ASSESSMENT OF FLOODS IN MVOMERO DISTRICT

A CASE OF DAKAWA WARD

By

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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Natural Resources Management of the University of Dodoma.

The University of Dodoma

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CERTIFICATION

The undersigned certifies that she has read and hereby recommends for the acceptance by the University of Dodoma, a dissertation titled **"Assessment of Floods in Mvomero District: A Case of Dakawa Ward"** in partial fulfillment of the requirements for the Degree of Master of Science in Natural Resources Management of the University of Dodoma.

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Dr. Mikova Kseniia

(SUPERVISOR)

Date……………………………………………

DECLARATION

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I**, Leudega Pauli Msoka,** declare that this dissertation is my own original work and that it has not been presented and it will not be presented in any other university for a similar or any other degree award.

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Date………………………………….

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ABSTRACT

In recent years, the flood has brought severe problems in Mvomero District. This phenomenon has led to uncertain conditions to the people's lives and property, as well as destructions of infrastructures. This study made an assessment of the effects of floods and flood management practices in Dakawa Ward which found in Morogoro Region. The study used household survey and interviews to collect data from 100 households and 8 key informants. Also, the study employed observation method to assess the quality of the drainage systems developed to control floods during the rain seasons.

The magnitude of flood was determined by the calculation of the recurrent intervals. Flood with 1% probability have the highest water stage (7.5m), they happen once in 100 years and they are more destructive. The recurrent interval of other flood shows the frequency of $H_{50\%}$ and $H_{90\%}$ and water stage (6.8m and 5.0m) respectively. The study results show that the villages in Dakawa Ward are affected by floods of different frequencies. Proper information about floods is not delivered, something which leads to severe problems since the residents are not prepared to rescue their lives and property. Frequently, residents' houses were demolished, electrical poles fell and caused power cut and roads were over-flooded and remained impassable for a long time. Water sources, dump sites, latrines and barnyards were flooded and, thus, damaged. Further, there was an outbreak of water-borne diseases, such as Diarrhea, Typhoid and Cholera and the majority of the affected people were the children. Livestock keeping and crop production were also severely impacted; consequently, animals were injured and died.

From the findings of the study, the researcher concludes that there is a lack of flood policy which is central in establishing an institute to give mandate to specific organs to deal with floods. The study recommends for the introduction and implementation of flood prediction practices, flood policy, and flood fight education. Lastly, continuous training of local residents on the best suited traditional and modern ways of flood management in Mvomero District needs to be implemented.

Key words: flood, flood effect, hydrological analysis of floods, flood management, Dakawa ward.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADPC	- Asian Disaster Preparedness Centre
AFR	- Audience Forum Report
APFM	- Associated Programme on Flood Management
DEM	- Digital Elevation Model
EAC	- East African Community
ESM	- Earth Science Model
ESRI	-Environmental Systems Research Institute
FEMA	-Federal Emergency Management Agency
FINS	- Flood Information and Notification System
GEOS	- Global Earth Observation System
GFDRR	-Global Facility for Disaster Reduction and Recovery
GIS	- Geographical Information System
GPS	- Global Positioning System
GCM	- Global Circulation Model
HPC	- High Performance Computing
IFRC	- International Federation of Red Cross and Red Crescent Societies
IOM	- International Organization for Migration
IDMC	- Internal Displacement Monitoring Centre
IFRC	- International Federation for Red Cross
ICT	- Information and Communication Technology
IIASA	- International Institute for Applied Systems Analysis
IWRM	- Integrated Water Resources Management
MWI	- Ministry of Water and Irrigation

NGOs	- Non-Governmental Organizations
NRC	-National Research Council Canada
NDMA	-National Disaster Management Authority
NEMC	- Nation Environmental Management Council
OCHA	- The United Nations Office for the Coordination of Humanitarian Affairs
PMFSM	- Project to Mobilize Food Security Initiatives in Mali
RCM	- Regional Climate Model
RI	- Recurrent Interval
TaGLA	- Tanzania Global Learning Agency
TMA	- Tanzania Meteorological Agency
UNESCO	-United Nations Educational, Scientific and Cultural Organization
UNFCCC	-The United Nations Framework Convention on Climate Change
UNICEF	- The United Nations Children's Fund
UNDP	- United Nations Development Program
URT	- United Republic of Tanzania
USGS	-United States Geological Survey
WBG	-World Bank Group
WMO	- World Meteorological Agency
WMS	- Web Map Service
WRWBO	- Wami-Ruvu Water Basin office

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

This chapter provides the background information about the flood management practices at Dakawa Ward in Mvomero District. Also, the chapter presents the background of the study, problem statement, the study aim, and the research specific objectives which guided the study. The last part of the chapter presents the significance of the study. All the above mentioned points provide the broad understanding of the topic under the study.

1.2 Background

Worldwide, disasters brought by natural hazards can force millions of people to flee their homes each year. Such displacement is a global phenomenon, and it is on a growing scale, frequency and complexity pose huge challenges for the exposed and vulnerable populations, governments, humanitarian and development organizations and disaster risk managers. During the period from 2008 to 2013 there were identified 161 countries in which registered the displacement of the people. Worldwide flood events account for nearly half of the deaths and one-third of all economic losses from natural hazards (UNESCO, 2008). Between 1985 and 2005, floods claimed the lives of over 112,000 people, affected more than 354 million people and caused approximately 520 billion Euros (US$690 billion) in financial damages (Bakker, 2006). In 2004, the United Nations Development Programme (UNDP) estimated that, on average, almost 200 million people in more than 90 countries are exposed to catastrophic flood events every year (UNDP, 2004). Also, disaster report of the United States of America reveals that average flood damage would be 10 percent higher which could incur the total cost of about $433 million annually. The vulnerability to floods is expected to rise in the last decades due to the change of climate and overpopulation of the riverbanks as well as urbanization (Kundzewicz *et al.*, 2008; IDMC & NRC, 2014).

The Global Circulation Model (GCM) and Regional Climate Model (RCM) provide estimates of the possible changes in precipitation and evapotranspiration patterns worldwide and, consequently, they lead to the change of climate. Hydrological modeling may be used subsequently for translating those changes in climate parameters into changes in river discharges, accounting for the expected evolutions in land use. Nevertheless, in a number of river basins, models predictions converge towards a clear increase in peak discharges both in terms of intensity and frequency. Therefore, managing flood risk will remain an issue of the primary importance and will increasingly require suitable flood protection strategies (Bachus & Coninx, 2007). Relatively, little is known about managing responses to the rising number of extreme weather events for the socially disadvantaged groups. Some studies were oriented to discover internationally relevant lessons from the Australian floods of 2010–2011 about managing extreme floods for specific vulnerable groups (Bell & Siedel, 2013). As well, the Thailand in 2011 suffered from the serious flooding started from July in the northern area and the flood went downward to the middle area and near Bangkok area in September and October. It was the first time that flood water reached the inner city of Bangkok and caused flash flood to many main industrial estates in the suburb of Bangkok. The damages of this flooding were estimated to be more than ten times of the previous major past flooding, especially to the industrial sector and in the ranking number four of disaster damage in the world (Koontanakulvong, 2011).

In Africa, seasonal forecast from the Project to Mobilize Food Security Initiatives in Mali (PMFSM) indicated the enhanced probabilities of heavy rainfall; notably, in the far west region of West Africa, straddling Southern Chad, northern Cameroon and Nigeria, and Eastern Niger where above-normal rainfall was the most likely outcome with a probability of 0.5 an equal likelihood of normal and above-normal rainfall conditions throughout the rest of the Sahel, with the associated probabilities of 0.4 and most likely normal conditions only in the Gulf of Guinea countries with a probability of occurrence of 0.5. When the forecast above-normal rainfall conditions did indeed materialize and severe floods occurred, the humanitarian community responded with an emergency response mode, lacking advanced knowledge on when and where floods were more likely to occur.

The 2007 floods claimed more than 300 lives across West Africa and occasioned severe damage to crops, homes, and infrastructure (Arame *et al.*, 2012). The situation Report on effects of the El-Nino Rains by Kenya Red cross (KRC, 2015), stipulated that the heavy rains experienced in different parts of the country resulted in floods and landslides/mudslides, which have so far affected 35,565 households and further displaced 12,398 households. These figures are likely to change as assessments are ongoing in different parts of the country. Further effects of the rains include damage to at least 16 schools, destruction of unconfirmed acreage of crops especially in Mt. Elgon, Kirinyaga, Narok, Busia, Kisumu, Tana River and Trans Nzoia counties. To date, thousands of livestock (to include cows, goats, sheep and donkeys mainly in Samburu, Marsabit, Narok, Isiolo and Laikipia counties) have been swept away by the floods further affecting the livelihoods of the already vulnerable populations. Infrastructural damages have also been reported (damage to road and bridges) in parts of Mt. Elgon Region, Tana River, Marsabit, Isiolo, Mandera, Wajir and Nandi counties.

Tanzania also suffered from floods annually. In 2014 heavy rain caused flash floods in the Dumila/Dakawa area in Morogoro Region, which displaced over 10,000 people and destroyed or damaged houses, roads, bridges, public buildings and crops. While in mid-April extensive rainfall over Dar es Salaam, Tanzania's largest city, caused flooding in all of the City's districts, affecting about 20,000 people, with the reported 19 deaths. The floods also caused damage to transport infrastructure and affected people had to relocate to churches and schools. The Tanzanian Red Cross Society distributed non-food items including blankets and mattresses to those affected and deployed 40 volunteers and three staff members to provide first aid/ambulance services as well as to participate in the search and rescue operations coordinated by the Government through the Fire and Rescue Brigade. Other affected areas in the country included Rorya District in Mara where 300 houses were damaged due to heavy rains and strong winds. The Southern region of Mbeya was also hit by flooding during the weekend of 19th April and, at least, three people died in Kyela District (OCHA, 2014).

Moreover, historical records show that several places in Tanzania regions, including Mvomero District have been experiencing floods. Particularly in the Kilombero and Wami rivers were registered floods in 2008 and 2011. Those floods had affected water supply system and depredation of riverside resources and cultivated crops and tree falls (UNICEF, 2013). The information sharing still a problem in many African countries existing climate information is not adequately designed to reach vulnerable groups dwelling at the most basic geographic levels in villages' settlements. Community radios constitute an effective means of reaching remote communities with information, but they are only seldom used to ensure that forecasts reach vulnerable communities in the regions. There was a lack of climate information, media outlets, and information-sharing systems so as to reach communities. Acquired knowledge to operate this information is very limited and for some places, they don't exist for example, in Southern Africa, available forecast information does not reach the community level at all (Arame *et al.*, 2012).

Hazlettt and Trent (2005) argued that flood analysis has significant impotencies, such as knowing the maximum flood peaks for different frequency in a particular area allows engineers to design bridges that can withstand the flooding expected over a specified time interval. Flood frequency analysis allows city planners to make a statistics-based prediction about where they should allow residential buildings and which areas are likely to be too flood-prone to locate a hospital. Moreover, the analysis helps authorities to provide warnings and determine evacuations time for the ready buildup areas. Also, Kidson *et al.* (2005) posited that analyses of the frequency of floods have been utilized for testing the assumptions about the continuous flood record over the very long time period. Data about flood peaks records helps hydrologists demonstrate distinct temporal clusters of floods

1.3 Problem Statement

There is an array of researches which explain about floods and impediments of floods in many parts of the world, mostly in Asia, Europe, and America and few in

Africa for the technologically developed countries like South Africa, Nigeria and Ghana (Ahmed *et al.*, 2013; Ndukwe, 2001). The great development exists worldwide about computerized technology for floods modeling and mapping. In Tanzania, till now hydrological prediction service is at the initial stage. Tanzania Meteorological Agency (TMA) provides a wide range of the meteorological predictions but almost nothing for the hydrological predictions. During the time with a high frequency of torrential rains TMA organized just weather warnings to the areas which could be threatened, without any specification and estimation of the flood beginning, peak stage, its date and total duration. Also, few studies have been done in Tanzania to explain flood management practices, especially about the prediction models (EAC, 2012; FIU, 2014; URT, 2013). Therefore, this study was proposed to fill this gap by making an assessment of the floods, its effects and flood management practices in Dakawa. The researcher selected Dakawa ward in Mvomero District because it is experienced floods almost every year.

1.4 Objectives

1.4.1 General Objective

The aim of the study was to assess the floods and its effects in Dakawa Ward.

1.4.2 Specific Objectives

i. To perform hydrological analysis of floods for long-term period.
ii. To assess the effect of floods in the study area.
iii. To examine the management practices for flood effect mitigation.

1.5 Research Questions

i. How are the floods patterns in long-term period?

ii. What are the effects of floods in the study area?

iii. What are the management practices for flood effect mitigation?

1.6 Significance of Research

This study has a significant contribution in identifying long-term pattern of the floods, areas that are frequently affected by flood in Dakawa Ward. The study provided statistical data about dates of flood beginning, its end, total duration, peak stages and its dates. As well, the findings of the study inform about the households which are more vulnerable to flood events in the study area. Moreover, the study has described why it is very important to establish flood policy is in Tanzania, as it gives the leaders, planners and policy makers a concrete reason why it needs to operate effectively.

Also, the study has identified some errors in the recorded hydrological data, thus this study helps to alert and remind the responsible organizations and others about the importance of those data in determining and making predictions of different disasters. Furthermore, the study has laid down the ground for future studies about the effects of flood disasters and their management practices.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

A research as a systematic process relays on the people's exploration and insights of others' that means research never stand in isolation with the surrounding environment no matter how the topic or the procedure is. This chapter reviewed and presents a description of the floods and its management practices Worldwide and in Africa particularly. Thus, this chapter presents a description of the reviewed theoretical and empirical literature reviewed in this study.

2.2 Definition of the Key Concepts

2.2.1 Flood

WMO (2009) defined flood as the excess of water (or mud) on land that is normally dry and it is a situation where in the inundation is caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or near the point where the rain fell.

2.1.2 Flood Peak

The United States Geological Survey (2016) defined the flood peak as the highest value of the stage or discharge attained by a flood.

2.2.2 Flood Wave

In hydrologic terms, flood wave is defined as a rise in stream flow to a crest and its subsequent recession caused by precipitation, snowmelt, dam failure, or reservoir releases (McCracken, 2005).

2.2.3 Flood Management

Flood management refers to all methods used to reduce or prevent the detrimental effects of flood. Flood relief refers to the methods used to reduce the effects of flood waters or high water levels. Flood management requires adaptation to specific situations, varying according to the nature of the floods, the flooding problem, and the socio-economic conditions (WMO, 2009).

2.3 Theoretical Review

2.3.1 Normative Theories

There are numerous *normative theories* that are very useful to emergency scenarios. These frameworks have been designed to specify the actions that are taken in first hand for emergency. It is assumed that their effectiveness will be enhanced if they abide by these *prescriptive* lessons. Most important, among these, is the collection of the ideas commonly referred to as "comprehensive emergency management". Through a series of common managerial functions, i.e. mitigation, preparedness, response, and recovery, emergency managers can organize their programmes for an all-hazard approach through implementing a series of broad strategies and specific tactics (Drabek, 2004). Multiyear planning can be guided by the "integrated emergency management" framework proposed. Also numerous other guidance documents have been prepared and proposed by the FEMA staff over the years (FEMA, 1987; 1996; 2002). Specific steps in building a community risk reduction programme have been formulated as (American Red Cross, 1992) have tactical management models such as the incident command system (ICS) and the National Incident Management System (NIMS). Components of and exercising strategies have been developed for key community structures like the emergency operations centers (EOC's). All of these "normative" theories are relevant to the emergency management and provide emergency managers with important theoretical foundations. This implies that government actions should focus on increasing public education and awareness to ensure that homeowners understand the risk they face and what they can do to mitigate flood effects. Also, promoting the risk mitigation measures by means of direct investment through insurance, property policies, early warning systems and strict enforcement of zoning, land use planning and floodplain development regulation.

2.3.2 The Theory of Flood Recurrence Interval

Floods occur for many reasons, such as long-lasting rainfall over a broad area and locally intense thunderstorm-generated rainfall. The probability of occurrence of a given flood can also be expressed as the chances of recurrence of similar or bigger floods in a certain number of years. These differences in the chances of experiencing floods of different sizes are expressed in the concept of a flood recurrence interval. A flood recurrence interval is defined as the average period of time for a flood that equals or exceeds a given magnitude (Tate, 1960). Mathematically flood recurrence time is expressed in equation:

$$RI = (N+1)/M \tag{1}$$

Where N – is the number of records (in years), and M – is the rank of a particular discharge/stage.

Normally, tabulation of the maximum discharge values that occurred during each year in the record is considered because the focus is on the recurrence interval of floods. Hence hydrologists recommend that it is best to have discharge records cover the longest span of time as possible since the larger number of years in a recurrence interval, the smaller the chances of experiencing that flood in a particular year. This implies that, with all hydrological data, for previous years, particular gauge station will pave way for hydrologists and scientists to make predictions about flood in any place.

2.4 Empirical Literature Review

2.4.1 Flood Management Worldwide

Worldwide flood management practices have largely focused on reducing flooding and reducing the susceptibility to flood damage. There has been development of various flood management approaches these include the traditional and modern ones. Traditional flood management approaches have employed structural and non-structural interventions, as well as physical and institutional interventions. These interventions have occurred before, during and after flooding, and have often overlapped. The traditional flood management interventions include source control to reduce runoff, storage of runoff and capacity enhancement of rivers. Whereas modern flood management interventions include use of computer controlled devices like satellites and Geographical Information Systems (GIS) in predicting and mapping. Land-use control is generally adopted where intensive development on a particular floodplain is undesirable. Providing incentives for development to be undertaken elsewhere may be more effective than simply trying to stop development on the floodplain. Where land is under development pressure, however, especially from informal development, land-use control is less likely to be effective (WMO, 2009).

Humans often decide that a stream should flow along a specified path for such reasons as flood control, enhancement of drainage, control of erosion, increasing access to the floodplain for development, or improvement of the appearance of the channel. Such channel modifications involve measures such as the straightening the channel, deepening or widening the channel, clearing vegetation from the banks, or lining the channel with concrete. In order to control floods, channel modification should involve increasing the channel cross-sectional area so that higher discharges will not increase the stage of the river. Straighter channels also allow higher velocity flow and, enable the stream to drain faster when discharges increase. Lining the channel with concrete provides a smoother surface over which the water can flow, thereby reducing friction and also increasing the velocity of the stream (Stephen, 2015)

In the United States, structural measures dominated the response to flooding form 20th Century. The floods of 1936 prompted the federal government to assume responsibility for flood control throughout the nation with a clear structural focus on the construction of levees, floodwalls, channel work, floodways and flood storage in reservoirs. In the 1993 Mississippi River flood, the presence of federal projects prevented over $18 billion in damages in the upper Mississippi and Missouri basins. The lower Mississippi River flood control project has costed over $10 billion, but it has prevented over $244 billion in damages. The relocation of flood prone structures in the upper Mississippi basin following the 1993 flood produced immediate benefits during the flood events in 1995, 1997 and 2001. The structural plan was construction of 2500 km of levees and floodwalls, channel stabilization and four major floodways. Tributaries are controlled by upstream flood storage reservoirs which protect the areas below them and have a relatively minor impact on the mainstream flows and flood stages (WMO, 2005). The United States national Hydrological weather services report (2002) argues that hydrologic forecasts in the United States of America are extremely effective in reducing flood damages. Advanced warnings for floods can reduce death and property losses as little as one hour of lead-time can result in a 10-percent reduction on flood damages. Benefits are archived from reservoir optimization by incorporating hydrologic forecasting data and information with operating schedules of cooperators such as the United State Corps of Engineers (USACE) and United States Bureau of Reclamation (USBR). During snowmelt runoff and other long-term flood events, forecasts and warnings alert the threatened communities to take action by sandbagging and constructing levees. This helps to reduce $163 million in each year. The nation weather service forecasts for short-term events also are quite effective in reducing flood damages. This report reveals that a safe assumption of average annual flood damage incurred would be 10 percent higher without the National Weather Service hydrologic forecasts, or $433 million annually (ibid).

Since 2005-06, the United Kingdom has progressively made flood warning service available to more households and businesses at risk. In 2007-08, 61 per cent of properties at risk across England and Wales could receive a flood warning if needed. This is ahead of the target agreed with the Government. The aim was to make flood warnings available to 72 per cent of households and businesses at risk in England and Wales by April 2010-11 and 80 per cent by April 2013. Flood warnings are provided when measurements of river or sea levels reach a threshold or trigger level, or when forecasts show that high-water levels are imminent. The use forecasts made for 1,163 river level locations and 805 coastal locations to ensure flood warnings are as accurate as possible for local communities (EAC, 2009; WMO, 2007).

Much of the land surface in the Netherlands is below sea level. It is the reason why the Netherlands have a high priority on safety against flooding. Levees (dikes) protect the economically important low-lying part of the Netherlands – roughly the western half of the country. The particular frequencies of occurrence, or risk levels, are determined by the national parliament. Levees along the coasts of densely-populated and highly industrialized parts of the country are to be designed to protect from all storms whose magnitudes would be exceeded only once in 10,000 years on average. The condition of flood control works, levees and fairways is monitored regularly. Every 5 years a formal report on flood safety is made. This involves re-determining the design floods using the statistical analysis of river flows in the period from 1900 to date. Furthermore, data regarding river cross-sections and vegetation types and densities are updated. Based on that information, the design flood levels are assessed, taking into account the effects of wind and a freeboard margin of half a meter for overtopping of the levee crests (Silva et al., 2004).

The Asian continent also is much affected by floods, particularly in China, India and Bangladesh. As the occurrence of flood events has become common, flood risk and flood prevention have raised public, political and scientific awareness; thus, it is from this contention comes the knowledge which GIS use for flood management (Wurbs, 1988). In China, the Law of Flood Control (1997) stipulated that every unit and individual has the obligation to protect the flood project and participate in flood fighting. Governments at different levels are responsible for the organization of flood fighting and relief work after flood disasters. Flood control plans should be integrated in basin plans and coordinated with the land-use plans, and the local interests should be subject to the interests of the whole basin; hence, the flood control and management processes should be exercised on the basis of coordination and cooperation among all the parties concerned, in flood prone areas, including the area to be protected, the storage and detention basin and the flood affected, area without protection should be clearly identified and delineated, and relevant policies and management rules should be formulated and implemented as soon as the flood plan is approved (WMO, 2002). In April 2006, Emergency Management Office of State Council was established being an operation center responsible for the emergency, information collection and comprehensive coordination. When disaster occurs, it coordinates various departments of the State Council for emergency or starts special standing command organizations, such as the national earthquake relief headquarters, flood control and drought relief headquarters and so on, or builds temporary command organization (Yi *et al.*, 2011).

Moreover, large complex models used information on the surface elevation as well as data on the subsurface drainage networks which was completed using software. This was combined with the information on the buildings and value of the exposed assets to estimate the total damage caused. For the 50-years event, the expected damage for Yizhuang was 497 million. Also one technical innovation has been made to model a number of vulnerable underpasses to identify flood risk hotspots. These have been combined with traffic simulation models to quantify the disruption to, allowing planners to understand the total impacts of floods. These results are being used to evaluate the effectiveness of different strategies to mitigate flood risk (CORFU, 2014).

In India, the National Disaster Management Guidelines (2008) identified that there is a lack of coordination among the agencies of the central government and the state governments as well as among the various departments of government. Guideline also recognized lack of institutional framework for coordinating the efforts of various agencies in setting up basin-wise organizations for flood management training, education and doing research in flood management. The flood response system lacks public participation. There is also lack of awareness among the people about simple ways of safeguarding their lives and properties during floods (NDMA, 2008). However, Nirmal (2011) argued that little have been done in some part of India like Damodar where Valley Scheme have served purpose of moderating the flood flows, showing that a tangible reduction to the extent of 53 to 80% has been achieved in the high flood years. Some embankments have provided a positive benefit by ensuring sustained protection against floods and river spills while on the other hand. Some embankments have aggravated the flood problems by rising river bed levels, decreasing their carrying capacity, causing drainage congestion in the countryside and distorting the levels/gradient of the outfall points (ibid).

Bangladesh is one of the most flood prone countries in the world, which is situated in South Asian sub-continent. Flood management strategy has been under continuous change since early sixties century. After the disastrous floods of 1987-88 the Government brought many changes in the flood management strategies. Most important change was in the development policy for different infrastructures. The Government decided to build all structures of strategic importance above the flood level of 100 years' frequency. Government also decided to construct school buildings in the flood prone areas with the provision of using them as temporary flood shelters.

As a result, all the national high ways were raised to meet the new standards. The Government also decided to stop encroachments on the floodplains and passed legislation controlling the developments in the flood plains and wetlands (WMO, 2013). The Flood Forecasting and Warning System (FFWS) is currently assisting government, disaster managers and the communities living in the flood prone areas in matters of flood preparedness and preparation of emergency mitigation plans. It now covers all the flood-prone areas of the country with 85 flood-monitoring stations, and provides real-time flood information and early warning with lead-times of 24 hours and 48 hours (Khan, 2007).

2.4.2 Flood Management in Africa

In Nigeria, the majority of the people who are located in the flood-prone area are aware of the danger involved and they have tried to protect and cope with flood effects. There are many mechanisms employed by the local people to deal with the negative impact of flood. These can be technological/structural coping mechanism referring to the structural activities employed by households living the flood-prone area to cope with flood losses or damages. These include the construction of houses to prevent floods or the use of materials that can minimize the flood losses and damage. For instance, people in flood prone areas such as Lagos, Ibadan and Abeokuta have taken to construct their house with the reinforced material and some houses with second floor to protect their lives and properties against flood. The other coping mechanisms are those activities and or social relationship and network among the community and local government that can help people to minimize the flood losses and damage (example the supply of relief materials and establishment of refugee camps house displaced people until the flood recedes). It must be noted that local people behave and develop mechanisms for coping, that if well understood can guide local authorities and communities to develop in partnership floods (UNFCCC, 2007; JSDA, 2012).

The East African Sub-Region is prone to natural hazards such as floods, droughts, earthquakes, landslides, strong winds, lightning and their secondary impacts of diseases and epidemics. Drought, floods, landslides and epidemics are the most frequent disasters in the Sub-Region. In order to address and effectively minimize impacts of disasters in the region, legal and institutional frameworks are necessary along with the other capacities required for this purpose. Thus, the East Africa Community Disaster Risk Reduction and Management (DRRM) strategy have emphasized its member countries to focus more on the proactive model and on prospective (future actions) which requires prevention, and the risk analysis to be part of development planning programmes and projects (EAC, 2012).

In South Africa, key component of the flood risk management strategy is the Master Plan which entails the upgrading of all 226 informal settlements within the metropolitan area. Nearly 25% of the settlements were affected by the floods of 2007 compared to the 80% in 2000. The improved situation can be attributed to Cape Town's pro-active cleansing operations, upgraded drainage systems, and the ongoing community education programmes. As far as other long-term actions, Cape Town's plan includes a technical assessment of all flood occurrences education on better house building techniques, stricter enforcement against migration into high risk areas, and the acquisition of land adequate for the relocation of people residing in areas of great flood risk (Wood, 2007; Hendricks, 2007).

In Kenya, the Ministry of Water and Irrigation (2009) has been established that flood management is the responsibility of the Department of Irrigation, Drainage and Water Storage, the Ministry of Water and Irrigation (MWI). In the department, there is no a section to deal exclusively with flood management issues. The procedure for monitoring is informal as there are no field staffs dedicated to keep track of flood situations or to take preventive or remedial measures during or after the floods. A number of flood protection works like dykes drainage channels river conservancy works were built in different river basins before and immediately after independence. The MWI owns these assets, but has no financial or organizational mechanism for their routine repairs and maintenance. Specific schemes for major repairs are planned and implemented from time to time without an overview plan (ibid). In Kenya, flood prediction commonly used traditional methods. Traditional indigenous weather and climate prediction practices are based on the indicators established over generations through keen observation of plants, animals, birds, insects, winds, lightning patterns and clouds. The predictions based on these indicators and human feelings support the early warnings issued by the elders to enable the community to cope with the anticipated natural hazard like flood. For example the Abanyala community of Budalang'i was, for instance, able to effectively predict the rains and floods during the early times by watching nature and associated behavior of animals and plants.

They were able to sound an alert in timely manner to enable the community members to adjust and cope with the coming of a disaster. These specific village elders play a very important role in early warning. The community uses specific sounds using drums, horns and loud noises to disseminate the early warnings (UNDP, 2008). In Lamu (Kenya), the planning and architecture of the town is used as a mitigating measure for floods. The town is built on a hilly ground with channels for easy drainage which minimizes flooding. However, in the event that flooding occurs, the architecture incorporates foot bridges (*Wikios*) connecting the upper levels (first floors) of houses. In Kwale, the coastal caves are used to mitigate flood disasters. The communities have established clear drainage systems leading to the caves and onwards to the ocean, to manage floods. These routes are held sacred to ensure their conservation. These routes are classified as routes used by evil spirits. This is to discourage people from using them which would lead to their blockage (UNEP, 2008; UNEP, 2009).

Recognizing the risks of climate-related disasters like floods, the Mozambique's Government has tried to put in place structures for managing and mitigating their impacts. A new National Policy on Disaster Management was passed in 1999, presided by the establishment of the Department for Combating Natural Disasters in 1977 which was replaced by the Disaster Management Institute. Under the new policy, preparedness for floods is facilitated by a flood early warning system. This provides forecasts of flood risk detects and monitors flooding, and puts out flood warnings when necessary, paving the way for a coordinated response. The flood early warning system is coordinated by the National Directorate of Water, together with the National Institute of Meteorology and the National Disaster Management Institute. This collaboration reflects the essential integration of hydrologic and climate information needed to understand and predict floods and to manage an effective response (GFDRR, 2014).

A flood risk analysis has been carried out in the Mozambique's major river basins to identify vulnerable areas and people. This found that 40 out of 126 districts are prone to flooding, and 5.7 million people in these districts are vulnerable. This was valuable starting point for planning and implementing measures to reduce vulnerability. Following the analysis of hydrological data, some equipments were upgraded and some new equipment installed, including two new radars and 15 new meteorological stations. In addition, Mozambique now has a tropical cyclone warning system, distinct from the flood early warning system. This informs people of the probable arrival of a tropical cyclone at least 48 hours in advance (Muianga & Filipe, 2005; WBG, 2014)

In Tanzania, National Environmental Policy of 1997 (NEP, 1997) recognizes environment as a cross-cutting issue that requires a holistic approach and multi-level management. In this perspective, the policy addresses climate change by involving different sectors, local government authorities and their respective stakeholders. However, up to 2001, all ministries in the country had no disaster management policies they only had other general policies on disaster requisites such as the concepts of mitigation and post disaster recovery. Now the Environmental Management Act (EMA) of 2004 under section 13-(1) provides the minister responsible for environment, the overall responsibility for matters related to the environment under Urgent Actions on Land Degradation and Water Catchments of 2006 (URT, 2012).

The Tanzania Meteorological Agency (TMA) issues weather warnings for Tanzania. It provides warnings and advisories on extreme rainfall based on the daily weather monitoring and possible flooding without a clear identification which areas exactly will be flooded. Weather warnings and advisories are disseminated by TMA to the public through various mass media and the disaster management department at the

Prime Minister's Office (TMA, 2010). However, there are some challenges in the efforts to manage flood risk in remote areas of Tanzania. There is no flood warning for specific communities except the general weather forecast from Tanzania Meteorological Agency. Therefore, it is difficult to predict area which will be flooded at a particular time. When there is dumping on drainage channels the City council and districts do not know about the weather on time because of accessibility problems in many settlements (EAC, 2012).

2.4.3 The Use of GIS in Flood Management

Land is a fundamental resource for almost all human uses. The use of land resources are shaped by the interaction of two broad sets of forces of human needs and environmental features and processes. Human actions to the natural resources are the product of individual and group behaviors within the specific social-economic and environmental settings thus there is the need to integrate GIS so as to make the best practices to manage natural resources (Zaman, 2015). Hence, here under are the two sided faces of GIS; first it helps to disseminate resources information and; second, it adds knowledge about resources utilization, policies making and lastly controlling it from degradation.

Also the GIS could be used as the decision support system. An example is from the analysis of a dam break flood management strategy for Sindair Dam in Georgia, USA. This new system provides a very versatile and reliable environment for estimating various flood damage and may greatly enhance decision making process for the future design of the flood proofing facilities (Hongai et al., 2011). In the worldwide are different ways that have been put in place to reduce the effect of flood. Example The US Geological Survey in cooperation with the City of Charlotte and Mecklenburg County, North Carolina, developed the Flood Information and Notification system (FINS) to address the need for prompt notification of flood conditions in urban areas where streams rise and fall rapidly. The flood information and notification system is based on a large network of stream flow gauging and rainfall stations that broadcast information within minutes of being recorded via radio telemetry. The system automatically notifies the National Weather Service and emergency responders in the Region when rainfall and stream flow indicate the likelihood of flooding, giving these agencies additional time to issue warnings and evacuate areas if necessary (Konred, 2014Badjana*et al.*, 2015).

Obtaining the goal of sustainable development within Africa's diverse communities requires that analysts and decision makers understand the characteristics of resource use as well as human conditions. GIS also helps users to plan for future events through various techniques that can be used for forecasting of scenarios. Examples may include flooding of settled areas, agricultural land, damage calculation and spread of diseases. People need to understand the underlying processes of floods as a disaster, disease, and poverty. GIS is an important tool for helping people map out plans for successfully achieving management strategies that are sustainable both at local and global levels (ESRI, 2002).

2.4.4 Mitigation Measures Against Floods Effect

Flood forecasting and warning is worldwide accepted and has been used since the latter half of the 20th century. It supplements almost all other structural as well as non-structural measures. Flood forecasting involves estimating when a flood is likely to cause damage or loss of life, what its magnitude will be (usually in terms of its maximum stage at a given location) and how long it will last. Flood forecasts are formulated and issued with a certain lead time, allowing the concerned authorities to take preventive and emergency measures. The effectiveness of a flood forecast and warning system is as much a function of the accuracy, time-lines and outreach of the forecast as of the response behavior and preparedness. Inflow forecasts for reservoirs, detention basins and bypass channels play an important role in flood peak alleviation (WMO, 2006).

Worldwide riverine flood events account for nearly half of the deaths and one-third of all economic losses from natural hazards worldwide (UNESCO, 2008). Between 1985 and 2005, riverine floods claimed the lives of over 112,000 people, affected more than 354 million people and caused approximately 520 billion Euros (US$690 billion) in financial damages (Bakker, 2006). In 2004, the United Nations Development Programme (UNDP) estimated that on average almost 200 million people in more than 90 countries are exposed to catastrophic flood events every year (UNDP, 2004). The vulnerability to floods is expected to rise in the future due to climate change and the steady increase of population as well as of urbanization (Kundzewicz et al., 2008).

In Africa, the occurrence of severe flood events has increased noticeably over the last years, affecting millions of people and hampering the economic development in the region, exerting enormous pressure on the affected countries (Dartmouth Flood Observatory, 2010). Therefore, considerable effort has been put into the mitigation of flood-induced damages in Africa over the last decade. During this period, there has been a significant and rapid increase in Africa in the number of institutions and research dedicated to dealing with flood management. The increased focus on flood management in Africa has the potential to significantly improve flood management in the region; however, the increased number of different institutions involved also complicates the coordination of research and implementation efforts. A clear understanding of what work is being undertaken by different groups is therefore critical for an efficient coordination of work as well as future knowledge and data sharing (Roo and Gadain, 2011).

The Guardian, in 2014, after huge flood which affected 41of the residents in Dar es Salaam Region, argues for the need for the effective disaster or emergence flood management system in Tanzania (The Guardian, 2014). Mitigation measures can be structural or non-structural. Structural measures use technological solutions, like flood levees. Non-structural measures include legislation, land-use planning and insurance. Mitigation is the most cost-efficient method for reducing the impact of floods. There is an observed mushrooming of construction in flood valleys such as the Msimbazi Valley. Effective urban planning does not allow people to dwell in areas prone to floods. However, there has not been in place effective measures to ensure that people do not construct in valleys (URT, 2012).

2.5 Policies related to Flood Management in Tanzania

Literature reviews of official documents in Tanzania detected that there is no direct government law or Act which address floods management issues. Analysis of the present official documents give wide range of law about water management issues as National Water Policy (NAWAPO) of 2002 directs that water resources management in Tanzania should be organized starting at the national level and spreading to the basin and sub-basin level. The United Nations Development Programme (UNDP) (since 2012) works closely with countries like Tanzania on matters oriented to disaster management, assisting them in implementing new laws and policies and establish new institutions addressing the need to anticipate and minimize the effects of disasters, prevent losses and recover when disaster occur. It does not address, develop and implement hydrological prediction system and inform people about floods events in Tanzania.

Tanzania Meteorological Agency (TMA) gives wide range of weather forecast such as the October-December2014 rainfall. TMA forecasts some areas were expected to receive rains above the normal. Unfortunately, the hydrological sector is not developed enough in TMA to organize hydrological prediction service and providing warnings to areas threatened with floods. Currently TMA provide just warnings about rainfall intensity and duration, those warnings are not informative and not useful for residents because they do not contain information about date and time that flood wil start and at what stage rise.

Additionally, no current official document that entails about flood management policies but only general information about Water Resource Management Act No. 11 of 2009 is provided which provides guidance for pollution control and issues discharge permits of effluents to water bodies, including the underground strata. Also, there are no clear interconnections of the governmental organization that are responsible for flood warnings which are Tanzania Meteorological Agency, the Ministry of Water and Vices President’s office.

2.6 Conceptual Framework

A conceptual framework is defined as the visual or written product one that explains, either graphically or in narrative form, the main things to be studied (Huberman, 1994).

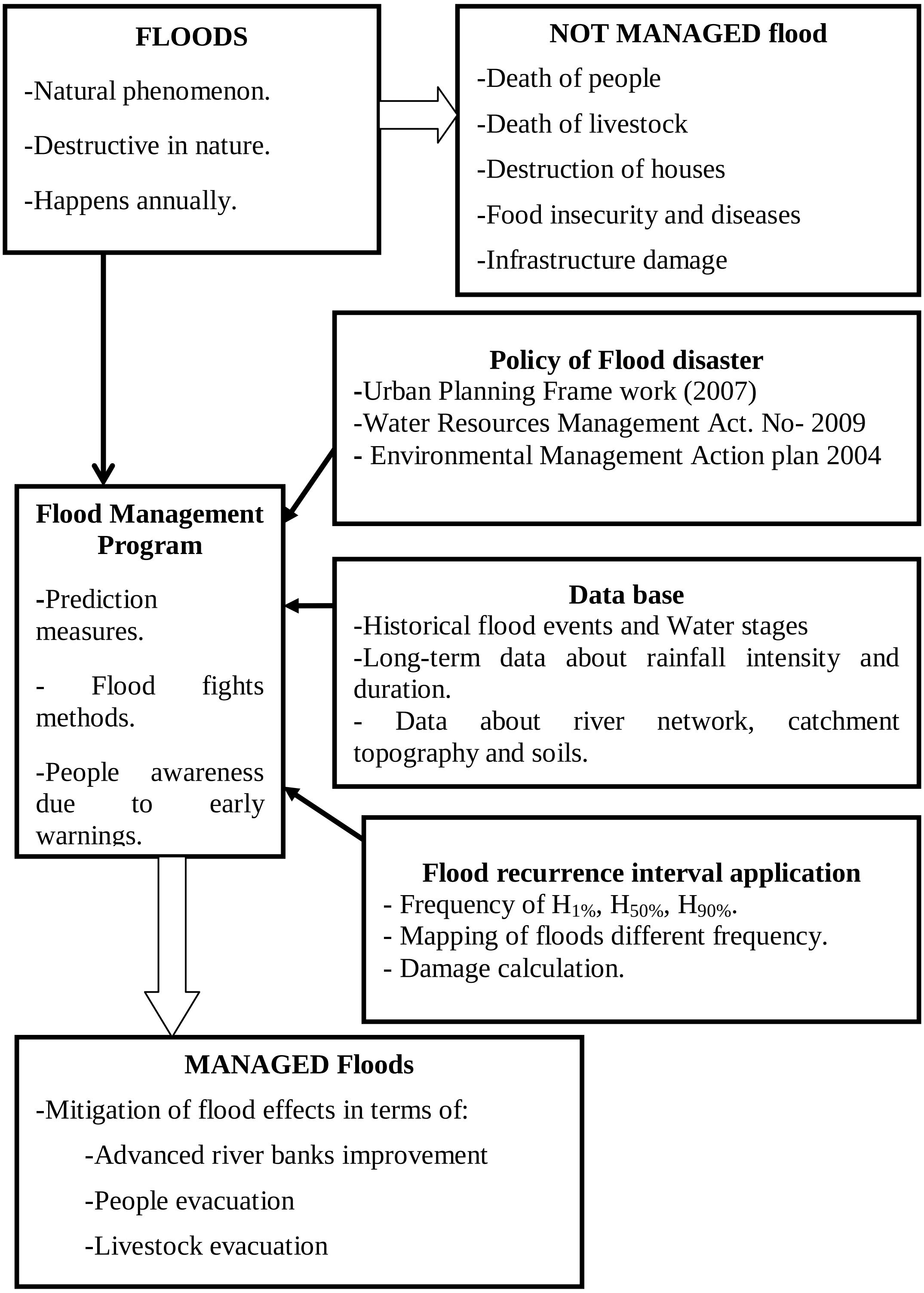

Figure 2.1: Conceptual Framework

Source: The Researcher (2016).

This framework is based on the assertion that flood happens as a natural phenomenon and if not managed can lead to problems such as death of people, death of livestock, destruction of houses, food insecurity, diseases and infrastructure damage. But if floods management practices, such as Prediction measures, flood fights methods and rise of people awareness due to early warnings are enhanced by flood policy they help to mitigate flood effect.

Flood mitigation measures include advance river banks improvement, people evacuation, livestock evacuation and the advance preparedness of flood stock and refuge.

2.7 Knowledge Gap

Globally, flood management practices have largely focused on reducing flooding and reducing the susceptibility to flood damage. There have been developments of various flood management approaches which include both traditional and modern ones. Traditional flood management approaches employ structural and non-structural interventions, as well as physical and institutional interventions (WMO, 2009). In United States, structural measures dominate the response to flooding whereby construction of levees, floodwalls, channel work, floodways and flood storage in reservoirs have been in place. The presence of flood management projects has prevented the loss of about $18 billion in the upper Mississippi and Missouri basins (WMO, 2005).

Also, for the Great Britain, especially England and Wales flood warnings are provided when measurements of river or sea levels reach a threshold or trigger level, or when forecasts show that high-water levels are imminent. The use of forecasts made for 1,163 river level locations and 805 coastal locations to ensure flood warnings are as accurate as possible for local communities (EAC, 2009). A lesson has been learnt from the Netherlands and Bangladesh where they have developed a high priority on safety against flooding. Levees (dikes) protect the economically important low-lying parts of the countries and other river areas close to basins. The particular frequencies of occurrence, or risk levels, are determined by Flood Forecasting and Warning System (FFWS) which assists government's, disaster managers and the communities living in the flood prone areas in matters of flood preparedness and preparation of emergency mitigation plans. It now covers all the flood-prone areas, and provides real-time flood information and early warning with lead-times of 24 hours and 48 hours. This has been the case for other Asian countries like China, Philippines and India which have also been Affected by floods severally (Silva 2004; Nirmal2011; WMO, 2013).

Many studies that are conducted on floods (EAC, 2012; FIU; 2014; URT, 2013) and most of them address causes and effects of floods and the general rainwater resources control without considering the early warnings and preparedness before floods events. For instance, Tanzania Ministry of Water and Irrigation (2003) argues that flood, generally, occurs on river floodplains as a result of high intensity and/or prolonged rainfall events. Other factors contributing to flooding are low soil storage and infiltration capacity in the upstream catchment, reduced conveyance capacity of the lower sections due to sedimentation and poor drainage in the flooded areas.

Currently, in Tanzania, few researches have been done to address flooding based on early warnings and preparedness. Particularly in Dakawa Ward there was no any single research that had been done before this study to address flood events. Also, through the review and analysis of official documents, it was revealed that there was no flood management practices in Tanzania. Thus, this study was proposed to help to raise awareness about flood early warning and various methods for flood management in Tanzania, Mvomero and specifically the areas vulnerable to flooding like Dakawa Ward.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes different techniques used to come up with the findings of the study. It includes the description of the study area, research design, research approach, target population, sampling methods and sampling frame, types of data and the methods of data collection, sources of data collection, its tools and data processing and analysis techniques.

3.2 Research Design

Kothari (2004) contend that a research design is an overall plan for obtaining answers to the questions being studied and handling the difficulties encountered during the research. Kothari and Frankfort (2008) mentioned some significance of research design in doing research. It stands for advanced planning of the methods to be adopted in collecting the relevant data, helps in time and financial management and to test a hypothesis. Generally, is a set of logical steps taken by the researcher to answer the research questions, and to draw the inference concerning the causal relationship between the variables under the investigation.

This study employed a descriptive research design due to the fact it is useful to obtain the information concerning the past and current status of the phenomena and to describe what exists with respect to the variables or conditions in a situation (Rwegoshora, 2006). The main aim of a descriptive research design is to provide an accurate and valid representation of the factors or variables that are relevant to the research questions (ibid). Thus, a descriptive research design was used to assess the floods and their management in the study area.

3.3 Description of Study Area

3.3.1 The Location of the Basin

Wami/Ruvu Basin is located on the eastern side of Tanzania, which lies between latitude 6°26'12.84" S and longitude 37°31'43.32"E.The Basin covers an area of about 66,820 km^2 and located in the six regions; i.e. Dar es Salaam, parts of the Coast Region, Morogoro, Dodoma, Tanga and Manyara. It has two major Rivers of Wami and Ruvu covering an area of 43,946 km^2 and 18,078 km^2 respectively. It is a stream body of running water moving to the lower level in a channel on land with a length of 29.83km^2 and Dakawa Ward adjacent to Wami River (URT, 2013).

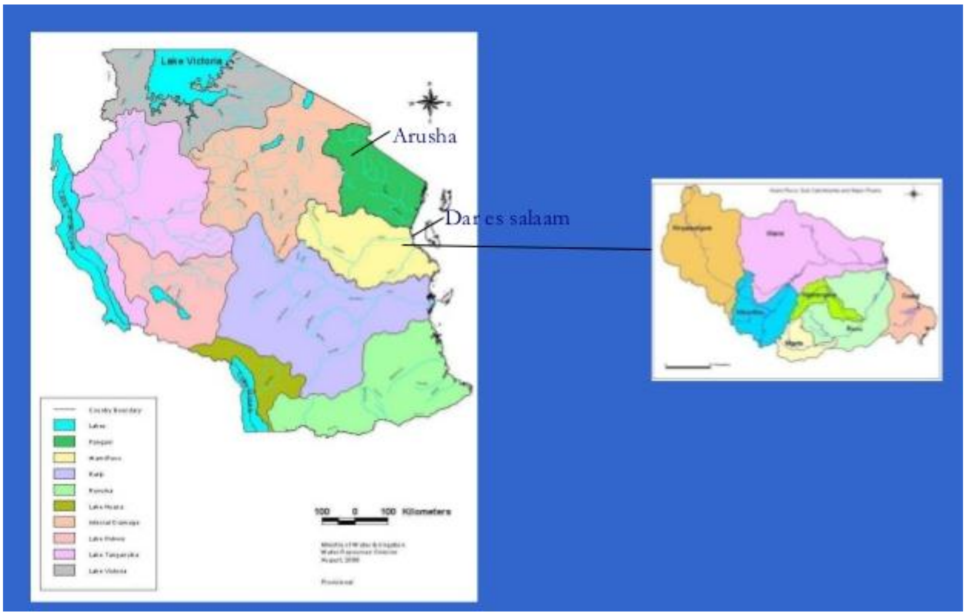

Figure 3.1: Location of Wami/Ruvu Basin in Tanzania

Source: WRWBO (2013)

3.3.2 Climate

Wami/Ruvu basin witnesses a wide range of rainfall and temperature regimes broadly falling under costal humid block with high rainfall and altitude dependent temperature, interior western highland arid with high seasonal temperature variation. The basin is located in eastern arc mountain. The elevations of those mountains consistently experience the heaviest rainfall in the basin - greater than 2000mm annually. It is in three times more than the amount of the rainfall in the lowland Dakawa (700mm) and four times less the amount of rainfall in the semi-arid region of Dodoma (500mm). The basin receives a bimodal type of rainfall with peaks in April and December for long and short rains respectively in May and October (SMMR, 2008). The annual mean temperature varies spatially across the Wami/Ruvu Basin raging between 22° C in the interior and 26° C in the coastal areas (Yanda & Munishi, 2007; Gomani *et al.*, 2010).

3.3.2 Relief

Wami River flows at the altitude between 380 meters and 1,520 meters above the sea level in Dakawa Ward, which is located 40km from Morogoro. This river goes across different landforms, such as Pane plane before it reaches floodplains. The landforms are described as follows: Peneplane is landform that is situated at an altitude range of < 520-480-m.a.s.l. The peneplane consists of ridge summits, ridge slopes with red soils and ridge slopes with sandy soils and valley bottoms. Lastly, alluvial plain which consists of flat topography with red soils situated at altitudes between 380-480 meters above the sea level. This plane has an extensive shallow drained soils with extensive slope of about 2-10%, seasonal water logging and covered by open bush land. Also, Dakawa is characterized by woodland and scattered cultivated lands (Baltazar *et al* 2001; Bucheyeki, 2015).

3.3.3 Water Stage at Wami/Ruvu Basin

Highest water levels in Wami/Ruvu River occur between April and June. The annual average flow in Wami/Ruvu River in 2012/2013 hydrological year was recorded to be below the long-term average. However, during the rainy season (March – May) the water stage was above the average. Daily water stage in Wami/Ruvu basin is represented the by water stage fluctuations in the Wami Dakawa Gauge station (1G1) and it is highly correlated to the rainfall pattern in the catchment whereby the highest level of about 507 meters above sea level was recorded in March – April (2013) which is equivalent to the storage of 16.6 Million cubic meters (WRWBO, 2015).

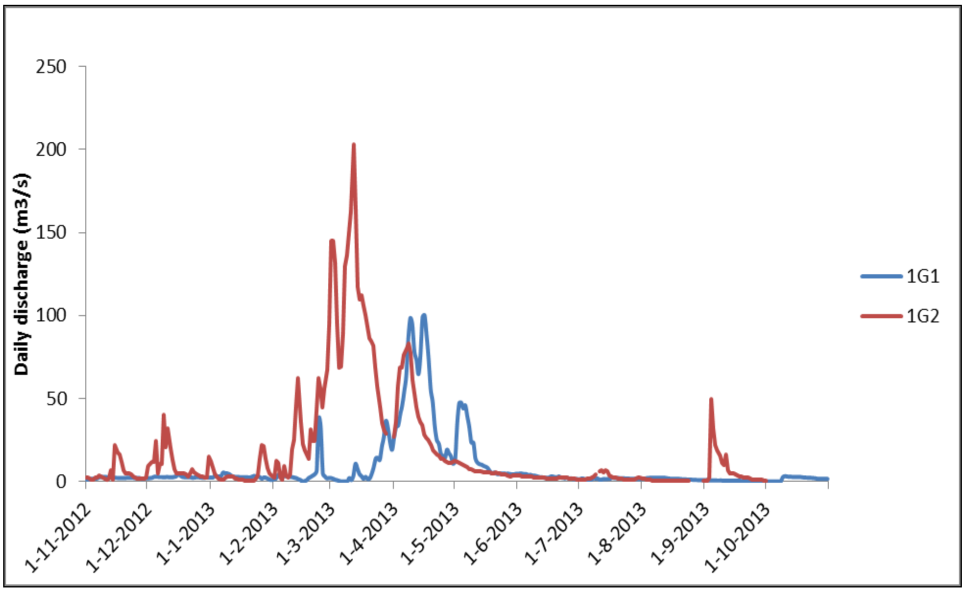

Figure 3.2: Daily flow regime in Wami River for Two gauge stations (Wami at Dakawa (1G1) and Wami at Mandera (1G2))

Source: WRBWO (2013).

3.3.4 Water Discharge at Wami/Ruvu Basin

The upstream catchments of Wami River have low coverage by the forest which results in lower rates of infiltration and hence, greater runoff immediately following a rain event. The lack of forest cover can accelerate soil erosion as well as flash floods following the periods of heavy rains. Wami River catchment has both unimodal and bimodal rainfall patterns. A unimodal pattern is usually observed in Kinyasungwe sub catchment and a bimodal pattern is observed in Mkondoa and Wami subcatchments. In the hydrological year 2012/2013, high rainfall was recorded at Zanka station were an annual precipitation was about 843.1mm followed by Wami/Ruvu station with about 619.8mm. Compared to most of the stations in Wami catchment the rainfall recorded for the hydrological year 2012/2013 showed 75% below the average of except Dodoma Maji Station whereby the percentage was within average (88%) and Zanka station rainfall recorded was above average exceeded 100% (Krishnaswamy *et al.*, 2012).

3.4 Selection of the Study Area

According to the data provided by the Wami/Ruvu water basin office, Morogoro Regional Executive office, and office of Mvomero districts the area which is mostly affected by floods in Morogoro Region is Dakawa Ward (Figure 3.3). The Red Cross in 2014 estimated that, about 10,000 people were displaced. The worst affected districts were Mvomero and Kilosa districts. According to the situation updates by the assessment team at Dakawa ward, most public buildings (schools, churches, mosques) along the Morogoro-Dodoma highway were submerged. This ward located in low-land area along Wami River which is annually flooding surrounding areas (UNFCCC, 2014). Also, the area was selected because it crosses Morogoro-Dodoma Road Bridge at Dumila and during flood of low frequency it could be washed away.

Figure 3.3: Dakawa Ward

Source: Open Street Map (2016).

Dakawa ward includes four villages Mirama, Luhindo, Sokoine and Wami-Dakawa which are located along the Wami River. The study was based on all villages in Dakawa ward because it was important to detect which area is frequently affected by flood waters and which measures are taken by the Government to mitigate it.

3.5 Research Approach

The study employed both qualitative and quantitative research approaches whereby the researcher had to record and analyze the words, opinion and understandings of respondents handled down by mouth. Silverman (2004) postulated that qualitative methodologies help the researcher to know how the respondents view and understand the world and construct meaning out of the experience. According to Bryman (2008), qualitative research is seen through the eyes of those studied and an understanding of the meaning which people attribute to their world. The qualitative research methodology helped a researcher to get more information and data on how to fight against the flood effects. Cohen (2007) argues that quantitative research, as defining factor in numbers, results from the process, whether the initial data collected produce numerical values, or whether non numerical values subsequently converted to numbers as part of the analysis process, as in content analysis. The qualitative approach also provided in-depth information which enhanced a deep understanding of parameters underlying this study.

3.6 Target Population

Cochrem (1963) defined the study population as a complete set of events/people or things that researcher is interested in and from which sample is taken. The target population in this study included the residents of Dakawa Ward, the ward executive officer, village executive officers, agricultural extensions officer and Irrigation engineer. These groups were thought to have formal and informal information related to the study; as well, they had enough experience about flood in this area.

3.7 Sampling Method and Sampling Frame

3.7.1 Sampling Method

A sample is a part of a population selected by the researcher for the study, whereas sampling is process of obtaining or taking a sample from a census. The study used simple random and purposive sampling procedures to get the sample of the study. Sampling method is concerned with the selection of a subset of individuals from within a statistical population to estimate the characteristics of the whole population (Cochram, 1963). The sampling techniques employed were simple random sampling and purposive sampling with the aim to have the population that was a representative to the whole ward without bias.

3.7.2 Sampling Frame

Kothari (2004) argued that a sampling frame that will be developed for getting the sample will adhere to the statistical specification for accuracy and repetitiveness. The respondents of the study included all the residents of the Dakawa ward and the key informants at Municipal and village/street level obtained from Wami/Ruvu WBO, Mvomero District office and respective village's offices.

3.8 Sample Size

A sample is a set of elements, which represent all features of a particular population (Kothari, 2004). Sekaran (2011) defined a sample size as the number of items to be selected from the universe to constitute a sample. It is the target group that must be of optimum size; that is, it should neither be excessive nor too small so as to get statistical inference. This sample size was determined using the formula developed by Yamane (1967) as indicated in equation (1):

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

Where n - the desired sample size; N - total population size; e -sampling error.

According to the Tanzania National Census of 2012, population in Dakawa Ward was37,321 residents. On a base of formula (2) at the sampling error, 10% of the estimated sample size was 100 respondents. By using Israel's formula (2009) for promotional sampling size to obtain the sample size for the four villages as indicated in equation (2)

$$n = \frac{N*P}{P} \qquad (3)$$

Where n-sample contribution, N- sample size, p - number of residents in a village and P-total is the number of residents in four villages. Application of formula (3) for studied villages of Dakawa ward allowed obtaining the proportional number of residents.

Mirama- 100 ×11,942/37321=32 residents

Wami-Dakawa - 100×8,584/37321=23 residents

Luhindo - 100×9,703/37321=26 residents

Sokoine - 100×7,091=19 residents

The researcher covered a sample size of 108 respondents as part of the population to be studied, where 100 were selected from residents and 8 were key informants. In this study ward executive officer (1), village chair persons (4), irrigation officer (1), agricultural extension officer (1), land officer (1) were purposively selected as key informants, while the researcher also selected 100 residents randomly. The researcher's target population was key informants and residents dwelling adjacent to the Wami River.

3.9 Unit of Analysis

A unit of analysis refers to the type of object whose characteristics are measured and in which we are interested (Kothari, 2004). The unit of analysis of this study was the residents of Dakawa Ward who annually affected by floods.

3.10 Parameters of Interest

A parameter is a relevant characteristic of a population (Kothari, 2004; Rassel, 1989). Households in this perspective referred to all people above 18 years of age due to the fact that it is the age which is considered to be a starting age of working class in Tanzania (URT, 1977).

3.11 Types of Data and Methods of Data Collection

3.11.1 Types of Data

3.11.1.1 Primary Data

These are the data which are directly obtained from respondents; in other words, they are the type of data which did not exist before (Bailey, 1978). In this study, the primary data used were obtained from interviews and questionnaire which collected in-depth responses from the sample. In this method researcher prepared questionnaires and interview guide which comprised the open and close ended questions.

3.11.1.2 Secondary Data

These are data already existing; they have been collected by others and found in other sources. They are obtained from various sources such as books, the internet, journals and published books (Bailey, 1978). As well, Kothari (2004) argued that the secondary data are those which have been collected by someone else. In this, the researcher reviewed the available documents that provide information important to respond the study questions. As well, data from Wami/Ruvu River Water Basin office about water stages for Wami River at two gauge stations (1GD2 –Wami River at Mkondoa; 1G1 – Wami River at Dakawa) were collected; these are those of the period of 1954-2014. Also researcher collected Rainfall data about precipitations of Ikombo met for period 1977-2014 from TMA.

3.11.2 Data collection Methods

Primary and secondary data have been used for this study. Published reports or unpublished documents and articles from the Internet were used to collect primary and secondary data. Thus the researcher used Interview, Survey method, Documentary review and Observation methods to collect required information.

3.11.2.1 Questionnaire Survey Method

Best and Kahn (2006) argues that a questionnaire has to be employed when actual information or opinions are needed. This study also employed questionnaire as a survey method to get more information from the residents about the study. Both closed and open ended questions were needed to collect the information from the residents affected by floods. To get more reliable data, questionnaires covered two aspects which were demographic aspect (Age, sex, and education as well socio-economic activities of respondents) and question related to flood effects and its management practices. For questionnaire to be effective following procedures were involved:

Firstly, questionnaires were prepared based on the objectives of the study, those questions were arranged from simple to complex in order to attract the respondents to fill all the questions about the effects of floods and its management practices (See Appendix 1). Clarity of language was highly considered to enable the understanding of the questions to all respondents.

Secondly, *recruitment* of the research assistant was done basing on the background and familiarity of the study area to simplify data collection process. Four research assistant were selected from study areas, one from each village of the study area. These research assistants selected because of their experience in floods and their basic knowledge of data collection.

The third step was the *training* of the research assistants who were recruited. Training of these assistants focused on the ways to introduce themselves to respondents, the ways of asking questions the way of probing the questions and translate the questionnaire from English to Kiswahili.

The fourth step was *pre-testing of the questionnaire*. This step was aimed at proving weather the questionnaire are clear, specific, interconnected and unambiguous so that the respondents can provide relevant answers to the study. To make sure there was no bias, four clusters were identified; one for each village and, thereafter, a lottery system was used to get the real sample size. For every village hundred houses were given numbers and written on the slip and mixed in a container. One piece of paper was picked from the container until the required sample was found. Lastly, questionnaire was administered. In this step face to face questionnaire survey was administered to hundred households. The researcher or a research assistant asked the respondents the questions from questionnaire and filled the answers accordingly in the questionnaire until all respondents surveyed. Hence, the researcher used this tool for data collection since it helped him to get more information in a reasonable time and cost efficient manner.

3.11.2.2 Interview Method

Kothari (2004) states that an interview is a desirable method of data collection since it is not an ordinary, everyday conversation as it involves giving questions to interviewees through oral or verbal communication. Therefore, interview was used in collection of data from the Ward officer, village chairpersons, agricultural extension officer and Land Officer purposely to get their responses and the impulses about the flood control in their areas. The researcher prepared an interview guide with close ended questions and open ended questions (See Appendix 2). This was used so as to get requisite information about the study. Face to face verbal integration was employed so as to encourage the respondents to answer all questions; this was influenced by researcher's signal, like nodding of head to show that he was very much interested to know the information from the respondents. Research avoided dullness behaviors to discourage the respondent.

3.11.2.3 Observation Method

Krishnaswami (2003) notes an observation as a classical method of scientific inquiry. What respondents do may differ from what is done in the actual field. The study employed observation method for data collection since it records behaviors that otherwise might be taken for granted, expected or go unnoticed in the study area. This helped the researcher to obtain the requisite information. In the field, the researcher observed houses which were frequently affected by floods also the researcher with the help of the Global Positions System (GPS) read and identified and the recorded elevations built-up areas above Wami River to determine their capacity to control floods.

3.11.2.4 Documentary Analysis

The documentary analysis was used; it included the analysis of the documentary materials such as books, magazines, official reports, and journals to get reliable data about the village population characteristics and the cost of properties destructed by floods in the previous time. Also, documentary analysis helped the researcher to get maps and other statistical information from the Water Basin Office, basically on the water stage, recorded water volumes and coordinates of water gauge station.

3.12 Tools for Data Collection

3.12.1 Questionnaire Tool

The questionnaire was administered to residents for obtaining the information and experience of the problem under the study. The questionnaire was divided into various parts which reflected the type of information needed to address specific objectives of the study and eventually to answer the research questions. The questionnaires included both closed and open questions. The closed questions were proposed to get the general information from the respondents while the open ended questions collected opinions and suggestions from the respondents in relation to the research questions.

3.12.2 Interview Guide

An interview guide is a list of questions asked to respondents and filled by researcher him/her-self (Ndunguru, 2007). An interview guide was used in order to seek data from participants about the floods management at Dakawa Ward. This instrument helped the researcher to avoid the problems of varying quality of interview data since it allowed the interviewer to ask direct questions. In the study, the researcher used a list of questions with no choices and asked the key informants then recorded the answer himself.

3.12.3 The Documentation Review

Documentary review method involves deriving information by carefully written document (Enon, 1988). Documentary review is the use of other sources, documents to support the argument or standpoint. The crucial issues surrounded by the type of the document and aptitude to use them as the reliable source of proof. The analysis of documentary research would be qualitative, quantitative or triangulation. The documents used in the study are journals, books, articles and tables, graphs of water stage.

3.13 Data Processing and Analysis

Data was processed and analyzed using both quantitative and qualitative methods, which involve the use of graphs, charts, tables with percentages generated by the Statistical Package for Social Science (SPSS) software (version 16.0) and Microsoft Excel (version Professional Plus 10). MapInfo 11.5 was used for digitization of base maps, mapping of studied houses and flood-prone areas. Also, the Recurrent Interval method was used to calculate the frequency of the floods with different size. It was calculated from 25 hydrological years. Flood frequency computation table was compiled (See Table 4.6). From published gauging data (1G1 Dakawa) dates were extracted and water stages of peak flow were ranked from the largest to the smallest. The largest stage was ranked M=1. The smallest stage was ranked 25^{th}, where 25 is the total of years for the present data. Next was to compute the recurrence interval. In computation of the recurrence interval (or return period) of each flood was done with formula (1):

$$RI = (N+1)/M \tag{1}$$

Where N – is the number of records (in years), and M – is the rank of a particular discharge/stage.

After that water stages were plotted versus its recurrence interval on logarithmic scale and the smooth curve was fitted in the points. Lastly, water stages of different probability were extracted (i.e. 1%, 50%, and 90%).

3.14 Reliability and Validity of Data

3.14.1 Reliability

To ensure that the data collected was reliable the following were done: first, the pretesting of questionnaire to insure that the information provided by the respondent is reliable and relevant to the objectives of the study and, thus, ambiguities of questions were avoided. Secondly, respondents were assured of the confidentiality of the information they provided, this helped to build their confidence and make them open to give out important information for the study. In addition, local people were involved to build the confidence of the respondents. To make it simple for the respondents, questionnaires were translated into Kiswahili and when necessary elaborated using local language.

3.14.2 Validity

Validity refers to the degree to which a study is accurate to reflect the specific concepts which the research is attempting to measure. It is a measure of accuracy and whether the instrument is actually measuring what it was intended to measure. To ensure the validity of data the questionnaire were tested in order to check if the tools contained reliable contents. Also, clarity of print out, front size, at last respondents was informed by the researcher about the aim of the research and confidentiality of their response so as to win their confidence (Trochim 2002).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter brings to the surface the findings and the researcher's discussion about hydrological analysis of floods for long-term period, assessment of the effect of floods in study area and examines the management practices for the mitigation of effect. The chapter starts by presenting the demography and socio-economic characteristics of the respondents, followed by the hydrological analysis, assessment of the flood effect and its management in study area.

4.2 Demography and Socio-Economic Characteristics

Each studied village had different number of households (See Table 4.1). The proportion of population in villages is thus represented; Wami-Dakawa 23.0%, Mirama 32% Luhindo 26% and Wami-Sokoine 19% own high percent of respondents

Table 4.1: Number of Respondents in Studied Villages

Village	Household number n = 100	Percent (%) n =100
Wami-Dakawa	23	23.0
Sokoine	19	19.0
Luhindo	26	26.0
Mirama	32	32.0
Total	100	100.0

Source: Field Data Survey (2015).

Identification of the characteristics of the respondents was not part of the specific objectives of the study. However, it is necessary to present this data for the reader to understand the background of the respondent from which the data were drawn. Characteristics of the respondents provide a snapshot on the suitability of the respondents for the study (Kirtiraj, 2012).

4.2.1 Age of Respondents

Except for the Morogoro regional Officers, Mvomero district officers and ward technocrats, respondents who range between 25 and 59 years were interviewed. It is evident from Table 3 that the respondents who were provided questionnaires aged 18-25 (18%), 26-35 (29%), 36-45 (39%) and 45 and above (14%) (See table 4.2). This indicates that the majority of the respondents were matured enough to provide information about the floods in the study area.

Table 4.2: Age of Respondents

Age	Frequency n=100	Percent (%) n=100
18-25	18	18.0
26-35	29	29.0
36-45	39	39.0
45-above	14	14.0
Total	100	100.0

Source: Author (2016).

The age of the respondents has an important relationship with the security of household and floods experiences since age determines individual's knowledge on flood management. A close analysis shows that majority (68.0%) of the respondents in both villages aged between 26 and 45 years. This implies that the majority of the household heads in both villages are in their productive age group, which means that they can engage in production activities especially food production and they were aware of the floods effects (URT, 2015).

4.2.2 Sex of the Respondents

Analysis of the data collected shows that three were more males involved in the study than females. This difference could be associated with the fact that most households were male headed (See Table 4.3).

Table 4.3: Gender of Respondents

Gender of respondents	Frequency n=100	Percent (%) n=100
Male	64	64.0
Female	36	36.0
Total	100	100.0

Source: Author (2016).

Traditionally, males in African societies are decision makers on many issues including the use of natural resources (water resource and land resource etc.). This dominance of the male headed households in Tanzania influence decisions at the family level. This could also be a case associated with more involvement of the males in farming, fishing, livestock keeping and trading activities across Dakawa Ward (Meshack, 2006). However, Mwasiti, (2014) argued that, due to African traditions, women are denied to talk and present to strangers family matters in the presence of men. This was the reason why very few females could be accessed to participate in the study

4.2.3 Education Level of Respondents

Education is one of the most important characteristics that might affect a person's attitudes and the way of looking and understanding at any particular social phenomena. In this way, the responses of an individual are likely to be determined by his educational status and therefore, it becomes imperative to know the educational background of the respondents. Hence, the variable 'educational level' was investigated by the researcher and the data pertaining to the education of respondents is presented in Table 4.4.

Table 4.4: Education Level of Respondents

Education Level	Frequency n=100	Percent (%) n=100
University	3	3.0
College	4	4.0
Secondary	53	53.0
Primary	31	31.0
None	9	9.0
Total	100	100.0

Source: Author (2016).

The majority of the respondents (84.0%) have just secondary and primary education. 9.0% of the respondents did not attend school at all. Others (37.0%) have the university and college education respectively. The respondents attaining higher education were very few. A considerable number of respondents were just functionally literate and more than 40% of them were illiterate. It can be concluded from the Table 4.4 that respondents were progressive in education but they were still far away from the higher education which is so important today to create a knowledge based society (Malimbwi *et al.*, 2001).

4.2.4 Socio-Economic Activities of the Respondents

It was realized that the activities that respondents engaged included farming (38 %), livestock keeping (25%), trade (23%), others (13%) and about 1% fishing activity (See Table 4.5). In other words, the person’s response to a problem can be determined by the type of occupation they are engaged in and, hence, variable occupation was investigated by the researcher and data pertaining to occupation is presented in Table 4.5. A large number of the respondents were farmers and livestock keepers who were mostly affected by floods. This shows that a flood is one of the major problems to farmers and livestock keepers at Dakawa area.

Table 4.5: Socio-Economic Activities of the Respondents

Socio-economic activities	**Frequency n=100**	**Percent (%) n=100**
Farming	38	38.0
Livestock keeping	25	25.0
Trade	23	23.0
Fishing	1	1.0
Others	13	13.0
Total	100	100.0

Source: Author (2016).

A person's activities do have a bearing on his or her personality and so the ways of looking at the problem behind. The quality of life is also determined by an individual's occupation and the incomes derived from it. The occupation of an individual also socialized in a particular fashion which, in turn, reflects the pattern of behaviors and the level of understanding of the particular phenomenon (Kirtiraj, 201)

4.3 Hydrological Analysis of Floods for Long-term Period

4.3.1 Screening of Hydrological Data

Flood studies depend heavily on the hydrological data. These data should be stationary, consistent, and homogeneous when they are used for analyses of the frequency of hydrological system. To determine whether the data meet these criteria, the researcher needs a simple but efficient screening procedure (Dahmen & Hall, 1990).

The data screening procedure for Wami River consisted of three principal steps. These are:

i. Rough screening of the water stage. The data was checked about its uniformity; particularly it helps to identify relocation of gauge station if any.

ii. Identification of the hydrological year. This was done for correct identification studied hydrological phenomena.

iii. Water stage plotting and verification. Within each hydrological year, there were verified water stages for identification of errors and discontinuities.

Water stages for the period 1954-2014 were obtained from Wami/Ruvu Water Basin Office (WRWBO) and plotted for whole period of observation for checking of uniformity (Figure 4.1). Analysis of the plotted data shows that gauge station was relocated at the end of 1971 year. Hence, in a long term period of 1954-1988 and 2006-2014 there exist two sets of data which are not compatible and not uniform. The first period starts in 1954 and ends in 1971, the second period start after the relocation of gauge station starts in 1972 and ends in 2014. Due to that, those sets of data can’t be used together. For this particular study, the second period of data which started 1972 to 2014 was selected.

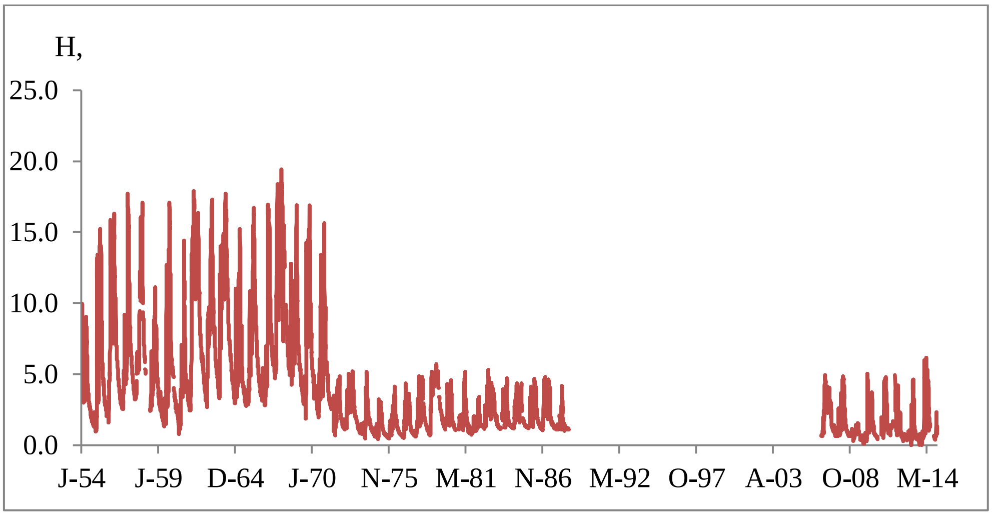

Figure 4.1: Long-term (1954-1988; 2006-2014) Distribution of Water Stages at Wami-Dakawa Gauge Station (1G1)

Source: Author (2016).

Identification of hydrological year was done with the use of rainfall data for weather station Ikombo-met for the period of 1977-2014. Sums of rainfall were calculated for long-term period for each month and plotted (Figure 4.2). Analysis of the long-term rainfall distribution shows that the months of June, July, August and September are dry. Very few precipitations could be observed in June and August, while July and September are completely dry. Due to that, for the beginning of the hydrological year was selected 01 September of the calendar year. In the beginning of September, due to long persistence of dry months (June, July and August), water stages in Wami River were supported only by the groundwater recharge into the river bed.

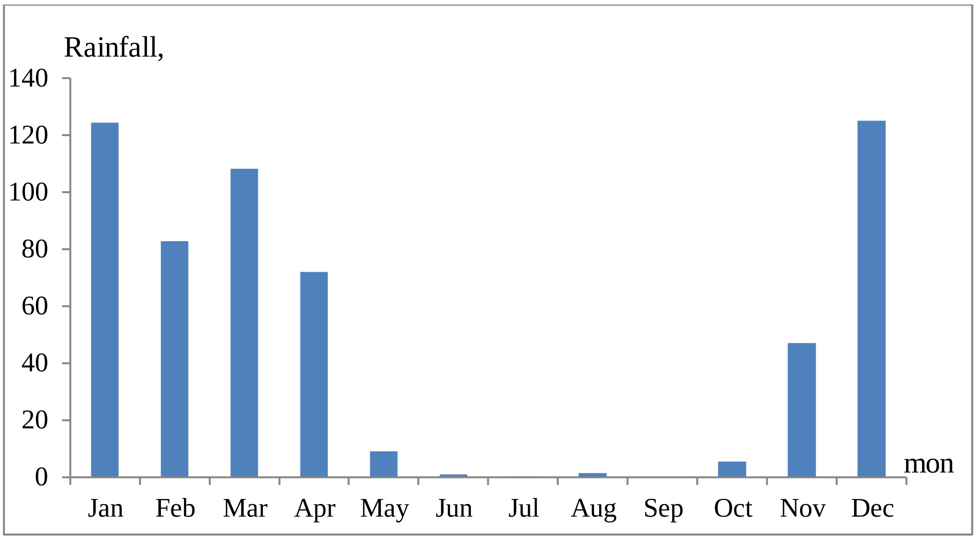

Figure 4.2: Long-term (1977-90, 2007-14) Rainfall Distribution at Ikombo-met Weather Station

Source: Author (2016).

This also noted by the WRWBO study (2013) which states that Wami-Dakawa station at Wami River are characterised by good groundwater aquifers which support river recharge during the dry season. If hydrological year starts on 01 September it ends 31 August of the following year. A hydrological year has two designations, for example the 1973-74 periods. That year starts on 01 September 1973 and ends on 31st August 1974. The hydrological years are not identical for different climatic zones. The United State Geological Survey (USGS), in its reports dealing with surface-water, defined the hydrological year as period between 01 October to 30 September designated by the calendar year in which it ends and which includes the 12 months (USGS, 2016).

The last step in data screening was verification of the water stages within a particular year. Within each hydrological year, there were plotted water stages and errors and discontinuities were identified. The used gauge station (1G1) detected errors in the calculation of the water stage each 31 day of the months December, January, March, May, July and August. Such an error was stable for a long-term period 1972-1988. For harmonization of data set all water stages for 31 day of the above mentioned months were recalculated as an average water stage between the neighboring days (For example, for 31st December were used of 1972 and 01st January of 1973).

4.3.2 Dakawa Floods

In the study of the Dakawa floods analysis was done for flood waves, its distribution and duration, as well for peaks of flow, their dates and water stages. In hydrologic terms, flood wave was defined as a rise in stream flow to a crest and its subsequent recession caused by precipitation, snowmelt, dam failure, or reservoir releases (McCracken, 2005). For the analysis of floods at 1G1 gauge station, the following parameters are needed: date of flood beginning (date), date of flood end (date), duration of flood (days), maximal water stage (Date and Hmax, m), lowest water stage before the beginning of floods (H_{dry}, m), increment of water stage from lowest water stage between dry season and maximal water stage (ΔH, m) and number of peaks within particular flood. The following criteria were used for the detection of the needed parameters:

i. At the beginning of the flood, the intensity of water stage raised one day on more than +5m.

ii. At the end of the floods, a stable intensity of water stage decreased in one day on more than -5m.

iii. The duration of floods was calculated as the difference in days between the beginning and end of the flood.

iv. The maximal water stage was selected as a day with the peak flow of a particular hydrological year. The date and water stage used.

v. Lowest water stage before beginning of flood (H_{dry}, m) was identified among low water stages in a dry season before the beginning of floods.

vi. Number of peaks detected individually for each flood.

From these criteria, floods analysed for 25 hydrological years (Appendix 3). Analysis of floods helps to identify its patterns. Particularly, floods could be grouped as floods with one wave, floods with two waves and sprawled floods (Figures 4.3-4.5). Figure 4.3 represent the floods with single wave for three hydrological years (1973-1974, 1980-1981 and 2012-2013). The study revealed that, there was single flood wave with high precipitations began on the mid of May and end in June. As well there was observed dry seasons in August - October and low precipitations in November to February. The highest peak with water stage above 5m was observed in May, 1974.

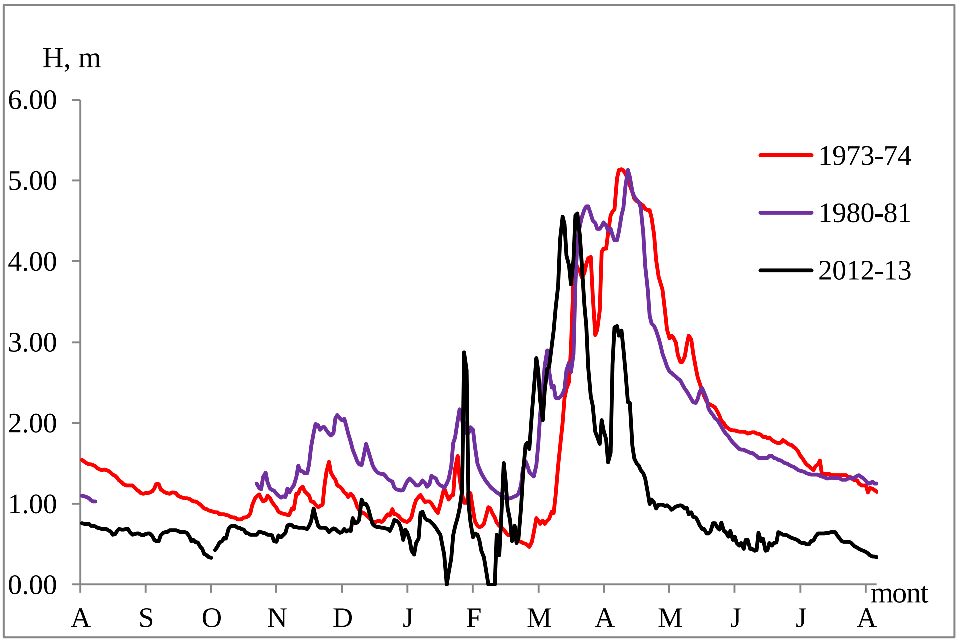

Figure 4.3: Floods with One Wave

Source: Author (2016).

The graph (Figure 4.4) represents two waves for hydrological years (1977-1978, 1985-1986 and 2009-2010) whereby the first waves start in November and reach recession in January while the second waves start in March and reaches its recession in June. High precipitations were recorded around December to February for the first wave and, second high precipitations were identified around March to January. Also, the maximum of the water stage was detected in January, April and May though there were slightly increase in water stage in February. Remarkably, the highest peak was observed in January in the hydrological year 2012-2013 which was 5.1 m. This means in the respective hydrological years, two explicit wet seasons were recorded.

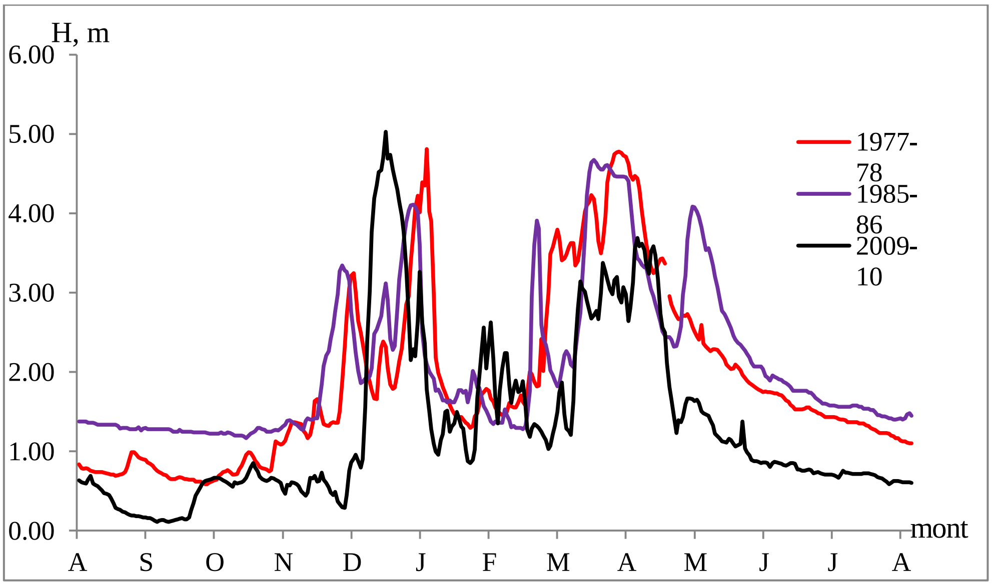

Figure 4.4: Floods with Two Waves

Source: Author (2016).

Figure 4.5 reveled that there were detected sprawled flood waves of the hydrological years (1972-1973, 1978-1979, and 2006-2007). This graph reveals that the precipitation rise starts on November and ends in June. These hydrological years, had almost an equal distribution of the precipitations in the months of November, December, January, February, March, April, May and June. However, the hydrological year 1978-1979 had highest precipitations compared to the rest of this wave. Also, the precipitations were identified in December, January and April. The highest floods peaks for this wave were on 23rd April in hydrological year 1978-1979 with water stage of 5.7m. This signifies that these were years with prolonged durations of rainfall and as rule the floods.

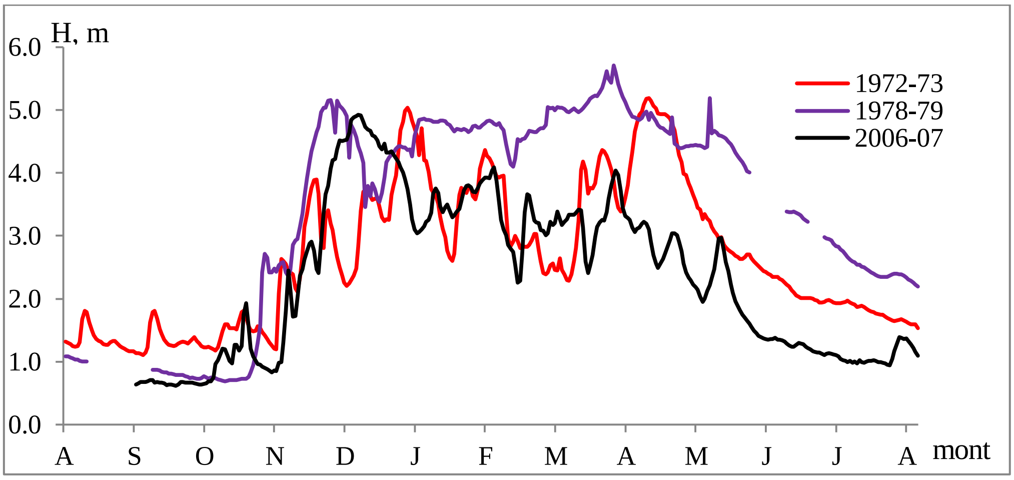

Figure 4.5: Sprawled Floods

Source: Author (2016).

Water stage data was used for 25 years (1971-2014), which was grouped in hydrological years and necessary data has been extracted (*Appendix 3*). After that, the researcher calculated average, minimal/earliest and maximal/latest water stages and dates. As well, for each researcher identified the dates and years with respective measures See table 4.6.

In Table 4.5, it has been shown that, on average, floods starts in 17th September (1979-1980, 2008-2009) and ends on 15th May (1987-1988, 2009-2010) for the recorded 25 hydrological years. The event on 17th Sept (1979-80, 2008-09) was with a total increment of 3.87m and 3 floods peaks. It is however indicted that, the earliest dates of the beginning of flood was 11th October and years with the earliest flood was 1982-1983 and the earliest dates of floods end was 1st February in the particular hydrological years. Likewise in 4th April to 21st June was recorded as the dates of the latest floods for hydrological years (1968-82, 2006-07).

Table 4.6: Parameters of Wami River floods at Dakawa for 1971-88, 2006-2014

Hydrological year	Date of flood beginning	Maximal water stage		Date of flood end	Duration of flood, days	Increment of water stage, m	Number of peaks
		Date	Hmax, m				
Average	17-Jan	29-Mar	4,60	15-May	122	3,87	3
Year of average	1979-80, 2008-09	1974-75, 2013-14	1983-84 1985-86	1987-88, 2009-10	1979-80 1982-83	1976-77	1979-80 1982-83
Minimal or earliest	11-Oct	1-Jan	1,53	1-Feb	46	1,26	1
Year of min or earliest	1982-83	2011-12	2008-09	2011-12	1981-82	2008-09	1973-74, 1975-76, 2012-13
Maximal or latest	4-Apr	31-May	6,17	21-Jun	203	6,17	6
Year of maximal or latest	1981-82	1971-72	2013-14	2006-07	2006-07	2013-14	1984-85

Source: Author (2016).

Generally, floods could have 3 peaks annually, but in some years, the number of peaks increased significantly and could reach 6 peaks, while in other years flood could have one explicit peak. In average, flood duration is 122 days. The amplitude of its variation is large. Shortest flood (46 days) has been detected in 1981-1982 hydrological year. Prolonged flood (203 days) has been detected in 2006-2007 hydrological year.

4.3.3 Flood Recurrence Intervals and Probabilities

From the data obtained in different sources about parameters of Wami River floods at Dakawa Gauge Station (1G1) for 25 years provided in (*Appendix 3),* Maximum water stages and its dates were identified, arranged in the Excel table from the largest to smallest and tabulated by equation (1) to get Flood Recurrent Interval (See Table 4.7). The recurrence interval is a statistical assessment of the average time that passes between floods of a certain magnitude. For example, *on average*, a 10-year flood will occur once every 10 years. In 100 years, there will likely be 10-year floods; therefore, there is a 10% chance of having a 10-year flood in any given year (Trent & Hazlett, 2005).

Table 4.7: Flood Recurrent Intervals for Maximum water stages for Wami River at Dakawa gauge station (1G1) in 25 years

Date	Maximum water stages, (m)	Rank, (M)	Recurrent Interval, (%)
16.03.2014	6,17	1	26.00
23.04.1979	5,71	2	13.00
05.01.1983	5,3	3	8.67
07.05.1973	5,18	4	6.50
06.05.1974	5,14	5	5.20
09.05.1981	5,13	6	4.33
13.01.2010	5,03	7	3.71
04.01.2007	4,92	8	3.25
01.01.2012	4,91	9	2.89
31.05.1972	4,84	10	2.60
11.04.2008	4,84	11	2.36
31.01.1978	4,81	12	2.17
27.04.2011	4,8	13	2.00
22.01.1987	4,74	14	1.86
06.05.1984	4,68	15	1.73
14.04.1986	4,67	16	1.63
16.04.2013	4,59	17	1.53
07.05.1980	4,58	18	1.44
15.05.1985	4,36	19	1.37
07.02.1977	4,33	20	1.30
03.04.1988	4,14	21	1.24
09.05.1976	4,12	22	1.18
09.05.1982	3,39	23	1.13
17.03.1975	3,2	24	1.08
07.05.2009	1,53	25	1.04

Source: Author (2016).

Calculations of flood recurrent interval have significant impotencies, such as knowing the flood recurrence interval which allows engineers to design bridges that can withstand the flooding expected over a specified time interval. Flood recurrence intervals also allow city planners to make a statistics-based prediction about where they should allow residential buildings and which areas are likely to be too flood-prone to locate a hospital. Moreover helps authorities to provide warnings and determine evacuations time for the ready buildup areas (Tate, 1960).

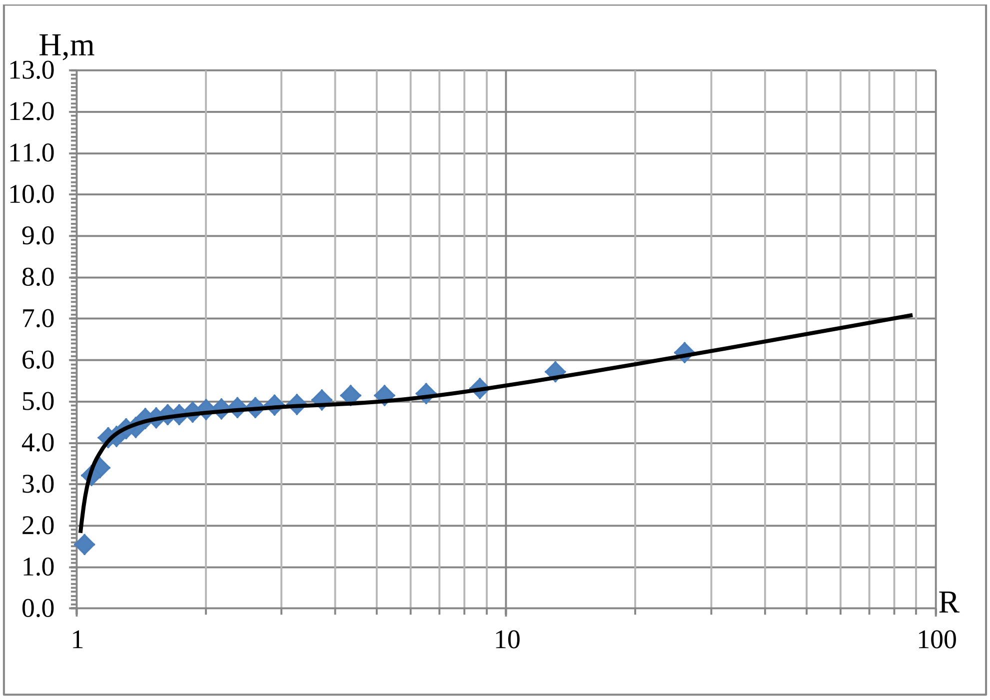

Figure 4.6: Flood Recurrent Interval of Maximal Water Stages at Wami River for 1G1 Gauge Station

Source: Author (2016).

Figure (4.6) shows a plotted graph of frequency maximum water stages in meters (H, m) against calculated recurrent interval (RI) for its respective dates in 25 hydrological years. Figure 4.6 was used to determine the expected water stages for different frequencies (i.e 1%, 50% and 90%). As shown by the graph, the means flood magnitude depends on water stages in the stream or river. Thus it must be noticed that this is not a prediction on when flood will occur but rather the probability of the flood of a given size. For instance, at 1% recurrent interval, it is expected the floods with highest water stage of about 7.5m will happen. This might happen once in 100 years. Also, at 50% recurrent interval it is expected that the flood with maximum 6.8m will happen and this might happen after every two years. Lastly, at the recurrent interval 90%, there are expected floods with maximum water stages of 5m.

4.4 Assessment of the Floods and its Effect in Dakawa Ward

4.4.1 Respondents' Perception on the Floods at the Study Area

4.4.1.1 The Affected Areas

Analysis of the data from the residents of Dakawa Ward shows that all villages were affected by floods. According to the respondent's responses the most affected area was Wami-Dakawa 50% and the next affected was Luhindo 28% which is located near Wami River in lowland areas. Also Sokoine 13% and Mirama 9% could be affected during floods of low frequency with the highest water stages (see Table 4.8). Mirama village which is located in the uplands close to Wami River in time to time could be inundated by high floodwaters. Sokoine Village which is located in lowlands and distant from Wami River could not be affected by inundated river.

Table 4.8: Villages Affected by the Floods

Village	Frequency n=100	Percent (%) n=100
Wami Dakawa	50	50,0
Sokoine	13	13,0
Luhindo	28	28,0
Mirama	9	9,0
Total:	100	100,0

Source: Author (2016).

With the sample size selected from total population of each village in Dakawa Ward, the researcher marked, among them the houses proximity to Wami River whose residents reported that the area over-flooded (See Figure 4.7). This was also enhanced by the researcher's observation and with the help of in GPS which was used to record the coordinates of the affected houses.

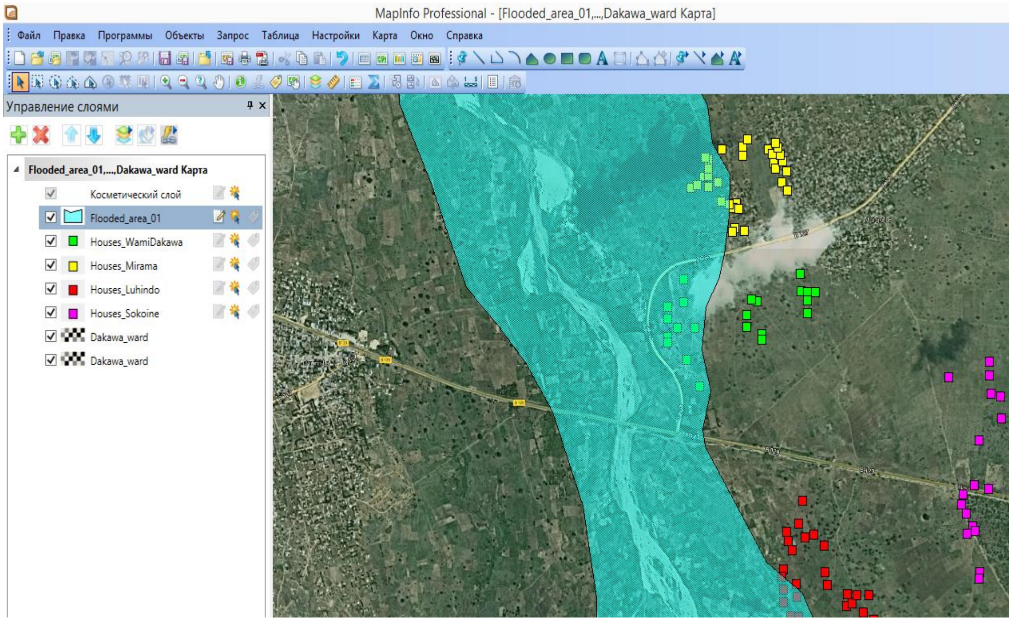

Figure 4.7: Flooded areas in Dakawa Ward in 2014

Source: Author (2016).

Furthermore, in January 2014 heavy rains caused flash floods in Dumila/Dakawa area in Morogoro Region. Many public buildings (schools, churches, mosques) along the Morogoro-Dodoma highway have been submerged. This led to the population displacements, extensive damages of infrastructure (roads, bridges, houses, schools, other public and religious buildings), fields for crops and, as well, some persons were reported dead (UNICEF & Red Cross, 2014).

4.4.1.2 Periodicity of Floods

It is evident that a majority of respondents (45 %) (See Table 4.9) had experienced flood occurrence once a year, whereas 24% of the respondents said that flood occurs twice a year. This brings a sense of the need of early warnings and preparedness at any time.

Table 4.9: Periodicity of Flooding

Periodicity	Frequency n=100	Percent (%) n=100
Once a year	45	45,0
Twice a year	24	24,0
Not every year	31	31,0
Total	100	100,0

Source: Author (2016).

However, climate change intensifies different disastrous phenomena, such as floods and droughts. Analysis of the historical data shows that, in Tanzania, since 2010 the periods with floods was receding in five times (EAC, 2002). The respondent's experience about the time of flood occurrence (See Table 4.10) shows that many floods events occur during night hours (36%), morning hours (25%) and evening time (22%).

Table 4.10: Floods Occurrence Time

Time for flood occurrence	Frequency n =100	Percent (%) n =100
Night hours	36	36.0
Morning hours	25	25.0
Afternoon hours	15	15.0
Evening hours	22	22.0
I Don't know	2	2.0
Total	100	100

Source: Author (2016).

The above observation came from the application of survey method to the selected resident who's stayed at Dakawa for many years. The Dakawa Ward Executive officer reported that:

> *In 2014 flooding started around 5.00am in the morning. Those floods were among the huge floods in the last 15 years and they were most destructive.*

During the night of January 2014, heavy rains caused flash floods in Dumila/Dakawa area in Morogoro Region which displaced over 10,000of people and destroyed or damaged houses, roads, bridge, public buildings and crops. The majority of the displaced people during the flood time lived in the open ground along the Morogoro-Dodoma road. Most of the affected villages have boreholes which were contaminated by flood muddy water (IFRC, 2014).

4.4.1.3 The Reasons of flood in Dakawa ward

The field data helped the researcher to detect several reasons of floods (See Table 4.11). The majority of the respondents (77%) said that the major reasons for the floods in Dakawa were the high rate of water inflow into river bed due to the heavy rains (49%), other factors were blocked culverts (15%) and lowland location of villages (13%). Whereas little contributing factors like disposal of wastes in river channels, sedimentations of river bed, clearing of vegetation cover, and wet/dry condition counts only about 22% for the remained percent. Dakawa cluster is one of the largest wetland systems in the sub-basin though part of it is informally inhabited by Maasai pastoralists and small scale farmers (URT, 2013). Moreover, TMA (2011) posited that vulnerability to climate variability is high in the informal settlements.

Table 4.11: Reasons of Floods in Dakawa Ward

Reasons for floods	Frequency n =100	Percent, % n =100
Dry/wet conditions before flood event	4	4.0
Clearing of vegetation in catchment area	5	5.0
Hard waste disposal in rivers	6	6.0
Accumulation of sediments within river bed	8	8.0
Lower plain	13	13.0
Blocked culverts under Dodoma-Morogoro bridge	15	15.0
High rate of water inflow into river bed due to the heavy rains	49	49.0
Total	**100**	**100.0**

Source: Author (2016).

Roads and railway embankments cut across the drainage lines may lead to an increased flooding effects and drainage congestion of the area (NDMA, 2008). Moreover, the Environment Agency (2009) argues that the factors that contribute to the increased floods include unplanned urbanization, soil erosion, inadequate sediment accumulation, subsidence and compaction of land, riverbed sedimentation and deforestation. Also, inadequate capacity of the rivers to contain within their banks the high flows brought down from the upper catchment areas (URT, 2013).

In addition, floods occur in river floodplains as a result of high intensity and prolonged rainfall events (URT, 2013). Other factors contributing to flooding are low soil storage and infiltration capacity, in the upstream catchments, reduced conveyance capacity of lower river sections due to the sedimentation and poor drainage in the flooded areas. This has been witnessed in Dakawa whereby Magole and Mkundi overflow Wami River during heavy rains. Furthermore, Yanda and

Munishi (2007) argue that the on-going clearing of forests for cultivation without terracing is widespread and the soil erosion has serious consequences for enhancement of sedimentation and hence reduces the depth of river channels that exacerbates flooding in Wami/Ruvu river basin.

4.4.2 Effect of Floods in Dakawa

4.4.2.1 Residents Perceptions on Water Quality

The research findings reveal that 67 % of the respondents' sources of water were over-flooded by floods of different size and only 33 % (See Table 4.12) were not affected by flood events due to their location. Together with the sources of water were over-flooded dump sides, latrines, and barnyards. Due to that, the water sources located in low-land areas were flooded and contaminated (See Plate 2), leaving majority around Dakawa Ward with no clean water.

Table 4.12: Floods Effect on Water Sources

Water Sources Affected	Frequency n =100	Percent n =100
Yes	67	67.0
No	33	33.0
Total	100	100.0

Source: Author (2016).

Floods may lead to contaminations of water with corrosive chemicals, heavy metal or other hazardous substances from storage or from chemicals already in the environment. Chemicals contaminations following floods in the USA included oil spills from refineries and storage tanks and pesticides. In particular, all of the surface water samples that were collected in 2006 were contaminated with the wastes from sources, such as domestic washing and sewage easily washed by flood waters (UNESCO, 2006).

Plate 4.1: ***Flooded Slaughter House***

Source: URT (2015).

However, in China, the most serious consequence of flooding was large-scale contamination of drinking water (surface water, groundwater, and distribution systems) which occurred in the year 2014. Drinking water was contaminated with microorganisms such as bacteria, sewage, heating oil, agricultural, industrial waste and chemicals. In such situations, water-borne illnesses that were usually associated with floods were inevitable (Murshed *et al.,* 2014).

Also, the effects of floods on water quality were supported by the respondents' response whereby majority (92%) were satisfied with water quality, evaluated it as be "good" and "average" which could be used for household needs (See Table 4.13). While after floods, 49% respondents claimed that the quality water becomes poor.

This means that floods events have affected water sources and reduced water quality at Dakawa Ward leaving residents with polluted water for domestic proposes. However, 33% of the responses that, the quality of water was good just even after the floods was perceived by the residents from the villages located far away from Wami River and in the high-land above Dakawa Plain which were not flooded, these areas include Mirama and Sokoine.

Table 4.13: Flood Effect on Perceived Water Quality

Response	Frequency n =100	Percent n =100
Quality of water before floods		
Good	67	67,0
Average	25	25,0
Poor	8	8,0
Total	100	100,0
Quality of water after floods		
Good	33	33,0
Average	18	18,0
Poor	49	49,0
Total	100	100,0

Source: Author (2016).

The increased effects on water quality have been experienced in New Orleans, Austria, the Czech Republic and Hungary. Recently the national report on the quality of water revealed that 45% of the assessed stream miles, 47% of the assessed lake acres, and 32% of the assessed bays square miles were classified as polluted by flood waters (APEC, 2015).

4.4.2.2 The Effect on Health

The respondents reported that flood affected all family members 33% in the ward, while 37% affected were children (See Table 4.14). Many children were injured during flood and others got diseases after the flood due to the contamination of their residential areas.

Table 4.14: Family Members Affected by Diseases or Injured

Group of family members	Frequency n =100	Percent (%) n =100
Children	37	27.0
Disabled	2	2.0
Elders	2	2.0
All	33	33.0
None	26	26.0
Total	100	100.0

Source: Author (2016).

The Government of Tanzania and UN's joint report on flood assessment in Morogoro Region after the flood of 2014 postulated that a total of 9,493 people have been affected of which 1,898 are children under the age of 5 years and 48% was women (UNFCCC, 2014).

Analysis of the post flood diseases shows that the majorities of the respondents (78%) were affected by Typhoid, Cholera and Diarrhea, whereas about 13% were affected by Worms and Hepatitis. Only 9% of all the respondents reported that they were not affected by diseases which were caused by floods (Table 4.15). Thus, it can be concluded that the rate of water-borne diseases was high during floods and post-floods times. This is due to the spreading of contamination from latrines, livestock farm and other sources over the large area.

Table 4.15: Diseases Caused by Floods at Dakawa

Diseases	Frequency n =100	Percent % n =100
Cholera	31	31.0
Diarrhea	29	29.0
Typhoid	18	18.0
Warms	12	12.0
Hepatitis	1	1.0
None	9	9.0
Total	100	100.0

Source: Author (2016).

In Argentina have been reported the increased cases of Cholera, Cryptosporidiosis, non-specific Diarrhea, Rotavirus, Typhoid and Paratyphoid in post-floods time. Several studies have implicated floods and water-borne disease out breaks because of the transportation of bacteria, parasites, and viruses into water systems. These studies showed a potential association between flood events and a range of water-borne infectious diseases in Italy also; including, Hepatitis A, and infectious Diarrhea (Lisa Brown & Virginia Murray, 2013).

4.4.2.3 Effect on Agriculture

Livestock

Likewise, torrent flood water impacted, severely, livestock keeping at the study area, many livestock died because was over-flooded. The field data shows that 41% of respondents lost chickens; more than 30% of respondents lost goats and more than 28% lost cows (See Table 4.16). It was detected that chickens were the most affected group of livestock because they are simply kept by many farmers and peasants and cost of its keeping is less compared to goats and cows. Agnote (2003) stipulated that chickens require only 21days for incubation with moderated temperature about of 30°C-20°C after maturedin18 weeks.

Table 4.16: Livestock Affected by Floods in Dakawa Ward

Number of livestock loss	Chickens n=100	Goats n=100	Cows n=100
1-5	10.0%	17.0%	8.0%
6-10	11.0%	9.0%	9.0%
Tens	18.0%	3.0%	10.0%
Hundreds	2.0%	1.0%	1.0%
Non	59.0%	70.0%	72.0%
Total	**100%**	**100%**	**100%**

Source: Author (2016).

Thus it can be concluded that, in the study area, few residents moved their livestock to upland areas to save them. Furthermore, after-flood, some livestock were affected by diseases due to the contamination of the area and particularly sources of water. Contamination of water resulted from floods which led to diseases, like Rinderpest (EAC, 2012). Rinderpest is a highly contagious and deadly viral disease with the potential to devastate cattle and other cloven hoofed animals. Flash floods and livestock diseases in Africa cause an annual loss of 1.1 million cattle and $168 million (ibid). Considering the living standard of people in the rural areas, floods events caused severe effect because rural residents are poor and don’t have other sources of income generation as they depend only on livestock keeping or crops cultivation.

Crops

Flood affects not only livestock; as well, it affects crops in the farms. The results show that 62% of the most cultivated crops (maize, rice and cassava), in Dakawa, were destroyed in farms (See Table 4.17). Also, fields with sweet potatoes, peas and vegetables (accumulate 48%) were washed away. As it was reported in paragraph 4.1.4, 38% of the respondents engaged in crop production, hence, it is only their source of income. As reported in FIU (2014), the increased uncertainty of the amount of precipitation leads to increased susceptibility of rain-fed agriculture to either early or late planting. Rainfall fluctuations after planting, generally, affect the growth, maturity, harvest, and post-harvest storage of crops (FIU, 2014).

Table 4.17: Crops Destructed During Flood

Types of crops	**Responses**	
	Frequency n =100	**Percent (%) n =100**
Sorghum	4	2.0%
Maize	52	26.0%
Cassava	31	15.5%
Rice	42	21.0%
Peas	23	11.5%
Vegetables	25	12.5%
Sweet potatoes	23	11.5%
Total	**200**	**100.0%**

Source: Author (2016).

Wami/Ruvu Basin Water Office Report (2010) dispute that the agricultural activities in the basin are rain fed crops and irrigation dependent. In Mvomero District, 30% of the farms employ irrigation using the perennial rivers. These include schemes such as Sugar plantations and smaller village rice schemes and maize farms that use traditional methods which could be flooded by floods of different frequency (WRBWO, 2014). An additional risk is added by the floods which can flood or wash away farmer plantations and leave them without income.

Similar effects were detected in many areas around the world, particularly in 2011 in Thailand more than 1.92 million hectares (4.74 million acres) of land including 1.35 million hectares (3.3 million acres) of rice fields were damaged due to the flood waters. This represented 12.5 percent of all cropland (AON, 2011). According to TMA (2015), in last ten years, floods were intensified due to climate change and the increase of rainfall intensity. As it was reported by the residents in study area floods now happen almost every year and sometimes twice a year. These affect the economic activities of residents particularly crop production and livestock keeping. Seasonally, residents lost their income.

4.4.2.4 Damage to the Infrastructure

Effect of floods in Dakawa ward has made the life for the residents miserable since 93% of the respondents reported that the floods caused roads to be flooded and impassable as well during floods with low frequency. The bridge which joins Dodoma Region and Morogoro Region could be collapsed; hence, it leads to the stacking of all transportation activities between regions (See Table 4.18). The railways also could be flooded by flood waters. Only 7% of the residents were not affected by floods as far as the infrastructure is the concern yet because this represents those residents in inner areas that do not depend much on transport networks for their general activities.

Table 4.18: Frequent Effects of Floods on Infrastructure

Floods Effects on Infrastructure	Frequency n =100	Percentage, % n =100
Bridge collapsed	37	37.0
Part of roads flooded and were impassable	53	53.0
Railways flooded	3	3.0
Neither of them	7	7.0
Total	100	100.0

Source: Author (2016).

Particularly, on the 21st January 2014, heavy rains caused flash floods in Dumila/Dakawa area in Morogoro Region. A day after, there was reported extensive damage to the infrastructure such as roads, bridges, houses, schools, other public and religious buildings (Red Cross, 2014). Similarly, in 2010 there was monsoon flood disaster in Pakistan. There was a massive and unprecedented flood. The damage to infrastructure was greatest in the mountainous area where many bridges collapsed rendering some areas completely inaccessible. Over the River Swat, all connecting bridges over a distance of 140 km were destroyed. The flood caused significant damage to phone lines, electric supply was interrupted in many large towns (UNICEF, 2010).

As well, in Dakawa Ward a majority of households had the power cut during and after floods (See Table 4.19). Furthermore, 61% of the sampled households indicated that there was power cut due to floods. The remaining 39% of the households indicated that there was no power cut because they were not connected to the power grid system.

Table 4.19: Power Cutoff During and After Floods

Power cutoff	Frequency n =100	Percentage, % n =100
Yes	61	61.0
No	39	39.0
Total	100	100.0

Source: Author (2016).

Till now, many residents in rural areas of Tanzania are not connected to the power supply system (UNICEF, 2010). Sudden fall of the electrical wires may raise other danger such as shots, fire outbreak at homes and in other areas. Also power cut delays economic productions in industries and factories at Dakawa Ward. Particularly, the Red Cross assessment (IFRC, 2014) found that the electrical poles were washed away due to the floods, and as a consequence, the power blackout in the area subsequently affected the water supply.

Additionally, it was detected from the analysis of the data that the residents' houses were destructed by floods. Some of the houses were completely destroyed, others had significant damage. More than half of the residents (62%) in Dakawa Ward reported that their houses were destroyed by floods (Table 4.20) whereas 38% of the respondents' houses were not affected by floods which occurred. Simple soil bricks and houses in saturated soil, especially during the long duration or recurrent flood, get rotten at the base; thus, they loosen the entire structure of the buildings and made them vulnerable to damage by torrent floods (ADPC, 2005). While some houses were not over-flooded because they were located far from Wami River were constructed by materials with cement which cannot be demolished easily.

Table 4.20: Houses Destructed by Floods

Response	Frequency n =100	Percentage, % n 100
Yes	62	62.0
No	38	38.0
Total	100	100.0

Source: Author (2016).

The official estimates indicated that 548 houses have been completely destroyed, more than 547 others suffered significant damage to walls, and 1,052 houses were surrounded by water in Mvomero District, but they were habitable (UNFCCC, 2014). The adverse effects of floods may include loss of life and property, mass migration of people and animals, environmental degradation, and shortages of food, energy, water and other basic needs (WMO, 2009). Moreover, the Red Cross Report in 2014 estimated that hundreds of houses in Dakawa ward have been brought down by the floods (See Plate 4.2). Many houses were washed away and many others were over flooded with mud.

Plate 4.2: **House Destroyed by Floods at Luhindo Village**

Source: URT (2014).

During floods and after floods officials reported that Dakawa Ward was mostly affected by property loss as well leaving many people homeless. This was due unexpected increase water levels (See Plate 4.1). The Red Cross reported that the most severe impact was in the District of Kilosa, Mvomero, and Gairo where a combined 4,086 homes, schools, businesses places and other structures were inundated by floodwaters (AON, 2014). Almost always, periodic floods lead to the displacement of the residents. So, within the last decades, Ghana, as well, has experienced periodic floods. Between 1995 and 2005, about GH¢300 billion worth of houses have been destroyed by floods, 100 lives have been lost either during the flood period or after the floods and 10,000 people have been displaced from their homes(Asumadu *et al.,* 2015).

4.4.2.5 Total Damage Estimation

Half of the residents (51%) reported the cost of damage between 60,000-millions of Tanzanian shillings (See Table 4.21). The cost includes loss of home appliances, livestock, crops, the cost of medication, treatment of water sources and clothes. Such size of damage was enormous considering that the residents of Dakawa are very poor and depend only on crops cultivation and livestock keeping which, as well, were affected by the floods.

Table 4.21: Damage Estimation

Costs, Tsh	Frequency n= 100	Percentage, % n= 100
1,000-10,000	2	2.0
10,000-50,000	14	14.0
60,000-100,000	25	25.0
100,000-Millions	46	26.0
None	13	13.0
Total	100	100.0

Source: Author (2016).

According to the reports published by the World Meteorological Organization (WMO), it is estimated that the total property damage due to floods in the world is more than 30 billion US dollars with over 8 million square kilometers of the total area affected by floods during the first eight months in 2002. The area affected by flood in the world is almost the size of the United States of America. During the August 2002, worst ever recorded floods disasters occurred in Central Europe affecting mainly Germany, Czech Republic and Austria. Similarly, the flood events, India, Nepal, and Bangladesh have affected the region severely (Anders *et al*., 2015: Gautam & Hoek, 2003).

4.5 Management Practices for Flood Effect Mitigation

4.5.1 Resident's Awareness about Floods Warnings

The finding from the key informants revealed that more than half (65.5%) of the respondents were getting flood warning through village meetings. Only 25% received warnings through radios while 12.5% responded that they were not aware of which source they could get flood forecast information (See Table 4.22). Thus, because of the lack of proper channels to disseminate information about the time which flood is expected and the magnitude of floods, the residents of Dakawa were seriously affected by floods because they were not prepared enough.

Table 4.22: Sources of Information about Flood Events

Sources of Floods Warnings	Percentage % n =100
I don't know	12.5
Radios	25.0
Meetings	62.5
Total	100.0

Source: Author (2016).

Interpretation of the predictions and other flood information to determine flood impacts on communities are of crucial important. Unfortunately, for a variety of reasons, deaths do roccur despite the improvements in providing flood forecasts and warnings. Normally, the information about floods is sent to residents through formal communication, newspapers, radios and television programme. This should go in parallel with educating the public on the importance of making follow up on various kinds of disaster information (URT, 2013).

The results obtained from the study indicated that 84% of respondents were not aware of the responsible institutions to provide flood warning in advance and only 16% reported that they were aware of the responsible institution to give them information about floods in advance (Table 4. 23). Also, 87% of respondents were not informed in advance about the flood occurrence time while (13 %) were reported that they were given information about floods in advance. Therefore, it can be concluded that, due to ineffective delivering of early warnings about floods done by responsible institutions, many residents were affected by floods.

Table 4.23: Flood Information Delivery System

Awareness	Responses n =100	Percentage (%) n =100
Respondents aware of responsible institution for flood information delivery	Yes	16.0
	No	84.0
Total		100.0
Information received in advance regarding flood events	Yes	13.0
	No	87.0
Total		100.0

Source: Author (2016).

It is evident from Table 4.24 that there was big number of respondents who were unable to get floods information. Hence, they were not able to evacuate their livestock and properties. Also, it was revealed that the information given through meetings and local radios by Local leaders (Village executive officers and Ward executive officers) contains data about current state of El-Nino event, as well as long time rainfall predictions for Tanzania. Unfortunately, this data contained very general information and it is non informative because it did not contain data about which areas, specifically in Dakawa Ward could expect floods, when and for how long, as reported by one of the village executive officer:

> *We normally call village assemblies to discuss some issues pertaining welfare and among that the security of our people. As you can see, most villagers are peasants. The matter of when it is going to rain and for how long it is of very crucial importance to us. So we need to find the most relevant information from Institutions responsible and inform our residents. This information sometimes informs about the effects of rain and can't measure the magnitude which could cause damage to our properties.*

Due to that, the residents of Dakawa Ward lack prior information about the occurrence of flood and also they don't have proper channels to disseminate the information quickly. While, technical and scientific knowledge on flood management is highly needed to reduce the severity of flood and to limit the impacts on the most vulnerable people and countries (Kettner, 2013). Key informants were interviewed about their knowledge of flood events and its management. The by Mirama Village Executive Officer reported the following:

> *It is obvious that people need the knowledge of flood management in our village and I think the whole country lacks enough knowledge about floods. Many residents continue to lose their lives through death, and permanent injuries or disabilities. It's has reached a moment that the government and other organizations must put more effort and emphasize on training of local communities in rural areas which are most vulnerable*

4.5.2 Flood Management Activities

The study finding from the key informants revealed that 50.0% of respondents were not involved in the fight against flood event because they were out of Dakawa and others were not given prior information about the occurring of the flood (Table 4.24). Nevertheless, (50%) of respondents were involved in the fight against flood though they had little knowledge about flood management practices. Residents in Dakawa just used common mechanisms to fight floods. These mechanisms included remove of sands and wastes from culverts and river bed by hand hoes and by filling sand bags beside riverbanks.

Table 4.24: Respondent's Experiences about the Control of flood

Experience	Percentage (%) n= 100
Those who were involved to fight against flood event (don't have knowledge about flood fight actions)	50.0
Not involved to fight against flood event (because they haven't information about flood forecasting)	37.5
Not involved to fight against flood event (because they stay far from affected ward)	12.5
Total:	100.0

Source: Author (2016).

The world experiences about flood management should help to get prepared, mitigate and have recovery strategies. In this way, the strategies should involve both physical structural adjustments that also consider local techniques as well as social adjustments that include the locally appropriate and up-to-date early warning systems and social protections (WMO, 2009)

Additionally, during the interview, one of the Village Executive officer remarks about flood fight experiences in Dakawa ward was quoted:

> *For that we know we are lacking expertise especially about flood management and also technical tools are not present. We only depend on effort and support from Prime minister's office or from Military marine force and, unfortunately, they appear after floods.*

Moreover, Tanzania should learn from other countries, like Nigeria and South Africa where community capacity building programme involves brochures; tips, workshops, and flood risk education, including notification to informal communities within flood prone areas which have been in place recently. As far as collation and information reporting, the City broadcasts weather warnings as well as regular flood incident reports.

The research finding shows that, 50% of respondents lack information about hydrological prediction, 37.5% of respondent's response was lack of flood fights knowledge (See Table 4.25). This implies that residents of Dakawa did not know how to rescue themselves from floods because there were no knowledgeable persons to initiate the management practices. Not only that but also 12.5% responded that there was lack of cooperation between governmental officers and residents during and after floods. That means that majority of residents in Dakawa ward don't have even common technical abilities to fight against flood.

Table 24: Challenges Associated with Flood Management

Challenges	**Responses**	
	Frequency n = 8	**Percent (%) n= 100**
Lack of hydrological prediction	4	50.0
Lack of flood fights knowledge	3	37.5
Lack of cooperation during and after flood	1	12.5
Total	**8**	**100.0**

Source: Author (2016).

The majority of respondents determined hydrological prediction as a major challenge which is associated with flood management. Data about hydrological prediction are not present due to that resident in Wami-Dakawa do not know in advance which are the dates when floods are expected to beginning, maximum water level and duration of flood. Hence due to that prior information system about the dates when floods beginning is not functioning effectively. Local residents in Dakawa Ward have no prior informants about the flood, due to that, residents and their settlements are not prepared which can lead to huge damage. The study further identified that most of the key informants have long time experiences of flood events in Dakawa and they are well informed about flood effects.

Also, there is the lack of cooperation between the Tanzania Meteorological Agency, Ministry of Water and Irrigation and the Vice president's office (division of environment). The analysis is made about flood awareness of the residents and revealed that the government and responsible institutions have not made any preparation in advance. An advance preparations require the establishment of early prior information, protection of settlement like the construction of levees, culverts and filing of sand bags alongside river banks, also, the establishment of refugee settlements for evacuation in case floods appeared. To reduce challenges of floods, Tanzania Emergency Preparedness and Response plan of 2002 suggested that, currently, there is lack of evacuation plan that provides a set of procedures to be followed during floods. It was also noted that there is a need to have emergency evacuation plan for specific hazards. The evacuation plans should clearly indicate pre-defined evacuation routes, evacuation sites, issues of transportation, especially, how vulnerable groups such as elderly, children, people with special needs, and prisoners can be evacuated during an emergency (URT, 2012).

The floods can be among the most challenging issues since this threaten the destruction of key infrastructure such as roads, railways and bridges as well as settlement in Dakawa. Hence the government and other organizations must make prior preparation of refugee settlement for the displaced people incase their homes are destructed by floods. These settlements should be located far from flood prone areas. Based on the flooding map, spatial planning can be conducted to delineate the areas suitable for the establishment of refugee settlements, flood evacuation and other human activities.

In the process of minimizing the challenges associated with floods, the Integrated Flood Management, like the Integrated Water Resources Management, should be established to encourage the participation of all flood prone areas, planners and policymakers at all levels. The approach should be open, transparent, and inclusive and communicative. It should require the decentralization of decision-making and should include public consultation and the involvement of stakeholders in planning and implementation (Hamidreza & Masoud, 2015).

4.5.3 The Support after Flood

Field data reveal that 32.0% of the respondents did not get any support from any governmental organization (See Table 4.26). Only 23% responded that they received food, water, medical treatment and placed in the prepared centers. While others could only get one of the few support from the government, as 35% received food and clean water, also 9.0% were given with short time shelter in governmental buildings like Dakawa Primary school and Dakawa Teachers Training College and 1.0% of the citizens who were injured were medically treated. This means that most of governmental and non-governmental organization supports were based on short time actions like provision of water and food.

Table 4.26: Actions Taken to Rescue Victims after Flood

Actions	Frequency n =100	Percent % n =100
Provision of food and water	35	35.0
Evacuation to refugee	9.0	9.0
Medical treatment	1	1.0
All above	23.0	23.0
None of above	32.0	32.0
Total	100.0	100.0

Source: Author (2016).

Without doubt, it is true that heavy rains and floods have caused destruction of the transport infrastructure (road, bridges, railway lines etc.) and affected the transportation activities in many regions of Tanzania, including Morogoro. The relevant authorities are encouraged to take appropriate actions such as strategic mitigation plans and allocate budgets for strengthening infrastructures strengthening in areas with high risk of floods to minimize any negative impacts (URT, 2015).

4.5.4 Effectiveness of Support

The results from the analysis of the data show those, 32% of government's and other organizations were not effective in flood prevention of problems (Table 4.27). While 46% of the respondents responded that, moderate support was given. And remaining (22%) responded that, government and other organization were effective enough to support the residents during and after the flood. This means that flood prone areas in Dakawa Ward are experiencing unwillingness of the government to support the residents on time and in a sufficient manner. Thus, there is a need for the government and non-government organizations to prepare, in advance, some strategies for supporting the residents during and after floods.

Table 4.27: Effectiveness of Support

Effectiveness	Frequency n =100	Percentage, % n =100
Very Effective	9	9,0
Effective	13	13,0
Moderate	46	46,0
Poorly	29	29,0
Very poor	3	3,0
Total	100	100,0

Source: Author (2016).

In African countries, flood reduction policies and institutional mechanisms do exist at various degrees of completeness. However, their effectiveness is limited in flood fighting; hence, there is the need for a strategic approach to improving and enhancing their effectiveness and efficiency by emphasizing floods reduction (AU, 2004; WMO, 2009).

European countries and other developed countries such as the United States of America, China has direct government involvement in flood effects reductions. This ranges from clear informed flood policies, construction of structural and non-structural infrastructures (WMO, 2005).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The main aim of this chapter is to present the conclusion of the key findings of the research and provide readers and societies a systematic and comprehensive assessment of the effects of floods and flood management procedures. This study was guided by three objectives which were to perform hydrological analysis of floods for long-term period, assess the effect of floods in the study area and examine the flood management practices and their effectiveness in mitigating flood. Data were collected from several sources which included different categories of respondents from the level of Region, District, Ward and streets through questionnaires, interviews, observation and documentary review. Simple random and purposive samplings were used as sampling strategies.

5.2 Summary of the Study

This study assessed the effects of flood and management practices in Mvomero District, specifically in Dakawa Ward. The study was guided by three specific objectives which were to perform a hydrological analysis of floods for long-term period, to assess the effect of floods in the study area and examine the floods management practices and their effectiveness in managing floods. The study focused on hydrological data analysis and perceptions of the local community members who were affected by the floods. This study took place in four villages of Dakawa Wards (Wami-Sokoine, Mkindo, Mirama and Wami-Dakawa) which were found in Movomero district. The study was based on survey of the 100 respondents. Also, the study involved 8 key informants that included: 1 ward executive officer, 4 village chair persons, 1 irrigation officer, 1 agricultural extension officer, 1 land officer.

5.3 Summary of the Findings

The findings of the study were obtained from 108 residents, which included 8 key informants and 100 residents sampled from four villages. Among the 100 residents, the majority (84%) of the respondents had primary and secondary school education level; most of them (68%) were of the age between 26 to 45 years. Moreover, among the respondents, 87% of the informants did not participate fully in flood management because of lack preparedness influenced by lack of flood information.

Specifically, the summary of the findings of the assessment of floods in Mvomero District and Dakawa Ward, in particular, are presented on the basis of their respective specific objectives below.

5.3.1 Hydrological Analysis of Floods for Long-term Period

For hydrological analysis, this study used the data obtained from Wami/Ruvu Water Basin Office (WRWBO) for long-term period 1954-1988 and 1972-2014. For clarity and consistency of results, hydrological analysis depends on long-term data which are compatible. The water stage screening shows that data were not compatible, for particular study second period data 1972-2014 were selected. For long-term rainfall distribution in Dakawa Ward, data obtained from Ikombo met recorded rainfall patterns. Analysis of rainfall distributions shows that, month June, July, August and September are dry for the study area while, April, May and June are recorded to have higher precipitations. Thus floods are more frequent in April, May and June.

Additionally, on a base of formulated criteria, were calculated long-term dates of the flood beginning, peak flow, flood end, flood duration and its water stages. Data for 25 hydrological years helps to identify the flood patterns in Dakawa Ward. Lastly, grouped and presented floods with waves as presented by graphs floods with one wave, floods with two waves and sprawled floods. Also water stages for different frequencies was identified such that water stage for 1%, 50% and 90% were 7.5m, 6.8m and 5m respectively. Generally, floods could have 3 peaks annually, but in some years number of peaks increased significantly and could reach 6 peak while in other years flood could have one explicit peak. In average flood duration is 122 days. The amplitude of its variation is large. Shortest flood (46 days) has been detected in 1981-1982 hydrological year. Prolonged flood (203 days) has been detected in 2006-2007 hydrological year.

5.3.2 Effect of Floods in Study Area

The findings of the study show that the causes of flood were; were the high rate of water inflow into the river bed due to the heavy rains, blocked culverts and lowland location of villages; as well, little contributing factors like disposal of wastes in river channels, sedimentations of river bed, clearing of vegetation cover and wet/dry condition of the river catchment. The majority of respondents agreed that water sources were over-flooded. Thus, the quality of water becomes poor. This means that floods events have affected water sources and reduced the quality of water at Dakawa Ward leaving the majority with no clean water. Due to the flow of contaminated flood water, the residents were affected by water-borne disease such as Diarrhea, Typhoid and Cholera and the majority of the affected people were children. Likewise, torrent flood water impacted severely livestock keeping at the study area. For example, it was reported that many livestock were washed away, injured and died. Also, the residents reported that their crops fields were washed away by floods. The crops affected were maize, rice and cassava. Additionally, the research revealed that, flood affected the infrastructure at Dakawa Ward. This was confirmed by the responses obtained from the respondents that houses were demolished, and the electrical poles collapsed leading to power cut, and transportation was affected. Further, it was reported that roads were over-flooded and remained impassable.

5.3.3 Management Practices for Flood effect Mitigation

The study revealed that there is lack of the effective flood policy which is central in mitigating the effects of flood. The flood mitigation procedures like early warnings and flood information delivery was not considered in reducing the effects of flood in the study area. The challenges experienced in Dakawa Ward due to flood management includes lack of knowledge to forecast the flood and the magnitude, the lack of modern and tradition flood fight techniques among residents of Dakawa as well lack of good cooperation among the residents and the responsible organizations during and after the floods. Particularly, the residents in the affected areas were not evacuated to refugee; some of them get only food, clean water and medical treatment. Despite the support given, the majority (78%) of the residents considered it less effective because it did not reach affected people on time and the support was not sufficient. All these led to different problems to the residents in Dakawa Ward.

5.4 Conclusion

Based on the research findings, flood problem is revealed to be a disaster in Dakawa Ward. Unlike, other disasters, floods bring many problems to people because they occur naturally. Hydrological analysis of floods for long-term period was done and the results show that floods could have 3 peaks annually but, in some years, number of peaks could reach 6 peaks, while in other years flood could have one explicit peak. Also, the results revealed that, months of June, July, August and September are dry for the study area while, April, May and June are recorded as wet season. Also, water stages of different frequencies were identified such that, water stage for 1%, 50% and 90% were 7.5m, 6.8m and 5m respectively. Flood with low frequency can lead to a great damage and if residents are not prepared to mitigate the flood they could be severely affected. In Dakawa Ward specifically, many residents' faced problems due to floods, such as the loss of livestock, loss of crops, displacements, destructed houses, destructed infrastructures, power cut, water-borne diseases and deaths. Contaminated flood waters flow into people's homes, public buildings and water sources are affected leading to the outbreak of water-borne diseases such as Diarrhea, Typhoid and Cholera. Majority of affected population are children.

Furthermore, the study revealed that there is lack of effective flood policy which is central for mitigation of the effects of floods, lack of proper channel for delivery of prior information about floods. Also, the study revealed that there is lack of modern and traditional flood fighting techniques among residents of Dakawa; as well, there is the lack of good cooperation among the residents and the responsible organizations during and after floods. Also, during the time of floods and after floods, the shelters were not provided to the victims. Despite the support given, the majority residents (78%) considered it to be less effective because it did not reach the affected people on time and it was not sufficient. Additionally, the study revealed flood management practices in the study area should involve different stages starting from mitigation, preparedness, and have recovery.

5.5 Recommendations

During the face to face interviews with the key informants, and through the findings from the questionnaire provided and documentary review, the participants identified specific actions that would be useful in controlling the floods. The recommendations are that flood management practices should involve different stages starting from mitigation, preparedness, and recovery. In this way, the strategies should involve both physical structural adjustments that also consider local techniques as well as social adjustments which are locally appropriate.

The government and other organizations responsible to flood management activities need to establish proper channel for sharing the information about flood. These must include early warnings and preparedness, as well as the formulation and implementation of flood management policy. There must be one database center where hydrological data, weather data and flood prediction will be done and disseminated accordingly.

As well, it is important for the communities to be prepared and develop proper mechanism for addressing the impacts of floods. There must be continuous education to the communities adjacent to flood-prone area about flood risk management programmes, enhance building capacity in construction of leaves, filling of sand bags and others to be initiated and implemented in Dakawa Ward.

Furthermore, different studies revealed that Tanzania should learn from other countries like Nigeria and South Africa where community capacity building programme involves brochures tips, workshops and flood risk education.

5.6 Area for Future Research

The research has covered a small part of flood assessment and its management practices by the use of maps and hydrological data available. Thus, the results may be of general to reflect on the maters regarding maps and hydrological characteristics of floods effects only at Dakawa Ward. Thus, the hydrological, meteorological data and past and recent maps can also be used to assess and predict the floods in all parts of the Tanzania and ensure safety to all citizens. The study of floods at Dakawa Ward was laid down the way for future searchers on how to perform hydrological analysis of floods for other affected settlement. Also, it is recommended to be focused on the study about flooded areas for floods of different frequency, estimation of the damages and the impacts of building material on the ability to resist abrasive effects of the flood waters.

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APPENDICES

Appendix 1: Questionnaires for Households

INTRODUCTION

Date of interview………………………. Questionnaire No…………………

Ward …………………

PART A: PERSONAL PARTICULARS

1. Sex of respondent (1) Male (2) Female
2. Age in years

(a) 10-18 (b) 18-25 (c) 25-30 (d) 30-45 (e) 45-60 and above

3. Education level

(a) University education (b) College education

(c) Secondary (d) Primary (e) None

4. What is your Economic activities (a) Farming (b) Livestock keeping

(b) Fishing or (d) Trade (e) others…………….

5. How many members in your family?

(a) Active adults ……………. (b)Children……………. (c)Old age persons………….

(d)Persons with disables ………………………

PART B: WHAT AREAS ARE AFFECTED BY FLOODS IN DAKAWA?

6 Do you know very well villages of Dakawa ward?

(a) YES (b) NO

7 Which village was mostly affected by flood in Dakawa?

………………………………………………………………………………………

8 How often this area affected by floods?

(a) Every year (b) twice a year (c) not every year (d) others……………

9 Please suggest reasons why flood affect this area more than other areas

(i)………………………………..

(ii)……………………………….

(iii)……………………………….

10 Have you experienced high water stage (flood) into river at this ward?

(a) Yes (b) NO

11 Which areas could be flooded by floods of different size?

12 Which month(s) of the year the area is mostly affected by floods?

……………………………………………………………….

13 Please, mention the date of the latest most destructive flood?

……………………………………………………………….

14 At which day time that flood has been started?

(a) Morning (b) afternoon (c) evening (d) night

15 Did you family affected by such flood?

(a) Yes (b) NO

17 If YES, Please specify how (tick any):

(a)	Some family member died	
(b)	Some family member was losted	
(c)	Some family member get diseases	
(d)	Livestock died	
(e)	Livestock was affected (by disease)	
(f)	Property loss	
(g)	Crop plantations was washed away	
(h)	Water sources was flooded and lost its quality	
(i)	Power lines was damaged	

18How many family members affected by flood?

19 Which water borne diseases affected your family?

(a) Diarrhea (i) rarely (ii) Often (iii) very frequently (iv) Not at all ( )

(b) Typhoid (i) rarely (ii) Often (iii) very frequently (iv) Not at all ( )

(c) Worms (i) rarely (ii) Often (iii) very frequently (iv) Not at all ( )

(d) Cholera (i) rarely (ii) Often (iii) very frequently (iv) Not at all ( )

(e) Hepatitis (i) rarely (ii) Often (iii) very frequently (iv) Not at all ( )

(f) Amoebic Dysentery (a) rarely (b) Often (c) very frequently (d) Not at all ( )

(g) Other diseases…………………………………………………………….

20. Please, specify in numbers what type of livestock did you have before flood?

Cows	Goat	Chicken

21 How livestock was affected?

(a) Died, (b) Get sickness (c) Injured (d) Washed away by flood and lost [ ]

22. How many livestock lost or get injured during flood?

Cows	Goat	Chicken	Duck

23. How many properties inside lost or destructed?

Type of property	Amount (Tsh)	Type of property	Amount (Tsh)

24. Please express the total loss in monetary terms...

25.Howwerecrops plantations affected?

(a) Over flooded, but some crops remain

b) Over flooded, all crops lost

c) Fertile soils was washed away

d) Not affected

26 Please can you tell size or the costs expected to be obtained selling your crops?

………..……………………………………………………………………………..

27. Please, specify the size of your plantation………………………………(ha, meters^2)

28. Which type of in your farm crops mostly affected?

(a)	Sorghum	
(b)	Maize	
(c)	Wheat	
(d)	Rice	
(e)	Ordinary beans	
(f)	Groundnuts	
(g)	Banana	
(h)	Irish Potato	

(i)	Sweet Potato	
(j)	Cassava	
(k)	Fruits	
(l)	Vegetables	

29. There is any road or railway destructed at your Area?

Road		Railway	
(a) YES	(b) NO	(c) YES	(d) NO

30. If YES how (tick any):

(a) Bridge collapsed (b) A part of road washed or eroded by flood [ ]

(c) A part of railway washed or eroded by flood (c) Over flooded and impassable

31.Was there problems of power cut resulting from floods? (a) Yes (b) No

32. If yes for how long? Please specify…………………………………………………..

33. What water sources are used in your area for drinking purposes?

(a) Tap water (b) Streams (c) River (d) Springs (e) Wells [ ]

(f) Boreholes (h) Water from ponds (g) Rain water harvesting

34. Which source of water is mainly used for domestic purposes in your area?

35. Why do you think it is the main source of water compared to others?

(a) It is near to residential area (b) Water flows throughout the year

(c) It offers clean and high quantity water (d) other reason [ ]

36. Who owns those sources of water in your village?

(a) Government (b) Individuals

(c) Community (d) Non-governmental organizations (NGOs)

(e) Others (specify)……………………………………………………………….

37. Does that water source was damaged during flood?

(a) YES (b) NO

38. If YES, please mention how:

(a) Was over flooded(b) Pipes was washed away

(c)Other………………………………………………………

39. Please, evaluate the water quality in your area before flood?

(a) Good (no taste, no smell and no color)

(b) Satisfied (has a light taste, has a smell and has light color)

(c) Unsatisfied (has a taste, has a smell and has a dark color)

40. Please, evaluate the water quality in your area after flood?

(a) Good (no taste, no smell and no color)

(b) Satisfied (has a light taste, has a smell and has light color)

(c) Unsatisfied (has a taste, has a smell and has a dark color)

41. Did you try to improve water quality in that water sources after flood?

(a)Yes (b) No

42. If YES, please mention the methods you used:

(a) Chlorination (by MORUWASA)

(b) Chlorination (by others ……………………….. specify)

43. What kind of Latrines do you use?

Please explain……………………………………………………………………………

44 May you please estimate amount of money invested on your farm

…………………………………………………………………………………….

45 Other properties that was lost due to flood? Please identify them ……………………………………………………………………….................................

...

PART E: What is the performance level of actions done by governmental organizations against the occurring floods events?

46 Do you know who are responsible in giving assistance in case you get experience of flood problems? (a) Yes (b) No [ ]

47 Are you always informed of the time and magnitude effects of heavy rain that will happen near or few days to come? (a) Yes (b) No [ ]

48 Is your Village/ ward authority takes immediate action once you get floods in your area? (a) Yes (d) NO [ ]

49 What kind of action taken by Government to support residents in areas affected by flood? (a) Food for affected families (b) Clean water (c) Shelter

(d) Transportation (e) All mentioned (f) other …………… [ ]

50 Those actions take how long? (a) Just few days (b) Long time period [ ]

51 How the actions effectiveness?

(a) Very effective (b) effective (c) moderate

(d) Less effective (d) not effective? [ ]

52 Are there other organizations that provide help during flood seasons?

(a) Yes (d) No [ ]

53If YES how many do you know?

54 If why? Please explain

………………………………………………………………………………………………

55 Have you ever invited or attended any meeting to discuss any outcomes of floods incidents at your ward and ways to eradicate or reduce those problems?

56 Have you in your meeting ever discussed the long time strategies for this problem? (a) Yes (b) No. If "Yes" for how long(a) 5-10 Years (b) 10-20 years [ ]

Appendix 2: Interview Guide for Key Informants

INTRODUCTION

Date of interview………………………. Interview No…………………

Name of interviewer……………………………. Ward …………………

PART A: PERSONAL PARTICULARS

1. Name of the respondents……………………………………………………
2. Occupation Position of the respondent…………………………………………………….
3. Sex of respondent 1). Male 2). Female
4. Age in years (c) 25-30 (d) 30-45 (e) 45 and above
5. What kind and level of education have you attained? [ ]

(a) University education (b) College education (c) Training Institution

PART B: what areas are affected by floods in Dakawa ward?

7 By your working experiences which area is mostly affected by flood here at Dakawa? ....

8 What are the reasons for flood? Describe the reasons please.

………………………………………………………………………………………

9 What is the population status of the area you have mentioned?

………………………………………………………………………………………

10 Which group of people mostly affected by flood incidents?

(a) Male (b)Female (c) children (d) aged people (e) adults

11 Why that specific group you have mentioned?

………………………………………………………………………………………………

12 What are old and modern ways used to disseminate the information?

………………………………………………………………………………………………

13 What are the responsibilities of your office regarding flood fights?

………………………………………………………………………………………………

14 Do you provide estimates of water discharge for Wami River?

………………………………………………………………………………………………

15 How often the estimates need to be updated?

………………………………………………………………………………………………

16 Please describe mechanisms that you use to update discharge information?

………………………………………………………………………………………………

17 How do you inform and households dwelling near the flood prone areas?

………………………………………………………………………………………………

18 Do you have a long time strategies to deal with the problems of floods in this area?

………………………………………………………………………………………………

19 If "Yes" what form of strategy and how long will it serve?

………………………………………………………………………………………………

20 What are the holding challenges of the scheme you have mentioned?

21 Who are the best beneficiaries of the phenomenon prediction?

…………………………………………………………………………………………

22 Do you use GIS for estimation of houses and other infrastructures in the proximity to flood prone areas?

…………………………………………………………………………………………

23 What is the hydrological characteristic of the area that is normally encounter water discharge?

…………………………………………………………………………………………

24 What is the duration interval for water discharge at Wami River stream?

…………………………………………………………………………………………

25 Which are the institutions and organizations involved in floods predictions?

…………………………………………………………………………………………

26 Are those bodies involved effective in dealing with challenges raised by floods?

(a) YES (b) NO [ ]

27 If is 'Yes" how effective are they?

(a) Very effective (b) Effective

(c) Moderate (d) Not effective [ ]

28 If "No" please Identify reasons for not being Effective

(a) Lack of flood management implements like Computers Technology, GPS and GIS

(b) Outdated technology for flood predictions estimates and control?

(c) Lack of skilled personnel to make best use of available technology?

(d) Peoples not aware of the best ways to defend themselves from flood impediments?

(e) Other………………………………………………………………………………

29 What are the best actions taken during time for frequent floods occurrence?

……………………………………………………………………………………………

30 What scale of the area and people affected by floods of different volumes of discharge? …………………………………………………………………………

31 Please mention ways that you can use to predict, inform people, and minimize the flood effect in Dakawa

(a)………………………….(b)………………………………..

(c)………………………….. (d)…………………………….. [ ]

Appendix 3: Parameters of Wami River floods at Dakawa Gauge Station (1G1) for Period 1971-88, 2006-2014 (25 years)

Hydrological year	H_{dry}, m	Date of flood beginning	Maximal water stage		Date of flood end	Duration of flood, days	Increment of water stage, m	Number of peaks	2nd peak		3rd peak		4th peak	
			Date	Hmax, m					Date	H, m	Date	H, m	Date	H, m
1971-72	0,67	31.01.1972	31.05.1972	4,84	16.06.1972	137	4,17	3	22.04.1972	4,59	21.05.1972	4,53		
1972-73	1,2	30.11.1972	07.05.1973	5,18	07.06.1973	189	3,98	2	18.04.1973	4,36				
1973-74	0,46	25.03.1974	06.05.1974	5,14	14.06.1974	81	4,68	1						
1974-75	0,43	07.03.1975	17.03.1975	3,2	07.06.1975	92	2,77	5	03.04.1975	2,55	16.04.1975	2,77	28.04.1975	3,04
1975-76	0,46	08.02.1976	09.05.1976	4,12	03.06.1976	116	3,66	1						
1976-77	0,53	31.12.1976	07.02.1977	4,33	21.02.1977	52	3,8	4	26.02.1977	3,08	08.05.1977	3,61	29.05.1977	3,04
1977-78	0,59	24.12.1977	31.01.1978	4,81	12.02.1978	50	4,22	2	30.12.1978	3,25				
1978-79	0,69	19.11.1978	23.04.1979	5,71	01.05.1979	163	5,02	3	23.12.1978	5,16	03.06.1979	5,19		
1979-80	1,1	28.01.1980	07.05.1980	4,58	28.05.1980	121	3,48	4	05.02.1980	4,29	11.03.1980	3,09	19.04.1980	4,14
1980-81	1,07	21.03.1981	09.05.1981	5,13	28.05.1981	68	4,06	2	20.04.1981	4,68				
1981-82	1,01	05.04.1982	09.05.1982	3,39	21.05.1982	46	2,38	2	11.04.1982	3,21				
1982-83	1,15	11.10.1982	05.01.1983	5,3	12.02.1983	124	4,15	2	04.12.1982	4,18				
1983-84	1,12	30.11.1983	06.05.1984	4,68	31.05.1984	183	3,56	4	17.04.1984	4,14	24.01.1984	3,95		
1984-85	1,17	11.11.1984	15.05.1985	4,36	31.05.1985	201	3,19	6	14.01.1985	4,34	06.04.1985	4,07		
1985-86	1,28	15.12.1985	14.04.1986	4,67	15.06.1986	182	3,39	5	25.11.1986	4,11	27.05.1986	4,08	20.03.1986	3,91
1986-87	1,06	11.12.1986	22.01.1987	4,74	10.06.1987	181	3,68	4	20.04.1987	4,61	27.12.1986	4,56	27.05.1987	4,08
1987-88	1,1	18.03.1988	03.04.1988	4,14	09.05.1988	52	3,04	2	20.04.1988	3,14				
2006-07	0,62	01.12.2006	04.01.2007	4,92	22.06.2007	203	4,3	3	24.04.2007	4,04	03.03.2007	4,09		
2007-08	0,62	25.03.2008	11.04.2008	4,84	14.06.2008	81	4,22	3	19.02.2008	3,66	23.12.2007	2,57		

2008-09	0,27	24.01.2009	07.05.2009	1,53	06.06.2009	133	1,26	3	13.04.2009	1,44	15.03.2009	1,41		
2009-10	0,29	27.12.2009	13.01.2010	5,03	20.05.2010	144	4,74	3	03.05.2010	3,69	28.02.2010	2,62		
2010-11	0,42	07.03.2011	27.04.2011	4,8	10.06.2011	95	4,38	2	02.04.2011	4,56				
2011-12	1,16		01.01.2012	4,91	01.02.2012		3,75	3	09.03.2012	4,19	21.01.2012	4,05		
2012-13	0	15.02.2013	16.04.2013	4,59	22.05.2013	96	4,59	1	09.04.2013	4,55	03.05.2013	3,19	23.02.2013	2,87
2013-14	0	20.01.2014	16.03.2014	6,17	16.06.2014	147	6,17	5	23.01.2014	5,97	15.04.2014	5,31	25.02.2014	4,85