63,670	37	65,137	38	61,848	36	-2,928	-2	1,467	1	-3,289	-2	-4,750	-3
Total	172,398	100	172,398	100	172,398	100	172,397	100								

Results from Figures 10 to 13 and Table 7 indicate that land use and land cover change is an issue of concern in the Umba River sub-catchment and off sub-catchment villages. The most vulnerable areas are those near natural forests and mostly in the upstream area where rivers originate. This finding corroborates results by Mango et al., (2018) that in the Eastern Africa region, most natural forest lands are increasingly converted to agriculture and settlement, a situation that has reduced water flows and hence increased water scarcity during dry seasons.

Extreme land use changes and increase of cultivated land were observed in the study area. The scattered cultivated land has increased from 4,529 ha in 1975 to 22,523 ha in 2015 which is a 395% increase within a period of 40 years. In addition, cultivated land had increased from 8,547 ha in 1975 to 28,556 ha in 2015, making a total increase of 234%. The analysis shows that major changes in cultivated land happened from 1995 to 2015 and more importantly the last ten years. For instance, cultivated land increased by 63% within the 10 years from 1995-2005 and 119% from 2005-2015. These are big changes within a period of 10 years as compared to only a 58.5% increase for the 20 years covering the period of 1975- 1995. Settlement area also changed from 54 ha in 1975 to 1005 ha with an increase of 941 ha which is equivalent to a 1761% increase. For the small study area (total coverage areas are 172,398 ha of land) with steep slopes and mountains these changes are significant and add more pressure to an already overpopulated area since the 1940s (Mascarenhas, 2000; Ngana and Madoffe, 2011). For the period of 20 years covering 1975-1995 the settlement area increased by 191% only, however it increased by 274 % for only 10 years from 2005-2015. This indicates that the study area is experiencing high population and land use change increases with time.

Plantation forest did not indicate any significant changes within the period of 40 years. On the other hand, the natural forest decreased from 27,545 ha in 1975 to 14,343 ha in 2015, which was a decrease of 48%. The bushland decreased by 28% from 39,283 ha in 1975 to 28,259 ha in 2015. The grassland also decreased, by 55%, from 18,220 ha in 1975 to 8,970 ha in 2015. The woodland decreased slowly by only 3% for the period of 40 years. However, this could be due to the fact that, some areas of the study and especially around water sources and along the Umba River, there were eucalyptuses that were introduced in the early 1990s with an intention to reduce soil erosion. It is clear from the produced maps and Table 4.1 that a significant decrease of natural forests, bushland, woodland and grassland happened over the period of 1995-2005 and 2005-2015. Cultivated land and scattered cultivated land increased in this period as well. This means that there is a close relationship between agricultural activities and decrease of natural forest, bushland, woodland, swamp and grassland. This finding corroborates similar studies in East Africa (Welde and Gebremariam, 2017; Mwangi et al., 2016) which found that land use types near rivers and watersheds are dominated by agricultural activities that have caused deforestation. During field visits and ground truthing, encroachments and farms were observed along the riverbanks throughout the Umba River course and had reduced the water flow path.

4.2.2 Assessment of LULCC in riparian zones

The Tanzania National Environment Act 2004 prohibits any human activity to take place within 60 m from the water source and banks of rivers (URT, 2004). However, during ground truthing, several farms within 1-5 meters from the water sources and rivers were observed. Most irrigation activities are within those ranges.

A buffer zone of 60 meters from the river centre was assessed to detect changes (Table 8). A previous study by Mwangi et al. (2017) concluded that in Tanzania and Kenya, encroachments because of agricultural expansion and harvest of forest resources pose a serious threat to water availability and biodiversity near rivers. Hyandye et al. (2018) and Mutayoba et al. (2018) investigated the impacts of land use change on water resources in the Ndembera watershed and Mbarali River sub-catchment respectively. The two studies concluded that encroachments for farming activities have increased siltation and affected water flow in those rivers.

Results have shown that from 1975 up to 2015 the Umba River has experienced land cover changes that may have affected vegetation cover and may have potentially caused erosion close to water sources. Within 60 m from the water source and bank of the river, six land use categories were found. They include bushland, cultivated land, grassland, natural forest, swamp and woodland. The natural forests, woodland and bushland within 60 m from the riverbank have decreased dramatically since 1975. For the years 1975 to 2015, the cultivated land increased from 261 ha to 1193 ha which was an increase of 400%. In the same period, bushland decreased by 36%, grassland decreased by 56% and natural forest decreased by 60%. Woodland and swamp decreased by only 4% and 9% respectively. The whole studied part of the sub-catchment had undergone land use changes which might have contributed to water challenges in the area. During ground truthing, in the downstream, I observed several patches of cultivated land near riverbanks. Since the downstream is characterized by flat slopes of land the area experiences intensive cultivation for about three times a year due to irrigation possibilities. I observed rice, maize, cabbage, potatoes and some other vegetables in farms near riverbanks. The remaining little land, especially downstream is gone at the expense of pastures and settlements while natural forests are replaced by shrubs and some showed total disappearance. The volume of water was observed to be to very small in the river channel and was not flowing as at some points it was blocked by farmers who diverted flow into their farms. This finding corroborates Kashagili et al. (2007), who found that the Great Ruaha River which used to be perennial up early 1990s, has ceased flowing especially during the dry season due to land use change and upstream

diversion of water into farms. This situation has caused conflicts among water users and jeopardizes the Ruaha National Park ecosystems. The Umba River also experiences dislocation, meanders and shifting of riverbanks and hence affects water resources and biodiversity. This finding affirms Mwangi et al. (2017) that the ever-increasing encroachments of rivers in East African countries might lead to severe soil erosion and related problems that water availability.

Table 8: The matrix showing land-cover changes within riparian zones, 1975-2015

Land Use/ Cover Types	Coverage								Land cover change	
	1975		1995		2005		2015		1975-2015	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Bushland	1,167	19	1,195	20	1,119	18	742	12	-425	-7
Cultivated Land	261	4	597	10	1,009	14	1,193	20	932	16
Grassland	554	9	632	10	372	6	245	4	-309	-5
Natural Forest	722	12	572	9	312	5	291	5	-431	-7
Swamp	1,250	20	309	5	697	11	1,294	21	44	1
Woodland	2,154	35	2,804	46	2,600	43	2,344	38	190	3
Total	**6,108**	100	**6,109**	100	**6,109**	100	**6,109**	100		

4.3 Climate variability and/or change in the Umba River sub-catchment

4.3.1 Rainfall Trends

Figures 14 and 15 present results of rainfall trends for Shagayu and Mnazi weather stations respectively. The trend analysis of Shagayu weather station (located in the highland) covers a period of 55 years of precipitation data from 1960 to 2015. Trend analysis of Mnazi weather station (located in the lowland) covers 33 years of precipitation from 1967 to 2000. There were no recorded rainfall data at Mnazi after the year 2000. The non-parametric Mann-Kendall test has been used for determination of the trends (Bosire et al., 2019; Hadgu et al., 2013; Gitau et al., 2018). Figure 14 indicates that years which received precipitation above 1200 mm include the years of 1960 (1429 mm), 1961 (1734 mm), 1962 (1294 mm), 1963 (1250.1mm), 1967 (1211 mm), 1978 (1508 mm), 1982 (1276 mm), 1997 (1475 mm) and 1998 (1265 mm). The years of which received minimum precipitation which was below 700mm for the last 55 years included 1971 (632.7 mm), 1973 (562.3 mm), 2012 (604.5 mm), 2013 (454.5 mm) and 2014 (479 mm). At Shagayu station, the maximum and minimum annual rainfalls recorded were 1508 mm (in the year 1978-the wettest year) and 455 mm (in the year 2013-the driest year) per year respectively. The mean annual rainfall for these 55 years is approximately 948 mm. At Mnazi station, the years that received high annual rainfall were 1978 and 1997, which were 1278 mm and 1151.2 mm respectively. The year with minimum annual rainfall was 1999 that registered only 393.4 mm.

Analysis of annual rainfall trends from the two stations shows upward (+) and downward (-) rainfall trends in time series which are not statistically significant. Trends investigation using the Mann-Kendall test at $\alpha = 0.05$ significance level for both stations, indicated apparent annual precipitation decreases at both stations but did not indicate any statistical significance and P- values were > 0.05. Similar findings were reported by studies conducted in East Africa (Tanzania, Kenya and Ethiopia), where the trends in the annual precipitation were not statistically significant but indicated inter-annual variability (Pauline et al., 2017; Asfaw et al., 2018; Hadgu et al., 2013; Mongi et al., 2010; Mondal et al., 2012; Bosire et al., 2018; Moyo et al., 2017).

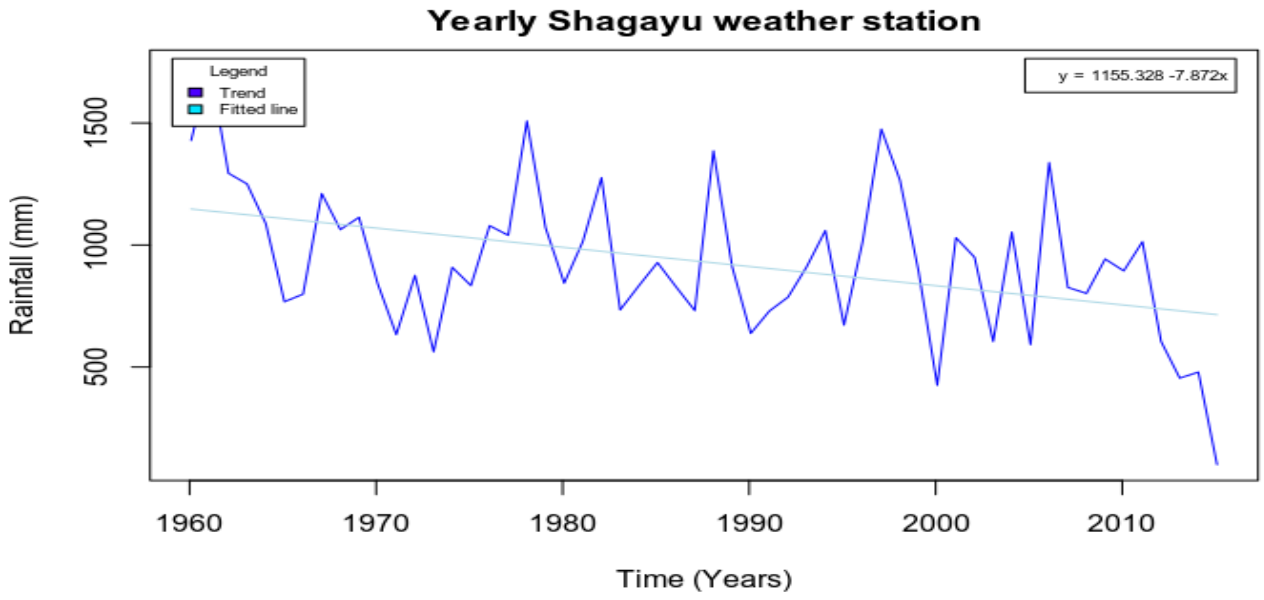

Figure 14: Shagayu weather station

Data source: TMA 2017

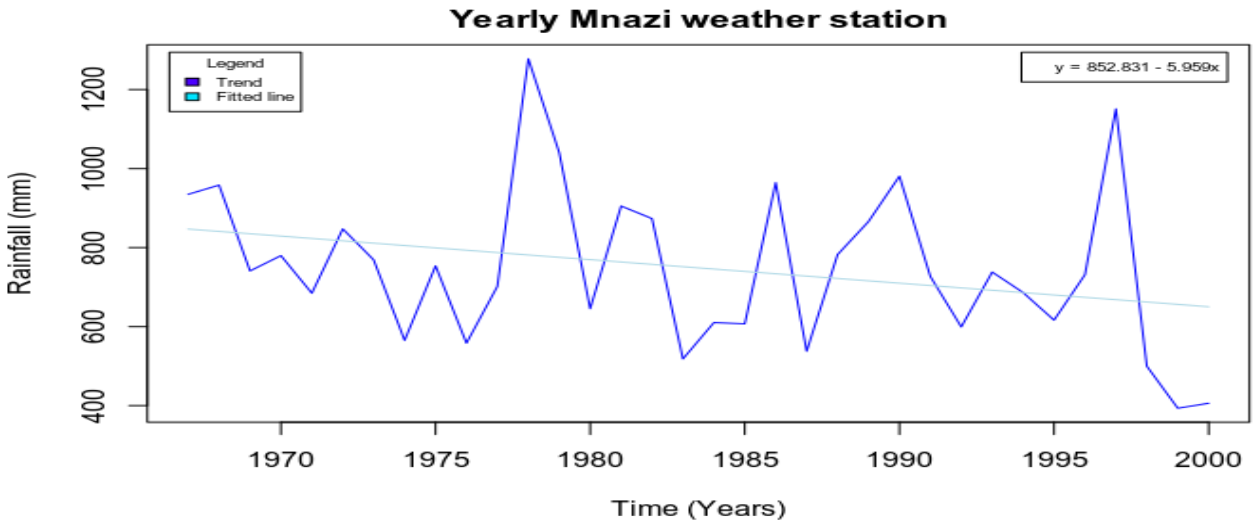

Figure 15: Mnazi weather station
Data source: TMA 2017

The comparative trend analysis of the two stations shows that Shagayu station has continued to register higher rainfall compared to Mnazi station from the period 1967 to 2000 (Figures 16 and 17). For instance, for the period of 33 years covering 1967-2000 Shagayu station registered mean annual rainfall of 943.9 mm while Mnazi station registered only 748.6 mm.

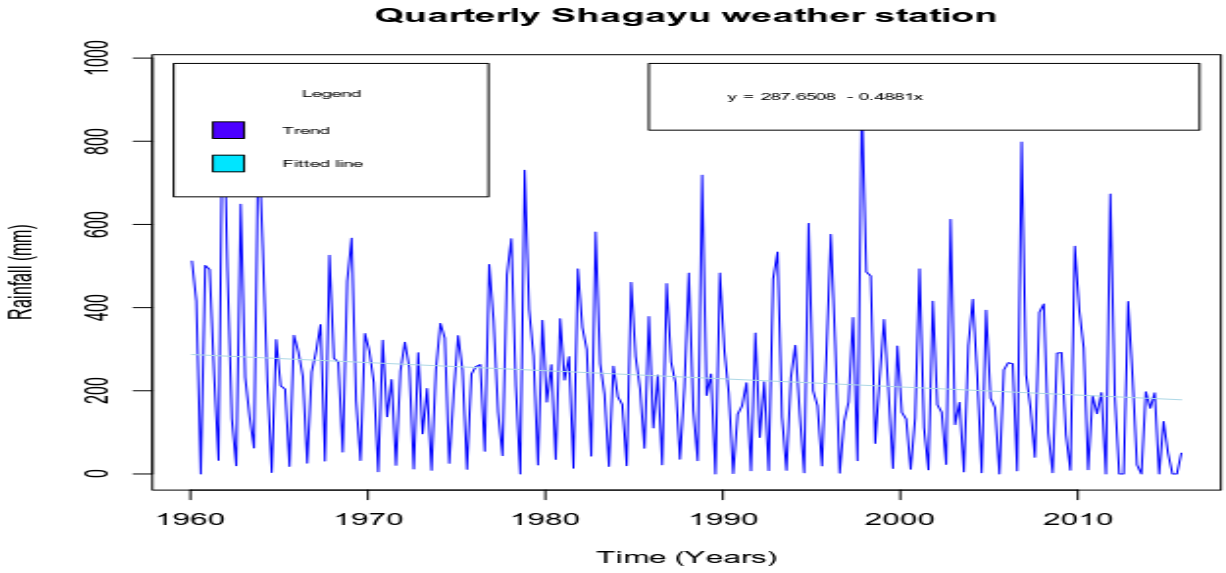

Figure 16: Shagayu weather station
Data source: TMA 2017

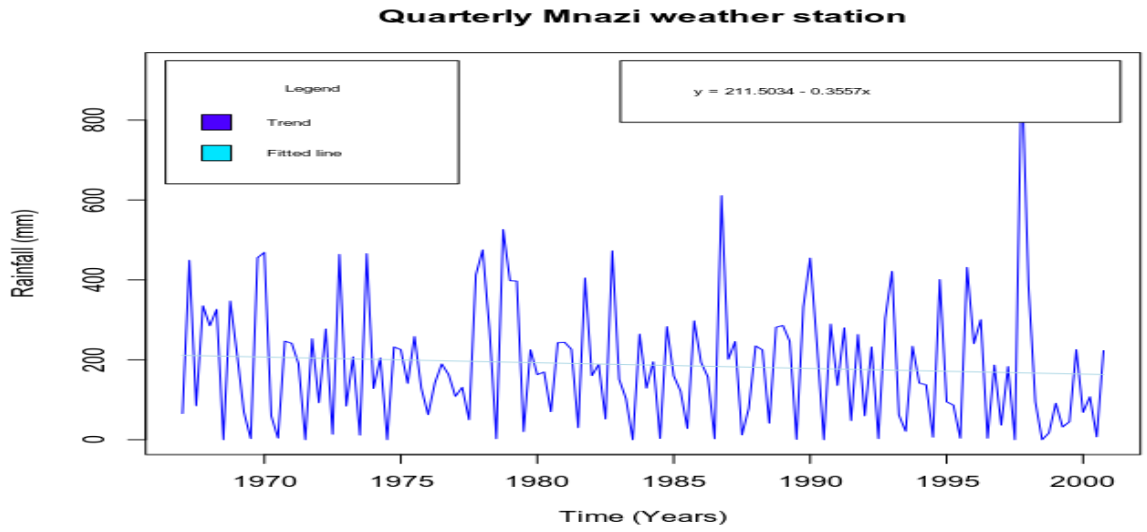

Figure 17: Mnazi weather station

Data source: TMA 2017

The monthly and quarterly analysis of precipitation data have affirmed that the Umba River sub-catchment and its neighbouring places receive bimodal rainfall patterns. This finding affirms Mahoo, et al., (2015) and Lushoto District Council (2016), that most places in Lushoto district including the Umba receive bimodal rainfall, with short-season rains covering October November and December (OND) and long season rains covering March, April and May (MAM). The data analysis indicates that the highlands receive an average of 800 mm – 1550 mm rainfall per annum compared to the lowlands that receive about 400 mm - 800 mm per annum. The trend season (in this study termed quarterly) analysis for long rains has the heaviest period of rains in April in both stations and is considered to play a great role in livelihood activities, particularly rain-fed farming. MAM rains are also important for recharging the available small wetlands and swamps and retaining the soil moisture which in turn become useful for irrigation in the period of July to September whereby most of the areas are dry. During field visits and transect walks in the study area during the period of July to early October of 2017, I observed several farmers who were practicing irrigation farming in Lunguza and Mng'aro villages due to water shortage. In the downstream area the river had zero flow due to obstructions and upstream diversions to farms. The seasonal trend analysis at both stations has indicated a declining rainfall trend though not statistically significant at Shagayu station. The monthly analysis indicates more frequencies of declining long season precipitations at both stations (Figures 18 and 19). This means that the study areas experience longer season inter-annual rainfall variabilities. The result agrees

with Philippon et al. (2002), Ndesanjo (2017), Wolff et al., (2011) and Asfaw et al. (2018) who found strong inter-annual variability for the last five decades in East Africa which affects farming plans and water resource availability.

The monthly rainfall analysis has indicated that at Shagayu station January, March, April and May receive the high averages of precipitation. However, April has recorded the highest rainfall for the period of 55 years with an average of 131.64 mm per month. The April of 1960 accrued the highest rainfall of 318.8 mm followed by 1997 that recorded 255 mm. The lowest records are recorded in 2012 and 2013, which both recorded 0mm. On the other hand, at Mnazi station, April, November and December have recorded high average rainfall. However, December has accrued the highest rainfall for the period of 33 years, with an average of 161. 2 mm. The December of 1997 is considered to have recorded the highest rainfall of 432 mm within the period of 33 years. For the same period, the April of 1998 recorded only 17 mm that was the lowest within the period of 33 years.

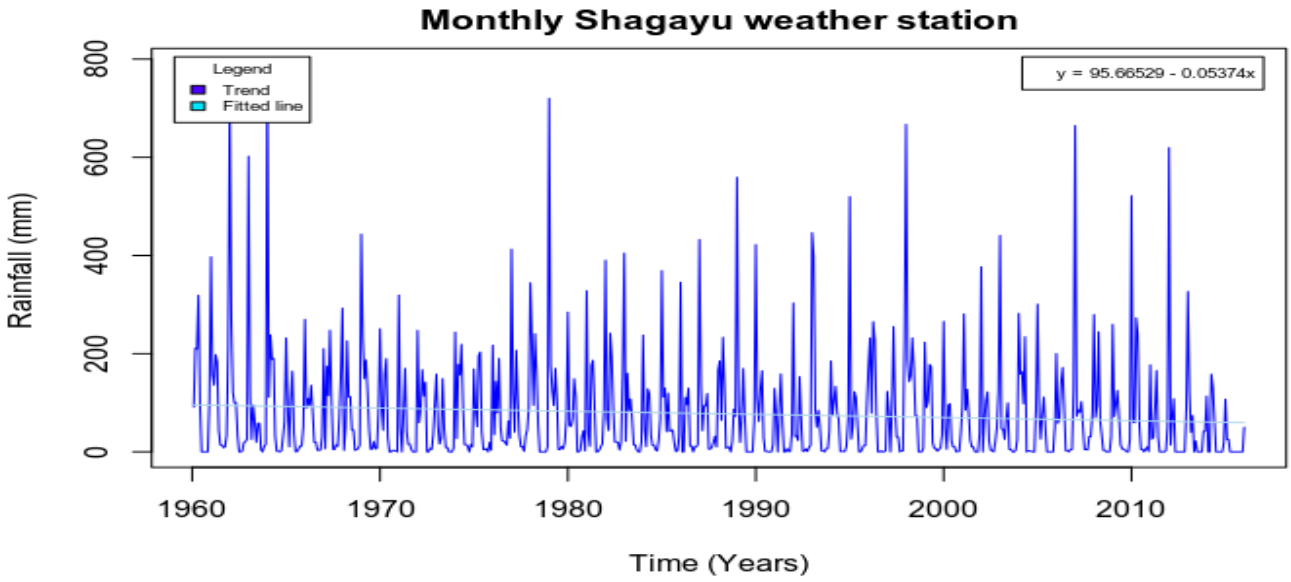

Figure 18: Shagayu weather station
Data source: TMA, 2017

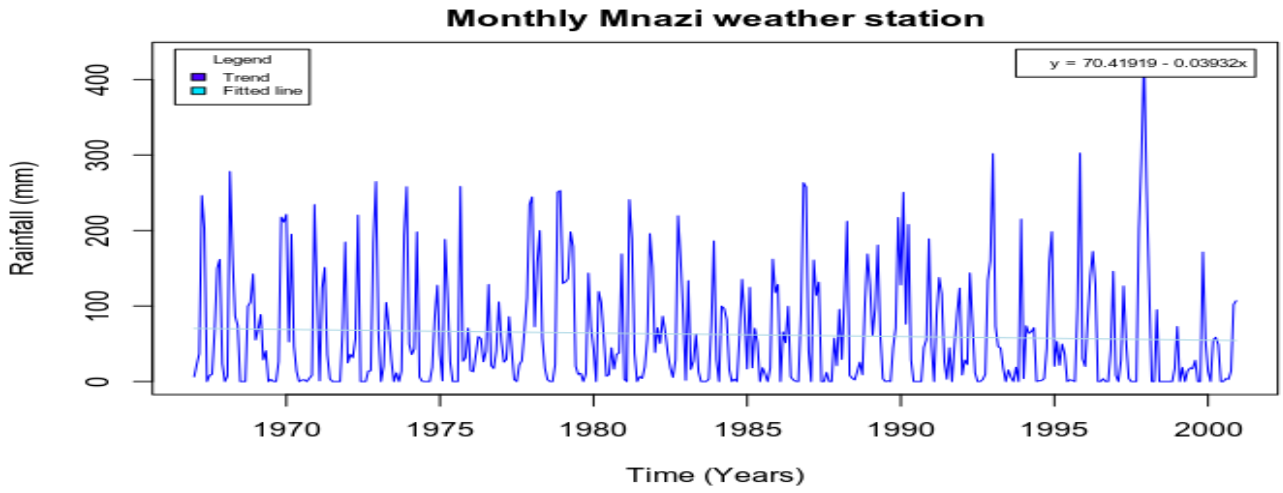

Figure 19: Mnazi weather station

Data source: TMA, 2017

4.3.2 Dry and wet events in the Umba River sub-catchment

Figures 20 and 21 show annual SPI for 55 and 33 years within the Umba River sub-catchment. The rainfall data are from two weather stations, one located in the highland/upstream (Shagayu station) and another one located in the downstream/lowland (Mnazi station). While Shagayu weather station borders Shagayu forest -the headwater for Umba River, Mnazi borders Mkomanzi National Park downstream.

It can be seen that the study areas are increasingly experiencing decreasing SPI, meaning that drought events are also becoming dominant in the Umba. Both weather stations have shown a downward trend in SPI value that is statistically significant (P- value < 0.05). The findings are in line with other earlier studies by Nicholson (2016) and Camberlin et al., (2003) showing that in recent years, annual rainfall is decreasing while drought events are increasing over the Eastern African region.

Figure 20 indicates that the years 1971-1975, 1984, 1992-1996, 2001-2004, 2005, 2009, and 2013-2015 were the driest. The extreme dry year was 2013 with an SPI value of -4. On the other hand, the years 1960-1965, 1977-1980 and 1997-1998 were the wettest years at Shagayu weather station. The years 1997 and 1998 are the extreme wet years with an SPI value of 3. The SPI values have clearly indicated that the highlands where the Umba River starts has been experiencing increased dry events for the last

two decades. The increasing dry events have become more frequent from the 1990s. For example, from 1960- 1990 (which is 30 years) the area had experienced only 5 drought events while from 1990-2015 (25 years) the same area experienced 12 events of droughts including an extreme dry year in 2013 (Table 17). These findings indicate that as time increases the highland experiences increased dry events.

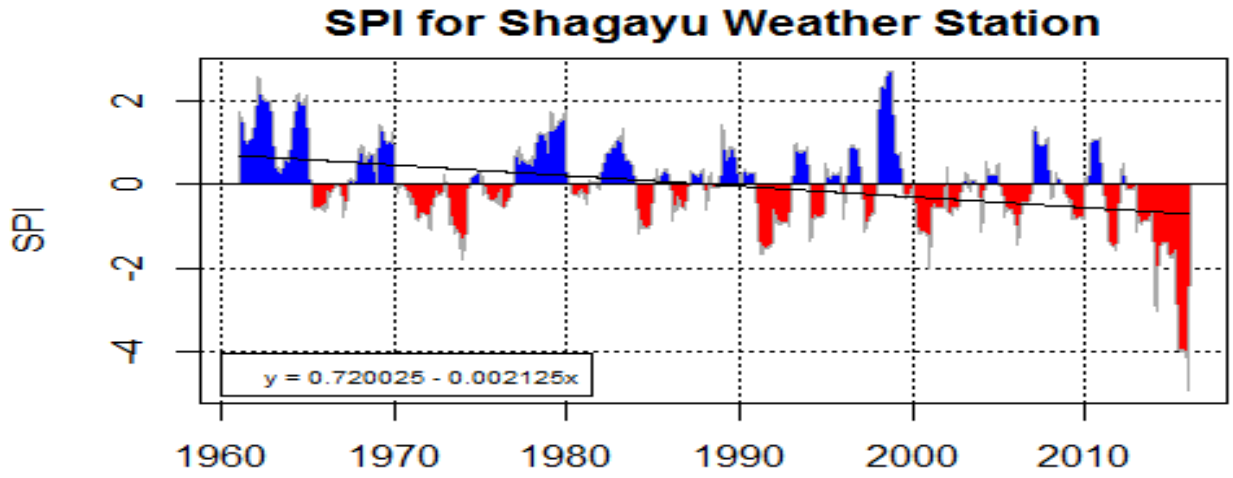

Figure 20: SPI time series calculated for Shagayu weather station, 1961-2015
Data source: TMA 2017

Figure 18 indicates that, in the downstream area of the Umba River sub-catchment, there are very few numbers of extreme wet years. The only registered extreme years were 1977 and 1998 with SPI values of 2 and above. The years 1967-1968, and 1997-1998 are the extreme wet years with SPI values above 2 at Mnazi station. On the other hand, the dry events are rather mixed between severe and moderate droughts but with increasing frequencies in the last decade. The extreme dry year was 1999 with an SPI value of -3.5.

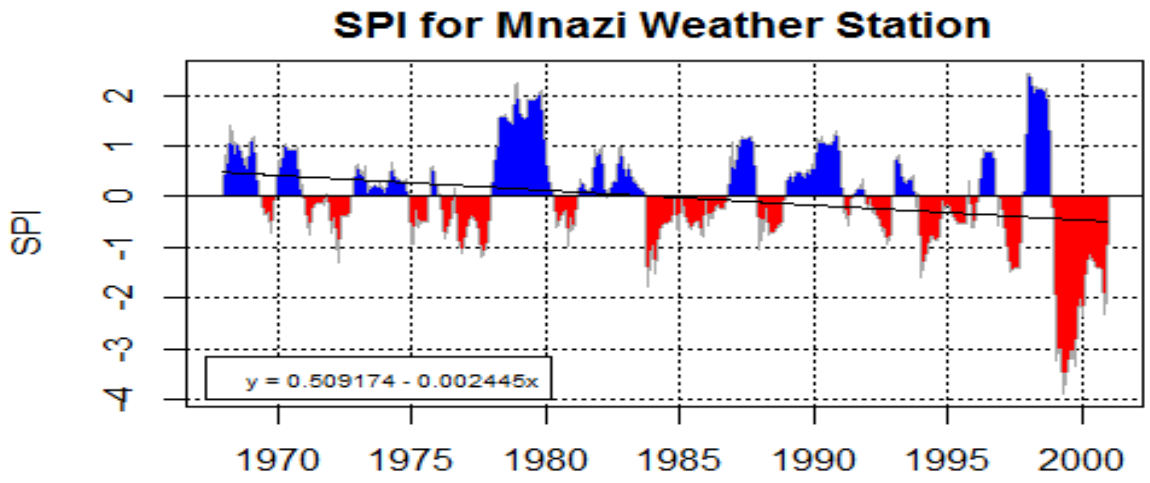

Figure 21: SPI time series calculated for Mnazi station, 1967-2000
Data source: TMA 2017

Table 9 indicates that the years 2013, 2014 and 2015 were extremely dry years. While 2012 was classified as very dry, the year 2011 was a very wet year. The drought events seem to be more pronounced in the upstream of the Umba River sub-catchment. For the period of 55 years, the area has recorded about 9 dry events in the years of 1975, 1984, 1993, 1994, 1996, 1999, 2001, 2005 and 2012. Moderate dry events numbered only 4 and occurred in the years of 1971, 1972, 1987 and 2009. On the other hand, Table 5.3 indicates that, in the same period of 55 years, the area has registered only 3 extreme wet years, which occurred in 1963, 1964 and 1998. However, the same period had 5 moderate wet events, which occurred in 1968, 1978, 1982, 1989 and 1997. The analysis shows that in the highlands of the Umba River sub-catchment the total dry events that range from extreme to moderately dry are 16, while the wet events are only 12. The total near normal events are 6 and include the years of 1966,1967,1974,1981, 1988 and 2002.

Table 9: Wet and dry events for Shagayu weather station based on SPI

Class/category	SPI values	Event occurrence year	Total events (1960-2015)
Extremely wet	2.00 and above	1963,1964,1998	3
Very wet	1.5 to 1.99	1969, 1979, 2008,2011	4
Moderately wet	1.00 to 1.49	1968, 1978, 1982,1989,1997	5
Near normal	-0.99 to 0.99	1966,1967,1974,1981, 1988,2002	6
Moderately dry	-1.49 to -1.00	1971,1972,1987,2009	4
Very dry	-1.99 to -1.50	1975,1984, 1993, 1994, 1996,1999, 2001, 2005, 2012	9
Extremely dry	-2 to less	2013, 2014, 2015	3

Data source: TMA, 2017

Table 10 presents annual rainfall SPI values in the downstream of the Umba River sub-catchments for the period of 33 years from 1967 to 2000. The findings indicate that the area is characterized by near-normal events with SPI values of between -0.99 to 0.99. The area has about 33.3% of near normal category years. Extremely wet events are recorded to have happened in 1977 and 1997. On the other hand, the area has recorded 5 very dry events, which occurred in the years of 1974,1976,1977,1993 and 1998.

Table 10: Wet and dry events for Mnazi weather station based on SPI

Class/category	SPI values	Event occurrence year	Total events (1967-2000)
Extremely wet	2.00 and above	1977,1997	2
Very wet	1.5 to 1.99	1978	1
Moderately wet	1.00 to 1.49	1967,1982,1989	3
Near normal	-0.99 to 0.99	1968,1971,1972,1979,1980,1984,1985,1986,1988,1992, 1994	11
Moderately dry	-1.49 to -1.00	1973,1975	2
Very dry	-1.99 to -1.50	1974,1976,1977,1993,1998	5
Extremely dry	-2 to less	1999	1

Data source: TMA, 2017

4.3.3 Intra-seasonal Rainfall Characteristics

In this thesis, the intra-seasonal rainfall characteristics, which include onset, cessation and length of rainfall, are computed for each year. Both weather stations (Shagayu and Mnazi) are used as they had daily data.

4.3.3.1 Observed onset of the rain season

It is very important to undertake an analysis of the onset of the rain season especially for water stressed areas and for farmers who depend on rain fed agriculture (Moyo et al., 2017). The analysis is also important to help households to decide better on their livelihood options. Results indicate that for the long season rains (MAM), the season onsets of the rains are concentrating in the third to the fourth week of March (Figures 22 and 23). TMA had reported that in the study area for the MAM seasons the rainfall is supposed to start on 1st of March (MacLeod, 2018). Starting in the third to fourth week of March would indicate that rain season for MAM will have started late by 14 to 20 days. Figure 19 shows incidences of rain season starting in the first week of March. However, this is only 7% of 55 years where these years and dates include; 1998 (8th March), 2008 (7th March), 2010 (10th March) and 2014 (6th March). In addition, incidences of late seasons of long rainfall (MAM) were observed in years of 1963 (26th April), 1983 (29th April) and 1984 (24 April). Similar findings are reported by previous studies (Kassile, 2013; Gitau et al., 2017; Kansiime et al., 2013) that there is an increasing tendency towards the delayed onset of the long rainfall in Eastern Africa and especially in Tanzania, Uganda and Kenya for the last 6 decades. The trend test and linear regression analysis show an apparent decreasing trend but it is not statistically significant.

Figure 23 indicates that at Mnazi station the MAM rain season starts in the second and third week of March. However, there are two years of very late onset of the MAM rain season. These years include 1994 where the rain started on 7th of May and 2000 where the season started on 24th of April. Still, early season onset was recorded in the years of 1967 (7th March), 1968 (6th March) and 1972 (8 March). The comparison analysis of both stations shows that Mnazi station is experiencing somewhat later onset of the MAM season while Shagayu station is experiencing relatively earlier onset in recent decades. However, there was no statistically significant trend in season onset at both stations and P-values were > 0.05. The general trends at both weather stations indicate great inter-annual variability for the last three to five decades. Also, the coefficient variability (CV) at both stations for MAM rain season are found to be low at 18%.

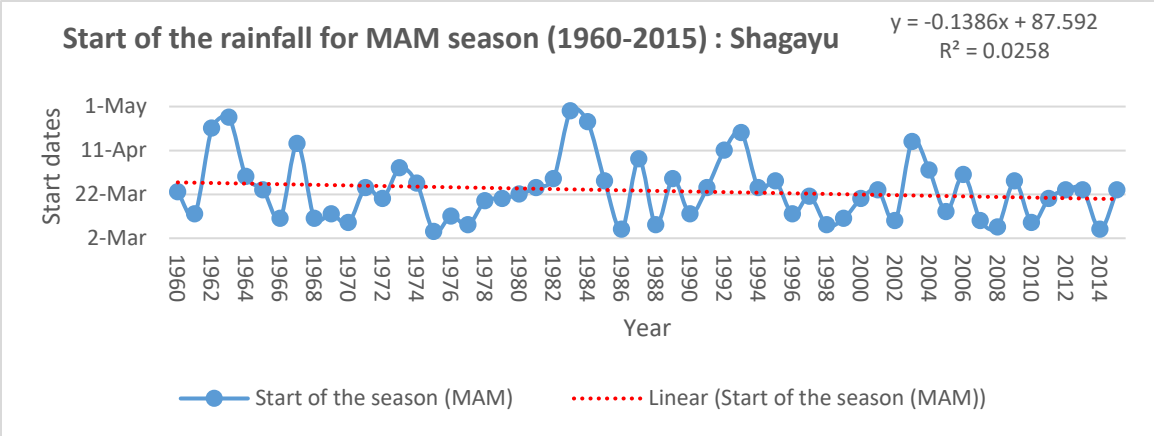

Figure 22: Rainfall onset (MAM) at Shagayu weather station
Data Source: TMA 2017

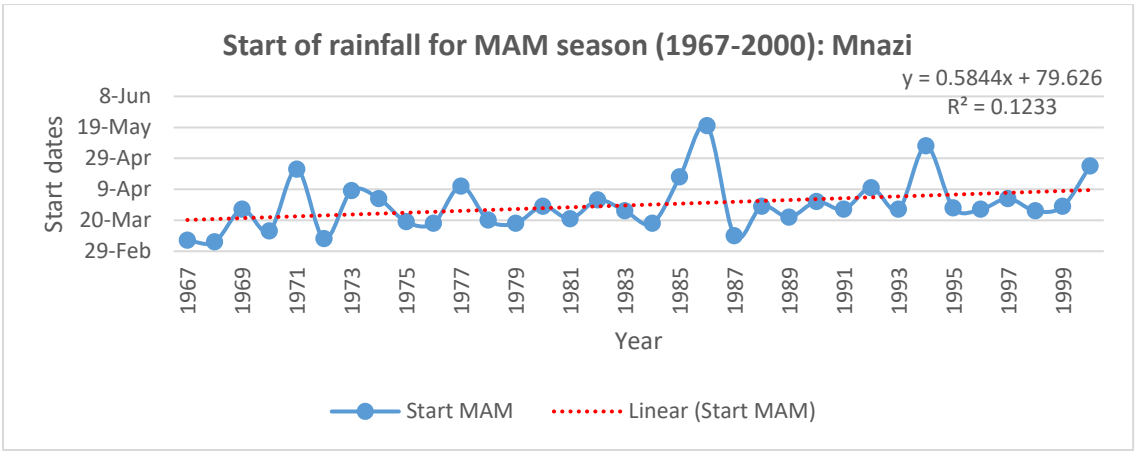

Figure 23: Rainfall onsets (MAM) at Mnazi weather station
Data source: TMA 2017

Figures 24 and 25 present the season onset for OND rain for Shagayu and Mnazi weather stations for the past 55 and 33 years respectively. The findings indicate inter-annual variability of OND season onset. Figure 24 shows that on average, rainfall onset starts in the first week of November. This has a slight difference in figure 25 here the average rainfall onset is in the third week of November. Cases for early onset of the rainfall are very few at Mnazi station and include years of 1982 (7th October) and 1990 (8th October). On the other hand, at Shagayu station, early onsets were in 1965 (7th October), 1977 (6th October) 1982 (11th October) and 1997 (5th October).

At Shagayu station incidences related to late-onset were not common, except for a few years such as 1962 (onset was 27th November), 2003 (onset was on 26th November) and 2007 (onset was on 9th December). Contrary to these findings, at Mnazi station the trend has indicated some years of late onset. For example, for a period of 33 years (1967-2000) the OND season onset has indicated ten years of late onset. Some of these years are: 1970 (onset was 3rd December), 1971 (onset was 2nd December), 1974 (onset was 2nd December), 1975 (onset was 26th December), 1976 (onset was 19th December), 1992 (onset was 14th December), 1993 (onset was 12th December), 1996 (onset was on 25th December), 1999 (onset was 21st December) and 2000 (onset was 3rd December). While the trend test showed an apparent increasing trend in onset date it was not statistically significant. Other relevant previous studies on annual and seasonal rainfall trends in East Africa showed an insignificant decrease with more annual and seasonal rainfall variability (Omoyo et al., 2015; Opiyo et al., 2014; Kansiime et al., 2013).

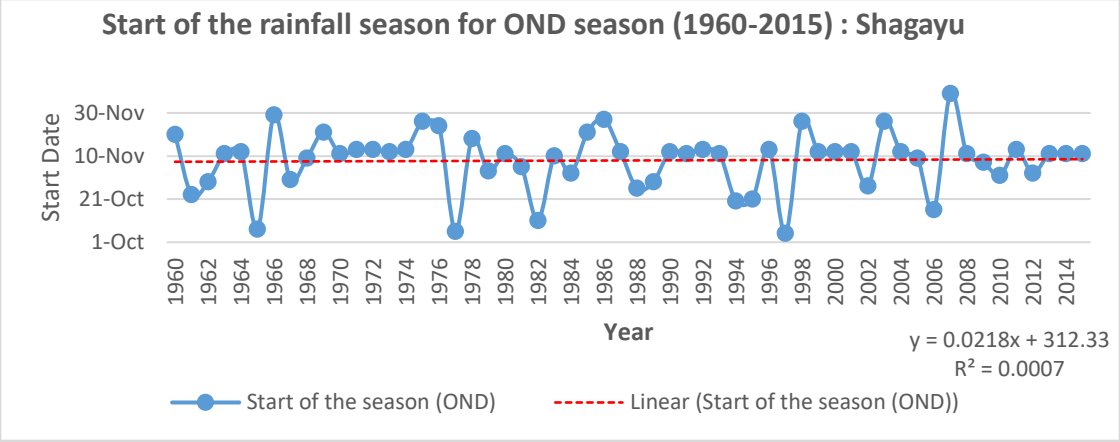

Figure 24: Rainfall onsets (OND) at Shagayu weather station
Source: TMA 2017

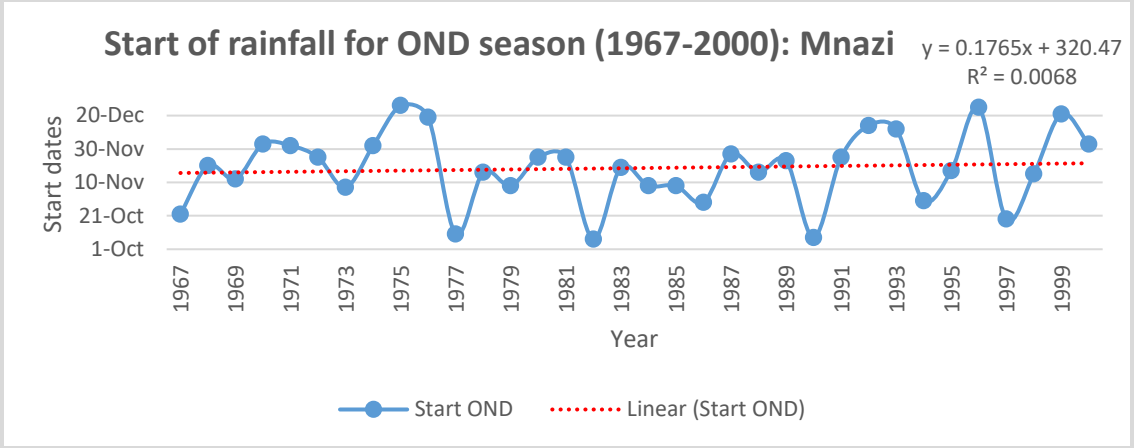

Figure 25: Rainfall onsets (OND) at Mnazi weather station
Data source: TMA 2017

4.3.3.2 Observed cessation of the rain season

Results indicate that for the MAM rainfall season the average cessation dates are in the first week 1st to 7th of June for both stations. However, at Shagayu station, early cessation was recorded in some years such as 2004 (cession was 20th May), 2009 (cessation was 19th May), 2013 (cessation was 15th May) and 2015 (cessation was 15th May). This indicates that there has been inter-annual variability of rainfall cessation in the last decade, and it increases with time (Figure 26). At Mnazi station, early cessation was recorded in the years of 1993 (cessation was 16th May) and 1999 (cessation was 15th May).

On late cessation, for the studied 55 years at Shagayu a limited percentage of years had above average cessation dates that range between 1st-7th June. For example, Figure 23 indicates that only 11% of 55 years recorded late cessation dates, including the years of 1966 (20th June), 1967 (18th June), 1968 (2nd July), 1997 (27th June) and 1998 (1st July). Mnazi station had only limited incidences of late cessation of the season (Figure 27)

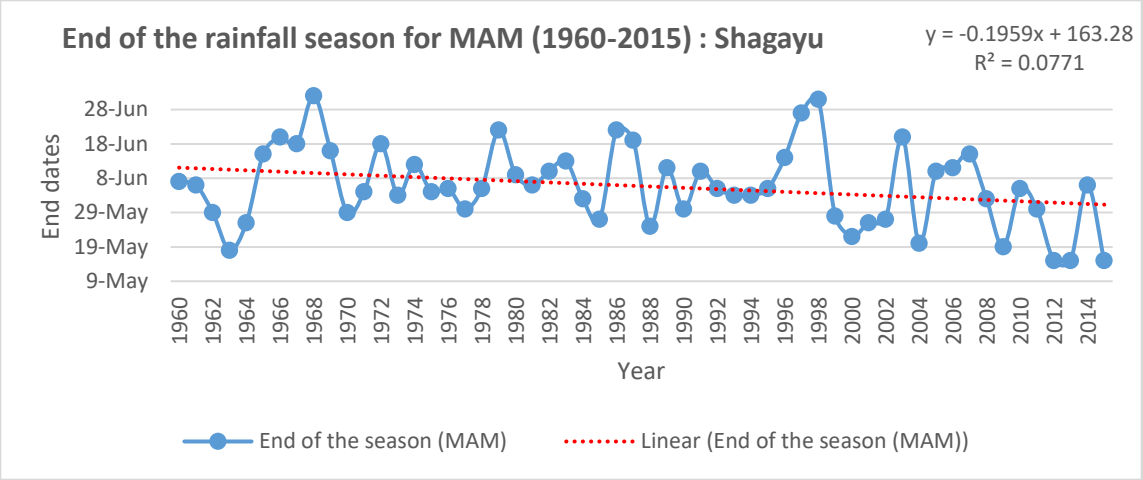

Figure 24: Rainfall cessation (MAM) at Shagayu weather station

Data source: TMA 2017

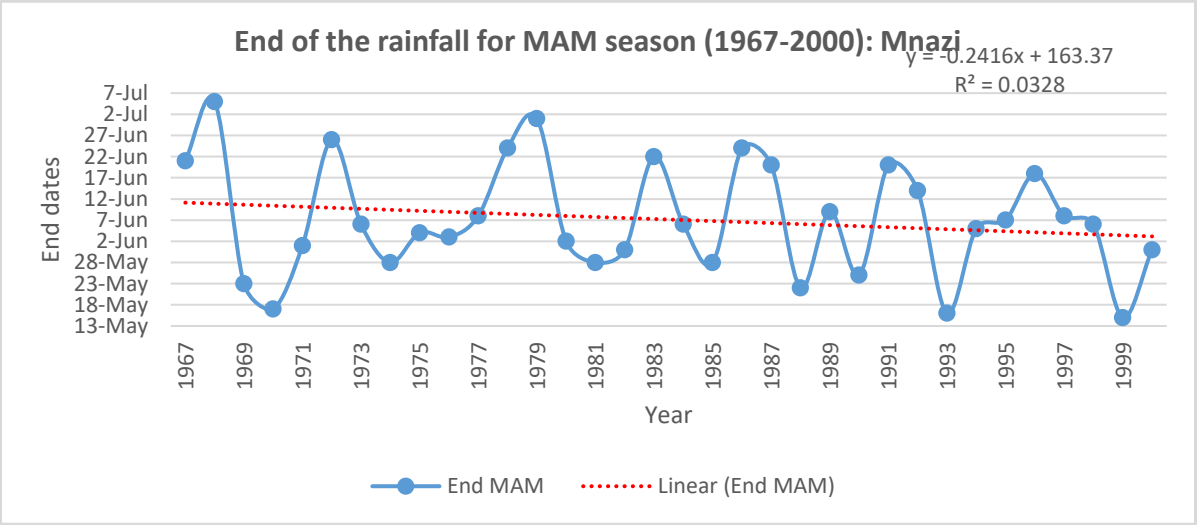

Figure 25: Rainfall cessation (MAM) at Mnazi weather station

Data source: TMA 2017

On the other hand, OND rainfall cessation dates at both stations showed inter-annual variability. The average season cessation dates at Shagayu station range between 8th -14th December (Figure 26), while at Mnazi, the average cessation date was between 26th-30th December. However, there were incidences where the rain season had late cessation. For example, from the year 1967-1969 and 1972-1979 the season cessation was in the first week of January (Figure 27).

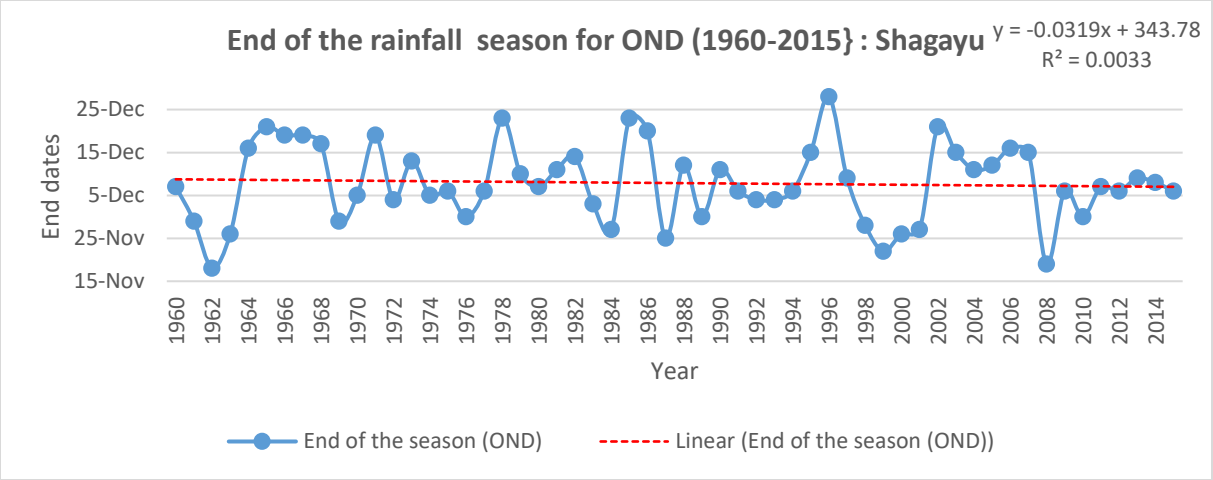

Figure 26: Rainfall cessation (OND) at Shagayu weather station

Source: TMA 2017

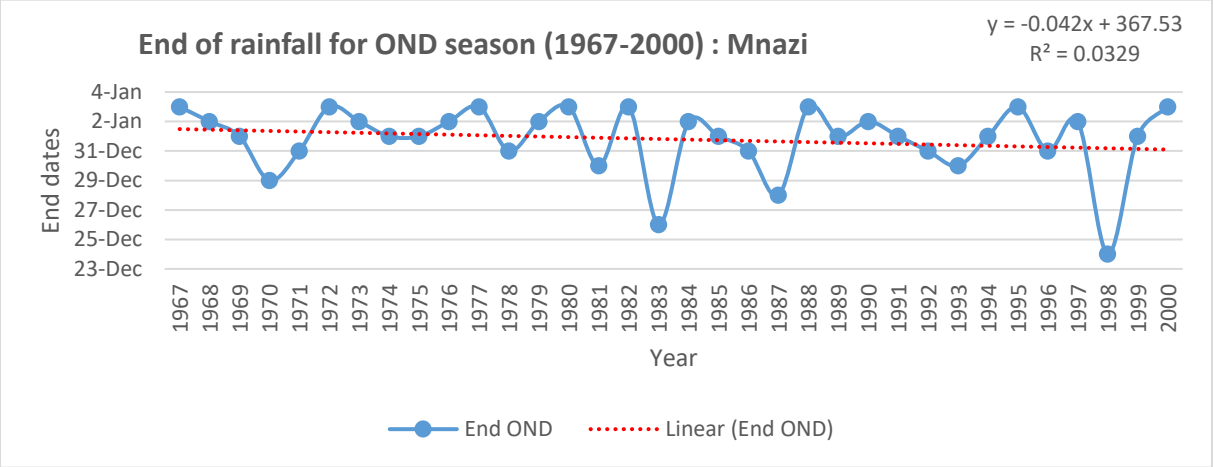

Figure 27: Rainfall cessation (OND) at Mnazi weather station
Source: TMA 2017

The trend test and linear regression showed apparent decreasing trends but they proved to be statistically insignificant. In other words, there is no statistical evidence that rain seasons are starting later and or ending sooner. This implies that other factors such as rainfall distribution and land use change may be affecting water availability and livelihood activities.

4.3.3.3 Length of the rainfall season

The results on the length of rain seasons for both OND and MAM at both stations indicate inter-annual variability (Figure 28 and Figure 29). These trends are influenced by variability in onset and cessation dates as seen in the sub-sections above. The average length of the MAM season at Shagayu

station is 75 days while at Mnazi station it is 71 days. Looking at the number of days, there is little difference in season length between stations despite their different locations. However, there is a larger difference in the average OND season length between the two stations. At Shagayu station the average length of the OND season is 30 days while at Mnazi it is 44 days. Trend tests for significance have showed no statistically significant changes in the length of the rainfall seasons at both stations. However, the analysis of OND rainfall shows that Mnazi has a high CV of 51% and Shagayu has a CV of 55%. Both indicate that the length of rain season is highly variable. For the MAM rains the analysis shows Shagayu had a 26% CV while Mnazi had a CV of 33% which is less variable at both stations.

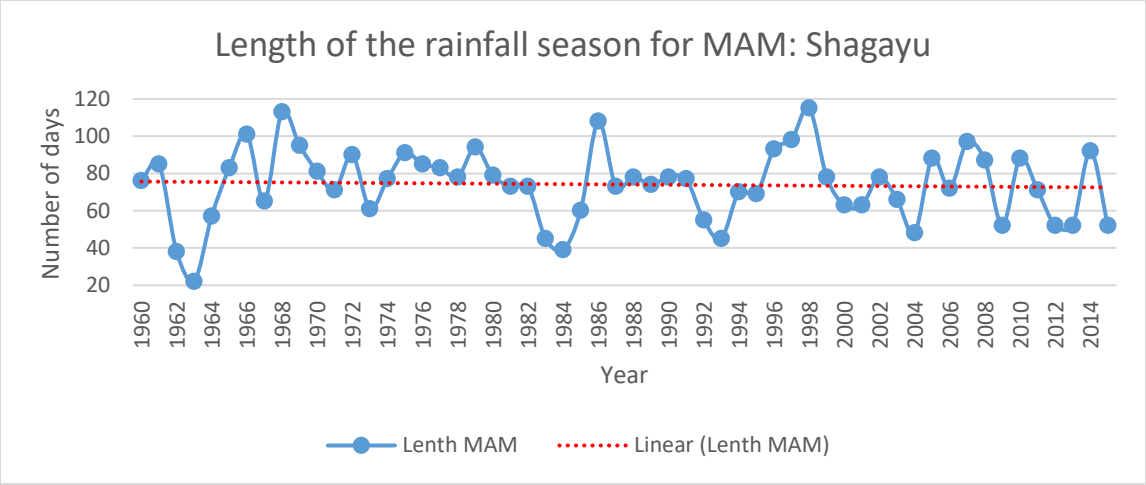

Figure 28: Length of the rain season (MAM) at Shagayu weather station
Data source: TMA 2017

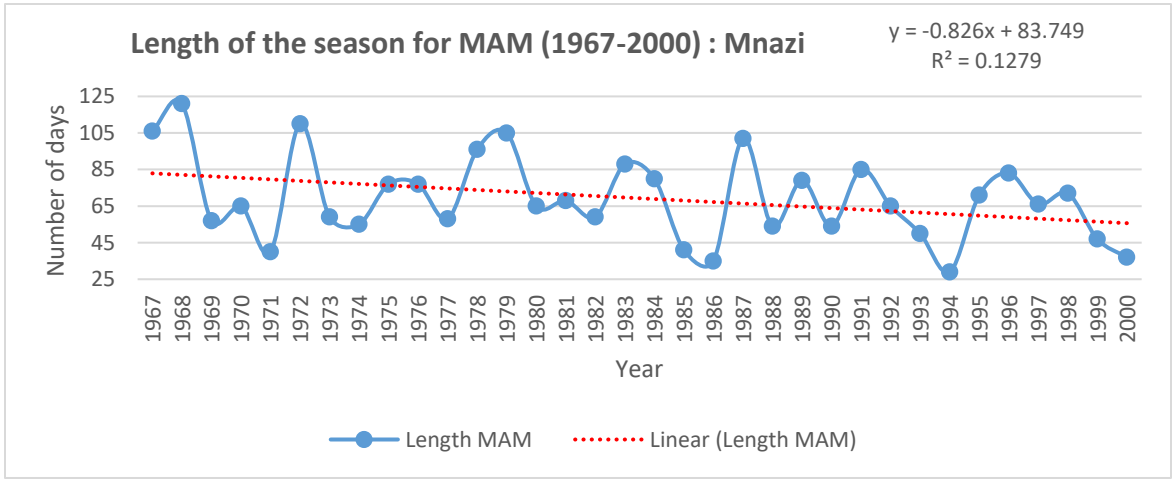

Figure 29: Length of the rain season (MAM) at Mnazi weather station
Data source: TMA 2017

4.4 Discussion

4.4.1 Impacts of LULCC on water resources

Results have indicated that the study area has experienced significant LULCC for the last 40 years. The most dominating land use categories include scattered cultivated land, bushland, grassland, settlement area, woodland, cultivated land, swamp, natural forests and plantation forests. Deforestation due to agricultural expansion activities (FAO, 2011) is highly pronounced in the study areas and may be among the reasons for water scarcity. This conforms to the findings by Guzha et al. (2018) that deforestation and expansion of farms lead to reduced water flows as a result of reduced infiltration and poor groundwater recharge. Liu et al. (2015) and Kashagili et al. (2007) found that limited water availability and low water flows are influenced by both vegetation and human activities upstream. The availability and scarcity of water after deforestation is determined by the intensity and magnitude of soil disturbances. This is in line with Gabiri et al. (2019), finding that undisturbed land with old vegetation cover has high infiltration rates because of enhanced soil porosity due to plant root activity. Under this situation surface runoff is strongly reduced while recharging ground water and enhancing lateral flow. Given the major changes in LULCC observed in the study area especially upstream and off-stream, it is clear that impacts on water resources may be linked to related factors such as effects on infiltration and soil erosion. This is in line with the conclusions of Carocci et al. (2009) that the impacts of LULCC on water resources are influenced by soil infiltrability and vegetation age. In the upstream and off-stream areas with reduced vegetation cover, steep slopes and clay soil may have led to accelerated runoff, i.e. faster water flow downstream leaving upstream and off-stream villages with no reliable water from baseflow especially during the dry seasons. Indeed, the impacts of LULCC which happen upstream have significant effects on sub-catchment processes over a range of temporal and spatial scales (Gumindoga et al., 2018). On the other hand, deep and porous soil (Guzha et al., 2018), deposited to relatively flat slopes covered with vegetation in the downstream villages, may have contributed to greater groundwater recharge compared to the upstream. It is very important to remember that water challenges are not influenced by LULCC alone. Other factors such as landscape features, population increase, climate change and or variability may also lead to water scarcity at catchment and sub-catchment level (Mwangi et al., 2017).

The 1761% increase of settlement area and 395% increase of scattered cultivated land in the study area indicate increasing expansion of human activities that led to encroachments on rivers, water sources and forests. Furthermore, bushland, grassland and natural forests within 60 m of rivers were the most affected by agricultural expansion in villages located upstream and downstream. Villages

located upstream These findings align well to those of Guzha et al. (2018), that most of the LULCC in watersheds of East Africa is due to smallholder farmers who tend to dominate those areas during the dry seasons for agricultural activities and end up creating settlements. However, analysing the causes of LULCC in the study area needs a special attention, as drivers are complex. Lambin et al. (2003) found that land use changes at local scales are driven by a combination of factors that include; population growth that lead to competition to limited resources, opportunities created by markets, weak institutions that fail to enforce law and policies, low capacity to adapt to changes caused by climate change/variability and local attitudes. This chapter exclusively focussed on the potential impacts of LULCC and climate change/variability on water availability.

4.4.2 Impacts of climate change/variability on water resources

The reliability, performance and consistency of rainfall have a great role to play in shaping water availability. The seasonal and strong interannual and intraseasonal variabilities of rains have an influence on both water availability and local livelihood activities. Results have revealed that rainfall in the study area is bimodal whereby the short-term rain season (OND) starts in the second to third week (11th-22nd) of October and ends in the last week of December. The long-term rain season (MAM) starts in the second week of March and ends in late May. The long rains have the heaviest period in April in almost all villages and play a great role in rain-fed farming that is common in the study area (Mahoo et al., 2015). Results show interannual and intraseasonal variability of rainfall in terms of amount, onset, cessation and length of the season (Tables 11 -12). The CV for start and end dates is relatively low and there are no significant trends in terms of late arrival or early cessation of rains despite the existence of variabilities.

Table 11: Rainfall onset and cessation dates in the upstream area of the Umba River (1960 – 2015)

Type of rain season	Average onset dates	Average cessation date	Average length of the rain season (days)
MAM	10th-20th March	1st -5th June	75
OND	1st-10th November	1st-6th December	30

Data source: TMA for Shagayu weather station, 2017

Table 12: Rainfall onset and cessation dates in the downstream area of the Umba River (1967 – 2000)

Type of rain season	Average onset dates	Average cessation date	Average length of the rain season (days)
MAM	20th-25th March	1st -5th June	71
OND	10st-20th November	20th-25th December	45

Data Source: TMA for Mnazi weather station, 2017

Results from Table 11 indicate that the rainfall onset dates of OND season are between 10th-20th November and that the average length of the rain season is 45 days. However, the analysis shows that due to interannual variability there are some years such as 1975 with very late season onset (26th December) and cessation was on 1st January. This means the length of the rain season was only 6 days. This was followed by the years 1977 and 1992 in which the lengths of the rainy seasons were only 14 days. The years 1993 and 1996 had OND rainfall seasons of 14 and 6 days respectively. Moyo et al. (2017) found that areas that experience low rainfall will face moisture stress and, in that situation, farmers should plant faster-maturing crop varieties. However, in the context of 6 to 14 days for rain seasons, it is not easy to grow anything. In this case, only irrigation can serve the purpose.

Rainfall patterns in the study area, while appearing to show a decline in annual means in line with other East African studies (Ndesanjo, 2017; Nicholson et al., 2018), are highly variable and trends are not significant. The apparent declining rainfall trend in most parts of East Africa is linked to Indian Ocean warming and is expected to continue (Rowel et al., 2015). The spatial declining pattern of rainfall trends is likely to affect farming yields, water resources and pasture. The extremes analyses using SPI have indicated clearly the increase of drought events in recent years and trend test has shown to be statistically significant. Some observable dry events are seen at Shagayu station which indicates extreme drought for three consecutive years; 2013, 2014 and 2015, while the year 2012 fall in the very dry category. On the other hand, Mnazi station had recorded two extreme droughts and five very dry events. These events must inevitably affect water resources in the study area.

4.5 Chapter summary

The chapter has assessed the potential impacts of the changes in land use and climate on water resources and livelihoods in the Umba River sub-catchment. GIS and remote sensing tools were employed for detecting land use and land cover change in relation to water resource availability and livelihoods for the period of 1975 to 2015. Furthermore, the study has presented and discussed the

role of climate variability/change in shaping water availability and livelihood in the study area. The non-parametric Mann-Kendall test has been used for determine whether there is significant or no in the trend in the annual rains. SPI was used to analyze the dry and wet events.

Results have shown that, for the last 40 years (1975-2015) the Umba River sub-catchment has experienced significant changes in terms of land use and land cover. The most dominant land use categories include scattered cultivated land, bushland, grassland, settlement area, woodland, cultivated land, swamp, natural forests and plantation forests. Expansion of agriculture, settlements and deforestation are the most important changes. Much of the natural forests have been converted into cultivated land and settlements.

Results have shown a 1761% increase in settlement area which indicates that the area is experiencing population growth and that the growth is most likely linked to other activities that led to expansion of livelihood activities and water demands. It was in the same period of time when bushland, grassland and natural forests within 60 m of rivers were mostly affected. This further indicated a clear relationship between population growth, settlement and agricultural expansion and land use change across the whole study area and specifically within 60 m from the riverbanks. The overall changes can be further connected to both water and land challenges in the study area.

The drivers of LULCC especially within 60 m of rivers were found to include; first, growth of populations that has increased demands for agricultural land and settlement area, second is changes in rainfall patterns due to climate variability that forces communities to find areas where they can practice irrigation farming.

Trends suggest that annual mean rainfall appears to be declining but the Mann-Kendall test did not detect any statistically significant trend ($P > 0.05$). Nevertheless, annual extreme events assessed using SPI for 55 and 33 years at Shagayu and Mnazi indicated that the Umba River sub-catchment is increasingly experiencing more drought events compared to wet events and the trend test has proved to be statistically significant (P- value < 0.05).

The seasonal analysis indicates interseasonal and intraseasonal variability of rainfall in terms of amount, onset, cessation and length of the season. In terms of the amount of annual mean, results show the apparent decreasing trend with time was not statistically significant.

Results from seasonal coefficients of variation showed that both MAM and OND show slight variability for onset and cessation dates. However, at both stations the length of the OND season is highly variable with a CV of 51% at Mnazi and 55% at Shagayu. MAM season length is less variable than OND at both at Mnazi (CV=33%) and Shagayu (CV=26).

Therefore, both changes in land use and climate are evident in the study. Both climate change and land use change have potential to have major impacts on water availability and livelihoods in the study area. Changes in natural forest into cultivated land have left the land bare and potentially highly vulnerable to erosion and poor infiltration. The land use change is likely to have increased surface runoff and possibly reduced ground water recharge and baseflows, a situation that may contribute to water scarcity for the long term.

CHAPTER 5
SOCIO-ECONMIC PROFILE AND LIVELIHOOD SYSTEMS

5.1 Chapter introduction

The chapter starts by presenting the socio-economic profiles of households in the Umba area. The chapter gives an account of history, policy and current tenure systems of land and water as inseparable natural capitals in the Umba. The data come from household surveys, group discussions, key informant interviews, PCA, field observations and relevant literature. I argue that; policies and history of tenure systems on land and water have played a great role in shaping the way households interact with water and land resources. The chapter also presents and discusses the villagisation initiative and its impacts on natural resource management and tenure systems in the Umba area. I argue that the tenure systems for land and water have been dynamic and have shaped how these resources are managed and conserved. Available livelihood capitals/assets and water demands and use in the study area are also presented. The available actors in the areas are identified along with their role in resource management, and I finish with a summary of the chapter. This chapter gives information and context that are crucial for thorough analysis and discussion of other empirical chapters, especially chapters 6 and 7. This chapter also brings up the Umba River sub-catchment for the first time as an example into the ongoing debate around linkages between complex climate-human-ecosystem interactions and how they shape ways in which households use livelihood capitals and develop livelihood strategies at a local scale. A resilience lens has been used to trace and understand human-nature interactions and household livelihood assets, history and policies within the Umba area.

5.2 Socio-economic profile

The socio-economic profile is a prerequisite to the study as it gives a clear understanding of the households under study. Fakere et al., (2017) observe that socio-economic profiles have the power to determine and define how households and individuals will access and utilize livelihood capitals. Studies have documented socio-economic profiles that have influenced natural resource and water access at the community level. For instance, Egyir (2007) asserts that the socio-economic factors affecting collection and distribution of Allanblackia spp in Ghana included gender, age, origin (ethnicity), marital status, family size, occupation type and wealth status. Allanblackia spp is a tree species found in natural forests of Sub Saharan Africa regions of which its seeds are used for making cooking oil and soap.

Mngumi (2016) identified and documented age, sex, level of education of the household head, occupation and size of the household to be crucial in the Mwanga District of Tanzania for deciding types of crops and other livelihood activities. King (2011) identifies space, age, educational level, tenure status and nature of household income as important factors that influence natural resource access and use in Mzinti village in South Africa.

In this thesis the socio-economic profile covers; education, sex, income sources and membership to different institutions (formal and informal). Institutions are considered in this chapter because King (2011) and Boelens et al., (2016) found that institutions can influence how households' access and use natural resources.

63% of all respondents across the study area were men and women made up only 37%. Further to that, the household survey has shown that many men have more than one wife. Men reported during the survey that having more than one wife is prestigious and source of labour. Looking at the given reasons for why one man should get married to more than one wife, I link this with patriarchal perceptions and dogma (Masoga and Shokane, 2016). A majority (87%) of respondents during the household survey were married (not necessarily official marriage, but living together).

This finding corroborates the findings of Fakere et al. (2017) and Jordaan et al. (2019) that most of the household heads are male, with almost twice as many as female household heads. In addition, 88 % of respondents were married while singles, divorced, separated, and widows/widowers were few. Songoro (2014) did a comparable study in the nearby villages and argued that families in Usambara are intact with few separations and divorces, while the few single-headed families are due to death. The household survey also showed that the culture does not allow a woman to separate from her first husband, even if there are misunderstandings. That could be one of the factors behind the low occurrence of separation and divorces. The household survey showed that the average ages of the respondents across villages were between 30-45 years, suggesting that the area has enough labour if well utilised.

Results from questionnaires showed that middle stream villages had 85 % of household heads with primary education, while 79% had attained primary education in the upstream villages. Downstream villages had 81% of household heads who had primary education. For off-stream villages, 68% of

household heads had attained primary education. The middle stream villages had only 6% of households' heads with no-formal education (had never attended any school), while the upstream and downstream villages had 8% each. The off-stream villages had 28% of household heads with no formal education. According to respondents from off-stream villages, the low level of education is due to limited schools and relevant infrastructure. In all studied villages a very few (7.5%) respondents had any secondary or tertiary education. This finding shows that the level of education of respondents in the study area is generally low, which concurs with wider literature on education levels in rural Tanzania. For example, Pauline (2015) argues that the education level of household heads in most of the surveyed villages in the Great Ruaha of Tanzania was only primary education, which indicates that the education level is low. For them to be able to utilize effectively the available livelihood assets, education level of the household plays a great role (King, 2011). It is argued that the attained level of education at household and community level is fundamental for building a prosperous society. In this context, scholars such as Ma et al. (2018) and Baiyegunhi et al. (2016) assert that households with low education and located far away from water sources had low capabilities for making choices on both livelihood activities and strategies and hence had limited opportunities to ensure sustainability. I argue that, as human-environmental interactions become more complex and dynamic it is important to give greater opportunities for education from an early age through to higher levels of education could assist in building and strengthening resilience in the future.

The household surveys show that the middle stream villages had 56% of respondents with membership of Village Community Banks (VICOBA), the upstream had 39% while the downstream villages had 52% of respondents. In off- stream villages, only 23% had membership to VICOBA and 21% of respondents were members of other informal small women serving groups. In this thesis, VICOBA refers to micro-finance and grassroots lending schemes which focus on low income community members through encouraging savings and access to micro loans needed for innovative income generating activities (Chipindula and Mwanga, 2015; Kato and Kratzer, 2013). Studies have documented how VICOBA schemes have empowered rural communities and especially women (Kato and Kratzer, 2013; Dobra, 2011). VICOBA allows poor people and women in particular to access financial services and use them innovatively to increase their economic gains (Dobra, 2011). In the study area, VICOBA were found to be receiving no external financial support but are based on members mobilized financial assets. People come together and contribute seed money which is used as startup funds which then keep on growing as people take loans and return with some interest.

Women with membership to VICOBA reported to have received empowerment skills and training on how to invest the loans they get to increase income and be able to contribute to household income and well-being. According to Dobra (2011) and Lushakuzi et al., (2017) VICOBA has positive social impacts for women's empowerment through self-employment, acquiring assets, diversification of livelihood activities and sources of income and promoting self-confidence needed for development. To support the above presentation on the role of VICOBA to women's empowerment and livelihood diversification, one woman said;

> "Through VICOBA, I was able to support my children by paying school fees and managed to open this shop. No need to wait for my husband to provide money anymore." **(Respondent HH137, Mwangoi village, 13th November 2016).**

For villages near the central sub-catchment; the downstream villages had 47% of respondents who are in Water Users Associations (WUA), while the middle stream villages had 41%, and upstream villages had 21% of respondents with membership to WUA. The off-stream villages had no membership to WUA due to lack of water sources and rivers. 5% of the respondents in the sample reported using financial services such as having bank accounts or accessing credit and these were people working as teachers, nurses or government employees. People with access to financial services such as banks in the middle stream area where VICOBA members.

5.2.1 Households' wealth

It is important to understand the wealth of the households (Kabede, 2009) as it determines how households interact and use livelihood capitals especially natural capitals. Table 14 summarizes the household's wealth owned by the family. Households were asked to group themselves according to wealth status, i.e. poor category, middle category and rich category (see Table 14).

Results by both FGDs and key informants showed that 71% in all areas considered themselves to belong to the poor wealth categories. Conversely, few respondents (1.5%) mainly from the middle stream and downstream considered themselves relatively rich. During the wealth ranking exercises in working groups, it was mentioned that the female-headed households in all parts of the sub catchment were ranked as poor. One of the reasons for such a result was mentioned that women have limited livelihood opportunities. This is comparable with the finding by Flato et al. (2016) that, female-headed households have remained poor because they have generally limited opportunities. In most cases, both culture and institutions have remained with the mindset that women are weak and that sources of

community development should come through men (Suhiyini et al., 2018). Even though ownership of materials was considered to depict the social status of respondents and put them into relatively poor categories, households headed by men who had more than one wife believed that they were relatively rich. An old man who was a key informant from Mng'aro village reported that many wives means wealth and adequate labour to men. However, in literature, there is ongoing debate that, although having more than one wife is still allowed by traditional culture in the sub Saharan African region, in most cases it is accompanied with conflicts and unequal treatment among spouses and especially the first wife who is always disadvantaged (Baloyi, 2013; Masoga and Shokane, 2016) and western church believers regard it as a pagan practice. I argue that, in the study area context, the assertion that having many wives means giving women rights is used to fulfil men's desire to use their wives to meet labour demands in farms. Women interviewed expressed concerns that they were not happy being the second wives and the marriage is associated with competition and conflicts with the first wife. Masoga and Shokane (2016) assert that there is still a challenge to balance cultural practices such as polygamy and safeguarding women's rights.

During FGDs, 47% of respondents who are located in the middle and downstream villages see themselves as richer than those who are found up and off stream. The reasons behind this differ depending on the location. The increase of material wealth in these areas was attributed to their location where they have relatively sufficient land for farming activities especially in downstream villages, while the middle stream is located along the main road to Lushoto town and people are engaged in petty business. The role of space and location of households and livelihoods access was well documented by King (2011) and Boelens et al. (2016) by arguing that historical spatial patterns and territories created by institutions and unbalanced power are likely to influence and shape natural resources access or lack of access. King (2011) adds that, as access to natural resources and opportunities remain central, location of the target stakeholders is crucial in shaping access.

Table 13: Households' wealth

Poor	Middle	Rich
No house or house of bad quality	Mud house or thatched with grass	Bunt bricks and thatched with iron sheets
No access for irrigation farms	Access or owned irrigation farms	Owned more irrigation farms
Food insufficient Little land for cultivation, usually no irrigation farms	At least food sufficient Land for cultivation and sometimes practice irrigation farming	Practically food security Enough land for cultivation and practice irrigation farming and grow crops each season
Limited financial resources	Can pay health services, school fees	Can pay health services, school fees
Limited labour force	Have labour force	Enough labour force
Use poor cultivation tools such as hand hoe	Use hand hoe for cultivation but can hire irrigation machine	Use hand hoe, but has irrigation machine and pays casual labour
Does not own a mobile phone	Own at least a bicycle, mobile phone, motorbike, goats, etc.	Own irrigation machine, car, farms, cattle, goats
Some household head is female	Household head is male with 2 wives	Household head is male with 2 or more wives

Source: Field survey, 2016

On the other hand, within the study area, there are spatial differences in wealth status. Discussions and comparison of location specific issues with key respondents revealed that 87% of households located in the off-stream considered themselves poor with limited access to resources. Upstream villages scored 73%, while the middle stream scored 57%. The downstream villages scored only 21% and are considered by key informants to be wealthy as they have relatively fertile land for cultivation and have traditional and more modern irrigation infrastructures. Informants indicated that households categorized in the middle and rich groups have enough resources to buy water-pumping generators for irrigation and have money to buy assets compared with their poor household counterparts. This finding corroborates Walelign and Jiao (2017) in finding that, despite the greater reliance of poor households on natural resources especially land and water, in most cases middle and richer households are able to extract more resources and benefit more than the poor. Respondents in the discussions revealed that those who are considered poor have limited access to resources and are in danger to even lose the little they have, especially during drought years with poor harvests. The situation was reported to be worse where the head of household is a woman. Women were found to

have limited access to productive means/assets and during prolonged droughts they would sell household properties including land.

5.2.2 Main livelihood occupation of the households

This study probed respondents to mention the activities in which they were involved to make their living and income sources. Various numbers of activities were mentioned as presented in Table 15, showing where they are common in the study village. The most mentioned livelihood activities included farming, petty business, livestock keeping, waged jobs, apiculture, self-employment and casual labour.

The farming activities are found in all studied villages and are at a small scale whereby households grow seasonal crops such as beans, maize and those villages located in the sub-catchment are growing vegetables such as cabbages, tomatoes and spinach to meet external market demands in cities such as Tanga and Dar es Salaam. In addition, people located in the middle stream had shops where they sell several items. Livestock keeping is common in the downstream areas due to the availability of free pasture and water. The large number of teachers for both secondary and primary schools, police and nurses were found in villages located in the middle and downstream areas which are located along the main roads and closer to small towns. Casual labour was provided by some farmers who had limited resources and were considered poor, where they were working in farms owned by teachers, nurses and or police and relatively rich people. Self-employment was common among the youth who were engaged in transport and carpentry.

Chamicha (2015) asserts that, alongside farming, other rural livelihood sources include keeping cattle, casual labour, shops, carpentry and government and religious services or jobs such as teacher, priest, imam, nurse, guard and extension worker. In the study villages, the guards were found in the middle stream villages where there is a centre known as Mwangoi where they were assuring security for shops. Interrogation with one old man who was the guards revealed that, some were employed by individual people who are relatively rich while others were employed and paid by groups of people with small shops and are paid per month. According to this guard, the money from other shops is collected by one person and given to the guard at the end of each month. However, these people have no employment contracts and everything is based on trust.

Table 14: Categories of household livelihood activities

Category of activities	Examples mentioned	Location
Farming	Growing crops for subsistence and income	All streams and off stream
Livestock	Keeping cattle, goats, sheep and poultry	Middle stream, downstream
Apiculture	Keeping bees for honey but at small scale	
Small scale businesses	Selling prepared food (*mama ntilie*), selling shops Commercial enterprises (e.g. kiosk, bar, guest houses)	Middle stream and downstream
Waged jobs	Agriculture extension officer, teacher, nurse Ward /village executive officer, politician, technician	Middle stream and downstream, downstream
Self-employment	Producing and selling charcoal Handicraft, Brick making Transport (*boda boda*/commuter bus/*daladala*)	All streams and off stream
Casual labour	Working in others farms	Up and off stream

Source: Field survey, 2016

Discussions with key informants and in FGDs revealed that although the majority of households (79%) are farmers, at least 15% across villages also do livestock keeping and casual labour, due to land and water shortages. These findings are comparable to Netar (2017) that in rural areas of developing countries, 75-85% of the total population rely on agriculture as a source of income and livelihood. Results show that people with waged jobs also had shops and had irrigation farms where they employ people to work for them. Some households had members who are self-employed, and or are employed as teachers and nurses.

5.3 Tenure systems and relevant policies

In the study area, land cannot be easily separated from other natural capitals such as water and forests. In that sense, a clear definition of land is important (Katani, 2010). The Tanzanian Land Act and Village Land Act number 4 and number 5 respectively defines the term "land" to include "the surface of the earth and earth below the surface including all substances with the exception of minerals and petroleum that form part of below surface, things that grow naturally on land and structure affixed to land". Therefore, water and plantation forests are part of the land but the natural forests are not part of this definition. However, in daily practices people consider both planted and natural forests to be part of their land (Katani, 2010). This sub-section will look at tenure systems and policies related to land and water.

5.3.1 Land policy and land tenure system

For the last 50 years, the land tenure system in the study area has undergone several historical changes that are linked to land changes at a national level. Back before colonialism, chiefs and head of tribes controlled and owned land and had responsibility to grant land for clans and individual households (Izumi, 1999). Results from key informants show that the chiefs were also responsible for solving related conflicts in their areas (Arntzen et al., 1986). However, during the German colonial era, all land in the country was declared crown land (Lange, 2008) whereby all fertile land areas in the Umba and Usambara highlands were alienated from local communities for establishment of settler plantations (Katani, 2010). In that process all fertile land owned by chiefs and customary land laws came under colonial state power (Kessy, 1998). Kessy adds that, after 1919 when the British conquered the German empire, the land was declared public but the power remained with the Governor. However, customary law and the use of chiefs helped the colonial administration in rural areas where they could not reach easily. The government after independence inherited and maintained public land from British colonial masters by just replacing the governor with the president. The chieftainship who had responsibility of land allocation under customary laws was abolished in 1963 (Lange, 2008). Abolishment of the chieftainship is criticised by several scholars in that it weakened customary laws and contributed largely to the unsustainable use of land and natural resources in rural areas, as formal institutions are not well established in those areas (Katani, 2010; Kessy, 1998; Sheridan, 2004). In most cases, the degraded land is that which is considered to be owned by nobody and or not in use at that moment. Since 1963, Tanzania has witnessed several changes of land law that intended to fit in with changing political philosophies and reforms in the economy at different times, such as the villagisation programme of the 1970s and community participation in natural resource management during the 1990s. At present, the land rights in the study area and in Tanzania as a country are granted either under statutory or customary laws (Katani, 2010). Under statutory laws the rights are approved in the name of the head of the country "the president". Together with the certificate of occupancy, the rights can be either granted to individuals or corporate bodies. On the other hand, under customary laws the right is inherited but is recognised by the Village Land Act No. 5 of 1999. Under Land Act No. 5 customary land rights are deemed rights to citizens and are according to the custom of a given tribe. The adjudication of customary land rights is vested in the village council and if required, can be assisted by the district council (URT, 1999). According to Katani (2010) the Village Land Act No. 5 is mandated to translate the customary ownership of land into a written document known as *Hati Miliki ya Kimila* (certificate of customary right of occupancy) which intends to ensure security of land

ownership by either individual, families, clans or any other recognized groups. While land rights under statutory law have a limit of either 33 or 99 years, the customary land rights have no time limit and are in respect of the customs of a given tribe (Kessy, 1998). One of the challenges with land ownership in relation to water resources, is that while the Water Resource Management Act of 2009 stipulates that customary land rights have the force of law in communities, a customary water right is equivalent to a statutorily issued water right, but at a point where water becomes scarce in a village, people fight to make sure water remains a public property and not otherwise (Wily et al., 2017).

5.3.2 Relevant water tenure and policies

Like land rights, water rights, can be traced back before colonialism in the 16th century. During that time, water sources and rivers were conserved and safeguarded under customary laws (Maganga et al. 2002). Chiefs and heads of clans had power over water rights and sometimes arranged patrols to ensure water sources were protected as required (Van Koppen, et al., 2004). It was during the German colonial regime that formal water rights were introduced (Van Koppen et al., 2004) and rights were vested in the authority of governors to safeguard colonial interests (Rajabu and Mahoo, 2008). This system was maintained by British colonial settlers under the Water Ordinance of 1923 (Rajabu and Mahoo, 2008) and by then it was only for irrigation farms in Kilimanjaro. The Water Ordinance of 1948 was enacted during the period of indirect rule systems of governing the then Tanganyika. Under this law the entire rights over water was vested to the governor of Tanganyika (Maganga et al., 2004; Kabudi, 2005). The law continued recognizing the water rights of native Africans to divert, abstract and or use water in accordance to their customary laws but only to ensure water for rural users (URT, 2006; Lein and Tegseth, 2009). In 1959 a Water Ordinance was passed by the colonial government which revised all water rights and removed customary law (Katani, 2010). This law created institutions responsible for water supplies for both rural and urban areas and was binding to the government departments. Under this law every one with an existing water right was strictly supposed to declare that right and make sure it was registered.

As with land rights, after independence in 1961, the new leadership inherited and maintained the colonial Water Ordinance (Maganga et al., 2002) and the authority was transferred to the president of the country. Since then, Tanzania has taken several initiatives that aimed at improving relevant policies including insisting on enhancing participation of beneficiaries (URT, 2006).

There was also a very notable event when the government proclaimed the 20-year rural water supply programme (1971-1991). An important aspect was that domestic water should be accessible within 400 metres (URT, 2006; Van Koppen et al. 2004). However, that has never been achieved, with reasons including inter alia the non-involvement of the beneficiaries, a top-down approach and a lack of decentralisation (URT, 2006; Maganga et al. 2002). As a way to take into account the reasons learnt from the failure, the current National Water Policy was adopted in 2002 (Maganga, et al., 2002) and emphasises community participation, decentralised management and cost sharing (URT, 2006). Furthermore, under this policy and the current relevant Water Resource Management Act No 11 2009, "water right" is granted by other government officials on behalf of the president (Lein and Tegseth, 2009, Kabudi, 2005; Katani, 2010). Some scholars document that both the policy and Act recognize the importance of customary laws, however, the challenge remains on government officials being observant to give the required attention which customary laws deserve (Juma and Mganga, 2005; Katani, 2010). Here the argument is that, as relevant institutions have limited staff and resources to reach all rural villages, the requisite attention to customary laws would have helped to address water challenges.

On the other hand, even though in the study area, focus group discussion in the sub-catchment indicated that 70% of the respondents knew the linkages between maintaining sub-catchment lands and protecting water sources, mechanisms and resources are seldom in place to translate that conceptual link into solid support for water management in the public interest (Kabudi, 2005; Songoro, 2014). This situation has had two consequences; the first is increased conflicts between those who own land near water sources on one part and the public on the other part. Each group claims to have rights to exploit the resources according to their requirements without interference. Second is the rate of degradation, which has caused many water resources that fall in private land to experience land use changes and hence causing water shortage in most of the villages and among other water users. Compared to other rural places in Tanzania, the value of land in the Umba sub-catchment is very high because of the high population and land itself being scarce. Most of the people are renting land from those who have enough or who are not ready to grow crops. Renting is common in the lowland areas, popularly known as *vitivo*. These are areas with fertile land and have water that can be used for irrigation. Those who rent these areas have to utilize them if they are to get back their money. At this point land degradation becomes more pronounced and water is over utilized causing conflicts among stakeholders.

5.3.3 Villagisation programme

In the early 1970s, Tanzania set a path towards socialism and self-reliance, with villagisation as a vital element (Lorgen, 1999). At the beginning the idea was implemented slowly and on a voluntary basis, but later, force was applied. Scholars like Shao (1986) compared the villagisation programme with the South African apatheid policy of robbing ancestral land from African populations and forcing them onto unfertile and arid land. This is supported by the fact that this programme caused millions of Tanzanians to leave their ancestral land. As of December 1976, about eleven million rural people had left their villages of origin to new areas where they had to establish new villages. This was approximately 70% of the whole population living in Tanzania at the time. According to Lorgen, (1999), the idea behind villagilisation was to ensure provision of social services to citizens in rural areas.

Discussions with key informants at Mng'aro village showed that most of the villages found downstream, such as Mng'aro, Mnazi and Lunguza, were formed during the villagisation initiative of the 1970s. However, villages found in the middle stream and upper stream areas of this study were not involved because they were already well established or the land was no longer available in other places. In this process, some villages such as Makangara village were totally closed as people were forced to move to Mng'aro and Lunguza villages where they could easily get water and practise agriculture. However, one of the old men who was young at the time says;

> "…..it was one of difficult times and I can not forget it, soldiers were forcing us to shift even at night, many people slept under trees. Some villages such as Makangara were totally closed." **An old person from Mng'aro village, 14th March 2017**

The above quote corroborates the argument by Shao (1986) that, in the process of moving to new settlements, the government used military and excessive force which violated people's rights and their properties. For instance, farmers who relied on annual crops regardless of crop status were moved to resettlements with the exception of perennial crops such as coffee and bananas. Houses and other properties were destroyed by the government to discourage moving back (Lorgen, 1999).

Scholars such as Kikula (1997) have established that the villagisation process had negative impacts on natural resources especially land, water and forest resources. The process promoted more natural resource competition and mismanagement of water resources (Franks et al., 2004). New villagers had to cut down forests to get construction materials for their new homes and this had impacts to both land and water resources. Kikula (1997) further documented that planners did not consider the issues

around soil and water. It was during and after villagisation that places with concentrated settlements with intensive and or unplanned cultivation, including areas such as the Umba subcatchment, started experiencing ecological issues such as deforestation and land degradation. It is argued that villagisation is at the essence of encroachments on water resources in the study area and seems to be associated with land use changes, depletion of vegetation cover due to deforestation and soil erosion.

Kikula's findings corroborate well with findings from both key informants and focus group discussions across villages that, during the villagisation period, unplanned new farms were established near forests or in forests themselves, a situation that increased deforestation and water resources encroachment rates. In the downstream areas, overgrazing was reported by key informants also to have emerged as a result of villagisation. In the Umba, the process caused loss of long term development informal institutions and people lost control of their grandfathers' water sources (Katani, 2010). The process also affected clan and family land and water ownership under customary laws, while elders were introduced to new land and left all their ancestors and rituals behind.

5.4 Actors and their interventions

During FGDs respondents mentioned existing and past actors who have worked in the area especially in water, land and forest interventions. Although all actors aimed at natural resource management, some intended to address soil erosion and improve land management while other were focused on conserving water sources, while some did both: water and land management. The mentioned actors are categorised into; Non-Government Organisation (NGOs), religious actors, international actors, informal and government owned actors. Formal and informal institutions will be discussed in detail in Chapters 6 and 7.

i. Non-Governmental Organisations

Key informants and FGDs identified three NGOs, which are Climate Action Network Tanzania (CAN TZ), Friends of Usambara and Climate Change, Agriculture and Food Security (CCAFS) still working in the area. CAN TZ is working with villages in the middle stream to conserve water sources. The informants reported that the organisation is involved in training both local government and village leaders and some selected villagers on integrated water and climate services for water and food security. Among other things, the work involves planting local and water friendly trees such as *mkuyu (Ficus sycomous), mvumo (Birassus aethiopum) and Muombeombe (Hallea rubrastepulata)* around water sources

and fencing endangered ones for rejuvenation. The Friends of Usambara works with local villages on planting indigenous trees on steep slopes to avoid further erosion. Friends of Usambara is dominant in the upstream villages. CCAFS is more documenting and conducting research studies on climate smart agriculture.

ii. Religious actors

Informants revealed that most people in the Umba are Muslims and that existing actors are linked to the Islamic religion across the study area. The roles of Islamic actors were linked to water and land management that include planting water friendly trees. However, in the upstream villages there is a Catholic Church parish which has a group of believers who are engaged in both water and land conservation.

iii. International actors

International organisations include the German Development Agency GIZ and the World Bank. While GIZ was involved in conservation and controlling land degradation (see Appendix 7), the World Bank is involved in water supply to the rural communities. However, these projects and initiatives have never managed to address the challenge in question (Mascarenhas, 2000), due to weak institutions and being top-down projects. These actors are concentrated in the upstream and middle stream villages.

It was reported that in the downstream areas, the Food and Agriculture Oragnisation of the United Nations was involved in supporting farmers on paddy rice research and development of irrigation infrastructure in the 1970s, as an intervention to the villagisation programme. However, at the moment no external actor was reported to be working there.

5.5 Forms of livelihood capitals

Quandt, (2018) and Habtemariam et al. (2018) argue that, at the household level, the assets available constitute a stock of capital and can be increased, stored, replaced or exhausted. In addition, Liu et al. (2018) establish that livelihood strategies of rural households depend upon the conditions of their livelihood capitals. Thus, understanding livelihood capitals of households helps in understanding livelihood conditions of that particular household. Building on the approaches of Rakodi (1999), Carney et al. (1999) and Bebbington (1999) I present and discuss the types of livelihood capitals possessed by households within the study villages.

5.5.1 Natural capital

In the study area three main natural capitals were mentioned by the respondents, which include; land, water resources and forest resources.

5.5.1.1 Land resources

In the upstream villages 57 (Goka village 32 and Kiranga village 15) participants responded to the household questionnaire and participated in the focus group discussions, of which 55 respondents (94%) had land ranging between 1.5 to 2.4 hectares. These are very small pieces of land for households that depend solely on farming for living. In the upstream, respondents were complaining that the government took a large piece of land during the establishment of Shagayu forest reserve and now they want it back as the population has increased. 72% of the respondents indicated that their land is very small, unfertile and stony. They also added that their land has is no longer productive due to being over cultivated, soil erosion and limited application of agricultural inputs such as fertilisers. It was revealed from participants that, in the villages, agricultural inputs are expensive and poor households cannot afford them.

In the middle stream, 73 participants responded to the household questionnaire, and 55 respondents (76%) owned 0.5 to 2 hectares of land. They complained that their piece of land is too small to produce enough food for the family throughout the year. A woman (HH189, 53 years of age) reported that;

> "As you can see our farms are very small and our family members are many. This farm is unfertile and cannot produce enough family food for the whole year. In this case, we have two options; one is to offer casual labour get money and buy food or go to friends downstream and rent 0.5 hectares where we can grow crops to meet family food demand". (**Respondent HH137, Dule M village, 29th November 2016)**

In the downstream areas, 72% of 118 households had land ranging from 1.5 to 2 hectares, 24% owned land of 2.5 to 3 hectares and 4% had land of 3 to 5 hectares.

Respondents revealed that, in the 1990s, a household could own land of more than 10 hectares but due to population growth, influx of people from outside to buy land and expansion of the prison barracks area, their land has decreased significantly. They mentioned that some families have even sold land to be able to take their children to secondary schools. They revealed, although their land is still relatively fertile, the increase of prolonged drought events, soil erosion and decrease of water in

the Umba River has decreased their agricultural produce. They also reported that some households are now experiencing food shortage. Respondent HH 223 with 73 years of aged claimed that;

> "In the 1960s, the whole settlements and farms you see used to be natural forests and anyone could clear bushes and open up a new farm. But now that is not possible as our population has increased especially because of immigrants who come for our fertile land, the prison barracks has also expanded their territories to acquire more land for agriculture. Conflicts on land resources are increasing now and then among neighbours. I am not sure how the situation will look like in ten years to come" (**Respondent HH 223, Lunguza village, 29th March 2017)**

In the off-stream villages, 93 participants who engaged in answering the questionnaire reported that the land owned by households was very small, with 92% of all households having less than 1 hectare which was used for agriculture. 8% of households which were regarded as relatively rich had land of more than 1 hectare but not more than 1.5 hectares. As in the upstream areas, the land was reported to be unfertile and stony. Respondents revealed that their villages face food shortages every year and some households have shifted to downstream or to other districts where they either offer casual labour in farms owned by people from town and cities, or they rent land to grow both food and cash crops.

5.5.1.2 Forest resources

In upstream villages, 97% of all 57 participants revealed that, for many years Shagayu forest has been sustaining their livelihoods by providing firewood, house thatch grasses and wildlife animals. They added that, from about 20 years ago the government increased conditions for accessing anything from the forest and one is to get permission from the authority, which takes time to get or they don't get it at all. Furthermore, respondents said, the reasons for introducing conditions was that people from the village were encroaching and degrading the forest resource. However, one of the respondents mentioned that the colonial government declared it as a reserve in the 1910s and since then it has been difficult to get it back even after independence, and now people have nowhere to live and grow crops. The responded HH157 said;

> "The forest land that was taken because of our uneducated grandfathers, the colonial government took Shagayu forestland, now Tanzania is independent we need the government to declare that forest to be used for farming and settlement" (**Responded HH157, Goka village, 8th July 2017)**

Both middle stream and off-stream villages reported having no forest. In the off-stream areas it was revealed that the only forest they had was degraded to zero and now the area is used as a village. They said it disappeared in the 1980s and people cut down all the trees and sold charcoal to towns and

divided the land among themselves. The remaining few patches of forest are in inaccessible locations which are on top of steep hills.

Respondents from downstream were reported to border the natural protected forest of Mkomazi which also has wildlife animals. Like in the upstream, respondents were complaining that they are not allowed to take anything from those forests especially getting firewood and growing crops during dry seasons, as these areas have some wetlands and fertile soil. They also complained about the frequent increase of protected land into their villages. In FGDs, one thing stood out at Lunguza village, that they understood the restriction of people to use protected forest resources is because some people misuse them and cause heavy deforestation.

5.5.1.3 Water resources

The upstream villages revealed that in recent years where rainfall became unreliable (refer also chapter 4) and is coming very late and ends abruptly, water from Shagayu forest is no longer reliable in sustaining their livelihood activities, especially irrigation farming. Five key informants out of 7 explained that since the early 1990s, water from Shagayu forest has decreased due to the increase of water users and due to encroachments. They associated this situation with land use and land cover changes that have changed most of the forest and catchment areas into settlement and farming areas. This was detected in chapter 4 that, for the last 40 years, the upstream areas have experienced significant land use change. In the upstream areas, only 22% of households in Goka village had water pipes but water was not coming out. During my visits and stay in upstream villages, I only saw water twice out of six occasions. This suggests that water supply has decreased at the source. The key informant reported that some water users take more water using fueled generators than what the source could supply, resulting in a lack of water for others. Furthermore, due to degradation of the environment in villages, some river springs and sources have dried out and Longoi stream which used to be a permanent stream has changed to seasonal since the 1990s.

In downstream villages, it was reported in group discussions that the sources of water they use for irrigation and domestic purposes originate from upstream and have decreased significantly for the last 10 years. They complained that the decrease of water has affected their livelihood activities and irrigation farming in particular. It was reported during FGDs that other villages upstream are enjoying access to natural resources and their services while downstream groups are suffering the scarcity of

the same resource and as a result, this has been causing tension and related conflicts. One of the key informants insisted that the district and relevant authority only pays any attention to supplying water to people with power, politicians and rich people. This indicates that people who are in the village's governing elite and politicians had higher chances to access water and land resources than those who are not connected to that group. Boelens et al. (2016) argue that limiting one group's access to water resources while favouring the other has increased dispossession of vulnerable groups and their livelihoods. This has created and increased social and environmental inequities (Roa-García, 2014), and could be termed as hydrosocial territories. On the other hand, the key informant ascertained that due to land degradation, cultivating near water sources, especially in upstream areas, has forced some households to shift to downstream for farming activities. This situation is reported by key informants to increase land demands and more tensions on water resources downstream.

In the middle and off-stream villages, it was pointed out in FGDs that these villages have acute water scarcity and especially in the off-stream villages. Respondents added that, due to limited land and water resources associated with low agricultural productivity some farmers engage in other activities apart from farming. The mentioned activity by the reporters included brick making, which takes place around riverbanks. According to the reporter, the bricks are made near riverbanks to avoid water costs. However, to burn the bricks made logs/wood of trees are cut and transported from forests, which are very far from where bricks are made. These logs are reported to be important during the burning of bricks but indeed their use increases the rate of forest degradation.

Based on the information from key informants, focus group discussions and household surveys, it can be established that, in the study area, the availability, utilization and use of natural resources (water, land and forest) across all villages tends to enhance households' livelihoods and one cannot easily separate them as they are interlinked. The utilization of forest resources is linked to water resources and land. However, the way these resources are utilized has created another unintended crisis such as degradation and migration to other places (Nawrotzki et al. 2012). The most affected villages are those located off-stream where the overutilization and degradation of forest and land has led to disappearance of water sources and river springs. The decrease of natural capitals in the middle stream, upstream and off-stream areas has resulted in the migration of people to downstream where they are opening more unsustainable irrigation farming and other activities, while those who cannot get land are offering casual labour to farms owned by people from Tanga, Lushoto and Dar es Salaam towns.

5.5.2 Social capital

Rakodi (1999) uses a practical example from Tanzania and argues that, in practice, in rural Tanzania social capital includes unity and spirit of participation, collective activity, connection with external groups and availability of village institutions such as courts, schools and markets. In the study area both traditional and religious beliefs exist and play a great role in uniting people, and promoting water resource conservation. Omobola (2014) asserts that both traditional and religious institutions are strong in rural areas and influence each other and people's culture.

In the off-stream villages, respondents from both key informant interviews and focus group discussions expressed the opinion that their social capital is linked with religion, whereby people who are in the same religions meet and discuss social and economic challenges and or opportunities together. It was also reported in group discussions that social capital is linked to neighbourhood, kinship and being in village social groups. Other network groups included VICOBA and funeral groups which are responsible for comforting each other in the case of loss of family members. However, it was reported that social networks are influenced by the wealth status a household has. In Hemtoye village, the household survey showed that households that are in the middle and rich wealth category have their social networks and are connected to other people of the same category outside the villages. The same finding was revealed in other villages under study. This has weakened social relationships within the village. The reasons given for why some who became rich change social relationships with relatively poor households, include the response that;

> 'You know my son… those who are slightly rich have created other friends and social networks with people of their level'. (**Respondent HH13, Mwangoi village, 30th November 2016**)

According to the heads of households, people who have invested in paddy and vegetables, hence becoming relatively rich, have created their own category and slowly weaken their social relationship with those in the poor category. These findings are in line with Paarlberg et al., (2018) and Rothstein and Uslaner (2005), that people with different social and economic classes have less likelihood to share a set of common interests or values, and that situation weakens their relationship with time. According to Cooper et al. (2013) one of the factors that weakens social relations is increasing inequalities that makes one side feel powerless and disadvantaged in competition for natural resources. Across the study villages, those who were considered poor had feelings that people in the relatively rich category were taking much water and land at the expense of the poor.

During focus group discussions in off-stream villages, it was reported that customary laws had a great role to play in strengthening social relationships for a long time at community and household levels. However, customary laws and their associated institutions are slowly dwindling in the public domain. For example, in Kwekifinyu (a village with acute water scarcity) a woman aged 71 years said that:

> "My son this village has no water I can tell you. All the water sources we conserved through our customary laws have disappeared. In those days one of our customary law was not kill anything/living organism and to not disturb the ecosystem around rivers unless is agreed by the whole village. This belief intended to show god that we are united to care a lot to the nature and will provide more water and for long time". **(Respondent HH123, Kwekifinyu village, 25th November, 2016)**

Results show customary laws and beliefs are still practised in villages and play a role in uniting people and solving social problems (Maganga et al. 2004), such as water and land conflicts, death and sometimes marriages. This finding links well to Maritz et al. (2013) and early work by Ostrom (1990) that strong customary laws are able to expedite collective actions and make local management of common resources possible. Across the sub-catchment, KII respondents confirmed that despite the challenges in maintaining social connections in villages, social links still play a great role including being sources of information. Key informants explained that people with social connections could have opportunities to get information on good crops and or varieties compared to those with limited links, as such information could be announced in the churches, mosques or in informal groups. Those with limited connections end up having no reliable access to resilient seeds then are subjected to risks and harsh climate.

In fact, in the downstream villages, social connections were reported by key informant respondents to be important in acquiring land and getting water for irrigation and hence reduce livelihood challenges. Key informants informed me that upstream and off stream farmers who shift to other places for land and water depend on social connections. The information gathered from key informants was that some households that have social links beyond their villages are assisted during illness, theft of farming tools and drought.

Information from both key informants and FGDs reveals that, in the study area, social capital is linked to social relations, connections, trust, unity and association activity. In all villages, most existing and strong social connections and links are more related to religious and social matters compared to social-economic group. On the other hand, customary laws still exist in villages and play a role in information sharing on improved crops, weather forecasts, and in social events such as weddings and funerals.

Household surveys showed that the few who are able to use social capital better, have managed to acquire land and irrigation farms in the downstream areas where they have in turn diversified their livelihoods and hence economies. I argue that, when well utilized, social capital can increase collective responsibility and accomplishments and could contribute to increasing household and community resilience.

5.5.3 Financial capital

As described by Godwin (2003), financial capital has high potential to facilitate economic production, and can lead to ownership or control of physical and natural assets. These are wealth resources such as cash, savings and credits that are useful in making household livelihood aims possible (Berge et al., 2011; Bee, 2007). Across villages, 86% of respondents from household surveys reported that financial capital is a challenging resource for households in the study areas because what they produce is sometimes not enough for households' consumption.

Household surveys indicated that 92% of all respondents from upstream and 94% from off stream villages where land and water shortage are critical, stated that it is not easy for them to get financial capital as most of the time they have little agricultural products to sell. Respondents added that, in the off-stream, farmers produce less that cannot even meet household food demands. This limits opportunities to get cash that could be used for livelihood diversification by investing in other non-farm activities. In the middle stream villages, 53% of households have access to financial resources as they are engaged in petty business and selling agricultural products. They buy crops from farmers downstream at a lower price and sell to people at a slightly higher price. Results show that women are more engaged in this business compared to men. They get soft loans from women serving revolving funds as well as VICOBA and they return the agreed amount at the end of each month so that other members also could access loans. The key informant insisted that, in order to access a loan, one needs to be a member and pay an agreed entry fee. The loan could take up to six months.

A woman from downstream put it clearly that;

> "As you can see here we have limited land and our area is becoming a small town which means depending of farming is not possible any more. In 2008 I realized that my fellow women who are members to VICOBA have more access to cash than farmers and those who are not members. I joined in the same year and now I ask for some cash and put it in my business I established as a result of getting profit from buying and selling crops. For sure I cannot complain I have access to cash and I no longer depend on farming " (**Key informant and VICOBA member, Mwangoi village, 23rd November 2016**).

Although, in the downstream areas, households were not engaging in buying and selling crops, the serving and revolving groups and VICOBA exist and were supporting farmers to buy improved crops and hire labour. It appears as if they have divided responsibilities within the sub-catchment, whereby the downstream households use financial capital to engage in production of crops as they have relatively fertile soil for agriculture, then after harvest they sell the surplus in cash to middle stream people who are engaged in buying and selling crops. However, 87% of all downstream respondents reported that, most of the livelihood activities where the majority of households are engaged are not bringing adequate financial returns that could be reinvested for further growth. They said after selling crops, most of the cash is used at home for buying clothes, family food, salt and soaps. They added that, how much is saved for future use and reinvestment depends on how much a household earned and if the price of crops was good and if the market was favourable. A key informant revealed that, across villages, lack of financial capital limits households' chances to reinvest in alternative livelihood options, especially small business. She added that;

> "… even those who dare to reinvest the little amount they get; they face challenges of droughts, market and competition with those with more experience and enough financial capital. At the end, even the small cash they had disappears" (**In-depth interview, Mung'aro, 18th March 2017**).

5% of all respondents across villages have access to formal financial services that include having bank accounts and a large number of them are found in the middle stream villages. This is similar to the studies of Katikiro (2014) and Bee (2007) who found that in rural Mtwara and Babati districts there was limited access to formal financial services by only 2.5% and 5% of people respectively. Most of the people who have acces to formal bank services are living near village centres (especially in the middle stream villages) and are either working as school teachers, nurses, business people and retired officers. This implies that the remaining majority (95%) do not have a tradition of saving in financial institutions. According to the household survey across the study villages, 78% of respondents cannot qualify for access to credits because they have no registered collaterals needed by financial institutions.

In the study area, the financial capital plays a great role for households especially in buying improved crops and sustenance of livelihoods. For the household to access financial capital one needs to have fertile land for agriculture that can produce surplus food for market and family, be a member of community banks to get soft loans, or provide casual labour for those few who have cash. However, a limited number of people can access financial capital as majority live in unfertile land, with small

pieces of land which are also affected by prolonged droughts. Unlike men, women were members of VICOBA and group revolving funds which assisted them to buy and sell crops and then pay back their loans. This has high potential to empower women if well utilized (Bee, 2007; Chipindula and Mwanga, 2015). It was requested by most of women's groups for having trainers of the trainees so that they are able to increase their knowledge and expertise on financial capital in the rural areas. Kato and Kratzer (2013) assert that when rural women who are members of VICOBA are given training on how to innovatively generate incomes, they can indeed contribute to economic growth of their families and communities and ensure social empowerment.

5.5.4 Human capital

Human capital is considered to include capacities of individuals who are innovative, knowledgeable, productive and capable to use skills both inherited and or acquired through training to bring socioeconomic development in the community (DFID, 2000). In the context of the study area, human capital includes stock of habits, knowledge, social attributes and expertise that influence and or guide the livelihood option choices at household and village levels.

Key informants revealed that, in the upstream and off stream villages, household heads had limited skills especially on understanding their livelihood activities and how to deal with associated challenges. In addition, from household surveys across villages, results showed that 67% of interviewed household heads had limited skills and understanding on connecting their livelihood activities with market demands especially outside their villages, as well as entrepreneurial skills.

Across villages, as shown in section 5.2, 80 % and 8 % of respondents had primary and no formal education respectively. The key informant reported that, since most people in the study villages have only primary education and some have no formal education, they cannot join the political elite as one may need certain skills, socio-economic capital and exposure. The key informant further added that;

> "…as you are aware managing current livelihood challenges including land shortage, water challenges and prolonged droughts requires skills as such interpreting climate information offered by extension workers and taking informed decisions. However, those skills are missing and that is why many households are suffering poverty" (**In-depth interview, Lushoto District Council, 14th March 2017**).

It was reported by the key informant that a household that has no such skills was likely to suffer from hunger and poverty especially during drought years. Human capital is also affected by diseases such as HIV/AIDS and malaria.

Results from household surveys show that households which had members with formal education, had well diversified livelihoods and had several sources of income including shops. I witnessed shops, irrigated farms and *bodaboda* (motor cycles) mostly owned by either a teacher or a nurse. This indicates that educated household heads have several sources of income. However, this was a small number (2-3%) of the households visited in all villages. Being able to generate income, these households had some financial flow and were able to buy fertile and productive land and access other natural resources such as water. The key informants also revealed that household heads with formal education had connections to political elites and district officers. Hence, they can get first-hand information regarding any opportunity arising in the village, such as taking part in data collection and remuneration during the national census, crop markets outside of the country and being appointed to represent others at district levels and committees.

Overall, information gathered from focus group discussions and key informants across villages, reveals that human capital is not yet well developed. 80% of heads of households have only primary education, which may not even have been completed as some dropped out. The limited number of well-trained personnel leads into limited options and techniques to diversify livelihoods, which lead to unsustainable utilization of natural resources and hence their degradation. This increases the vulnerability of the responsible community. The significant land use and land cover change that was observed in chapter 4 could be linked to human capital. A good example is from off-stream villagers who have degraded the only forest they had in the village that led to the disappearance of water sources and increased poverty levels and vulnerability. In addition, human capital is connected to the availability of resources in a certain locality. Hence, in villages where water and land are scarce, even trained workers such as teachers, extension workers, police and nurses refused to take posts from the government. This situation causes these areas to remain underdeveloped and disadvantaged. It was suggested by respondents that the creation of community learning centres could reduce the problem.

5.5.5 Physical capital

In principle, there is a close relationship between improved infrastructure and livelihood opportunities at household and community levels (DFID, 1999). Improved infrastructures play a great role in stimulating efficiency that supports movement of agricultural and other related inputs and outputs, communication networks, transport of labour and energy to markets and production sites. However, like in many parts of the rural Tanzanian mainland (Ndulu, 2006), I observed that in the upstream and off stream villages basic infrastructure such as roads and communication networks were less developed. I observed that, only a few routes in the middle and downstream areas are served with earth /mud (unpaved) roads and or gravel roads to provide access to small towns and urban markets especially in Lushoto town and Tanga City. Discussion with key informants revealed that most of these roads are not passable during *masika* (rainy) season.

Results from key informants show that 90% of households where the study was conducted, with the exception of middle stream villages which are near the Mlalo to Lushoto gravel road, are far away from the connecting roads. During the field visit I witnessed many villages and especially off-stream villages having no reliable road which can be used throughout the year and had no transaction service. The off-stream areas also have neither market place nor post-harvest storage facilities. One of the respondents expressed that;

> "……in this village (Dule M) we have no post-harvest infrastructure and we have been experiencing post-harvest losses. Just to give you an example, last year we lost a lot of potatoes and cabbages as they were so many and the only solution was to give cabbages to people free of charge". (**Respondent HH236, Dule M, 29th November 2016**)

Most of the food processing facilities and milk collection centres are in Mwangoi which is a small town and centres such as in the middle stream villages. FGDs reported that those facilities are privately owned, run to meet business objectives and sometimes farmers cannot afford to use the facilities. As a result, most households reported selling their farm produces in local and sometimes black markets where they get low prices. Off-stream villages have no reliable maize milling machine due to lack of electricity, while it is expensive to transport maize from upstream villages to Mlalo, sometimes one might still find no power to run the milling machines.

In relation to storage infrastructure and market challenges, during my field visits in 2016 at Mung'aro and Dule M villages, I witnessed most households throwing away bags and bags of rotten cabbages,

tomatoes and other vegetables due to lack of markets and storage facilities. In these villages farmers told me that such a situation causes high capital losses to households. They expressed that they were very worried about the losses as they got some loans from friends and some sold their properties to invest in agriculture, but this loss gives no hope anymore and their few remaining properties are likely to be sold to cover the loans if they were to avoid being jailed. The respondents showed their concern that neither the central government nor the local government was committed to intervene in the situation.

On water supply infrastructure, Lushoto as a district depends on gravity schemes (Lushoto District Report, 2016). However, during FGDs and household surveys across villages, 89% of respondents reported to have no reliable water supply due to water volume decreases and disappearance of some water sources. Key informants reported that villages such as Mwangoi, Kiranga and Goka have shallow wells which are facilitated by the mountainous nature of the area. Still, during household surveys a majority of respondents said that more than 90% of households have no water networks and spend much time looking for this important resource. Discussion in groups revealed that in some downstream villages the mountainous nature has allowed water to flow downhill as surface streams and springs that in turn are tapped for different uses. However, the key informant and household surveys reported that water tapping technology is unimproved and does not ensure water availability throughout the year due to prolonged droughts, competing demands and poor infrastructure. On the part of water for irrigation, FGDs reported the situation to be challenging as some of the existing infrastructures are very old and were constructed to serve a limited number of users in the 1970s. I argue that, in rural areas water scarcity and related contestations are linked to power relations and inequalities, prolonged droughts and poor infrastructure and these increase vulnerability of the responsible households and community. This corroborates Hakansson (2019) who concludes that the ability of rural households to cope with droughts differs with time and depends on how these households were integrated into national and regional economies and systems when those droughts occurred. In most cases, the effects of droughts were associated with the processes of stratification in control and access of local resources.

In the context of the study area, physical capitals include roads, water irrigation infrastructures, schools, market places, water storage, post-harvest storage facilities and communication networks. Well-improved roads and other relevant infrastructures including water offer greater potential for

farmers to access markets in time and spend less time looking for water. Since, more than 90% of people are farmers, it was repeatedly mentioned that community post-harvest infrastructures are needed with at least one in each zone (off-stream, upstream, middle stream and downstream). These infrastructures will reduce post-harvest losses that force farmers to sell their produce at any cost, fearing rotting of their agricultural produce. In addition, the area being mountainous with poor roads makes transportation difficult and expensive, especially during rain seasons. This creates a situation whereby most households give up, sell their produce in black markets, and in turn get less money despite the efforts and resources invested.

5.6 Water Resource Use and Demands

In rural areas of Tanzania, the water resource is still playing a fundamental role for both household livelihoods and for sustaining ecosystems (Kangalawe, 2016; Lalika et al., 2017). In the Umba River sub-catchment and its nearby villages, water is a key tool for ensuring wellbeing and livelihoods of most households. Key informants reported that 65% of water resources across the sub-catchment are used for irrigation activities. Most of the irrigated crops are maize, paddy, beans, cabbage and Irish potatoes.

5.6.1 Water resource use and demands in the upstream villages

Key informants reported that the upstream area is where most of the streams that make the main Umba River start and it is the location of Shagayu forest that acts as a source for these rivers and/or streams. The area is mountainous with steep slopes and has some flat land where people grow their crops. The key informant explained that since the land is stony and steep with flat farming areas being limited, farmers tend to encroach on the river to grow their crops. During field visits, I witnessed farms with several crops cultivated in the uplands, bottom valleys and in the available small wetlands. Some of the crops grown were maize, beans and vegetables. The main Umba River had a small amount of water that originates from Shagayu forest. Household questionnaire respondents revealed that in the upstream areas, water is needed and used for irrigation and domestic uses; however, it is not enough to meet the requirements of the villages at the moment. The decline of water in upstream areas was reported during focus group discussions to have affected most of the household livelihood activities, especially irrigation farming activities, which need water to perform better in terms of production.

5.6.2 Water resource use and demand in the middle stream

As in other parts of the sub-catchment, the household surveys indicated that in the middle stream about 60% of households still depend on agricultural activities for their livelihoods but are also engaged in small business as was explained in in the previous section. The household survey showed that 89% of water demands and use activities fall under irrigation and domestic categories. In addition, this area is a semi-town known as Mwangoi, which serves several villages and religious institutions especially Islamic institutions. Therefore, on Friday water is needed in most of the mosques as people from other villages come for worship. Farmers undertake their irrigation farming activities on both riverbanks and water sources. Some of the grown crops include vegetables, maize and cassava. Vegetables are under irrigation and hence need a lot of water. This situation has caused most of the households to compete for water resources and especially during the dry period. In response to water scarcity, households have encroached on the river and opened farms associated with intensive application of pesticides, a situation which pollutes water, while farming interrupts water flow. Results from the analysis of land-use change in chapter 4 showed significant land-use changes in which many areas have been converted into agricultural land and settlements. The key informant was concerned that the national water policy and Environmental Management Act 2004, which declare that no activity should be within 60 m of the river, is not respected.

5.6.3 Water resource use and demand in the lowlands/down stream

This is a large bowl-shaped depression of about 65 square kilometer and it is surrounded by hills (Conte, 2004). In other ways this is a valley bottom area, which has the so-called *vitivo* (*kitivo,* sing.). *Kitivo* is a local name to mean fertile land, especially with alluvial soils, which have been eroded and deposited by the floods of Usambara's mountain streams. The key informant reported that, these areas have attracted the majority of people due to their combination of fertile soil and rather flat areas that can support irrigation farming using locally made water channels. The flat land also attracts pastoralists who come looking for pasture and water. The *vitivo* have a climate which is quite hot and suitable for crops such as maize, rice, sweet potato, beans, sorghum and millet (Conte, 1999). Irrigation farming is part and parcel of water demand and use in several households in this area. During my transect walk and ground truthing, one of the respondents recorded mentioning that;

> "As you can see those green grasses and flat land are good for farming. Most of our water comes from upstream via Mwangoi, Dule and Mlalo town to here. The major water uses here are first to irrigate our farms so that our crops can grow, second is our homes and as you can see cattle depend on this water. Also, note the prison barrack depends on this water. With all

these water users our water is not enough and we are competing every day". **(Respondent, HH177, farmer from downstream, 6th December 2016)**

Information from both key informants and FGDs indicates that as competition intensifies, especially during the dry period (late June to early October), farmers encroach the bank of the river. During field visits and transect walks, I saw several farms which were cultivated near riverbanks, a situation that has caused a lot of siltation and river meander. Establishing farms near water sources and riverbank causes siltation into the river and affects water flow. On the other hand, during the rainy season, water loses its way and flows onto farms causing losses and sometimes floods. One of the respondents reported that;

> "…. the water in the Umba River has decreased compared to 20 years ago, now we have no river but a just a small channel with coloured little water. All these areas used to be part of the River but now are the farms and settlements". **(An old woman from Mng'aro, 5th December 2016)**

Regarding the ongoing situation downstream, 67% of household surveys from Mng'aro village indicated that small rivers such as the Makangara and Bagaya Rivers that feed the main Umba River have changed into seasonal rivers that are totally dry during summer seasons. In addition, household respondents reported that the Makangara has a lot of salt and the water is not good to use domestically, especially during the dry season. However, given the acute shortage of water, most households in Mng'aro village have no alternative but to use salty water from the Makangara River. At the same time, more irrigation farms have been opened by communities upstream, a situation which reduces the amount of water and increases conflicts among water users.

5.6.4 Water resource use and demand in the off-stream villages

The off-stream areas in this study are villages that are located about 10 -25Km away from the main river sub-catchment and have no direct access to Umba River water resources. In the context of this study, Kwekifinyu and Hemtoye were studied. Household survey respondents reported existing water scarcity in their villages. One of the key informants reported that;

> "… to tell you the truth and avoid cheating, there is a huge problem of water in terms of quantity and quality. In short, there is no water in this village. Our water sources have declined in number, and some have disappeared totally. Even those available have no water as demands are higher than what the sources can produce" (**An old woman from Hemtoye village, 13th March 2017).**

In these villages, water was reported during household surveys to be used to meet domestic needs while access could support farming activities and livestock. Some of the crops grown in Hemtoye and Kwekifinyu villages include; maize, tomato, onions, Irish potatoes and beans, but they are grown at a very small scale due to water and land scarcity. Field visits and observations witnessed few river channels that were showing some signs of existence but had no water throughout the day. During FGDs, women reported that water scarcity is accompanied with many challenges that have negative impacts socially and economically for them and their children. Houweling (2015) asserts that in rural areas, women spend a lot of time both on walking and waiting for water at water sources. The situation becomes even tougher during the dry season as water decreases and women have to walk about four kilometers to the shallow wells. Women in the off-stream villages reported having to wake up at 04:00 am so that they can be at the water queue, and have to wait for four to five hours. Women revealed that, during the rainy season (March-May), they have options to get water from several sources. Women are willing to travel to distant wells if they get an impression that the nearby water source has unsuitable water for their family (Yerian et al., 2014; Houweling, 2015). However, they complained that they cannot attend other social and economic events as they spend much time looking for water for their families. Economically, time spent looking for water could have been used for other socio-economic activities such as farming. They reported cases where conflicts happen at water sources due to competition to access water and or because of favoritisms for some women in the queue (Yerian et al., 2014). However, these conflicts are mostly solved through discussion and family or friendly reconciliations (Facius et al., 2008).

5.7 Chapter summary

Chapter 5 has presented and discussed the main socioeconomic features of households and related wealth status in the study area. The livelihood activities in the study area include; farming where all farmers operate at a small scale with limited financial capital, while those with very limited resources are providing casual labour in farms owned by teachers and nurses. The youth are self-employed and mostly in local transport where they work as drivers of motorcycles. While access to financial resources was limited to few people especially those employed as teachers, police, nurses and some business people, the other groups include those with membership to cooperatives, especially VICOBA. Those with access to loans and credits are able to diversify their livelihood portfolio and maintain their living standard as compared to those with no access to loans and credits. While all villages still depend on natural capital especially land, water and forests to sustain their living, these resources are not equally

distributed. Villages located upstream and off-stream have limited fertile land and water resources. However, off-stream villages have the most limited resources as their land is unfertile, stony, most of water sources are dry and villages have no forest. This makes the off-stream villages more vulnerable as compared to other villages. People in these villages shift to downstream villages which have, relatively, enough land for agriculture and can obtain water to support irrigation farming. The current tenure systems and policies for water and land have been found to have a long historical background and have undergone several changes since the pre-colonial era up to the present. It has been found that land and water rights have remained vested to a top leader of the country, which during colonial rule was the governor and is now the president. Findings also indicate that despite the challenges of being abolished, customary laws have continued to play a role in supporting statutory laws in the management of water and land resources in rural areas. However, abolishment of chieftainships and the introduction of the villagisation programme largely weakened customary laws, contributed to natural capital degradation, and related conflicts. On the other hand, livelihood capitals area not equally distributed in the study area and this increases competition. Households have continued to engage in different livelihood activities; however, agriculture is still dominant and employs the majority of people. However, some households are now engaging in other non-farming activities. The chapter builds a foundation from which other chapters (6-8) shall be discussed and concluded.

CHAPTER 6
WATER RESOURCE AVAILABILITY, INSTITUTIONS AND CONTESTATIONS

6.1 Chapter introduction

Chapters 4 and 5 have explored the impacts of changes in land use and climate and socio-economic profiles in the study area. The overall findings are that the livelihoods of people in the study area depend mainly on natural capitals especially water, forests and land resources, and that the three are interlinked and have been changing in a decreasing state with time due to unsustainable human-nature interactions. The scenario of decreasing natural capitals increases level of vulnerability, competition and contestations, which threaten and shape household livelihood options, choices and resilience.

It is now appropriate in this chapter to explore and provide more information on the perception of water scarcity and effects of water scarcity on household livelihoods. The chapter also assesses the existing water related institutions (both formal and informal), and their roles in ensuring water resource availability in the study area. Related challenges such as contestations and conflicts and their management strategies are also discussed in this chapter. The chapter argues that, both formal and informal institutions have power over each livelihood capital that includes governing water associated demands and allocation procedures and outcomes, and they tend to act as a mediator of the whole process. Finally, the chapter ends with a short summary. Overall, this chapter argues that the decreasing trend of water resources availability in the study area has reframed the way water is governed and how water users react and opt for a certain livelihood strategy in different parts of the study area. In this chapter, I combine the concept of resilience (Kelly et al., 2015; Quandt, 2018), the concept of waterscape (Irvine et al., 2016; Karpouzoglou and Vij, 2017; Kliskey et al., 2019) and the concept of hydrosocial territory (Boelens et al., 2016; Lopez et al., 2019) to describe and analyse water resource scarcity, allocation, institutions and the related hydrosocial waterscapes in the study area.

6.2 Community perceptions on water scarcity

This section assesses community perceptions on water scarcity in the Umba. The results presented and discussed are from households, elderly key informants, PCA and focus group discussions. The community perceived and linked water scarcity to: land degradation (changes in land use), climate change/ and or variability, introduction of eucalyptus and limited budgets allocated for water development. These results are discussed and compared with relevant findings from chapter 4.

6.2.1 Perceptions on land degradation and water scarcity

Right from the beginning of the discussion and interaction, respondents indicated their awareness and concern about the changes in land use patterns. For instance, on land-use change perceptions, key informant respondents across villages reported that in the 1950s up to the 1960s, the Umba River sub-catchment had enough natural forests and other vegetation in general. They further reported that the area had fertile soil and enough water sources that supported annual river flow and other human activities such as irrigation farming. There was no complaint regarding water availability and everyone was able to abstract water for various uses.

Further results from group discussions showed that, since the late 1970s, their forests, land and water/rivers started experiencing a decline due to the increase of human activities such as unsustainable farming, overgrazing, brick making, charcoal production and encroachments for settlements and irrigation farming. Although respondents had different views on when land-use change became intense, analysis of information from focus group discussions and the exercise of participatory community analysis (PCA) across villages showed that 57% agreed from the 1980s to 2000s to be the periods that experienced the most land-use changes. Finding from group discussion respondents indicated that people perceive that land-use changes lead to degradation of water sources, soil erosion and deforestation, especially upstream, which in turn have resulted in the disappearance of some forest resources, streams and water sources, which used to be permanent. The change of the Longoi stream from permanent into a seasonal river is perceived to be caused by degradation of forests upstream. Respondents linked those changes in natural capital use to have affected water resource availability in their localities. This finding aligns with the study by Chattopadhyay et al., (2005) which found that land-use change has serious implications for water quantity and over-all hydrological conditions.

Observations on the timing mentioned by the respondents, with the use of a resilience lens which is able to trace the history of changes, it is vividly apparent that those changes are closely associated with villagisation and policy changes that happened between the late 1960s to the early 1980s. I argue that monocentric policies and the villagisation programme which were introduced by the government in the 1970s led to dramatic biophysical changes that contributed to the current environmental problems and degradation. In group discussions, respondents reported the negative impacts of land-use change including land degradation and the disappearance of vegetation and specific indigenous tree species such as *mkuyu (Ficus sycomous), mvumo (Birassus aethiopum) and Muombeombe (Hallea rubrastepulata)*. These

indigenous trees are important for conserving water sources and maintaining soil fertility. They were reported to reduce soil erosion while at the same time ensuring the availability of firewood.

Although people were unable to tell how much land has been changed, people did still perceive that land has changed its use, especially from forest to settlement and cultivation. Community perceptions are in line with Landsat image analysis for 1975, 1995, 2005 and 2015 (explained in chapter 4), where land use changes increased scattered cultivation by 395%, settlements expanded by 1761% and farms opening within 60 m of the water sources were found to be dominant. On the other hand, natural forests and bushland have decreased with time and most changes happened in the last 2 decades. Relevant studies (Niya et al., 2019; Msofe et al., 2019; Naschen et al., 2019) assert that land use changes, compounded by deforestation and expansion of agricultural activities close to water sources, affect water sources and reduce water flows and hence reduce water infiltration and underground water recharge. The anthropogenic land cover change can substantially alter surface water flow by affecting interception, infiltration and evapotranspiration (Kliskey et al., 2019).

6.2.2 Perceptions on climate change/variability and water scarcity

In the study area, water scarcity is perceived to be caused by changes in rainfall in terms of unreliability, delayed onset, early cessation, poor distribution and shortened length of the season. The analysis of both focus group discussions and household surveys across villages shows that respondents perceive water scarcity to be linked to increased prolonged droughts that affect river discharge and water availability in small wetlands and some water sources or streams. According to the elderlies and local narratives, they perceive rainfall has changed by decreases in the amount per season as compared to the 1960s and 1970s. Elderly respondents also perceive that, since the 1990s, rainfalls have become unpredictable, unreliable, unevenly distributed and with variable onsets. The changes are perceived to have come with changes in the water resource availability and hence affecting livelihood activities. Complaints from households were that the rains are not well distributed within the seasons and not predictable in recent years, hence affecting planning and local livelihood activities. These findings were also noted during the group discussions and PCA. In the study area decrease of rainfall is more related with the timing of rains and availability of water resources in the Umba River to support crop cultivation seasons or irrigation practices. Communities mentioned droughts after El Niño (referring to 1999) and recent ones which happened in 2013, 2014 and 2015 to be very strong. One of the respondents reported;

> "….the whole part of the Umba and neighboring villages experienced serious droughts for about three to four years consecutively from 2013 to 2016. All water sources and the Umba river dried out and we faced acute water shortage. We did not harvest anything as all crops got dried in farms." (**In-depth key informant interview, Mwangoi, village, 27th November 2016**).

The findings from elders and household surveys are comparable and support the finding from rainfall trend analyses in chapter 4. In chapter 4 the rainfall performance for 55 years at Shagayu station and Mnazi station shows the trends in annual mean rainfall to be possibly declining but trends are not (yet) statistically significant ($P > 0.05$). However, the assessment of extreme events depicted that the Umba is increasingly experiencing more drought events compared to wet events and droughts have become common in the last two decades. The analysis of droughts using SPI was able to depict 2013, 2014 and 2015 as years with extreme drought events which align well with community perceptions. In addition, the seasonal analysis results show the apparent decreasing trend with time, especially later onset, earlier cessation hence shortened length of the rain season, but these were not statistically significant.

Results from seasonal coefficients of variation showed that both MAM and OND have slightly variable onset and cessation dates. However, at both stations the length of the OND and MAM season have highly variability with 51% at Mnazi and 55% at Shagayu. However, no enough statistical evidence for a shortening rain season there could be increasing variability. Several studies (Mango et al., 2018; Hadgu et al., 2013; Gitau et al., 2017; Bosire et al., 2019) have indicated that variabilities in rainy seasons confuse communities and have significant consequences on local livelihoods, rivers and water resources, in both the short-term and long term (Kahsay, 2013). On the other hand, the recent increase of drought events in both localities forces farmers to shift to downstream and encroach water sources for growing short-maturing vegetable varieties. Asfaw et al., (2018) and Mugalavai et al. (2008) had a similar finding that in Ethiopia and Kenya respectively, drought events and unreliable rains have caused communities to encroach wetlands and water sources to grow maize and beans (Naschen et al., 2019). This situation has contributed to water source destruction and caused water shortages in those areas. I argue that the current and future climate trends will have negative impacts on water availability and access that will lead to agricultural intensification in the watersheds and or sub catchments and that if not well handled, this will lead to more natural resource conflicts, contestations and increased household vulnerabilities.

6.2.3 Perceptions on the introduction of Eucalyptus

Respondents located in the upstream and middle stream villages perceive that the water scarcity in the Umba is partly linked to the introduction of Eucalyptus. Eucalyptus tree species were introduced in the 1980s by an NGO to control soil erosion in the upstream villages and in the border of Shagayu forest. According to key informants, these trees have consumed a lot of water and cause the soil to remain unproductive and water sources have become dry. Although eucalyptus tree species were reported to be introduced in the upstream, the trees are spread all over along the Umba River sub-catchment. Group discussion respondents revealed that seeds are transported by water when it rains. In literature, it is well documented that eucalyptuses are fast-growing trees species that are associated with environmental challenges, including depleting water sources, loss of soil fertility while dominating other species (i.e. alien invasive species) (Albaugh et al., 2013; Mukund and Palanisami, 2011). According to Guzha et al. (2018) eucalyptus reduces water stored in the soil profile and eventually reduces general water flow. Their impacts on water resources, especially in many places of Africa and Asia, have remained as a controversial issue (Mukund and Palanisami, 2011). Still, respondents were clear that, in their experience, the introduction of water demanding eucalyptus planted near water sources, has played a role in reducing the discharge and hence water challenges in the area. Even leaders mentioned the decline and water challenges in the upstream as follows;

> "The status of water has decreased although I cannot tell you the percentage but is huge. In the 1970s, 1980s and early 1990s, we used to hear the voices of water from Umba River, but now nothing is heard any more and we think those eucalyptus trees you see are responsible for this situation." **(Water users' leaders from Upstream, 13th November 2016)**

The increasing numbers of eucalyptus are also associated with the disappearance of some water springs in both upstream and middle stream villages that used to provide water during rain seasons.

6.2.4 Perceptions on budgets allocated for water

Across the study villages, respondents had a perception that water scarcity in the area is because of a lack of budget allocated for water development in their villages. Here the community believes that the local government authority is not investing enough resources to solve water scarcity issues. During group discussions across villages, respondents linked water scarcity with existing water infrastructures, which were built about 3 decades ago when the area had few people and now have high water leakages due to their age and lack of maintenance. Other studies (FAO, 2015; Venot et al., 2013; Maliwichi et al., 2012) have documented the challenge of lack of repair and maintenance of water related infrastructure in rural areas. This has led to water leakages and poor performance of small-scale

irrigation and rural water access (Mutambara et al., 2014; Mdee, 2014). On infrastructure, a head of household at Mng'aro was quoted as saying;

> "…..the water pipes that bring water to our village were built in 1972, by then Mng'aro village had around 100 households or less, but now we are more than 600 households so it is not easy for everyone to get water through these outdated infrastructures which also lack frequent maintenance" **(Head of household Mng'aro village, 16th June 2017)**

Information from informants revealed that for many years, the government had not been putting aside a budget for water in those villages, and no maintenance has been done in recent years. This aligns with findings by Quinn and Tilley (2013) that the Tanzanian water budget allocation for rural water access has declined significantly since 2011. Jiménez and Pérez-Foguet (2010) found that, weaknesses that continue undermining rural water strategies in Tanzania are at local levels and include lack of sustainability and maintenance of constructed infrastructures, poor quality water services, and difficulties for targeting the poor who are in real need of water. It was also found that the budget has remained heavily dependent on donor support and its allocation is unresponsive to the need (Carlitz, 2017). Key informants were concerned that the local authority was putting aside financial resources in each budget year to make sure water is available for almost everyone in towns such as Lushoto and Mulalo, while water is from their localities and they are responsible for conservation. In literature, Boelens et al. (2016) and Crow et al. (2014) term this as a hydrosocial territory which leads to inclusion of some groups and exclusion of some groups or access and denial to water resources, with simultaneous dispossession of vulnerable groups and their livelihoods which creates social and environmental inequalities

6.3 Effects of water scarcity to households' livelihoods

The analysis of household livelihood activities in chapter 5 has indicate that 79% of the households in the study area are engaged in agricultural activities. Although most of farmers still depend on rain fed agriculture, the household survey indicated that 37% of farmers in the sub-catchment are relying on traditional irrigation farming where water is a main input. In addition, key informants reported that an increase of prolonged drought events and variability of rainfall has motivated more farmers to embark into irrigation farming. It is in that context therefore, that any scarcity of water in the sub-catchment is seen to affect household livelihood activities, especially irrigation farming activities, which need water to perform better in terms of production. A farmer with 65 years old age from a downstream village reported that:

> "Water scarcity has affected paddy rice and vegetable production in the area. In the 1990s, water was enough and one acre of land was able to yield 15-28 sacks each weighing 50 kilograms. But in recent years water has been insufficient and or not available in some years and the productivity has declined per acre to 5-8 sacks weighing 50 kg and sometimes we get zero". (**A 65 year old farmer, Lunguza village, 17th December 2016**).

During focus group discussions, respondents from downstream revealed that water scarcity has affected even vegetable productivity and that sometimes when they have no water for irrigation, their crops dry totally and they incur a total loss in terms of financial resources and time invested. Results further reveal that water scarcity associated with low productivity has led to food insecurity at household levels and in the sub-catchments. Group discussion respondents reported that, in 2014 and 2015 when they experienced consecutive dry events, they had a very serious shortage of food in most villages and had to depend on external donors to help them. The key informant from the district reported that across villages, 47% farmers either sell their land or get trapped into debts. This finding corroborates the findings of Dobricic (2013) and Udamale et al. (2015) that, in rural areas, water shortages for irrigation leaves farmers with no alternative but to delay payments and incur growing debts as they strive to find money to ensure food security.

The analysis of information from both household and key informants revealed that the abandonment of yams that used to be not only a staple food but also a reliable crop in markets in the city of Dar es Salaam was due to an increase of droughts and water shortages. This had a great economic impact on farmers according to one of the key informants. As water became unreliable, the productivity of yams went down to zero and they were replaced by paddy rice that is expected to be abandoned if the water scarcity trend continues with the current scenario. The analysis of results shows that the decline and abandonment of some crops is linked to unemployment and change of livelihood activities. During group discussions it was reported that farmers who were growing vegetables and noticed the production is going down year after year have decided to do other non-farming activities such as charcoal burning and sand extraction. These activities in turn have impacts on water sources and the environment and indeed increase conflicts among resource users. On the same note, women farmers have remained unemployed and some are providing casual labour to those who have farms downstream, but this is unreliable.

Results from household surveys in upstream and off stream villages show that people spend much time (day and night) looking for water to irrigate their farms. This time could have been used in other livelihood activities such as non-farm activities so that they could earn additional income. Although

the cost implications cannot be easily established, they still need to be considered as an important resource being lost. Apart from water for irrigation, households across villages also reported the challenge of water for domestic use which is not available and forces people to spend much time on queuing for as much as 3 to 5 hours. Across villages, people reported buying water for domestic use. This situation has caused most of the households to compete around water sources and especially during the dry period. In response to water scarcity, households have encroached the river and opened farms associated with intensive application of pesticides a situation which pollutes water, while farming interrupts water flow. Some farmers from upstream and off-stream villages have shifted to downstream villages while the youth have migrated to cities and towns where they do casual work. Some pastoralists have migrated to Mkomazi National park where they have caused conflicts as it is not permitted to keep cattle in national parks of Tanzania.

6.4 Contestations and conflicts over water

In places where water and land resources are scarce due to both natural (can include drought and flood events) (Naschen et al., 2019) and social interactions, several groups emerge to defend their interests and govern how that resource could be used in the form of access, quantity, time and quality (Le Billon and Duffy, 2018; Frerks et al., 2014). Boelens et al., (2016) and Seemann (2016) assert that conflicts over water and land have various dimensions, putting those who own the resource against those who own nothing, those located upstream against those downstream and those who have power against those who have no power. Since rural people in the study area depend largely on natural resources for their livelihoods, water scarcity leads to community struggle over the resource.

6.4.1 Characterisation of water resource conflicts

Before discussing the details of water conflicts in the study area, it is important to note that water conflicts are complex and are connected to, day to day life and livelihoods of the community in the Umba. According to Bijani and Hayati (2015), there are three major linkages between conflict and water which are; first, access to adequate quantity and quality. Such conflict may occur when there is unbalanced access to water resources due to unharmonized allocation of water among water users such as farmers and urban water users. Second is the loss of water sustained livelihoods due to water scarcity. If water supported livelihoods fail due to water scarcity, people will be forced to find other alternatives to support their life. This may even include illicit activities and may cause related conflicts. Last is water management, whereby sometimes water may be available but poorly governed and managed due to weak

institutions, lack of transparency, lack of sufficient infrastructures, ambiguous jurisdictions and competing interests (Lopez et al., 2019; Hommes et al., 2016).

As elaborated below, this study has identified six types of water resource availability and use conflicts in the Umba River sub-catchment. These include: farmers versus pastoralists; farmers versus formal institutions; community versus conservationists; upstream versus downstream; irrigators versus other water users; and farmer (s) versus farmers. The last four are the most reportedly active in the study area, where the resources that are most contested differ depending on the location within or outside the sub-catchment (Table 16). For instance, in the upstream the contested resources include water, land and forest resources; in the middle stream the contested resources are water and land; in the downstream the contested resources include land, water, forest and pasture. In the off-stream areas the contested resources include land and water, but water is more reported than land.

Table 15: Location, actors and resources contested in the study area

Village name (s)	Location in the sub-catchment	Actors involved	Resources contested
Goka & Kiranga	Upstream	Farmers, Local Government Authority, conservationists	Water, forest and land
Dule M & Mwangoi	Middle stream	Farmers, Local Government Authority	Water & land
Mn'aro & Lunguza	Downstream	Farmers, pastoralists, conservationists, government institutions,	Water, land, forest & pasture
Kwekifinyu & Hemtoye	Off-stream	Farmers, other water users	Water & land

Source: Field Survey, 2016

6.4.2 Types of water related conflicts in the area

The decision and process to classify existing conflicts in the study area was done to provide an understanding of who is involved and in which circumstances these waters and or resource related conflicts occur. The classification was also informed by scholars such as Mbonile (2005) who classified types of conflicts in the Pangani River Basin by looking at actors involved in those conflicts. In this study I also undertake the analysis of water related conflicts based on Boelens et al., (2016) and Lopez et al., (2019) who look at water as a very political resource which is disputed through power relationships and that at some point, water flows are directed and redirected which leads to access and exclusion of some groups while favouring others. As a result, and with time, these lead to specific hydrosocial territory, which may be imagined (planned or materialised) to meet interests, visions and

power of certain actors or groups (Lopez et al., 2019; Boelens et al., 2016). FGDs and KIIs were fundamental in the whole process of classifying water related conflicts in the study area. The existing conflicts are outlined below.

6.4.2.1 Farmers versus fellow farmers

As explained earlier in the previous sections, a large amount of water in the Umba River sub-catchment is used for irrigation. Key informant respondents from downstream villages reported that in the 1970s, few farmers were practicing irrigation farming and the remaining majority were practicing rain-fed agriculture. However, as population increased and rains became unreliable in the area the situation changed. Increasing numbers of new irrigated farms were opened by both local people and others who bought land to grow paddy rice for business purposes. This went hand in hand with the introduction of short-term crops such as spinach, carrot, potatoes and cabbage. More local canals which tap water directly from the main river to the farms are reported to have been constructed. In the upstream and middle stream areas, farmers are reported to have bought petrol-fueled water pumping generators so that they can pump water into their farms -but pumping a lot of water into their farms denies water to those with no pumping generators. According to key informants, demands for water for irrigation activities have been increasing beyond what formal institutions and water allocation committees can manage. Some farmers started abstracting more water to irrigate their farms. This situation created more tensions as some farmers could see other fellow farmers taking more water while their crops were drying. This is in line with what Lopez et al. (2019) report through a hydrosocial territory lens, that at a point where water is scarce leading to powerful groups that exclude other groups from access, the excluded groups will form an alliance to demand their water rights within the territory that causes complex water related disputes and struggles.

Results from focus group discussions show farmer versus farmer conflicts are common across the sub-catchment. However, further results reveal that downstream villages are the most affected as they are linked to immigration. The key informant narrated that the conflict starts when an individual or group of farmers diverts water into his or her/their farms when they were not supposed to do so on that day. Other farmers who were supposed to get water become angry and unblock the barrier to allow water to flow down. In cases where the first farmer resists unblocking the water barrier then farmers can even fight. Group discussion respondents further revealed that, most of the time, water for irrigation is available at night and most of the water channels are locally made and pass through

several farms depending on where the farm to be irrigated is located. Also, recently, generators are causing conflicts, since they have high capacities for pumping much water and after a few hours, they leave the rivers with little water or empty. Then neighbouring farmers will not be able to obtain water for their farms. They will therefore try to remove the generators and the owner of the generator will not agree, hence conflict ensues. According to the key informant respondents, conflicts related to water pumping by generators are common in the midstream and upstream areas while downstream there are more conflicts related to water diversions. Since off-stream villages have no rivers there was no such type of conflict reported.

6.4.2.2 Farmers versus pastoralists

Results from household surveys show downstream areas have pastoralists who keep cattle locally (taking them out during the day for free pasture and returning them at night). Results further show that, during the dry season, Masai pastoralists from other places in Tanzania and Kenya bring their cattle into the valley bottoms of the Umba River so that they can get free pasture and water. However, during this dry period farmers also need the same land and water for growing vegetables. Farmers consider these areas to be areas for crop farming, while pastoralists consider them to be areas of cattle saviour during dry seasons. Everyone considers his/her demand for water and land more important than the other. Studies (Abrahams and Carr, 2017; Raleigh and Dominic, 2012) assert that some parts of East Africa are experiencing pastoralist and farmer conflicts related to water and pasture due to an increase of drought events. One of the farmers from Lunguza village was quoted saying that;

> "Longer droughts which have been happening since 2012 associated with rain uncertainties have increased the number of pastoralists with a huge number of cattle looking for water and pasture putting pressure on our villages and crops and this has intensified conflicts between pastoralists and we farmers". (**An old farmer, Lunguza village, 17th December 2016**).

During field work I personally witnessed the conflict between farmers and pastoralists at Lunguza village which is located downstream. In this conflict pastoralists were claiming that farmers have expanded their farms and obstructed livestock routes for water and grazing land. They further claimed that the land was owned by pastoralists for decades. On the other hand, farmers were saying the route is sufficient for cattle to go to the river while on grazing land they were saying pastoralists should shift and go to the forests where there are no settlements and farms. However, the advice by farmers was not accepted by pastoralists who said it was dangerous for them, as all forests fall under the Mkomanzi National Park and are considered to be no touch zones. As the conflict grew in terms of the number of farmers, the district officer had to intervene, whereby he called for a mediation meeting to discuss

among actors and it was decided that farmers must give up some areas so that cattle could pass through to the river. Farmers did not agree with the suggestion and left the meeting, but the district commissioner insisted that the agreement must be respected by everyone.

6.4.2.3 Downstream versus upstream

Most of the water that flows in the Umba River starts upstream and in fact the river drains its water from Shagayu Forest Reserve. In this study, the upstream versus downstream conflict is determined by location, land ownership, level of education, age, gender and influence with the government. In the upstream area, farmers who are located and owning land near water sources have good opportunities to utilize water for irrigation but all the complaints are always directed towards them. Those aged 65 years were not always engaged in conflict as they said they had no energy to do so and they leave all the fights in the hands of their sons. On the other hand, women regardless of their age were reported in both key informant interviews and focus group discussions to have less time to engage in conflict as their husbands and their sons could do so. Influence with the government was also reported to have contributed to this type of conflict. Key informants reported that farmers which are well connected to either the ruling political party and or government were getting move favour compared to other groups and this could increase conflict intensity. This finding tallies with the findings of Bijani and Hayati, (2015) that most of the farmers downstream believe that a lot of water is consumed upstream with no plan to consider downstream water demands and that this creates contestations and conflicts around the resource. Bijani and Hayati (2015) further documented that, in most cases farmers in the upstream have more influence on government policies and can influence decisions to favour their benefits. In contrast to the study of Bajani and Hayati, in the Umba sub-catchment, people with influence and connections with the government are located in the middle stream and most of leaders are from there. On this, the key informant revealed that the influence is very historical as most of old secondary schools and towns are located in the middle stream, a situation which has favoured people from this area to get education early while some even become government ministers.

On the other hand, key informants revealed that, due to water scarcity, some farmers upstream have encroached water springs and rivers as they expand their farms, causing land and river degradation. Sometimes upstream farmers abstract water so that they can get water for irrigation. This has been reported to affect the amount of water flowing to midstream and finally downstream areas where most of the irrigated farms are located. One of the old people from downstream was quoted saying that;

> "The scarcity and conflicts of water in our areas are due to favouritisms and nepotism by most of the political leaders who are from and some living in the middle stream. They always make sure water from upstream is intensively used and the little remaining is left to flow to downstream. Try to look at all water projects including the big water collection and supply tanks, all are located in the middle stream no matter what. This is unfair and we shall fight for our right" (**In-depth interview with farmer, Mng'aro village, 16th December 2016**).

It was revealed from focus group discussions that related conflicts start when downstream farmers start seeing their crops drying at the expenses of water shortage. Men with knives and *pangas* and or machetes start climbing the mountains, monitoring where water has been abstracted. When they find the abstracted area they remove it without any negotiation and sometimes the conflicts start at that point. Komakech et al. (2010) and Mbonile (2005) found that, in the Pangani basin and Nduruma River, conflicts are now arising frequently because upstream users abstract most of the water and leave their downstream neighbours with water scarcity. Field observations revealed that sometimes the conflicts are due to unimproved institutions and infrastructures as much water gets lost in the earth and locally made irrigation channels. Before the soil can allow water to flow it must first absorb enough water and get wet, this takes time especially during the dry season.

6.4.2.4 Water users versus conservationists

In Tanzania, protected areas are controversial and complicated, as they give rights to some groups (tourists and government institutions) to access and use accrued benefits and resources while denying/restricting access and or displacing other groups, especially neighboring local communities (Brockington and Wilkie, 2015). In the Umba, both the upstream and downstream areas border Shagayu Forest Reserve and Mkomazi National Park respectively. In the upstream areas, the conflicts start when farmers encroach the forest reserves for water, firewood and farming land. Upstream farmers think that the Shagayu forest reserve has taken a large land area which could have been used to support agriculture and the ever-growing population. On the other hand, the district department responsible for forestry and natural resources says Shagayu forest is a Protected Area and cannot be interfered with by communities. In Tanzania, this approach by Protected Area Authorities has been criticized in that communities can be dwelling on the edge of a natural resource rich park and reserve but are restricted to gather firewood, wild foods, to hunt, or are not allowed to walk to their farms on the other side of the park. This makes local communities fight for their lost livelihood opportunities, symbolic rights and lost history. Some groups will always protest their loss of power and control over their environments as well as the interference caused by introduced conservation regulations (Brockington and Wilkie, 2015). Using a hydrosocial territory lens, Swyngedouw and Boelens (2018)

argue that territorial conflicts and struggles are beyond the target natural resources per se, but include the need to gain lost meaning, norms, freedom and representation in the decision-making processes.

For the downstream side where the Mkomazi National Park is located, the area has become an archetype in the field of conservation studies (Brockington and Homewood, 2001). When this park was first gazetted as a game reserve in the 1950s it had several thousand people and tens of thousands of livestock for much of its existence and later all residents were evicted (Brockington and Homewood, 2001). This has created tensions among local communities and the park to the extent of creating antagonist groups. Farmers from Mng'aro and Lunguza villages reported that the presence of Mkomazi National Park and other conservation patches in the hills and mountains have increased conflicts that include conservationists, farmers and pastoralists. Maasai pastoralists want these areas so that they can practice transhumance between uplands and lowlands during dry seasons. In its location the downstream region has flat and relatively fertile soil which can support agricultural activities, however, people from upstream, off-stream and middle stream areas are also looking at the same resources downstream. While the interests of farmers include acquiring land for farming expansion, establishing settlements and to be able to get both firewood and water, respondents revealed that the conservationists, especially leaders of Mkomazi National Park, are not willing to let the area be interfered with by the community. Respondents reported that the community is not even allowed to collect firewood. As communities are forced to enter the forests, national park armed soldiers challenge them. Brockington and Wilkie (2015) argue that in this area, the disputes are more related to contests for traditional territorial claims, land taken in the name of conservation as well as evictions and exclusion from benefits from the park, and is linked to the older history of how the park was created and how its governance has been changing. Some scholars link the existing conflict between the downstream communities and the park as the outcome of the power of top-down policies which led to chasing away thousands of farmers and pastoralists from the landscape (Brockington and Wilkie, 2015; Swyngedouw and Boelens, 2018). It also shows how injustices of policy and related actions could lead to more conflicsts and poverty within local communities (Swyngedouw and Boelens, 2018; Anderson and Bolling, 2016; Hakansson, 2019).

The key informants were concerned that, as land and water continue to shrink, communities use force to enter these conserved areas and the conflicts continue. These findings corroborate the study of Mbonile (2005) which found that in 1998 and 2000, the Pangani basin witnessed several conflicts that

resulted in several community members being taken to court and then to jail, due to entering the national park without permission. According to Mbonile, this conflict brought together farmers and pastoralists against the Mkomazi National Park and was centred on the utilization of water resources during the drought period. In this conflict, the community decided to set fire to the forest with major damage to biodiversity and loss of wildlife species. This event led park leaders to discover that they will not be able to ensure conservation without community participation and in that sense, community members were allowed to utilized agreed forest resources (Burgoyne and Kelso, 2014). As Boelens et al. (2016) argue, despite the fact that reasons and strategies of making territory differ among actors, even the produced territories and how local communities' to protect their water-based territories become dynamic and complex. However, at a point of defending their hydrosocial territory, these local water actors tend to put aside their internal differences/conflicts to mobilise themselves and collectively defend to control the main territorries. This may also involve the grassroots forming alliances, as happened between the farmers and pastoralists who decided to forget their internal conflicts and formed an alliance against the giant Mkomazi National Park and government authorities.

6.4.2.5 Communities versus government institutions

In the Umba River sub-catchment, different institutions which use water do exist. Some of these institutions include those owned by religions such as mosques and others owned by government such as schools, dispensaries, while downstream there is a prison barracks. Respondents from downstream where this type of conflict exists reported that religious institutions are close to the communities and therefore, cannot be in conflict with them. Discussion with key informants in the downstream area revealed that communities were concerned on how water was allocated to the neighboring prison barracks. They reported that the prison barracks gets water for almost ten hours each day and they get enough water for irrigation and domestic use. However, according to the respondents, the community and other stakeholders only get water in the evening when the pressure would have declined due to over use by the prison barracks. Complaints by communities are built on the understanding that prison barracks population was not big enough to be given water for such a long time. They also argue that the prison barracks is owned by the government, which therefore should set aside funds for improving infrastructure rather than competing with farmers who have less power, no mandate and/or financial resources. On water conflicts of this nature, Swyngedouw (2006) asserts that, with the exception of arid places, most problems of water access have little or nothing to do with availability or absolute scarcity. He continues that the problems come with access and equitable distribution of

available water resources. Swyngedouw finishes with important and relevant advice that institutions need to answer the question of why some social groups have no or limited access to water while others have adequate supply and abundance. This question relates well to the quotation from one old man from downstream who said:

> "I am sure there are no real water problems in this Umba except off-stream villages. For our case water is redirected and overused by people in the upstream and especially middle streams because they are well supported by powerful leaders in the government who direct the district authority where water should go without telling them why. We can see government institutions such as this prison barracks taking a huge portion and water for irrigation farming without considering us, this is not right and is very unfair, soon we will demand our rights!" (**In-depth interview with farmer, Lunguza village, 17th December 2016**).

Looking at this through a hydrosocial territory waterscapes lens, it can be established that in the Umba River the water flow is contested and has become contestable (Seemann, 2016), shaped by both power relations and political economy. The decision to give much water to the prison barracks so that they can irrigate their farms is disproportionate and excludes other relevant groups, especially smallholder farmers. This has impacts on farmers' livelihood activities as water is needed for irrigation in their farms and they spend much time looking for water instead of working in their farms. On this, Boelens et al. (2016) argue that the processes of resources dispossession increase vulnerability of some groups and their livelihoods and creates social and environmental inequalities. It is through this materialized, forced legal structure and imbalanced power relations, that unequal distribution of water resources and decision making in the Umba leads to this type of conflict and keeps on emerging.

6.4.2.6 Irrigators versus other water users

Conflicts related to water in the Umba sub-catchment are connected to many sectors at once such as farming, livestock, households and other uses. For the farmers, water for irrigation is a more crucial resource needed to ensure agricultural productivity. Any contestations and waterscape over water rights and access have a high likelihood to destabilize agricultural productivity and will not be accepted by farmers. For example, any water obstructions for brick making and sand extraction in the river have caused conflicts with farmers who are engaged in irrigation farming. One farmer in the middle stream, where this type of conflict was repeatedly reported, narrated shortly that

> "we farmers in this area consider sand extraction and brick making dangerous to our farming activities as they take a lot of s water. Any attempt to manipulate our water right and access, and our first reaction includes destruction of the bricks and returning all the sands in the river, then opening water to flow down." **(A farmer at Dule M village, 14th December, 2016)**

On the other hand, households need water for drinking and other domestic uses. However, this water is diverted into farms by farmers; as a result, water becomes contaminated, getting too colored and dirty to be used by human beings at home. Conflicts do emerge when households attempt to stop water diversion into farms by farmers so that they can get water for domestic uses. The conflicts related to water were reported to become more serious especially during the dry seasons and when water diversion is accompanied with fueled water pumping generators. Water becomes polluted by petrol and soil to the extent that it cannot be easily used.

6.4.3 Managing water related conflicts

The main goal for managing water related conflicts is to ensure harmonization and peace, but also water availability for everyone in terms of acceptable quantity and quality for livelihoods and human health (Woodhouse and Muller, 2017). This should also include ecosystems and risk reduction such as floods. At a point where these are complex, collective actions among stakeholders such as government institutions, water user groups or individuals and with other multiple actors and across scales, approaches become crucial (Baldwin et al., 2018). In this situation scholars (Ostrom, 2014; Dell'Angelo et al., 2016; Kellner et al., 2019) have recommended the use of a polycentric water governance approach which entails ensuring interconnectedness of stakeholders across levels, with multiple actors, bottom up and top-down linkages, as well as coordinated and enhanced efforts lead to effective results and sustainability.

In the Umba, discussion with respondents showed that water related conflicts are solved through negotiations between responsible stakeholders. Some of the conflicts, especially those involving farmers versus farmers or water users versus water allocators, were reported to be solved through either committees or village government authorities. It was also reported by the respondents that some of these conflicts were solved by informal institutions such as elderly people including *mzee wa mfereji* (meaning the elderly of the irrigation channel) who knew the villages well. This approach of managing water related conflicts was reported to be common among off-stream villages and downstream. Where conflicts were found to be beyond villages and local committees, then Village Executive Officers, Ward Executive Officers and sub-catchment responsible committees were responsible for handling them. At some points where conflicts included other natural resources such as land and forestry, responsible departments were involved.

According to group discussions and interviews, for conflicts which were not managed through discussion and at local levels, district officials and political leaders were asked to intervene. The district officials, that included the District Commissioner, District Executive Director, lawyers, and relevant departments, had to engage with all stakeholders through stakeholder meetings. Most of the time these kinds of conflicts could be solved within one day, as they involved reading village maps or land use planning if available. Also, for conflicts that involve other institutions such as Mkomazi National Park, the responsible authorities such as the Tanzania National Parks Authority (TANAPA) and Ministry of land, housing and settlement development are involved.

6.5 Water Relevant Institutions

Relevant official documents such as the National Water Policy (NAWAPO) of 2002 and Water Resource Management (WRM) Act No. 11 of 2009 insist that formal institutions (Kabogo et al., 2017) should govern water resources in Tanzania. The formal organisational structure includes the Ministry for Water and Irrigation, Water Basin, Catchment which are part of the Ministry, Sub-catchment, and Water Users Associations (Figure 30). At a district level where the catchment or sub-catchment falls, there is the department of water resources which is not included in the Ministry of water structure as it falls under Local Government Authority, which is an independent Ministry responsible for local government. At the basin level, formal institutions continue to dominate and the WRM Act No. 11 of 2009 recognises and emphasizes these formal institutions. Informal institutions do exist quietly alongside the formal structures but need to pay special attention to notice them. At the catchment level, informal institutions start to gain some strength (Sokile and van Koppen, 2004). It is under the sub-catchment level whereby informal institutions are found to be stronger and are working to cover formal weaknesses, as they take advantage of being better established with the grassroots than formal institutions.

As per NAWAPO and WRM Act No. 11 of 2009, emphasis is placed on the establishment, registering and strengthening of formal Water Users Associations (WUAs) whereby under the current institutional framework, the registrar is the Water Basin (URT, 2009; Mehari et al., 2009). The role of WUAs is considered to be the 'eye' of the Water Basin that coordinates and supervises day to day water protection activities and solves conflicts related to water resources in their constituencies. WUAs are established to ensure participation of local communities in the management of water resources. WUAs also are established to create space to accommodate local community interests and

livelihood requirements (Kabogo et al., 2017). Beyond increasing ownership, the NAWAPO and WRM Act No. 11 of 2009 intend to empower water users to participate and influence the processes and outcomes of use and management of water resources and relevant land (Katani, 2010; Van Koppen et al., 2016). Under these acts, water resources are allocated at basin, catchment, sub-catchment and village levels. In Tanzania, the expectation is that WUAs are the smallest unit and are registered independently within their respective Water Basin Authority (Kabogo et al., 2017). The WRM Act also gives an opportunity for several WUAs under one sub-catchment to come together and form one apex WUA (Mehari et al., 2009). This structure has included a range of stakeholders, but there is no official representation of informal institutions. Woodhouse and Muller (2017) and Ostrom (2014) insist on the importance of including informal institutions in water resource management especially at local levels, as they are well established on the ground and most of decisions start from there.

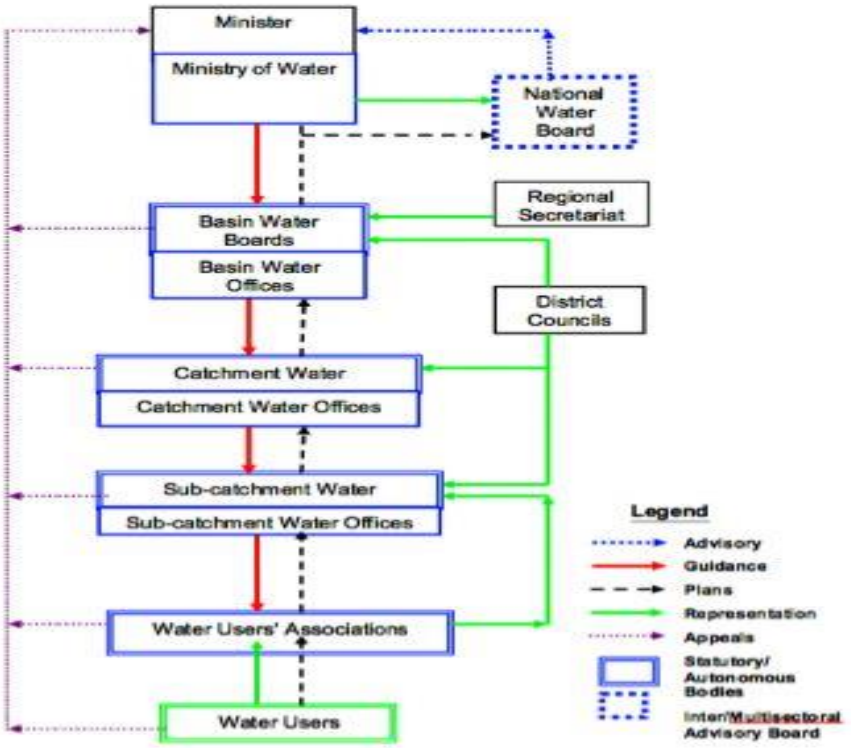

Figure 30: Water resource management institutional framework in Tanzania

Data source: Kabogo et al., 2017

6.5.1 Formal institutions in the Umba

Cleaver (2002) calls formal institutions "bureaucratic" with clear structures, contracts and legal rights. As stated above, NAWAPO 2002 and the Water Resource Management Act (WMRA) No 11 of 2009, put strong emphasis on community participation in water management and hence formulation of Water Users Associations (WUAs). WUAs intend to make sure that communities play a major role in the water sector, including being day-to-day water users, guardians, conservers and managers of water sources. In the context of the Umba sub-catchment the key informants reported that their formal institution is *Umoja wa Watumiaji Wa Maji Mto Umba* (UWABU). Unlike other normal WUAs which are small and manage a single irrigation canal, UWABU is an association of water users in the Umba River sub-catchment with a mandate to coordinate and represent WUAs to the Pangani Water Basin Authority. UWABU was registered in 2005 with registration number PBWB/WUA/1B/01 and its main offices are located in the middle stream of the sub-catchment (Figure 31). In that regard UWABU may be considered an apex of several WUAs.

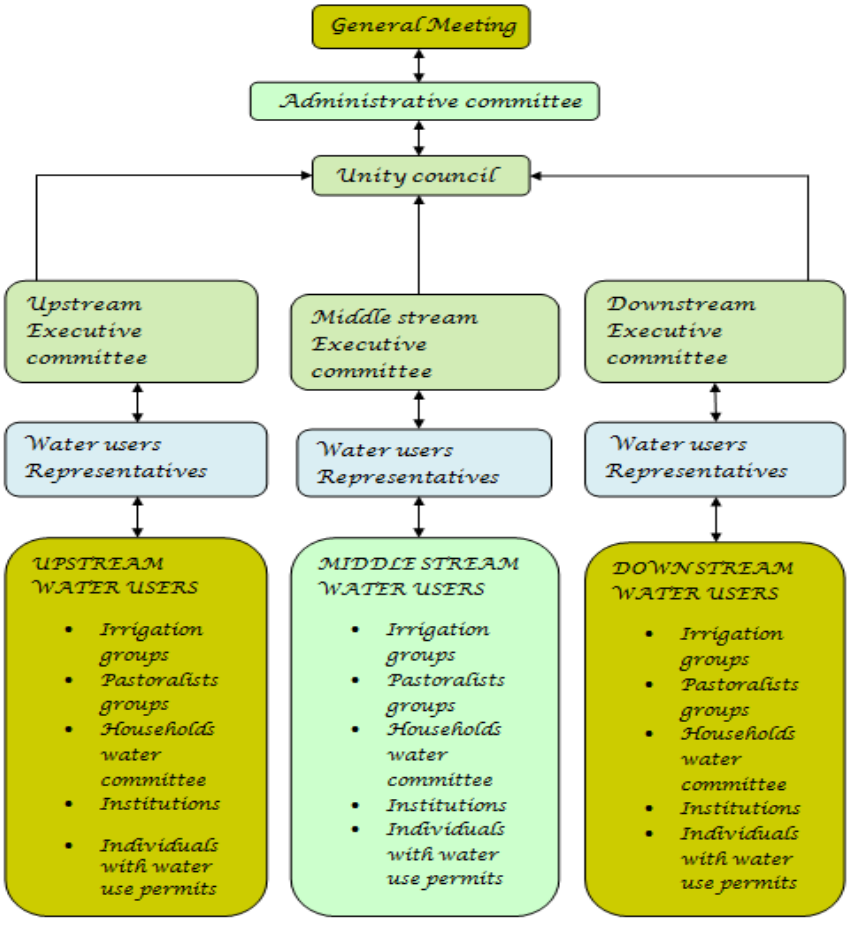

Figure 31: UWABU institutional structure
Source: UWABU, 2005

The roles of UWABU as a formal institution that represents the Pangani Water Basin in the Umba River sub-catchment and vice versa include; overseeing day to day activities of water resource protection, solving water related conflicts in the sub-catchment, organizing general meetings for members and representing members interests in the Pangani water basin meetings. Other roles include collecting water users' fees, assessing new memberships before they are sent to the basin office, ensuring water allocation in a fair manner, ensuring water availability for all stakeholders, raising awareness on water conservation and management in the sub-catchment and advising stream committees on water related issues.

UWABU officials revealed that the representation to UWABU is from all groups, stakeholders and streams as follows, with the administration structure and the responsibilities of each part explained in the following subsections. The leadership committee has six representative members selected by the UWABU general meeting. The three top positions (chairperson, secretary and treasurer) are equally divided from the upstream, middle stream and downstream stakeholders. The association council has twenty-one members of which six are members from the leadership committee and the other fifteen are from stream working committees. Five members represent each working committee. The leadership committee heads the association council in all water related matters. The association council is responsible for resolving conflicts in their specific areas, monitoring water use in their sub-catchment and updating the top position of UWABU. This council has twelve women representatives and nine men, the reason for this composition was due to deliberate efforts by women to make sure that they sit in the water decision-making bodies as they suffer the most from water shortages at both family and committee levels. On women's participation in water committees, Komakech et al. (2013) found that in all sub-catchments the number of women involved in water committees was outstanding and the reason was that they are responsible in obtaining water for family members.

Interrogation with UWABU officials revealed that the sub-catchment has three stream water management committees namely; upstream water management committee, middle stream water management committee and downstream water management committee. Each committee has five members composed of chairperson, secretary and treasurer and the other two are members. Their responsibilities include; receiving membership applications at stream level; managing water and membership fees and making sure agreements from the general assembly are implemented. The UWABU water users constitute different groups in the whole sub-catchment. Each group has a

representative in the general meeting and has its own constitution and leadership. All other institutions and individuals with water use permits in the sub-catchment are represented under this category. The water users representatives' responsibilities include; to link stream committees and water users, resolving water users disputes, defending interests of the groups in other authorities and protecting water sources in their localities.

6.5.2.1 UWABU Achievements

Results from both key informants and group discussions show that UWABU has helped to reduce conflict in collaboration with elders who represent informal institutions, especially between upstream and downstream, farmers and pastoralists and farmers and conservers. It was added by key informants that, since UWABU leaders are from within the villages, they have an advantage of inviting respected old people who can solve any arising conflict in the sub-catchment. This finding affirms Kabogo et al. (2017) who found that in Wami/Ruvu basin, leaders of WUAs have used their experiences and knowledge of the history of the areas to solve conflict between farmers and pastoralists. Also, this type of water governance that involves everyone and promotes both bottom up and top down approaches and across scales has been documented to reduce conflicts and improve livelihood resilience, with case studies including the Ewaso Ng'iro River basin of Mount Kenya (Baldwin et al., 2015; Dell'Angelo et al., 2016) and the Thau lagoon basin in France (Aubin et al., 2019).

Another achievement is that based on my interaction with households, it can be sensed that people have some knowledge on the importance of managing the environment, and when asked how they know, they say it was presented by UWABU leaders during village meetings. This shows how UWABU has managed to raise awareness in the community in the study villages. UWABU leaders said the remaining next steps will be using knowledge to revive and conserve the lost water sources as a strategy towards livelihood resilience and sustainability pathways.

Creation of one unit within UWABU that has increased togetherness. UWABU includes several villages and several WUAs. Through general meetings, members are able to network and share knowledge beyond UWABU. The association also serves as a uniting forum for several villages and it is through UWABU that farmers and pastoralists are able to meet and discuss water issues.

The last achievement reported and witnessed is on women's engagement and empowerment; women from different parts of the sub-catchment are involved in the UWABU leadership at different scales. This has given them an opportunity to build more confidence to influence decision making processes while making sure that water challenges that affect women are tabled and discussion for finding concrete answers is concluded.

6.5.2.2 Challenges facing UWABU

UWABU has limited trained personnel who are able to manage and coordinate it in a situation where water continues to decline while demands are increasing. Most of the leaders were normal villagers and most have little or no background in managing such diverse networks with constrained resources and with complex conflicts and interests. Relevant studies have concluded that the big challenge facing WUAs in rural Tanzania is limited capacity of formal institutions at the local level to deal with the mix of environmental and social aspects affecting the quantity, quality and seasonality of the water resources (Jimenez and Perez-Foguet, 2010). The key informant reported that the Basin Authority does not allow capacity building for UWABU leaders so that they are able to deal with increasing water related conflicts within the sub-catchment. It was also reported that power exercised from the district is considered strong for water resources in the sub-catchment, but with no close follow up when it comes to management and allocating resources (Carlitz, 2016; Jimenez and Perez-Foguet, 2011).

In terms of strengthening ways to ensure meaningful participation of all stakeholders, results from respondents show that they think they are not given equal chances to participate in decision-making processes. Some respondents even went further to mention that UWABU leaders are not adhering to the constitution and guidelines and show favoritism and nepotism. Meetings are not held as required and some stakeholders, especially pastoralists, complained that they are not part of the UWABU leadership and sometimes were not invited to those meetings. However, on this UWABU leaders mentioned that when pastoralists are invited they never show up for meetings.

One key informant from UWABU said they are not paid; they have a motorcycle given by the Pangani water basin authority for patrols, but it is not always fueled. This limits their capacity to operate and meet stakeholders most of the time. On the other hand, this has given more opportunity for informal institutions to be seen as strong, well organized and trusted, as they are always available to volunteer and solve conflicts with no expectation for financial support (Mutambara et al., 2015).

There were some important questions related to the UWABU being controlled remotely by top officials from either the district authority or Ministry, that reshape investment and infrastructure development funded by donors to ensure water access in the sub-catchment. The key informants gave an example of the recent (2015/2016) water access project supported by the World Bank that aimed at benefiting two villages. While two selected UWABU leaders technically participated in identifying two villages to be supported, later the project was diverted and the third village was added to the beneficiary villages. The informant did not disclose the person or institution that directed the addition of the third village as it was dangerous to do so. The informant added that adding the third village means increasing the number of water users beyond the planned budget and quantity of water. Most of the stakeholders were not sure how the decision of inviting the third village was reached, and by who. Although the Basin Water Board gave permission for the two villages which applied for water use/abstraction permits the third village was not in the application of the permit nor the supply map. This was well put by one key informant that;

> "We were surprised to see the diversion of water to the third village which is not even included in the concluded map and architectural drawing. We are not sure who influenced this and when?" (**A key informant from UWABU, 12th June 2017)**

From the quotation and using hydrosocial territory and waterscapes lenses, it seems the process to add another village to the World Bank funded project was not discussed even by the benefitting villages and people from UWABU who are responsible to ensure the success of the project. It could be possible that top leaders and or politicians reshaped the project to include the third village, because either those top leaders or politicians are from that village or they have other competing interests. The sustainability of this type of project is always questionable as it has all signs of top down approaches and hydrosocial waterscapes. According to respondents in most cases, the politics in the area have been imposing top-down approaches on the management of water resources. These results confirm World Bank (2018) findings that the failures of local rural water supply projects are linked to a history of centralization and politicization in water and related sectors. There are still incomplete decentralization processes at local and community levels that lead to misalignment of responsibilities, that in turn affect accountability relationships and delivery. Carlitz (2016) and World Bank (2018) have concluded that there are high level political and electoral influences that tend to dominate and reshape rural water project decisions and actual work that in turn lead to sub optimal public services. On the same note, results from respondents revealed that most of these projects have brought waste of much money, increased tension and have become like a white elephant. Of course, in that type of

competition, the losers are powerless communities. This finding confirms van Koppen et al. (2016) that formal institutions, especially under Integrated Water Resource Management, negatively affected smallholders' access to water resources and increased complaints. Most of the traditional furrow irrigation remained unimproved, malfunctioning, poorly operated and maintained with high water losses (van Koppen et al., 2016; Mul et al., 2011).

6.6 Informal institutions

Informal institutions at sub-catchment level existed even before independence and were recognized under tribal chiefs (van Koppen et al., 2007; Sokile et al., 2005; Kabogo et al., 2017). It is relevant to argue that, at the grassroots level, informal institutions are older and more experienced than existing formal water institutions. Sokile and van Koppen (2004) assert that informal institutions have managed to solicit deference and recognition at the grassroots levels when it comes to water resource management. In fact, formal institutions are consequential of and depend on informal institutions for their stability and strength (Sokile et al., 2005; Saleth and Dinar, 2004).

In the study area, informal institutions are at the grassroots level, independent from formal institutions but well linked to culture, norms, values, taboos and customs led by respected local leaders. These are people who know the norms, culture and traditions in the Umba. Key informants reported that, in the Umba, existing informal institutions are not separate from socio-economic interactions, or negotiations, and they consist of various players with diversified interests. This is in line with findings by Franks and Cleaver (2007) and Saleth and Dinar (2004) who argue that, at the sub-catchment level, informal institutions are players with influence to develop the means to govern water resource access and use.

At village levels across the study area, some customs and norms were reported to be practiced including restricting the undertaking any activity near water sources as it was against the will of the gods. Others include restriction of cutting trees, setting bush fires and grazing near water sources, customs whereby one should report to the leader on the intention to abstract water and reporting any existing conflict among water users. Respondents further revealed that it is a taboo to kill snakes living near water sources and they believe that the snake is friendly to people and is there to protect water sources. Since they believe that gods and spirits live in undisturbed water sources, it was prohibited to cultivate and grow crops in those areas as one would destroy god's home. Although these traditions,

by-laws and customs are not documented, they are well known to households and villages and are overseen by the elders (*mzee wa mila*) who are known and respected by the communities.

Key respondents revealed that everyone fears breaching agreed beliefs and norms so that the gods are not angry which would bring punishment. They said the punishment could include prolonged droughts, floods and diseases that may have negative impacts on the person responsible and/ or the livelihood of the whole community. These findings corroborate Katani (2010) and Kabogo et al., (2017) who found that, in rural areas such as Ukerewe in Tanzania, local people will not kill black or green snakes living near water sources as those are gods and are there to make sure water is available. Kabogo et al., (2017) assert that breaching informal institutions could make the gods angry and sometimes punish the whole of society and people's livelihoods. Therefore, these taboos, beliefs and rules ensure the sustainability of water sources and organisms living there (Mosha et al., 2016; Cleaver, 2012). In the downstream area, one old woman aged 72 years was quoted reporting;

> "Our norms intend to make sure that people do not interfere and disturb water sources as they are home of our ancestors who give us water. In fact, when I was young, in the village, water sources were considered a property of the whole public and no one was allowed to tamper with public resources. Everything abnormal done was quickly reported to the head of clan and we go there to apologize on behalf of that person." **(An old woman at Lunguza village, 18th June 2017)**

From the quotation above, it is clear that the head of the clan was a very respected and responsible person when it came to water resources management. It was reported the community could select an old person to supervise and make sure that everything is in order and observed for the benefit of the whole village. The selected old man was unpaid and was happy with the prestigious role to make sure the customary laws were respected.

In the study area, existing informal institutions are associated with livelihood activities of households. The intention is to ensure water sources are undisturbed by livelihood activities. It is likely that the National Environmental Management Act 2004, which restricts people from doing anything with 60 m of rivers, comes from and is linked to informal institutions. Results show that in the sub-catchment, informal institutions perform both roles as enablers (can facilitate negotiations and agreements to solve conflicts and water allocation issues) and controllers (can guide procedures). However, the studied area has a high level of interaction and overlap between formal and informal institutions (Komakech et al., 2012; Mosha et al., 2016; Sokile et al., 2005). This means that natural resources in

this area are managed through mixed institutional forms and arrangements. Nevertheless, official documents (including the WRM Act No. 11 of 2009 and NAWAPO, 2002) insist that formal institutions have the entire mandate and power. On the other hand, communities still perceive that formal institutions in their area are weak and do not represent majority interests especially on water access, compared to the role played by informal institutions. Respondents challenged the UWABU administration that reports to the water basin authority, while informal institutions report to the head of the clan and local water users and have neither bureaucracy nor fees. Some respondents even reported that the reason why the government wants to weaken informal institutions is to ensure that formal institutions can collect water fees. This finding affirms Nkonya et al. (2016) and Kabogo et al. (2017) who found that at rural and sub-catchment levels, people were not applying for water use permits because they observe and remain loyal to customary laws. This implies that it is not easy to elude informal institutions but both formal and informal can work together to address the water fee issue and enhance management of natural resources.

In solving conflicts, it was reported that, elders who oversee informal institutions were responsible for ensuring that all conflicts are resolved as soon as they arise. It was only at a high stage of the conflict that the village council could be consulted and in case of a failure to address it, the conflict could be referred to ward level; if still not solved it can be referred to the district level. During my field visits, there was no serious case reported to have gone beyond district level and most of the cases/conflicts were resolved through traditional/customary laws. This is with the exception of one conflict between farmers and pastoralists that I reported in the previous section. Responses from group discussions showed that all formal institutions, including primary courts, invite these local leaders (who lead informal institutions) to give advice before any formal judgments are reached. Therefore, it is the fact that in the study area, for the formal judgement to be strong and valid, it needs support from prevailing traditional norms. Practically, this means traditional/customary institutions remain powerful and influential compared to formal institutions.

6.7 Water allocation process in the Umba River sub-catchment

Results from key informants indicate that in the study area the contemporary water allocation processes can be traced back to the 1960s, when water was allocated to households through gravity canals and was needed for building houses. Respondents further added that during this time water was cheap and easy to get. On the other hand, household surveys revealed that in the downstream

areas, the water resource allocation process became more visible in the 1970s after the villagisation programme and when people started growing paddy rice and yams. Respondents added that from the late 1970s and 1980s there were periods of drought that decreased water in the Umba River. It was during this time that more farmers started practising irrigation farming and more water was needed to meet increasing demands. As water demands increased beyond available supply, competitions and conflicts started to emerge frequently, and then heads of clans had to call for meetings and find ways to allocate water and solve conflicts. Informal water user groups started organising themselves based on their social relationship and location and started meeting and discussing how to share the available water resources. Social ties played a great role in securing water resource access at local level (van Koppen et al., 2016; Bolling, 2013; Maritz et al., 2013; Mul et al., 2011) because of existing strong norms that ensured collective action and predictable behaviour to share water resources (Ostrom, 2014; Liddle et al., 2016; OECD; 2015). Key informants reported that the informal organisation process under local elderly leaders continued until the 2000s when the NAWAPO was founded, which insisted on creating formal structures, while UWABU was registered in 2005.

6.7.1 Factors underpinning water resource allocation

Results show that the factors that underpin water resource allocation in the study area include increased demands for irrigation farming, hence the need to meet competing needs, especially downstream. Another factor mentioned was water scarcity that forces the need for proper water utilization and allocation. They also reported that other factors include the state of immediate demands such as water needed to rescue drying crops in farms, domestic and religious institutional demands, the nature of terrain and distance from the river or water source and ensure getting water for household use.

Key informants revealed that getting water for domestic use is the first priority, followed by water for irrigation. The nature of the terrain and distance from water source also were reported to have a role to play in water resource allocation. This is because some villages such as Hemtoye and Kwekifinyu are located at the top of mountains and hence cannot be supplied with water that depends on gravity canals. This means that villages which are located far away from the water source cannot access water, while those near water sources or rivers have direct water. Local communities across villages were using the traditional irrigation canals which are earth made with no cement and directly tap/divert water from the main river and allocate/direct to the irrigable farms on duty by gravity. It was also

reported that these types of irrigation canals could be easily redirected by other farmers to their farms. Ofusu (2011) asserts that although local farmers can easily divert water from the main river, this method requires a substantial volume and after one farmer has finished irrigating his/her farm, water is directed to another farmer. In the following sub-section, I present and discuss the whole process governing water allocation in the study area.

6.7.2 Water resource allocation: process and decisions

Results from key informants show that before formal institutions, water allocation was guided by customary laws whereby anyone who wanted water from a shared source could just inform the clan leader on his/her intention to divert water and would then be able to go ahead. However, in the early 1980s when water become scarcer, they formed informal groups of water users and since then water started being allocated by leaders of the groups. In this sense, water was allocated on a rotation basis and everyone had to respect and wait for his/her turn. It was also mentioned that some people could exchange rotation among themselves if someone had an emergency that could interfere with his/her crops.

Now NAWAPO, 2002 and WRM Act No. 11 of 2009 guide the water allocation process and power is given to formal institutions. However, at ground level, both formal an informal institution was found working together and in general, the informal institution dominates. Villages located in the sub-catchment have water allocation committees (formal and informal) for water allocation. Each committee has a chairperson, secretary and treasurer. Sometimes a traditional leader heads the committee. These members are considered representatives of other water users, especially smallholder farmers. They meet every week to discuss and agree on where the water should go in the following week.

In the downstream villages, there are six WUAs that operated under canal irrigations (*mifereji*) namely Kwepune A, Kwepune B, Kwemichungwa, Kwemvungwe, Makokani, and Makola Tanga. During FGDs it was reported that they have agreed each canal will get water for three days consecutively before water shifts to another canal/*mifereji.* On the first day the allocation starts with the first group of water users, with one irrigation canal (*mfereji*) serving around 50 water users/farmers. Water users within a respective canal normally agree on how to distribute water among themselves within the three days. Every three days water will shift to other group until finally it will come back to the first user

group. Under normal circumstance, water will come back to the first water users after twelve days since the last day of water allocation. It was reported that on occasion, water is not accessible or not enough to meet the requirements of all users within a certain water canal. It is during these hard times that water users within the canal will spend the whole night in farms waiting for water. When it happens, that water is insufficient and the canal on duty does not get water, it means it has to wait until its next turn; to do otherwise would lead to conflict. One of the farmers from Lunguza village said;

> "In case the river has no water on your duty day, that is bad luck for your crops as you need to wait until those on duty have water and their turn is over. We respect this because we all committed at the meeting, so no excuse." **(A farmer at Lunguza village, 20th June 2017).**

The quotation above indicates how farmers are committed to respect and wait for their irrigation duty day. Waiting for your duty day reduces conflicts that could be caused by the process of taking water on other duty days. However, results show that some farmers are not able to wait for their located day and may divert water beforehand. In such circumstances, that farmer will be reported to the leader of the canal and can be given a penalty of either money or any punishment agreed by the committee members. Key informant respondents reported that it is easy for untrusted farmers to divert water from traditional irrigation canals as they are not made of cement and or concrete materials. In the Dakawa irrigation schemes of Tanzania, the local government had restricted and used force to destroy traditional furrow irrigation infrastructure because of the high amount of water loss causing conflicts due to water stealing (Mdee, 2014). However, the ability to make sure this is achieved in the Umba is questionable as the ability of local institutions to allocate water to farmers depends largely on the capacity of the available infrastructure. Respondents from downstream and middle stream areas during group discussions revealed that unimproved infrastructures tend to be labour intensive. Hence farmers in the middle and downstream areas were already using both sprinklers and hosepipes that are considered water efficient and require less human labour. The efficiency of these technologies was also reported from other parts of Tanzania by other researchers (Oates et al., 2017; Mdee, 2014; Kahimba et al., 2015). Although sprinkler or drip irrigation methods were perceived by farmers to be water efficient as compared to tradition furrow irrigation, they were also perceived to be expensive for them (Oates et al., 2017; Kahimba et al., 2015; Mdee, 2014).

In the middle stream, formal water users had again appointed a group of three people who oversee the water allocation process and make sure both farming and non-farming activities get water as

agreed. The area has two canals, namely Shundai and Kwemtaa, which serve about 1,000 and 500 households respectively. Each canal has not less than three *Kitongoji* (sub villages) with different water users. Those canals are not reliable as they get dry during the summer seasons, a situation that causes problems for water users. Each water user gets water through agreed water allocation schedules. During group discussion, respondents reported that the agreement is for each water user group to be allocated water for two days in each *kitongoji* for both canals. It was reported by key informants that initially, they were allowing three days to get water for livelihood activities, but later this changed as households and religious institutions especially mosques wanted water during prayers. On each Friday, water is left for households and religious matters in all *vitongoji* at once. However, water supply was reported to be insufficient for all users and smallholder farmers became the losers (Oates et al., 2017), while some never respected the agreed water allocation procedures. The key informant reported that, some farmers from off-stream and upstream have decided to shift to downstream areas where they buy land for agriculture. Some farmers have decided to engage in other non-farming activities such as petty business while others have decided to encroach on rivers and water sources.

For the upstream part, most of rivers that were earmarked to provide water for irrigation have been reported to have been totally dried out. During my field visits, I witnessed that farmers are practising irrigation by getting water directly from the riverbed using a bucket. In FGDs, respondents reported that water is allocated by alternating where one group of water users gets water for two days and then the water goes to the next group. However, farmers did not respect water allocation procedures as everyone could take the available water without considering their neighbour. Some were reported to use fuel power generators to pump water into their farms. Downstream water users considered this unfair as it denies their right to water. According to key informants and FGDs, some farmers even grow their crops near the riverbank. In all streams in this section of the river, there were reports of a growing habit of cultivating around rivers that result in the total disappearance of some rivers and water sources.

6.8 Chapter summary

In this chapter I have explored community perceptions on water scarcity and how these perceptions relate to physical findings in chapters 4 and 5. The chapter has used information collected through FGDs, key informants, household surveys and reviewed literature for comparison with previous work. I have analysed and demonstrated how communities perceive and consider reasons for water scarcity

and how water scarcity affects and shapes households' livelihoods in the Umba sub-catchment and off-stream villages. Six types of water related conflicts have been identified and demonstrated to be linked to both power relations and or water resource decrease and scarcity in the Umba River. Most of these conflicts are reconciled through discussions among communities under the leadership of respected elders. Institutions (both formal and informal) have been assessed by looking at their structures, strengths and how they are rooted into communities. Due to the legal emphasis on formal institutions to govern water resources in the sub-catchment and village levels, particular attention was paid to them. Results have shown that a formal institution (UWABU) is working to ensure water availability to stakeholders but faces a number of challenges that include limited financial and human resources to the extent that it is not able to keep pace with the growing complexities and hydrosocial waterscapes of water allocation challenges in the study area. On the other hand, it is established that informal institutions play a major role in handling water challenges in the sub-catchment that include facilitating water allocation, water governance systems that follow a polycentric approach and solving and reducing conflicts in the study area. However, these important institutions are not recognized by either NAWAPO, 2002 or the WRM Act of 2009. I argue that informal institutions are deeply rooted into communities and are well respected to the extent that communities rely on and trust them in handling water related challenges. This is due to the fact that allocation of water in the Umba sub-catchment needs to be well-coordinated, emphasizing equitable access, inclusive decision making, harmonized power relations that encourage sustainable human-nature interactions and sustainability. Resilience, waterscapes and hydrosocial territories have been combined to ensure analysis and understanding of existing complexities and challenges facing water resources. I argue that, in most cases, for understanding human-environmental interactions and outcomes related to livelihoods, and how they are shaped by power relations and institutions, it is important to draw on different concepts to ensure inclusiveness, deepening and broadening coverage of issues. While each concept plays its role related to the specific topic of emphasis, they later converge for strengthening meaning.

CHAPTER 7
LIVELIHOOD TRAJECTORIES

7.1 Chapter introduction

This chapter explores the key livelihood trajectories in the study villages for the past 35 years. It intends to assess and document how changes (both physical, socio-economic, institutional and policy wise) that have happened over time (as presented in chapters 4, 5 and 6) have shaped the individual and household trajectories. The chapter examines and documents the pathways by which some households were able to retain their livelihood security while others were not able. In this thesis, I combine the concepts of resilience (Quandt, 2018; Volpato and King, 2019) and hydrosocial territory (Boelens et al., 2016) to provide further clarification of livelihood options and institutions. The chapter assesses the life histories of selected households / individuals to get an understanding of their local settings, livelihood pathways, challenges, and strategies to address them (Quandt, 2018; Kliskey et al., 2019).

Attention was directed towards understanding the nature and scope of socioeconomic, environmental and institutional dynamics that touch different households' livelihood activities and their related outcomes. The first section explains methods through which livelihood trajectories were built, while the second section summarises notable changes in the Umba as captured from chapters 4, 5 and 6. The following section is on individual household livelihood trajectory cases and where identified during household surveys from different locations of the study area. Livelihood diversification strategies follow and finally are the livelihood outcomes. The last section gives a summary of the chapter that reflects livelihood pathways and ways to revamp trajectories.

7.2 Methods used to build livelihood trajectories

Studies (Sallu et al., 2010; West, 2013; Katikiro, 2014; Wilson et al., 2018) have used the concept of livelihood trajectories to identify and explain the pattern and trends of livelihoods of individuals or groups of people. In order to trace and understand how communities' livelihood activities in the study villages have been transforming to better or poorer situations, this study has employed livelihood resilience as a methodology (Fang et al., 2019; Valbuena et al., 2015; Kelly et al., 2015; Quandt, 2018). The methodology has been documented by several researchers (Quandt, 2018; Lancelotti et al., 2016; West, 2013; Tittonel, 2013; Valbuena et al., 2015) to be appropriate to examine individual, single and groups of households strategic behaviours linked both in a historical repertoire and in social diversity.

There is also a consensus that livelihood trajectories when combined with other approaches have the capacity to penetrate into beliefs, opportunities, demands, aspirations, limitations and more importantly can be contextualized in relation to power and institutions (Boelens et al., 2018; Sallu et al., 2010; Kliskey et al., 2019; Folke, 2016; Tanner et al., 2015; Quandt et al., 2017).

Livelihood trajectories of the selected households were assessed using a mixed-methods approach, including household surveys, PCA, key informant interviews and secondary data. In the analyses, I considered households' livelihoods to be multi-dimensional, encompassing socioeconomic, political, institutional, social and ecological aspects. The approach was motivated by de Haan (2006) who argues that the analyses of today's households' livelihoods should consider a range of livelihood capitals, economic opportunities, markets, infrastructures, connection and networks, which are not necessarily located in one specific place. In this regard, livelihood trajectory is conceptualized and based on different life periods/events, localities, and/or experiences.

The main assumption behind the development of livelihood trajectories in the study area is that livelihood strategies and options are not static and have been changing over time under different environmental situations, landscapes and institutional settings. It is under this milieu, this chapter assesses the pathways that influence changes in livelihoods with time and whether they are moving into resilient or vulnerable scenarios (Sallu et al., 2010; Tanner et al, 2015).

There was limited documented evidence in the study area showing how water and other natural resources challenges in the study area affect various scopes of livelihoods. Evidence from key informants to household heads and more importantly from other African rural areas such as Botswana (Sallu et al., 2010; West, 2013), Togo (De Haan, 2006), Madagascar (Benoit-Cattin and Andrianirina, 2012), Burkina Faso, Kenya (Valbuena et al., 2015) and coastal areas of Tanzania (Katikiro, 2014) were reviewed. Documented evidence from this literature has revealed that ecological and socioeconomic changes and status shape household livelihoods in many ways and indeed have been used to build a foundation which is discussed in this chapter.

7.3 Notable changes in the Umba

7.3.1 Environmental changes

For the last four decades, considerable changes in biophysical settings have happened and have affected households' livelihoods in the study area. Results from chapter 4 have shown changes in land use whereby scattered cultivated land and settlements have increased by 395% and 1761% respectively. Natural forests and bushlands that act as water source areas have decreased. The analysis has further indicated that the greatest changes in cultivated land and settlements happened from 1995 to 2015. On the other hand, results from the analysis of historical rainfall data showed that apparent trends in annual mean rainfall are declining but are not statistically significant. Extreme events especially drought years are however increasing with time and the trend test has proved to be statistically significant. There is more interannual and interseasonal rainfall variability. The coefficients of variation in the rain season length have shown that the length of the rain season has become unpredictable with a possibility to have decreased. Findings from community perceptions in chapter 6 on changes in land use and climate are very comparable in revealing a belief that, from the late 1980s to the early 1990s, natural forests, land and water/rivers started declining due to unsustainable farming, overgrazing, recurrence of droughts, brick making, charcoal production and forest encroachments for settlements. People perceived that land has changed its use, especially from forest to settlement and cultivation. On climate variability, communities also had comparable views that the rain seasons have become shorter with drought events affecting water sources and farming. The most affected crops mentioned included yams, bananas, maize, beans and paddy rice.

7.3.2 Changes in livelihood capitals

Chapter 5 has shown that most households in the study area still rely on natural capital, especially land and water. Narrations from selected households and elders revealed that for the last 35 years, the households' livelihoods in all studied villages have experienced changes. Changes include livelihood capitals and especially dwindling of natural capitals such as natural forests, water sources, rivers and fertile land that are crucial to household's livelihoods. The dwindling of natural capitals was again comparable to LULCC findings in Chapter 4. The reasons mentioned for the decline again included both land use change, unsuitable utilization and the villagisation programme that made communities leave their ancestral land and start life in another area. Also, Chapter 5 has shown that compared to former decades when people were able to get financial capital by selling surplus crops, now the situation has changed as people get no surplus because the land has become less fertile, while water scarcity and competition have increased, leading to low productivity. On the other hand, the

introduction and spread of diseases such as HIV/AIDS in the 1980s, malaria and pneumonia are reported to affect both human labour, financial capital and other important capitals (Lushoto District Council, 2016).

7.3.3 Changes in institutions and legislations

Linked to that, Chapters 5 and 6 show that institutions and policies governing water and land have undergone several changes that have affected communities and their related livelihood activities. Some notable changes include abolishment of chieftainships in 1963 that used customary laws to control, safeguard and distribute land to both clans and individuals (Katani, 2010). Unlike during the colonial era where chiefs helped colonial governors to protect land and water sources, under the new tenure systems land and water resources are entrusted to the president of Tanzania. As explained in Chapter 5, the abolishment of the chief system before developing a strategy to strengthen formal institutions has caused significant degradation of land and water sources, which in turn affects community livelihoods (Lange, 2008). While the Village Land Act No. 5 of 1999 recognises customary laws, the WRM Act No. 11 of 2009 has totally ignored them and some scholars see formal institutions striving to weaken them, while formal institutions themselves are not able to replace the role played by informal institutions (Kabogo et al., 2017). These changes have in turn changed how communities access water rights by creating more bureaucracy in the way they manage water resources.

Overall, these changes have shaped households livelihood activities and trajectories, which are followed by households and individuals. In the following sections, I present and discuss some selected households' livelihood trajectories by looking back over three and a half decades.

7.4 Households trajectory analyses

This section investigates the households' trajectory of selected samples from 4 locations which are upstream, off-stream, middle stream and downstream. Guided by chapters 4, 5 and 6 different challenges specific to each location are identified through interrogating the history of the narrators.

7.4.1 Household trajectory in the upstream villages

Case 1:

The upstream area of the Umba River is considered to be populated with limited fertile land and water resources but with a cool climate (Huijzendveld, 2008). During the field visit and transect walk, it was observed that the land is very mountainous with steep slopes and in most places the land is stony.

Narrator HH31 (aged 57 years) is a head of household with 7 household members. He was born and grew up in Goka village that is located upstream. His village is located near the headwaters of the main Umba River. He says that when he was growing up, most villages located upstream were enjoying water which was flowing from Shagayu forest through several channels and was perennial. He also says water was passing every corner of their village and they were growing bananas. During the rainy season only one road which is far away was used, as many other shortcut roads were full of water and water could remain for some weeks to one month. He further explained that the rain season would start on time and would end sometime in mid-June which means it ended later than it does now.

> "You see in the 1980s and somehow 1990s rain could come on time no matter what. The whole area here was green and the climate was very good but sometimes very cold. And you must remember after it has rained even if it was little do not try to use this path or try to close that Umba River you see now looking like a small channel. It was very dangerous and many people died. Being born here, water was not an issue and you could get water from anywhere easily and nothing like irrigation existed. When the government-built water pipes that tapped water from Shagayu forest, the pressure was high and one could get water as soon as possible. Now the pipes have no water and even when it comes, it takes half an hour or more to fill one bucket of twenty litres. We went to the water source located in the forest want I can say the source has no water! In addition, before this situation, people could grow maize, bananas, sugarcane and even beans; we could only hear on radios issues of food insecurity, but not in our village. However, beans sometimes were affected by heavy rains. But at the moment I am talking with you, things are opposite, as you can see the river has changed to a channel and all bananas were affected by droughts, we are no longer growing maize because they need enough rain. Now we have switched to growing vegetables especially cabbages, carrots, spinach and tomatoes where we sell them and buy maize flour for our family food. My family has a plan to start growing onions but I am not sure if could perform better on our stony and unfertile land". **(HH31 from Goka village, 17th May 2017**).

The narrative from respondent HH31 indicates that in the 1980s the upstream area had rainfall which was sufficient and predictable. They were even growing crops that need more water such as bananas and were not practicing irrigation farming. However, after poor performance of rains they had to change to irrigation farming and abandon growing bananas and maize because they need more rainfall which was no longer available. While they were not buying food, now they have to grow vegetables so that after selling they can buy maize flour which is used as food. This means that when vegetables lack a market as everyone is already growing them, or they are affected by water shortages that cause a poor harvest, this family will be vulnerable to food insecurity and later could potentially shift to loans and then be trapped into more poverty.

Case 2:

Narrator HH68 is a farmer from Kiranga village just neighouring Goka village where the previous case is referring to. The age of narrator HH68 is around 73 as he doesn't know his age. He has no formal education but he is on the board of the village primary school. He was born in the village but some of his relatives shifted to other new villages during villagisation in the 1970s. He says in 1959 he was given a piece of land by his family to start agricultural activity on his land as he prepared himself for his own family. He says the land was around 4.5 acres equivalent to 2 hectares, although he had no interest in farming he started slowly and later became used to it. In the years 1975 and 1976, there were major droughts that affected farming activities and they could not harvest anything in those years. Some people sold their land so that they could buy food, but he says no one was ready to buy it as everyone was budgeting for food in the next week or month. He says his family tried to go to local markets that were happening every Thursday to convince people to come and buy their land but it was not easy to get a buyer. He says, later they got one who agreed to buy it at very cheap price and with a condition that the land should be near the Umba River. Since the parents' land which was on sale was a bit far from the river they agreed to take part of HH68's land and sell so that they can buy food and he would be compensated with another piece of land at another place which is not near the Umba River. That was in early 1976 and he agreed. After selling it he went with his father to Lushoto town to buy maize flours as it was scarce in the neighboring environment. He says they used bicycles to travel more than 50 kilometers so that they can save money.

He says in that year the MAM rain season didn't perform well and again there was no harvest. After seeing that, he agreed with his wife for him to go to Morogoro where he can provide casual labour in a sugarcane plantation and get money to buy food for his family and parents. In Morogoro he got a job and earned some money and after saving, went back with maize flour and beans. Back home he found another piece of land was already sold to the man who bought the first piece of land. His parents wanted to get more cash to buy food for them and his wife with one baby. Since then, they had no land any more that bordered the Umba River.

> ……"I cannot complain to my late father, as he had no alternative to feed the family, he was getting old and my wife had a little baby. However, it is like we were giving land free as the price was very low" **(Respondent HH68, Kiranga village, 2nd June 2017).**

Narrator HH68 went on that, again in 1984 there was another drought which caused hunger in most villages including Kiranga. He says people who had land near the Umba River opened farms along the

river and caused serious degradation. Some went to Shagayu forest and opened farms. Although the government intervened using armed game scouts, more degradation was already happening. He says he was among the people who entered Shagayu forest for farming.

> "….yes we were chased by armed game reserve people; but I think I contributed disturbing the water sources in the forest as I was growing maize near where natural water was originating. What I can tell you, is that wet land was an issue and many people from other villages came to that source and opened farms" **(Respondent HH68, Kiranga village, 2nd June 2017).**

He says, in the late 1970s and early 1980s an NGO came to intervene and address ongoing land degradation and they introduced eucalyptus tree species (Figure 32) that were grown on land along the Umba River to reduce soil erosion and land degradation (see Chapter 6). He adds that, although everyone was happy when they were growing trees, now it's a crisis as most of water sources have become dry and agricultural land has become unfertile.



Figure 32: Eucalyptus tree species at Kiranga and Goka villages
Source: Field survey, 2016

He further narrated that, even those who had some land near the river are no longer productive because eucalyptus has dominated everything including what used to be agricultural land. That is why people have now encroached more into the rivers to grow vegetables. He reports that others who still have energy have decided to shift downstream to find land for cultivation or provide casual labour, and while he wished to shift, but is already too old.

7.4.2 Household trajectory in off-stream villages

Case 3:

This case study is narrated by a woman (HH1) aged between 66 to 69 (she does not know her age) and her husband aged 72 years (HH2). She was born in another village but came to Hemtoye village in 1969 after marriage. She says by that time the area was green and people were growing several crops such as maize, beans and cassava. On the other side, HH2 was born in Hemtoye but his parents came from another village. Both had good land by then with a good life. Water was flowing in most streams and they even grew bananas. According to HH2, there was one big forest where they could go and collect fire wood. She says the forest was owned by the village and controlled by the clan leader but everyone could get fire wood and other non-timber resources. HH2 adds that even building materials for their house came from that forest.

According to HH2, from 1974 to early 1976, the area experienced droughts that affected their livelihood activities and even some people migrated to other villages and have never come back. He continues by saying that some people sold most of the valuable things they owned including land so that they could buy food. Every one suffered that hunger, he said. He said, "I and my wife we agreed to exchange our land for food so that we can survive". He continued:

> "Since then we never managed to buy another piece of land although we expected to do so. Our land has remained small and at this age we don't expect to get money to buy expensive land in the village. Some people decided to burn and sell charcoal in Lushoto town but few could buy. It was during that time when our only natural forest started being degraded. And since the government was already abolishing our heads of clan to control natural forest and water sources, there was no one taking care. People continued to exploit it until the 1980s when people started establishing houses and it totally became a village. People divided the forest among themselves and others came from far away to grab land and establish settlements". **(Respondent HH2, Hemtoye village, 30th May 2017).**

On water, HH1 explained that in the early 1970s water was available but later in the 1980s it started disappearing and especially after the establishment of settlements in the natural forests and increase of drought events. She said:

> "…as you can see my age I am very old and I am not able to fight for water with young ladies and women at the water source. I just wake up and take my bucket to the water source if I am

> lucky one will say you are old fetch water and go home; if I am not lucky I will wait until my turn comes" **(Respondent HH1, Hemtoye village, 30th May 2017).**

On livelihood, HH1 and HH2 narrated that, because of frequent droughts and limited rainfall, they had to abandon growing bananas and maize as they were not performing well. They say that now they are sometimes growing beans and maize but it is not easy to get enough for food. HH2 said some people have now shifted to downstream villages where they can grow vegetables and paddy rice. He added;

> "…but when they come back they say water is a challenge and villages have started changing like our villages, I am not sure where are we going and how will young people survive?" **(Respondent HH2, Hemtoye village, 30th May 2017).**

7.4.3 Household trajectory in downstream villages

Case 4:

As explained in Chapter 5, this is an area which has relative fertile land, and people are growing paddy rice and vegetables. In this area, pastoralists also come for free pasture and water during dry seasons. A participant HH232 at 65 years of age is a farmer with two wives. Each wife has her own house and farms. He says he was born in Makangara village but when he was 18 years old, the government asked everyone in Makangara village to leave and they were given several new villages where they can go. He said that, it was the villagisation programme (*vijiji vya ujamaa*) which I defined and explained in Chapter 5. He says it started like a request but after one year it become a command and they had to leave their farms, houses and everything which cannot be shifted easily.

"Soldiers came and forced us to leave the next day" he said. His parents went to the other village but he joined his uncle who decided to shift to Mnga'ro village which is located downstream. He says it was a very hard time to experience as there was so much rain and they had never been to that place. Some people died because of heavy rains and malaria, but he and his uncle's family survived.

Although they were growing maize and beans in Makangara village, after they had arrived at Mng'aro village they started preparing a new farm where they could grow paddy rice and yams.

> "I can assure you it was a hard time to experience in life and we suffered as we had no money even to buy food. We went to the bush and opened up the farm you see", (he was pointing to the farm) "I took a piece of forest and another one was taken by my uncle then we started cutting trees. It took us much time but we continued and everyone was busy doing the same in several places of downstream". **(Respondent HH232, Mng'aro village, 2nd July 2017).**

He says then, they grew paddy rice, yams and maize and that they were not irrigating as the area there was a wetland. He further adds that after the droughts of the 1980s many people started coming

downstream from other villages for growing paddy rice, but water was decreasing to the extent that even neighbours started struggling to get water for their farms and the prison barracks had opened big paddy rice farms and were taking water.

> "…water from upstream was declining and everyone started being worried, we had to change the type of paddy rice to those which need less water. Many people stopped growing an important staple food I liked most called yams". **(Respondent HH232, Mng'aro village, 2nd July 2017).**

According to HH232 some farmers shifted to growing vegetables because of three reasons: one was a decrease of water in the Umba river which increased competition and conflicts, second was land shortage as many people were coming downstream and shifted to vegetables as they need less land and less water. The last reason was the availability of markets and increase of vegetable demands in Dar es Salaam and Tanga towns. He concludes that, as water and land have continued to decline while more people are coming he does not know what will happen in the future.

7.4.4 Household trajectory in middle stream villages

Case 5:

The middle stream is now acting like a centre of all villages and is located along the main road to Lushoto town, which is the headquarters of the district. Respondent HH312 is a woman of 49 years old. She lives with her family with 3 children but another two are already employed by the government. She was born in that village but her parents migrated from Kilimanjaro region and they came for farming in Mwangoi village. She says that her parents were growing maize and beans early in the 1980s and later they stopped farming and they started buying and selling crops from farmers. She gave the reasons for change were due to the low harvest while land became unfertile and was affected by high rates of erosion and degradation. Also, population had increased in the area and the land they owned was small as the government took some of their farm and established primary and secondary schools and a dispensary. Also, people bought some of her family's land and built residential houses, guest houses and kiosks. Also, she says business people from Lushoto bought land and built some crop stores whereby after harvest, everyone could bring their crops to Mwangoi as a centre. A farmers training centre was also built in that village by the local government where farmers were trained in sustainable agriculture. She says, all those forced people to change from solely farming to a mixed type of livelihood occupation. Some remained with small farms and some even sold the land and went downstream where they bought another piece of land and established a new life. She further narrated that, her husband also joined the business of buying and selling crops. The model was to buy crops

during or soon after harvest and or give money to the farmers even before they harvest so when they harvested the crops they directly belonged to the person who gave money. Both approaches may disadvantage the farmer who has no time to wait for the market to determine the price.

In 1996 her husband was in a car accident when he was carrying the crops he had bought from farmers downstream. His spinal cord was injured, and he never has stood up since then. She says they had to sell everything they had to take him to hospital, but still he never became normal. She said, the life changed and she had to find way to keep the family moving, children attending school and paying medical costs for her husband, as they had no insurance. Although at the beginning, she was growing only a garden at home, she realized that could not make her advance her family to the next level economically. She joined VICOBA and a women entrepreneur's group at Mwangoi where they opened a shop to pack and sell milk they collect from pastoralists downstream. She continues by narrating that;

> "My young brother, I had no alternative but to change immediately and take responsibilities. Everyone was depending on me, my children, my husband and even my old parents. I managed to pay fees for my children in private schools and colleges, my husband is still alive although he cannot stand up and due to my motivation, our entrepreneurship group elected me as a treasurer; at the same time, I am now a secretary for UWABU" **(Respondent HH312, Mwangoi village, 30th June 2017).**

She says, she decided to work for UWABU so that she can represent women in pushing for water availability and access. The shift from farming to business gave her an opportunity to interact with people who connected her with markets for their milk and other entrepreneurial trainings.

Overall, looking at the five cases above, it is clear that families and households have been changing with time depending on where they are located and the resources they own. Some of the trajectories meant moving towards greater vulnerability, for example the cases from upstream and off-stream. The reasons seem to be again linked to availability of resources and education levels of household heads. Changes in government policies and programmes also might put people into vulnerable situations (Katani, 2010). A good example is the case of the villagisation policy in the downstream area and how it led to natural capital degradation and at the same time separated people. Yet there was no government compensation for the programme's impacts (Kikula, 1997). Still, people had to find a way to live no matter the sitution.

7.5 Livelihood diversification strategies

Household livelihood diversification in rural areas has been documented to mean household efforts to construct various portfolios of activities and assets in order to ensure wellbeing (Tanner et al., 2015; Martin and Lorenzen, 2016). In literature, there is an ever-growing debate on the reasons for livelihood diversification in rural areas of developing counties (Volpato and King, 2018; Jiao et al., 2017; Barret et al., 2001; Liu and Lan, 2015; Walelign et al., 2017). In the studied villages, households had different livelihood strategies. The quality of these strategies undertaken by different people was reported to differ depending on location and availability of livelihood resources. Discussion with respondents has shown that households choose a strategy that they feel is possible for them. The implication of this approach is that some of the strategies such as charcoal burning does not necessarily have positive outcomes. Some of the options are influenced and some restricted by policies, institutions and plans. Households are applying a combination of livelihood activities (Brown et al., 2006) and choices across studied villages. The types of livelihood strategies practised in the studied villages include;

a. Farming as a livelihood strategy
b. Mixing crop farming and keeping cattle as a livelihood strategy
c. Non-farming as a livelihood strategy
d. A combination/mixture of farming and non-farming livelihood strategies

Based on field observation, discussions at household level and results from trajectory analysis, it is very clear that assets such as human, financial and natural assets are the major hindrances to successful livelihood diversification strategies.

7.5.1 Typology of livelihood strategies in relation to water resources

As stated in the previous sections, efforts towards household's livelihood strategies differ from one household to another and village-to-village. The major determinants include location, natural resources/assets available, household education level, membership to cooperatives, access to credits and market demands that can be helpful for pursuing livelihood goals. This finding fit wells into the argument of Volpato and King, (2018) that the determinants of livelihood diversification at household level are distinct but overlap, and include factors such as available assets, seasonality, risk, markets, policies and coping behaviour. In all studied villages, four clusters that form the portfolio of livelihood strategies with a connection to water resources are identified. These clusters were:

Cluster 1. Risky farming only as a livelihood strategy

Most of the households engaged in this type of livelihood strategy are poor and located far away from water sources. They grow crops in unfertile soils and have limited social networks and financial supports. Although these households are found in all villages, about 67% are located in off-stream and upstream villages with limited land and water. Households that are headed by a single parent, especially women, fall under this category, categorised as poor with no diversified livelihood strategies. These households have many dependents, especially young children. The only way to diversify livelihood was based on working for others in farms where they were paid per day. Households under this category are very exposed to vulnerability to poverty because their lives depend on rain fed farming and have limited financial capital. Informants reported that food insecurity and poverty are the main challenges of households under this category, as they cannot diversify their income. Although some were reported to get some financial assistance from the Tanzania Social Action Fund (TASAF), they complained that the amount is very little for them to reduce the vulnerability and chronic poverty they are trapped in.

Cluster 2. Poorly diversified farming livelihood strategy

This cluster category is made-up of households which have some pieces of land or can rent land near water sources and engage in local and traditional small irrigation farming. Although they grow crops for food and cash, most of the seasons are unsuccessful and the harvests are for the subsistence kind of life only (Ellis, 1999). These households have no cash to hire labour or buy large land areas for farming. They are reported to have limited skills and access to financial institutions. However, they are better off than cluster one. When asked why people in this cluster have remained poor despite their access to water resources for irrigation, one of the respondents (HH65) from this cluster put it clearly that;

> "….as you can see we have small pieces of land, we cultivate these areas each season, we grow the same crops and we have no means to mechanize our farms. Water has been declining at a very high speed and we have no machines to pump water into our farms we only use our bucket and if someone is sick then no irrigation shall take place that day." (**HH65, Dule M village, 17th November 2016**).

The explanation from respondent HH65 was verified through field observations and ground truthing, during which I was able to see members of households taking water with buckets to irrigate their tomato gardens (Figure 33).



Figure 33: People fetching water to irrigate tomato garden at Mwangoi village
Source: Field survey, 2016

Since some households in this cluster had some pieces of land and had poor technology, especially on irrigation, their livelihood strategies included diversifying crops, but they did so by cultivating near water sources and rivers (Figure 34).



Figure 34: Part of the river encroached at Kiranga village
Source: Field survey, 2016

The above habit of cultivating near water sources and riverbanks is very common in the studied villages. As a result, river streams have started becoming dried out. One of the uncles who was in the village justified this to me by saying that;

> "Most of the days I stayed with my uncle; his wife was leaving at 4 AM to go to fetch water at the few remaining but unreliable sources where people were in a queue since 3 AM. Later even that source also was dried. The only way was to buy water every day from water vendors who used motorcycles. You can imagine in this poor rural village people look for money to buy food and spend some on water." **(Uncle, Hemtoye village, 17th December 2016)**

Households in this cluster have no health insurances (for family members) while malaria is a major disease disturbing human capital. As a result, farmers sell the properties to take family members to costly hospitals. The informants also revealed farmers faced the challenge of crop price fluctuations in the market. Farmers are not connected to markets and after harvest, they have to wait for local buyers who have connections in towns such as Tanga and Dar es Salaam cities (Figure 35).



Figure 35: Sacks of sweet potatoes waiting for customers from towns
Source: Field survey, 2016

Cluster 3. Viable diversified activities livelihood strategy

The cluster 3 category is rather similar to cluster 2 in some respects. However, households in this cluster have more livelihood capitals (natural, financial, social and sometimes human) compared to clusters 1 and 2. They can produce more and sell to the markets, to get money to diversify their livelihoods. They were reported to be able to wait until the price in the local market is stable and then sell their crops. They engage in irrigated crop farming on land which is above 2 ha but found in more than one location, petty business and some have their own water pumps. They also have access to some microfinancing institutions and can use their houses as collateral. Respondents explained that households under this category are able to hire and pay workers/labour and some of these people are

educated and/ or have educated household members who are living in towns and can help them to access loans and other support. Some people under this cluster are working for the government which is why they are always financially in good positions. In principle, households under this cluster are resilient to seasonal conditions and have fewer vulnerability exposures as their livelihoods are more diversified (Denton et al., 2014). The challenge facing households under this cluster is that government institutions have not managed to improve physical infrastructures such as irrigation schemes, roads and access to electricity connections. However, those who are close to infrastructures such as roads and local market centres are engaging in buying motorcycles for transportation purposes, have maize and rice milling machines, sewing machines and have small restaurants for selling both soft and other drinks. Others were even working in carpentry. These are found in both middle stream and downstream areas. Masunungure and Shackleton (2018) and Valbuena et al. (2015) assert that rural projects (such as roads and electricity) in South Africa, Zimbabwe, Tanzania and Kenya, have played a potential role to strengthen rural households and are drivers of positive change and transformation.

7.5.2 Outcomes of the livelihood strategies

In this chapter, the outcome of livelihood strategies in the study area is assessed at institutional and household levels. Institutional outcomes were linked with households who were joining both formal and informal institutions and how they were able to reduce vulnerabilities while at the same time creating opportunities for more income, food and access to credits (Merrey and Cook, 2012). Formal institutions such as UWABU had a large number of member households who wanted to be assured of water access. Those affiliated with UWABU to some extent had opportunities to raise their voices and were considered in water access, compared to those who were not affiliated. Households which managed to obtain some resources and became members of Village Cooperative Banks (VICOBA) had more opportunities to access credits and loans. They had opportunities to get training on entrepreneurship and livelihood diversifications from local experts such as teachers and nurses. This helped them in the process of diversifying livelihoods and increasing household livelihood resilience. In terms of income and earnings, household members who are affiliated with VICOBA were found in a better-off situation compared to those who are not connected. It was also reported that in a situation where a member has a serious financial and/or any challenge, the group is able to contribute something to that colleague as a way to give him/her relief. It is easy for a member of VICOBA to secure loans that could be used for reinvestments or constructing a house and pay back slowly.

Furthermore, those connected to informal institutions had opportunities to get access to information that was helpful for their farming activities. Some of the information was reported to include free health services, the importance of farming using ridges and improved agricultural inputs. This kind of information is helpful to poor farmers. Those who are not linked to these institutions, especially informal institutions including churches and mosques, were among the vulnerable group.

Households that were engaging in both farming and non-farming activities were reported to be resilient and less poor compared to those who depended only on farming activities. In villages near the sub-catchment with good irrigation infrastructures and access to markets, to increase their income the earnings from farming are reinvested in other non-farming livelihood options. This was reported to ensure the flow of cash to the specific household while at the same time reducing chances for loss. In rural Ethiopia, Gebru et al. (2018) found that households with access to credits and markets, membership to cooperatives and access to extension services were better off compared to those without.

Migration to areas (downstream) where there is relatively fertile land for farming and favourable for business was one of the strategies used by household members located upstream and off-stream. This finding corroborates Scoones (1998) and de Haan (1999) whereby migration of individuals and labour in rural areas of developing countries is among the central strategies of livelihoods and that should be supported by relevant institutions. After getting land, growing crops, harvesting and selling, some of the cash is sent back by farmers to their villages of origin for their wives, fathers and constructing decent houses (West, 2013). Some reported that they invest the money in shops to diversify livelihoods. However, in cases where the climate is associated with prolonged droughts, life becomes difficult and the whole family suffer the results. I argue that households who have diversified their livelihoods into non-farming activities have remained more resilient than those who are dependent on rain fed agricultural activities with a small area of land.

7.5.3 The role of institutions in transforming households' livelihoods

This sub-section discusses how institutions and policies have shaped and either influenced and/or restricted households' livelihoods/vulnerabilities in the studied villages. Both informal and formal institutions work together in some rural areas as formal institutions still need special support from informal institutions.

7.5.3.1 Formal institutions and households' livelihoods

In one way or another, households pursue their livelihoods within the context of set government policies and frameworks. The impacts of these policies and frameworks on households depend on how formal natural capital institutions are arranged and have managed to put in place access and use of those resources (Carlitz, 2016). In all circumstances, responses from household heads and group discussions were concerned that formal institutions are not doing their jobs that could benefit and transform households from experiencing water challenges to resilience and water access. This was noted by HH304, who is a farmer at Mng'aro village of 67 years old, who noted that;

> "…. what I can assure you my son, people in this area are working hard by spending at least 9 hours a day in farms negotiating water access for irrigating crops. Some buy inputs, water pumping generators and pay labour, when we harvest we start looking for markets but surprises from the government which did not do anything for poor farmers like me is that, a farmer is not allowed to sell maize and/or rice to Kenya as a strategy to ensure national food security. At the end of the time our farm produces will not be bought by the government nor any one and we have no storage facilities. This is a very frustrating situation." (**HH304, Mng'aro village, 04th June 2017**)

The comment by a respondent HH304 who is an old man implies that the government institutions are not fully responsible for transforming households to a more resilient situation. Instead, the government comes with restrictions on farmers selling their crops. There were many cases where farmers complained about poor infrastructure characterized by a lack of maintenance culture. This increases vulnerability of farmers and endanger their livelihoods.

At some point, water related institutions tend to purposely diverge from the main objective of their existence which is ensuring sustainable water access among stakeholders despite their location and status; instead they create hydrosocial territories between those who have power and wealth to have access and deny access to those without power and wealth. It was mentioned during FGDs that the role of formal institutions in a certain locality is constructed and determined by politicians and power relations. In some villages, there were irrigation schemes (though not well developed but existing) not because formal institutions had resources only for those localities but because top leaders ordered those resources to be directed in those areas. Villages that are well connected to both district and political party (especially ruling party) elites were reported to have opportunities to attract development resources to their localities. Villages that had no strong connections with the ruling party and formal institutions or decision makers have remained poor, marginalized and with weak provision of social services. On this, Boelens et al., (2016) argue that access to water and natural resources is at

some point illegally institutionalized, at the expense of others and at the cost of intensifying the repression of more contentious and hydro-territorial institutions. At the end, villages who have been denied access start demanding their rights and change sub-catchment sites into areas for contestations, conflicts and endless struggles (Seemann, 2016; Lopez et al., 2019).

Key informants reported that LGAs in Tanzania are mandated to make sure people in their territories live and enjoy a good environment and improved livelihoods. In order to achieve this, different bylaws and regulations are formulated. However, households were concerned that first, they are not fully engaged in the process and it becomes difficult to implement the formulated bylaws on the ground as among other things they favour some groups. Discussions with key informants revealed that the majority of bylaws do not consider the concerns and views from households and local communities. The danger of this approach is that leaders may have no chance to include all necessary issues from the grassroots. As a result, bylaws are challenged right from the beginning and hence it is difficult to achieve the intended goals. Using the hydrosocial territory lens, this corroborates Boelens et al. (2016) in that territorial struggles are beyond natural resources access but also include meaning, norms, knowledge, power in decision-making and discourses and increase as unfavorable policies and regulations increase. Also, formal institutions are facing additional challenges; mistrust and resistance from communities, limited experienced and well-trained staff and poor management plans. These together have resulted in institutional inefficiency and hence difficulties to ensure compliance to policies and laws. Bylaws formulated and owned by semi-formal institutions such as UWABU and VICOBA were reported to be working well with limited complaints directed to them. Discussions revealed that their bylaws are formulated by representatives from all stakeholders and therefore are very inclusive and accepted by the majority. The key informant put it clearly that UWABU and VICOBA are involving all stakeholders in all fundamental procedures. He added that participation of communities helps to reduce tension and conflicts at the same time increasing ownership and togetherness. I argue that, in a situation where water is facing complex challenges, a monocentric governance structure and decision-making process will fail to yield the intended results while polycentric governance structures which engage and include multiple actors, across scales and sectors, while promoting bottom up decision making, has an opportunity ensure sustainable pathways to target local communities with no contestations (de Coninc et al., 2018; Baldwin et al., 2018).

7.5.3.2 Informal institutions and households' livelihoods

In this thesis, informal institutions include groups of unregistered but influential elders (also called traditional leaders), religious institutions, tribal associations, unregistered cooperative associations and leaderships of households. In all studied villages, informal institutions were found playing a great role (both seen and unseen) which contributes to households' wellbeing in one way or another. The capacities of these institutions might not be easy to measure but respondents were able to demonstrate that some institutions such as those related to religion have played a great role in their lives. For instance, in the health sector, specialized doctors from big hospitals in towns are invited to come and attend followers at the village level. One key informant commented that:

> "We thank our imam for inviting specialized doctors who come and check our health especially eyes, teeth, and ears. Although, this action does not occur frequently, it is very helpful for many of us who are poor and have no medical insurance. This is very motivating to remain in my religion." **(Key informant, Goka village, 22nd February 2017)**

The above comment by a key respondent, although not related to water resources, indicates that the roles played by informal institutions are beyond physical things and of course are tied to beliefs but are important. Something to remember is that formal and informal institutions overlap in many ways to support the same community livelihoods. In addition, when the two (formal and informal) institutions work together they make access and use of livelihood assets easy. Informal institutions have elderly people who are influential and have wisdom on the management and use of livelihood assets especially for land, water and forests but often ignored (Katomero and Georgiadou, 2018). Key informants reported that traditional leaders are familiar and knowledgeable with useful rituals, taboos and norms that are related to water resource conservation. For example, in off-stream and downstream areas, it was reported that the elderly spends their time supervising traditional conservation initiatives within the society. Traditional leaders educate the community on what their descendants want on water issues. This includes some taboos that no one is allowed to cut a tree or kill anything near water sources and riverbanks. The notion is that the ancestor will become angry and punish the whole village. Based on responses during group discussions, I contend that informal institutions are internally immersed within the society and have created ownership, secureness, openness and togetherness.

7.6 Chapter summary

This chapter has explored the livelihood pathways undertaken by studied households. Findings have shown that the paths applied by a certain household were intended to have positive outcomes regardless of the nature of the path. Households are applying different livelihood strategies, including diversification of livelihoods, migration and promoting local irrigation farming. Factors determining household's choice and or adoption of certain livelihood diversification strategies are influenced by access to credit, location within the sub-catchment, household education level, membership to VICOBA, church and mosque associations, land size owned by the household, age of the household head and access to water for irrigation. Households located upstream and off-stream of the Umba River are more vulnerable as they have limited land which is unfertile and stony as well as serious water challenges which take up much time and labour, which would otherwise have been used in farms and other productive activities. Despite the fact that water is challenging, households in all areas still consider farming as the most reliable option to be practised. Respondents indicated clearly that natural capitals, especially water and land, are limited and hence act as a major hindrance to successful livelihood related strategies. The situation of livelihood trajectories is still not enhanced. The success of any livelihood option is dependent on well-established institutions and policies. However, existing government institutions are either reported to have no resources and are not well connected to local communities, or they have developed power asymmetry and hydrosocial territories among water users. Policies and bylaws are not developed and enforced in an inclusive manner and this has made the Umba River sub-catchment an area of conflicts and endless struggles. I argue that a monocentric governance of water resources with formal institutions alone has failed to deliver the required results and has increased water related conflicts. Water conflicts and contestations in the sub-catchment cannot enhance adjustment strategies that are thought to bring long term solutions and build community resilience. However, institutions (both formal and informal) which embrace inclusive and enhanced policies and water users will trigger collaborations and ensure livelihood resilience at both household and community levels.

CHAPTER 8
SYNTHESIS, CONCLUSIONS AND CONTRIBUTIONS

8.1 Chapter introduction

Water is a critical natural resource, which sustains livelihoods and meets crucial socio-economic and ecological needs among rural households in the Umba area. However, water availability and allocation in the Umba have continued to face challenges that affect communities' livelihoods. This study was inspired by the fact that the Umba sub-catchment is considered as the breadbasket area for the Tanga region, especially for vegetable and rice production, and also provides water for households' domestic use. However, the study area faces water scarcity challenges that are linked to a number of factors that include land use and land cover changes, climate change and or variability, population increase, power relation issues and limited capacities of formal institutions to handle growing water demands. This chapter presents a synthesis of key findings of the study. Based on these it elaborates the conclusions and contributions of the thesis.

8.2 Synthesis of key findings

As specified in chapter one, the overarching question for this study is: how do changes in biophysical environment and social dynamics that include institutions affects water resource availability and allocation for livelihoods in the Umba River sub-catchment? To answer the above question several sub-questions have been considered as mentioned under Chapter 1. I combined three concepts: resilience; waterscapes and hydrosocial territories.

Results from Chapter 4 show that between 1975 and 2015, the study area has experienced significant changes in terms of land use and land cover. These changes are linked to how the community has been interacting with the natural capitals (especially water sources, land and forest resources) as they strive to sustain themselves and promote their livelihoods. Further analysis shows settlements and scattered cultivation are the major expanding land use categories with percentage increases of 395% and 1761% respectively over the study period. At the same time, natural forests and bushland were decreasing as settlements and scattered cultivation increased, a situation that proves a clear relationship between these land categories. Areas within a designated buffer zone of 60 m from the riverbank showed a decrease of natural forests with an increase in patches of cultivated land. Moreover, most of these changes seem to be more prominent in the period after 1995 and have been increasing with time. These results are comparable to community perceptions on what they call 'land degradation' covered in Chapter 6.

The analysis of historical rainfall data revealed apparent trends in annual mean rainfall to be declining but the Mann-Kendall test showed no statistically significant decline. On the other hand, the analysis of extreme events using SPI have showed a significant increase of drought events with time. For example, the four-year period that started in 2012 with a very dry year in the SPI scale extended to a consecutive three years (2013-2015) of extreme dry years. Further results show the presence of inter-annual and intra-seasonal rainfall variabilities. The coefficients of variation of onset and cessation of the rain seasons have proven to be low but the length of the rain season has shown high variabilities (CV of 55%) and therefore, rain seasons are unpredictable and this affect perceptions. Results from the community in Chapter 6 showed corroborating views that that the rain season has become shorter and the rain timing is no longer predictable, while years of droughts have increased and they were able to cite examples of the 2010s droughts that caused acute water shortages in the study area.

Chapter 5 has shown that, in the study area, natural capitals (land and water) are closely linked to household livelihoods and are interlinked among themselves. However, water resources are dwindling, increasing struggles, contestations and conflicts on its allocation to meet competing demands. Results further indicate that 79% of respondents are smallholder farmers, who in principle still depend on natural capital especially water and land. Six broad factors identified in Chapter 5 on choice of livelihood and livelihood strategy in the study area include; locations that involve sound allocation and access to water resources, education level of head of household, wealth owned by a household, access to fertile land, age, sex and distance to the main road and center from the village. Chapters 6 and 7 added complexity and more nuanced understanding by interrogating the role of changing water availability and contestations. Villages that are located in the downstream area engage in irrigation and rain fed agriculture as well as livestock keeping. Those in upstream and off-stream villages where there is limited land and water and with steep slopes are now engaged in providing casual labour to sustain their lives and or migrating to downstream. The location factor has also indicated that in the study area, livelihood capitals are not equally distributed and that influences the households' livelihood activities. On the other hand, policies and legislations that are linked to water and land tenure systems have undergone several changes since independence and have shaped and affected how people interact, use and conserve/protect those resources. Most of the changes in water and land tenure systems have had negative impacts and have caused resource degradation opposite to the intended objectives.

Results from Chapter 6 indicate clearly that the effects of water challenges linked to droughts and rainfall variability have affected households' livelihoods and irrigation farming in particular. It was reported that lack of water led to the abandonment of some important staple foods such as yams which were also a contributing financial capital to downstream households. Also, loss and low productivity were reported to affect households and have contributed to food insecurity. A good example was given on how limited water for irrigation in downstream villages has affected paddy rice productivity in the area, from harvesting 15-28 sacks per acre in the 1990s to 5-8 sacks and sometimes zero productivity. Results further indicate that, as water has continued to be scarce, some farmers have remained unemployed as they can neither cultivate crops nor provide casual labour to farms as no one is doing cultivation. The years from 2012 to 2015 were cited as an example when many farmers sold their properties and some were trapped into loan burdens.

Conflicts related to water resources in the study area are complex and are linked to land and households' livelihood activities. In this study, six types of water resource access and use conflicts have been identified, which include; farmers versus pastoralists; farmers versus formal institutions; community versus conservationists; upstream versus downstream; irrigators versus other water users; and farmer (s) versus farmers. The last four seem to happen most commonly and all over the study area while the conflict between farmers and pastoralists is common only in the downstream area due its flat land for transhumance. In the study area, the resources that are contested differ depending on the location within or outside the sub-catchment. For instance, in the upstream area the contested resources include water, land and forest resources; in the middle stream the contested resources are water and land; in the downstream area the contested resources include *kitivo* land, water, forest and pasture. In the off-stream areas the contested resources include land and water, but water is more reported than land. Despite the fact that these conflicts are due to resource scarcity, the issue of power relations and unharmonised or skewed interests by formal institutions cannot be ignored and are linked to configured hydrosocial territories. For instance, the inclusion of the third village into the World Bank project by an unknown organ without involving actors and beneficiaries shows clearly how contestable territories are created to favour some groups. Results have shown that these conflicts are mediated through coming together and holding conversations between responsible stakeholders, in most cases via informal institutions through respected elderly people of the irrigation canal (*mzee wa mfereji*) who are very familiar with the history of the villages. At a point where there could be no agreements then formal institutions, especially village government leaders, will take the responsibility but they will still

need to include and consult with *mzee wa mfereji*. Failure to solve that conflict means that then the district is consulted but there were limited cases of that nature reported.

Results show that at the sub-catchment level both formal and informal institutions exist. The former is legally mandated to take all responsibilities related to water resource management and allocation to stakeholders. However, formal institutions still face challenges that include being perceived by the community as weak, bureaucratic in nature, failing to penetrate the grassroots, which have grown and strengthened over time by informal institutions. Also, the introduction of water uses fees being collected by formal institutions while water access and allocation are not improving has caused much resistance that again causes the community to think it is better to maintain their informal institutions which are led by the respected heads of clan and or respected elders. Households see the informal as a reliable and trusted institution that helps to solve water related challenges.

Lastly are results from Chapter 7, which revealed that livelihood status in the study area has undergone several changes and has been evolving with time. The changes are related to both institutional changes and changes in natural capitals on which households' livelihoods depend. Livelihood trajectories are determined by the thresholds which unfold in terms of how natural capitals and especially water is allocated and utilized, by who, when, where and under which circumstance and or process. Both formal and informal institutions face a challenge from increasing contestations and conflicts due to imbalanced allocation of water resources and uncertainty around what will happen in the future, on the other side the community faces the challenges of building their trajectories in the context of misallocated water resources and bureaucratic institutions (Grafton et al., 2019). As a result, some community members have become unemployed with accumulating debts. The analysis of narrated stories from households located in different villages and streams shows that the livelihoods of households are still dependent on rainfed agriculture, natural capital such as land, forest and water sources. However, rainfall is no longer reliable and not enough to support farming activities, land has become limited and unfertile, forests have disappeared and water sources have declined, affecting irrigation farming. The most affected households are those located in the upstream and off-stream areas as those resources were found to be very limited in those locations. These findings suggest that livelihood trajectories in the study areas are more influenced by resource decline as compared to opportunities. Therefore, for individuals and households in the future, the trajectory is perceived by the community to be unknown but is likely to change in a more negative direction, especially due to

the observed continued water resource degradation, climate change and limited capacity of formal institutions.

8.3 Conclusions

Changes in both land use and climate are happening, and vividly appear to have contributed to water resource challenges in the study area. On land use changes, agricultural expansion activities have had negative impacts on both land and water sources and have limited their capacity to support human needs. Climate change and or variability impacts provide an additional burden to the impacts caused by land use change on water and land. A combination of the impacts from both changes have led into serious water scarcity and has affected household livelihoods which still depend on rain fed agriculture.

The community in the study area is still depending largely on dwindling natural capitals especially water. Efforts for allocating these livelihood capitals, especially water, for livelihoods among stakeholders, elicit different perceptions and reactions depending on where they are located in the sub-catchment and how they are allocated to stakeholders. This corroborates the argument of Hommes et al. (2016) that water allocation in the Lima region of Peru is done in such as a way that some territories have abundance and over allocation while other groups have serious scarcity and if it happens that they have access, they get water of poor quality. This has created a struggle and contestation situation among stakeholders. Merrey and Cook (2012) assert that the strength and weakness of institutions will determine how shared natural resources such as water and land are allocated in an equitable way to benefit everyone in the stream catchments and the remainder is kept for the future generation. The bias in water allocation leads to more contestations, conflicts, degradation and hydrosocial waterscapes. Active participation and engagement of all key stakeholders is a prerequisite to conflict resolution and sharing common resources (Ostrom, 2014). It has high potential to fill the existing knowledge gap, increase ownership and resource protection and management, share available water resources and at the same time reduce water resource conflicts.

The household trajectories are strongly linked to changes in biophysical environment and shaped by changes in policies, legislations and institutions. Water availability and access as well as related conflicts contribute to household and individual choices of the trajectory. In the present study, changes have indicated more decline and struggle than being positive and increasing resilience. As Anderson and Bollig (2016) argue, while on one hand communities had tried to build their resilience and trajectories,

on the other hand, conflicts and unequal power relations as well as biophysical environmental changes have increased vulnerabilities and the collapse of production systems. Most households have found themselves encroaching and degrading water sources, with food insecurity and being trapped into loans as they struggle to build their livelihood trajectories. Compared to informal institutions the role of formal institutions has remained passive and sometimes silent (Kabogo et al., 2017). I argue that in the Umba, changes that affects water availability and livelihoods are influenced by both the biophysical environment, such as changes in land use and rainfall variations, as well as social dimensions and the politics within UWABU that lead to allocating water to places with political leaders, government institutions such as prison barracks and rich people, while denying places with a majority of poor people, a situation that has led to conflicts and contestations. All these together play an increasing role in determining livelihood strategies and households' livelihood trajectories.

In the study area, water availability and access for improved livelihoods and enhanced livelihood trajectories are shaped by how it is allocated by responsible institutions and accessed by communities. Formal institutions that are legally responsible for water allocation, access and management have their own struggle to fulfil these functions, including their overly bureaucratic nature, top-down approaches, limited acceptability by local water users and limited resources. On the other hand, these institutions are responsible for creating hydrosocial territories that create two groups; those who are favoured and have access and those who are denied or delayed to access (Boelens et al., 2016; Swyngedouw and Boelens, 2018). These have led into different types of conflicts that include upstream versus downstream, farmers versus pastoralists, water users versus conservationists, irrigators versus other water users and communities versus government institutions. These conflicts are resolved either in collaboration with informal institutions or by informal institutions alone. Rather than simply being the effect of changes in land use and climate, changes in water availability in the sub-catchment are due to a combination of variations in rainfall, changes in land use and land cover, and the politics and practice of allocation of water via complex hydrosocial waterscapes. Over time this combination of forces has affected availability and access to water leading to struggle, contestations and conflicts between people living in different locations along the river, and within each area. Differential access to the five forms of capital (social, human, natural, financial and physical) plays an important role in determining how each household is able to reshape its livelihood trajectory in the context of decreased water access.

8.4 Reflections on dissertation contributions

This section shows how this thesis has made contributions and deepened discussions on water and household livelihood resilience in the context of the East African region. Below I present my contributions made to the methodology and conceptual/theoretical framework.

8.4.1 Methodological contribution

This thesis applied mixed methods which involved combining qualitative and quantitative methods and data within a single investigation to ensure broader, complete and synergistic understanding of biophysical environment and social cultural changes, dynamics and power challenges in relation to water and livelihoods in the Umba. This approach helped me to overcome the limitations of either quantitative or qualitative methodologies (Almeida, 2018). This was important because a study on climate-human-ecosystem interactions requires broader perspectives and methodology from different disciplines such as ecology, physical and human geography, economics, sociology and or political science i.e. combining natural and social sciences (Tobi and Kampen, 2018). However, the number of scientific studies in the field of water resources and climate have mostly focused on describing a single approach, forgetting the wider and comparative overviews of other approaches (Venkatesh et al., 2016; Tobi and Kampen, 2018).

Quantitative methods: GIS and remote sensing traced and showed the percentages of land use and cover changes since 1975-2015 in all studies villages and how the land use changes were leading to encroachment and interference with water sources and further degradation/erosion, especially in the upstream and off-stream villages. The most dominant land use changes were identified to include a decrease of natural forests and swamps, with a major increase of scattered cultivation areas and settlement area expansion. On climate; Mann-Kendall was used to test the significance of the rainfall trends for the last 55 and 33 years in the upstream and downstream weather stations but the test did not depict any statistically significant trend ($P > 0.05$). However, the area has been experiencing both interannual and interseasonal variations of rainfall that have contributed to existing water challenges and households' livelihoods. On the other hand, SPI was used to assess extreme events in the Umba River sub-catchment and showed an increase of more drought events compared to wet events with a statistically significant trend (P- value < 0.05). SPI was able to detect the three years of consecutive drought events which were later reported in the qualitative methods. But physical data alone were not enough to explain how people react and position themselves and how institutions deal with changes and water scarcities. Qualitative methods (household surveys, key informant interviews, participatory

community analysis and group discussions) provided information on histories and how government policies have been changing especially the villagisation programme of the 1970s which forced people to leave their ancestral land and shift to establish new settlements in the Umba, which contributed to natural resource degradation especially water sources, land and forests. Qualitative methods also traced histories of crops grown and those which have been abandoned such as yams; they noted perceptions on rainfall which corroborated well with meteorological data that rains have changed and are unequally distributed in the season. The existing institutions, both formal and informal, were identified and assessed through qualitative methods and informal institutions were found to be more respected, trusted, well rooted into communities and helpful in water management, allocation and conflict resolution at a local scale. Qualitative methods also helped to understand the existing hydrosocial waterscapes that include contestations and struggles on water access for livelihood activities.

Literature on resilience, hydrosocial territories and waterscapes show that there are still knowledge gaps, especially on case studies that bring strongly quantitative and qualitative methods together to assess and understand water and livelihood related issues. Using the Umba case, I contribute to both methodology and literature by demonstrating how combining quantitative methods and elements from physical geography and science (using remote sensing and GIS; SPI and Mann-Kendall for a period of 40 years of data) and qualitative methods and elements (use of in-depth interviews, focus group discussions, household surveys and field observations), ensured detailed data collection, triangulations and provided the best possibility of answering related questions (Maister, 2017). I argue that mixed methods give an opportunity for corroboration of results, enhance discussion to understand complexities and uncertainties facing water in an integrative way, with emphasis on the interconnections of several issues and components in the contemporary rural setting in the global south. Also, I argue that mixed methods should go beyond combined methods to integrate all elements of the study and philosophical underpinnings.

8.4.2 Contribution to the conceptual frameworks

Understanding water, household livelihood and environmental dynamics and changes together is a complex task, and a comprehensive conceptual framework is required to capture all conceptual dimensions and especially those related to social-ecological systems, society-nature interactions, power and power relations and related outcomes for society. With that in mind, I brought together the concept of resilience which has a background in ecological sciences and hydrosocial territories, with waterscapes (political ecology) originating from human geography and cultural ecology (Quandt, 2016)

to understand how human-environmental interactions are linked to water, environmental problems and power issues. Scholars have argued that resilience thinking and hydrosocial territory and waterscapes (political ecology) have different origins and therefore are incompatible (Turner, 2016; Quandt, 2016). However, recent works (Quandt, 2016; Turner, 2016; Kliskey et al., 2019) explore the links and suggest that bringing these conceptual/approaches together in theoretical frameworks will help in understanding complexities linked to interactions of history, human livelihood practices and ecological responses (Turner, 2014; Quandt, 2016). Drawing on these debates and theoretical framework issues, I applied resilience thinking to understand climate-human-ecosystem interactions and how they shape household livelihoods, pathways and sustainability or vulnerability (Anderson and Bollig, 2016) in addition to understanding changes in land use and their impacts on human livelihoods. Since resilience thinking does not strongly integrate social dimensions, institutions and power relationships in the social-ecological systems, and has no defined indicators to measure resilience, I brought in the concepts of hydrosocial territory and waterscapes to make sure I have multiple lenses helpful for defining systems of resilience management, politics (Quandt, 2016) and power relations, as well as identifying surrogates for measuring social-ecological resilience (Boelens et al., 2016). Also, hydrosocial territory and waterscapes are strongly criticized for lack of engagement with ecology and the biophysical environment (Quandt, 2016), for which integrating resilience was important to fill this gap. In filling the conceptual gap, resilience thinking helped to understanding biophysical status and changes that have taken place in the last 40 years in the Umba-sub catchment and how these changes lead to household livelihood trajectories/pathways.

Using resilience, I assessed the history and up to date status of biophysical environmental changes (from 1975-2015) which was dominated by land use change due to settlement expansion, decrease of natural forest and expansion of scattered cultivation in the water sources and forests over time. It was also possible to trace and assess the riparian zones within 60 m from the river bank and showed a significant decrease of vegetation and increase of patches of cultivated land over the last 40 years. In general, it was learnt that, in the off stream and upstream villages, land has decreased, forcing people to expand farms encroaching water sources, which mostly happened in the 1990s. Also, across villages, settlement area has increased by 1761% from 1975 up to 2015 affecting areas which used to be water sources. This led to significant land degradation and has affected water availability in the Umba. The resilience thinking also traced the climate (rainfall variations) and how these changes are shaping the

status of water and livelihoods in the Umba. SPI indicated an increase of extreme events since the 1990s but the worst scenario was in 2012-2015 where the area was dry for four years consecutively. I argue that, resilience thinking was important in assessing environmental changes in relation to water availability for livelihoods and their contributions in determining household vulnerability and or resilience.

On the other hand, hydrosocial territory and waterscapes assessed the role of institutions (formal and informal) especially UWABU as a legal entity responsible for water allocation, but found it was not trusted by local communities as it was considered weak and used to favour political and rich people within and outside the sub-catchment. It was also noted that in infrastructure development and access of water, villages with politicians and elites are more favoured compared to other places, which has created and increased territories of those with access rights and those who have no rights or losers. These territories are developed either through project design or by diverting project targets during implementation where they manipulate UWABU leaders, the case of the World Bank funded project being a vivid example. This has increased tension, contestations and water access related struggles which cannot be addressed by UWABU alone. The six types of conflicts include: farmers versus pastoralists; farmers versus formal institutions; community versus conservationists; upstream versus downstream; irrigators versus other water users; and farmer (s) versus farmers. In contrast to UWABU and related conflicts, hydrosocial territories showed how people across the sub-catchment are respecting and trusting informal institutions when it comes to water source management, allocation and solving related conflicts. Here it was seen that informal institutions are able and are well established at the grass roots with respected elderly people who have the power to use their wisdom, which leads to conflict resolution. I argue that water challenges in the Umba and village settings should not be understood by looking at biophysical changes that include changes in land use and climate events and their related impacts separately, but rather should consider the role of unequal power and power relations as well as formal and informal institutional settings in the whole process together. Therefore, the use of three concepts together in one study should complement each other and address critiques of one another in understanding human -nature interactions, changes and power relationship dynamics (Kohlitz, 2018).

Using the Umba case study; I contribute to the conceptual framework by demonstrating the relevance and importance of understanding water resource and livelihood dynamics and challenges through

combined concepts (resilience, hydrosocial territories and waterscapes). The combined framework revealed results which would have not been revealed through one concept. For instance, it was not possible for hydrosocial territories and waterscapes to quantify: percentages of land use and cover changes, location and time of changes; extreme events of droughts and wet years since the 1960s and testing to understand if those changes are significant or not to the current water challenges. This was possible with resilience thinking, due to the fact that in the Umba this information was not documented and some elderly people who were available in the 1960s have passed away and those available may not have good memories as they are very old. On the other hand, available legal institutions, historical social changes and previous policy change were understood through hydrosocial territories and waterscape lenses. This helped to trace and understand the politics that led to people in the middle having abundant water while the outer sub-catchment has scarcity and or when they get access it is of poor quality. It helped to understand why the World Bank project was diverted to another village which was not in the plan and these two concepts, how social institutions are leading to contestations and conflicts among water users themselves and institutions. I argue that, in the Umba, water resources and livelihoods are experiencing complexities and uncertainties in terms of biophysical environment, social dimensions, institutions and power relations which are interlinked and cannot be understood using a single based discipline and approach. Therefore, the integration of resilience and political ecology leads into a comprehensive and "hybrid" conceptual framework needed to investigate and understand complexities, contradictions, uncertainties and social dimensions of water in the contemporary world at household and community level.

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APPENDICES

Appendix 1A: Lists of Key Informant Interviewees

No	Location	Date
1.	Lushoto	09.11.2016
2.	Lushoto	09.11.2016
3.	Lushoto	09.11.2016
4.	Lushoto	10.11.2016
5.	Lushoto	10.11.2016
6.	Upstream	13.11.2016
7.	Upstream	13.12.2016
8.	Upstream	14.12.2016
9.	Upstream	14.12.2016
10.	Middle stream	17.11,2016
11.	Middle stream	17.11,2016
12.	Middle stream	17.11,2016
13.	Lushoto	25.12.2016
14.	Lushoto	25.12.2016
15.	Lushoto	25.12.2016
16.	Lushoto	25.12.2016
17.	Dule/Middle steam	29.11.2016
18.	Mwangoi/Middle steam	29.11.2016
19.	Middle stream	29.11.2016
20.	Mwangoi Village	29.11.2016
21.	Down stream	05.12.2016
22.	Down stream	05.12.2016
23.	Down stream	05.12.2016
24.	Down stream	06.12.2016
25.	Down stream	06.12.2016
26.	Hemtoye/off stream	17.12.2016
27.	Goka/Upstream	22 .02. 2017
28.	Goka/Upstream	22.02.2017
29.	Kiranga/Upstream	22.02.2017
30.	Kiranga/Upstream	22.02.2017
31.	Hemtoye/off stream	13.03.2017
32.	Hemtoye/off stream	13.03.2017
33.	Hemtoye/off stream	17.03.2017
34.	Upstream	18.06.2017
35.	Off stream	30.05.2017
36.	Off stream	30.05.2017
37.	Off stream	30.05.2017
38.	Off stream	30.05.2017
39.	Off stream	30.05.2017
40.	Upstream	02.06.2017
41.	Upstream	02.06.2017

42.	Upstream	02.06. 2017
43.	Middle stream	12.06.2017
44.	Middle stream	12.06.2017
45.	Mng'aro/down stream	16.06.2017
46.	Mng'aro/down stream	16.06.2017
47.	Mng'aro/down stream	17.06.2017
48.	Mng'aro/down stream	17.06.2017
49.	Lushoto	17. 06.2017
50.	Down stream	18.06.2017
51.	Down stream	18.06.2017
52.	Down stream	18.06.2017
53.	Down stream	18.06.2017
54.	Middle stream	30.06.2017
55.	Middle stream	30.06.2017
56.	Middle stream	30.06.2017
57.	Middle stream	30.06.2017
58.	Middle stream	30.06.2017
59.	Middle stream	30.06.2017
60.	Middle stream	30.06.2017
61.	Middle stream	30.06.2017
62.	Middle stream	30.06.2017
63.	Middle stream	30.06.2017
64.	Middle stream	30.06.2017
65.	Middle stream	30.06.2017
66.	Down stream	01.07.2017
67.	Down stream	01.07.2017
68.	Down stream	01.07.2017
69.	Down stream	2.07.2017
70.	Down stream	2.07.2017
71.	Down stream	2.07.2017
72.	Downstream	2.07.2017
73.	Downstream	2.07.2017
74.	Downstream	2.07.2017

Appendix 1B: Meetings of Focus Group Discussions

No	Location	Date
1.	Upstream -Kiranga village	12.11.2016
2.	Upstream –Goka village	12.11.2016
3.	Upstream –Rangwi village	12.11.2016
4.	Off stream/Hemtoye	14.11.2016
5.	Off stream/Kwekifiyu	14.11.2016
6.	Middle stream	17.11.2016
7.	Down stream	05.12.2016
8.	Down stream	05.05.2017

Appendix 2A: A sample Household Questionnaire

Questionnaire Number

SECTION A: BACKGROUND INFORMATION

A. General Information

District: **Lushoto**	Interview date:
Ward:	Researcher's Name:
Village:	Household ID:

A. Household Demographic Characteristics

	Respondent	**Response**
A1	Sex of respondent	
A2	Relationship with household head	
A3	Age of household head *(Actual number of years)*	
A4	Marital status of household head	
A5	Education level of household head	
A6	Position of household head in the community	
A7	Other occupation of head of household head	
A8	Number of people that belong to this household	
A9	Number of household members who earn income in your family	
A10	Ethnicity	
A11	Household wealth rank category (poor, medium or rich)	
A12	How long have you been in this village?	
A13	If migrated, when?	
A14	If migrated, reason for migration	

SECTION B: LIVING CONDITIONS AND ASSETS

B1. What are your main sources of income and how important are these sources to your livelihood?----------

B2. Do you own land for crops? Yes (1) No (2)

B3. Please mention all crops grown by your household?----------

B4. What livestock do you own?

Assets	**Do you own?** *1= yes* *2=no*	**If yes, how many?**	**Purpose for keeping** *1= For food* *2= For cash* *3=Equally for cash and food* *4=For prestige*
a. Cattle			
b. Goats/ Sheep			
c. Poultry (chickens, guinea fowls)			

d. Pigs			
Other (specify)……			

B5. What major agricultural and domestic assets/implements do you have?

Assets	**Do you own** *1= yes* *2=no*	**Number**
a. Ox-drawn plough		
b. Ridging plough		
c. Cultivator		
d. Irrigation equipment (e.g. treadle pump, water pump, etc) Other (specify)……		
e. Sprayer		
f. Planter		
g. Radio/TV		
h. Bicycle		
i. Mobile phone		
j. Sewing machine		
k. Other (specify) ……		

B6. Is this household/individual a member in Various Social or Local Institutions and Credit Facilities?

Membership	**Number of Men**	**Number of Women**
Religious institution		
Savings and credit cooperation society (SACCOS)		
Village community Bank (VICOBA)		
Water users Association		
Village government (environment, finance, health, land committee etc.)		
Labor association groupings		
Others: please specify		

SECTION C: HOUSEHOLD'S LIVELIHOOD ACTIVITIES AND INCOME SOURCES

C1. Which main income sources/activity do you have in this household? ----------
---

C2. What other occupations do you engage yourself in different seasons? ----------
---

C3. What are the main expenditures for your cash income? ----------
---

SECTION D: WATER RESOURCES ALLOCATION AND LIVELIHOOD ACTIVITIES

D1. What is your household main sources of water? ----------

D2. How long does it take you to go to water source, get water and come back including waiting time? ------
---

D3. What are the main uses of water sources in this household? ----------
---

D4. Is this household practicing irrigation farming or pasturing near/around Umba River or its tributary?
Yes (1) No (2)

D5. If yes, where do you get your irrigation water from?

Surface water (Rivers)	Ground water	Rain harvesting	Others

D6. What kind of irrigation do you use for surface irrigation?

Gravity/Canal	Pumping	Other (specify)

D7. Is this household experiencing water access related challenges? Please mention them----------
---
D8. In your view what are the main causes of water access challenges in your household? ----------
---
D9. What are the main household's livelihood activities usually affected by water allocation challenges? -----
---
D10. How do you ensure getting water for your livelihood activities from the river? ----------
---
D11. Have you noticed any change in water resource of Umba river from year to year in your life span?
Yes (1), No (2), Don't know (3)

D12. If yes, what is/are the changes? _____ (Multiple responses possible)

D13. What do you think are the causes for the changes you have seen?----------
---

D14 Have you ever changed your livelihoods practice/agriculture/business etc. because of changesin water resources? Yes (1), No (2), Don't know (3)

D15. Who would you say has been most affected by the change in water between now and 20 years ago?
Farmers (1), pastoralists (2), Entire family affected the same (3) Do not know (4)

D16. How households' lives today different as compared to the past 20 years because of the changes in water in the Umba river? (Multiple response possible)----------
---

D17. Do you remember when water allocation system was introduced? ----------
---

D18. What are the main reasons for undertaking water resource allocation for household's livelihood activities? ----------

SECTION E: STAKEHOLDER PARTICIPATION AND WATER RESOURCES ALLOCATION

E1. Is any of your household members participating in water allocation process? Yes (1) No (2)

E2. If no please mention why? ----------

E3. How are decisions on water resource allocation reached? ----------
---

E4. What procedures one needs to follow in order to obtain water for economic activities? ----------
---

E5. Which criteria are used in allocating water for livelihood activities to the villagers?
a. ----------
b. ----------
c. ----------

E6. Are all people equally considered during water allocation process? Yes (1), No (2)

D7. If no, please explain why all people are not equally considered during water allocation process----------
---

E8. Who are the main stakeholders with power to make decision on how water should be allocated? ---------
---

E9. When did you start experiencing difficulty in obtaining water for economic activities in this village?
a. 1970- 1980 ---------- b. 1980- 1990 ---------- c. 1990- 2000----------d. 2000s----------

E10. Please, can you mentions different reasons that have contributed to water scarcity in your village?
a. ----------
b. ----------
c. ----------

E11. Is there any connection between water scarcity and water source conservation challenge in the village? Yes (1), No (2)

E12. If yes, explain how water source conservation challenge has caused such problem----------
---

E13. Is there any bureaucracy or political interference when it comes to water allocation decision from the responsible authority? Yes (1) No (2)

E14. If yes which kind of bureaucracy or political interference do you face?
a. ----------
b. ----------

c. ----------

E15. Which steps have you taken personally to solve the problem of water scarcity? ----------

E16. Is the village government or district government helping you to solve problem of water scarcity? Yes (1), No (2)

E17. If yes, please explain how? ----------

E18. If no, please explain why?----------

SECTION F: COMMUNITY PERCEPTIONS AND REACTION ON WATER ALLOCATION PROCESS

F1. How would you describe the procedures of obtaining water resource in this village?
a. Very good---------- b. Good---------- c. Bad---------- d. Very bad----------

F2. If bad please, explain why? ----------

F3. Which steps have you taken personally to solve the problem of water scarcity? ----------
F4. Is the village government or district government helping you to solve problem of water scarcity?
Yes (1), No (2)

F5. If yes, please explain how? ----------

F6. How do you normally react to the decision reached on water allocation? ----------
---

F7. Have you ever experienced conflict over water resources in this village? Yes (1), No (2)

F8. If yes, what was the nature/cause of that conflict? ----------

F9. How such conflict was handled? ----------

F10. Are the following organs responsible for water administration available in your village?
a. Village environmental committee---------- b. Water User Association ----------
c. Natural resource committee---------- d. I don't know----------

F11. How would you describe the efficiency of these bodies in terms of administering water issues in this area? a. Very efficient--------- b. Moderately efficient---------- c. Not efficient at all----------
F12. If these bodies are not efficient, please explain why? ----------
F13. Please provide suggestion on how water scarcity problem could be solved.
a. ----------
b. ----------
c. ----------

SECTION G: LIVELIHOOD TRAJECTORIES OF CONTEMPORARY HOUSEHOLDS

G1. How would you compare water availability for livelihood activities for the past twenty years to now and twenty years to come?
a. Availability to be the same----------b. Availability will be low----------c. Availability will be increased ----------

G2. What do you suggest to be done in order to improve water allocation in this village? ----------

G3. Do you think that the available water allocation strategies can be useful for improving household livelihood? Yes (1), No (2) , I do not know (3), No response (4)

G4. If yes, how will they lead to transformation? What will trigger transformation?G5. What do you think you can do in the future to be able to adapt to water challenges/ changes if they persist?

Appendix 2B: Checklist for Guide Questions for Key informant Interview (for Different Officials (incl. Water manager, Agriculturalist, Livestock Officers, Land Experts and Natural Officials) at Different Levels

1. What are the main sources of income for households in the Umba river sub catchment?
2. What is the status of livelihood in the villages around Umba river sub catchment? Can you give any indicator across different groups? Wealth ranking? Social differentiation? Livelihood pathways?
3. How would you describe the current status of water sources in the Umba river sub catchment?
4. Are there any past, present and future changes in water of Umba river and how are they perceived and explained by the local communities?
5. Based on your knowledge what do you consider to be the main cause for water changes in the Umba river sub catchment?
6. What are the factors for water resource allocation in the Umba river sub-catchment? And when did water allocation start?
7. Who are the main stakeholders for water allocation? How are they involved in the process?
8. How are decisions on water resource allocation reached, by whom and at which levels of scale? What are the criteria used? Why?
9. What has been people's experience of power relations and conflicts on water resource allocation and use?
10. How do different groups within the community perceive and react to the decisions reached, and how these perceptions and reactions shaped by gender, class, ethnicity etc?

11. What capacity does the community/household have to address water problems they face? How can these be used to enhance livelihoods trajectories for households?
12. Based on your experience, how can the livelihood trajectories of contemporary households in Umba river sub-catchment be conceptualized and interpreted?

Appendix 3A: Guide questions for Focus Group Discussion

1. What are the different activities that households in the community use to support their livelihoods? What are the defining characteristics of these activities? Which are water resource-based? Which are not?

2. Who is involved in those livelihood activities (men/women, children, different social and economic groups) and how many households depend on them? When do these activities take place (time of the day/month/seasons) and where?

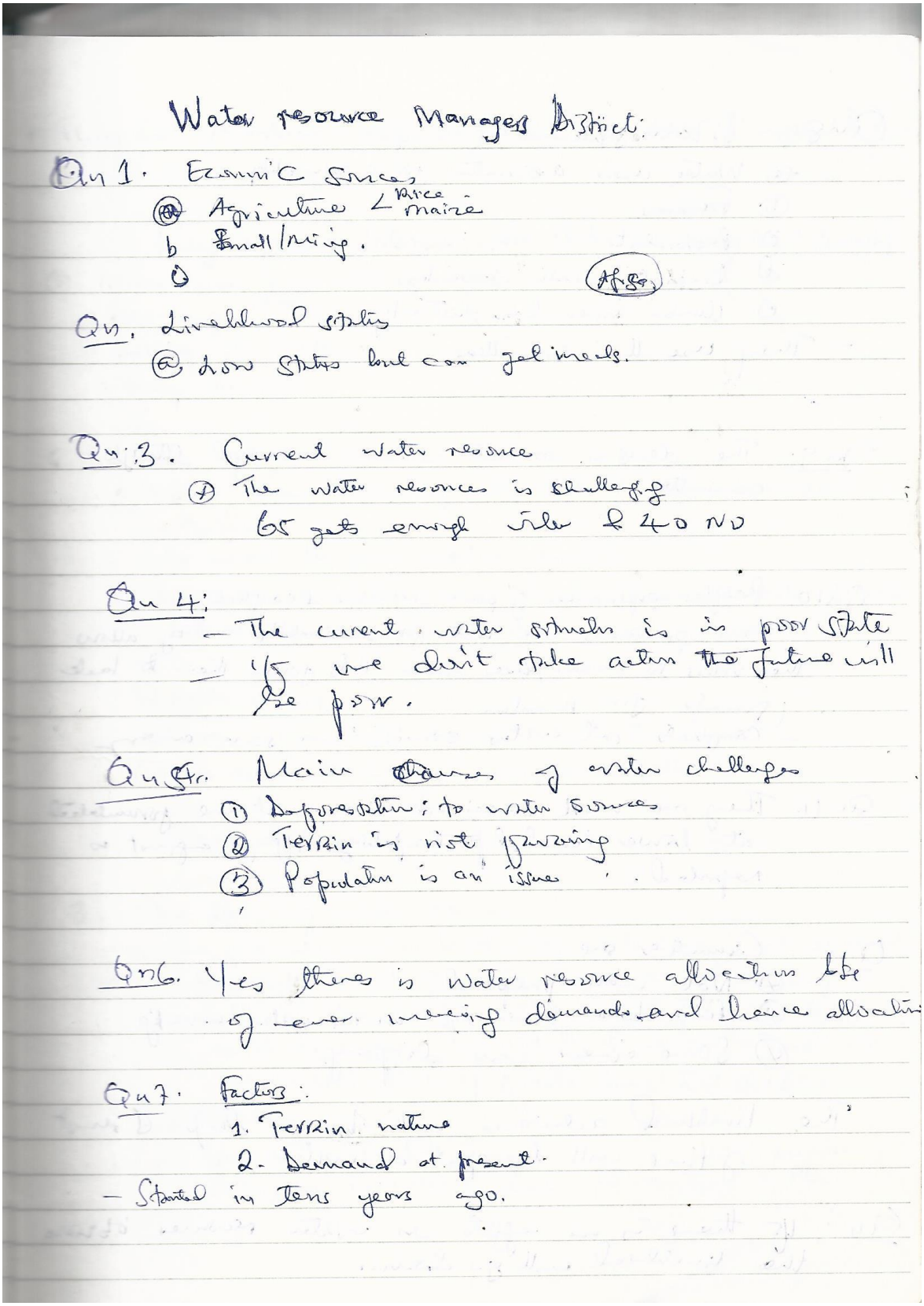
3. What are the potential natural resources available in this village (resource mapping, trend analysis, and identification of the drivers of environmental change)

4. What have been the main water problems in your village over the past 10 or 20 years?

5. What is the current status of Umba river associated activities? Do you notice any change (positive or negative) in water of the Umba river and its tributaries over the last 10, 20 years? How has this affected livelihood?

6. When and how did you start practicing water resource allocation in the Umba river sub catchment? What are the reasons behind water allocation?
13. How decisions on water allocation reached? How do different groups within the community perceive and react to the decisions reached, and how these perceptions and reactions shaped by gender, class, ethnicity etc?
7. How decisions on water allocation shaped by power relations in the community?
8. What formal organizations and associations are there in the community? Who provide advice on how water should be allocated for economic activities? (such as agriculture, pastoralism, petty trade, casual jobs etc. should be discussed here)
9. What rules, regulations and customs are in place for the water resources? Who is affected by them and how? If they are not respected why? (Constraints for the people to respect them).
10. How have water resources been affected by demographic, economic and environmental change?
11. Which factors in the social and institutional environment that inhibit household from taking advantage of livelihood opportunities or creating new opportunities for themselves?
12. Who takes the decision about household livelihoods? On what basis are the decisions made?
13. How the alternative courses of action are created to water availability reduce for enhancing household livelihoods in the gradient of reduced water resource due to various drivers such as overexploitation, population growth and encroachment?
14. How do you see your livelihood status in 10 years to come? Who is in good status/bad (wealth ranking exercise)

Appendix 3C: Sample field notes



Water resource Managers District:

Qn 1. Economic Sources
(a) Agriculture < Rice / maize
b Small/mining.
c

(Afsa)

Qn. Livelihood status
(a) Low status but can get meals.

Qn 3. Current water resource
(A) The water resources is challenging
65 gets enough water & 40 NO

Qn 4:
- The curent water situation is in poor state
- If we don't take action the future will be poor.

Qn 5. Main causes of water challenges
(1) Deforestation; to water sources
(2) Terrain is not favoring
(3) Population is an issue

Qn 6. Yes there is water resource allocation like of ever meeting demands and hence allocation

Qn 7. Factors:
1. Terrain nature
2. Demand at present.
- Started in tens years ago.

Qu8: Main stakeholders
- (a) Water users association for sustainability
- (b) Farmers
- (c) Pastoralists
- (d) District water departments.
- (e) Umba river basin Authority

– They use their committees

Qu9: The decision on water allocation is reached through committees.

Qu10: People's experience of power relations & conflicts;
Some politicians are not for sustainability as they allow their voters to consider/use water. This forces them to lack funds for maintain.
– Conflicts at water sources are soon away

Qu11. They are well received as most are formulated at lower level & participatory. If go against is reported.

Qu. Committees are
- (1) Not well prepared
- (2) Few know knowledge on rain water harvesting
- (3) Some owners are disparity.

The livelihood activities will obvious drop & most of time will be spent on water.

Qu: If there is no efforts on water resources obvious the livelihood will go down.

Appendix 4: Wits ethics approval certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mwanga

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H16/07/24**
PROJECT TITLE	Contested waterscapes in the Umba River sub-catchment of Tanzania: Water resource allocation for households' livelihood activities
INVESTIGATOR(S)	Mr S Mwanga
SCHOOL/DEPARTMENT	GAES/
DATE CONSIDERED	22 July 2016
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	02 October 2019

DATE 03 October 2016 **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Curtis, C Prof Samson, M Dr.

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature

03 / 10 / 2016
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 5: Letter from regional commission introducing Sixbert to district

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

Simu: 027 2642421
Fax: 027 2647752
E-mail: ras.tanga@tamisemi.go.tz
Unapojibu tafadhali taja:
Kumb Na. DA.228/258/03/134

Ofisi ya Mkuu wa Mkoa
S.L.P 5095
TANGA

28 Oktoba, 2016

Mkurugenzi Mtendaji
S. L. P 32
LUSHOTO

YAH: KUMTAMBULISHA *BW. SIXBERT MWANGA* MWANAFUNZI WA MASOMO YA SHAHADA YA UZAMIVU (PhD) KUFANYA UTAFITI KATIKA HALMASHAURI YA LUSHOTO

Tafadhali rejea mada tajwa hapo juu

Ofisi ya Mkuu wa Mkoa wa Tanga imepokea barua ya maombi ya kufanya utafiti kwa ajili ya masomo ya uzamivu (PhD) ya tarehe 15/10/2016.

Kwa barua hii namtambulisha kwako ***Bw. Sixbert Mwanga*** kwa ajili ya kufanya utafiti katika eneo la Mto Umba kwa muda wa miaka mitatu. Utafiti huo upo katika kanda ya mazingira wenye kichwa cha habari ; **"Contested Waterscapes in the Umba River Sub-Catchment of Tanzania: Water Resource Allocation for Households' Livelihood Activities"** Mwanafunzi huyu anatarajia kufanya utafiti huo kuanzia tarehe 19/10/2016 hadi 19/10/2019.

Ni matumaini yangu atapatiwa ushirikiano anaohitaji.

Jaha, A.M
Kny; KATIBU TAWALA MKOA
TANGA

Nakala: Katibu Tawala Mkoa
TANGA – Aione kwenye Jalada

Bw. Sixbert Mwanga Mwanafunzi (PhD)

Appendix 6: Letter from district introducing Sixbert to villages



JAMHURI YA MUUNGANO WA TANZANIA
HALMASHAURI YA WILAYA LUSHOTO
(Barua zote zitumwe kwa Mkurugenzi Mtendaji wa Wilaya)

MKOA WA TANGA:
Simu Na027-2977216/2660110.
Telefax 027-2977216/2660110.
E-mail lushotoded@yahoo.com
Ukijibu tafadhali nukuu:

S.L.P. 32,
Lushoto,
TANZANIA.

LUSHOTO DISTRICT COUNCIL

Kumb Na. LDC/C.10/33/VOL.II/37 09/11/2016

Maafisa Watendaji Kata,
Kata ya .....
Halmashauri ya Wilaya,
S.L.P. 32,
LUSHOTO

YAH. KUMTAMBULISHA BW. SIXBERT MWANGA.
Tafadhali husikeni na somo tajwa hapo juu.

Ofisi ya Mkurugenzi Mtendaji Halmashauri ya Wilaya ya Lushoto inakuarifu kuwa mtajwa hapo juu ni mtafiti Mwanafunzi wa Masomo ya Shahada ya Uzamivu (PhD).

Mtajwa anaomba kufanya utafiti katika eneo la Mto Umba kwa Muda wa Miaka Mitatu.

Hivyo mpokeeni na kumpa ushirikiano ili aweze kukamilisha Utafiti wake kwa muda alioomba.

Nawatakia utekelekezaji mwema.

THOMAS LYIMO
AFISA USAFI NA MAZINGIRA
HALMASHAURI YA WILAYA
LUSHOTO.

Nakala kwa:- Mkurugenzi Mtendaji (W),
LUSHOTO:- aione kwenye jalada

Appendix 7: Table with % of memberships

Membership

		Percent	Valid Percent	Cumulative Percent
Valid	Religious institution	1.4	5.1	5.1
	SACCOS	5.7	20.5	25.6
	VICOBA	15.6	56.4	82.1
	WUA	2.1	7.7	89.7
	Village government	2.1	7.7	97.4
	Entrepreneurial group	.7	2.6	100.0
	Total	27.7	100.0	
Missing	System	72.3		
Total		100.0		

Membership2

		Percent	Valid Percent	Cumulative Percent
Valid	VICOBA	2.8	30.8	30.8
	WUA	1.4	15.4	46.2
	Village government	2.1	23.1	69.2
	Labour association	1.4	15.4	84.6
	Entrepreneurial group	1.4	15.4	100.0
	Total	9.2	100.0	
Missing	System	90.8		
Total		100.0		