ASSESSING EFFECTS OF INFORMAL URBAN SETTLEMENTS ON THE FREQUENCY OF FLOODS OF LINGADZI RIVER IN LILONGWE, MALAWI

MASTER OF SCIENCE DEGREE IN WATER RESOURCES MANAGEMENT AND DEVELOPMENT THESIS

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MZUZU UNIVERSITY

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ASSESSING EFFECTS OF INFORMAL URBAN SETTLEMENTS ON THE FREQUENCY OF FLOODS OF LINGADZI RIVER IN LILONGWE, MALAWI

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A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES OF MZUZU UNIVERSITY IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN WATER RESOURCES MANAGEMENT AND DEVELOPMENT

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DECLARATION

I hereby declare that this thesis titled ''*Assessing effects of informal urban settlements on the frequency of floods of Lingadzi River in Lilongwe, Malawi''*, has been written by me and presents a record of my research work. All citations, references and borrowed ideas have been duly acknowledged. This thesis is being submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Water Resources Management and Development at Mzuzu University. None of the present work has been submitted previously for any degree or examination at any other University.

Name of Student: SUSAN KUMWENDA

Signature Date………………………...

CERTIFICATE OF COMPLETION

The undersigned, certify that this thesis is a result of the author's own work and that to the best of our knowledge, it has not been submitted for any academic qualification within Mzuzu University or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered herein was demonstrated by the candidate through an oral examination held on **01 December 2023**

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DEDICATION

Dedicated to my Father who motivated and invested in my education and to my Mother who sacrificed her career to take care of myself and my sister.

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ABSTRACT

Urban low-income households in informal settlements located in floodplains are highly susceptible to natural disasters. Regardless there is lack of information on how the growth of the settlements affects flood frequency in urban areas of Malawi. This study was carried out to assess the effect of informal urban settlements on flood frequency along the Lingadzi River where the river passes through urban informal settlements of Mtandire on the right bank and Area 49 Shire on the left bank. A quantitative research design was applied, the Settlements of Mtandire and Area 49 were purposely selected while households living around the river were randomly selected from a sample size of 222. Data was collected through, household surveys, interviews, and the United States Geological Survey website (USGS). Results show that housing in the settlements is mostly characterized by single-story and standalone housing with simple architectural designs covering small areas, constructed from low quality iron sheets, and wall material. Results have also shown the presence of settlements in the delineated 10, 50, and 100-year flood inundation maps of Lingadzi River covering Mtandire, Area 49, Mtsiliza and Area 47. Further, results indicate that community perception incline towards flood occurrence changing in the area with annual flood occurrence since 2016/17 rain season. The study concludes that construction of low-quality housing in flood-prone zones, close to the river banks has an impact on increased level of vulnerability to natural disasters such as flooding in the settlements. Recommendations are made for serious investment in sensitization campaign and enforcement of existing laws and regulations from all stakeholders and authorities involved.

Keywords: *Informal settlements, Flood occurrence frequency, Floodplain, Flood mapping, Mtandire, Area 49 Shire.*

ABBREVIATION AND ACRONYMS

CDC	Community Development Committees
CEPM	Country Environmental Profile for Malawi
DCCMS	Department of Climate Change and Meteorological Services
DEM	Digital Terrain Models
DoDMA	Department of Disaster Management Affairs
DWR	Department of Water Resources
EC	European Commission
ECH	European Commission Humanitarian
EEA	European Environmental Agency
EPA	Extension Planning Area
FC	Fuhrman Center
FEMA	Federal Agency Management
FIRM	Flood Insurance Rate Maps
FRC	Flooding Related Consequences
FRI	Flow Regulation Infrastructure
GDP	Gross Domestic Product
GIS	Geographic Information System

GNI	Gross National Income
GPS	Geographic Positioning System
HECRAS	Hydrologic Engineering Center River Analysis System
ITCZ	Intertropical Convergence Zone
IWA	International Water Association
LCA	Lilongwe City Assembly
MG	Malawi Government
MFREP	Malawi Floods Emergency Recovery Project
NO	National Geographic
NFI	National Flood Insurance
NSO	National Statistics Office
NUP	National Urban Policy
NWP	National Water Policy
NWRA	National Water Resources Authority
NWRMP	National Water Resources Master plan
RASMAPPER	River Analysis System Mapper
SWCP	Soil and Water Conservation Plan
SFHA	Special Flood Hazard Areas

SPSS	Statistical Package for Social Sciences
SRTM	Shuttle Radar Topography Mission
UN DESA	United Nations Department of Economic and Social Affairs
UN HABITAT	United Nations Human Settlement Program
USG	United States Government
USGS	United States Geological Survey
WB	World Bank
WRA	Water Resources Areas
WRA	Water Resources Act
WUA	Water Users Association

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CHAPTER 1. INTRODUCTION

1.1 Background

Informal settlements are an important supplement to the inadequate formal housing supply in cities (Zhang et al.,2020). They are however characterized by lack of security of tenure, basic services, city infrastructure, and compliance with planning and building regulations often situated in geographically and environmentally hazardous areas (Malawi Government, 2019c). Residents often have limited access to adequate housing, and basic services such as transportation, education, and healthcare (John, 2020). In many of the world's major cities demand for land accompanied with Poor enforcement of urban plans meant to guide the utilization and development of land in the cities has equated to the growth of informal settlements in non-designated, high-risk areas including floodplains, forest reserves and river banks (Phiri, 2019; John, 2020). This has resulted in the weakening of urban resilience to climate change, disaster risks, and shocks such as flooding (Malawi Government, 2015b). Some of the key urban hazard risks are associated with floods, especially for people settled in floodplains (Eldho et al., 2018).

Flooding in urban floodplains has become a priority for disaster risk prevention agencies, urban planners, and communities residing in the flood zones (Doong et al., 2016). Floods are an essential part of the natural process in any river system. Floodplains are flat lands located next to a river or water body, prone to flooding in the event of over bank spill (Ndabula et al., 2012). Floodplains play a vital role in increasing the ability of rivers to contain floods by absorbing flood and pollutant peaks in the process minimizing the risk of flooding (Kiedrzyn´ska et al., 2014). Floodplains are meant to be managed and delineated based on the volume of water from a 100-year flood that they can handle (Jie and Burrows, 2021). In periods of high-water discharge in the river, they are likely to be covered with water.

Floodplains' ability to retain water, allows them to buffer the effects of heavy rainfall in the process protecting surrounding communities from flood damage (United States Government, 2022). Floodplains are however very attractive for infrastructure development and agricultural activities due to their planar morphology and water availability which has left many former natural floodplains vulnerable to increased pressure from urban sprawl (Mazzoleni et al., 2021). The European Environmental Agency (EEA) report of 2016 found that in 'Europe, up to 90% of floodplains have been lost during the past centuries or are no longer able to serve as functioning natural ecosystems providing flood risk reduction and habitats favoring a high biodiversity'. The phenomenon has translated to the growth of flood risk zones as settlements and infrastructures are taking the space that rivers required to temporarily store flows during periods of high flows and floods (Bernhard et al.,2020).

The fight against these disasters and floodplain encroachment has been made easier in recent years through the development of important tools such as flood inundation mapping and community participation, allowing authorities and residents to properly identify floodplains and characterize their settlements (Antony et al., 2021). It is therefore imperative that flooding impact preventive measures depend on the identification of the flood-prone areas and their settlement dynamics (Galligari et al., 2020). Estimation of flood extent and flood hazards is vital for the development of flood evacuation and disaster management plans (Eldho et al., 2018). The availability of flood inundation maps, delineating flood-prone regions is essential for safe, organized and effective flood risk management and early warning systems in flood-prone regions (Saleem et al., 2021). The inflow of low-complex, easy-to-access flood mapping tools in recent years has been crucial in delineating flood-prone regions in vulnerable areas of the world (Afshari et al., 2018).

Remote Sensing has been essential in post-flood mapping in Nsanje District, Malawi in enhancing flood risk management through the development of flood inundation maps of recorded flooding events (Gondwe and Shukla, 2021). Hydrological Modeling employing, the HYDROSHEDS dataset, DEM, Remote Sensing and Geographic Information System (GIS) was crucial for the mapping of flood-prone areas along Lingadzi River downstream in Salima district, concentrating on known flood-prone regions of the river, located in rural regions (European Commission Humanitarian, 2012).

Information on flood occurrence and Flood mapping in informal urban settlements together with non-traditionally known flood-prone zones in the majority of Malawian rivers remains a challenge (Malawi Government, 2015b). The information gap makes identifying existing floodplains challenging, especially in informal urban area where unplanned developments are taking place whilst locals are subjected to regular flooding which never makes the headlines, relying mostly on local knowledge to determine response to flooding (Mokkenstorm et al., 2021). Currently, related studies have focused on rural areas, major flood-prone rivers/ zones and responses to particular flooding events (Gondwe and Shukla, 2021). The River under this study passes through central Malawi including informal urban areas of the capital city, Lilongwe. The rapid increase in rural-to-urban migration for economic gains has been attributed to the growth of informal settlements some of which are located along Lingadzi River floodplains and have been crippled by frequent flooding in recent years (World Bank, 2016).

1.2 Problem statement

Informal settlements characterized by poor housing and infrastructure often located in the most unsafe locations, such as floodplains are particularly susceptible to flooding disasters (Chen et al., 2017).

The settlements building structures distinguished by poor quality construction materials remain the cause of their vulnerable to effects of flooding (Anwana and Owojori, 2023). Settlements in floodplains result in a reduction in the size of the floodplains leading to their failure to function properly in the process making redundant their ability to deliver environmental services such as flood control to the surrounding communities (Kiedrzyn´ska et al., 2014). The floodplain is no longer able to perform regulating, cultural and provisional services such as flood protection, water purification, nutrient collection, fertile soil formation, recreation, tourism, and a secure water supply (EEA, 2016). Due to floodplain informal settlement along the Lingadzi River, the surrounding communities are at risk of flood damage, water pollution, and river ecosystem damage (Rahadiati et al., 2021; Floodlist, 2015). Flooding is mostly localized and seldom makes it to headlines (Laisi, 2016). Currently, there is limited data on informal settlements characteristics, flood inundation maps to demarcate floodplains and flood occurrence frequency along Lingadzi River in Lilongwe. Studies have been carried out in other parts of the world to determine floodplain settlements in informal settlements and flooding independently, (Forkuo et al.,2014; Fosu et al., 2012). Henceforth this study was set to assess the impact of informal urban settlements in Lingadzi River floodplain on flood occurrence frequency using settlements characteristics, hydrological modelling and local knowledge.

1.3 Study objectives

The main objective of the study was to assess the effect informal urban floodplain settlements may have on flood frequency along Lingadzi River.

Specifically, the study aimed to achieve the following objectives:

a) To assess the characteristic of informal settlements in the floodplain of Lingadzi River in Lilongwe city.

b) To delineate the floodplain of Lingadzi river in Lilongwe city through the development of 10, 50, and 100 years flood inundation maps.

c) To evaluate flood occurrence frequency changes in the urban floodplain of Lingadzi River in Lilongwe city between 1990 and 2020.

1.4 Research questions

a) What is the characteristic of settlements present in the floodplain of Lingadzi River around the study area?

b) What is the estimated 10, 50, and 100-year floodplain of Lingadzi River around the study areas?

c) Are there changes in flood occurrence frequency in the urban floodplain of Lingadzi River around the study area between 1990 and 2020?

1.5 Significance of the study

This study will assist Lilongwe City Assembly (LCA) in identifying characteristics of settlements present in the urban floodplains of Lingadzi River in the process aid in flood risk and response management in the area. Department of Disasters Management Affairs (DoDMA), LCA, and National Water Resources Authority (NWRA) will be assisted in identifying flood-prone zones along urban areas of Lingadzi River paving the way for better management of floodplain settlements which in return has the potential to minimize loss of property, lives, and the ecosystem. Socially the results will guide residents of Area 49 Shire, Mtandire and the surrounding communities to understand the nature of the area they are living in and come up with strategies on how to deal with the risk.

It will also encourage mindset change when constructing housing in floodplains, which must be done under professional guidance and in line with Water Resources Regulations and acts. Academically the findings will open doors in filling the gaps for researchers in Malawi on informal urban settlements, flood inundation mapping and flood occurrence, at the same time identify areas of potential further study.

1.6 Ethical consideration

Research ethical approval was sought from Mzuzu University Research Ethics Committee (MZUNIREC). Approval and permit to conduct research were granted under protocol reference number MZUNIREC/DOR/22/102. Consent for interviews was sought from participants with signed consent forms. Personal data was anonymized.

1.7 Research Limitations

The following limitations were encountered while undertaking the study:

1) Some of the respondents did have enough history of the dwelling house and area.
2) It was difficult to find participants who had lived in the area for more than 35 years to interview who would have accurate knowledge on flood occurrence in the area.

CHAPTER 2. LITERATURE REVIEW

This chapter will focus on reviewing the literature on settlement characteristics, floodplain inundation map techniques, informal settlements, urban flooding and community perception of flood risk.

2.1 Floodplain Development and guidelines

Floodplain is the part of a river most prone to flooding in the event of over bank spill emanating from high-intensity rainstorm surface runoff or deliberate discharge from a reservoir (Ndabula et al., 2012). Floodplain development requires great coordination between the community and planners. Different countries have approached floodplain development differently. The United States of America has developed a well-organized plan on floodplain settlement which has ensured floodplain protection. For instance, the 2021 article 'Floodplain Management for the Local Government Leader Critical changes to the national flood insurance program are on the horizon', by Claire Jubb illustrates how the United States has addressed the issue of community participation in floodplain management by shifting focus from building water control structures to encouraging the construction of more resilient buildings in less hazardous locations while incentivizing communities by providing a National Flood Insurance Program (NFIP) for properties developed in floodplains.

The NFIP allows participating communities to collaborate with Federal Agency Management (FEMA), and areas designated on Flood Insurance Rate Maps (FIRMs) are defined. Provision of flood insurance to those living in such locations is facilitated. The community agrees to enforce regulations to minimize risk to any development in the designated areas.

The purchase of mandatory insurance with a federally backed mortgage is required in areas mapped by FEMA as high risk known as Special Flood Hazard Areas (SFHA). The methodology for assessing premium for the program is based on flood zone, time of construction relative to the designation of the flood zone, type of construction (basement, elevated, etc.), and height above the flood zone elevation where the structure is built. The intervention has had its challenges with communities complaining of high insurance premiums in some cases. The strategy has however allowed authorities to manage floodplain settlement in the process reducing disasters associated with the risk.

The city of Cape Town in South Africa has developed floodplains management strategies through the Floodplain and River Corridor Management Policy, (2009). The policy was aimed at protecting floodplains and river corridors while ensuring balanced consideration of potential flood risk, environmental impacts and socio-economic needs. It emphasizes the need for planned and well-designed developments in line with stipulated conditions. The policy defines a floodplain as an area susceptible to inundation by a 100-year flood. Management and coordination of the areas are governed by fair and stringent evaluation and control guidelines. Permitted development, land use and activities carried out in the areas must conform to the guidelines stipulations below:

A) The Obstruction of free-flow water within the 20-year flood line area is not permitted.
B) Developments or activities between the 50 and 100-year flood lines may be permitted, under conditions dimmed acceptable by the city.
C) High-risk developments with particular evacuation or emergency response will only be permitted above the 100-year flood line.

D) Proposed development or redevelopment within the floodplain can only be approved if supported by report from a registered professional engineer to ensure the structure can withstand the forces and effects of floodwaters.

E) The service of a qualified registered engineering professional is required in areas where floodplain demarcation has not been carried out to decide on the floodplain. This is to be conducted before any detailed planning and must be by accepted practice.

The strategies adopted by the city are simple and easy to implement, which can easily be incorporated by cities in Malawi for effective floodplain management and development.

2.1.1 Floodplains Development in Malawi

Malawi lacks coherent strategies and guidelines on floodplain management and development, however, the Water Resources Regulations 2018 and Water Resources Act 2013 outlines some directions on how best water resources can be managed. Part X of the Regulations lays down rule on how floodplains in Malawi can be managed. The Regulations defines a 100-year flood as a 'flood that on average occurs once in every one hundred years' and riparian land as 'land that occurs along watercourses or water bodies such as flood plains or river banks'; the following strategies have been put in place by the regulations in Part X to direct floodplains management and development in Malawi:

A) Cultivation and development activities within the 100-year flood level are prohibited or as may be determined by the Authority.

B) The Authority may, for good reason, demarcate the riparian boundary of any water course or body on any land from time to time, on either side of the river.

C) The authority may be requested by a riparian land owner to demarcate the riparian boundary on his land, at the cost of the Authority.

D) The Authority shall require the land owner to place permanent recognizable beacons in demarcating the riparian boundary at his cost at sufficient intervals to adequately represent the line of the riparian boundary.

E) Any person who undertakes any of the proscribed activities on riparian land without approval by the Authority commits an offence.

F) The Authority may, by an order, instruct a riparian land owner or user, at his cost, to develop and implement a Soil and Water Conservation Plan (SWCP) containing the details specified in the Seventeenth Schedule.

G) The Authority may, by order, instruct a riparian land owner or user, to desist from any proscribed activity or to improve the condition of the riparian land in the interests of meeting the water quality objectives.

H) The authority may facilitate support to a riparian land owner or user to improve the condition of the riparian land, upon request.

Even though the regulations have laid down rules to govern floodplains, it does not give an in-depth analysis on enforcement and implementation strategy. It also fails to outline the type of settlements acceptable in the areas. There is however need for heavy investments in learning and engagement with other institutions in the region on how implemented has been done.

The Water Resources Act enacted in 2013 paved the way for the 'provision for the management, conservation, use, and control of water resources; for the acquisition and regulation of rights to use water; and for matters connected therewith or incidental thereto'.

The act mandated to manage water resources in the country paved the way for the establishment of the National Water Resources Authority (NWRA) (Malawi Government, 2013). The authority has the following powers and functionality a) to develop principles, guidelines, and procedures for the allocation of water resources; (b) to monitor, and from time to time reassess, the National Water Policy (NWP) and the National Water Resources Master Plan (NWRMP) (c) to receive and determine applications for permits for water use; (d) to monitor and enforce conditions attached to permits for water use; (e) to regulate and protect water resources quality from adverse impacts; and finally (f) to manage and protect water catchments.

Under the act's preliminary provisions, it declares watercourses protected areas. The provision declares that beds, banks of watercourses, lakes, and adjacent land strips are to be public land giving the Authority powers to determine and regulate the management thereof. Cultivation and carrying out any activity within the bed and banks of watercourses and lakes and their adjacent land strips can only be determined by the Authority. The provisions give guidance on the use of land adjacent to the watercourse and the channels to be followed when undertaking activities around these areas. The Act however lacks clear guidance on floodplain management and development as well as the provision of clear floodplain boundaries or inundation areas.

2.2 Flood occurrence frequency

2.2.1 Flood occurrence history in Malawi

Malawi's susceptibility to flooding is influenced by its geographic position and terrain, the country's location exposes it to both tropical and subtropical weather systems, contributing to seasonal rainfall patterns and flood risk (World bank, 2011).

Flooding in the country occurs seasonally, primarily during the wet season, spanning from November to April. Heavy rainfall which occurs during this period often leads to riverine and flash floods (Mokkenstorm et al., 2021). Most flooding events in Malawi are localized and hardly make the news headlines but still have devastating effects on communities making it difficult to quantify flooding history (Liasi, 2016). A review of the NWRMP, (2014) chapter 3 on Water Resources gives an insight into flooding history in some of Malawi's major water bodies. The review reveals that ten major floods were experienced across the country between 1985 to 2010. They primarily affected the southern region with high-frequency floods observed in Songwe River in the northern part of the country. Several districts in the northern and southern regions were affected especially along the lakeshore areas.

The NWRMP indicates frequent flood occurrences in the Shire, Songwe, North Rukuru Rivers, and Lake Malawi. Flooding in the Shire River has been recorded annually, and devastating floods in the River were recorded in 1989, 1997, 2005, and 2012. The 2012 floods had a confirmed depth of 1 meter, the largest since 1993. The strength of flood water breached the levee located at Osiyana Village. The devastating 1997 flood resulted in an overflow of water into the Elephant Marsh located on the southern bank of the Shire River, washing away the railway embankment and the S151 road at Chiromo. A new river channel flowing parallel to the original Shire River now known as the New Shire River was created.

Further, the NWRMP established that Songwe River located in Northern Malawi records flooding events on an annual basis lasting a few days in the rainy season. The River experiences flash flooding from tributary convergence in its lower reaches. Regular flooding has been recorded in North Rukuru River, Flooding occurs from runoff due to heavy rainfall.

Historical records indicate 104 millimeters of rainfall was recorded during the April 2011 floods. Most notable flooding events recorded in the northern region, include the 2011 and 2009 Songwe River floods. The NWRNP discloses that the central region recorded flooding along the Lifidzi River on March 17, 2011, due to heavy rains causing the river to overflow. 136 households (of which 96 were female-headed) were evacuated to Naliomba Primary School in Salima District.

In recent history the 2015 nationwide floods were one of the most devastating, heavy rains led to widespread flooding, affecting over a million people, displacing thousands, and causing numerous fatalities (Floodlist, 2015). The March 2019 flooding caused by heavy rains affected several districts of Malawi, displacing thousands of people and leading to loss of life and property damage (Malawi Government, 2019a). Several studies have examined the effectiveness of disaster preparedness and response mechanisms in Malawi however Collaboration with international organizations and neighboring countries remain essential for mitigating flood impacts in Malawi (ECH, 2012). The reports like most publications in Malawi concentrated on flooding history for major rivers and known flood-prone zone, data on flooding events taking place in other rivers remains a gap.

2.2.2 Urban flooding

Urban flooding has garnered significant attention in recent years due to the increasing frequency and severity of flooding events in urban areas. It constitutes the flooding of land or property within a densely constructed environment occurring quickly due to faster flow times (United States Government, 2015). Urban flooding results from a combination of natural and anthropogenic factors.

These include heavy rainfall leading to higher surface runoff and river discharge rates, inadequate drainage systems, urbanization, discharge, climate change, and encroachments on drainage areas such as lakes, wetlands, and riverbeds (ClearIAS, 2022). Urban flooding has substantial adverse effects on urban environments, including damage to infrastructure, disruption of daily life, economic losses, and public health risks (Miller and Hutchins, 2017). Technology advancement in hydrological and hydraulic modeling have been crucial in predicting and simulating urban floods, aiding urban planners and policymakers in making informed decisions regarding flood mitigation measures (Saleem et al., 2021).

Urban flooding in Malawi has been a recurring issue and continues to devastate communities primarily driven by a combination of factors, including heavy rainfall, inadequate drainage systems, and urbanization (World Bank. 2017). Urban flooding in Malawi continues to cause substantial negative impacts on businesses and households (Munthali et al., 2020).

2.3 Malawi urban planning and profile

2.3.1 Urban demographic in Malawi

Urban Settlements can be defined as 'areas with some central place activities comprising, market, district, sub-regional, regional and national centres' (Malawi Government, 2019c). Results from the 2018 population and housing census indicate that Malawi has an estimated population of 17,563,749 most of which are based in rural areas with 989,318 of the inhabitant's dwelling in Lilongwe, 52,948 in Area 49 and 66,574 in Mtandire (Malawi Government, 2018a). There has been an increase in urbanization in recent years attributed to rural-urban migration leading to the growth of urban informal settlements (World Bank, 2016).

The census revealed that the urban population contributed to 16 percent of the national population with an annual growth rate of 5.2 percent against an annual national growth rate of 2.9 percent. The share of the national population residing in urban areas has progressively increased from 6.4 percent of the national population at independence in 1964 to 10.1 percent in 1987 and estimated at 17 percent in 2018 (United Nations, 2018).

2.3.2 Urban informal settlements

United Nations Habitat iii issue Journal 22 on Informal settlements, (2015) defines informal settlements as urban areas ranging from squatting to informal rental housing characterized by a lack of security of tenure, basic services, city infrastructure, and compliance with stipulated planning and building regulations, often located in high risk and hazardous areas. A review of the Journal reveals that Informal settlements exist in urban contexts all over the world, in various forms and typologies. Settlements are caused by a wide range of factors including population growth, rural-urban migration, lack of affordable housing, weak governance, economic vulnerability and underpaid work, discrimination, marginalization, and displacement caused by conflict, natural disasters, and climate change. Settlement dwellers are likely to experience social and economic exclusion, basic services deficits, limited access to land and property, and exposure to climate change and natural disasters. The increase in population migrating to cities in search of economic opportunities, has resulted to the spontaneous formation of informal settlements on the outskirts of urban areas, providing accommodation for the increasing urban population in Malawi (World Bank, 2016). Informal settlements in Malawi typically exhibit poor housing conditions, with overcrowded and substandard dwellings lacking access to basic services such as clean water and sanitation (Malawi Government, 2019c).

Land tenure in informal settlements is often unclear, leading to issues of land ownership and property rights, many residents lack legal recognition and security of tenure (Urban Landmark, 2013).

2.3.3 Urban floodplains in Lilongwe

Like any other modern city, Lilongwe is facing rapid urbanization with a growth rate averaging more than 4 percent per annum (Malawi Government, 2018a). The city has not been short of disasters over the years, ranging from accidents, floods, and fires, to environmental degradation, and disease epidemics (United Nations, 2011). Previously not categorized as a traditional flooding city evident by its exclusion from the 2015 Malawi Floods Emergency Recovery Project (MFREP) report on disaster management there is a huge gap in the guiding framework from local authorities on how to manage damages caused by the recent flooding events in the city (Malawi Government, 2015a).

The surge in informal and formal settlements in floodplain zone has not helped the situation, poor coordination has seen the rise of settlements in undesignated areas (Malawi government, 2019c). The growth of urban settlements in flood-prone regions poses a great risk of river flooding in communities and requires an urgent response Handayani et al. (2020). Data on urban floodplains, developments of floodplain and population living in Lilongwe however remains a challenge.

2.4 Floodplain inundation mapping techniques

Flood inundation mapping is a pivotal tool in the fight against flooding disasters, authorities can use the maps to enforce settlements out of such disaster-prone areas (Antony et al., 2021). There are tools available to aid in the development of flood inundation maps, with the advancement in software technologies, it has become easier to delineate flood zones (Romali et al., 2018).

Cherenzia (2010) in the write-up 'GIS and Floodplain Mapping and Analysis' describes a simple technique that can be used to develop flood inundation maps using Geographic Information System (GIS) and Hydrologic Engineering Centre River Analysis System (HECRAS) developed by the U.S. Army Corps of Engineers. The use of HECRAS in floodplain hydraulic modelling is widely popular. The program offers features that allow it to receive input data from GIS.

The methodology involves inputting a Digital Terrain Model (DEM) in GIS to generate 3-dimensional spatial information such as the topology of an entire stream, the cross-sectional shape, size of each stream and travel distance of flow in the main channel. This is used to generate a hydrological model for the stream. The generated data is then exported to HECRAS for hydraulic analysis where it is incorporated with hydrologic and hydraulic data inputs such as Manning's roughness coefficient, contraction and expansion coefficients, and any hydraulic structures (e.g. bridges, dams, culverts). The model is then run in HECRAS and results are exported back to GIS where inundation mappings can be formulated. According to the publication inundated area can be calculated by subtracting the flood surface elevation from the land surface elevation model at each location. GIS can be used to represent and demonstrate the horizontal spread of the floodplain. The depth of flooding can also be visualized by generating a raster data structure, which demonstrates the relationship between the depth of inundation and spread. The advancement in technology has allowed GIS to be a great tool in floodplain analysis and mapping.

2.4.1 Similar studies on flood occurrence and floodplains

Similar studies carried out in different parts of the world have established the influence of floodplain encroachment in floodplains and its impact on flooding.

A Study conducted under the title 'Urbanizing the floodplain: Global changes on imperviousness in flood-prone areas' by Andreadis, et al., (2021), set out to study the growing concern of increasing urban developments in floodplains, found that approximately a total of 105,657 km^2 comprising 16.2% of the world's urban area was within the 100-year floodplain as of 2015. Further, the study discovered that encroachments in urban floodplain areas with an average probability of 1/100 years of flooding have almost doubled since 1985 (from 8.2 to 16.2%). In the United States of America, Fuhrman Centre, (2017) reported that an 'average of 15 million people in America lived in the 100-year floodplain between 2011-2015, representing nearly 5% of the nation's population. More than 30 million people nearly 10% of the nation's population—lived in the combined 100- and 500-year floodplain during this period.

A study carried out by Ndabula et al., (2012) to map, monitor and characterize the floodplain of the Kaduna River in the Kaduna region of Nigeria using Models found that the largest extent of floodplain encroachment was observed in areas near the central business district (CBD) indicating greater risk and high potential of flood damage in events of flooding. Further, the study revealed that approximately 52.83% of urban floodplains of the river had been encroached. The methodology approach from the research team involved a three-step analysis suggested by (Dodson and Li, 1999) involving data collection and preparation, extraction of floodplain boundary from the Digital Elevation Model (DEM), and floodplain encroachment mapping and analysis. The study used ArcGIS and remote sensing to model the floodplain encroachment. The encroachment was quantified by superimposing the delineated floodplain boundary over the respective built-up layers, floodplain layers were overlaid over existing fragmented sub-centres built-up layers of 1967, 1987, 1995, 2001 and 2009 respectively, and clipped out, converted to polygons and spatial measurement of the area to estimate Encroachment extents.

Okaka and Odhiambo (2018) carried out a study in the flood-prone informal settlements of Mombasa Kenya to assess the perception of households to flood and health risk in the area. The study utilized household surveys randomly sampling 390 households. The surveys were supported by focus group discussions (FGD) and key Informants interview (KII). The study found that the majority of settlers perceived flooding as high risk with a negative healthy impact.

2.5 Community perception of flood risk

Community perception of flood risk involves the understanding of how individuals and communities perceive and respond to the threat of flooding. Individuals' perception of the risk can be influenced by a combination of factors, including personal experiences, proximity to water bodies, and socioeconomic status (Shah et al., 2022). Cultural beliefs and social networks have also been shown to influence perceptions of flood risk, with communities' possession strong social ties being more resilient in the face of flooding, as they often engage in collective action and information-sharing (Abunyewah et al., 2023). Communities trust in local authority's ability to manage flood risks also plays an important role. High trust level communities are more likely to follow evacuation orders and adopt recommended flood preparedness measures (Seebeaur and Babcicky, 2017). Higher levels of resilience communities, characterized by adaptive capacity and social cohesion, tend to have more accurate perceptions of flood risk and are better prepared to mitigate its impacts (Lwin et al., 2020). Improving communication strategies are essential for improving community perceptions of flood risk, tailoring messages to the local context, providing clear and timely information, and involving community members in decision-making can enhance preparedness and reduce risk perception discrepancies (Botzen and Aerts 2016). Effective risk management and reduction strategies should take into account these multifaceted perceptions to enhance community resilience and reduce the impacts of flooding (Mehryar et al., 2022).

CHAPTER 3. MATERIALS AND METHODS

This chapter presents materials and methods that have been used to tackle the three research objectives.

3.1 Description of study area

This study was conducted in the floodplains of Lingadzi River at Mtandire and Area 49 Shire informal settlements in Lilongwe, Central Malawi. Lilongwe the capital city of Malawi is located between latitudes 9°22‟S and 17°03‟S and longitudes 33°40‟E and 35°55‟E (Gondwe et al., 2013). The city lies at 1200 and 1400 meters above sea level on the plains of central region of Malawi (Gondwe et al., 2018). Annual rainfall ranges between 700 and 2400 millimetre (mm), averaging 1180 mm per annum, accompanied by temperatures averaging between 12 ˚C to 32˚C (Sajidu et al., 2013), (as shown in Figure 1).

The city is home to approximately 989,318 inhabitants (Malawi Government, 2018a). The city’s economy is largely agriculture based, the majority are small-scale farmer’s dependent on rain- fed agriculture (World Bank, 2023). The Agriculture sector in Lilongwe which contribute heavily to the economy is however limited to only a third of gross domestic product (GDP) (World Bank Group, 2018). The countries per capita Gross National Income (GNI) was at US$320 in 2016, one of the lowest in the world. Income growth per capita growth was estimated at an average of 1.5 percent between 1995 and 2014, (World bank, 2017).

Lingadzi River, 1290km long flows at 1024 meters above sea level and falls within the Linthipe River and Dwangwa River Water Resources Areas (Malawi Government, 2014).

The perennial river spreads across several districts in Central Malawi (Liasi, 2016) and passes through Lilongwe urban where it has been heavily affected by rapid urbanization along its banks (Halle and Burgess, 2006), (as shown in Figure 1). The emerging settlement of Area 49 located in Lilongwe is characterized by both formal and informal settlements. The settlement has an estimated population of 52,948 (Malawi Government, 2018a). It was initially designated as a traditional high-density location (United Nations, 2011). Area 49 has some corners of the residence lying along the Lingadzi River. Settlements close to the river have been affected by flooding events during the rainy season causing devastating effects to residents. The high-density settlement of Mtandire is characterized by unplanned informal housing some of which are located close to the banks of the Lingadzi River.

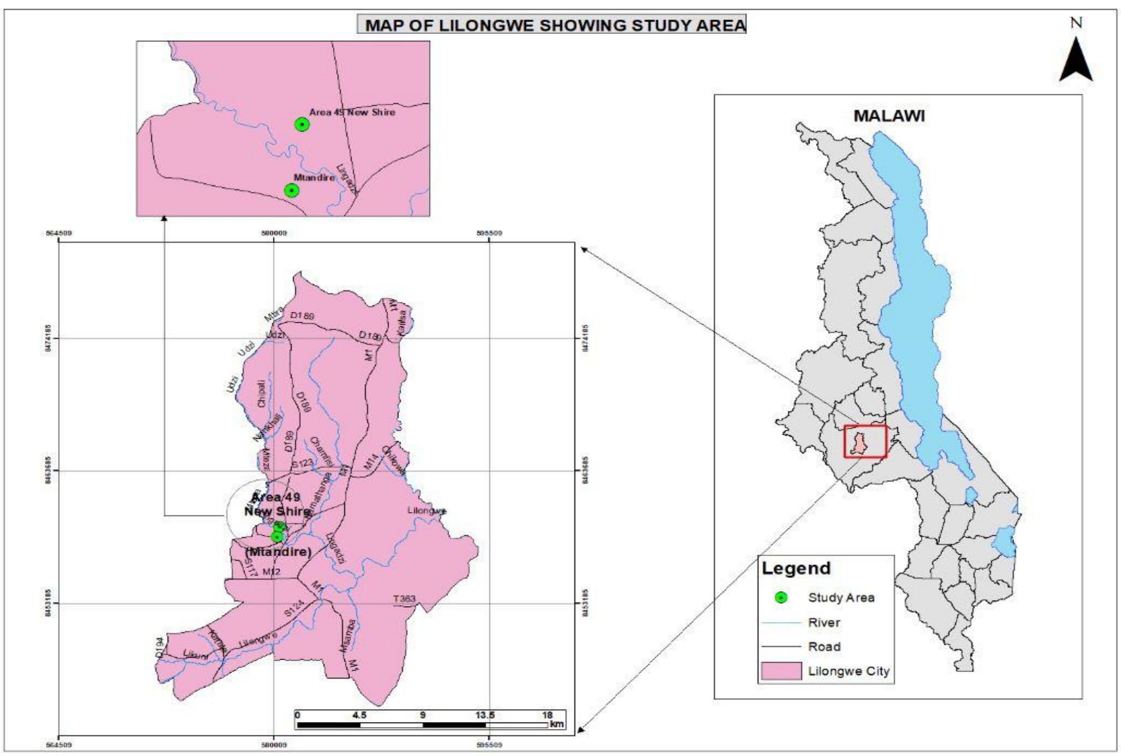


Figure 1: Map of study Area

The settlement is home to about 66,574 inhabitants (Malawi Government, 2018a). Settlement is characterized by housing located close to one another, constructed without guidelines from authorities. This fast-growing settlement is a hub for urban informal settlements in Lilongwe.

3.1.1 Study Area Selection Rational

The Study areas were selected for fitting into the narrative of an informal settlement present in a floodplain.

3.2 Study Design

The research was carried out using quantitative research methods. Quantitative data was obtained and analyzed to answer the three research questions.

3.2.1 Sampling and Sample Size

Sampling Methods

Sampling was utilized to determine the number of interviews and household surveys to be conducted. Two-stage cluster sampling was employed firstly, purposively selecting the informal urban settlements of Mtandire and Areas 49 Shire located along Lingadzi. After selecting the two settlements participants living close to the river were then selected randomly. Data was collected from a combined total sample size of 222 households and local respondents comprising of 145 in Mtandire due to its higher population and 77 in Area 49.

Sample size

The formula used for known population size (Daniel, 1999) was utilized to determine the size of surveys and interviews conducted with residents.

$$n = \frac{N * X}{(X + N - 1)},$$

n = sample size 222 local settlers and housing structure

N = population Size

X =Zα/2² *p*(1-p) / MOE2,

Z = The critical value of the Normal distribution at α/2

MOE = The margin of error

P = The sample proportion

Sample size has been calculated with assumptions as shown in Table 1. Data has been collected from a total sample size of 222 local residents and households.

Table 1: Sample size calculation

Study area	Population of study Area	No. of respondents with 9 % non-respondents
Mtandire	66,574	145
Area 49	52,948	77
Total	**119,522**	**222**

3.2.2 Data collection and management instruments

Data was collected on 14th and 15 December 2022 with the help of enumerators upon receiving clearance from MZUNIREC. To characterize the informal settlements, housing and surrounding characteristics data such as access to basic facilities, wall and roofing material, structure age and land tenure was collected using a structured questionnaire.

To delineate the floodplain of Lingadzi River, a Digital Elevation Model (DEM) collected from the USGS website was used to produce flood inundation maps including inundation boundary, depth, flow, water surface elevation and velocity. Data was collected by firstly visiting the website https://earthexplorer.usgs.gov/, followed by the following steps:

1. Defining the Search Area.
2. Selecting STRM Data Sets.
3. Customizing Search Area by adjust additional filters such as data range, cloud cover, and data format.
4. Searching Data to see if datasets match criteria.
5. Previewing Data by clicking dataset to preview it on the map.
6. Adding Data to Cart by clicking "Add to Cart" button.
7. Accessing cart by clicking the cart icon at the top-right of the page.
8. Reviewing and downloading: select download options (e.g., format, projection), click "Download" to start the download process.
9. Downloading Data: system generated a download link allowing download of DEM data to computer.

Data on Flooding intensity and frequency, Space covered by flood waters and the number of flooded days was collected through unstructured questionnaires to determine flood occurrence frequency changes, Table 2 has more detail.

Table 2: Methodology Matrix

Objective	Research Method	Data Type	Data Collection Tools	Research Variables	Data Analysis Method	Data Analysis Tools
To assess the characteristic of informal settlements in floodplain of Lingadzi River in Lilongwe city.	Quantitative	Primary data	Household surveys	a) Access to basic facilities. b) Wall & roofing material. c) Structure age. d) Land tenure.	Building quality rating scale (Zhang *et al*., 2020)	Descriptive statistics/ Frequency analysis using SPSS and Excel
To delineate the floodplain of Lingadzi river in Lilongwe city through development of 10, 50- and 100-years flood inundation maps.	Quantitative	Secondary Data (DEM)	United States Geological Survey (USGS) website	a) Inundation Boundary b) Depth and velocity c) Water surface Elevation	Floodplain analysis (Dodson and Li, 1999)	Inundation mapping using RAS Mapper HECRAS 3.2.1
To evaluate flood occurrence frequency changes in urban floodplain of Lingadzi river in Lilongwe city.	Quantitative	Primary Data	Household Interviews. a) Local residents.	a) Flooding intensity and frequency. b) Space covered by flood waters c) property damage d) No. flooded days	Indigenous knowledge flood occurrence analysis (Kihupi *et al*., 2002).	Descriptive statistics/ Frequency & crosstabs analysis using SPSS and Excel

3.3 Data analysis methods

3.3.1 Field survey data

Surveys involved quick assessment of buildings randomly in Mtandire and Area 49 Shire. In total, 145 residents were assessed in Mtandire and 77 residents in Area 49 Shire. A modified scoring criterion as presented in Table 3 adapted from Zhang et al. (2020) was utilized to analyze the collected data. The collected data was checked for quality control, inputted and analyzed in Statistical Package for Social Sciences (SPSS) (IBM® SPSS ® Statistics version 23) and plotted in Excel. The data was analyzed using descriptive statistics specifically frequency.

Table 3: Building quality rating scale adapted from Zhang et al., (2020)

Evaluating Indicator	Observation	Score
Basic Facilities	30% and below have access to roads, water, electricity or toilet/latrine	1
	30–70% have access to roads, water, electricity or toilet/latrine	3
	70% and above have access to roads, water, electricity or toilet/latrine	5
Roofing materials	30% and below are concrete, ceramic tile, or high quality iron sheet	1
	30–70% are concrete, ceramic tile, or high quality iron sheet	3
	70% and above are concrete, ceramic tile, or high quality iron sheet	5
Wall materials	30% and below are permanent materials such as bricks or cement	1
	30–70% are permanent materials such as bricks or cement	3
	70% and above are permanent materials such as bricks or cement	5

Interviews with locals of Mtandire and Area 49 Shire

Interviews were carried out with local residents using an unstructured questionnaire. The respondents were identified in each house that participated in quick assessments composed of the same total sample size of 222 encompassing 145 residents in Mtandire and 77 residents in Area 49 Shire. Data was processed through Indigenous knowledge flood occurrence analysis (Kihupi et al., 2002), using residents' perceptions and experiences of flood occurrence in the area. Descriptive statistics specifically frequency and cross-tabulations in SPSS (IBM® SPSS ® Statistics version 23) and Excel was employed to analyze and illustrate findings.

3.3.2 Hydrological and Hydraulic modelling

The HECRAS and River Analysis System Mapper (RASMapper) models were used to produce flood inundation maps. HECRAS software is a river modelling tool capable of performing one-dimensional steady flow, and one and two-dimensional unsteady flow calculations. RASMapper is a GIS interface within HECRAS for creating river geometry and visualizing results. The modelling involved extracting DEM for Lilongwe from USGS website, study area DEM was extracted then catchment for Lingadzi river was delineated. The extracted DEM was then loaded into RASMapper to Create 1D river geometry encompassing river center line, river banks, flow path, and cross section and assigning manning’s value. The next stage involved geometry data import and processing in HECRAS model. A 1D steady flow analysis was carried out in HECRAS Model which involved inputting steady flow data, boundary conditions and 1D flow plan, lastly the model was run and results viewed as shown in Figure 2.

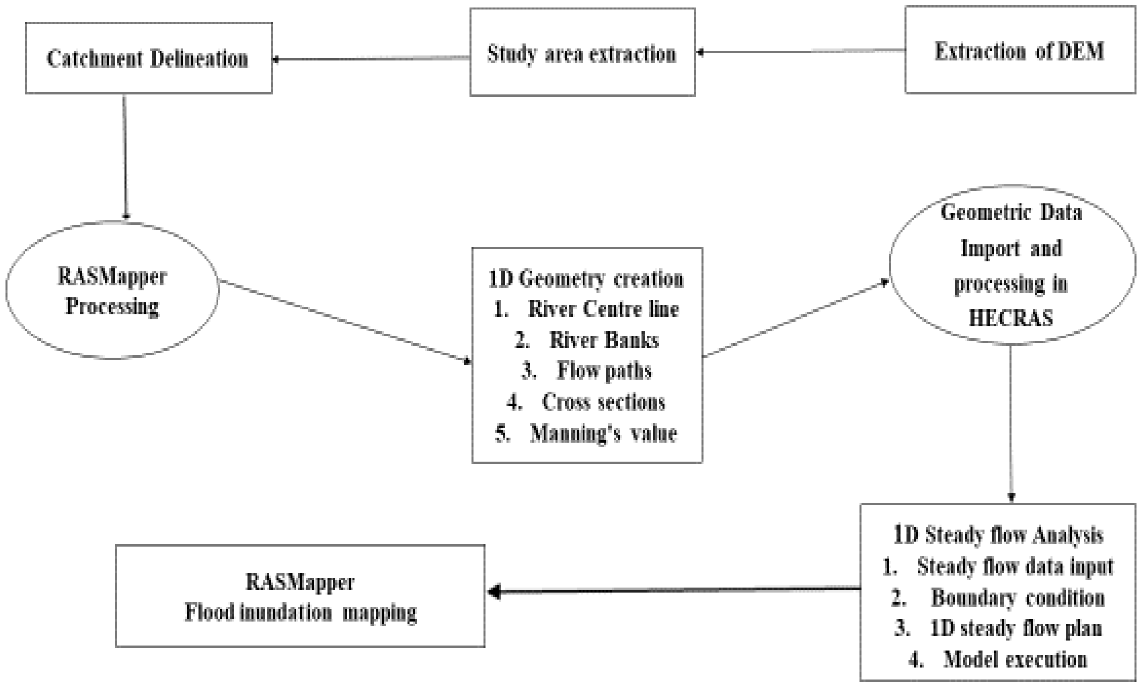


Figure 2: Flood modelling flow diagram.

The HEC-RAS model has been preferred for its easy access as open-source software and its easy-to-use interface. The model required input data comprising DEM, Manning's coefficient, flow data and boundary conditions to perform hydrological and hydraulic modelling. Flow data was calculated using the Rational method for peak flood estimation as illustrated by (Krishnamurthy, 1987). A methodology on Floodplain analysis as presented by (Dodson and Li, 1999) has been utilized, the three-step include;

1. Data collection and preparation (DEM data).
2. Model creation and execution (RASMapper and HECRAS).
3. Floodplain mapping (RASMapper and GIS).

Flood inundation map development involved 11 steps as illustrated;

1. Create new project.

Before building the HECRAS model, a new project was created by selecting the File, then New Project menu item on the main RAS interface, a file name was assigned, all project files will begin with the file name.

2. Create base project data using RASMapper.

RASMapper was used to create the geometry for the HECRAS model, to create this, the RASMapper button in the main RAS interface was clicked.

3. Set coordinate system for the project

The coordinate system was projected to WGS84, a projection file was downloaded together with DEM (esri PRJ file.) The projection was used to project any data brought into RASMapper. This includes terrain data and land cover data when new datasets or background data such as shape files and web imagery were created.

4. Create new RAS Terrain.

During this stage RASMapper effectively imported the terrain data (it creates a copy from the input dataset) based on the specified parameters. During the import process, the data was rounded, converted, tiled (for zoom levels), and re-projected (if necessary) to the coordinate system specified. A new file was created on disk, a terrain.hdf file containing information RASMapper uses to manage the terrain data. A terrain.vrt file that can be used to visualize the terrain data in other programs, and a Terrain.tif for the data that was imported (multiple .tif files will be created if the user specified multiple inputs). The Terrain.hdf file was then loaded into RASMapper for visualization and use and appeared as shown in Figure 3.

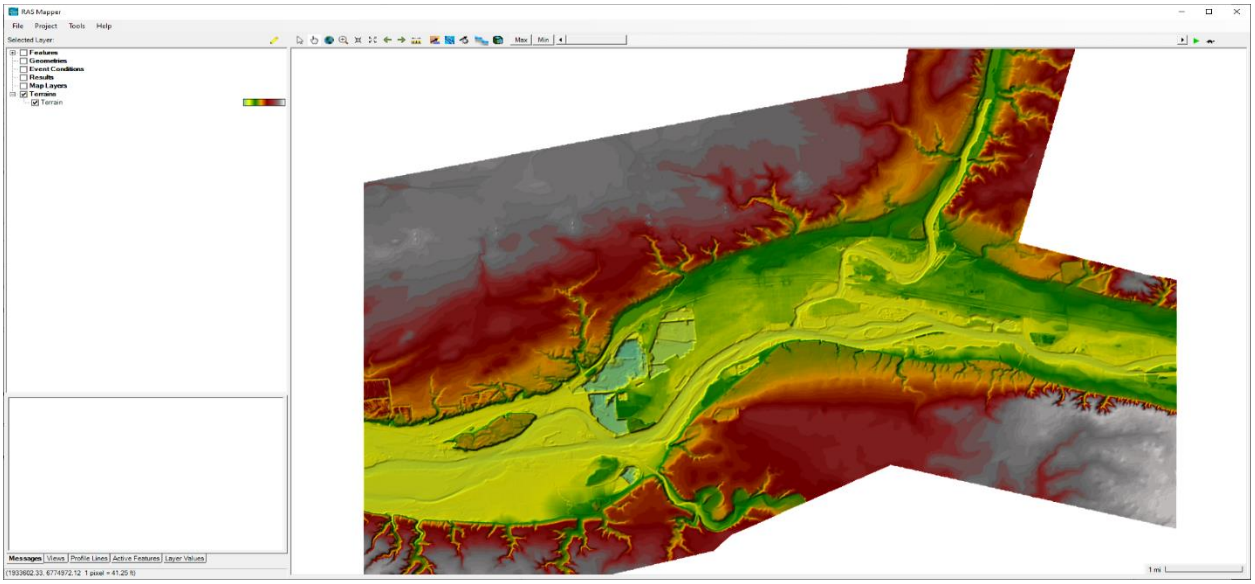


Figure 3: Create new RAS Terrain

5. Create 1D geometry

The first step in creating any steady or unsteady model is to create 1D geometry. The geometry is used to get an understanding of the river system. It involves creating the river system, bank lines, flow path lines and cross-sections, as shown in Figure 4.

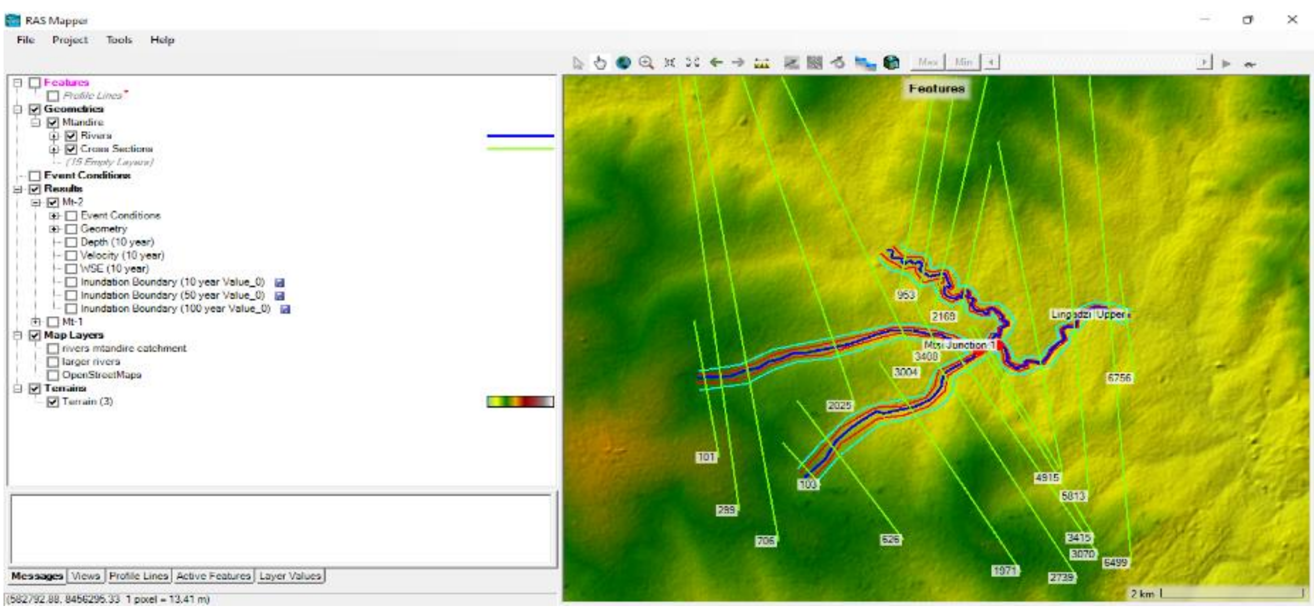


Figure 4: Creating of river geometry in RAS mapper

6. Import created geometry data from RAS Mapper to HECRAS.

The created I D geometry data in RAS Mapper was imported to HECRAS for analysis, as shown in Figure 5.

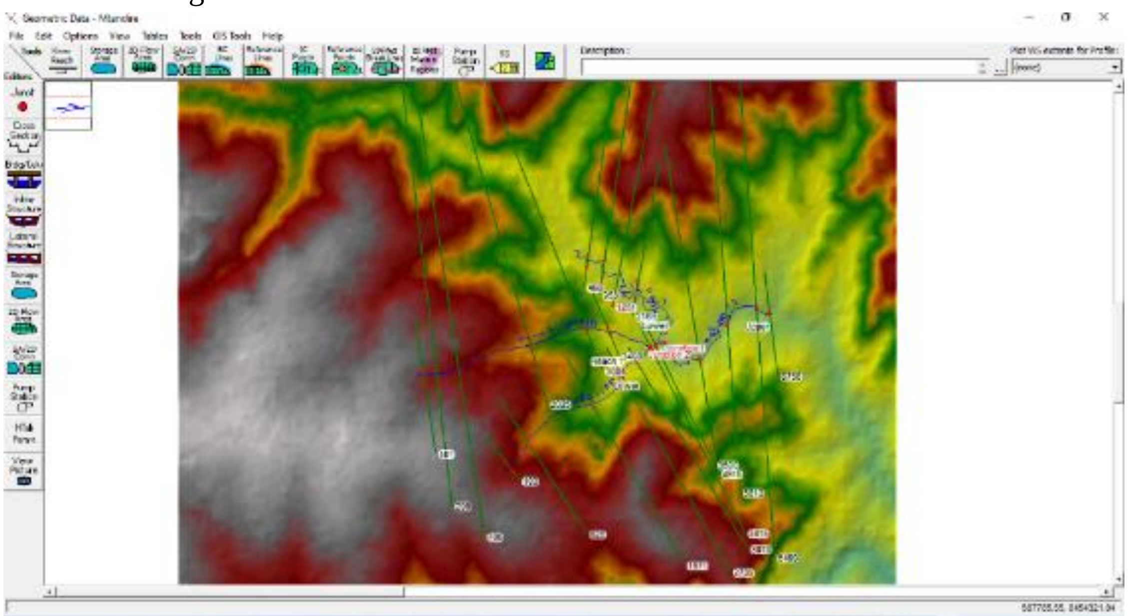


Figure 5: Imported river geometric data.

7. Create 1D steady flow data in HECRAS

To create 1D steady flow data in HECRAS, flow data for the range of flows for profiles 10-year, 50-year and 100-year were created. Process involved entering a downstream boundary condition, as shown in figure 6.

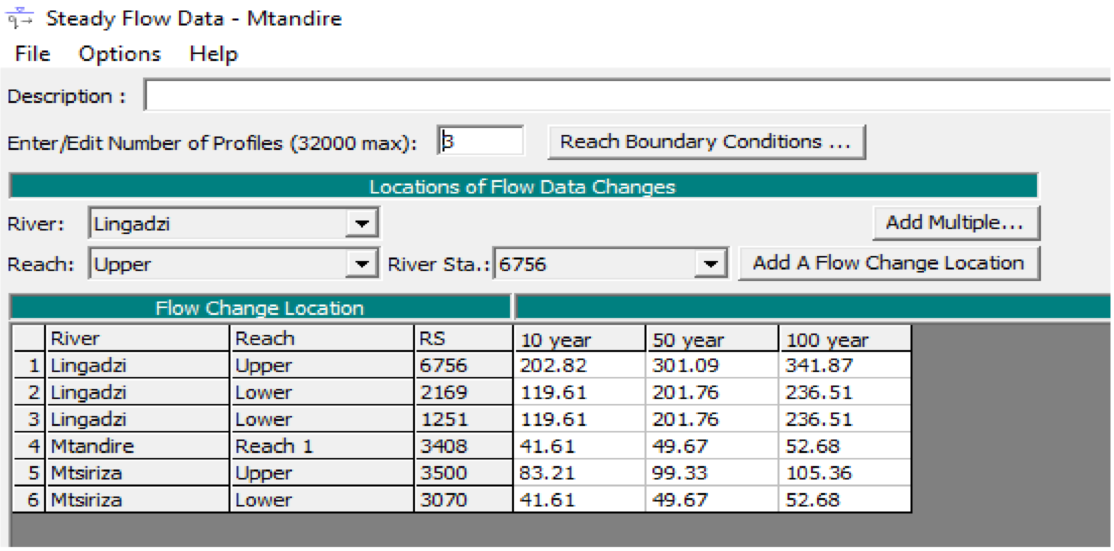


Figure 6: Creating 1D data in HECRAS

8. Create 1D Steady Flow Plan.

Next stage involved creating a Steady Flow plan using initial geometry and steady flow data.

Once a plan was created, the model was ready to compute hydraulic analysis.

9. Run the model.

Model was run in HECRAS according to information inputted as shown in Figure 7.

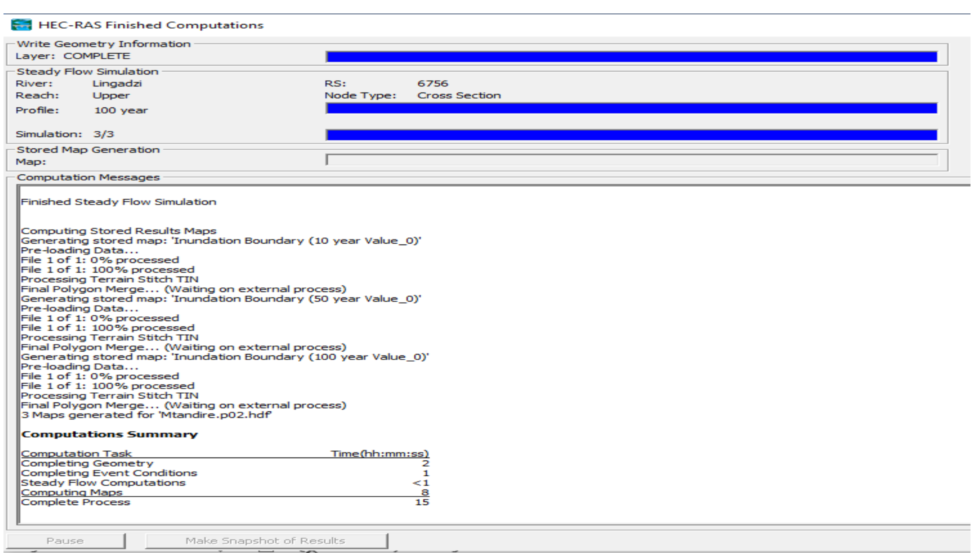


Figure 7: Model running process

10. View results

flood maps were viewed in RAS Mapper; they can be exported to GIS to create maps as shown in Figure 8.

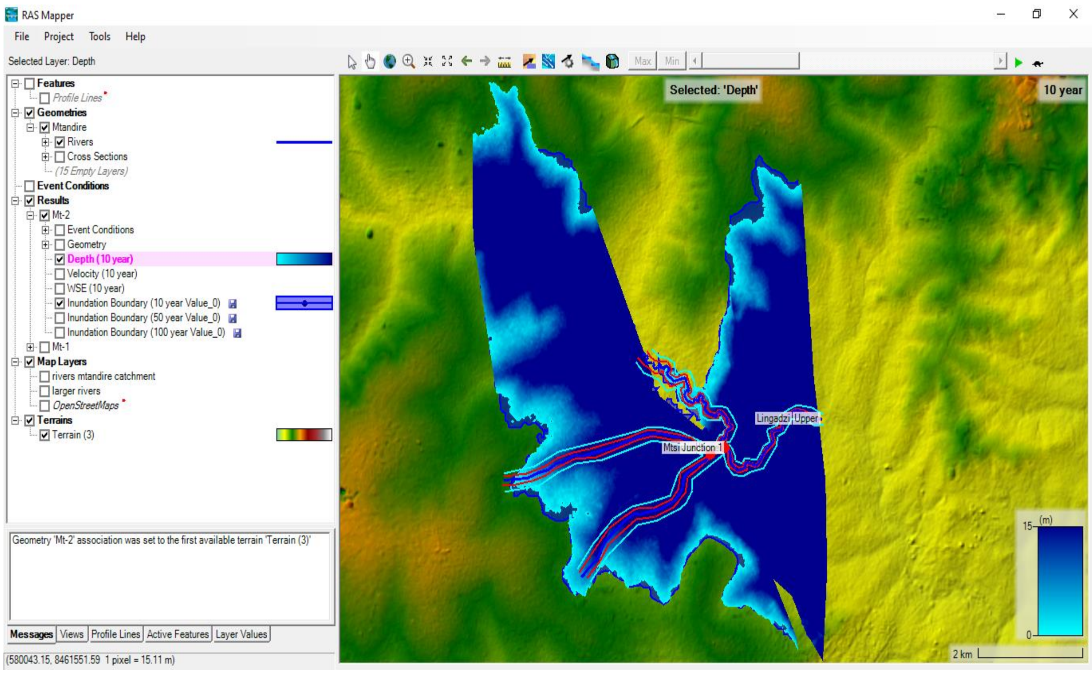


Figure 8: Flood inundation mapping results

3.3.3 Quality control and reliability of results

To ensure that results were accurate and controlled, enumerators were given lunch breaks and pocket money. DEM Data was sourced from the USGS website which is a liable platform for data acquisition. Outputs from the analysed data for the three research questions has been presented in chapter four.

CHAPTER 4. RESULTS

This chapter presents results from analyzed data and is organized according to the research objectives. Firstly, the results of characterization of informal settlements, secondly delineation of floodplains, and lastly flood occurrence frequency.

4.1 Characteristics of informal settlements in floodplain of Lingadzi River at Area 49 Shire and Mtandire in Lilongwe City

The results indicate that overall over 70 percent of the settlements have access to basic facilities such as assess to roads, water, electricity and sanitation facilities, giving the settlements a rating of 5 on the rating scale according to Zhang et al., (2020). Even though most of the housing was constructed with iron sheets, overall less than 30 percent had high quality roofing material giving the settlements a score of 1 on the rating scale. Overall over 70 percent of households had permanent bricks or cement as building materials giving them a score of 5 on the rating scale, as shown in table 4.

Table 4: Settlement rating scale score

Evaluating Indicator	Observation	Overall Score
Basic facilitates	70% and above have access to roads, water, electricity or toilet/latrine.	5
Roofing materials	30% and below are concrete, ceramic tile, or high quality iron sheet.	1
Wall materials	70% and above are permanent materials such as bricks or cement.	5

The settlements are characterized by lack of access to quality and improved basic services expected in urban settlements. However, Area 49 Shire has mixed housing characteristics, including formal housing with modern architectural designs, distinctive boundaries, good roofing and wall material while others are informal without distinctive boundaries and roads network. Some houses were under construction as shown in Figure 9. Mtandire is dominated by single-story, semi-detached and standalone housing with simple architectural designs covering small areas. Houses have no distinct boundary and are located close to one another with poor unpaved road network, low quality iron sheets and compromised wall material as shown in Figure, 10.

4.1.1 Population characteristics of Area 49 and Mtandire

There was a marginal difference in the age of respondents between those below and above the age of 35, considering Malawi has a young population. This was helpful because the respondents had some kind of knowledge of what has been happening in the locations in terms of flooding history. The majority of respondents were female with a larger portion coming from Mtandire, as shown in Table 5.

Figure 10: Area 49 housing characteristic

Figure10: Mtandire housing characteristic

Table 5: Study area demographics

Characteristic	Description	Percentage (%) (*n*=222)
	Male	29.7
Gender of respondents	Female	70
	Below 35	50.5
Age of respondents	35 and above	49.5

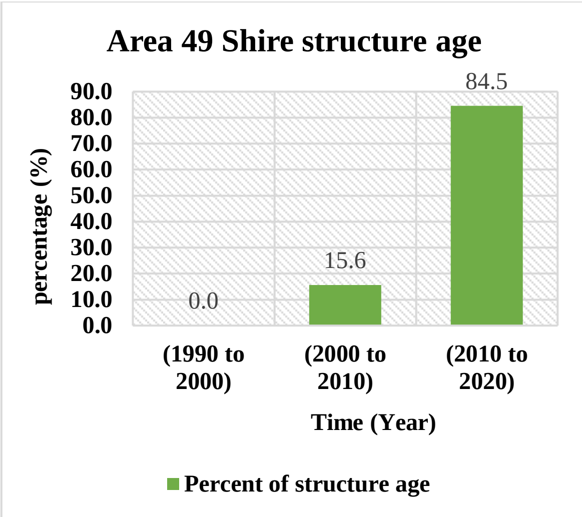
4.1.2 Structure Age of Area 49 Shire and Mtandire

Area 49 structure Age

Area 49 Shire is a new growing settlement evidenced by no records of houses constructed between 1990 and 2000. The majority of the housing in the area was constructed between 2010 and 2020 representing 84.5 percent, houses constructed between 2000 and 2010 represent 15.6 percent details are as shown in Figure 11. Noticeable some houses were still under construction in the area.

Mtandire structure age

Mtandire had 9.7 percent of households built between 1990 and 2000. The majority of the houses in the settlements were constructed between 2010 and 2020 representing 57.2 percent of households. Houses constructed between 2000 and 2010 represented 33.1 percent, details are as shown in Figure 12.



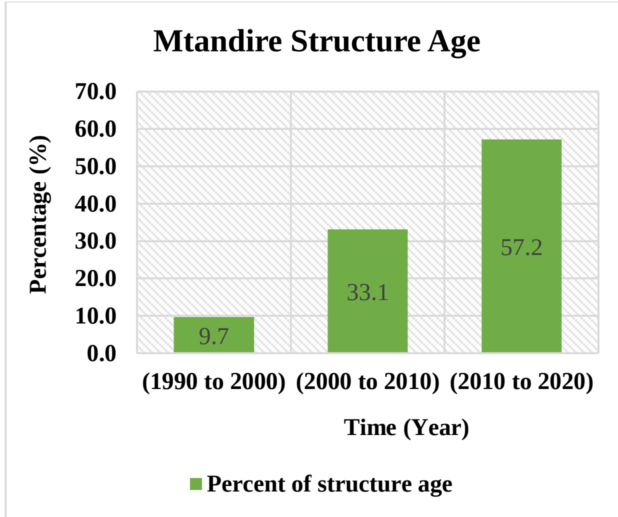
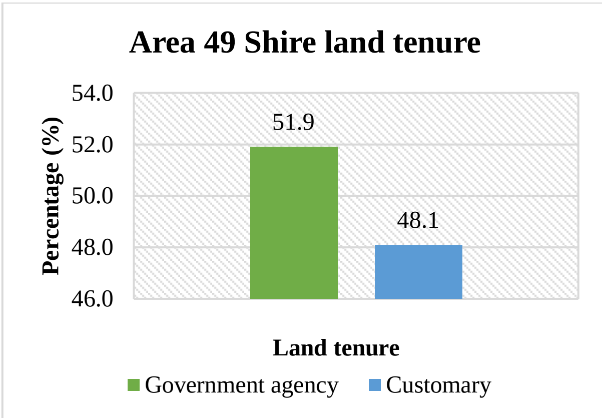


Figure 11: Age of surveyed structures in Area 49 Shire

Figure 12: Age of surveyed structures in Mtandire

4.1.3 Land Tenure at Area 49 Shire and Mtandire

Land acquisition in the study area was mainly under customary land tenure sold with the aid of a traditional leader. In recent years with the coming in of the government, some of the land has been integrated into the government system at a cost to the land owner. A composition of 51.9 Percent in Area 49 Shire and 6.2 percent in Mtandire belong to this category. The land is now under government entities such as LCA, Ministry of Lands and Housing as well as Malawi Housing Cooperation. Customary tenure constitutes 48.1 percent in Area 49 Shire and 93.8 percent in Mtandire as shown in figures 13 and 14.



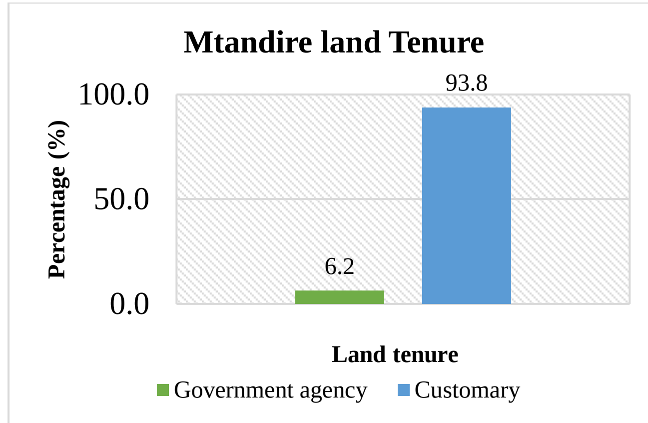


Figure 13: Area 49 Shire land tenure

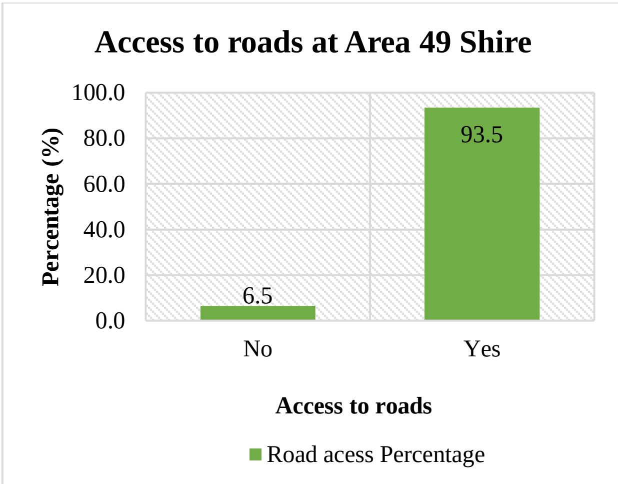
Figure 14: Mtandire land tenure

4.1.4 Settlement Access to basic facilities

The majority of the dwelling homes in the two settlements have some kind of access to basic facilities. The challenge transpires from the quality and condition of the facilitates, most of which was constructed from low quality materials, without expertise and constitutes inadequate sanitation. Some of the houses in Area 49 Shire are still under construction and are occupied by individuals who are guarding the houses. The houses lack connection to Lilongwe Water Board (LWB) water supply and Electricity Supply Corporation of Malawi (ESCOM) electricity supply, this has translated to the dependence on wells for water supply.

4.1.5 Access to road at Area 49 Shire and Mtandire

Results indicate 93.5 percent of the houses in Area 49 Shire have access to road network compared to 75.9 percent in Mtandire. The settlements in Mtandire were found to have had access to some kind of road network with unpaved surface. The road infrastructure is however not in desirable condition, not clearly defined, accessed mostly by foot and marred by potholes. Respondents corresponding to 6.5 percent in Area 49 Shire did not have direct access to a road network compared to 24.1 percent in Mtandire details are illustrated in Figures 15 and 16.



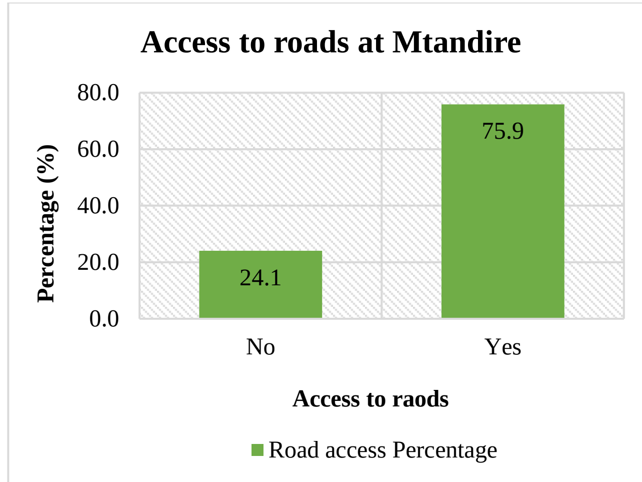
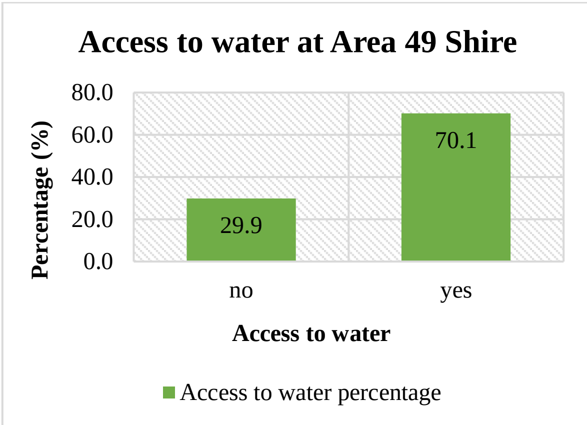


Figure 15: Access to road in Area 49 Shire

Figure 16: Access to road Mtandire

4.1.6 Access to water at Area 49 Shire and Mtandire

A total of 70.1 percent in Area 49 Shire and 53.7 percent in Mtandire admitted to having some kind of access to a potable water supply system through LWB either directly into the dwelling home or from a kiosk as well as from borehole. Some of the kiosks have broken taps, some are in good conditions, however they are open at particular hours only and settlers can only draw water during those hours. Most of the boreholes are privately own and managed by owners. On the other hand, 29.9 percent in Area 49 Shire and 46.3 percent in Mtandire admitted to not having access to portable water supply mostly depending on water directly from the stream or open wells, as shown in Figures 17 and 18.



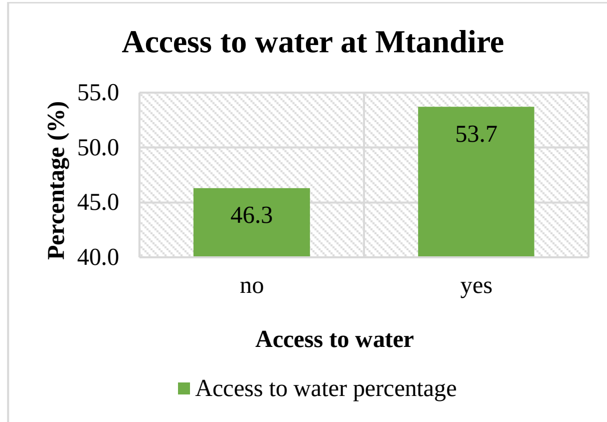
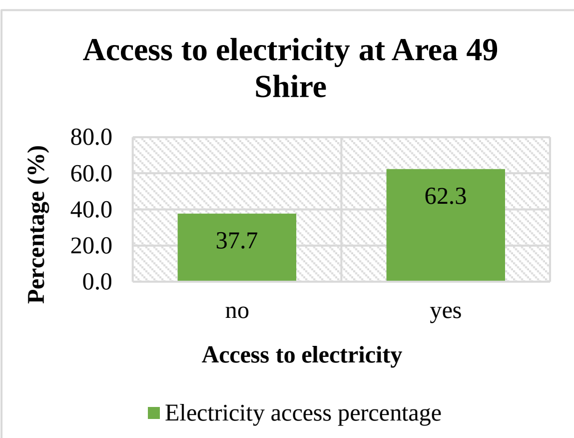


Figure 17: Access to water in Area 49 Shire

Figure 18: Access to water in Mtandire

4.1.7 Access to electricity at Area 49 Shire and Mtandire

Access to electricity comprised 62.3 percent of households in Area 49 Shire compared to 52.4 percent in Mtandire. The power supply was either through ESCOM or individual solar connections. Respondents comprising of 37.7 percent in Area 49 Shire and 47.6 percent in Mtandire admitted to not having access to electricity directly in their homes, as shown in Figures 19 and 20



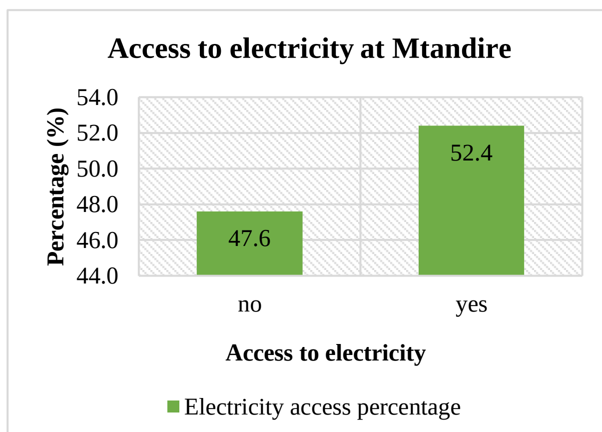


Figure 19: Access to electricity in Area 49 Shire

Figure 20: Access to electricity in Mtandire

4.1.8 Access to sanitation facilities at Area 49 Shire and Mtandire

The majority of surveyed households translating to 89.6 percent in Area 49 Shire and 96.6 percent in Mtandire have access to sanitation facilities in the form of pit latrines and toilets, mostly located outside the homes. Latrines are mostly constructed by locals without proper procedure hence not structurally sound. Settlements lacking access to sanitation facilities constituted 10.4 percent in Area 49 Shire and 3.4 percent in Mtandire, results are shown in Figures 21 and 22 below.

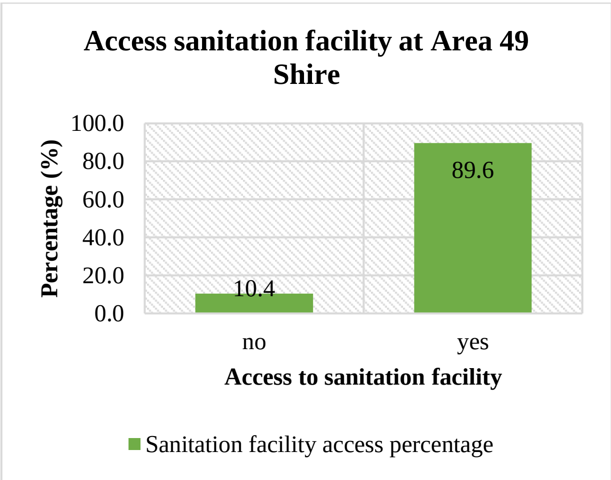


Figure 21: Access to sanitation in Area 49 Shire

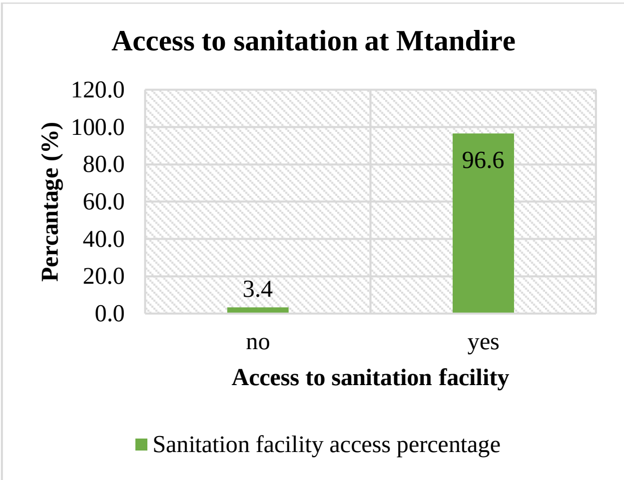


Figure 22: Access to sanitation in Mtandire

4.1.9 Roofing material at Area 49 Shire and Mtandire

Overall 30 percent and below of surveyed houses were constructed with high-quality iron sheets. Roofing was mainly composed of low-quality iron sheets marred by leakages during the rainy season. A few surveyed houses were built with grass-thatched roofing. Even though the majority (100 percent Area 49 Shire and 95.9 percent Mtandire) of housing had iron sheet roofing. They were considerably of low quality, grass-thatched roofing constituted 4.1 percent of households in Mtandire as shown Figures 23 and 24.

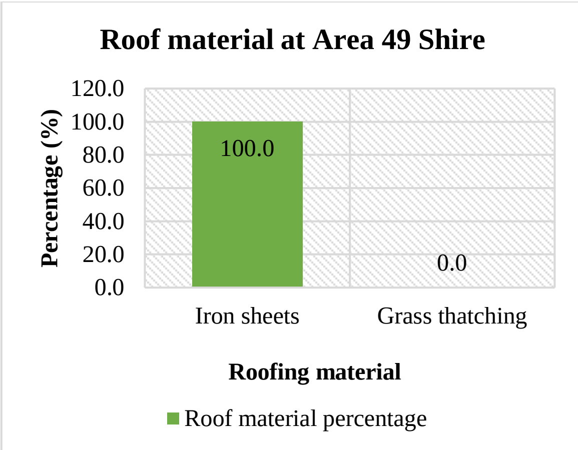


Figure 23: Roof material Area 49 Shire

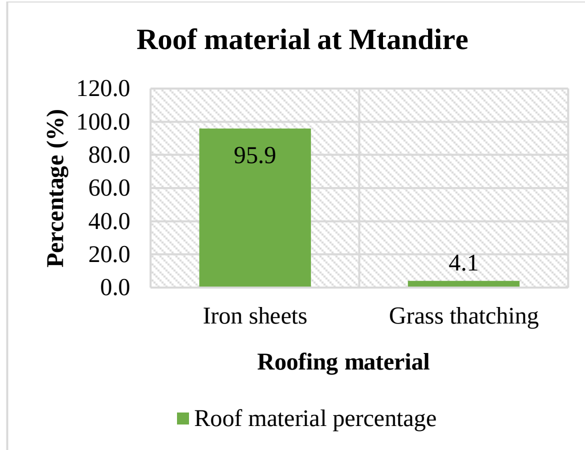


Figure 24: Roof material Mtandire

4.1.10 Wall material at Area 49 Shire and Mtandire

Burned bricks, unburned bricks and cement blocks constituted wall material in houses. A significant percentage (81.8 in Area 49 Shire and 55.9 in Mtandire) of houses were built from burned bricks while 14.3 percent in Area 49 Shire and 6.2 percent in Mtandire had cement blocks as wall material. Unburned bricks represented 3.9 percent in Area 49 Shire and 37.9 in Mtandire, as shown in Figures 25 and 26.

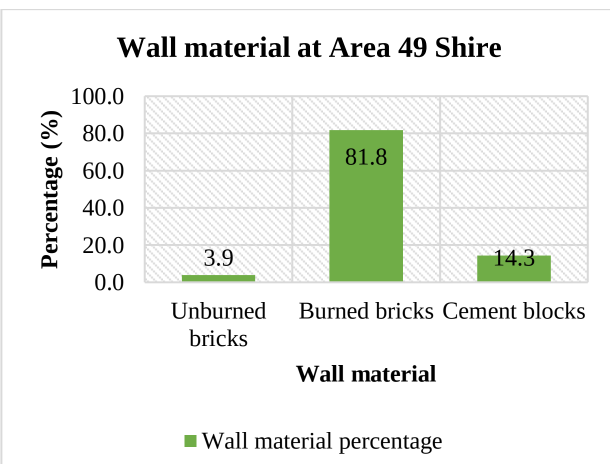


Figure 25: Wall material in Area 49 Shire

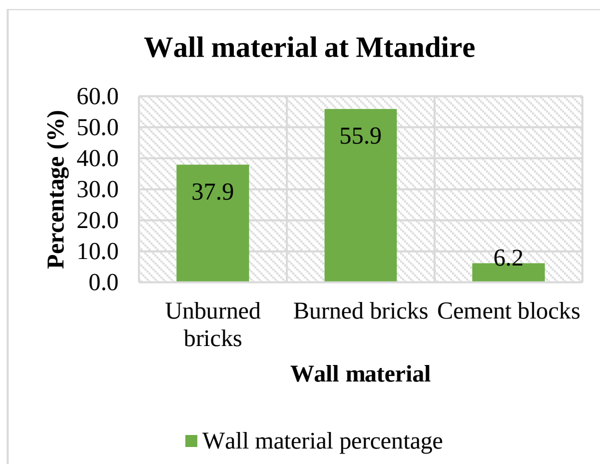


Figure 26: Wall material in Mtandire

4.2 Delineation of the floodplain of Lingadzi River in Lilongwe City at Area 49 Shire and Mtandire through development of 10, 50 and 100-years flood inundation maps.

The floodplain of Lingadzi River in the study area has been quantified through inundation boundary showing spots where flooding may occur at different locations in the settlements, as shown in figures 29, 32 and 35. Mtandire falls within generated inundation boundary, however only some Parts of Area 49 are covered in the inundation boundary. Inundation boundary on the eastern side reaches M1 road around Area 47 and Area 15. To the south it covers most parts of Area 47, Mtandire and Mtsiliza, other parameters quantified are as follows:

a) Water surface elevation, entailing the height of floods of various magnitudes and frequencies in the floodplains relative to a specified datum (as shown in Figures 29, 32 and 35). It indicates how high the water is expected to rise during a flood event in the settlements. The information is valuable for emergency planning, land use decisions, and flood risk assessments, as it helps communities prepare for and respond to flooding events.

b) Water velocity, indicate the maximum velocity (or speed of the water) in flooding at any given location (as shown in Figures 29, 32 and 35). It is crucial in assessing the potential risks and impacts of the flooding in the settlements. Higher water velocities can lead to more significant erosion, increased damage to structures, and pose greater danger to people and property. This information can also help in making evacuation plans, determining suitable flood control measures, and assessing the overall flood risk to a region.

c) Water depth, illustrating maximum estimated depth at a given point during a flood with the respective Annual Exceedance Probability (AEP) determined for 10, 50 and 100-year return periods, it is typically measured in feet or meters above a reference point, such as ground level or a specific benchmark, (as shown in Figures 29, 32 and 35). The depth of potential flooding illustrates how high the water level could rise in a given area around the delineated inundation boundary during a flood event. It is a crucial in understanding the potential impact of flooding on the settlements, and the safety of inhabitants in the affected areas. It is vital in aiding decision making regarding evacuation, flood protection measures, and disaster preparedness.

Inundation maps for the three return periods have been developed as shown in Figures 29, 32 and 35. The inundation maps have been overlaid with an open street map allowing the visualization of settlements constructed in the floodplain.

4.2.1 10-year flood inundation map at Area 49 Shire and Mtandire

The inundation boundary for the 10-year flood were quantified as illustrated in Figure 29. Figures 27 and 28 describe depth and velocity statistics at different locations in the floodplain.

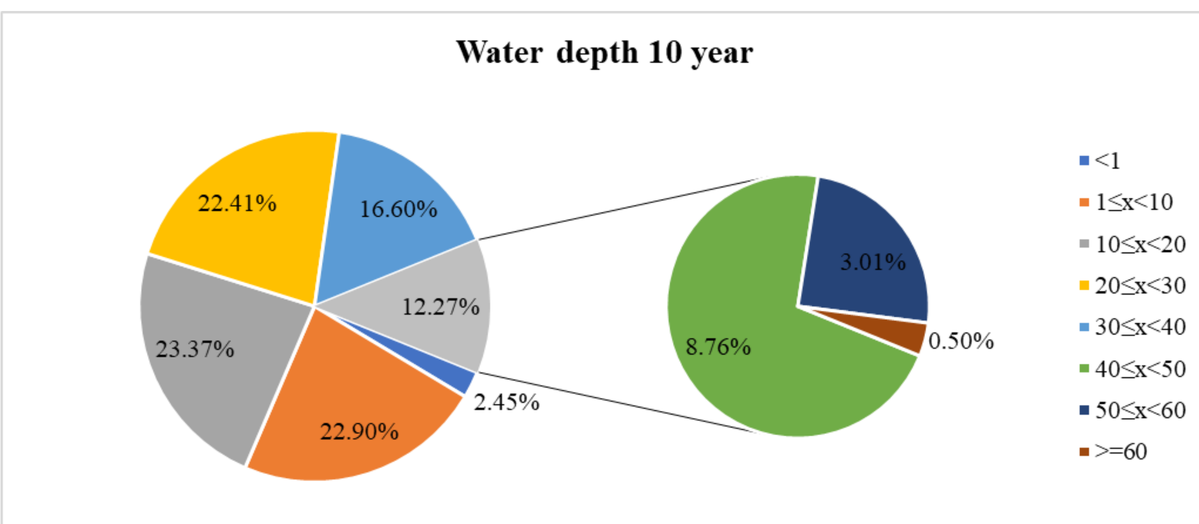


Figure 27: Distribution of water depth across the floodplain for 10-year flood

Observations made on the map boundary indicate presence of settlements in the floodplain. The surface water elevation ranges between 1060 and 1100 meters, the water depth between 0 and 64.82 meters, and lastly, water velocity ranges between 0 and 0.65 meters per second.

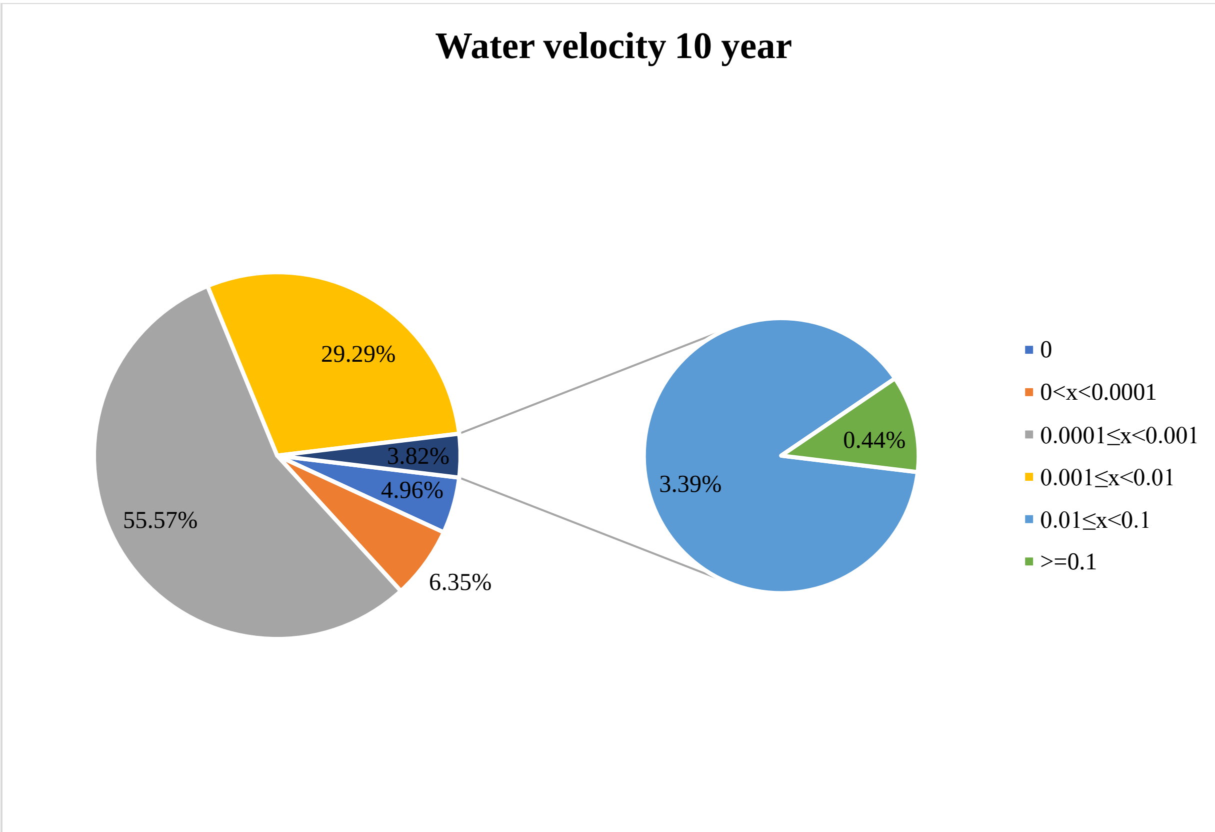


Figure 28: Distribution of water velocity across the floodplain for 10-year flood

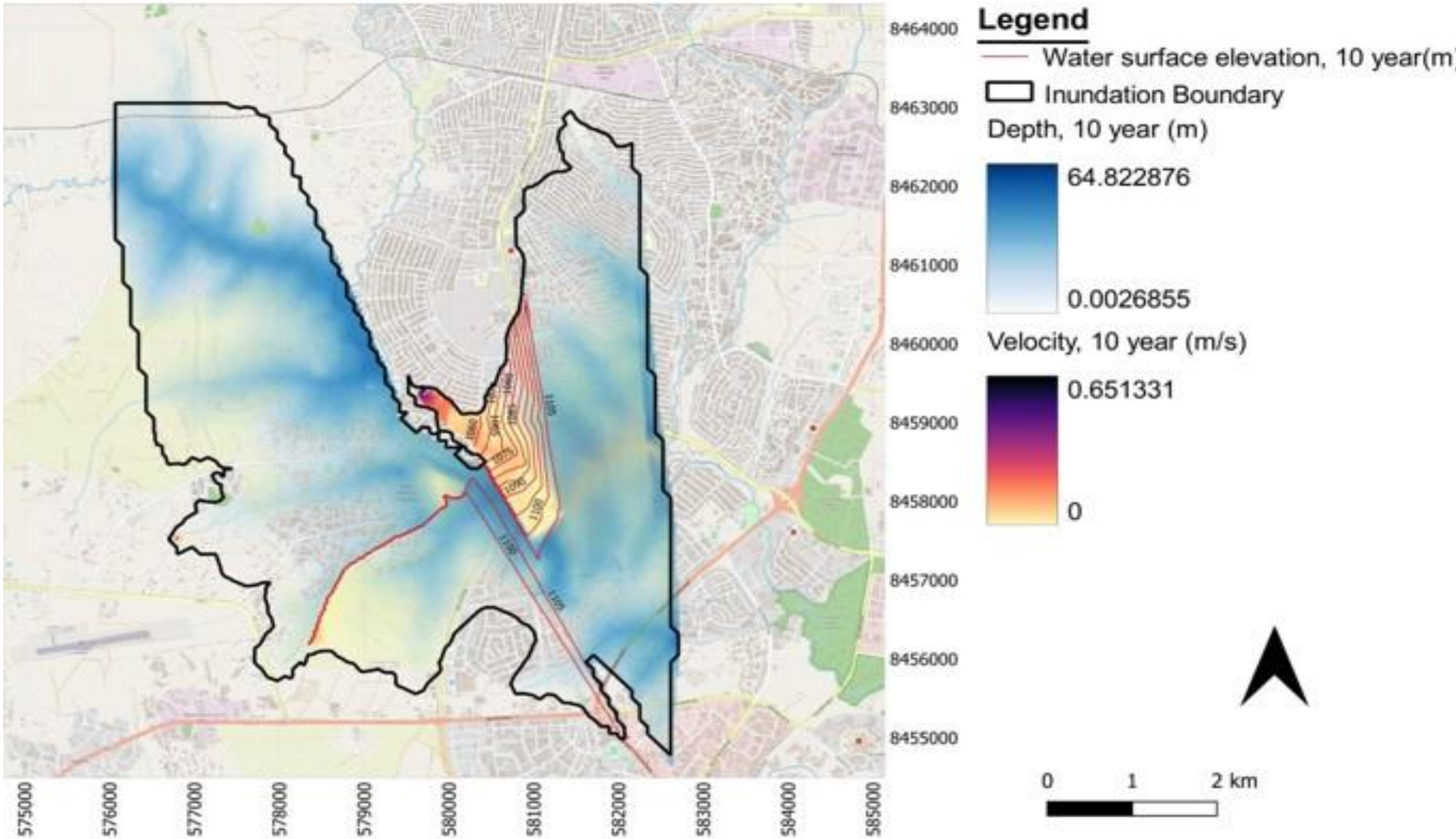


Figure 29: Flood inundation map for 10-year flood

4.2.2 50-year flood inundation map at Area 49 Shire and Mtandire

The inundation boundary for a 50-year flood was quantified as illustrated in Figure 32. Figures 30 and 31 describe depth and velocity statistics at different locations in the floodplain. The surface water elevation ranges between 1060 and 1100 meters, the water depth between 0.04 and 64.87 meters, and lastly, water velocity ranges between 0 and 1.48 meters per second.

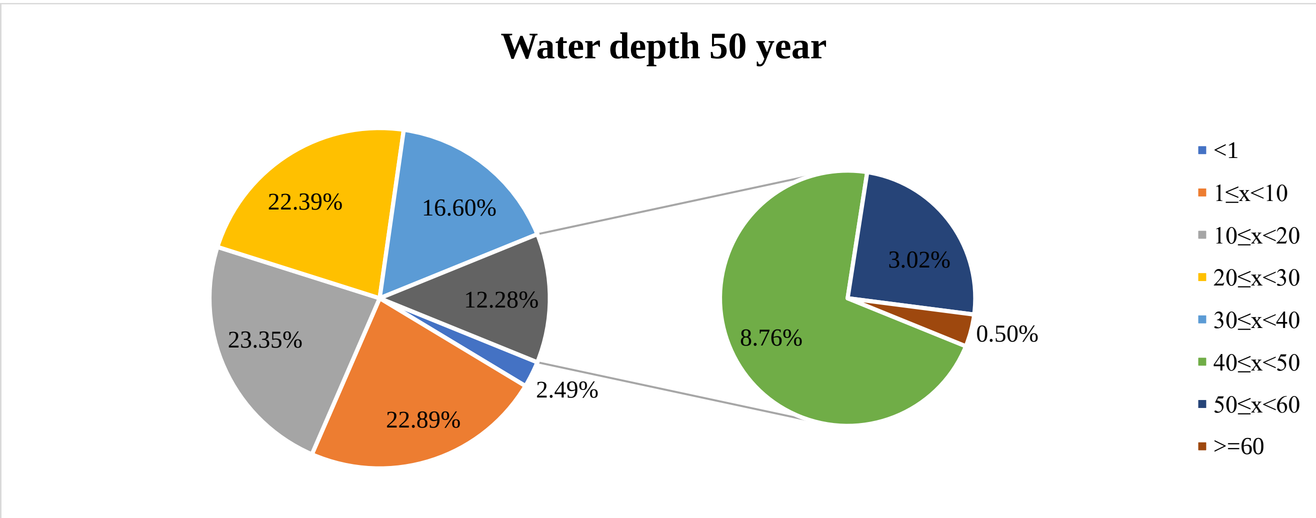


Figure 30: Distribution of water depth across the floodplain for 50-year flood

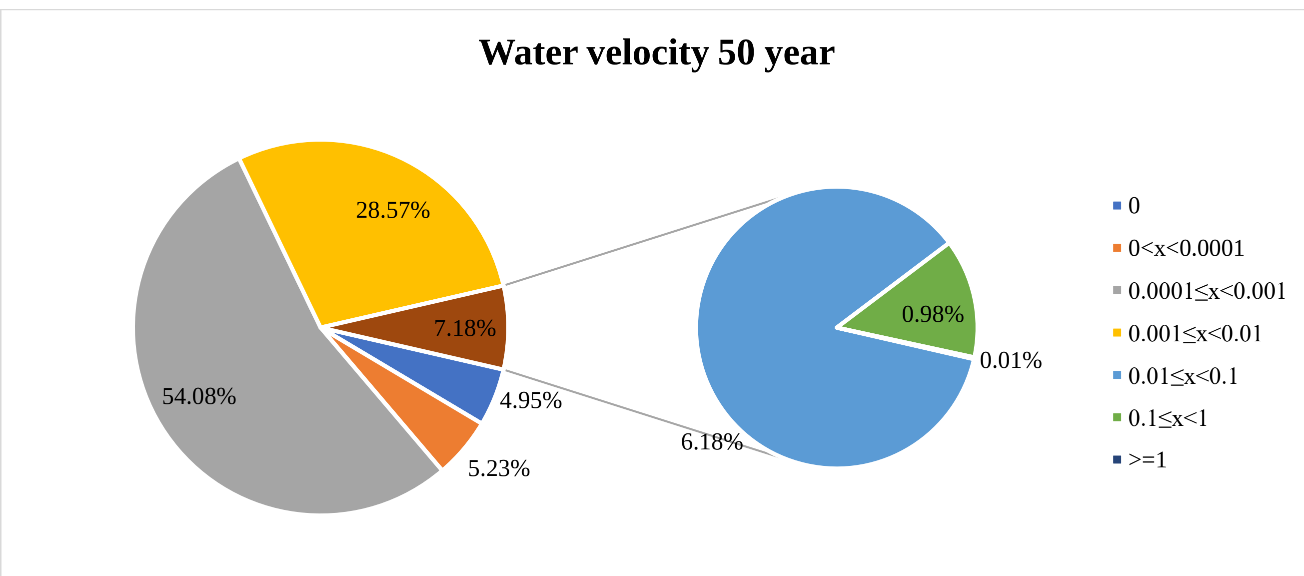


Figure 31: Distribution of water velocity across the floodplain for 50-year flood

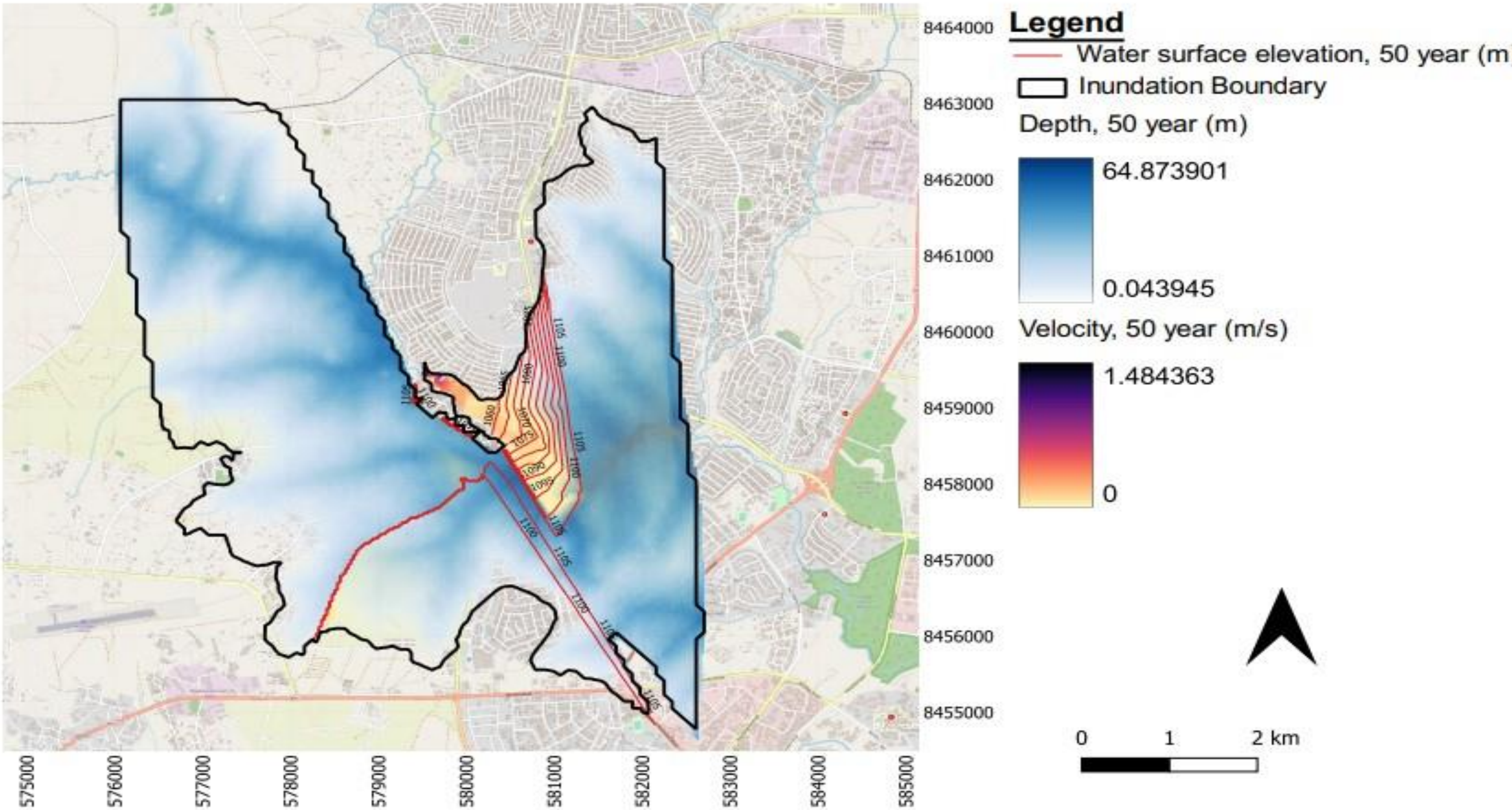


Figure 32: Flood inundation map for 50-year flood

4.2.3 *100-year flood inundation map at Area 49 Shire and Mtandire*

The inundation boundary for a 100-year flood was quantified as illustrated in Figure 35. Figures 33 and 34 describe depth and velocity statistics at different locations in the floodplain. The surface water elevation ranges between 1060 and 1100 meters, the water depth between 0 and 64.90 meters, and lastly, water velocity ranges between 0 and 2.40 meters per second.

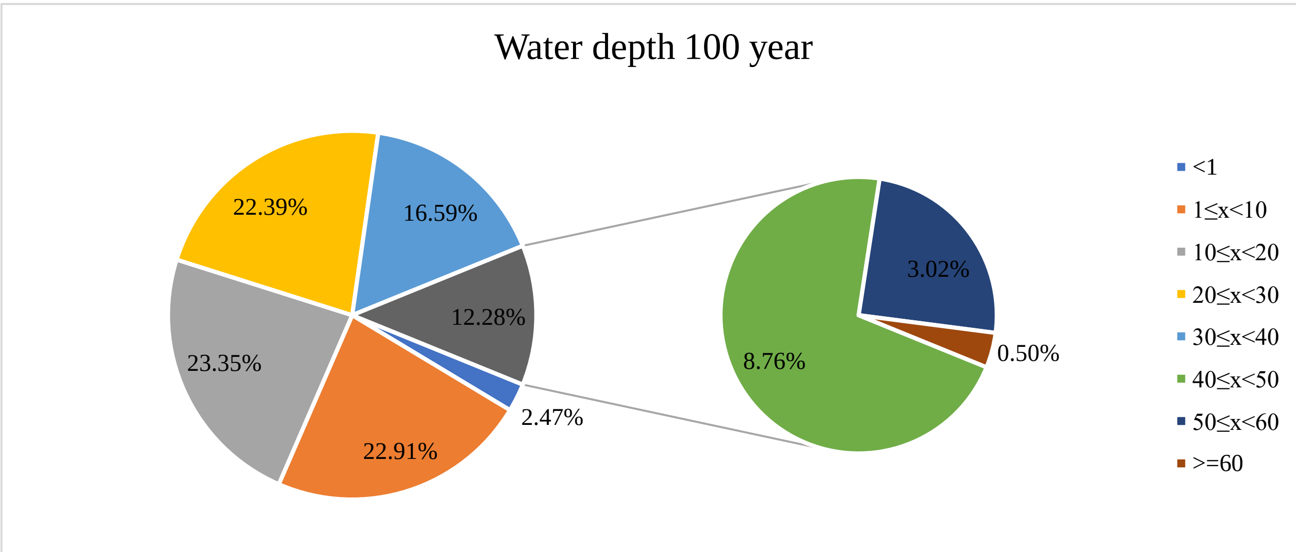


Figure 33: Distribution of water depth across the floodplain for 100-year flood

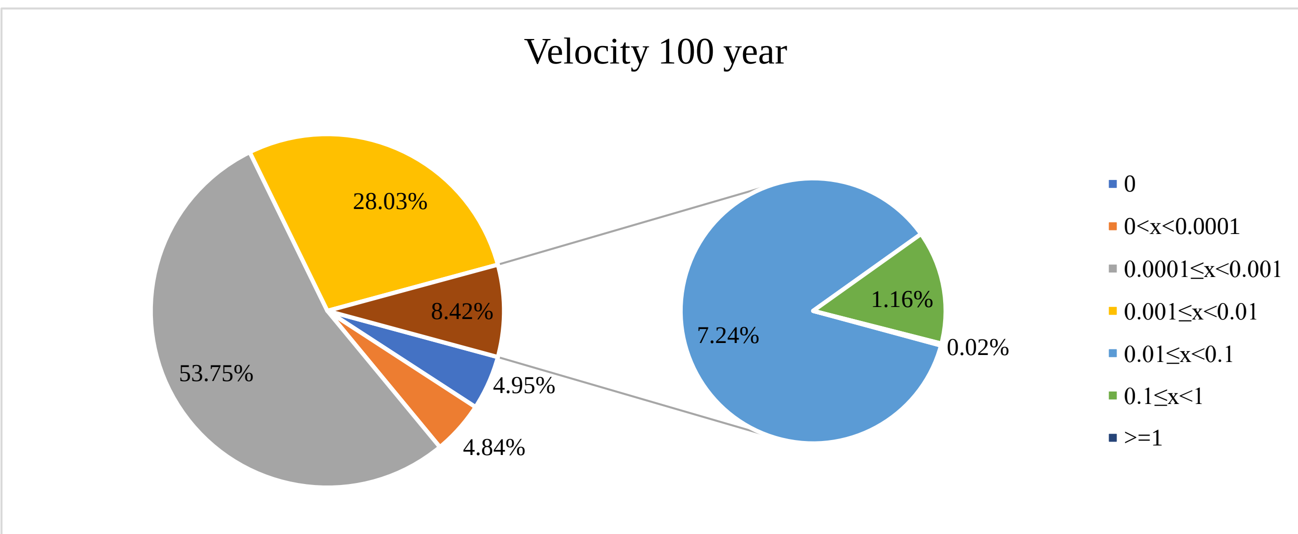


Figure 34: Distribution of water velocity across the floodplain for 100-year flood

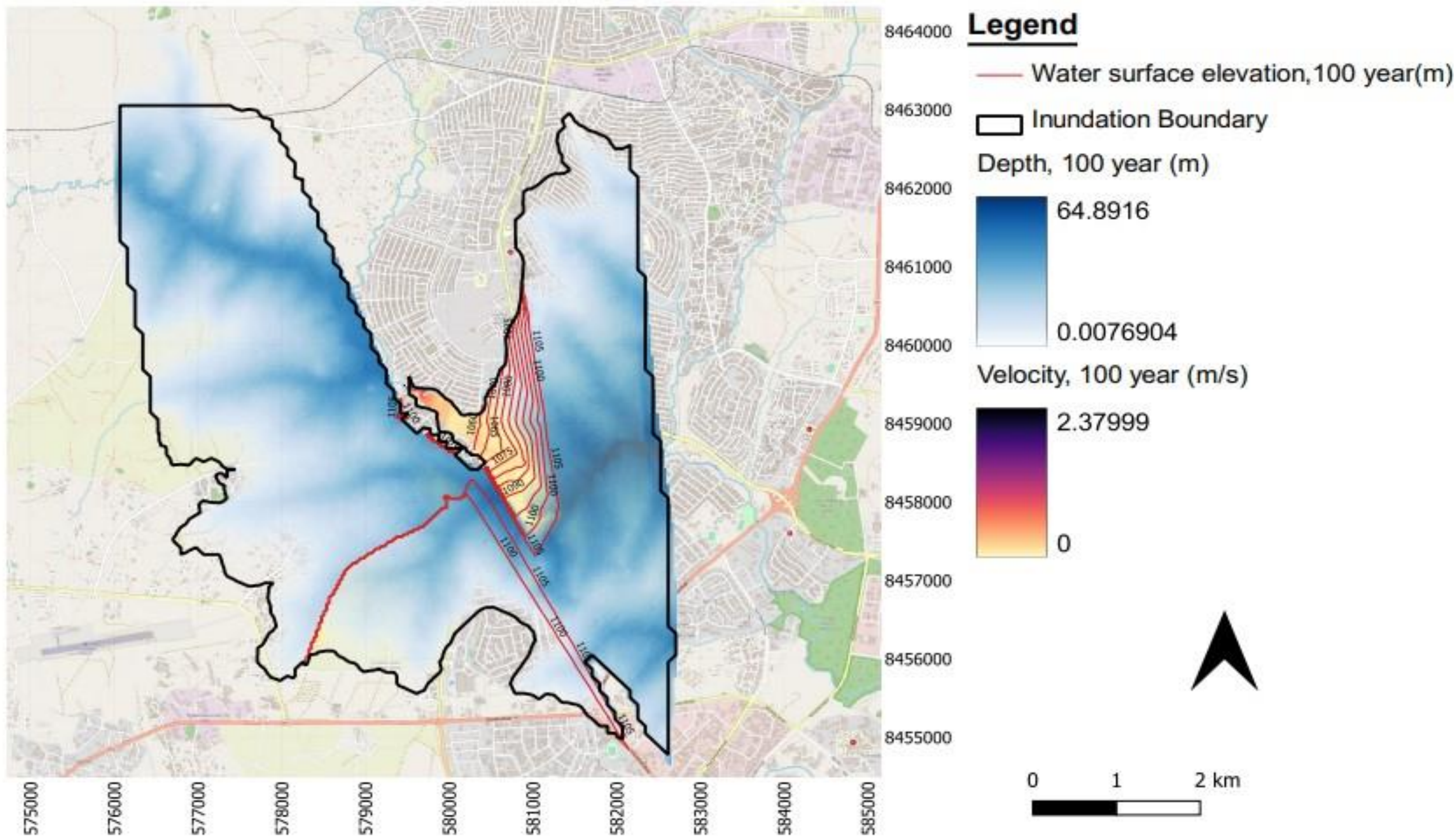


Figure 35: Flood inundation map for 100-year flood

4.3 Evaluation of flood occurrence frequency changes in urban floodplain of Lingadzi River in Lilongwe city at Area 49 Shire and Mtandire

Local knowledge analysis indicates that flooding has occasionally affected the residents of Mtandire and Area 49 Shire. The areas have been hit by two major flooding events in 1981 and 1992. According to locals flooding has however become an annual occurrence since the 2016/17 rain season. The large magnate flooding events which result in significant damage make it to the headlines. Residents however are occasionally affected by damages to livestock, houses and roads. Overall respondents agree that there has been an increase in flooding events, rainfall intensity, space covered by flood waters, flooding frequency, number of flooded days and damage caused by flooding in the areas.

Results on length of stay in the area indicate that 69.4 percent of respondents had stayed in the area for not more than 15 years. 20.3 percent have lived in the area between 15 and 30 years. Only 10.4 percent have lived in the area for over 35 years, results are shown in Figure 36.

Figure 36: Length of stay in study area

4.3.1 Rainfall intensity at Area 49 Shire and Mtandire

The research revealed through local perception is that rainfall intensity in the areas has increased, reasons given by respondents to justify the increase include:

a) In the face of heavy rainfall flooding occurs faster.

b) As flooding occurs flood waters turns to cover a larger area than in the past.

70 percent of the respondents in Area 49 Shire and 79 percent in Mtandire were in this view that indeed rainfall intensity had increased by that it floods at a faster rate during rainfall than in the past, 23 percent in Area 49 and 17 percent in Mtandire believed it is because the flooding turns to cover a larger area while 6 percent in Area 49 Shire and 4 percent in Mtandire believed that rainfall intensity has remained the same, results are as shown in Figures 37 and 38. Rainfall data from Department of Climate Change and Meteorological Services (DCCMS) between 1985 and 2005 is not conclusive in terms of increased as shown in Figure 41.

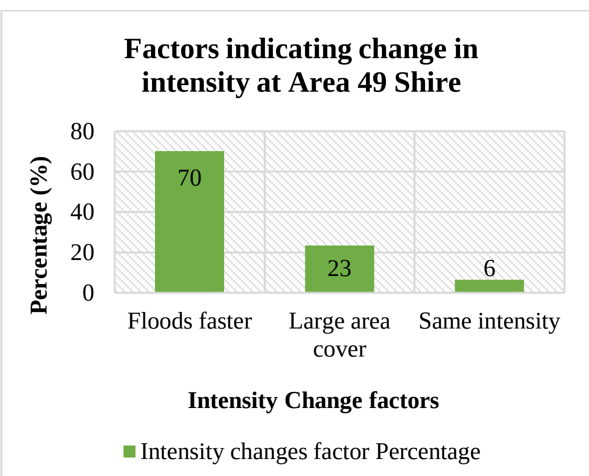


Figure 37: Indicators of intensity changes in Area 49 Shire

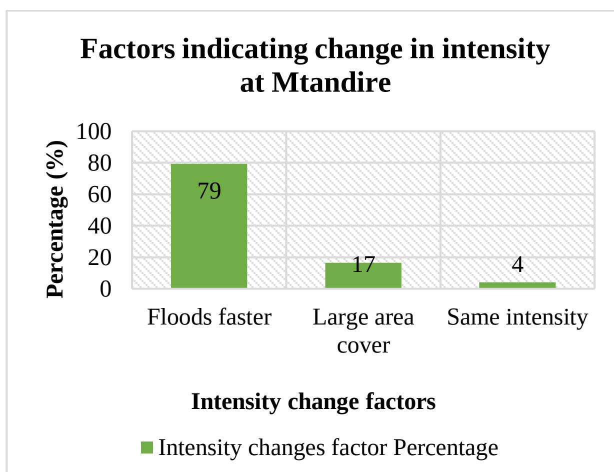


Figure 38: Indicators of intensity changes in Mtandire

4.3.2 Flooding frequency at Area 49 Shire and Mtandire

The locals indicated that flooding frequency in the study area has increased over the years, through local knowledge, reasons justifying an increase in frequency include;

a) Seasonal flooding has been noticed to have increased in recent years.

b) Property damage has been notice to increase during the rainy season.

Historical observed climatic data however, does not indicate significant raise in rainfall patterns in the country, there are no clear increase patterns noticeable as shown in Figure 44. World bank, (2020) also indicated lack of significant changes in rainfall patterns in Malawi. Results as illustrated in Figures 39 and 40 indicate show that 68.8 percent in Area 49 Shire and 75.9 percent in Mtandire believed flooding frequency increase is justified through seasonal flooding while 31.2 percent in Area 49 Shire and 24.1 percent in Mtandire believed it can be justified through increased property damage.

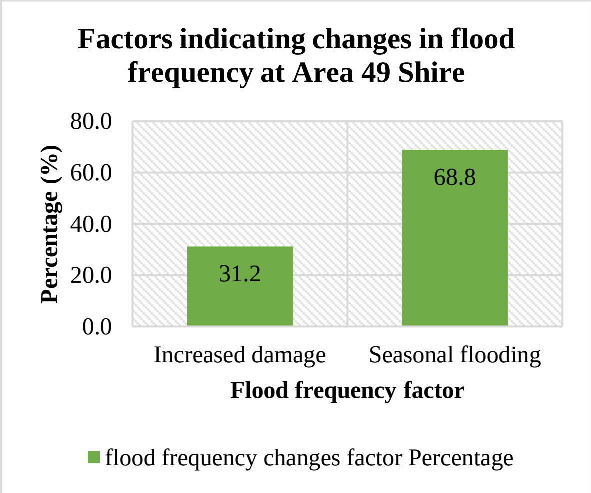


Figure 39: Indicators of flood frequency changes in Area 49

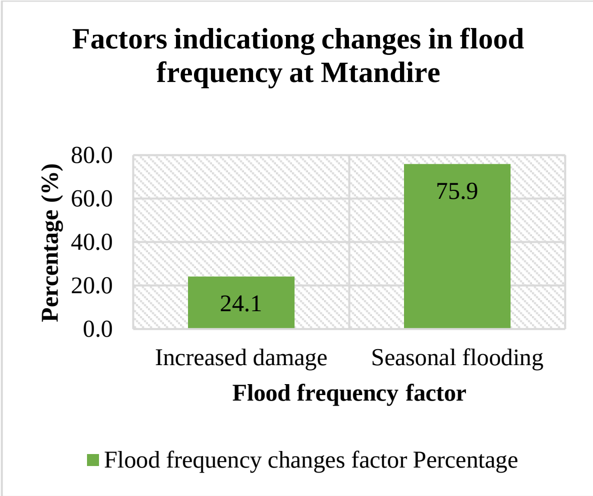


Figure 40: Indicators of flood frequency changes in Mtandire

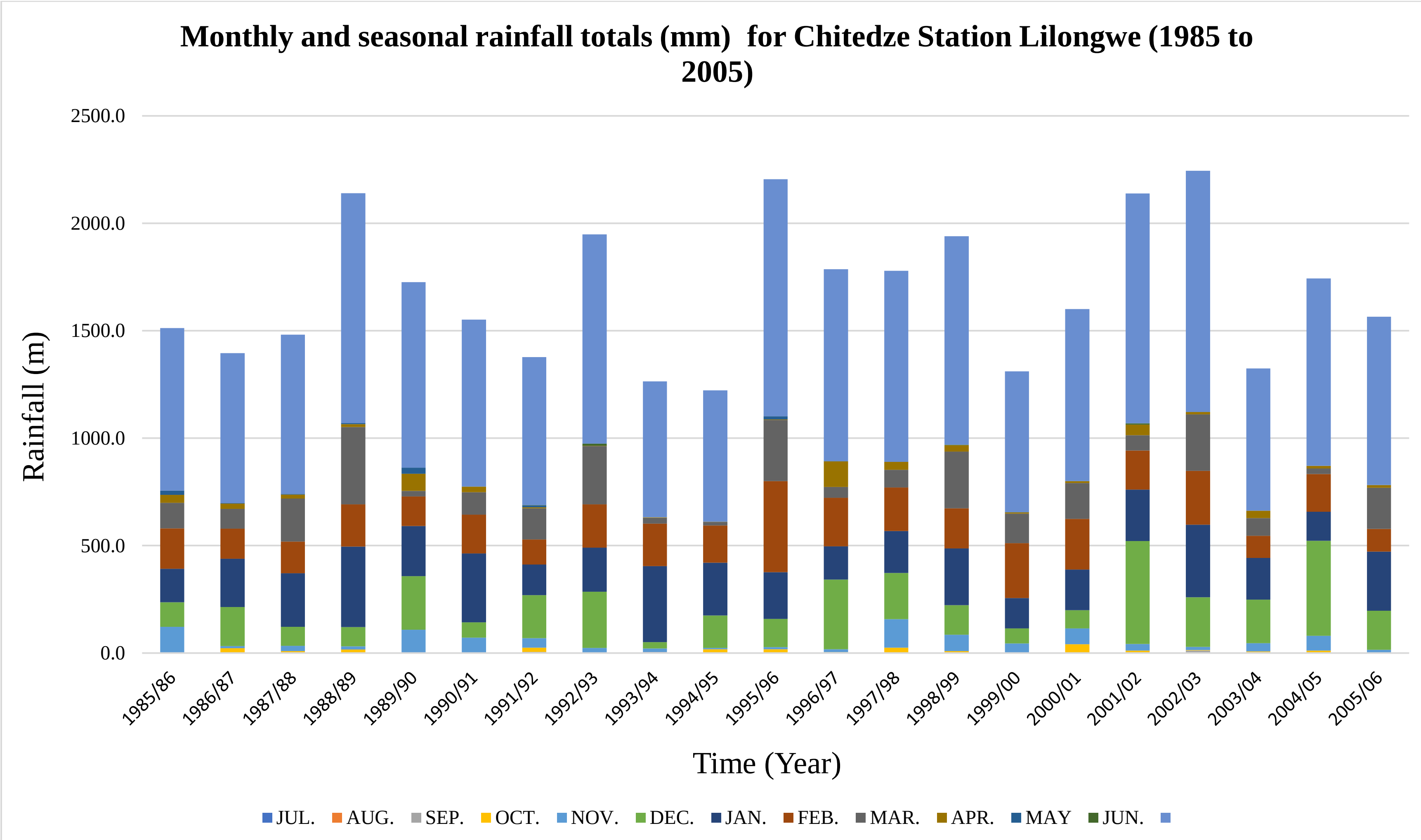


Figure 41: Historical rainfall data for Malawi sourced from DCCMS

4.3.3 Space covered by flood waters at Area 49 Shire and Mtandire

There have been changes is area covered by floodwater over the years illustrated by local knowledge analysis. Respondents indicating increase in area covered by flood waters constitutes 67.1 percent in Area 49 Shire and 65.5 in Mtandire. Figure 42 taken in January 2023 show behavior of flood water during rainfall in Mtandire.

Figure 42: Space covered by water in Mtandire

Some respondents believed that the area covered by flood waters has decreased over the years (5.4 percent in Area 49 Shire and 8.3 Percent in Mtandire), others believed it has remained the same (14.4 Percent Area 49 Shire and 15.9 percent in Mtandire) and others believe that it fluctuates from season to season (13.1 percent in Area 49 Shire and 10.3 percent in Mtandire), as shown in Figures 43 and 44.

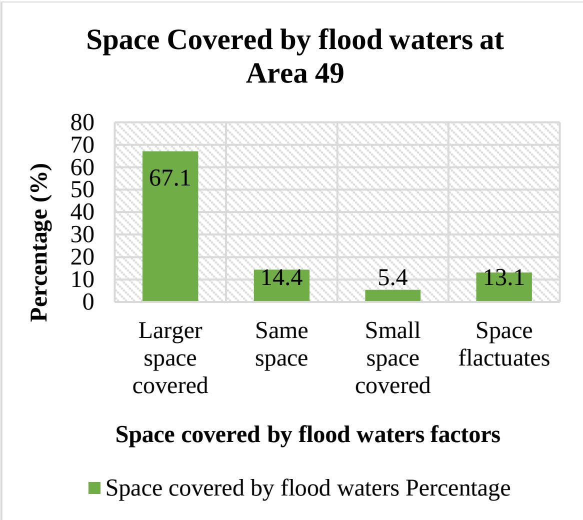


Figure 43: Flood water coverage analysis Area 49

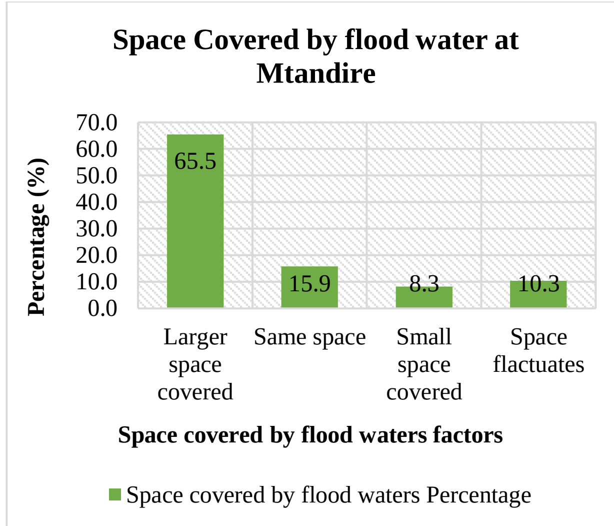


Figure 44: Flood waters coverage analysis Mtandire

4.4.4 Property damage at Area 49 Shire and Mtandire

Respondents reported an increase in property damage due to flooding over the years. Damage on fence, walls, roof, livestock and sometimes life has been observed during almost every rainy season since the 2016/7 season. Even though 77.9 percent in Area 49 Shire and 75.9 percent in Mtandire believed that there was increase in damage due to flooding in the areas others opinions included decrease in damage (1.3 percent in Area 49 Shire and 4.8 percent in Mtandire), fluctuating damage (15.6 percent Area in 49 and 9.7 Percent in Mtandire), no damage (3.9 percent in Area 49 Shire and 8.3 percent Mtandire) and same damage (1.3 percent in Area 49 Shire and 1.4 percent in Mtandire), as shown in Figures 45 and 46.

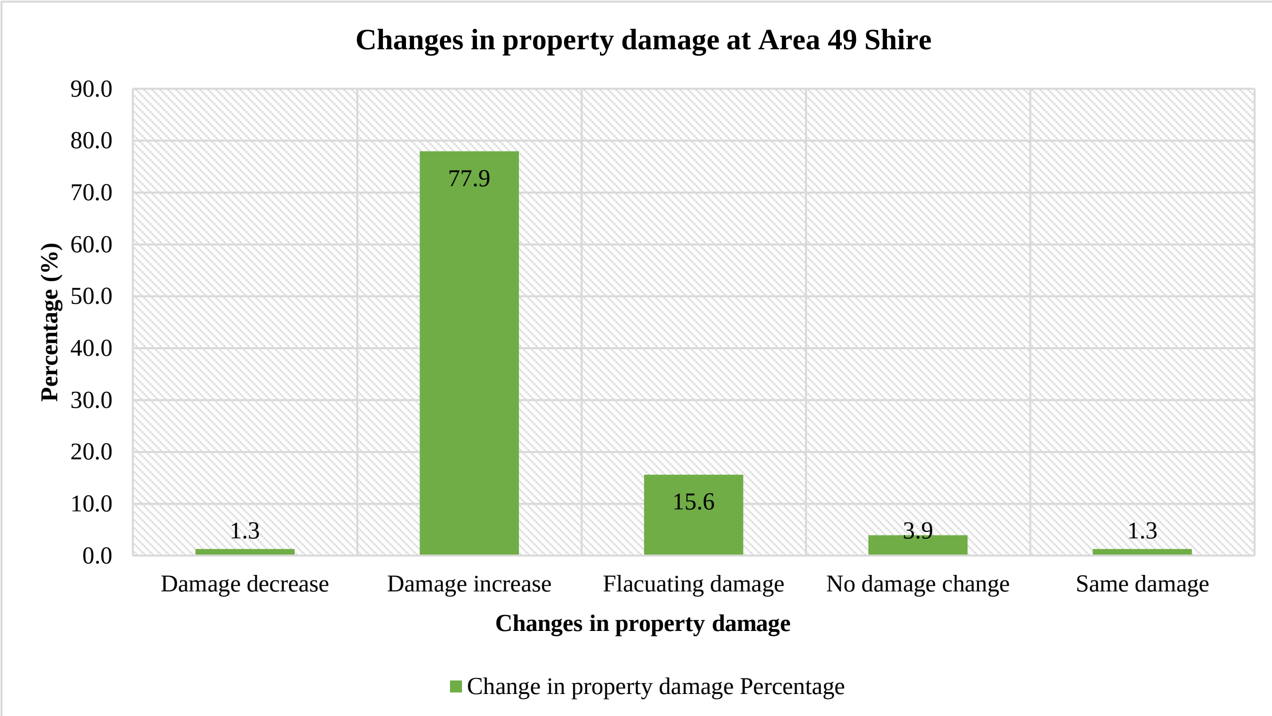


Figure 45: Changes in property damage in Area 49 Shire

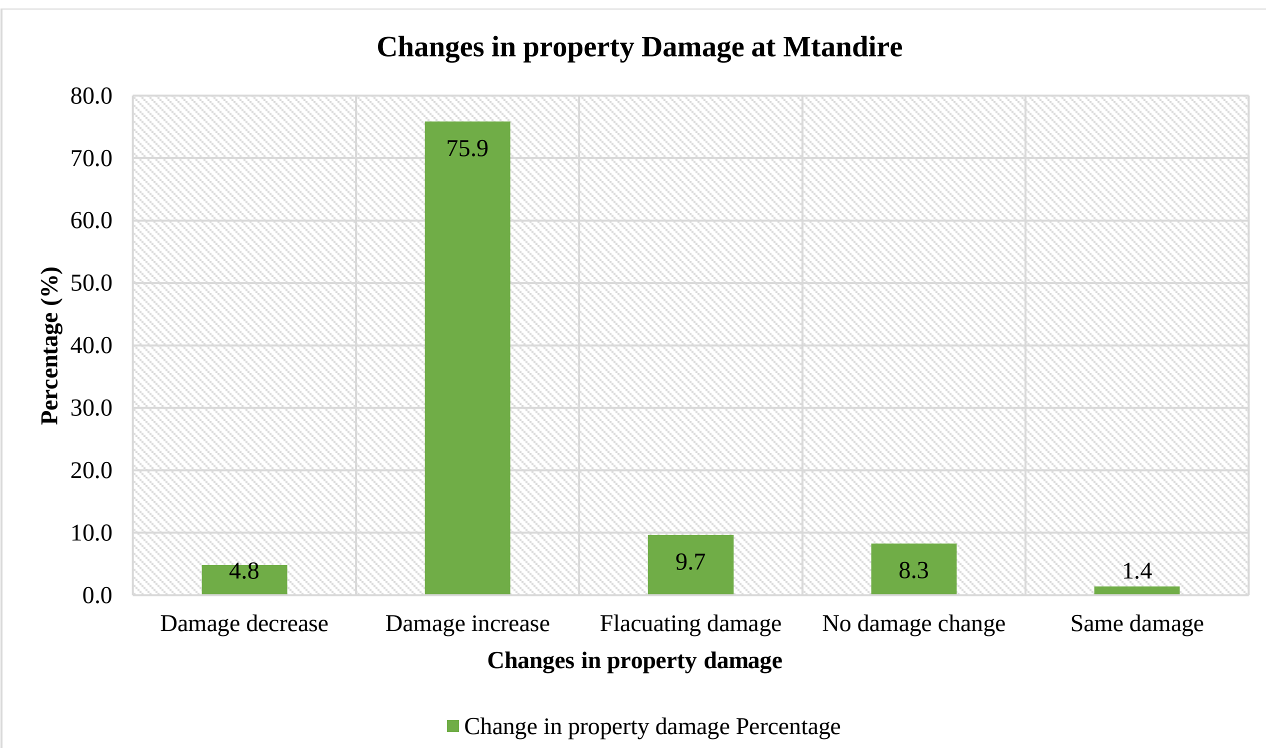


Figure 46: Changes in property damage in Mtandire

4.4.5 Number of flooded days at Area 49 Shire and Mtandire

There has been an increase in the number of flooded days during flooding events in recent years according to local knowledge analysis. The majority of respondents agreed that the flooding turns to take several days and that water takes longer to go back to lower levels (83.1 percent in Area 49 Shire and 75.2 percent in Mtandire). Respondents representing 1.3 percent in Area 49 Shire and 8.3 percent in Mtandire believed that the number of flooded days have decreased finally, 15.6 percent in Area 49 Shire and 16.6 percent in Mtandire believed they have remained constant, results are shown in Figures 47 and 48.

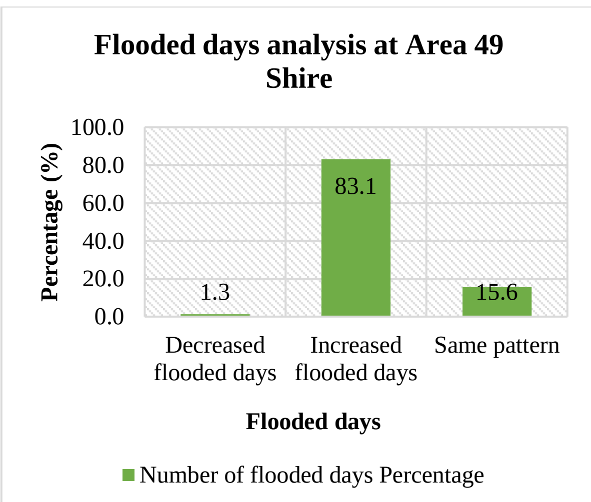


Figure 47: Flooded days analysis Area 49

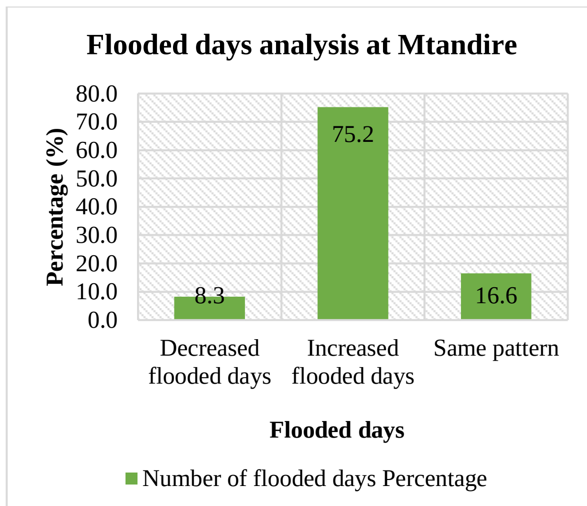


Figure 48: Flooded days analysis Mtandire

4.6 Conclusion

Results from the analysis in Chapter four have characterized the informal settlements and confirmed the presence of informal settlements in floodplain of Lingadzi River, detailing the presence of settlements in undesignated area which in turn has meant residents have been affected by the river's flooding during rainy season. Chapter four has presented findings from both quantitative and qualitative analysis addressing the three research questions of the study. In-depth discussion of the findings will be tackled in chapter five and recommendations in chapter six.

CHAPTER 5. DISCUSSIONS

This chapter discusses results from the settlement characterization, flood inundation mapping and flood frequency occurrence presented in chapter Four. The discussion is based on the study conducted to address the three research questions. A comparison with other similar studies is also illustrated.

5.1 Characteristic of informal settlements in floodplain of Lingadzi River in Lilongwe city at Area 49 Shire and Mtandire

It has been revealed that the settlements are characterized mostly by simple, stand-alone housing lacking facilities expected in urban society (such as distinctive boundary, paved roads, direct piped water supply, flush toilets and quality iron sheets) most of which are in poor condition. The UN, (2015) also confirms that informal settlements are excluded from urban opportunities and disengaged from broader urban systems. The results also aligned with Zhang et al., (2020), who revealed that informal settlements have become a vital supplement to the inadequate formal housing supply in most sub-Saharan cities however, the settlements lack conformation to the social, economic and environmental characteristics of sustainable development, this has also confirmed by this study. A study by Sakijege et al., (2014) found that construction in informal settlements was carried out with insufficient attention to acceptable technical practice, this study also observed lack of technical expertise in construction of most dwelling houses and sanitation facilities. Informal settlements are vital to the social-economic markup of most sub-Saharan cities as backed by the reviewed literature. However, it is important to understand how the presence of the settlements in high-risk areas such as floodplains are influencing the occurrence of flooding in these areas. There is, therefore, a need for better policies in how these settlements are organized and managed so that they can conform to urban planning guidelines and have facilities indicative of urban society which can able to withstand natural disasters.

5.1.1 Structure age at Area 49 Shire and Mtandire

With a significant percentage of housing in the settlements constructed within the last decade, the effect has been the growth of informal settlements. The settlements have now been constructed in places where the river normally releases water in times of high flow. Settlements have been constructed lacking appropriate drainage structure and conformation to building regulations. The EEA, (2016) also observed increase in the presence of settlements in floodplains in most European cities in recent decades.

5.1.2 Land tenure at Area 49 Shire and Mtandire

Buildings were constructed on land which was acquired through customary laws without guidance from relevant authorities. Construction of housing in urban floodplains requires guidance from Authorities from LCA and NWRA as observed in Malawi Government, (2013). These results concur with the Malawi Government, (2019c) through the NUP which highlighted the lack of coordination in land acquisition in urban Area.

5.1.3 Access to basic facility at Area 49 Shire and Mtandire

Even though the settlements scored 5 on the rating scale entailing over 70 percent access to basic facilities, the current status of the services is below acceptable levels. Although there is some access to road network, water, electricity and sanitation in the settlements, the quality of the services is below standards and needs to be improved. Inhabitants face challenges due to inadequate infrastructure, impacting their daily lives. This has also been echoed in UN, (2015) who found that informal settlements lack access to basic facilities.

5.1.4 Access to roads at Area 49 Shire and Mtandire

The road network is mostly unpaved and in poor condition characterized by dust and potholes. Settlers rely mostly on bicycle and foot to move from one place to another. The roads remain underdeveloped and poorly maintained leading to difficulties in transportation, especially in rainy season. The limited road infrastructure can impact access to essential services and economic opportunities. These results are in line with the findings of Zhang et al., (2020), who found that informal settlements had limited access to better services.

5.1.5 Access to water at Area 49 Shire and Mtandire

Access to clean water in the informal settlements is a significant challenge. Residents mostly rely on communal kiosks for water supply often sourced in open buckets, located at a distance and overcrowded at peak hours. This leads to long waiting hours, sometimes unsanitary conditions and compromised water quality. Some houses have access to piped water systems, wells and boreholes. However, ensuring clean water remains an ongoing challenge in the settlements. The results tally with Visagie and Turok**,** (2020) who also found Lack of planning in informal settlements in most African cities has translated to lack of infrastructure that would improve access to clean water, sanitation and electricity.

5.1.6 Access to electricity at Area 49 Shire and Mtandire

Electricity in the settlements is sourced from either the national grid through ESCOM or through solar power. The high cost of electrification means most households cannot afford direct connection from the national grid. Results from Annamalai et al., (2016) also found access to electricity in informal settlements a challenge in most African cities.

5.1.7 Access to sanitation facility at Area 49 Shire and Mtandire

Sanitation facilities in the settlements are mostly located outside the houses, this can be a hazard, especially at night. In some cases, residents have to share sanitation facilities which can be a health hazard. High figure in the lack of sanitation facilities in Area 49 is attributed to the significant number of houses still under construction. Results also coincides with John, (2020) that found that sanitation facilities were located outside houses in the informal settlements of Tanzania.

5.1.8 Roofing material at Area 49 Shire and Mtandire

Overall less than 30 per cent of households have high-quality roofing material even though 97.3 per cent had iron sheet roofing. This according to Zhang et al., (2020) gives the settlements a low score in terms of roofing material. The roofing was mostly characterized by low-quality iron sheets lacking professional installation, fitted in place with rocks, marked by collusion and likely to leak during the rainy season. The results concur with Sakijege et al., (2014) that also noticed poor workmanship in informal housing. A minority of the housing had grass-thatched roofing which is not aesthetically conducive to the urban setting and has a high potential for leakages at ridges, valleys or corners. The roofing is vulnerable to damage during heavy rains and strong winds and may easily be damaged during floods.

5.1.9 Wall material at Area 49 Shire and Mtandire

Wall material in the settlements is characterized by burned bricks and cement blocks giving the settlements a high score on the rating scale according to Zhang et al., (2020). However, it was observed that low-quality mortar was used to construct the walls. In some cases, mud was noticed to have been utilized as mortar for wall construction with burned bricks.

In addition, 26 percent of walls comprised unburned bricks. Both scenarios make the buildings vulnerable to disasters during heavy rainfall and flooding. Poor construction technique in informal settlements was also observed by Sakijege et al., (2014).

5.2 Flood inundation maps of Lingadzi river in Lilongwe city in Mtandire and Area 49

The inundated area was overlaid with an open street map (as shown in Figures 29, 32 & 35) some settlements are observed to be under the delineated inundation maps. The features under inundation maps comprises of settlements, road infrastructure and agricultural land making the settlements vulnerable to flooding events at any given time. Field surveys confirmed the scenario, homes were noticed to have been constructed close to the river banks. This has been taking place regardless of clause 3.4.17 of the NWP which states that" there *shall be no agricultural and infrastructure construction activities below the 477- meter above mean sea level contour line along Lake Malawi and below the 100-year flood water level along rivers, except where written authority from the responsible minister is granted".* A similar study by Fosu et al., (2012) along the Susan River in Ghana also revealed significant floodplain encroachment by informal settlements located close to the river which has led to frequent flooding.

5.2.1 Inundation boundary at Area 49 Shire and Mtandire

The floodplain inundation boundary for the three return periods are shown in Figures 29, 32 & 35. The difference between the inundation boundaries including space and ground coverage for the three return periods cannot be noticed under the HECRAS 1D steady flow analysis. These results are consistent with the findings of Hajibavov et al. (2017) that found similar results for 5, 10, 50 and 100–year return periods on HECRAS 1D steady flow analysis, however the study found different results for the four return periods from a HECRAS 2D unsteady flow analysis.

The inundation boundary was different in terms of space and ground coverage. The inundation boundary for this study covers areas around Area 18, Area 47, Area 49, Mtandire and Mtsiliza. The results show that there is some encroachment of the floodplain and more needs to be done to manage the situation.

5.2.2 Water depth at Area 49 Shire and Mtandire

The water depth for the three return periods had maximum of 64.87 meters, 64.82 meters and 64.89 Meters respectively, there is a significant difference in the depth percentage spread across the floodplain (as shown in Figure 29, 32 & 35). Water depth is significantly high in areas along the main channel of the Lingadzi River and its tributaries. The water gently flows across the floodplain as it lowers in depth (as shown in Figures 29, 32 & 35) covering most of the boundary. The results are consistent with study conducted by Forkuo et al., (2014), that also found that water depth was higher in areas along the river channel in their study.

5.2.3 Water velocity at Area 49 Shire and Mtandire

There are noticeable differences in water velocity between the three return periods with maximum of 0.65m/s 1.48 m/s and 2.38 m/s respectively (as shown in Figures 29, 32 & 35). Higher water velocities could be attributed to higher sloping ground while lower velocities could be attributed to flat areas and areas further away from the main river channel and its tributaries. Areas with higher water velocity, depth and elevation are likely to experience significant erosion, increased damage to structures, and pose greater danger to people and property.

5.3 Flood occurrence frequency changes in urban floodplain of Lingadzi River in Lilongwe city Area 49 Shire and Mtandire

Flood occurrence pattern has changed in Malawi affecting communities that were not traditionally known to have been flood-prone (Malawi Government, 2019b).

The results from this study indicate that the perception of locals is that there have been changes in flood occurrence in the areas with noticeable changes in rainfall intensity, flooding frequency, space covered by flood waters, property damage and number of flooded days, however data from DCCMS does not give a clear indication on significant increase in rainfall pattern. Community perception on increase was also echoed by Kasel et al., (2019) in Ghana, who through local knowledge analysis found that locals felt that there were significant changes in rainfall patterns concerning changes in precipitation, specifically about onset, quantity, intensity and distribution with noticeable effects on the flood occurrence in their locations. While they may be arguments as to what has caused the significant changes in flood occurrence such as rainfall changes attributed to climate change we can also not dispute the fact that in recent years Malawi has seen the growth of urban informal settlements in vulnerable spaces. The land use changes have affected the occurrence of flooding in vulnerable areas which were not previously designated as flood-prone regions.

5.3.1 Rainfall intensity at Area 49 Shire and Mtandire

The results from community perception indicates that there has been a shift in rainfall intensity in the last decades. This is echoed by the fact that flood water turns to occupy a larger space than before and it takes less time for flooding to occur compared to previous decades. Increased flooding intensity has been observed on an annual basis since the 2016/7 rain season according to the community which has been supported by various reports such as Floodlist, (2015); Davies, (2017). Locals observe that when rainfall occurs it takes less time for the area to become flooded, this can however also be eluded to the growth of settlements close to the river banks which have increased surface runoff from the river as the structures significantly reduce water infiltration.

This has resulted in the increase of peak discharge, volume and frequency of floods in the streams (United States Government, 2015). These sentiments were also eluded by Davies, (2017), that reported increase in flooding events in the informal settlements along Lingadzi River. Rainfall data from DCCMS between 1985 and 2005 does not show consistent increase in rainfall pattern.

5.3.2 Flooding frequency at Area 49 Shire and Mtandire

Local knowledge revealed that community perception is that flooding frequency has increased over the past decades. Flooding has been noticed on an annual basis since the 2016/7 season. With floods occurring each rainy season and increased property damage. The frequency changes could also be attributed to settlements being constructed close to the river banks which causes slight changes in river flow to be noticed, this can be substantiated by the DCCMS data which does not indicate significant increase in rainfall pattern.

5.3.3 Space covered by floodwaters at Area 49 Shire and Mtandire

In general, outcome was that the community perceived that space covered by flood waters has increased over the years backed by the fact that damage from flood waters had increased, more houses have been affected and larger space is covered by flood waters. It is evident that settlements have increased in size but also the water seems to cover a larger distance. These results are consistent with Kasel et al., (2019) that also found that community perception indicated changes in space covered by flood water.

5.3.4 Property damage at Area 49 Shire and Mtandire

The community indicated that there has been an increase in the property damage due to flood waters. Damage ranges from walls, roads, roofs, livestock and sometimes even loss of life. Settlers close to the river banks observed more frequent damage. Davies, (2017) aslo reported damage due to floodwatres in Lingadzi River.

5.3.4 Number of Flooded days at Area 49 Shire and Mtandire

Results from community perception indicated an increase in the number of flooded days. It takes longer time for the water to return to normal levels when flooding occurs. This could also be attributed to the growth of settlements in undesignated areas with water-logged conditions. Those staying closer to the river believed it takes longer for flood waters to clear.

CHAPTER 6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study was set to assess effects of informal urban floodplain settlements on increased flood frequency along the Lingadzi River. On characterizing the informal settlements of Mtandire and Area 49 Shire results found that the majority of housing in the settlements lack access to quality and improved basic facilities (paved roads, electricity and piped water supply) expected in urban settlements. The settlements are marked by single-story, semi-detached and standalone housing with simple architectural designs covering small areas, roofed with low quality iron sheets and compromised building material. The majority lacking distinct boundaries and paved road network constructed after 2010. However, some housing in the settlements has been distinguished by formal designs with modern architectural, electricity, distinctive boundaries and good qualify wall as well as roofing material. The study has therefore shown that construction of low-quality housing in flood-prone zones, close to the river banks has an impact on increased level of vulnerability to natural disasters such as flooding.

The delineated 10, 50 and 100-year flood maps indicate the presence of settlements in floodplain. Regions where flooding may occur at different locations can also be noticed, with areas located close to the river and its tributaries registering high water depth. There is a slight difference between Water depth, and water velocity for the different return periods which can be noticed on the generated maps. The difference in inundation boundary for the different return periods is not noticed under the computation and simulation used for this analysis.

Flood occurrence frequency in the study area has been on the increase since the 2016/17 rain season, with flooding occurring every rainy season.

An increase in flooding intensity, space covered by flood waters, number of flooded days and damage caused by flood waters has been noticed over the years. Local perception indicates the belief that flood occurrence frequency is changing in the area. It is therefore imperative that heavy investment is made in strategic institutional and stakeholder framework towards effective floodplain management that will allow for better management of flood-prone regions in the area that in the end will help in the reduction of damage caused by flooding.

6.2 Recommendations

Recommendations made to stakeholders involved including planners and residents on how they can adapt to the situation including:

A) Guidelines should be put in place to direct the type of infrastructure to be constructed in floodplains for all new developments. New developments must be approved by authorities before construction to ensure conformity to standards and buildings codes.

B) There is need for better enforcement strategies from the LCA and NWRA on clauses stipulated in the 2018 Water Resources Regulation on floodplain settlements, encroachments and building codes. Studies involving different floodplain delineation techniques and software should be explored.

C) Development of Sensitization programs in flood-prone zones through the distribution of maps and community awareness programs so residents are aware and knowledgeable of the existing flood-prone zones. Flood risk mitigation strategies must be put in place in the areas to help communities deal with annual flooding events.

REFERENCES

Abunyewah, M., Erdiaw-Kwasie, M.O., Okyere, S.A., Thayaparan, G., Byrne, M., Lassa, J., Zander, K.K., Fatemi, M., and Maund, K., 2023, ‘ Influence of personal and collective social capital on flood preparedness and community resilience: Evidence from Old Fadama, Ghana’, International Journal of Disaster Risk Reduction, 94 (2212-4209), 103790, viewed on 2 July 2023, from https://doi.org/10.1016/j.ijdrr.2023.103790.

Afshari, S., Tavakoly, A. A., Mohammad, A. R., Zheng, X., Follum, M. L., Omranian, E., and Fekete, B., 2018, ‘Comparison of new generation low-complexity flood inundation mapping tools with a hydrodynamic model’, Journal of Hydrology, 566(2018), 539-556.

Alani, M., 2016, ‘Channel Flow and Flood Estimate’, *De* Gruyter Open, 59(2016), 30-48.

Annamalai, T.R., Devka, G., Mahalingam, A., Benjamin, S., Rajan, S.C., Deep A., 2016, ‘What is the evidence on top-down and bottom-up approaches in improving access to water, sanitation and electricity services in low-income or informal settlements?’, EPPI-Centre, Social Science Research Unit, UCL Institute of Education, University College London.

Andreadis, K., Wing, O., Colven, E., Gleason, C., Bates, P., and Brown, C., 2021, ‘Urbanizing the floodplain: Global changes on imperviousness in flood-prone areas’ Environmental Research Letters, 17(2022), 104024, Viewed on 12 December 2022, from DOI:10.1088/1748-9326/ac9197.

Antony, R., Abdu, K., and R.S, V., 2021, ‘Flood Hazard Assessment and Flood Inundation Mapping’, Current Trends in Civil Engineering, 209-218, viewed in January 2023, from DOI:10.1007/978-981-15-8151-9_20.

Anwana, E.O. and Owojori, O.M., 2023, 'Analysis of Flooding Vulnerability in Informal Settlements Literature: Mapping and Research Agenda. Social Sciences', 12(1), 40, viewed on 2 October 2023, from https://doi.org/10.3390/socsci12010040

Bai, X., Dawson, R., Ürge-Vorsatz, D., Delgado, G., Barau, A., Dhakal, S., and Robert, D., 2018, 'Six research priorities for cities and climate change', Nature, 555(2018), 23-25.

Bernhard, S., Christoph, H., and H. H., 2020, 'Floodplain losses and increasing flood risk in The context of recent historic land use changes and settlement developments: Austrian case studies', Journal of flood Risk Management, 13(2018), e12610, viewed on 12 July 2023, from DOI:10.1111/jfr3.12610.

Botzen, W., and Aerts J.C.J.H., 2016, 'The effectiveness of flood risk communication strategies and the influence of social networks', Environmental Science & Policy, 60 (1462-9011), 44-52, viewed on 2 June 2023, from https://www.researchgate.net/publication/299415756.

Munthali, M.G., Mustak, S., Adeola, A., Botai, J., Singh, S.K., Davis, N., 2020, 'Modelling land use and land cover dynamics of Dedza district of Malawi using hybrid Cellular Automata and Markov model, Remote Sensing Applications', Society and Environment, 17(2352-9385), 100276, viewed on 2 October 2023, from https://doi.org/10.1016/j.rsase.2019.100276.

Cherenzia, F.S., 2010, 'GIS and Floodplain Mapping and Analysis' viewed on 2 March 2022, from https://www.researchgate.net/(PDF) Floodplain Mapping Using HEC-RAS and ArcGIS (researchgate.net).

Chinguwo, D., and Deus, D., 2022, 'Assessment of community-based flood early warning system in Malawi', National Library for Medicine, 14(1), 1166.

Daniel, W. W., 1999, ‘Biostatistics: A Foundation for Analysis in the Health Sciences’, John Wiley & Sons, 7th edition, Viewed on 12 September 2022, from doi/10.1002/1097-0258(20010130)20:2<324AID-SIM635>3.0.CO;2-O.

Davies, R., 2017, ‘Hundreds Displaced, 2 Missing as Floods Hit Lilongwe’, Flood list, viewed on 14 February 2022, from https://floodlist.com/africa/Malawi.

Desalegn, H., and Mulu, A., 2021, ‘Ethiopia Mapping flood inundation areas using GIS and HEC-RAS model at Fetam River, Upper Abbay Basin, Ethiopia’, Scientific African, 12(8), e00834, viewed on 2 June 2023, from DOI:10.1016/j.sciaf.2021.e00834.

Devitt, L., Neal, J., Coxon, G., Savage, J., and Wagener, T., 2022, ‘Flood hazard potential reveals global floodplain settlement patterns’, Nature communications, 14(1), 280, doi: 10.1038/s41467-023-38297-9.

Dodson, R., and Li, X., 1999, ‘The Accuracy and Efficiency of GIS-Based Floodplain Determinations’, viewed on 4 June 2022, from https://proceedings.esri.com/library/userconf/proc99/proceed/papers/pap809/p809.htm.

Doong, D., Lo, W., Vojinovic, Z., Lee, W., and Lee, S., 2016, ‘Development of a New Generation of Flood Inundation Maps—A Case Study of the Coastal City of Tainan, Taiwan’, Water, 8(11), 521. https://doi.org/10.3390/w8110521.

European Commission., 2013, ‘Land Use Change and Land Management Influence floods in small catchments’, Science for Environmental policy, viewed on 26 August 2022, from https://environment.ec.europa.eu/research-and-innovation/science-environment policy_en#:~:text=A%20European%20Commission%20initiative%20providing,easy%2Dto%2D understand%20way.&text=Science%20for%20Environment%20Policy%20(SfEP,ENV)%20of%20the%20European%20Commission.

European Commission Humanitarian., 2012, 'Linthipe and Lingadzi River System Study Central Region River Basin, Malawi. Lilongwe', viewed in December 2022, from Downloads/linthipe-and-lingadzi-river-system-study_final_report_2012-02-29_sm.pdf.

European Union., 2016, 'Floodplain management: reducing flood risks and restoring healthy ecosystems', European Environmental Agency, viewed on 14 January 2023, from https://www.eea.europa.eu/highlights/floodplain-management-reducing-flood-risks.

Eldho, T., Zope, P., and Kulkarni, A., 2018, 'Urban flood management in coastal regions using numerical simulation and geographic information system', Integrating Disaster Science and Management, 205-219, viewed on 3 October 2022, from DOI:10.1016/B978-0-12-812056-9.00012-9.

Etikitan, I., and Bala, K., 2017, 'Combination of probability random sampling method with non-probability random sampling method (sampling versus sampling methods)', Biometrics & Biostatistics International Journal, 5(6), 210-213, viewed of 3 September 2022, from DOI: 10.15406/bbij.2017.05.00148.

Fuhrman Center., 2017, 'More than 30 million people live in US floodplain. New York', Wagner school of public services, viewed on 17 March 2023, from https://furmancenter.org/thestoop/entry/new-data-from-the-nyu-furman-center-finds-that-more-than-30-million-people.

Federal Emergency Management Authority., 2021, 'Floodplain management', Federal Agency Management Journal, viewed on 12 June 2023, from https://www.fema.gov/floodplain-management.

Floodlist., 2015, 'Floods Leave Malawi Facing Worst Food Crisis in 10 Years', viewed on 4 October 2023 from https://floodlist.com/africa/floods-malawi-facing-worst-food-crisis-10-years.

Forkuo, E., Fusi, C., and Mensah, Y. A., 2014, 'GIS-based River Inundation and Flood Hazard Mapping', GSS Journals, 3(1), 1-15.

Fosu, C., Forkuo, K., and Asare, M., 2012, 'River Inundation and Hazard Mapping – a Case Study of Susan River', Global Geospatial Conference, viewed on 7 February 2023, from https://scholar.google.com/scholar?q=River+Inundation+and+Hazard+Mapping+%E2%80%93+a+Case+Study+of+Susan+River&hl=en&as_sdt=0&as_vis=1&oi=scholart.

Galligari, A., Tanila, F., and Massazza, G., 2020, 'Floodplain Settlement Dynamics in the Maouri Dallolat Guéchémé, Niger: A Multidisciplinary Approach', Sustainability, 12(14), 5632.

Gaur, A., Yamazaki, D., and Simonovic, S., 2019, 'Flooding Related Consequences of Climate Change on Canadian Cities and Flow Regulation Infrastructure', Water, 11(1), 63.

Gondwe, S. V., and Shukla, S. H., 2021, 'Mapping Flood Risk of Nsanje District in Malawi', Journal of Remote Sensing & GIS, 11(3), 11-34.

Gondwe, S., Muchena, R., and Boys, J., 2018, 'Detecting Land Use and Land Cover and Land Surface Temperature Change in Lilongwe City, Malawi', Journal of Remote Sensing & GIS, 9 (2), 17-26.

Hajibavov, F., Ozkul, B. D., and Terzi, F., 2017, 'Floodplain Modeling and Mapping Using the Geographic Information Systems (GIS) and HEC-RAS/Hec-GeoRAS Applications: Case of Edirne, Turkey', Geographical Information Science Research- UK, viewed 11 January 2023, from https://www.researchgate.net/publication/324909670_Floodplain_Modeling_and_Mapping_Usin g_the_Geographical_Information_Systems_GIS_and_Hec-RASHec

GeoRAS_Applications_Case_of_Edirne_Turkey.

Halle, B., and Burgess, J., 2006, ‘Country Environmental Profile for Malawi’, Commission of the European communities, viewed on 14 December 2022, from https://aei.pitt.edu/50267/1/Malawi.2006.

Handayani, W., Chigbu, U., Rudiarto, I., and Putri, I., 2020, ‘Urbanization and Increasing Flood Risk in the Northern Coast of Central Java—Indonesia: An Assessment towards Better Land Use Policy and Flood Management’, Sustainability, 9(10), 343, viewed on 3 June 2023, from https://doi.org/10.3390/land9100343.

Hartmann D. L., Klein Tank A., and Rusticucci, M., 2013, ‘Observations: Atmosphere and surface. Intergovernmental Panel on Climate Change’, Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 159-254.

Icaga, Y., Tas, E., and M, K., 2016., ‘Flood inundation mapping by GIS and a hydraulic model (HEC RAS): a case study of Akarcay Bolvadin sub basin, in Turkey’, Acta Geobalcanica, 2(2), 111-118, DOI: https://doi.org/10.18509/AGB.2016.12.

John, R., 2020, ‘Flooding in Informal Settlements: Potentials and Limits for Household Adaptation in Dar es Salaam City, Tanzania’, American Journal for Climate Change, 9(02), 68-86.

Jubb, C., 2021, ‘Floodplain Management for the Local Government Leader Critical changes to the National Flood Insurance Program are on the horizon’, The International Capital Market Association, viewed on 29 October 2022, from https://icma.org/articles/pm-magazine/floodplain-management-local-government-leader.

KaseI, R., Kalanda-Joshua, M.D, and Benefor, D., 2019, ‘Rapid urbanization and implications for indigenous knowledge in early warning on flood risk in African cities’, Journal of the British Academy, 7(s2), 183–21, DOI https://doi.org/10.5871/jba/007s2.183.

Kiedrzyn´ska, E., Kiedrzyn´ski, M., and Zalewski, M., 2014, ‘Sustainable floodplain management for flood prevention and water quality improvement’, Natural Hazards, 76(2), 955-977.

Kihupi, N. I., Kingamkono, R., Rwamugira, W., Kingamkono, M., Mhita, M., and Brien, K., 2002, ‘Promotion and Integration of Indigenous Knowledge in Seasonal Climate Forecasts’, Drought Monitoring Center (Harare, Zimbabwe), viewed on 20 May 2023, from http://www.sadc.int/dmc/Research/PilotProjects/Promotion%20And%20Integration%20Of%20I ndigenous%20Knowledge%20In%20Seaso na.pdf.

Kikwasi, G., and Mbuya, E., 2019, ‘Vulnerability analysis of building structures to floods: The case of flooding informal settlements in Dar es salaam, Tanzania’, International Journal of Building Pathology and Adaptation, Vol. 37(5), 629-656, Viewed on 30 September 2023, from https://doi.org/10.1108/IJBPA-07-2018-0056.

Devitt, L., Jeffrey, N., Coxon, G., Savage, J., and Wagener, T., 2022, ‘Flood hazard potential reveals global floodplains settlement patterns’, Nature communication, viewed on September 22, from https://doi.org/10.1038/s41467-023-38297-9.

Liasi, E., 2016, ‘Development of a flood-frequency model for the river basins of the central region of Malawi as a tool for Engineering design and disaster preparedness in flood-prone area’, University of South Africa, viewed on 4 December 2023, from http://hdl.handle.net/10500/23597.

Likoya, E., 2015, 'Attribution of the risk of extreme flood events to climate change in the context of changing land use and cover case study of Shire River basin flood of 2015', University of Cape Town, viewed on March 9 2023, from https://open.uct.ac.za/handle/11427/31607.

Lwin, K., Pal, I., Shrestha, S., Warnitchai, P., 2020, 'Assessing social resilience of flood-vulnerable communities in Ayeyarwady Delta, Myanmar', International Journal of Disaster Risk Reduction, 51 (01), 101745, viewed on 30 September 2023, from https://doi.org/10.1016/j.ijdrr.2020.101745.

Malawi Government., 2005, 'National Water Policy', Lilongwe, Malawi.

Malawi Government., 2011, 'Water Resources Investment Strategy, Final Report, Component 2', Lilongwe, Malawi. viewed on 4 April 2023, from https://iwa-network.org/wp-content/uploads/2015/12/Case-study_Malawi_final.pdf.

Malawi Government., 2013, 'Water Resources Act', Lilongwe, Malawi.

Malawi Government., 2014, 'National Water Resources Master Plan', Lilongwe. Malawi.

Malawi Government., 2015, 'Environmental and Social Management Framework, Malawi Floods Emergency Recovery Project (MFERP)', Lilongwe Malawi. viewed on 5 January 2023, https://www.gfdrr.org/sites/default/files/Malawi%20%20Floods%20Emergency%20Recovery%0Project%20%20environmental%20assessment%20%20Environmental%20and%20social%20management%20framework.pdf.

Malawi Government., 2015, 'Scaling-up Early Warning Systems and Use of Climate Information in Malawi – Feasibility Assessment', viewed on 2 February 2023, from https://pims.undp.org/attachments/5710/214506/1697418/1697699/FP-UNDP-100915-5710 Annex%C2%A0II%20resized.pdf.

Malawi Government., 2016, 'Republic of Malawi Urbanization Review', Lilongwe, Malawi.

Malawi Government., 2018, 'Malawi Population and housing census', National Statistics Office, Zomba, Malawi.

Malawi Government., 2018., 'Water Resources Regulations', Lilongwe, Malawi.

Malawi Government., 2019, 'Flash floods in Malawi: Case studies for 2013, 2015, 2016 and 2017 seasons, 2018', viewed on 2 December 2022, from https://etrp.wmo.int/pluginfile.php/34702/mod_resource/content/2/Malawi_Flash_Flood_Case_Studies_2013%202015%202016%202017.pdf.

Malawi Government., 2019, 'Malawi 2019 Floods Post Disaster Needs Assessment Report', Viewed on May 4 from, https://www.unicef.org/malawi/media/1756/file/Malawi%202019%20Floods%20Post%20Disaster%20Needs%20Assessment%20Report.pdf.

Malawi Government., 2019, 'National Urban Policy', Lilongwe, Malawi.

Mehryar, S., Surminski, S., and Swenja, J.O., 2022, 'Investigating flood resilience perceptions and supporting collective decision-making through fuzzy cognitive mapping', Science of The Total Environment, 837(0048-9697), viewed on 3 October 2023, from https://doi.org/10.1016/j.scitotenv.2022.155854.

Miller, J. D., and Hutchins M., 2022, The impacts of urbanization and climate change on urban flooding and urban water quality: A review of the evidence concerning the United Kingdom, Journal of Hydrology: Regional Studies, Volume 12(2214-5818), 345-362, viewed on 29 September 2023, from https://doi.org/10.1016/j.ejrh.2017.06.006.

Mokkenstorm, L. C., van den Homberg, M. J., Winsemius, H., and Persson1, A., 2021, 'River Flood Detection Using Passive Microwave Remote Sensing in a Data Scarce Environment: A Case Study for Two River basins in Malawi', Frontiers in Earth Science, 9(670997), viewed on 5 May 2023, from https://doi.org/10.3389/feart.2021.670997.

National Geographic Society., 2016, 'Floodplains', viewed on 2 April 2023, from https://education.nationalgeographic.org/resource/flood-plain/.

Ndabula, C., Jidauna, G., Oyatayo, K., Averik, P., and Iguisi, E., 2012, 'Analysis of Urban Floodplain Encroachment: Strategic Approach to Flood and Floodplain Management in Kaduna Metropolis, Nigeria', Journal of Geography and Geology, 4(1), 170-182.

O'Brien, G., Dickens, C., Baker, C., Stassen, R., and Van Weert, F., 2020, 'Sustainable Floodplains: Linking E-Flows to Floodplain Management, Ecosystems, and Livelihoods in the Sahel of North Africa', Sustainability, 12(24), 10578, viewed on 3 Mach 2023, from https://doi.org/10.3390/su122410578.

Okaka, F. O., and Odhiambo, B. D., 2018, 'Households' perception of flood risk and health impact of exposure to flooding in flood-prone informal settlements in the coastal city of Mombasa', International journal of climate change and strategic management, 11(4), 592-606, DOI:10.1108/IJCCSM-03-2018-0026.

Park, K., and Lee, M., 2019, 'The Development and Application of the Urban Flood Risk Assessment Model for Reflecting upon Urban Planning Elements', Water, 11(5), 920, https://doi.org/10.3390/w11050920.

Phiri, Y., 2019, Urban Planning and Urban Disaster Resilience: Effects of Poor Urban Planning and Development in the Cities of Malawi', International Congress on Urban Studies, 4(2019).

Rahadiati, A., Munawaroh, and Suryanegara, E., 2021, 'The Impact of Flooding on Settlement Along the Jangkok River Mataram, Indonesia'. IOP Conference Series: Earth and Environmental Science, 750 (012003), DOI 10.1088/1755-1315/750/1/012003.

Romali, N., Yusop, Z., and Ismail, A. Z., 2018, 'Application of HEC-RAS AND ARC GIS for floodplain mapping in Segamat town, Malaysia', International Journal of GEOMATE, 14(43), 125-131, DOI:10.21660/2018.43.3656.

Sajidu, S., Monjerezi, M., Ngongondo, C., and Namangale, J., 2013, 'Country Water Resources Profile', University of Malawi.

Sakijege, T., Sartohadi, J., Marfai, M. A., Kassenga, G. R., and Kasala, S. E., 2014, 'Assessment of adaptation strategies to flooding: A comparative study between informal settlements of Keko Machungwa in Dar es Salaam, Tanzania and Sangkrah in Surakarta, Indonesia', Journal of disaster risk studies, 6(10), 1-10, viewed on 2 February 2023, from DOI:10.4102/jamba.v6i1.131.

Salami, R., Von Meding, J., and Giggins, H., 2017, 'Urban settlements vulnerability to flood risks in African cities: A conceptual framework', Journal of Disaster Risk Studies, 9(1), 9, viewed on 2 4 January 2023, from DOI:10.4102/jamba.v9i1.370.

Saleem, O., HeisterMann, M., and Bronstert, A., 2021, 'Efficient Hazard Assessment for Pluvial Floods in Urban Environments: A Benchmarking Case Study for the City of Berlin, Germany', Water, 13(18), 2476, viewed on 6 December 2022, from http://dx.doi.org/10.3390/w13182476.

Sathya, A., and Thampi, S., 2020, 'Flood Inundation Mapping of Cauvery River Using HEC-RAS and GIS', Advances in Civil Engineering, 15-23, viewed on 12 October 2022, from DOI:10.1007/978-981-15-5644-9_2.

Seebeaur, S., and Babcicky, P., 2017, 'Trust and the communication of flood risks: Comparing the roles of local governments, volunteers in emergency services and neighbors', Journal of Flood Risk Management, 11(3), 305-316 viewed on 01 October 2023, from 10.1111/jfr3.12313.

Shah, A.A., Ajiang, C., Khan, N.A., Alotaibi, B.A., Tariq, M.A.U.R., 2022, 'Flood Risk Perception and Its Attributes among Rural Households under Developing Country Conditions: The Case of Pakistan', Multidisciplinary Digital Publishing Institute -Water, 14(6), 992, viewed on 1 October 2023, from https://doi.org/10.3390/w14060992.

South African Government., 2009, 'Floodplain and River Corridor Management Policy', Cape Town City Council, viewed on 3 July 2023, from https://www.westerncape.gov.za/assets/departments/transport-public works/Documents/floodplain_and_river_corridor_management_policy.pdf.

United Nations., 2011, 'Lilongwe urban profile', UN Habitat, Regional and Technical Cooperation Division, viewed on June 30, 2022, from https://unhabitat.org/malawi-lilongwe-urban-profile.

United nations., 2015, 'Informal settlement', *UN Habitat*, viewed on 12 May 2023, from https://sustainabledevelopment.un.org/content/documents/1726Habitat%20Global%20Activties %202015.pdf.

United Nations., 2018, 'World Urbanization prospects', United Nations Department of Economic and Social Affairs, viewed on 5 October 2022, from https://population.un.org/wup/publications/Files/WUP2018-Report.pdf.

United Nations Development Program., 2021, 'COVID-19 Pandemic Response in Malawi' viewed on 20 April 2023, from https://www.undp.org/malawi/publications/covid-19-response-malawi.

Urban LandMark., 2013, ‘Operation of the Market Study How the poor access, hold and trade land February, research in two settlements in Lilongwe’, Progresses Research Development, 5(2503201), 1-80, viewed on 17 September 2023, from http://www.urbanlandmark.org.za/downloads/malawi_2013.pdf.

United States Governments., 2015, ‘urban flooding awareness act’, Illinois Department of natural resources, viewed of 2 October 2023, from https://dnr.illinois.gov/content/dam/soi/en/web/dnr/waterresources/documents/final-ufaa-report.pdf**.**

United States Government., 2022, ‘Why are Wetlands Important’, Environmental Protection Agency, viewed on 10 February 2023, from https://www.epa.gov/wetlands/why-are-wetlands important.

Visagie, J., and Turok, I., 2020, ‘Getting urban density to work in informal settlements in Africa’, Environment and Urbanization, 32(2), 351-370 viewed on 14 October 2023 from, https://doi.org/10.1177/0956247820907808

Wasko, C., Westra, S., Nathan, R., Orr, H., Villarini, G., Villalobos Herrera, R., and Fowler, H., 2021, ‘Incorporating climate change in flood estimation guidance’, The loyal society, 379(2195), 548, viewed on 3 September 2022, from DOI:10.1098/rsta.2019.0548.

Williams, D. S., Costa, M. M., Celliers, L., and Sutherland, C., 2018, ‘Informal Settlements and Flooding: Identifying Strengths and Weaknesses in Local Governance for Water Management’, Water, 10(7), 871, viewed on 4 November 2022, from https://doi.org/10.3390/w10070871.

World Banks., 2011, ‘Climate Risk and Adaptation Country Profile Vulnerability, Risk Reduction, and Adaptation to Climate Change, viewed on 2 October 2023, from https://climateknowledgeportal.worldbank.org/sites/default/files/201810/wb_gfdrr_climate_change_country_profile_for_MWI.pdf.

World Bank., 2016, 'Republic of Malawi Urbanization review', World Bank, viewed on 12 April 2023, from https://documents.worldbank.org/curated/en/913881468045241225/pdf/P146675-MalawiUrbanizationReview-Final-withCover.pdf.

World Bank., 2017, 'International development association economic development, Malawi Economic monitor', World Bank Group, viewed on 3 May 2023, from https://documents1.worldbank.org/curated/en/536051495634418308/pdf/115253-REVISED-JUNE-2-50p-Malawi-Economic-Monitor-5-final-Jun-2-2017.pdf.

World Bank., 2018, 'Malawi Systematic Country Diagnostic: Breaking the Cycle of Low Growth and Slow Poverty Reduction', World Bank Group, viewed on 2 June 2023, from https://elibrary.worldbank.org/doi/abs/10.1596/31131.

World Bank., 2020, 'Climatology Country Profile: Malawi', World Bank Climate Change Knowledge Portal, viewed on 14 June 2023, from https://climateknowledgeportal.worldbank.org/country/malawi

World Bank., 2023, 'New Pathways to Commercialize Agriculture in Malawi, World Bank Blogs, viewed on 17 June 2023, from https://blogs.worldbank.org/nasikiliza/new-pathways-commercializeagriculturemalawi#:~:text=The%20World%20Bank's%202022%20Poverty,rate%20as%20high%20as%2055%25.

Zehra, D., Mbatha, S., Campos, C., Queface, A., Baleza, A., Cavoli, C., and Parikh, P., 2019, 'Rapid flood risk assessment of informal urban settlements in Maputo, Mozambique: The case of Maxaquene', International Journal for disaster risk reduction, 40(2019), 101270, viewed on 12 January 2023, from https://doi.org/10.1016/j.ijdrr.2019.101270.

Zhang, J., Shuang Chen, S., Gao, Q., Shen, Q., Kimirei, I., and D.W, M., 2020, 'Morphological Characteristics of Informal Settlements and Strategic Suggestions for Urban Sustainable Development in Tanzania: Dar es Salaam, Mwanza, and Kigoma', Sustainability, 12(9), 3807, viewed on 3 August 2022, from https://doi.org/10.3390/su12093807.

APPENDICES

Appendix: 1 Research ethical clearance

MZUZU UNIVERSITY

DIRECTORATE OF RESEARCH

Mzuzu University
Private Bag 201
Luwinga
Mzuzu 2
MALAWI
TEL: 01 320 722
FAX: 01 320 648

MZUZU UNIVERSITY RESEARCH ETHICS COMMITTEE (MZUNIREC)

Ref No: MZUNIREC/DOR/22/102 **12/12/2022.**

Susan Kumwenda,
Mzuzu University,
P/Bag 201,
Luwinga,
Mzuzu 2.

nyachipetasue@gmail.com

Dear Susan,

RESEARCH ETHICS AND REGULATORY APPROVAL AND PERMIT FOR PROTOCOL REF NO: MZUNIREC/DOR/22/102: ASSESSING EFFECTS OF INFORMAL URBAN SETTLEMENTS IN FLOODPLAINS ON INCREASED FREQUENCY OF FLOODS ALONG LINGADZI RIVER IN LILONGWE

Having satisfied all the relevant ethical and regulatory requirements, I am pleased to inform you that the above referred research protocol has officially been approved. You are now permitted to proceed with its implementation. Should there be any amendments to the approved protocol in the course of implementing it, you shall be required to seek approval of such amendments before implementation of the same.

This approval is valid for one year from the date of issuance of this approval. If the study goes beyond one year, an annual approval for continuation shall be required to be sought from the Mzuzu University Research Ethics Committee (MZUNIREC) in a format that is available at the Secretariat. Once the study is finalised, you are required to furnish the Committee with a final report of the study. The Committee reserves the right to carry out compliance inspection of this approved protocol at any time as may be deemed by it. As such, you are expected to properly maintain all study documents including consent forms.

Wishing you a successful implementation of your study.

Committee Address:

Secretariat, Mzuzu University Research Ethics Committee, P/Bag 201, Luwinga, Mzuzu 2; E-mail address: mzunirec@mzuni.ac.mw

Yours Sincerely,

Gift Mbwele

SENIOR RESEARCH ETHICS ADMINISTRATOR

For: CHAIRMAN OF MZUNIREC

MZUZU UNIVERSITY
RESEARCH ETHICS COMMITTEE
12 DEC 2022
PRIVATE BAG 201, LUWINGA
MZUZU 2

Committee Address:
Secretariat, Mzuzu University Research Ethics Committee, P/Bag 201, Luwinga, Mzuzu 2; E-mail address: mzunirec@mzuni.ac.mw

Appendix 2: Building assessment survey checklist

MZUZU UNIVERSITY

PRIVATE BAG 201

LUWINGA

MZUZU

<u>Household Settlement characteristics questionnaire checklist</u>

Assessing effects of informal urban settlements in floodplains on increased frequency of floods along Lingadzi River in Lilongwe

Program**: Masters of Science in Water Resource Management**

Name of the Researcher**: Susan Kumwenda**

Email**: <u>susankumwenda@yahoo.co.uk</u>**

Cell**: <u>0999280911</u>**

Information obtained for the study that can be identified with respondent will remain confidential and can only be disclosed with permission from respondent**.**

i. I agree to participate in the study.

yes	No

ii. I understand the purpose and nature of this study and I am participating voluntarily.

yes	No

iii. I grant permission for the data generated from this interview to be used in the researcher's publications

yes	No

	Personal data	
Gender of Respondent	Male	Female
Age of Respondent	0-35 yrs	35yrs above

General observation of house and surrounding

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

1. **Access to basic facilities**

Road

yes	No

Electricity

yes	No

Water

yes	No

Latrine/ toilet

yes	No

2. **Wall & roofing material**

Iron sheet

yes	No

Grass thatched

yes	No

Burned Bricks

yes	No

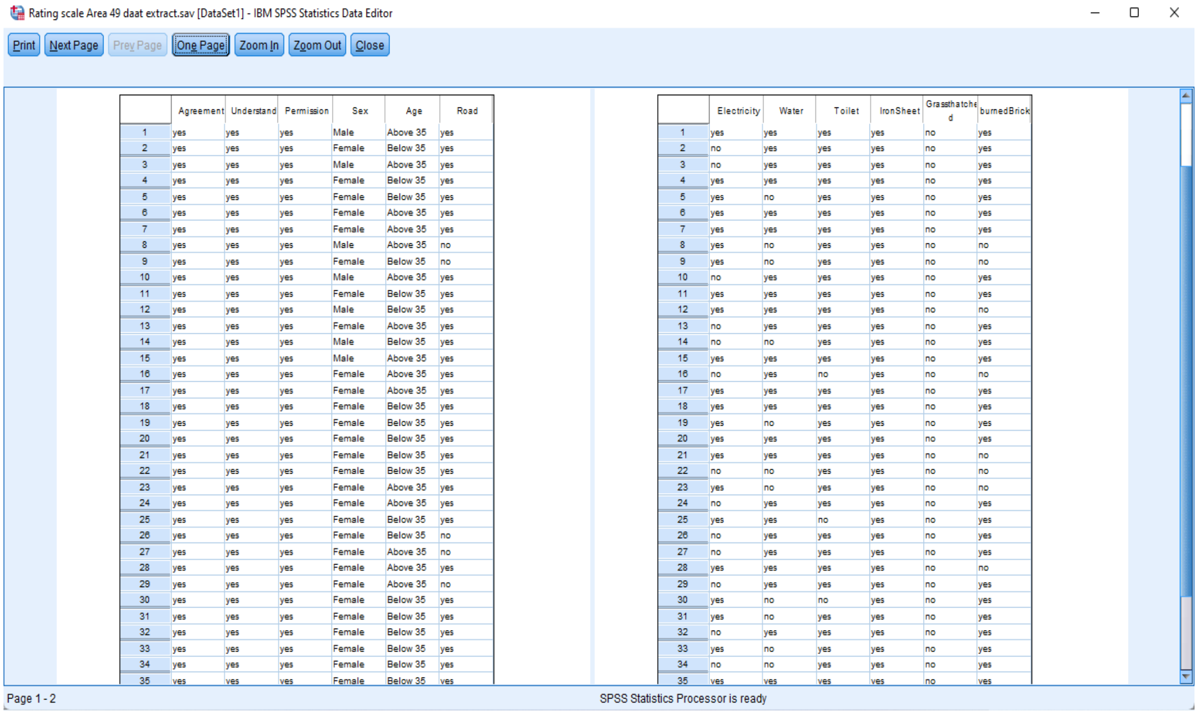
Mud bricks

yes	No

Cement blocks

yes	No

Appendix 3: Area 49 building assessment survey data.



Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	Agreement	Understand	Permission	Sex	Age	Road
1	yes	yes	yes	Male	Above 35	yes
2	yes	yes	yes	Female	Below 35	yes
3	yes	yes	yes	Male	Above 35	yes
4	yes	yes	yes	Female	Below 35	yes
5	yes	yes	yes	Female	Below 35	yes
6	yes	yes	yes	Female	Above 35	yes
7	yes	yes	yes	Female	Above 35	yes
8	yes	yes	yes	Male	Above 35	no
9	yes	yes	yes	Female	Below 35	no
10	yes	yes	yes	Male	Above 35	yes
11	yes	yes	yes	Female	Below 35	yes
12	yes	yes	yes	Male	Below 35	yes
13	yes	yes	yes	Female	Above 35	yes
14	yes	yes	yes	Male	Below 35	yes
15	yes	yes	yes	Male	Above 35	yes
16	yes	yes	yes	Female	Above 35	yes
17	yes	yes	yes	Female	Above 35	yes
18	yes	yes	yes	Female	Below 35	yes
19	yes	yes	yes	Female	Below 35	yes
20	yes	yes	yes	Female	Below 35	yes
21	yes	yes	yes	Female	Below 35	yes
22	yes	yes	yes	Female	Below 35	yes
23	yes	yes	yes	Female	Above 35	yes
24	yes	yes	yes	Female	Above 35	yes
25	yes	yes	yes	Female	Below 35	yes
26	yes	yes	yes	Female	Below 35	no
27	yes	yes	yes	Female	Above 35	no
28	yes	yes	yes	Female	Above 35	yes
29	yes	yes	yes	Female	Above 35	no
30	yes	yes	yes	Female	Below 35	yes
31	yes	yes	yes	Female	Below 35	yes
32	yes	yes	yes	Female	Below 35	yes
33	yes	yes	yes	Female	Below 35	yes
34	yes	yes	yes	Female	Below 35	yes
35	yes	yes	yes	Female	Below 35	yes

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
1	yes	yes	yes	yes	no	yes
2	no	yes	yes	yes	no	yes
3	no	yes	yes	yes	no	yes
4	yes	yes	yes	yes	no	yes
5	yes	no	yes	yes	no	yes
6	yes	yes	yes	yes	no	yes
7	yes	yes	yes	yes	no	yes
8	yes	no	yes	yes	no	no
9	yes	no	yes	yes	no	no
10	no	yes	yes	yes	no	yes
11	yes	yes	yes	yes	no	yes
12	yes	yes	yes	yes	no	no
13	no	yes	yes	yes	no	yes
14	no	no	yes	yes	no	yes
15	yes	yes	yes	yes	no	yes
16	no	yes	no	yes	no	no
17	yes	yes	yes	yes	no	yes
18	yes	yes	yes	yes	no	yes
19	yes	no	yes	yes	no	yes
20	yes	yes	yes	yes	no	yes
21	yes	yes	yes	yes	no	no
22	no	no	yes	yes	no	no
23	yes	no	yes	yes	no	no
24	no	yes	yes	yes	no	yes
25	yes	yes	no	yes	no	yes
26	no	yes	yes	yes	no	yes
27	no	yes	yes	yes	no	yes
28	yes	yes	yes	yes	no	no
29	no	yes	yes	yes	no	yes
30	yes	no	no	yes	no	yes
31	yes	no	yes	yes	no	yes
32	no	yes	yes	yes	no	yes
33	yes	no	yes	yes	no	yes
34	no	no	yes	yes	no	yes
35	yes	yes	yes	yes	no	yes

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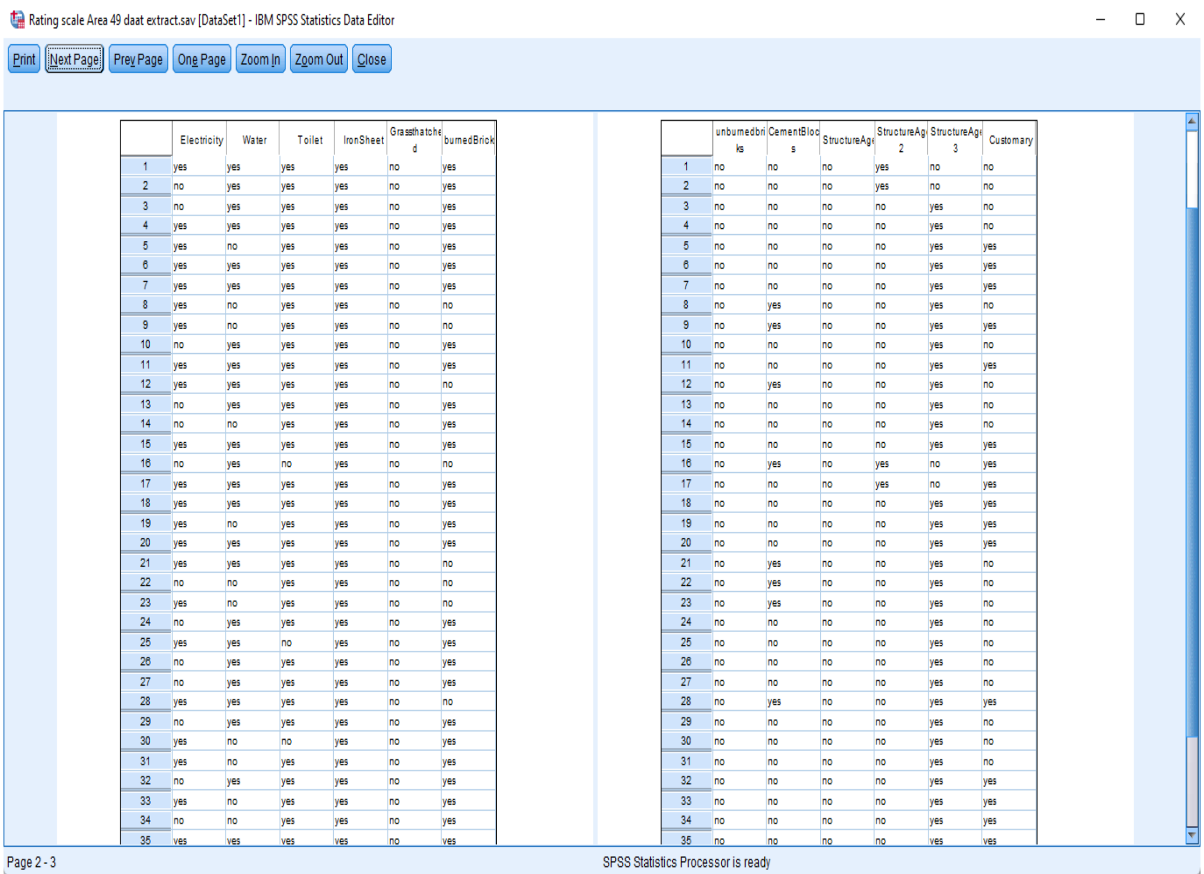

Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
1	yes	yes	yes	yes	no	yes
2	no	yes	yes	yes	no	yes
3	no	yes	yes	yes	no	yes
4	yes	yes	yes	yes	no	yes
5	yes	no	yes	yes	no	yes
6	yes	yes	yes	yes	no	yes
7	yes	yes	yes	yes	no	yes
8	yes	no	yes	yes	no	no
9	yes	no	yes	yes	no	no
10	no	yes	yes	yes	no	yes
11	yes	yes	yes	yes	no	yes
12	yes	yes	yes	yes	no	no
13	no	yes	yes	yes	no	yes
14	no	no	yes	yes	no	yes
15	yes	yes	yes	yes	no	yes
16	no	yes	no	yes	no	no
17	yes	yes	yes	yes	no	yes
18	yes	yes	yes	yes	no	yes
19	yes	no	yes	yes	no	yes
20	yes	yes	yes	yes	no	yes
21	yes	yes	yes	yes	no	no
22	no	no	yes	yes	no	no
23	yes	no	yes	yes	no	no
24	no	yes	yes	yes	no	yes
25	yes	yes	no	yes	no	yes
26	no	yes	yes	yes	no	yes
27	no	yes	yes	yes	no	yes
28	yes	yes	yes	yes	no	no
29	no	yes	yes	yes	no	yes
30	yes	no	no	yes	no	yes
31	yes	no	yes	yes	no	yes
32	no	yes	yes	yes	no	yes
33	yes	no	yes	yes	no	yes
34	no	no	yes	yes	no	yes
35	yes	yes	yes	yes	no	yes

	unburnedbricks	CementBlocks	StructureAge	StructureAge2	StructureAge3	Customary
1	no	no	no	yes	no	no
2	no	no	no	yes	no	no
3	no	no	no	no	yes	no
4	no	no	no	no	yes	no
5	no	no	no	no	yes	yes
6	no	no	no	no	yes	yes
7	no	no	no	no	yes	yes
8	no	yes	no	no	yes	no
9	no	yes	no	no	yes	yes
10	no	no	no	no	yes	no
11	no	no	no	no	yes	yes
12	no	yes	no	no	yes	no
13	no	no	no	no	yes	no
14	no	no	no	no	yes	no
15	no	no	no	no	yes	yes
16	no	yes	no	yes	no	yes
17	no	no	no	yes	no	yes
18	no	no	no	no	yes	yes
19	no	no	no	no	yes	yes
20	no	no	no	no	yes	yes
21	no	yes	no	no	yes	no
22	no	yes	no	no	yes	no
23	no	yes	no	no	yes	no
24	no	no	no	no	yes	no
25	no	no	no	no	yes	no
26	no	no	no	no	yes	no
27	no	no	no	no	yes	no
28	no	yes	no	no	yes	yes
29	no	no	no	no	yes	no
30	no	no	no	no	yes	no
31	no	no	no	no	yes	no
32	no	no	no	no	yes	yes
33	no	no	no	no	yes	yes
34	no	no	no	no	yes	yes
35	no	no	no	no	yes	yes

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	unburnedbricks	CementBlocs	StructureAge	StructureAge 2	StructureAge 3	Customary
1	no	no	no	yes	no	no
2	no	no	no	yes	no	no
3	no	no	no	no	yes	no
4	no	no	no	no	yes	no
5	no	no	no	no	yes	yes
6	no	no	no	no	yes	yes
7	no	no	no	no	yes	yes
8	no	yes	no	no	yes	no
9	no	yes	no	no	yes	yes
10	no	no	no	no	yes	no
11	no	no	no	no	yes	yes
12	no	yes	no	no	yes	no
13	no	no	no	no	yes	no
14	no	no	no	no	yes	no
15	no	no	no	no	yes	yes
16	no	yes	no	yes	no	yes
17	no	no	no	yes	no	yes
18	no	no	no	no	yes	yes
19	no	no	no	no	yes	yes
20	no	no	no	no	yes	yes
21	no	yes	no	no	yes	no
22	no	yes	no	no	yes	no
23	no	yes	no	no	yes	no
24	no	no	no	no	yes	no
25	no	no	no	no	yes	no
26	no	no	no	no	yes	no
27	no	no	no	no	yes	no
28	no	yes	no	no	yes	yes
29	no	no	no	no	yes	no
30	no	no	no	no	yes	no
31	no	no	no	no	yes	no
32	no	no	no	no	yes	yes
33	no	no	no	no	yes	yes
34	no	no	no	no	yes	yes
35	no	no	no	no	yes	yes

	Governmentgency
1	yes
2	yes
3	yes
4	yes
5	no
6	no
7	no
8	no
9	no
10	yes
11	no
12	yes
13	yes
14	yes
15	no
16	no
17	no
18	no
19	no
20	no
21	yes
22	yes
23	yes
24	yes
25	yes
26	yes
27	yes
28	no
29	yes
30	yes
31	yes
32	no
33	no
34	no
35	no

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Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	Governmentgency
1	yes
2	yes
3	yes
4	yes
5	no
6	no
7	no
8	no
9	no
10	yes
11	no
12	yes
13	yes
14	yes
15	no
16	no
17	no
18	no
19	no
20	no
21	yes
22	yes
23	yes
24	yes
25	yes
26	yes
27	yes
28	no
29	yes
30	yes
31	yes
32	no
33	no
34	no
35	no

	Agreement	Understand	Permission	Sex	Age	Road
36	yes	yes	yes	Female	Above 35	yes
37	yes	yes	yes	Female	Above 35	yes
38	yes	yes	yes	Male	Above 35	yes
39	yes	yes	yes	Female	Below 35	yes
40	yes	yes	yes	Female	Below 35	yes
41	yes	yes	yes	Female	Above 35	yes
42	yes	yes	yes	Male	Above 35	yes
43	yes	yes	yes	Female	Above 35	yes
44	yes	yes	yes	Male	Below 35	yes
45	yes	yes	yes	Male	Below 35	yes
46	yes	yes	yes	Male	Above 35	yes
47	yes	yes	yes	Male	Above 35	yes
48	yes	yes	yes	Female	Above 35	yes
49	yes	yes	yes	Male	Above 35	yes
50	yes	yes	yes	Male	Below 35	yes
51	yes	yes	yes	Female	Above 35	yes
52	yes	yes	yes	Female	Below 35	yes
53	yes	yes	yes	Male	Below 35	yes
54	yes	yes	yes	Female	Above 35	yes
55	yes	yes	yes	Female	Below 35	yes
56	yes	yes	yes	Female	Above 35	yes
57	yes	yes	yes	Female	Above 35	yes
58	yes	yes	yes	Female	Below 35	yes
59	yes	yes	yes	Female	Above 35	yes
60	yes	yes	yes	Female	Below 35	yes
61	yes	yes	yes	Female	Below 35	yes
62	yes	yes	yes	Male	Below 35	yes
63	yes	yes	yes	Male	Above 35	yes
64	yes	yes	yes	Male	Below 35	yes
65	yes	yes	yes	Male	Above 35	yes
66	yes	yes	yes	Male	Above 35	yes
67	yes	yes	yes	Male	Below 35	yes
68	yes	yes	yes	Male	Above 35	yes
69	yes	yes	yes	Female	Above 35	yes
70	yes	yes	yes	Male	Below 35	yes

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Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	Agreement	Understand	Permission	Sex	Age	Road
36	yes	yes	yes	Female	Above 35	yes
37	yes	yes	yes	Female	Above 35	yes
38	yes	yes	yes	Male	Above 35	yes
39	yes	yes	yes	Female	Below 35	yes
40	yes	yes	yes	Female	Below 35	yes
41	yes	yes	yes	Female	Above 35	yes
42	yes	yes	yes	Male	Above 35	yes
43	yes	yes	yes	Female	Above 35	yes
44	yes	yes	yes	Male	Below 35	yes
45	yes	yes	yes	Male	Below 35	yes
46	yes	yes	yes	Male	Above 35	yes
47	yes	yes	yes	Male	Above 35	yes
48	yes	yes	yes	Female	Above 35	yes
49	yes	yes	yes	Male	Above 35	yes
50	yes	yes	yes	Male	Below 35	yes
51	yes	yes	yes	Female	Above 35	yes
52	yes	yes	yes	Female	Below 35	yes
53	yes	yes	yes	Male	Below 35	yes
54	yes	yes	yes	Female	Above 35	yes
55	yes	yes	yes	Female	Below 35	yes
56	yes	yes	yes	Female	Above 35	yes
57	yes	yes	yes	Female	Above 35	yes
58	yes	yes	yes	Female	Below 35	yes
59	yes	yes	yes	Female	Above 35	yes
60	yes	yes	yes	Female	Below 35	yes
61	yes	yes	yes	Female	Below 35	yes
62	yes	yes	yes	Male	Below 35	yes
63	yes	yes	yes	Male	Above 35	yes
64	yes	yes	yes	Male	Below 35	yes
65	yes	yes	yes	Male	Above 35	yes
66	yes	yes	yes	Male	Above 35	yes
67	yes	yes	yes	Male	Below 35	yes
68	yes	yes	yes	Male	Above 35	yes
69	yes	yes	yes	Female	Above 35	yes
70	yes	yes	yes	Male	Below 35	yes

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
36	yes	no	yes	yes	no	yes
37	no	yes	yes	yes	no	yes
38	no	no	yes	yes	no	yes
39	no	no	yes	yes	no	no
40	yes	yes	yes	yes	no	yes
41	no	yes	yes	yes	no	no
42	yes	no	yes	yes	no	yes
43	yes	yes	yes	yes	no	yes
44	no	yes	yes	yes	no	yes
45	no	yes	yes	yes	no	yes
46	no	yes	yes	yes	no	yes
47	no	no	yes	yes	no	yes
48	yes	yes	yes	yes	no	yes
49	yes	yes	no	yes	no	no
50	yes	yes	yes	yes	no	yes
51	no	no	yes	yes	no	yes
52	yes	yes	yes	yes	no	yes
53	yes	yes	yes	yes	no	no
54	yes	yes	yes	yes	no	yes
55	yes	yes	yes	yes	no	yes
56	yes	yes	yes	yes	no	yes
57	no	yes	yes	yes	no	yes
58	no	no	yes	yes	no	yes
59	yes	yes	yes	yes	no	yes
60	yes	yes	yes	yes	no	yes
61	yes	yes	yes	yes	no	yes
62	no	no	yes	yes	no	yes
63	no	no	no	yes	no	yes
64	yes	yes	yes	yes	no	no
65	yes	yes	no	yes	no	yes
66	yes	yes	yes	yes	no	yes
67	yes	yes	yes	yes	no	yes
68	no	yes	yes	yes	no	yes
69	yes	yes	yes	yes	no	yes
70	yes	yes	yes	yes	no	yes

Page 5 - 6 SPSS Statistics Processor is ready

Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
36	yes	no	yes	yes	no	yes
37	no	yes	yes	yes	no	yes
38	no	no	yes	yes	no	yes
39	no	no	yes	yes	no	no
40	yes	yes	yes	yes	no	yes
41	no	yes	yes	yes	no	no
42	yes	no	yes	yes	no	yes
43	yes	yes	yes	yes	no	yes
44	no	yes	yes	yes	no	yes
45	no	yes	yes	yes	no	yes
46	no	yes	yes	yes	no	yes
47	no	no	yes	yes	no	yes
48	yes	yes	yes	yes	no	yes
49	yes	yes	no	yes	no	no
50	yes	yes	yes	yes	no	yes
51	no	no	yes	yes	no	yes
52	yes	yes	yes	yes	no	yes
53	yes	yes	yes	yes	no	no
54	yes	yes	yes	yes	no	yes
55	yes	yes	yes	yes	no	yes
56	yes	yes	yes	yes	no	yes
57	no	yes	yes	yes	no	yes
58	no	no	yes	yes	no	yes
59	yes	yes	yes	yes	no	yes
60	yes	yes	yes	yes	no	yes
61	yes	yes	yes	yes	no	yes
62	no	no	yes	yes	no	yes
63	no	no	no	yes	no	yes
64	yes	yes	yes	yes	no	no
65	yes	yes	no	yes	no	yes
66	yes	yes	yes	yes	no	yes
67	yes	yes	yes	yes	no	yes
68	no	yes	yes	yes	no	yes
69	yes	yes	yes	yes	no	yes
70	yes	yes	yes	yes	no	yes

	unburnedbriks	CementBlocs	StructureAge	StructureAge2	StructureAge3	Customary
36	no	no	no	no	yes	no
37	no	no	no	no	yes	no
38	no	no	no	no	yes	no
39	no	yes	no	no	yes	no
40	no	no	no	no	yes	no
41	yes	no	no	yes	no	yes
42	no	no	no	no	yes	yes
43	no	no	no	yes	no	yes
44	no	no	no	no	yes	no
45	no	no	no	no	yes	yes
46	no	no	no	no	yes	yes
47	no	no	no	no	yes	yes
48	no	no	no	no	yes	no
49	no	no	no	no	yes	yes
50	no	no	no	no	yes	yes
51	no	no	no	no	yes	no
52	no	no	no	no	yes	yes
53	no	yes	no	no	yes	yes
54	no	no	no	no	yes	yes
55	no	no	no	no	yes	no
56	no	no	no	no	yes	no
57	no	no	no	no	yes	no
58	no	no	no	no	yes	yes
59	no	no	no	no	yes	yes
60	no	no	no	no	yes	no
61	no	no	no	no	yes	no
62	no	no	no	no	yes	yes
63	no	no	no	no	yes	yes
64	yes	no	no	no	yes	no
65	no	no	no	no	yes	no
66	no	no	no	no	yes	no
67	no	yes	no	no	yes	yes
68	no	no	no	no	yes	yes
69	no	no	no	yes	no	no
70	no	no	no	yes	no	no

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Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	unburnedbri ks	CementBloc s	StructureAge	StructureAge 2	StructureAge 3	Customary
36	no	no	no	no	yes	no
37	no	no	no	no	yes	no
38	no	no	no	no	yes	no
39	no	yes	no	no	yes	no
40	no	no	no	no	yes	no
41	yes	no	no	yes	no	yes
42	no	no	no	no	yes	yes
43	no	no	no	yes	no	yes
44	no	no	no	no	yes	no
45	no	no	no	no	yes	yes
46	no	no	no	no	yes	yes
47	no	no	no	no	yes	yes
48	no	no	no	no	yes	no
49	no	no	no	no	yes	yes
50	no	no	no	no	yes	yes
51	no	no	no	no	yes	no
52	no	no	no	no	yes	yes
53	no	yes	no	no	yes	yes
54	no	no	no	no	yes	yes
55	no	no	no	no	yes	no
56	no	no	no	no	yes	no
57	no	no	no	no	yes	no
58	no	no	no	no	yes	yes
59	no	no	no	no	yes	yes
60	no	no	no	no	yes	no
61	no	no	no	no	yes	no
62	no	no	no	no	yes	yes
63	no	no	no	no	yes	yes
64	yes	no	no	no	yes	no
65	no	no	no	no	yes	no
66	no	no	no	no	yes	no
67	no	yes	no	no	yes	yes
68	no	no	no	no	yes	yes
69	no	no	no	yes	no	no
70	no	no	no	yes	no	no

	Governmentgency
36	yes
37	yes
38	yes
39	yes
40	yes
41	no
42	no
43	no
44	yes
45	no
46	no
47	no
48	yes
49	no
50	no
51	yes
52	no
53	no
54	no
55	yes
56	yes
57	yes
58	no
59	no
60	yes
61	yes
62	no
63	no
64	yes
65	yes
66	yes
67	no
68	no
69	yes
70	yes

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SPSS Statistics Processor is ready

Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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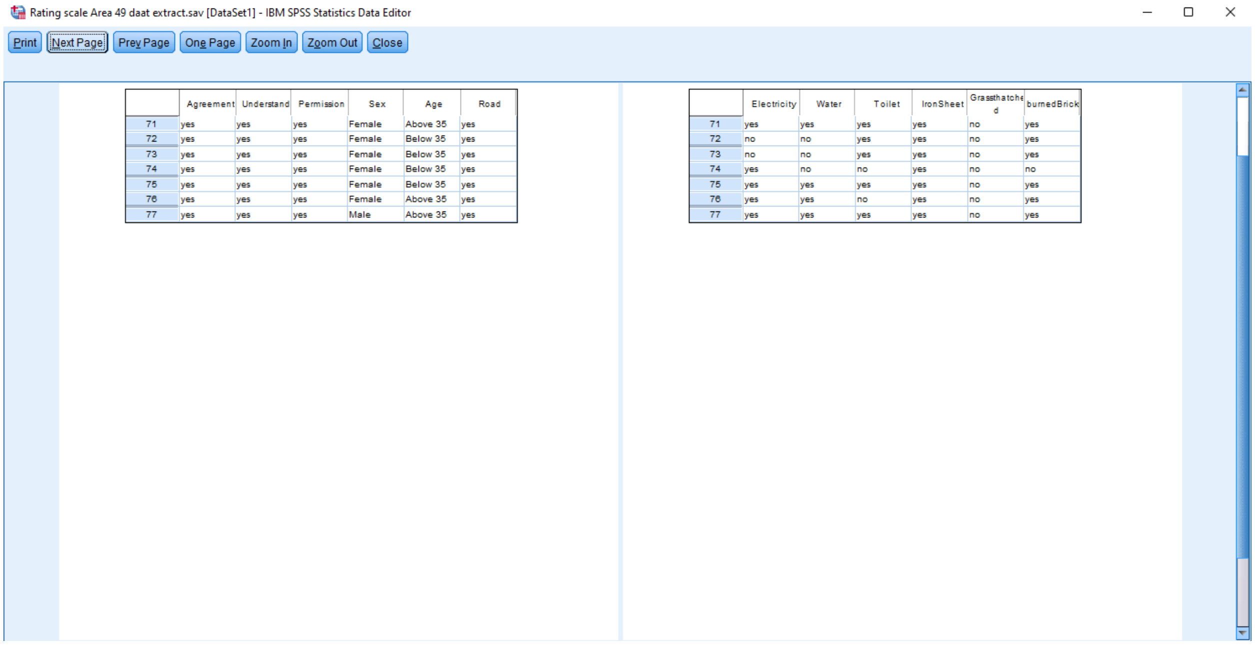
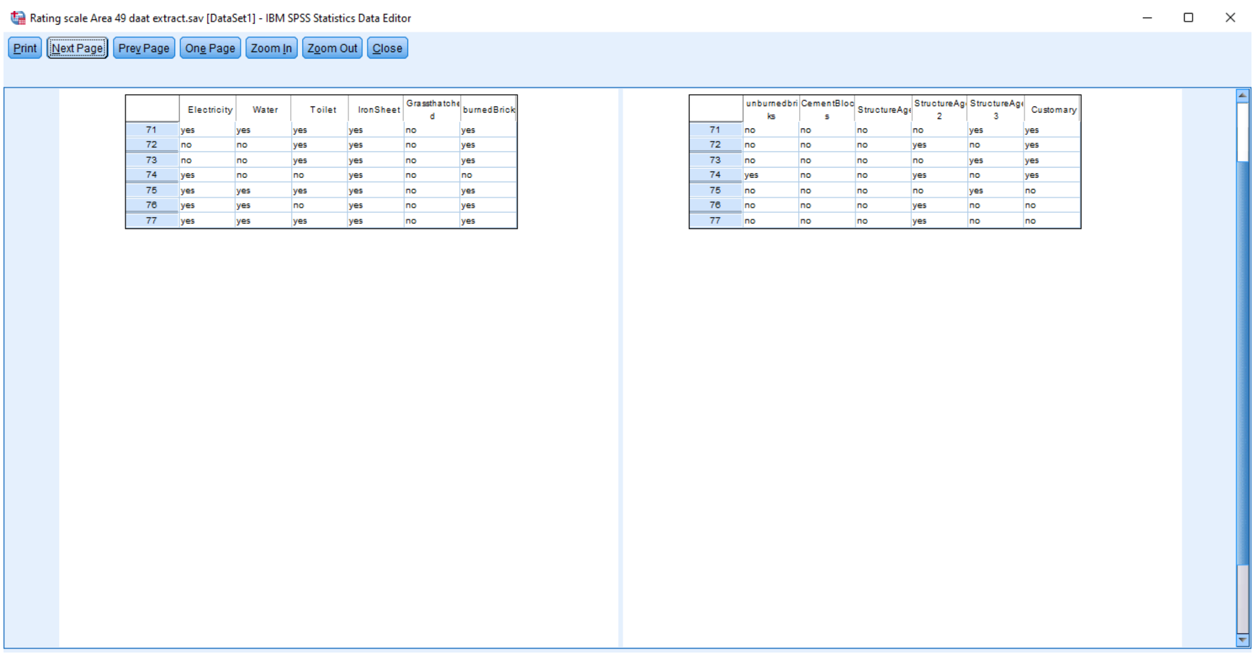
	Governmentgency
36	yes
37	yes
38	yes
39	yes
40	yes
41	no
42	no
43	no
44	yes
45	no
46	no
47	no
48	yes
49	no
50	no
51	yes
52	no
53	no
54	no
55	yes
56	yes
57	yes
58	no
59	no
60	yes
61	yes
62	no
63	no
64	yes
65	yes
66	yes
67	no
68	no
69	yes
70	yes

	Agreement	Understand	Permission	Sex	Age	Road
71	yes	yes	yes	Female	Above 35	yes
72	yes	yes	yes	Female	Below 35	yes
73	yes	yes	yes	Female	Below 35	yes
74	yes	yes	yes	Female	Below 35	yes
75	yes	yes	yes	Female	Below 35	yes
76	yes	yes	yes	Female	Above 35	yes
77	yes	yes	yes	Male	Above 35	yes



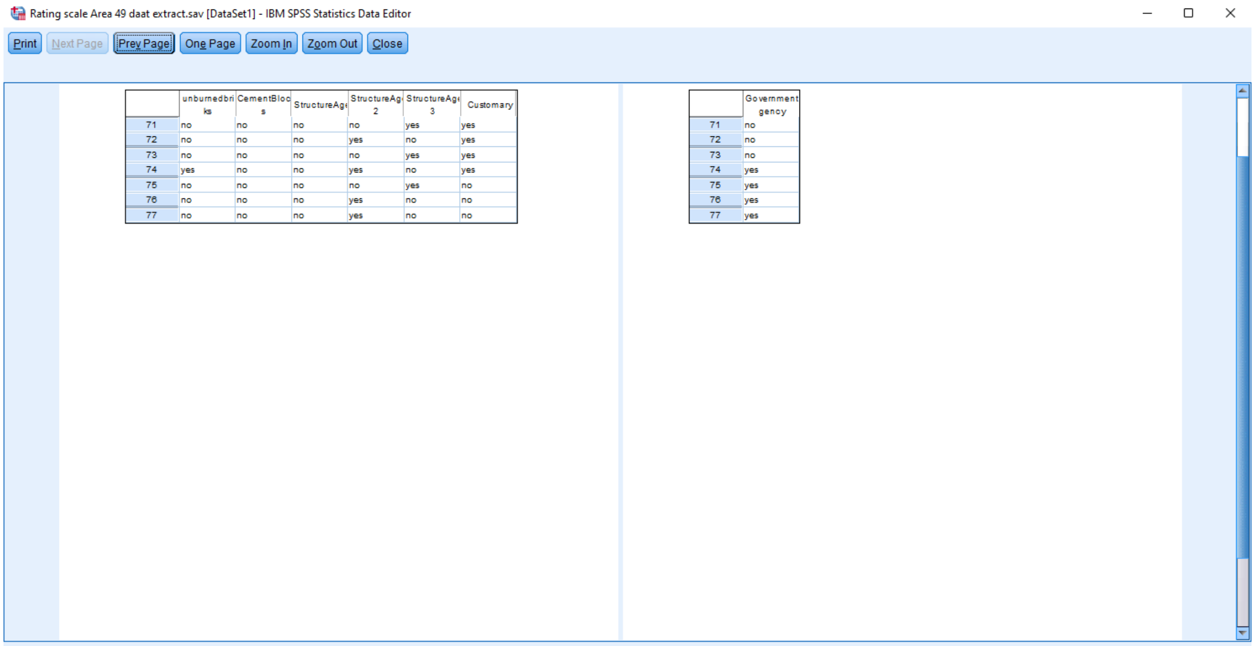
	Agreement	Understand	Permission	Sex	Age	Road
71	yes	yes	yes	Female	Above 35	yes
72	yes	yes	yes	Female	Below 35	yes
73	yes	yes	yes	Female	Below 35	yes
74	yes	yes	yes	Female	Below 35	yes
75	yes	yes	yes	Female	Below 35	yes
76	yes	yes	yes	Female	Above 35	yes
77	yes	yes	yes	Male	Above 35	yes

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
71	yes	yes	yes	yes	no	yes
72	no	no	yes	yes	no	yes
73	no	no	yes	yes	no	yes
74	yes	no	no	yes	no	no
75	yes	yes	yes	yes	no	yes
76	yes	yes	no	yes	no	yes
77	yes	yes	yes	yes	no	yes



	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
71	yes	yes	yes	yes	no	yes
72	no	no	yes	yes	no	yes
73	no	no	yes	yes	no	yes
74	yes	no	no	yes	no	no
75	yes	yes	yes	yes	no	yes
76	yes	yes	no	yes	no	yes
77	yes	yes	yes	yes	no	yes

	unburnedbricks	CementBlocs	StructureAge	StructureAge2	StructureAge3	Customary
71	no	no	no	no	yes	yes
72	no	no	no	yes	no	yes
73	no	no	no	no	yes	yes
74	yes	no	no	yes	no	yes
75	no	no	no	no	yes	no
76	no	no	no	yes	no	no
77	no	no	no	yes	no	no



Rating scale Area 49 daat extract.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	unburnedbricks	CementBlocs	StructureAge	StructureAge2	StructureAge3	Customary
71	no	no	no	no	yes	yes
72	no	no	no	yes	no	yes
73	no	no	no	no	yes	yes
74	yes	no	no	yes	no	yes
75	no	no	no	no	yes	no
76	no	no	no	yes	no	no
77	no	no	no	yes	no	no

	Governmentgency
71	no
72	no
73	no
74	yes
75	yes
76	yes
77	yes

Appendix 4: Mtandire building assessment survey data.

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
1	yes	yes	yes	Female	Above 35	yes
2	yes	yes	yes	Female	Below 35	yes
3	yes	yes	yes	Male	Above 35	no
4	yes	yes	yes	Female	below 35	no
5	yes	yes	yes	Female	Below 35	no
6	yes	yes	yes	Female	Above 35	yes
7	yes	yes	yes	Female	Above 35	yes
8	yes	yes	yes	Male	Above 35	no
9	yes	yes	yes	Female	Below 35	no
10	yes	yes	yes	Male	Above 35	yes
11	yes	yes	yes	Female	Below 35	yes
12	yes	yes	yes	Male	Below 35	yes
13	yes	yes	yes	Female	Above 35	yes
14	yes	yes	yes	Male	Below 35	yes
15	yes	yes	yes	Male	Above 35	yes
16	yes	yes	yes	Female	Above 35	yes
17	yes	yes	yes	Female	Above 35	yes
18	yes	yes	yes	Female	Below 35	yes
19	yes	yes	yes	Female	Below 35	no
20	yes	yes	yes	Female	Below 35	no
21	yes	yes	yes	Female	Below 35	no
22	yes	yes	yes	Female	Below 35	no
23	yes	yes	yes	Female	Above 35	no
24	yes	yes	yes	Female	Above 35	no
25	yes	yes	yes	Female	Below 35	no
26	yes	yes	yes	Female	Below 35	no
27	yes	yes	yes	Female	Above 35	no
28	yes	yes	yes	Female	Above 35	yes
29	yes	yes	yes	Female	Above 35	no
30	yes	yes	yes	Female	Below 35	no
31	yes	yes	yes	Female	Below 35	no
32	yes	yes	yes	Female	Below 35	yes
33	yes	yes	yes	Female	Below 35	no
34	yes	yes	yes	Female	Below 35	no

Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
1	no	yes	yes	yes	no	no
2	no	yes	yes	yes	no	yes
3	no	no	yes	yes	no	yes
4	yes	no	yes	yes	no	yes
5	yes	no	yes	yes	no	yes
6	yes	yes	yes	yes	no	yes
7	yes	yes	yes	yes	no	yes
8	yes	no	yes	yes	no	yes
9	yes	no	yes	yes	no	no
10	no	yes	yes	yes	no	yes
11	yes	yes	yes	yes	no	yes
12	yes	yes	yes	yes	no	no
13	no	yes	yes	yes	no	yes
14	no	no	yes	yes	no	yes
15	yes	no	yes	yes	no	yes
16	no	yes	no	no	yes	no
17	yes	yes	yes	yes	no	yes
18	yes	yes	yes	yes	no	yes
19	yes	no	yes	yes	no	no
20	yes	yes	yes	yes	no	yes
21	yes	yes	yes	yes	no	no
22	no	no	yes	yes	no	no
23	yes	no	yes	yes	no	no
24	no	yes	yes	yes	no	no
25	yes	yes	yes	yes	no	no
26	no	yes	yes	yes	no	no
27	no	yes	yes	yes	no	yes
28	yes	yes	yes	yes	no	no
29	no	yes	yes	yes	no	yes
30	yes	no	yes	yes	no	yes
31	yes	no	yes	yes	no	no
32	no	yes	yes	yes	no	no
33	yes	no	no	yes	no	no
34	yes	no	yes	yes	no	no

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
1	no	yes	yes	yes	no	no
2	no	yes	yes	yes	no	yes
3	no	no	yes	yes	no	yes
4	yes	no	yes	yes	no	yes
5	yes	no	yes	yes	no	yes
6	yes	yes	yes	yes	no	yes
7	yes	yes	yes	yes	no	yes
8	yes	no	yes	yes	no	yes
9	yes	no	yes	yes	no	no
10	no	yes	yes	yes	no	yes
11	yes	yes	yes	yes	no	yes
12	yes	yes	yes	yes	no	no
13	no	yes	yes	yes	no	yes
14	no	no	yes	yes	no	yes
15	yes	no	yes	yes	no	yes
16	no	yes	no	no	yes	no
17	yes	yes	yes	yes	no	yes
18	yes	yes	yes	yes	no	yes
19	yes	no	yes	yes	no	no
20	yes	yes	yes	yes	no	yes
21	yes	yes	yes	yes	no	no
22	no	no	yes	yes	no	no
23	yes	no	yes	yes	no	no
24	no	yes	yes	yes	no	no
25	yes	yes	yes	yes	no	no
26	no	yes	yes	yes	no	no
27	no	yes	yes	yes	no	yes
28	yes	yes	yes	yes	no	no
29	no	yes	yes	yes	no	yes
30	yes	no	yes	yes	no	yes
31	yes	no	yes	yes	no	no
32	no	yes	yes	yes	no	no
33	yes	no	no	yes	no	no
34	yes	no	yes	yes	no	no

Rating scale Mtandire.sav

	unburnedbricks	CementBlocks	StructureAge	StructureAge2	StructureAge3	Customary
1	yes	no	yes	no	no	yes
2	no	no	no	yes	no	yes
3	no	no	yes	no	no	yes
4	no	no	no	no	yes	yes
5	no	no	yes	no	no	yes
6	no	no	yes	no	no	yes
7	no	no	yes	no	no	yes
8	no	no	no	no	yes	no
9	yes	no	no	no	yes	yes
10	no	no	yes	no	no	no
11	no	no	yes	no	no	yes
12	yes	no	no	no	yes	yes
13	no	no	no	no	yes	yes
14	no	no	no	no	yes	yes
15	no	no	no	no	yes	yes
16	yes	no	no	yes	no	yes
17	no	no	no	yes	no	yes
18	no	no	yes	no	no	yes
19	yes	no	no	no	yes	yes
20	no	no	no	no	yes	yes
21	no	yes	no	no	yes	yes
22	no	yes	no	no	yes	yes
23	yes	no	no	no	yes	yes
24	yes	no	no	no	yes	yes
25	yes	no	no	no	yes	yes
26	yes	no	no	no	yes	yes
27	no	no	yes	no	no	yes
28	no	yes	no	no	yes	yes
29	no	no	yes	no	no	yes
30	no	no	no	no	yes	yes
31	yes	no	no	no	yes	yes
32	yes	no	yes	no	no	yes
33	yes	no	no	no	yes	yes
34	yes	no	no	no	yes	yes

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Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	unburnedbri ks	CementBloc s	StructureAge	StructureAge 2	StructureAge 3	Customary
1	yes	no	yes	no	no	yes
2	no	no	no	yes	no	yes
3	no	no	yes	no	no	yes
4	no	no	no	no	yes	yes
5	no	no	yes	no	no	yes
6	no	no	yes	no	no	yes
7	no	no	yes	no	no	yes
8	no	no	no	no	yes	no
9	yes	no	no	no	yes	yes
10	no	no	yes	no	no	no
11	no	no	yes	no	no	yes
12	yes	no	no	no	yes	yes
13	no	no	no	no	yes	yes
14	no	no	no	no	yes	yes
15	no	no	no	no	yes	yes
16	yes	no	no	yes	no	yes
17	no	no	no	yes	no	yes
18	no	no	yes	no	no	yes
19	yes	no	no	no	yes	yes
20	no	no	no	no	yes	yes
21	no	yes	no	no	yes	yes
22	no	yes	no	no	yes	yes
23	yes	no	no	no	yes	yes
24	yes	no	no	no	yes	yes
25	yes	no	no	no	yes	yes
26	yes	no	no	no	yes	yes
27	no	no	yes	no	no	yes
28	no	yes	no	no	yes	yes
29	no	no	yes	no	no	yes
30	no	no	no	no	yes	yes
31	yes	no	no	no	yes	yes
32	yes	no	yes	no	no	yes
33	yes	no	no	no	yes	yes
34	yes	no	no	no	yes	yes

Rating scale Mtandire.sav

	Government gency
1	no
2	no
3	no
4	no
5	no
6	no
7	no
8	no
9	no
10	yes
11	no
12	no
13	no
14	no
15	no
16	no
17	no
18	no
19	no
20	no
21	no
22	no
23	no
24	no
25	no
26	no
27	no
28	no
29	no
30	no
31	no
32	no
33	no
34	no

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Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Government gency
1	no
2	no
3	no
4	no
5	no
6	no
7	no
8	no
9	no
10	yes
11	no
12	no
13	no
14	no
15	no
16	no
17	no
18	no
19	no
20	no
21	no
22	no
23	no
24	no
25	no
26	no
27	no
28	no
29	no
30	no
31	no
32	no
33	no
34	no

Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
36	yes	yes	yes	Female	Above 35	no
37	yes	yes	yes	Female	Above 35	no
38	yes	yes	yes	Male	Above 35	no
39	yes	yes	yes	Female	Below 35	no
40	yes	yes	yes	Female	Below 35	no
41	yes	yes	yes	Female	Above 35	no
42	yes	yes	yes	Male	Above 35	yes
43	yes	yes	yes	Female	Above 35	yes
44	yes	yes	yes	Male	Below 35	yes
45	yes	yes	yes	Male	Below 35	yes
46	yes	yes	yes	Male	Above 35	yes
47	yes	yes	yes	Male	Above 35	yes
48	yes	yes	yes	Female	Above 35	yes
49	yes	yes	yes	Male	Above 35	yes
50	yes	yes	yes	Male	Below 35	yes
51	yes	yes	yes	Female	Above 35	yes
52	yes	yes	yes	Female	Below 35	yes
53	yes	yes	yes	Male	Below 35	yes
54	yes	yes	yes	Female	Above 35	yes
55	yes	yes	yes	Female	Below 35	yes
56	yes	yes	yes	Female	Above 35	yes
57	yes	yes	yes	Female	Above 35	yes
58	yes	yes	yes	Female	Below 35	yes
59	yes	yes	yes	Female	Above 35	yes
60	yes	yes	yes	Female	Below 35	yes
61	yes	yes	yes	Female	Below 35	yes
62	yes	yes	yes	Male	Below 35	yes
63	yes	yes	yes	Male	Above 35	yes
64	yes	yes	yes	Male	Below 35	yes
65	yes	yes	yes	Male	Above 35	yes
66	yes	yes	yes	Male	Above 35	yes
67	yes	yes	yes	Male	Below 35	yes
68	yes	yes	yes	Male	Above 35	yes
69	yes	yes	yes	Female	Above 35	yes

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
36	yes	yes	yes	Female	Above 35	no	yes	no	yes	yes	no	no
37	yes	yes	yes	Female	Above 35	no	no	yes	yes	yes	no	no
38	yes	yes	yes	Male	Above 35	no	no	no	yes	yes	no	yes
39	yes	yes	yes	Female	Below 35	no	no	no	yes	yes	no	no
40	yes	yes	yes	Female	Below 35	no	yes	yes	yes	yes	no	yes
41	yes	yes	yes	Female	Above 35	no	no	yes	yes	yes	no	no
42	yes	yes	yes	Male	Above 35	yes	yes	no	yes	yes	no	yes
43	yes	yes	yes	Female	Above 35	yes	yes	yes	yes	yes	no	yes
44	yes	yes	yes	Male	Below 35	yes	no	yes	yes	yes	no	yes
45	yes	yes	yes	Male	Below 35	yes	no	yes	yes	yes	no	yes
46	yes	yes	yes	Male	Above 35	yes	no	yes	yes	yes	no	yes
47	yes	yes	yes	Male	Above 35	yes	no	no	yes	yes	no	yes
48	yes	yes	yes	Female	Above 35	yes	yes	yes	yes	yes	no	yes
49	yes	yes	yes	Male	Above 35	yes	yes	yes	yes	yes	no	no
50	yes	yes	yes	Male	Below 35	yes	yes	yes	yes	yes	no	yes
51	yes	yes	yes	Female	Above 35	yes	no	no	yes	yes	no	yes
52	yes	yes	yes	Female	Below 35	yes	yes	yes	yes	yes	no	yes
53	yes	yes	yes	Male	Below 35	yes	yes	yes	yes	yes	no	no
54	yes	yes	yes	Female	Above 35	yes	yes	yes	yes	yes	no	yes
55	yes	yes	yes	Female	Below 35	yes	yes	yes	yes	yes	no	yes
56	yes	yes	yes	Female	Above 35	yes	yes	yes	yes	yes	no	yes
57	yes	yes	yes	Female	Above 35	yes	no	yes	yes	yes	no	yes
58	yes	yes	yes	Female	Below 35	yes	no	no	yes	yes	no	yes
59	yes	yes	yes	Female	Above 35	yes	yes	yes	yes	yes	no	yes
60	yes	yes	yes	Female	Below 35	yes	yes	yes	yes	yes	no	yes
61	yes	yes	yes	Female	Below 35	yes	yes	yes	yes	yes	no	yes
62	yes	yes	yes	Male	Below 35	yes	no	no	no	yes	no	yes
63	yes	yes	yes	Male	Above 35	yes	no	no	no	yes	no	yes
64	yes	yes	yes	Male	Below 35	yes	yes	yes	yes	yes	no	no
65	yes	yes	yes	Male	Above 35	yes	yes	yes	yes	yes	no	yes
66	yes	yes	yes	Male	Above 35	yes	yes	yes	yes	yes	no	yes
67	yes	yes	yes	Male	Below 35	yes	yes	yes	yes	yes	no	yes
68	yes	yes	yes	Male	Above 35	yes	no	yes	yes	yes	no	no
69	yes	yes	yes	Female	Above 35	yes	yes	yes	yes	yes	no	yes

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	unburnedbricks	CementBlocks	StructureAge	StructureAge2	StructureAge3	Customary	Governmentgency
36	yes	no	yes	no	no	yes	no
37	yes	no	yes	no	no	yes	no
38	no	no	yes	no	no	yes	no
39	yes	no	yes	no	no	yes	no
40	no	no	no	no	yes	no	yes
41	yes	no	yes	no	no	yes	no
42	no	no	no	no	yes	yes	no
43	no	no	yes	no	no	yes	no
44	no	no	no	no	yes	no	yes
45	no	no	no	no	yes	yes	no
46	no	no	no	no	yes	yes	no
47	no	no	no	no	yes	yes	no
48	no	no	no	no	yes	no	yes
49	no	no	no	no	yes	yes	no
50	no	no	no	no	yes	yes	no
51	no	no	no	no	yes	no	yes
52	no	no	no	no	yes	yes	no
53	no	yes	no	no	yes	yes	no
54	no	no	no	no	yes	yes	no
55	no	no	no	no	yes	yes	no
56	no	no	no	no	yes	yes	no
57	no	no	no	no	yes	yes	no
58	no	no	no	no	yes	yes	no
59	no	no	no	no	yes	yes	no
60	no	no	no	no	yes	no	yes
61	no	no	no	no	yes	no	yes
62	no	no	no	no	yes	yes	no
63	no	no	no	no	yes	yes	no
64	no	yes	no	no	yes	yes	no
65	no	no	no	no	yes	yes	no
66	no	no	no	no	yes	yes	no
67	no	yes	no	no	yes	yes	no
68	no	yes	no	no	yes	yes	no
69	no	no	no	yes	no	yes	no

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Government gency
36	no
37	no
38	no
39	no
40	yes
41	no
42	no
43	no
44	yes
45	no
46	no
47	no
48	yes
49	no
50	no
51	yes
52	no
53	no
54	no
55	no
56	no
57	no
58	no
59	no
60	yes
61	yes
62	no
63	no
64	no
65	no
66	no
67	no
68	no
69	no

Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
71	yes	yes	yes	Female	Above 35	yes
72	yes	yes	yes	Female	Below 35	yes
73	yes	yes	yes	Female	Below 35	yes
74	yes	yes	yes	Female	Below 35	yes
75	yes	yes	yes	Female	Below 35	yes
76	yes	yes	yes	Female	Above 35	yes
77	yes	yes	yes	Male	Above 35	yes
78	yes	yes	yes	Female	Above 35	yes
79	yes	yes	yes	Female	Above 35	yes
80	yes	yes	yes	Female	Above 35	yes
81	yes	yes	yes	Female	Above 35	yes
82	yes	yes	yes	Female	Below 35	yes
83	yes	yes	yes	Female	Below 35	yes
84	yes	yes	yes	Female	Below 35	yes
85	yes	yes	yes	Female	Below 35	yes
86	yes	yes	yes	Female	Above 35	yes
87	yes	yes	yes	Female	Below 35	yes
88	yes	yes	yes	Female	Below 35	yes
89	yes	yes	yes	Male	Below 35	yes
90	yes	yes	yes	Female	Below 35	yes
91	yes	yes	yes	Female	Below 35	yes
92	yes	yes	yes	Male	Above 35	yes
93	yes	yes	yes	Female	Above 35	yes
94	yes	yes	yes	Female	Below 35	yes
95	yes	yes	yes	Male	Above 35	yes
96	yes	yes	yes	Female	Below 35	yes
97	yes	yes	yes	Male	Below 35	yes
98	yes	yes	yes	Male	Above 35	no
99	yes	yes	yes	Female	Above 35	yes
100	yes	yes	yes	Female	Below 35	no
101	yes	yes	yes	Male	Below 35	yes
102	yes	yes	yes	Female	Below 35	no
103	yes	yes	yes	Female	Below 35	yes
104	yes	yes	yes	Male	Above 35	yes

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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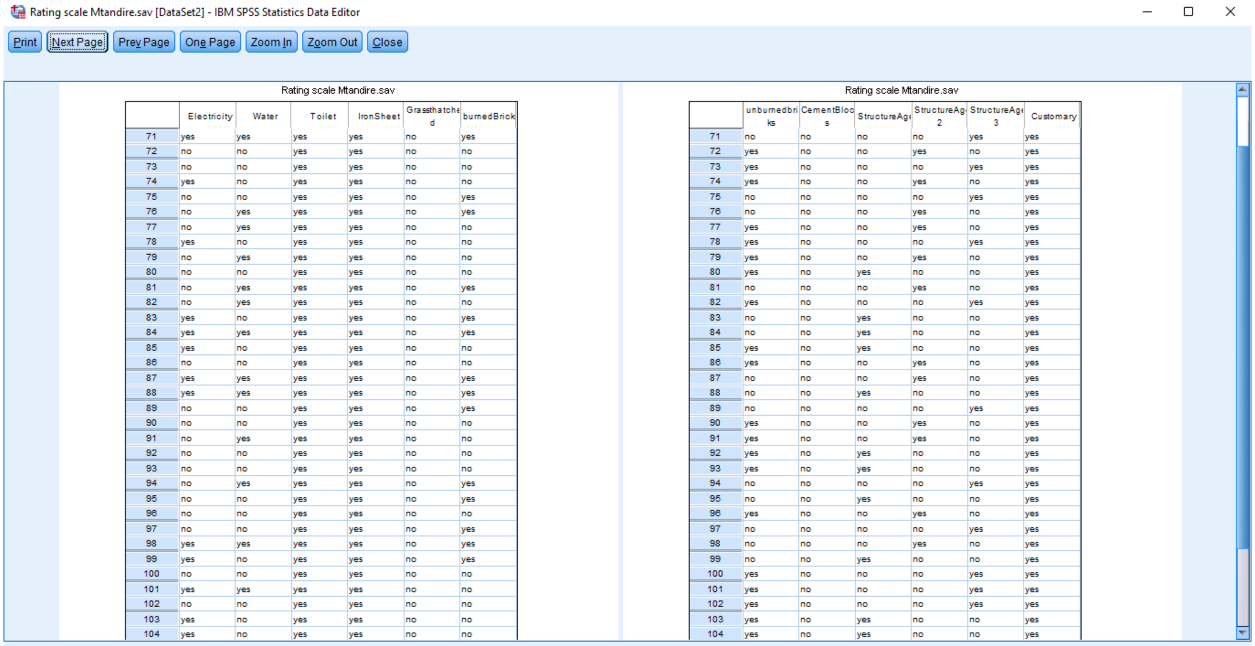
Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
71	yes	yes	yes	Female	Above 35	yes
72	yes	yes	yes	Female	Below 35	yes
73	yes	yes	yes	Female	Below 35	yes
74	yes	yes	yes	Female	Below 35	yes
75	yes	yes	yes	Female	Below 35	yes
76	yes	yes	yes	Female	Above 35	yes
77	yes	yes	yes	Male	Above 35	yes
78	yes	yes	yes	Female	Above 35	yes
79	yes	yes	yes	Female	Above 35	yes
80	yes	yes	yes	Female	Above 35	yes
81	yes	yes	yes	Female	Above 35	yes
82	yes	yes	yes	Female	Below 35	yes
83	yes	yes	yes	Female	Below 35	yes
84	yes	yes	yes	Female	Below 35	yes
85	yes	yes	yes	Female	Below 35	yes
86	yes	yes	yes	Female	Above 35	yes
87	yes	yes	yes	Female	Below 35	yes
88	yes	yes	yes	Female	Below 35	yes
89	yes	yes	yes	Male	Below 35	yes
90	yes	yes	yes	Female	Below 35	yes
91	yes	yes	yes	Female	Below 35	yes
92	yes	yes	yes	Male	Above 35	yes
93	yes	yes	yes	Female	Above 35	yes
94	yes	yes	yes	Female	Below 35	yes
95	yes	yes	yes	Male	Above 35	yes
96	yes	yes	yes	Female	Below 35	yes
97	yes	yes	yes	Male	Below 35	yes
98	yes	yes	yes	Male	Above 35	no
99	yes	yes	yes	Female	Above 35	yes
100	yes	yes	yes	Female	Below 35	no
101	yes	yes	yes	Male	Below 35	yes
102	yes	yes	yes	Female	Below 35	no
103	yes	yes	yes	Female	Below 35	yes
104	yes	yes	yes	Male	Above 35	yes

Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
71	yes	yes	yes	yes	no	yes
72	no	no	yes	yes	no	no
73	no	no	yes	yes	no	no
74	yes	no	yes	yes	no	no
75	no	no	yes	yes	no	yes
76	no	yes	yes	yes	no	yes
77	no	yes	yes	yes	no	no
78	yes	no	yes	yes	no	no
79	no	yes	yes	yes	no	no
80	no	no	yes	yes	no	no
81	no	yes	yes	yes	no	yes
82	no	yes	yes	yes	no	no
83	yes	no	yes	yes	no	yes
84	yes	yes	yes	yes	no	yes
85	yes	no	yes	yes	no	no
86	no	no	yes	yes	no	no
87	yes	yes	yes	yes	no	yes
88	yes	yes	yes	yes	no	yes
89	no	no	yes	yes	no	yes
90	no	no	yes	yes	no	no
91	no	yes	yes	yes	no	no
92	no	no	yes	yes	no	no
93	no	no	yes	yes	no	no
94	no	yes	yes	yes	no	yes
95	no	no	yes	yes	no	yes
96	no	no	yes	yes	no	no
97	no	no	yes	yes	no	yes
98	yes	yes	yes	yes	no	yes
99	yes	no	yes	yes	no	yes
100	no	no	yes	yes	no	no
101	yes	yes	yes	yes	no	no
102	no	no	yes	yes	no	no
103	yes	no	yes	yes	no	no
104	yes	no	yes	yes	no	no

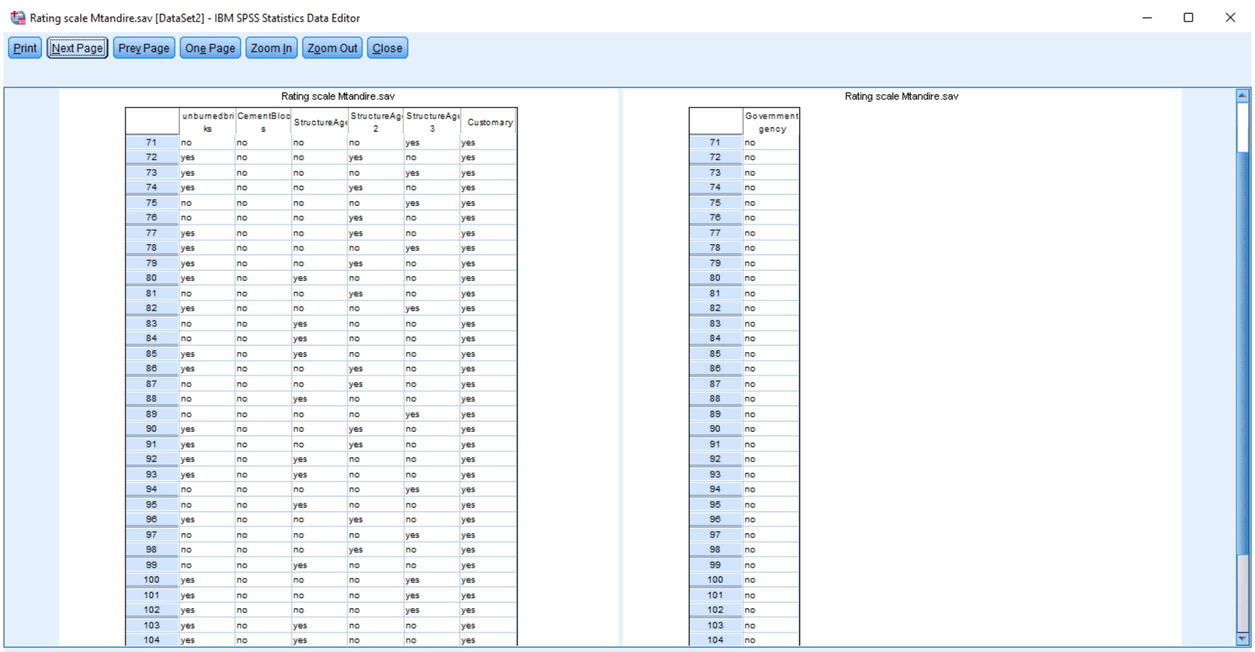


Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
71	yes	yes	yes	yes	no	yes
72	no	no	yes	yes	no	no
73	no	no	yes	yes	no	no
74	yes	no	yes	yes	no	no
75	no	no	yes	yes	no	yes
76	no	yes	yes	yes	no	yes
77	no	yes	yes	yes	no	no
78	yes	no	yes	yes	no	no
79	no	yes	yes	yes	no	no
80	no	no	yes	yes	no	no
81	no	yes	yes	yes	no	yes
82	no	yes	yes	yes	no	no
83	yes	no	yes	yes	no	yes
84	yes	yes	yes	yes	no	yes
85	yes	no	yes	yes	no	no
86	no	no	yes	yes	no	no
87	yes	yes	yes	yes	no	yes
88	yes	yes	yes	yes	no	yes
89	no	no	yes	yes	no	yes
90	no	no	yes	yes	no	no
91	no	yes	yes	yes	no	no
92	no	no	yes	yes	no	no
93	no	no	yes	yes	no	no
94	no	yes	yes	yes	no	yes
95	no	no	yes	yes	no	yes
96	no	no	yes	yes	no	no
97	no	no	yes	yes	no	yes
98	yes	yes	yes	yes	no	yes
99	yes	no	yes	yes	no	yes
100	no	no	yes	yes	no	no
101	yes	yes	yes	yes	no	no
102	no	no	yes	yes	no	no
103	yes	no	yes	yes	no	no
104	yes	no	yes	yes	no	no

Rating scale Mtandire.sav

	unburnedbricks	CementBlocs	StructureAge	StructureAge2	StructureAge3	Customary
71	no	no	no	no	yes	yes
72	yes	no	no	yes	no	yes
73	yes	no	no	no	yes	yes
74	yes	no	no	yes	no	yes
75	no	no	no	no	yes	yes
76	no	no	no	yes	no	yes
77	yes	no	no	yes	no	yes
78	yes	no	no	no	yes	yes
79	yes	no	no	yes	no	yes
80	yes	no	yes	no	no	yes
81	no	no	no	yes	no	yes
82	yes	no	no	no	yes	yes
83	no	no	yes	no	no	yes
84	no	no	yes	no	no	yes
85	yes	no	yes	no	no	yes
86	yes	no	no	yes	no	yes
87	no	no	no	yes	no	yes
88	no	no	yes	no	no	yes
89	no	no	no	no	yes	yes
90	yes	no	no	yes	no	yes
91	yes	no	no	yes	no	yes
92	yes	no	yes	no	no	yes
93	yes	no	yes	no	no	yes
94	no	no	no	no	yes	yes
95	no	no	yes	no	no	yes
96	yes	no	no	yes	no	yes
97	no	no	no	no	yes	yes
98	no	no	no	yes	no	yes
99	no	no	yes	no	no	yes
100	yes	no	no	no	yes	yes
101	yes	no	no	no	yes	yes
102	yes	no	no	no	yes	yes
103	yes	no	yes	no	no	yes
104	yes	no	yes	no	no	yes



Rating scale Mtandire.sav

	unburnedbricks	CementBlocs	StructureAge	StructureAge2	StructureAge3	Customary
71	no	no	no	no	yes	yes
72	yes	no	no	yes	no	yes
73	yes	no	no	no	yes	yes
74	yes	no	no	yes	no	yes
75	no	no	no	no	yes	yes
76	no	no	no	yes	no	yes
77	yes	no	no	yes	no	yes
78	yes	no	no	no	yes	yes
79	yes	no	no	yes	no	yes
80	yes	no	yes	no	no	yes
81	no	no	no	yes	no	yes
82	yes	no	no	no	yes	yes
83	no	no	yes	no	no	yes
84	no	no	yes	no	no	yes
85	yes	no	yes	no	no	yes
86	yes	no	no	yes	no	yes
87	no	no	no	yes	no	yes
88	no	no	yes	no	no	yes
89	no	no	no	no	yes	yes
90	yes	no	no	yes	no	yes
91	yes	no	no	yes	no	yes
92	yes	no	yes	no	no	yes
93	yes	no	yes	no	no	yes
94	no	no	no	no	yes	yes
95	no	no	yes	no	no	yes
96	yes	no	no	yes	no	yes
97	no	no	no	no	yes	yes
98	no	no	no	yes	no	yes
99	no	no	yes	no	no	yes
100	yes	no	no	no	yes	yes
101	yes	no	no	no	yes	yes
102	yes	no	no	no	yes	yes
103	yes	no	yes	no	no	yes
104	yes	no	yes	no	no	yes

Rating scale Mtandire.sav

	Governmentgency
71	no
72	no
73	no
74	no
75	no
76	no
77	no
78	no
79	no
80	no
81	no
82	no
83	no
84	no
85	no
86	no
87	no
88	no
89	no
90	no
91	no
92	no
93	no
94	no
95	no
96	no
97	no
98	no
99	no
100	no
101	no
102	no
103	no
104	no

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Government gency
71	no
72	no
73	no
74	no
75	no
76	no
77	no
78	no
79	no
80	no
81	no
82	no
83	no
84	no
85	no
86	no
87	no
88	no
89	no
90	no
91	no
92	no
93	no
94	no
95	no
96	no
97	no
98	no
99	no
100	no
101	no
102	no
103	no
104	no

Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
106	yes	yes	yes	Female	Above 35	yes
107	yes	yes	yes	Female	Below 35	yes
108	yes	yes	yes	Female	Above 35	yes
109	yes	yes	yes	Female	Above 35	no
110	yes	yes	yes	Female	Above 35	yes
111	yes	yes	yes	Female	Above 35	yes
112	yes	yes	yes	Female	Above 35	no
113	yes	yes	yes	Male	Above 35	yes
114	yes	yes	yes	Female	Below 35	yes
115	yes	yes	yes	Female	Above 35	no
116	yes	yes	yes	Female	Below 35	yes
117	yes	yes	yes	Female	Above 35	yes
118	yes	yes	yes	Male	Below 35	no
119	yes	yes	yes	Male	Below 35	yes
120	yes	yes	yes	Male	Below 35	yes
121	yes	yes	yes	Female	Below 35	no
122	yes	yes	yes	Male	Above 35	yes
123	yes	yes	yes	Female	Above 35	yes
124	yes	yes	yes	Female	Above 35	yes
125	yes	yes	yes	Female	Above 35	yes
126	yes	yes	yes	Female	Below 35	yes
127	yes	yes	yes	Female	Above 35	yes
128	yes	yes	yes	Female	Below 35	yes
129	yes	yes	yes	Male	Above 35	yes
130	yes	yes	yes	Female	Below 35	yes
131	yes	yes	yes	Female	Below 35	yes
132	yes	yes	yes	Female	Above 35	yes
133	yes	yes	yes	male	Above 35	yes
134	yes	yes	yes	Male	Below 35	yes
135	yes	yes	yes	Female	Below 35	yes
136	yes	yes	yes	Female	Below 35	yes
137	yes	yes	yes	Female	Below 35	yes
138	yes	yes	yes	Female	Below 35	yes
139	yes	yes	yes	Female	above 35	yes

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
106	yes	yes	yes	Female	Above 35	yes
107	yes	yes	yes	Female	Below 35	yes
108	yes	yes	yes	Female	Above 35	yes
109	yes	yes	yes	Female	Above 35	no
110	yes	yes	yes	Female	Above 35	yes
111	yes	yes	yes	Female	Above 35	yes
112	yes	yes	yes	Female	Above 35	no
113	yes	yes	yes	Male	Above 35	yes
114	yes	yes	yes	Female	Below 35	yes
115	yes	yes	yes	Female	Above 35	no
116	yes	yes	yes	Female	Below 35	yes
117	yes	yes	yes	Female	Above 35	yes
118	yes	yes	yes	Male	Below 35	no
119	yes	yes	yes	Male	Below 35	yes
120	yes	yes	yes	Male	Below 35	yes
121	yes	yes	yes	Female	Below 35	no
122	yes	yes	yes	Male	Above 35	yes
123	yes	yes	yes	Female	Above 35	yes
124	yes	yes	yes	Female	Above 35	yes
125	yes	yes	yes	Female	Above 35	yes
126	yes	yes	yes	Female	Below 35	yes
127	yes	yes	yes	Female	Above 35	yes
128	yes	yes	yes	Female	Below 35	yes
129	yes	yes	yes	Male	Above 35	yes
130	yes	yes	yes	Female	Below 35	yes
131	yes	yes	yes	Female	Below 35	yes
132	yes	yes	yes	Female	Above 35	yes
133	yes	yes	yes	male	Above 35	yes
134	yes	yes	yes	Male	Below 35	yes
135	yes	yes	yes	Female	Below 35	yes
136	yes	yes	yes	Female	Below 35	yes
137	yes	yes	yes	Female	Below 35	yes
138	yes	yes	yes	Female	Below 35	yes
139	yes	yes	yes	Female	above 35	yes

Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
106	no	no	yes	yes	no	no
107	no	no	yes	yes	no	no
108	no	no	yes	no	yes	no
109	yes	yes	yes	yes	no	no
110	yes	yes	yes	yes	no	yes
111	yes	yes	yes	yes	no	yes
112	yes	yes	yes	no	no	yes
113	no	no	yes	no	no	yes
114	yes	yes	yes	yes	no	no
115	yes	yes	yes	yes	no	yes
116	yes	yes	yes	yes	no	yes
117	no	yes	yes	yes	no	yes
118	no	no	yes	yes	no	yes
119	yes	no	yes	yes	no	yes
120	yes	no	yes	yes	no	yes
121	yes	yes	yes	yes	no	yes
122	no	no	yes	yes	no	yes
123	yes	yes	yes	yes	no	no
124	yes	yes	yes	yes	no	yes
125	no	no	yes	no	yes	no
126	no	no	yes	yes	no	no
127	no	no	yes	yes	no	no
128	no	no	yes	yes	no	no
129	yes	no	yes	yes	no	no
130	yes	no	no	yes	yes	no
131	no	no	yes	yes	no	no
132	yes	no	yes	yes	no	yes
133	yes	yes	yes	yes	no	yes
134	no	no	yes	yes	no	yes
135	no	no	yes	yes	no	no
136	no	yes	yes	yes	no	yes
137	yes	yes	yes	yes	no	yes
138	yes	yes	yes	yes	no	yes
139	no	no	yes	no	no	no

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
106	no	no	yes	yes	no	no
107	no	no	yes	yes	no	no
108	no	no	yes	no	yes	no
109	yes	yes	yes	yes	no	no
110	yes	yes	yes	yes	no	yes
111	yes	yes	yes	yes	no	yes
112	yes	yes	yes	no	no	yes
113	no	no	yes	no	no	yes
114	yes	yes	yes	yes	no	no
115	yes	yes	yes	yes	no	yes
116	yes	yes	yes	yes	no	yes
117	no	yes	yes	yes	no	yes
118	no	no	yes	yes	no	yes
119	yes	no	yes	yes	no	yes
120	yes	no	yes	yes	no	yes
121	yes	yes	yes	yes	no	yes
122	no	no	yes	yes	no	yes
123	yes	yes	yes	yes	no	no
124	yes	yes	yes	yes	no	yes
125	no	no	yes	no	yes	no
126	no	no	yes	yes	no	no
127	no	no	yes	yes	no	no
128	no	no	yes	yes	no	no
129	yes	no	yes	yes	no	no
130	yes	no	no	yes	yes	no
131	no	no	yes	yes	no	no
132	yes	no	yes	yes	no	yes
133	yes	yes	yes	yes	no	yes
134	no	no	yes	yes	no	yes
135	no	no	yes	yes	no	no
136	no	yes	yes	yes	no	yes
137	yes	yes	yes	yes	no	yes
138	yes	yes	yes	yes	no	yes
139	no	no	yes	no	no	no

Rating scale Mtandire.sav

	unburnedbricks	CementBlocs	StructureAge	StructureAge 2	StructureAge 3	Customary
106	yes	no	no	yes	no	yes
107	yes	no	no	yes	no	yes
108	yes	no	no	yes	no	yes
109	yes	yes	no	no	yes	yes
110	no	no	no	no	yes	yes
111	no	no	no	no	yes	yes
112	no	no	no	yes	no	yes
113	no	no	no	no	yes	yes
114	no	yes	no	no	yes	no
115	no	no	no	no	yes	yes
116	no	no	yes	no	no	yes
117	no	no	no	yes	no	yes
118	no	no	no	no	yes	yes
119	no	no	no	yes	no	yes
120	no	no	no	yes	no	yes
121	no	no	yes	no	no	yes
122	no	no	no	no	yes	no
123	yes	no	no	no	yes	yes
124	no	no	yes	yes	no	yes
125	yes	no	no	yes	no	yes
126	yes	no	no	yes	no	yes
127	yes	no	no	yes	no	yes
128	yes	no	yes	no	no	yes
129	yes	no	yes	no	no	yes
130	no	no	yes	no	no	yes
131	yes	no	no	no	yes	yes
132	no	no	yes	no	no	yes
133	no	no	no	yes	no	yes
134	no	no	no	no	yes	yes
135	yes	no	no	yes	no	yes
136	no	no	no	no	yes	yes
137	no	no	no	yes	no	yes
138	no	no	yes	no	no	yes
139	yes	no	yes	no	no	yes

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	unburnedbricks	CementBlocs	StructureAge	StructureAge 2	StructureAge 3	Customary
106	yes	no	no	yes	no	yes
107	yes	no	no	yes	no	yes
108	yes	no	no	yes	no	yes
109	yes	yes	no	no	yes	yes
110	no	no	no	no	yes	yes
111	no	no	no	no	yes	yes
112	no	no	no	yes	no	yes
113	no	no	no	no	yes	yes
114	no	yes	no	no	yes	no
115	no	no	no	no	yes	yes
116	no	no	yes	no	no	yes
117	no	no	no	yes	no	yes
118	no	no	no	no	yes	yes
119	no	no	no	yes	no	yes
120	no	no	no	yes	no	yes
121	no	no	yes	no	no	yes
122	no	no	no	no	yes	no
123	yes	no	no	no	yes	yes
124	no	no	yes	yes	no	yes
125	yes	no	no	yes	no	yes
126	yes	no	no	yes	no	yes
127	yes	no	no	yes	no	yes
128	yes	no	yes	no	no	yes
129	yes	no	yes	no	no	yes
130	no	no	yes	no	no	yes
131	yes	no	no	no	yes	yes
132	no	no	yes	no	no	yes
133	no	no	no	yes	no	yes
134	no	no	no	no	yes	yes
135	yes	no	no	yes	no	yes
136	no	no	no	no	yes	yes
137	no	no	no	yes	no	yes
138	no	no	yes	no	no	yes
139	yes	no	yes	no	no	yes

Rating scale Mtandire.sav

	Governmentagency
106	no
107	no
108	no
109	no
110	no
111	no
112	no
113	no
114	yes
115	no
116	no
117	no
118	no
119	no
120	no
121	no
122	yes
123	no
124	no
125	no
126	no
127	no
128	no
129	no
130	no
131	no
132	no
133	no
134	no
135	no
136	no
137	no
138	no
139	no

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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Rating scale Mtandire.sav

	Governmentgency
106	no
107	no
108	no
109	no
110	no
111	no
112	no
113	no
114	yes
115	no
116	no
117	no
118	no
119	no
120	no
121	no
122	yes
123	no
124	no
125	no
126	no
127	no
128	no
129	no
130	no
131	no
132	no
133	no
134	no
135	no
136	no
137	no
138	no
139	no

Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
141	yes	yes	yes	Female	Above 35	yes
142	yes	yes	yes	Male	Above 35	yes
143	yes	yes	yes	Female	Above 35	yes
144	yes	yes	yes	Male	Below 35	yes
145	yes	yes	yes	Female	Below 35	yes

Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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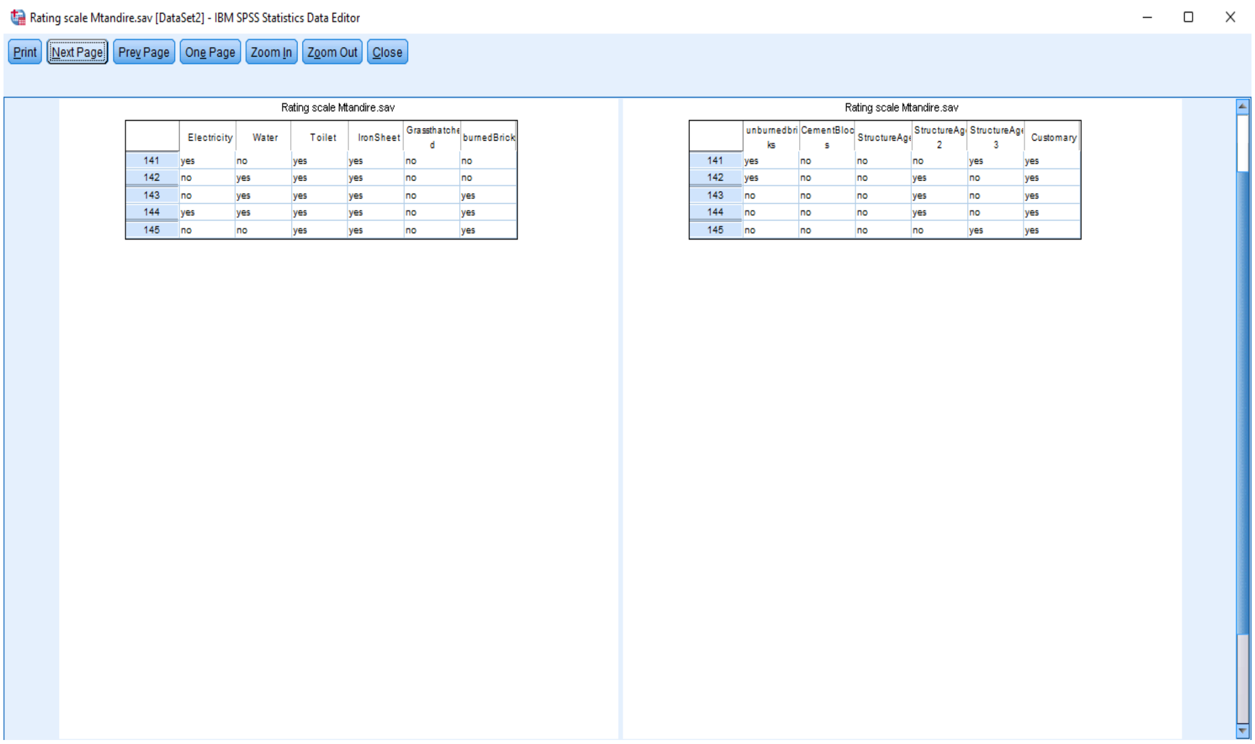
Rating scale Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Road
141	yes	yes	yes	Female	Above 35	yes
142	yes	yes	yes	Male	Above 35	yes
143	yes	yes	yes	Female	Above 35	yes
144	yes	yes	yes	Male	Below 35	yes
145	yes	yes	yes	Female	Below 35	yes

Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
141	yes	no	yes	yes	no	no
142	no	yes	yes	yes	no	no
143	no	yes	yes	yes	no	yes
144	yes	yes	yes	yes	no	yes
145	no	no	yes	yes	no	yes



Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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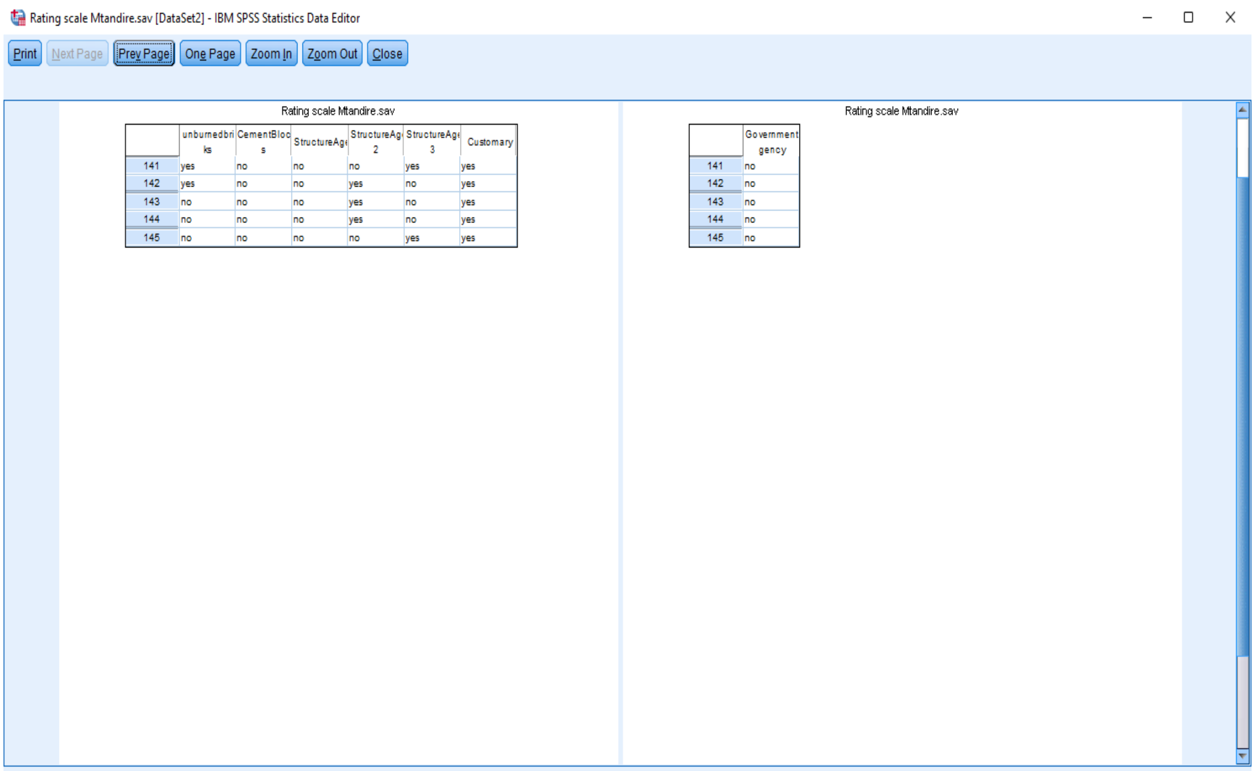
Rating scale Mtandire.sav

	Electricity	Water	Toilet	IronSheet	Grassthatched	burnedBrick
141	yes	no	yes	yes	no	no
142	no	yes	yes	yes	no	no
143	no	yes	yes	yes	no	yes
144	yes	yes	yes	yes	no	yes
145	no	no	yes	yes	no	yes

Rating scale Mtandire.sav

	unburnedbricks	CementBlocs	StructureAge	StructureAge 2	StructureAge 3	Customary
141	yes	no	no	no	yes	yes
142	yes	no	no	yes	no	yes
143	no	no	no	yes	no	yes
144	no	no	no	yes	no	yes
145	no	no	no	no	yes	yes



Rating scale Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

Print | Next Page | Prev Page | One Page | Zoom In | Zoom Out | Close

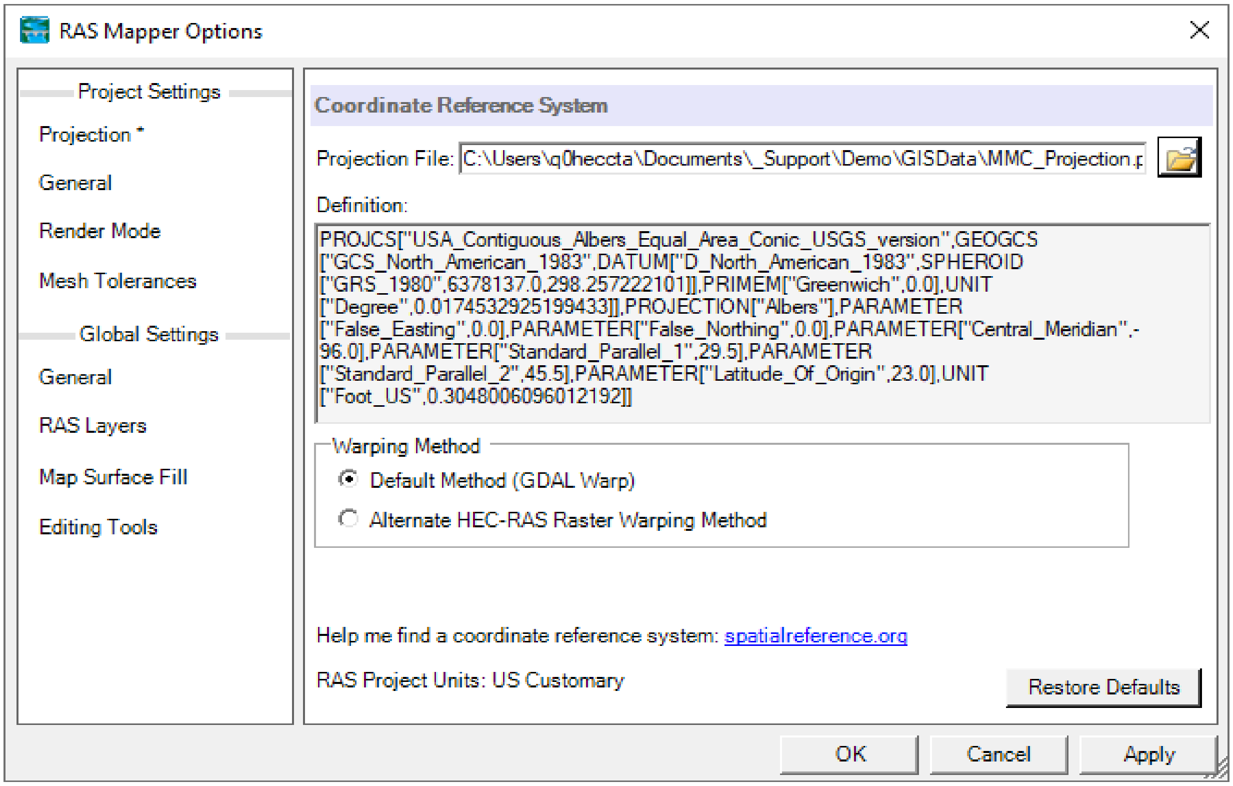
Rating scale Mtandire.sav

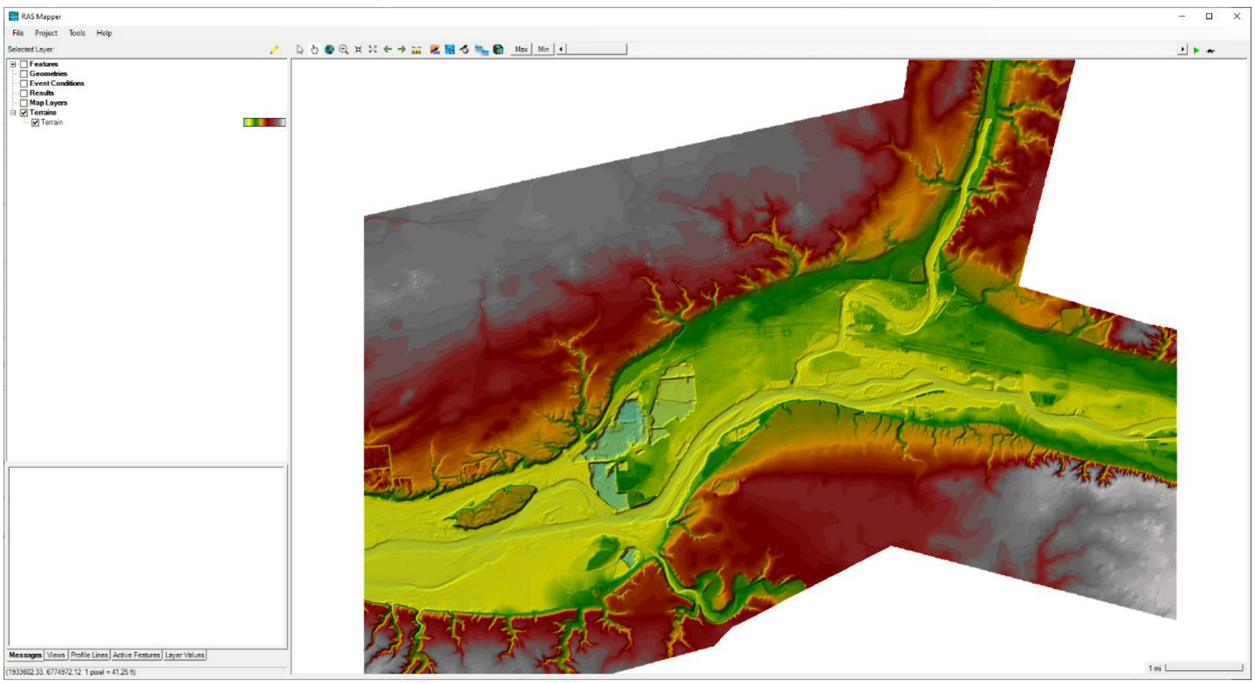
	unburnedbricks	CementBlocs	StructureAge	StructureAge 2	StructureAge 3	Customary
141	yes	no	no	no	yes	yes
142	yes	no	no	yes	no	yes
143	no	no	no	yes	no	yes
144	no	no	no	yes	no	yes
145	no	no	no	no	yes	yes

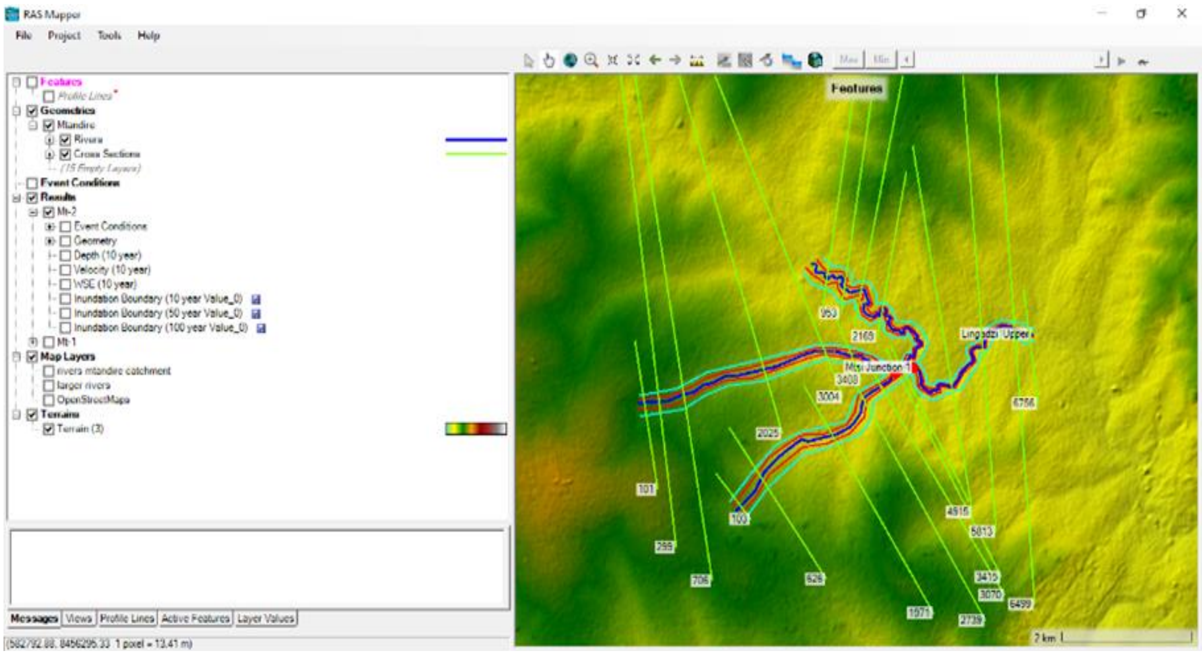
Rating scale Mtandire.sav

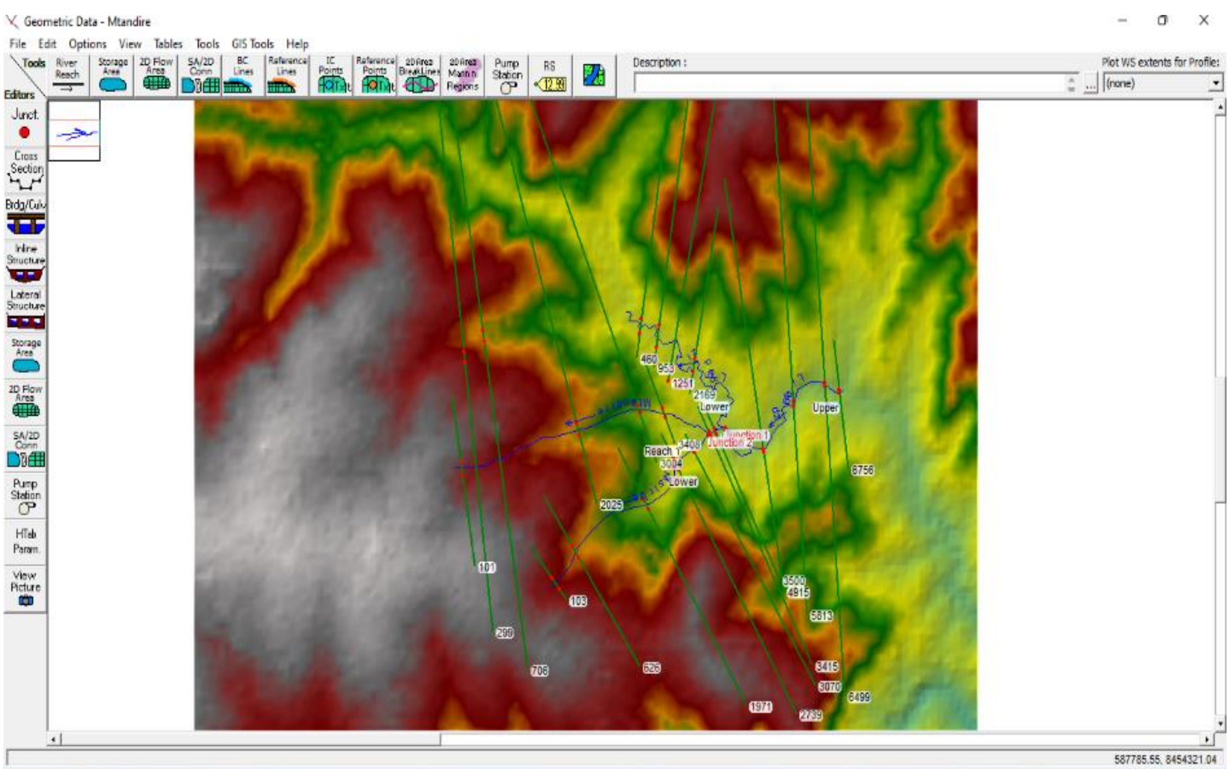
	Governmentgency
141	no
142	no
143	no
144	no
145	no

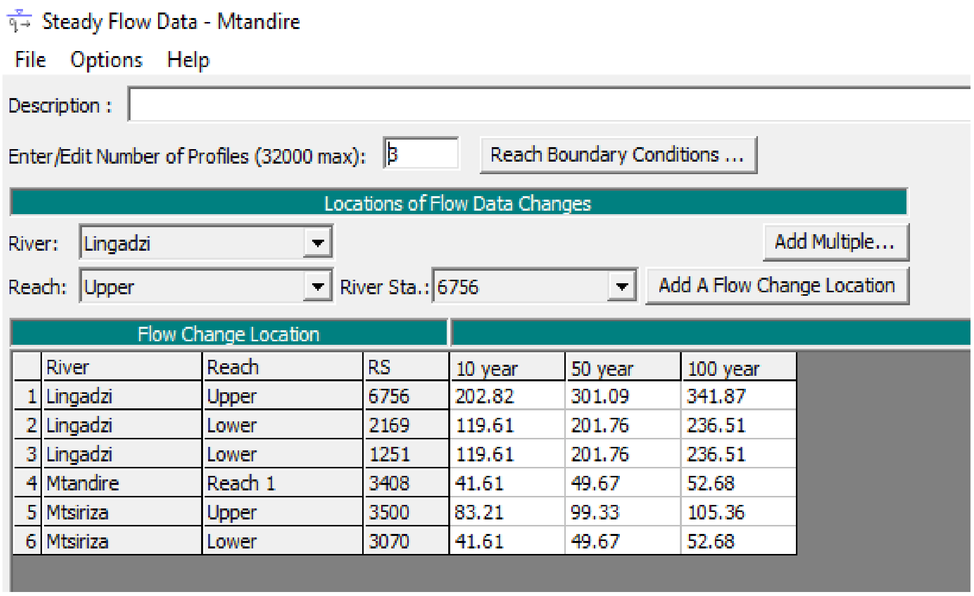
Appendix 5: DEM data and simulations for Lingadzi River Study Area using HECRAS



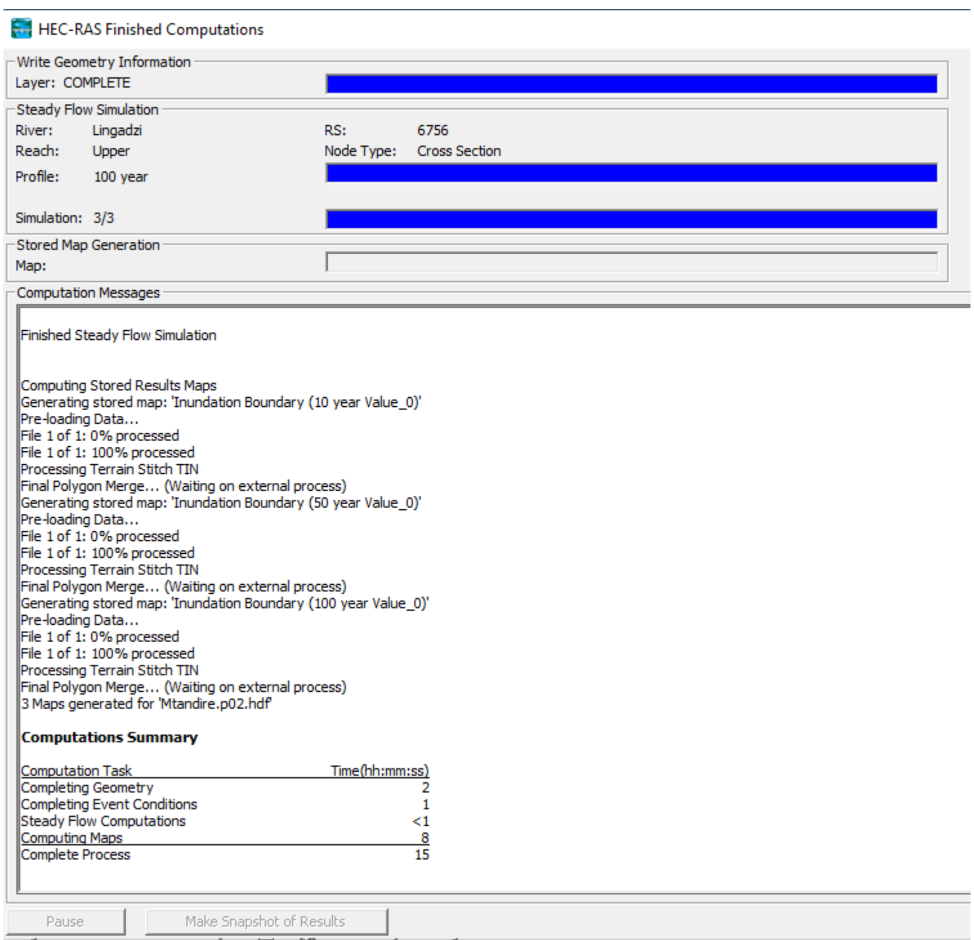


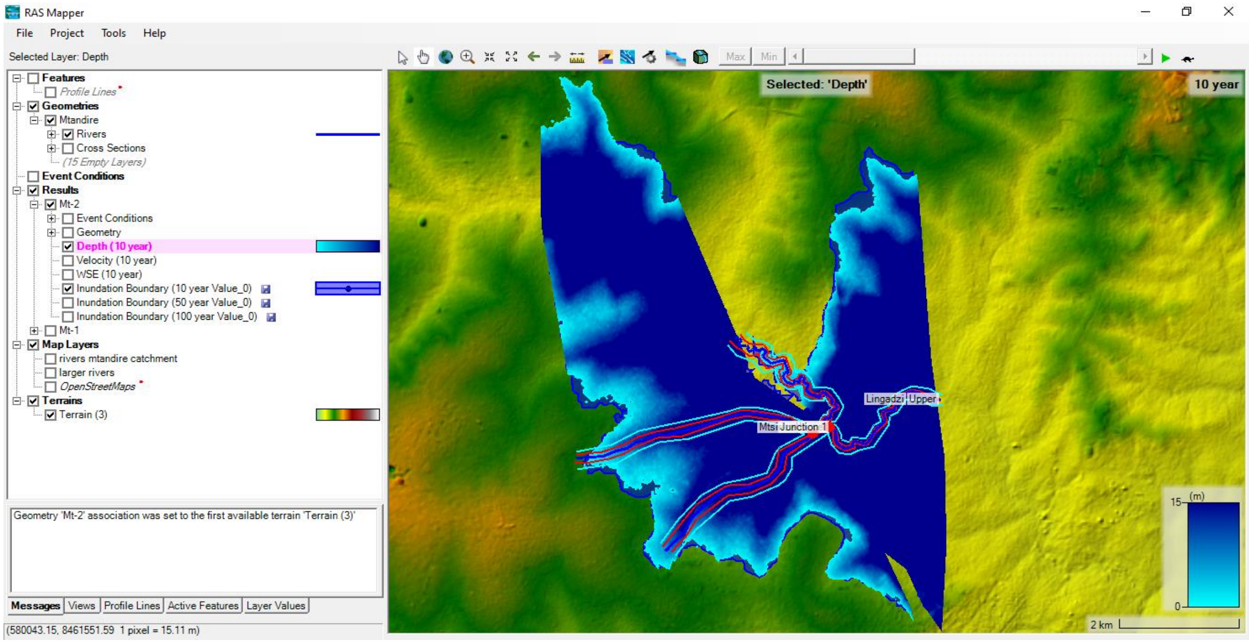





Steady Flow Data - Mtandire
File Options Help
Description :
Enter/Edit Number of Profiles (32000 max): 3
Reach Boundary Conditions ...
Locations of Flow Data Changes
River: Lingadzi
Add Multiple...
Reach: Upper
River Sta.: 6756
Add A Flow Change Location
Flow Change Location

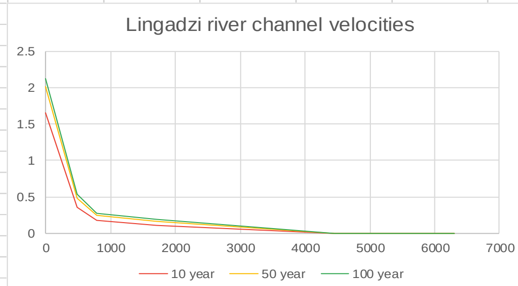
	River	Reach	RS	10 year	50 year	100 year
1	Lingadzi	Upper	6756	202.82	301.09	341.87
2	Lingadzi	Lower	2169	119.61	201.76	236.51
3	Lingadzi	Lower	1251	119.61	201.76	236.51
4	Mtandire	Reach 1	3408	41.61	49.67	52.68
5	Mtsiriza	Upper	3500	83.21	99.33	105.36
6	Mtsiriza	Lower	3070	41.61	49.67	52.68


HEC-RAS Finished Computations
Write Geometry Information
Layer: COMPLETE
Steady Flow Simulation
River: Lingadzi
RS: 6756
Reach: Upper
Node Type: Cross Section
Profile: 100 year
Simulation: 3/3
Stored Map Generation
Map:
Computation Messages
Finished Steady Flow Simulation
Computing Stored Results Maps
Generating stored map: 'Inundation Boundary (10 year Value_0)'
Pre-loading Data...
File 1 of 1: 0% processed
File 1 of 1: 100% processed
Processing Terrain Stitch TIN
Final Polygon Merge... (Waiting on external process)
Generating stored map: 'Inundation Boundary (50 year Value_0)'
Pre-loading Data...
File 1 of 1: 0% processed
File 1 of 1: 100% processed
Processing Terrain Stitch TIN
Final Polygon Merge... (Waiting on external process)
Generating stored map: 'Inundation Boundary (100 year Value_0)'
Pre-loading Data...
File 1 of 1: 0% processed
File 1 of 1: 100% processed
Processing Terrain Stitch TIN
Final Polygon Merge... (Waiting on external process)
3 Maps generated for 'Mtandire.p02.hdf'
Computations Summary
Computation Task Time(hh:mm:ss)
Completing Geometry 2
Completing Event Conditions 1
Steady Flow Computations <1
Computing Maps 8
Complete Process 15
Pause
Make Snapshot of Results

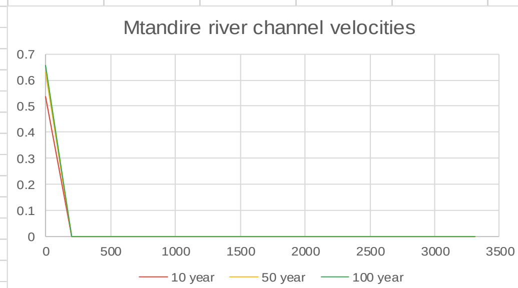

RAS Mapper
File
Project
Tools
Help
Selected Layer: Depth
Features
Profile Lines
Geometries
Mtandire
Rivers
Cross Sections
(15 Empty Layers)
Event Conditions
Results
Mt-2
Event Conditions
Geometry
Depth (10 year)
Velocity (10 year)
WSE (10 year)
Inundation Boundary (10 year Value_0)
Inundation Boundary (50 year Value_0)
Inundation Boundary (100 year Value_0)
Mt-1
Map Layers
rivers mtandire catchment
larger rivers
OpenStreetMaps
Terrains
Terrain (3)
Geometry 'Mt-2' association was set to the first available terrain 'Terrain (3)'
Messages
Views
Profile Lines
Active Features
Layer Values
(580043.15, 8461551.59 1 pixel = 15.11 m)
Selected: 'Depth'
10 year
Lingadzi Upper
Mtsi Junction 1
15
(m)
0
2 km

Appendix 6: Channel velocity

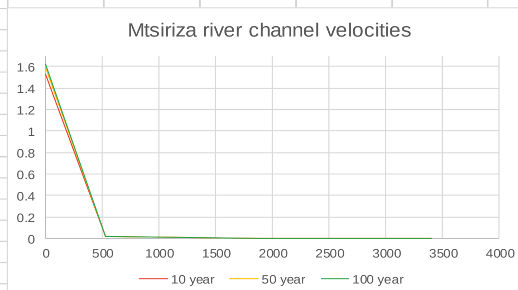
Label	Vel Chnl 10 ye	Label	Vel Chnl 50 ye	Label	Vel Chnl 100 year
x	y	x	y	x	y
0	1.65388453	0	2.009426355	0	2.128270864
492.8999939	0.351289213	492.8999939	0.487149894	492.8999939	0.53621155
790.8999023	0.178213701	790.8999023	0.251751482	790.8999023	0.278477103
1709.199829	0.107466444	1709.199829	0.166410938	1709.199829	0.189329311
4453.90979	1.89E-03	4453.90979	2.81E-03	4453.90979	3.18E-03
5352.309937	1.56E-03	5352.309937	2.31E-03	5352.309937	2.62E-03
6038.710083	1.21E-03	6038.710083	1.79E-03	6038.710083	2.03E-03
6295.81012	2.50E-03	6295.81012	3.71E-03	6295.81012	0.004216518



Label	Vel Chnl 10 ye	Label	Vel Chnl 50 ye	Label	Vel Chnl 100 year
x	y	x	y	x	y
0	0.538160026	0	0.627743661	0	0.657119691
197.6000214	1.02E-04	197.6000214	1.24E-04	197.6000214	1.32E-04
604.8000336	1.70E-04	604.8000336	2.03E-04	604.8000336	2.15E-04
1924.200058	2.38E-04	1924.200058	2.84E-04	1924.200058	3.01E-04
2903.600143	2.75E-04	2903.600143	3.28E-04	2903.600143	3.47E-04
3307.20015	9.95E-04	3307.20015	1.19E-03	3307.20015	1.26E-03

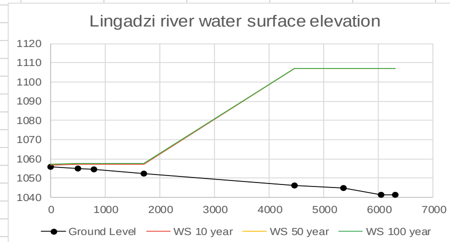


Label	Vel Chnl 10 ye	Label	Vel Chnl 50 ye	Label	Vel Chnl 100 year
x	y	x	y	x	y
0	1.523899913	0	1.593385696	0	1.617185354
522.7999878	1.35E-02	522.7999878	1.58E-02	522.7999878	1.67E-02
1867.499939	1.57E-03	1867.499939	1.87E-03	1867.499939	1.98E-03
2635.599915	1.47E-03	2635.599915	1.75E-03	2635.599915	1.85E-03
2966.399963	1.16E-03	2966.399963	1.38E-03	2966.399963	1.46E-03
3312.119965	9.44E-04	3312.119965	1.13E-03	3312.119965	1.19E-03
3397.420074	9.65E-04	3397.420074	1.15E-03	3397.420074	1.22E-03

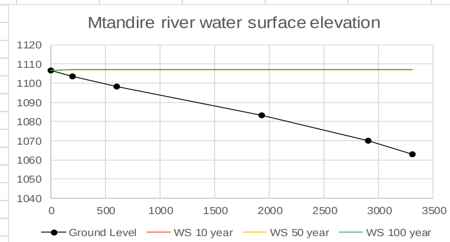


Appendix 7: Water surface elevation graphs

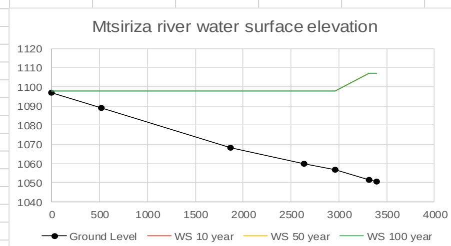
Label	Ground	Label	WS 10 year	Label	WS 50 year	Label	WS 100 year
x	y	x	y	x	y	x	y
0	1056	0	1056.824348	0	1056.988952	0	1057.048484
492.8999939	1054.829956	492.8999977	1057.120665	492.8999977	1057.428516	492.8999977	1057.53731
790.8999939	1054.52002	790.8999104	1057.13659	790.8999104	1057.456273	790.8999104	1057.56968
1709.199982	1052.542969	1709.199803	1057.142469	1709.199803	1057.467732	1709.199803	1057.583595
4453.909943	1046.17395	4453.909943	1106.822859	4453.909943	1106.873833	4453.909943	1106.891544
5352.309967	1044.849976	5352.310101	1106.822859	5352.310101	1106.873833	5352.310101	1106.891544
6038.709991	1041.187012	6038.71025	1106.822859	6038.71025	1106.873833	6038.71025	1106.891544
6295.809998	1041.310059	6295.810278	1106.822859	6295.810278	1106.873833	6295.810278	1106.891544



Label	Ground	Label	WS 10 year	Label	WS 50 year	Label	WS 100 year
x	y	x	y	x	y	x	y
0	1106.567993	0	1106.720763	0	1106.762658	0	1106.777169
197.6000061	1103.505005	197.6000131	1106.822859	197.6000131	1106.873833	197.6000131	1106.891544
604.8000183	1098.01001	604.8000139	1106.822859	604.8000139	1106.873833	604.8000139	1106.891544
1924.200043	1083.22998	1924.200037	1106.822859	1924.200037	1106.873833	1924.200037	1106.891544
2903.600067	1069.902954	2903.600126	1106.822859	2903.600126	1106.873833	2903.600126	1106.891544
3307.200073	1062.866943	3307.200123	1106.822859	3307.200123	1106.873833	3307.200123	1106.891544



Label	Ground	Label	WS 10 year	Label	WS 50 year	Label	WS 100 year
x	y	x	y	x	y	x	y
0	1096.97998	0	1097.705053	0	1097.758408	0	1097.776937
522.7999878	1088.839966	522.7999772	1097.835278	522.7999772	1097.900837	522.7999772	1097.923682
1867.499939	1068	1867.499889	1097.835278	1867.499889	1097.900837	1867.499889	1097.923682
2635.599915	1060	2635.599833	1097.835278	2635.599833	1097.900837	2635.599833	1097.923682
2966.399902	1056.630005	2966.399883	1097.835278	2966.399883	1097.900837	2966.399883	1097.923682
3312.119904	1051.578979	3312.119904	1106.822859	3312.119904	1106.873833	3312.119904	1106.891544
3397.419907	1050.744019	3397.420009	1106.822859	3397.420009	1106.873833	3397.420009	1106.891544



Appendix 8: Catchment characteristics

		i_2	i_5	i_{10}	i_{20}	i_{50}	i_{100}	i_{200}	i_{1000}	
		41.56	52.83	59.21	64.79	70.68	74.96	77.76	88.72	
	Mean Annual	**Predicted flood (growth factors)**								
Region	**Flood**	**q2**	**q10**	**q20**	**q50**	**q100**	**q200**	**q500**		
I*	3.34.A0.51	0.9	1.94	2.35	2.88	3.27	3.68	4.21		
II	9.57.A0.45	0.9	1.92	2.32	2.83	3.21	3.62	4.14		
III	15.00.A0.55	0.9	1.76	2.1	2.51	2.82	3.14	3.51		

km)	Length of stream (km)	height at 10%	height at 85%	slope	Tc (hrs)	Tc(min)
13.32	4.14	1051.600	1096.600	0.01449	1.011	60.65
km)	Mean Annual Flood (MAF)					
856.002	104.55					
Central Plateux Zones						
	Rainfall intensity (mmh-1) for duration of					
Return period (yrs)	24	6	3	1	0.5	0.25
2	2.8	8.9	15.9	41.7	66.8	85.6
5	3.5	11.5	20.8	53.0	81.5	103.8
10	3.9	13.1	23.8	59.4	89.5	111.3
20	4.2	14.3	26.4	65.0	96.0	117.0
50	4.7	16.0	29.6	70.9	102.9	122.6
100	5.1	17.1	31.6	75.2	107.7	126.7
200	5.3	18.0	33.0	78.0	111.0	130.0
1000	6.6	21.0	38.0	89.0	124.0	144.0
	Description	**Value**	**Proportion (%)**	**Weighted Value**		
Vegetation/ Land use (C1)	Thick bush	0.05	4.2	0.002		
	Cultivated land	0.20	65.9	0.132		
	Built-Up Area	0.32	29.9	0.096		
Soil type and drainage (C2)	Deep well drained soil*	0.10	100	0.100		**Krishnamurthy (1987)**
Slope (C3)	Very flat or gentle (<5%)	0.05	100	0.050		
Total Runoff Coefficient, C=C1+C2+C3				0.38		
Built Up, Urban / Built Up, Nc	29.9					
CULTIVATED DAMBO	6.4					
Forest Plantation	4.2					
RAINFED HERBACEOUS CI	23.1					
RAINFED HERBACEOUS CI	35.7					
Deep,well drained,dark brown	100					
0-2 (flat to almos	100					
0	1103					
57.03839659	1103					
178.0351076	1104					
386.2692014	1101					
493.216195	1098					
638.6361436	1097					
752.7129368	1094					
915.297382	1096					
1016.127975	1094					
1116.958567	1091					
1221.319448	1091					
1325.680329	1091					
1500.469514	1087					
1604.280963	1086					
1708.092412	1086					
1852.283685	1084					
1989.428118	1081					
2066.218409	1079					
2185.735629	1077					
2292.682623	1075					
2417.199219	1076					
2566.073805	1072					
2665.954637	1074					
2765.83547	1072					
2944.08046	1069					
3122.894923	1064					
3294.30693	1063					
3454.529248	1058					
3577.194959	1055					
3665.385709	1055					
3771.377799	1054					
3864.065194	1052					
3945.357416	1052					
4073.693809	1050					
4139.427313	1051					
4139.427313	1051					
4139.427313	1051					

C	q_2	q_5	q_{10}	q_{20}	q_{50}	q_{100}	q_{200}	q_{1000}
0.38	58.41	74.24	83.21	91.06	99.33	105.36	109.28	124.70
	29.21		41.61	45.53	49.67	52.68	54.64	62.35
	94.09		202.82	245.68	301.09	341.87	384.73	440.14
	35.68		119.61	154.62	201.76	236.51	275.45	315.44

Appendix 9: flood occurrence frequency questionnaires

MZUZU UNIVERSITY

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LUWINGA

MZUZU

<u>Household survey questionnaire</u>

Assessing effects of informal urban settlements in floodplains on increased frequency of floods along Lingadzi river in Lilongwe

Program**: Masters of Science in Water Resource Management**

Name of the Researcher**: Susan Kumwenda**

Email**: <u>susankumwenda@yahoo.co.uk</u>**

Cell**: <u>0999280911</u>**

Information obtained for the study that can be identified with respondent will remain confidential and can only be disclosed with permission from respondent**.**

iv. I agree to participate in the study.

yes	No

v. I understand the purpose and nature of this study and I am participating voluntarily.

yes	No

vi. I grant permission for the data generated from this interview to be used in the researcher's publications

yes	No

	Personal data		
Sex of Respondent	Male	Female	
Age of Respondent	0-35 yrs	35yrs above	
Length of residency in the area	0-15yrs	15-30yrs	above 30yrs

1. Has there been an increase in Flooding intensity in the past ten years compared to previous decades? if yes explain.

2. Have there been changes in flooding frequency in the past ten years compared to previous decades? if yes explain.

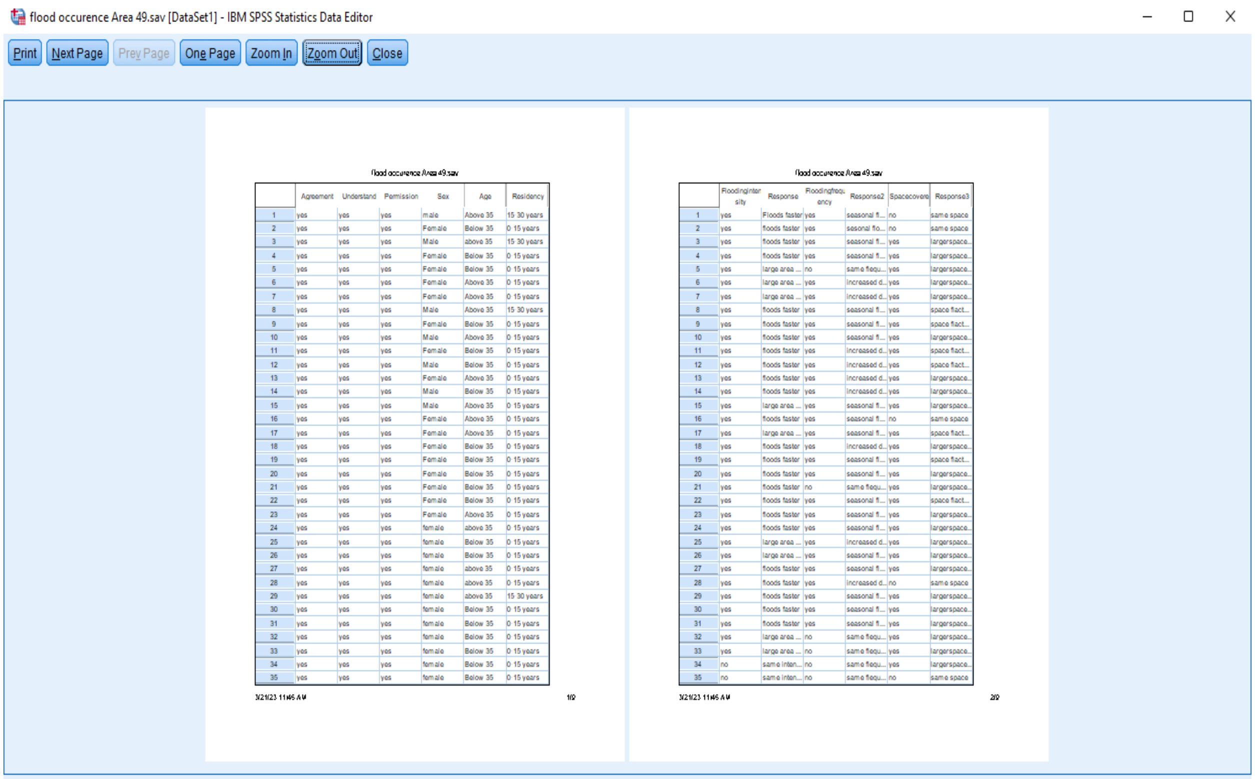
3. How many flooding events occurred between 1990 and 2020 and which years?

4. Have there been changes in Space covered by flood waters in the past ten years compared to previous decades? if yes explain.

5. Have there been changes in infrastructure damage and losses due to flooding in the past ten years compared to previous decades? if yes explain.

6. Have there been changes in number of flooded days in the past ten years compared to previous decades? if yes explain

Appendix 10: Area 49 flood frequency results



flood occurence Area 49.sav

	Agreement	Understand	Permission	Sex	Age	Residency
1	yes	yes	yes	male	Above 35	15-30 years
2	yes	yes	yes	Female	Below 35	0-15 years
3	yes	yes	yes	Male	above 35	15-30 years
4	yes	yes	yes	Female	Below 35	0-15 years
5	yes	yes	yes	Female	Below 35	0-15 years
6	yes	yes	yes	Female	Above 35	0-15 years
7	yes	yes	yes	Female	Above 35	0-15 years
8	yes	yes	yes	Male	Above 35	15-30 years
9	yes	yes	yes	Female	Below 35	0-15 years
10	yes	yes	yes	Male	Above 35	0-15 years
11	yes	yes	yes	Female	Below 35	0-15 years
12	yes	yes	yes	Male	Below 35	0-15 years
13	yes	yes	yes	Female	Above 35	0-15 years
14	yes	yes	yes	Male	Below 35	0-15 years
15	yes	yes	yes	Male	Above 35	0-15 years
16	yes	yes	yes	Female	Above 35	0-15 years
17	yes	yes	yes	Female	Above 35	0-15 years
18	yes	yes	yes	Female	Below 35	0-15 years
19	yes	yes	yes	Female	Below 35	0-15 years
20	yes	yes	yes	Female	Below 35	0-15 years
21	yes	yes	yes	Female	Below 35	0-15 years
22	yes	yes	yes	Female	Below 35	0-15 years
23	yes	yes	yes	Female	Above 35	0-15 years
24	yes	yes	yes	female	above 35	0-15 years
25	yes	yes	yes	female	Below 35	0-15 years
26	yes	yes	yes	female	Below 35	0-15 years
27	yes	yes	yes	female	above 35	0-15 years
28	yes	yes	yes	female	above 35	0-15 years
29	yes	yes	yes	female	above 35	15-30 years
30	yes	yes	yes	female	Below 35	0-15 years
31	yes	yes	yes	female	Below 35	0-15 years
32	yes	yes	yes	female	Below 35	0-15 years
33	yes	yes	yes	female	Below 35	0-15 years
34	yes	yes	yes	female	Below 35	0-15 years
35	yes	yes	yes	female	Below 35	0-15 years

3/21/23 11:46 AM 1/9

flood occurence Area 49.sav

	Floodinginten sity	Response	Floodingfrequ ency	Response2	Spacecovere	Response3
1	yes	Floods faster	yes	seasonal fl...	no	same space
2	yes	floods faster	yes	sesonal flo...	no	same space
3	yes	floods faster	yes	seasonal fl...	yes	largerspace...
4	yes	floods faster	yes	seasonal fl...	yes	largerspace...
5	yes	large area ...	no	same flequ...	yes	largerspace...
6	yes	large area ...	yes	increased d...	yes	largerspace...
7	yes	large area ...	yes	increased d...	yes	largerspace...
8	yes	floods faster	yes	seasonal fl...	yes	space flact...
9	yes	floods faster	yes	seasonal fl...	yes	space flact...
10	yes	floods faster	yes	seasonal fl...	yes	largerspace...
11	yes	floods faster	yes	increased d...	yes	space flact...
12	yes	floods faster	yes	increased d...	yes	space flact...
13	yes	floods faster	yes	increased d...	yes	largerspace...
14	yes	floods faster	yes	increased d...	yes	largerspace...
15	yes	large area ...	yes	seasonal fl...	yes	largerspace...
16	yes	floods faster	yes	seasonal fl...	no	same space
17	yes	large area ...	yes	seasonal fl...	yes	space flact...
18	yes	floods faster	yes	increased d...	yes	largerspace...
19	yes	floods faster	yes	seasonal fl...	yes	space flact...
20	yes	floods faster	yes	seasonal fl...	yes	largerspace...
21	yes	floods faster	no	same flequ...	yes	largerspace...
22	yes	floods faster	yes	seasonal fl...	yes	space flact...
23	yes	floods faster	yes	seasonal fl...	yes	largerspace...
24	yes	floods faster	yes	seasonal fl...	yes	largerspace...
25	yes	large area ...	yes	increased d...	yes	largerspace...
26	yes	large area ...	yes	seasonal fl...	yes	largerspace...
27	yes	floods faster	yes	seasonal fl...	yes	largerspace...
28	yes	floods faster	yes	increased d...	no	same space
29	yes	floods faster	yes	seasonal fl...	yes	largerspace...
30	yes	floods faster	yes	seasonal fl...	yes	largerspace...
31	yes	floods faster	yes	seasonal fl...	yes	largerspace...
32	yes	large area ...	no	same flequ...	yes	largerspace...
33	yes	large area ...	no	same flequ...	yes	largerspace...
34	no	same inten...	no	same flequ...	yes	largerspace...
35	no	same inten...	no	same flequ...	no	same space

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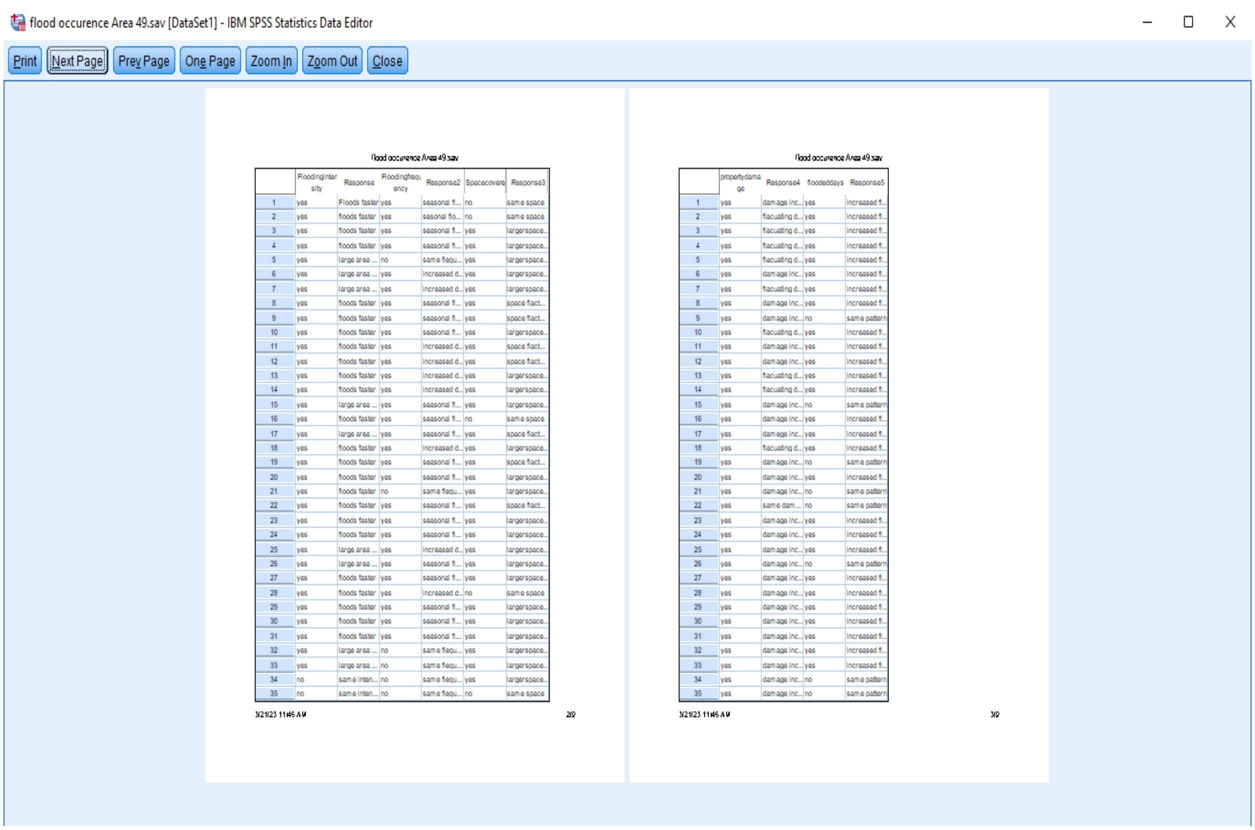

flood occurence Area 49.sav

	Floodinginten sity	Response	Floodingfrequ ency	Response2	Spacecovere	Response3
1	yes	Floods faster	yes	seasonal fl...	no	same space
2	yes	floods faster	yes	sesonal flo...	no	same space
3	yes	floods faster	yes	seasonal fl...	yes	largerspace...
4	yes	floods faster	yes	seasonal fl...	yes	largerspace...
5	yes	large area ...	no	same flequ...	yes	largerspace...
6	yes	large area ...	yes	increased d...	yes	largerspace...
7	yes	large area ...	yes	increased d...	yes	largerspace...
8	yes	floods faster	yes	seasonal fl...	yes	space flact...
9	yes	floods faster	yes	seasonal fl...	yes	space flact...
10	yes	floods faster	yes	seasonal fl...	yes	largerspace...
11	yes	floods faster	yes	increased d...	yes	space flact...
12	yes	floods faster	yes	increased d...	yes	space flact...
13	yes	floods faster	yes	increased d...	yes	largerspace...
14	yes	floods faster	yes	increased d...	yes	largerspace...
15	yes	large area ...	yes	seasonal fl...	yes	largerspace...
16	yes	floods faster	yes	seasonal fl...	no	same space
17	yes	large area ...	yes	seasonal fl...	yes	space flact...
18	yes	floods faster	yes	increased d...	yes	largerspace...
19	yes	floods faster	yes	seasonal fl...	yes	space flact...
20	yes	floods faster	yes	seasonal fl...	yes	largerspace...
21	yes	floods faster	no	same flequ...	yes	largerspace...
22	yes	floods faster	yes	seasonal fl...	yes	space flact...
23	yes	floods faster	yes	seasonal fl...	yes	largerspace...
24	yes	floods faster	yes	seasonal fl...	yes	largerspace...
25	yes	large area ...	yes	increased d...	yes	largerspace...
26	yes	large area ...	yes	seasonal fl...	yes	largerspace...
27	yes	floods faster	yes	seasonal fl...	yes	largerspace...
28	yes	floods faster	yes	increased d...	no	same space
29	yes	floods faster	yes	seasonal fl...	yes	largerspace...
30	yes	floods faster	yes	seasonal fl...	yes	largerspace...
31	yes	floods faster	yes	seasonal fl...	yes	largerspace...
32	yes	large area ...	no	same flequ...	yes	largerspace...
33	yes	large area ...	no	same flequ...	yes	largerspace...
34	no	same inten...	no	same flequ...	yes	largerspace...
35	no	same inten...	no	same flequ...	no	same space

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flood occurence Area 49.sav

	propertydama ge	Response4	floodeddays	Response5
1	yes	damage inc...	yes	increased fl...
2	yes	flacuating d...	yes	increased fl...
3	yes	flacuating d...	yes	increased fl...
4	yes	flacuating d...	yes	increased fl...
5	yes	flacuating d...	yes	increased fl...
6	yes	damage inc...	yes	increased fl...
7	yes	flacuating d...	yes	increased fl...
8	yes	damage inc...	yes	increased fl...
9	yes	damage inc...	no	same pattern
10	yes	flacuating d...	yes	increased fl...
11	yes	damage inc...	yes	increased fl...
12	yes	damage inc...	yes	increased fl...
13	yes	flacuating d...	yes	increased fl...
14	yes	flacuating d...	yes	increased fl...
15	yes	damage inc...	no	same pattern
16	yes	damage inc...	yes	increased fl...
17	yes	damage inc...	yes	increased fl...
18	yes	flacuating d...	yes	increased fl...
19	yes	damage inc...	no	same pattern
20	yes	damage inc...	yes	increased fl...
21	yes	damage inc...	no	same pattern
22	yes	same dam ...	no	same pattern
23	yes	damage inc...	yes	increased fl...
24	yes	damage inc...	yes	increased fl...
25	yes	damage inc...	yes	increased fl...
26	yes	damage inc...	no	same pattern
27	yes	damage inc...	yes	increased fl...
28	yes	damage inc...	yes	increased fl...
29	yes	damage inc...	yes	increased fl...
30	yes	damage inc...	yes	increased fl...
31	yes	damage inc...	yes	increased fl...
32	yes	damage inc...	yes	increased fl...
33	yes	damage inc...	yes	increased fl...
34	yes	damage inc...	no	same pattern
35	yes	damage inc...	no	same pattern

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flood occurence Area 49.sav

	propertydamage	Response4	floodeddays	Response5
1	yes	damage inc...	yes	increased fl...
2	yes	flacuating d...	yes	increased fl...
3	yes	flacuating d...	yes	increased fl...
4	yes	flacuating d...	yes	increased fl...
5	yes	flacuating d...	yes	increased fl...
6	yes	damage inc...	yes	increased fl...
7	yes	flacuating d...	yes	increased fl...
8	yes	damage inc...	yes	increased fl...
9	yes	damage inc...	no	same pattern
10	yes	flacuating d...	yes	increased fl...
11	yes	damage inc...	yes	increased fl...
12	yes	damage inc...	yes	increased fl...
13	yes	flacuating d...	yes	increased fl...
14	yes	flacuating d...	yes	increased fl...
15	yes	damage inc...	no	same pattern
16	yes	damage inc...	yes	increased fl...
17	yes	damage inc...	yes	increased fl...
18	yes	flacuating d...	yes	increased fl...
19	yes	damage inc...	no	same pattern
20	yes	damage inc...	yes	increased fl...
21	yes	damage inc...	no	same pattern
22	yes	same dam...	no	same pattern
23	yes	damage inc...	yes	increased fl...
24	yes	damage inc...	yes	increased fl...
25	yes	damage inc...	yes	increased fl...
26	yes	damage inc...	no	same pattern
27	yes	damage inc...	yes	increased fl...
28	yes	damage inc...	yes	increased fl...
29	yes	damage inc...	yes	increased fl...
30	yes	damage inc...	yes	increased fl...
31	yes	damage inc...	yes	increased fl...
32	yes	damage inc...	yes	increased fl...
33	yes	damage inc...	yes	increased fl...
34	yes	damage inc...	no	same pattern
35	yes	damage inc...	no	same pattern

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flood occurence Area 49.sav

	Agreement	Understand	Permission	Sex	Age	Residency
36	yes	yes	yes	female	Below 35	15 30 years
37	yes	yes	yes	female	above 35	0 15 years
38	yes	yes	yes	male	above 35	0 15 years
39	yes	yes	yes	female	Below 35	0 15 years
40	yes	yes	yes	female	Below 35	0 15 years
41	yes	yes	yes	female	above 35	0 15 years
42	yes	yes	yes	male	above 35	0 15 years
43	yes	yes	yes	female	above 35	0 15 years
44	yes	yes	yes	male	Below 35	0 15 years
45	yes	yes	yes	male	Below 35	0 15 years
46	yes	yes	yes	male	above 35	0 15 years
47	yes	yes	yes	male	above 35	15 30 years
48	yes	yes	yes	female	above 35	0 15 years
49	yes	yes	yes	male	above 35	0 15 years
50	yes	yes	yes	male	Below 35	0 15 years
51	yes	yes	yes	female	above 35	0 15 years
52	yes	yes	yes	female	Below 35	0 15 years
53	yes	yes	yes	male	Below 35	0 15 years
54	yes	yes	yes	female	above 35	0 15 years
55	yes	yes	yes	female	Below 35	0 15 years
56	yes	yes	yes	female	above 35	0 15 years
57	yes	yes	yes	female	above 35	0 15 years
58	yes	yes	yes	female	below 35	0 15 years
59	yes	yes	yes	female	above 35	0 15 years
60	yes	yes	yes	female	below 35	0 15 years
61	yes	yes	yes	female	below 35	0 15 years
62	yes	yes	yes	male	below 35	0 15 years
63	yes	yes	yes	male	above 35	0 15 years
64	yes	yes	yes	male	below 35	0 15 years
65	yes	yes	yes	male	above 35	0 15 years
66	yes	yes	yes	male	above 35	0 15 years
67	yes	yes	yes	male	below 35	0 15 years
68	yes	yes	yes	male	above 35	0 15 years
69	yes	yes	yes	female	above 35	0 15 years
70	yes	yes	yes	male	below 35	0 15 years

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flood occurence Area 49.sav

	Agreement	Understand	Permission	Sex	Age	Residency
36	yes	yes	yes	female	Below 35	15 30 years
37	yes	yes	yes	female	above 35	0 15 years
38	yes	yes	yes	male	above 35	0 15 years
39	yes	yes	yes	female	Below 35	0 15 years
40	yes	yes	yes	female	Below 35	0 15 years
41	yes	yes	yes	female	above 35	0 15 years
42	yes	yes	yes	male	above 35	0 15 years
43	yes	yes	yes	female	above 35	0 15 years
44	yes	yes	yes	male	Below 35	0 15 years
45	yes	yes	yes	male	Below 35	0 15 years
46	yes	yes	yes	male	above 35	0 15 years
47	yes	yes	yes	male	above 35	15 30 years
48	yes	yes	yes	female	above 35	0 15 years
49	yes	yes	yes	male	above 35	0 15 years
50	yes	yes	yes	male	Below 35	0 15 years
51	yes	yes	yes	female	above 35	0 15 years
52	yes	yes	yes	female	Below 35	0 15 years
53	yes	yes	yes	male	Below 35	0 15 years
54	yes	yes	yes	female	above 35	0 15 years
55	yes	yes	yes	female	Below 35	0 15 years
56	yes	yes	yes	female	above 35	0 15 years
57	yes	yes	yes	female	above 35	0 15 years
58	yes	yes	yes	female	below 35	0 15 years
59	yes	yes	yes	female	above 35	0 15 years
60	yes	yes	yes	female	below 35	0 15 years
61	yes	yes	yes	female	below 35	0 15 years
62	yes	yes	yes	male	below 35	0 15 years
63	yes	yes	yes	male	above 35	0 15 years
64	yes	yes	yes	male	below 35	0 15 years
65	yes	yes	yes	male	above 35	0 15 years
66	yes	yes	yes	male	above 35	0 15 years
67	yes	yes	yes	male	below 35	0 15 years
68	yes	yes	yes	male	above 35	0 15 years
69	yes	yes	yes	female	above 35	0 15 years
70	yes	yes	yes	male	below 35	0 15 years

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flood occurence Area 49.sav

	Floodingintensity	Response	Floodingfrequency	Response2	Spacecovered	Response3
36	yes	floods faster	yes	seasonal fl...	yes	largerspace...
37	yes	floods faster	yes	increased d...	no	same space
38	yes	floods faster	yes	seasonal fl...	yes	largerspace...
39	yes	floods faster	yes	seasonal fl...	yes	largerspace...
40	yes	floods faster	yes	seasonal fl...	yes	largerspace...
41	yes	large area ...	yes	increased d...	yes	largerspace...
42	yes	large area ...	yes	seasonal fl...	yes	flactuates
43	yes	floods faster	yes	seasonal fl...	yes	largerspace...
44	no	same inten...	no	same flequ...	no	same space
45	yes	large area ...	yes	seasonal fl...	yes	largerspace...
46	yes	floods faster	yes	increased d...	yes	largerspace...
47	yes	floods faster	yes	seasonal fl...	yes	largerspace...
48	no	same inten...	yes	seasonal fl...	yes	largerspace...
49	yes	floods faster	yes	seasonal fl...	yes	largerspace...
50	yes	floods faster	yes	seasonal fl...	yes	largerspace...
51	yes	floods faster	yes	seasonal fl...	yes	largerspace...
52	yes	floods faster	yes	seasonal fl...	yes	flactuates
53	yes	floods faster	no	same flequ...	yes	largerspace...
54	yes	floods faster	no	same flequ...	yes	largerspace...
55	no	same inten...	no	same flequ...	yes	flactuates
56	yes	large area ...	yes	seasonal fl...	yes	largerspace...
57	yes	floods faster	yes	increased d...	yes	largerspace...
58	yes	floods faster	yes	increased d...	yes	flactuates
59	yes	large area ...	yes	seasonal fl...	yes	largerspace...
60	yes	floods faster	yes	increased d...	yes	largerspace...
61	yes	floods faster	yes	increased d...	yes	largerspace...
62	yes	large area ...	yes	increased d...	yes	flactuates
63	yes	large area ...	yes	increased d...	yes	flactuates
64	yes	large area ...	yes	increased d...	yes	flactuates
65	yes	floods faster	no	same flequ...	yes	largerspace...
66	yes	floods faster	yes	same flequ...	yes	largerspace...
67	yes	floods faster	no	same flequ...	yes	largerspace...
68	yes	floods faster	yes	increased d...	yes	largerspace...
69	yes	floods faster	yes	increased d...	yes	largerspace...
70	yes	floods faster	no	same flequ...	yes	largerspace...

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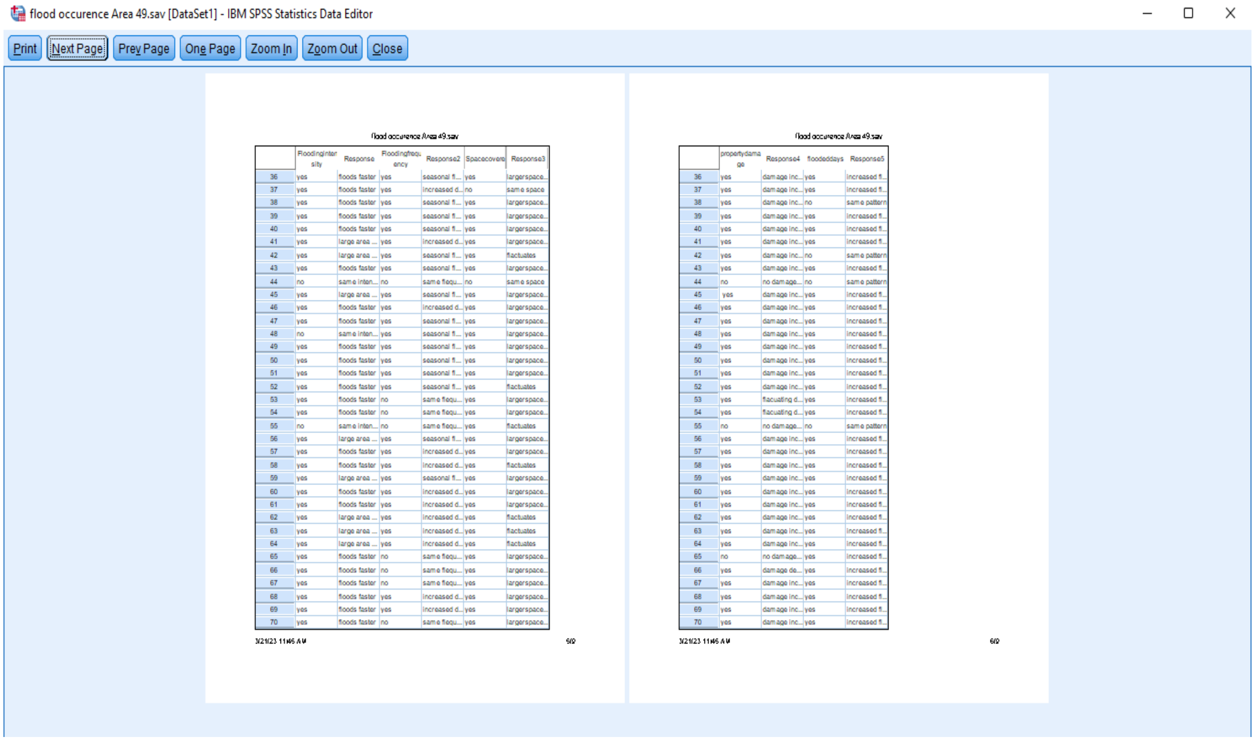

flood occurence Area 49.sav [DataSet1] - IBM SPSS Statistics Data Editor

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flood occurence Area 49.sav

	Floodingintensity	Response	Floodingfrequency	Response2	Spacecovere	Response3
36	yes	floods faster	yes	seasonal fl...	yes	largerspace...
37	yes	floods faster	yes	increased d...	no	same space
38	yes	floods faster	yes	seasonal fl...	yes	largerspace...
39	yes	floods faster	yes	seasonal fl...	yes	largerspace...
40	yes	floods faster	yes	seasonal fl...	yes	largerspace...
41	yes	large area ...	yes	increased d...	yes	largerspace...
42	yes	large area ...	yes	seasonal fl...	yes	flactuates
43	yes	floods faster	yes	seasonal fl...	yes	largerspace...
44	no	same inten...	no	same flequ...	no	same space
45	yes	large area ...	yes	seasonal fl...	yes	largerspace...
46	yes	floods faster	yes	increased d...	yes	largerspace...
47	yes	floods faster	yes	seasonal fl...	yes	largerspace...
48	no	same inten...	yes	seasonal fl...	yes	largerspace...
49	yes	floods faster	yes	seasonal fl...	yes	largerspace...
50	yes	floods faster	yes	seasonal fl...	yes	largerspace...
51	yes	floods faster	yes	seasonal fl...	yes	largerspace...
52	yes	floods faster	yes	seasonal fl...	yes	flactuates
53	yes	floods faster	no	same flequ...	yes	largerspace...
54	yes	floods faster	no	same flequ...	yes	largerspace...
55	no	same inten...	no	same flequ...	yes	flactuates
56	yes	large area ...	yes	seasonal fl...	yes	largerspace...
57	yes	floods faster	yes	increased d...	yes	largerspace...
58	yes	floods faster	yes	increased d...	yes	flactuates
59	yes	large area ...	yes	seasonal fl...	yes	largerspace...
60	yes	floods faster	yes	increased d...	yes	largerspace...
61	yes	floods faster	yes	increased d...	yes	largerspace...
62	yes	large area ...	yes	increased d...	yes	flactuates
63	yes	large area ...	yes	increased d...	yes	flactuates
64	yes	large area ...	yes	increased d...	yes	flactuates
65	yes	floods faster	no	same flequ...	yes	largerspace...
66	yes	floods faster	no	same flequ...	yes	largerspace...
67	yes	floods faster	no	same flequ...	yes	largerspace...
68	yes	floods faster	yes	increased d...	yes	largerspace...
69	yes	floods faster	yes	increased d...	yes	largerspace...
70	yes	floods faster	no	same flequ...	yes	largerspace...

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flood occurence Area 49.sav

	propertydamage	Response4	floodeddays	Response5
36	yes	damage inc...	yes	increased fl...
37	yes	damage inc...	yes	increased fl...
38	yes	damage inc...	no	same pattern
39	yes	damage inc...	yes	increased fl...
40	yes	damage inc...	yes	increased fl...
41	yes	damage inc...	yes	increased fl...
42	yes	damage inc...	no	same pattern
43	yes	damage inc...	yes	increased fl...
44	no	no damage...	no	same pattern
45	yes	damage inc...	yes	increased fl...
46	yes	damage inc...	yes	increased fl...
47	yes	damage inc...	yes	increased fl...
48	yes	damage inc...	yes	increased fl...
49	yes	damage inc...	yes	increased fl...
50	yes	damage inc...	yes	increased fl...
51	yes	damage inc...	yes	increased fl...
52	yes	damage inc...	yes	increased fl...
53	yes	flacuating d...	yes	increased fl...
54	yes	flacuating d...	yes	increased fl...
55	no	no damage...	no	same pattern
56	yes	damage inc...	yes	increased fl...
57	yes	damage inc...	yes	increased fl...
58	yes	damage inc...	yes	increased fl...
59	yes	damage inc...	yes	increased fl...
60	yes	damage inc...	yes	increased fl...
61	yes	damage inc...	yes	increased fl...
62	yes	damage inc...	yes	increased fl...
63	yes	damage inc...	yes	increased fl...
64	yes	damage inc...	yes	increased fl...
65	no	no damage...	yes	increased fl...
66	yes	damage de...	yes	increased fl...
67	yes	damage inc...	yes	increased fl...
68	yes	damage inc...	yes	increased fl...
69	yes	damage inc...	yes	increased fl...
70	yes	damage inc...	yes	increased fl...

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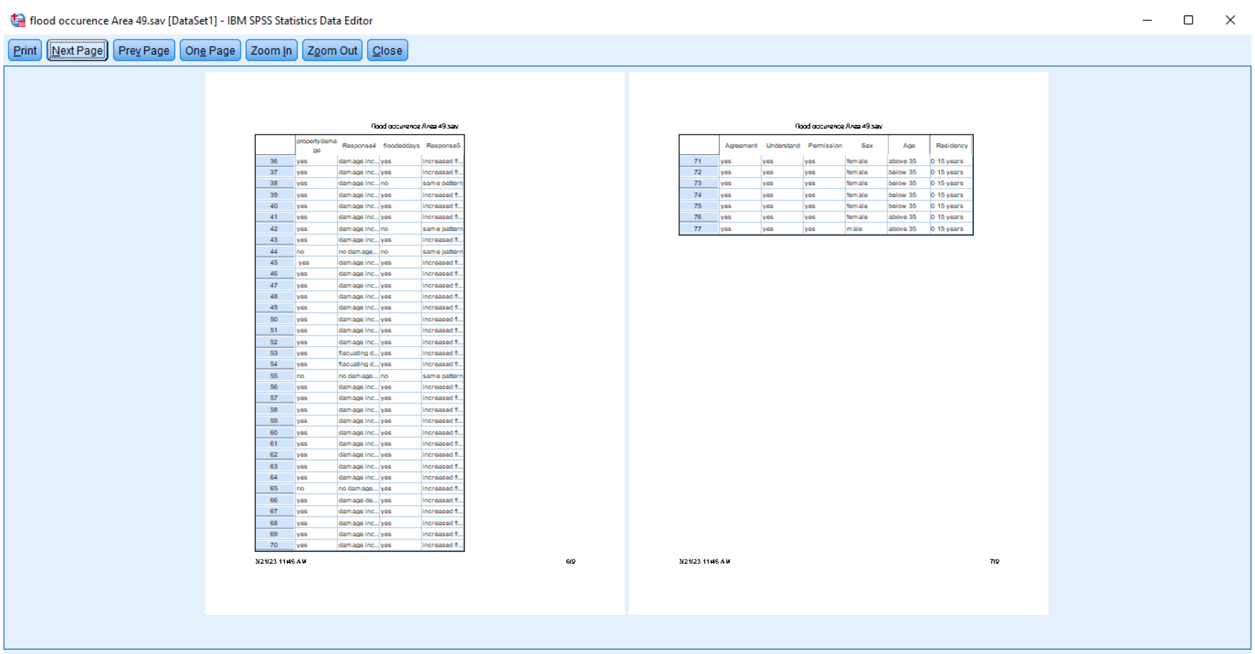

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flood occurence Area 49.sav

	propertydamage	Response4	floodeddays	Response5
36	yes	damage inc...	yes	increased fl...
37	yes	damage inc...	yes	increased fl...
38	yes	damage inc...	no	same pattern
39	yes	damage inc...	yes	increased fl...
40	yes	damage inc...	yes	increased fl...
41	yes	damage inc...	yes	increased fl...
42	yes	damage inc...	no	same pattern
43	yes	damage inc...	yes	increased fl...
44	no	no damage...	no	same pattern
45	yes	damage inc...	yes	increased fl...
46	yes	damage inc...	yes	increased fl...
47	yes	damage inc...	yes	increased fl...
48	yes	damage inc...	yes	increased fl...
49	yes	damage inc...	yes	increased fl...
50	yes	damage inc...	yes	increased fl...
51	yes	damage inc...	yes	increased fl...
52	yes	damage inc...	yes	increased fl...
53	yes	flacuating d...	yes	increased fl...
54	yes	flacuating d...	yes	increased fl...
55	no	no damage...	no	same pattern
56	yes	damage inc...	yes	increased fl...
57	yes	damage inc...	yes	increased fl...
58	yes	damage inc...	yes	increased fl...
59	yes	damage inc...	yes	increased fl...
60	yes	damage inc...	yes	increased fl...
61	yes	damage inc...	yes	increased fl...
62	yes	damage inc...	yes	increased fl...
63	yes	damage inc...	yes	increased fl...
64	yes	damage inc...	yes	increased fl...
65	no	no damage...	yes	increased fl...
66	yes	damage de...	yes	increased fl...
67	yes	damage inc...	yes	increased fl...
68	yes	damage inc...	yes	increased fl...
69	yes	damage inc...	yes	increased fl...
70	yes	damage inc...	yes	increased fl...

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flood occurence Area 49.sav

	Agreement	Understand	Permission	Sex	Age	Residency
71	yes	yes	yes	female	above 35	0-15 years
72	yes	yes	yes	female	below 35	0-15 years
73	yes	yes	yes	female	below 35	0-15 years
74	yes	yes	yes	female	below 35	0-15 years
75	yes	yes	yes	female	below 35	0-15 years
76	yes	yes	yes	female	above 35	0-15 years
77	yes	yes	yes	male	above 35	0-15 years

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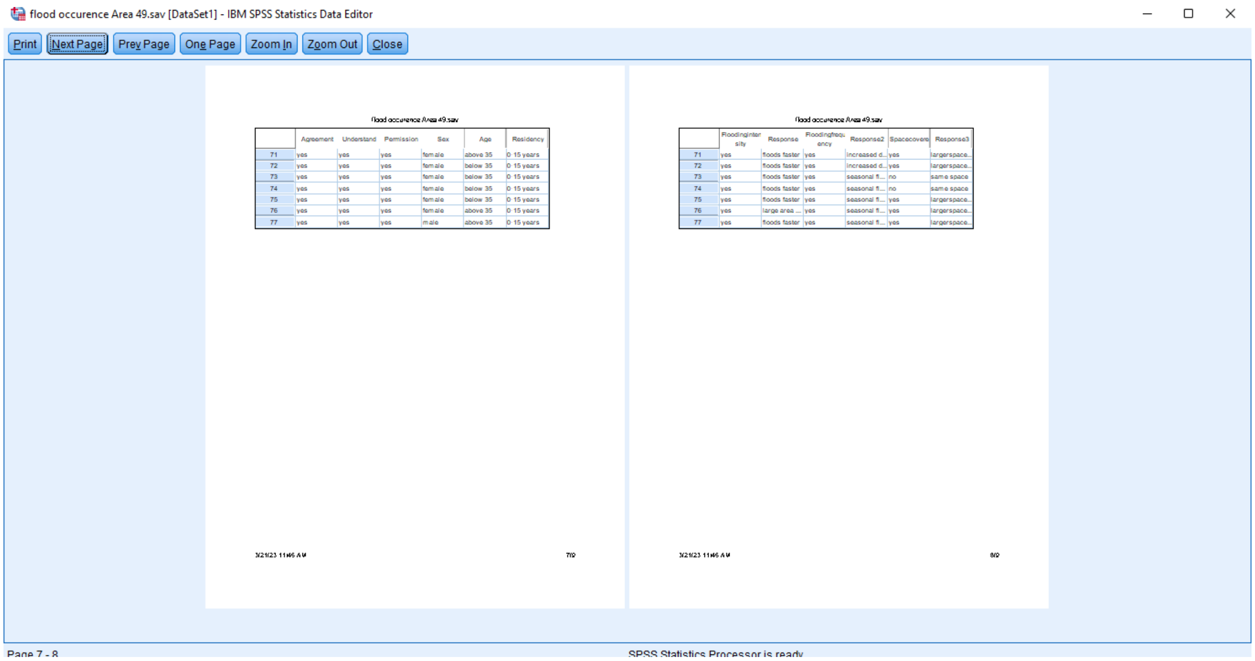
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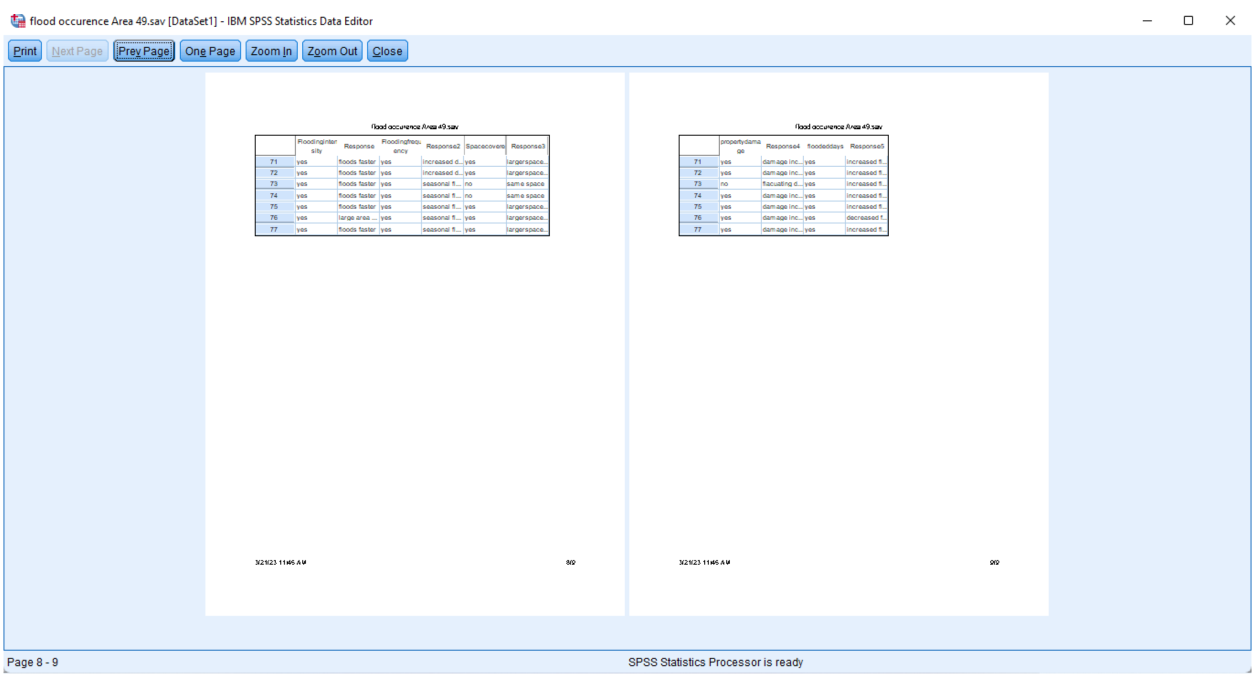
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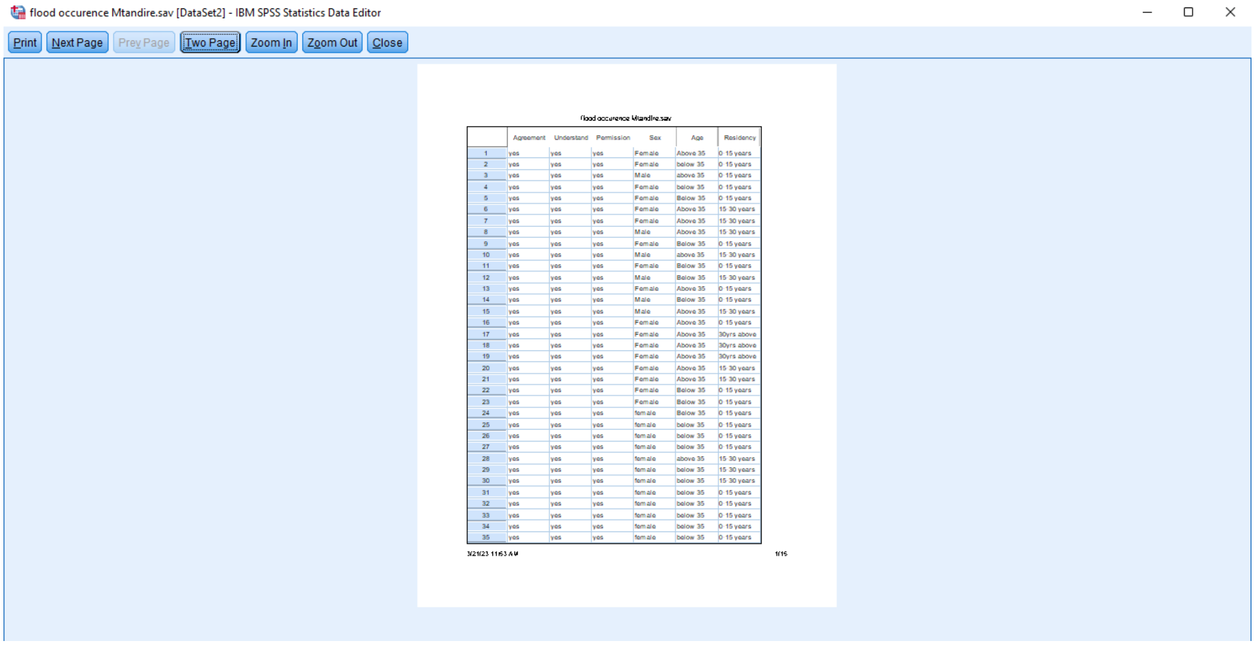
Appendix 11: Mtandire flood frequency results



flood occurence Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Residency
1	yes	yes	yes	Female	Above 35	0-15 years
2	yes	yes	yes	Female	below 35	0-15 years
3	yes	yes	yes	Male	above 35	0-15 years
4	yes	yes	yes	Female	below 35	0-15 years
5	yes	yes	yes	Female	Below 35	0-15 years
6	yes	yes	yes	Female	Above 35	15-30 years
7	yes	yes	yes	Female	Above 35	15-30 years
8	yes	yes	yes	Male	Above 35	15-30 years
9	yes	yes	yes	Female	Below 35	0-15 years
10	yes	yes	yes	Male	above 35	15-30 years
11	yes	yes	yes	Female	Below 35	0-15 years
12	yes	yes	yes	Male	Below 35	15-30 years
13	yes	yes	yes	Female	Above 35	0-15 years
14	yes	yes	yes	Male	Below 35	0-15 years
15	yes	yes	yes	Male	Above 35	15-30 years
16	yes	yes	yes	Female	Above 35	0-15 years
17	yes	yes	yes	Female	Above 35	30yrs above
18	yes	yes	yes	Female	Above 35	30yrs above
19	yes	yes	yes	Female	Above 35	30yrs above
20	yes	yes	yes	Female	Above 35	15-30 years
21	yes	yes	yes	Female	Above 35	15-30 years
22	yes	yes	yes	Female	Below 35	0-15 years
23	yes	yes	yes	Female	Below 35	0-15 years
24	yes	yes	yes	female	Below 35	0-15 years
25	yes	yes	yes	female	below 35	0-15 years
26	yes	yes	yes	female	below 35	0-15 years
27	yes	yes	yes	female	below 35	0-15 years
28	yes	yes	yes	female	above 35	15-30 years
29	yes	yes	yes	female	below 35	15-30 years
30	yes	yes	yes	female	below 35	15-30 years
31	yes	yes	yes	female	below 35	0-15 years
32	yes	yes	yes	female	below 35	0-15 years
33	yes	yes	yes	female	below 35	0-15 years
34	yes	yes	yes	female	below 35	0-15 years
35	yes	yes	yes	female	below 35	0-15 years

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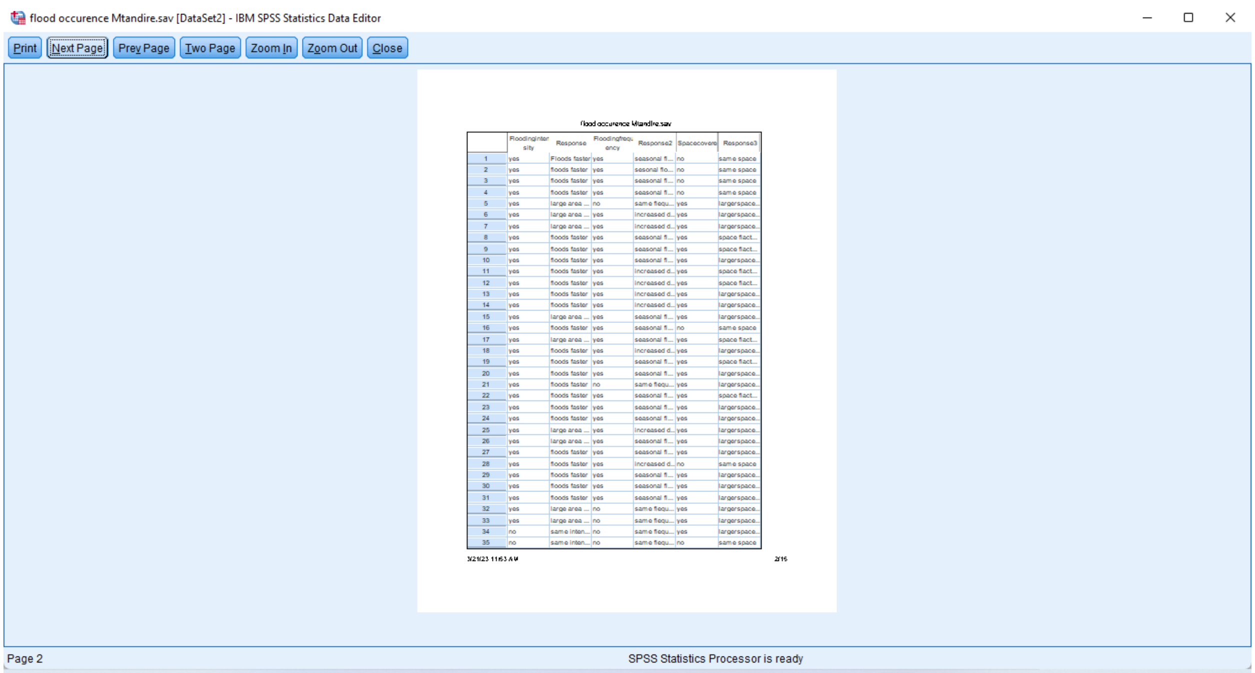

flood occurence Mtandire.sav

	Floodinginten sity	Response	Floodingfrequ ency	Response2	Spacecovere	Response3
1	yes	Floods faster	yes	seasonal fl...	no	same space
2	yes	floods faster	yes	sesonal flo...	no	same space
3	yes	floods faster	yes	seasonal fl...	no	same space
4	yes	floods faster	yes	seasonal fl...	no	same space
5	yes	large area ...	no	same flequ...	yes	largerspace...
6	yes	large area ...	yes	increased d...	yes	largerspace...
7	yes	large area ...	yes	increased d...	yes	largerspace...
8	yes	floods faster	yes	seasonal fl...	yes	space flact...
9	yes	floods faster	yes	seasonal fl...	yes	space flact...
10	yes	floods faster	yes	seasonal fl...	yes	largerspace...
11	yes	floods faster	yes	increased d...	yes	space flact...
12	yes	floods faster	yes	increased d...	yes	space flact...
13	yes	floods faster	yes	increased d...	yes	largerspace...
14	yes	floods faster	yes	increased d...	yes	largerspace...
15	yes	large area ...	yes	seasonal fl...	yes	largerspace...
16	yes	floods faster	yes	seasonal fl...	no	same space
17	yes	large area ...	yes	seasonal fl...	yes	space flact...
18	yes	floods faster	yes	increased d...	yes	largerspace...
19	yes	floods faster	yes	seasonal fl...	yes	space flact...
20	yes	floods faster	yes	seasonal fl...	yes	largerspace...
21	yes	floods faster	no	same flequ...	yes	largerspace...
22	yes	floods faster	yes	seasonal fl...	yes	space flact...
23	yes	floods faster	yes	seasonal fl...	yes	largerspace...
24	yes	floods faster	yes	seasonal fl...	yes	largerspace...
25	yes	large area ...	yes	increased d...	yes	largerspace...
26	yes	large area ...	yes	seasonal fl...	yes	largerspace...
27	yes	floods faster	yes	seasonal fl...	yes	largerspace...
28	yes	floods faster	yes	increased d...	no	same space
29	yes	floods faster	yes	seasonal fl...	yes	largerspace...
30	yes	floods faster	yes	seasonal fl...	yes	largerspace...
31	yes	floods faster	yes	seasonal fl...	yes	largerspace...
32	yes	large area ...	no	same flequ...	yes	largerspace...
33	yes	large area ...	no	same flequ...	yes	largerspace...
34	no	same inten...	no	same flequ...	yes	largerspace...
35	no	same inten...	no	same flequ...	no	same space

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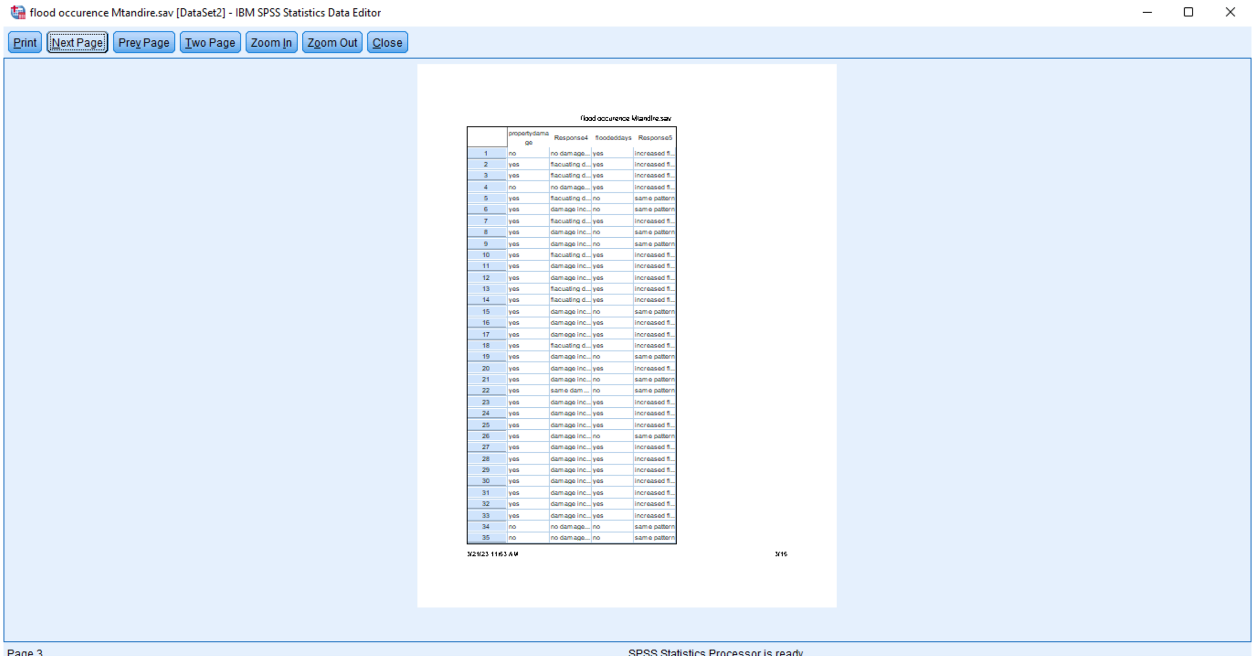

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	propertydamage	Response4	floodeddays	Response5
1	no	no damage...	yes	increased fl...
2	yes	flacuating d...	yes	increased fl...
3	yes	flacuating d...	yes	increased fl...
4	no	no damage...	yes	increased fl...
5	yes	flacuating d...	no	same pattern
6	yes	damage inc...	no	same pattern
7	yes	flacuating d...	yes	increased fl...
8	yes	damage inc...	no	same pattern
9	yes	damage inc...	no	same pattern
10	yes	flacuating d...	yes	increased fl...
11	yes	damage inc...	yes	increased fl...
12	yes	damage inc...	yes	increased fl...
13	yes	flacuating d...	yes	increased fl...
14	yes	flacuating d...	yes	increased fl...
15	yes	damage inc...	no	same pattern
16	yes	damage inc...	yes	increased fl...
17	yes	damage inc...	yes	increased fl...
18	yes	flacuating d...	yes	increased fl...
19	yes	damage inc...	no	same pattern
20	yes	damage inc...	yes	increased fl...
21	yes	damage inc...	no	same pattern
22	yes	same dam...	no	same pattern
23	yes	damage inc...	yes	increased fl...
24	yes	damage inc...	yes	increased fl...
25	yes	damage inc...	yes	increased fl...
26	yes	damage inc...	no	same pattern
27	yes	damage inc...	yes	increased fl...
28	yes	damage inc...	yes	increased fl...
29	yes	damage inc...	yes	increased fl...
30	yes	damage inc...	yes	increased fl...
31	yes	damage inc...	yes	increased fl...
32	yes	damage inc...	yes	increased fl...
33	yes	damage inc...	yes	increased fl...
34	no	no damage...	no	same pattern
35	no	no damage...	no	same pattern

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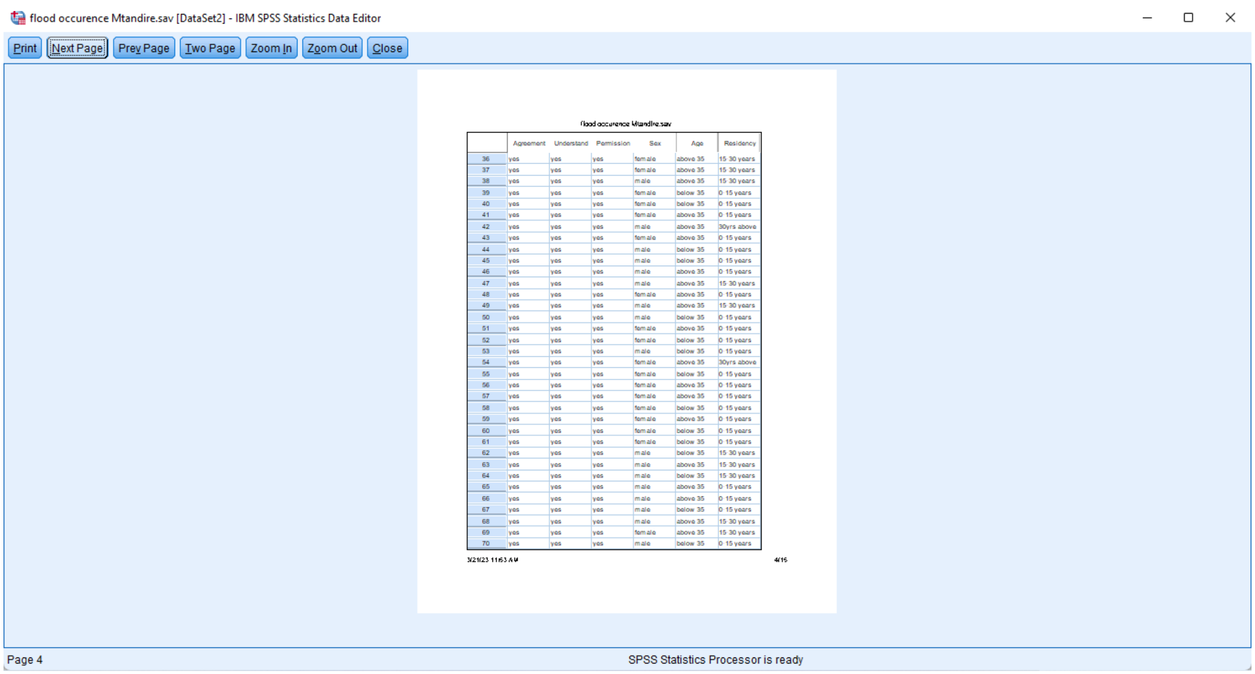

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Residency
36	yes	yes	yes	female	above 35	15-30 years
37	yes	yes	yes	female	above 35	15-30 years
38	yes	yes	yes	male	above 35	15-30 years
39	yes	yes	yes	female	below 35	0-15 years
40	yes	yes	yes	female	below 35	0-15 years
41	yes	yes	yes	female	above 35	0-15 years
42	yes	yes	yes	male	above 35	30yrs above
43	yes	yes	yes	female	above 35	0-15 years
44	yes	yes	yes	male	below 35	0-15 years
45	yes	yes	yes	male	below 35	0-15 years
46	yes	yes	yes	male	above 35	0-15 years
47	yes	yes	yes	male	above 35	15-30 years
48	yes	yes	yes	female	above 35	0-15 years
49	yes	yes	yes	male	above 35	15-30 years
50	yes	yes	yes	male	below 35	0-15 years
51	yes	yes	yes	female	above 35	0-15 years
52	yes	yes	yes	female	below 35	0-15 years
53	yes	yes	yes	male	below 35	0-15 years
54	yes	yes	yes	female	above 35	30yrs above
55	yes	yes	yes	female	below 35	0-15 years
56	yes	yes	yes	female	above 35	0-15 years
57	yes	yes	yes	female	above 35	0-15 years
58	yes	yes	yes	female	below 35	0-15 years
59	yes	yes	yes	female	above 35	0-15 years
60	yes	yes	yes	female	below 35	0-15 years
61	yes	yes	yes	female	below 35	0-15 years
62	yes	yes	yes	male	below 35	15-30 years
63	yes	yes	yes	male	above 35	15-30 years
64	yes	yes	yes	male	below 35	15-30 years
65	yes	yes	yes	male	above 35	0-15 years
66	yes	yes	yes	male	above 35	0-15 years
67	yes	yes	yes	male	below 35	0-15 years
68	yes	yes	yes	male	above 35	15-30 years
69	yes	yes	yes	female	above 35	15-30 years
70	yes	yes	yes	male	below 35	0-15 years

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flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Floodingintensity	Response	Floodingfrequency	Response2	Spacecovere	Response3
36	yes	floods faster	yes	seasonal fl...	yes	largerspace...
37	yes	floods faster	yes	increased d...	no	same space
38	yes	floods faster	yes	seasonal fl...	yes	largerspace...
39	yes	floods faster	yes	seasonal fl...	yes	largerspace...
40	yes	floods faster	yes	seasonal fl...	yes	largerspace...
41	yes	large area ...	yes	increased d...	yes	largerspace...
42	yes	large area ...	yes	seasonal fl...	yes	flactuates
43	yes	floods faster	yes	seasonal fl...	yes	largerspace...
44	no	same inten...	no	same flequ...	no	same space
45	yes	large area ...	yes	seasonal fl...	yes	largerspace...
46	yes	floods faster	yes	increased d...	yes	largerspace...
47	yes	floods faster	yes	seasonal fl...	yes	largerspace...
48	no	same inten...	yes	seasonal fl...	yes	largerspace...
49	yes	floods faster	yes	seasonal fl...	yes	largerspace...
50	yes	floods faster	yes	seasonal fl...	yes	largerspace...
51	yes	floods faster	yes	seasonal fl...	yes	largerspace...
52	yes	floods faster	yes	seasonal fl...	yes	flactuates
53	yes	floods faster	no	same flequ...	no	same space
54	no	same inten...	no	same flequ...	no	same space
55	no	same inten...	no	same flequ...	no	same space
56	yes	large area ...	yes	seasonal fl...	yes	largerspace...
57	yes	floods faster	yes	increased d...	yes	largerspace...
58	yes	floods faster	yes	increased d...	yes	flactuates
59	yes	large area ...	yes	seasonal fl...	yes	largerspace...
60	yes	floods faster	yes	increased d...	yes	largerspace...
61	yes	floods faster	yes	increased d...	yes	largerspace...
62	yes	large area ...	yes	increased d...	yes	flactuates
63	yes	large area ...	yes	increased d...	yes	flactuates
64	yes	large area ...	yes	increased d...	yes	flactuates
65	yes	floods faster	no	same flequ...	yes	largerspace...
66	yes	floods faster	no	same flequ...	yes	largerspace...
67	yes	floods faster	no	same flequ...	yes	largerspace...
68	yes	floods faster	yes	increased d...	yes	largerspace...
69	yes	floods faster	yes	increased d...	yes	largerspace...
70	yes	floods faster	no	same flequ...	yes	largerspace...

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flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	propertydamage	Response4	floodeddays	Response5
36	yes	damage inc...	yes	increased fl...
37	yes	damage inc...	yes	increased fl...
38	yes	damage inc...	no	same pattern
39	yes	damage inc...	yes	increased fl...
40	yes	damage inc...	yes	increased fl...
41	yes	damage inc...	yes	increased fl...
42	yes	damage inc...	no	same pattern
43	yes	damage inc...	yes	increased fl...
44	no	no damage...	no	same pattern
45	yes	damage inc...	yes	increased fl...
46	yes	damage inc...	yes	increased fl...
47	yes	damage inc...	yes	increased fl...
48	yes	damage inc...	yes	increased fl...
49	yes	damage inc...	no	same pattern
50	yes	damage inc...	yes	increased fl...
51	yes	damage inc...	yes	increased fl...
52	yes	damage inc...	yes	increased fl...
53	no	no damage...	no	same pattern
54	no	no damage...	no	same pattern
55	no	no damage...	no	same pattern
56	yes	damage inc...	yes	increased fl...
57	yes	damage inc...	yes	increased fl...
58	yes	damage inc...	yes	increased fl...
59	yes	damage inc...	yes	increased fl...
60	yes	damage inc...	yes	increased fl...
61	yes	damage inc...	yes	increased fl...
62	yes	damage inc...	yes	increased fl...
63	yes	damage inc...	yes	increased fl...
64	yes	damage inc...	yes	increased fl...
65	no	no damage...	no	same pattern
66	yes	damage de...	no	same pattern
67	yes	damage inc...	yes	increased fl...
68	yes	damage inc...	no	same pattern
69	yes	damage inc...	no	same pattern
70	yes	damage inc...	yes	increased fl...

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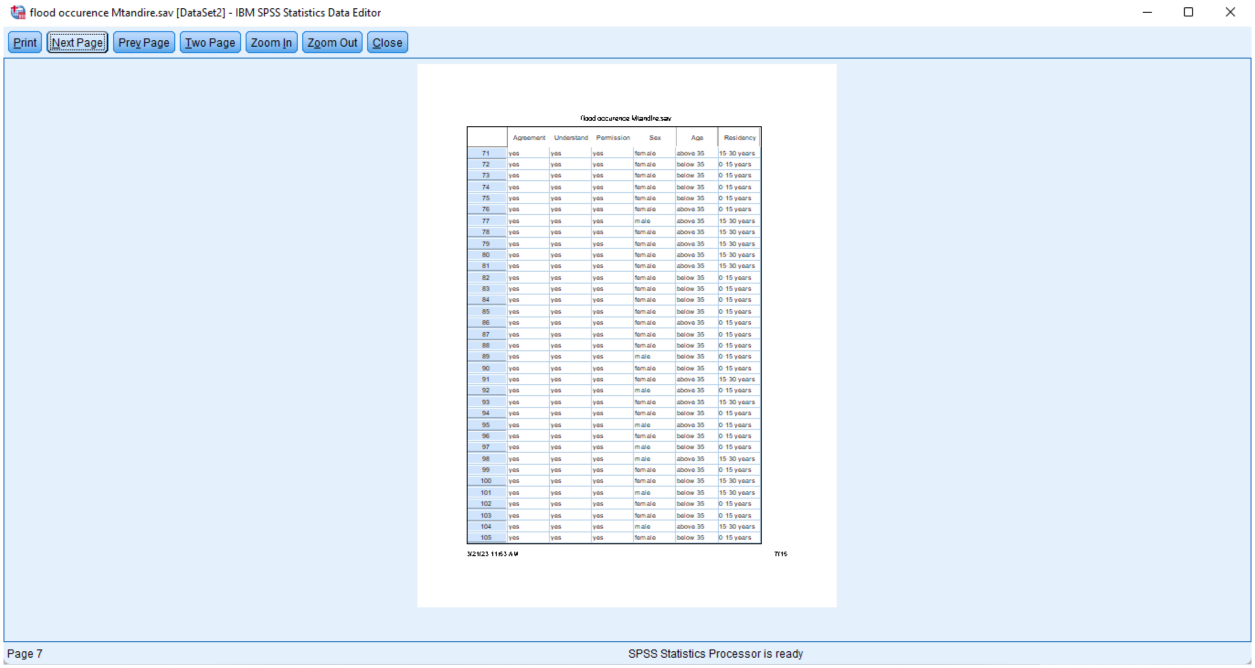

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Residency
71	yes	yes	yes	female	above 35	15-30 years
72	yes	yes	yes	female	below 35	0-15 years
73	yes	yes	yes	female	below 35	0-15 years
74	yes	yes	yes	female	below 35	0-15 years
75	yes	yes	yes	female	below 35	0-15 years
76	yes	yes	yes	female	above 35	0-15 years
77	yes	yes	yes	male	above 35	15-30 years
78	yes	yes	yes	female	above 35	15-30 years
79	yes	yes	yes	female	above 35	15-30 years
80	yes	yes	yes	female	above 35	15-30 years
81	yes	yes	yes	female	above 35	15-30 years
82	yes	yes	yes	female	below 35	0-15 years
83	yes	yes	yes	female	below 35	0-15 years
84	yes	yes	yes	female	below 35	0-15 years
85	yes	yes	yes	female	below 35	0-15 years
86	yes	yes	yes	female	above 35	0-15 years
87	yes	yes	yes	female	below 35	0-15 years
88	yes	yes	yes	female	below 35	0-15 years
89	yes	yes	yes	male	below 35	0-15 years
90	yes	yes	yes	female	below 35	0-15 years
91	yes	yes	yes	female	above 35	15-30 years
92	yes	yes	yes	male	above 35	0-15 years
93	yes	yes	yes	female	above 35	15-30 years
94	yes	yes	yes	female	below 35	0-15 years
95	yes	yes	yes	male	above 35	0-15 years
96	yes	yes	yes	female	below 35	0-15 years
97	yes	yes	yes	male	below 35	0-15 years
98	yes	yes	yes	male	above 35	15-30 years
99	yes	yes	yes	female	above 35	0-15 years
100	yes	yes	yes	female	below 35	15-30 years
101	yes	yes	yes	male	below 35	15-30 years
102	yes	yes	yes	female	below 35	0-15 years
103	yes	yes	yes	female	below 35	0-15 years
104	yes	yes	yes	male	above 35	15-30 years
105	yes	yes	yes	female	below 35	0-15 years

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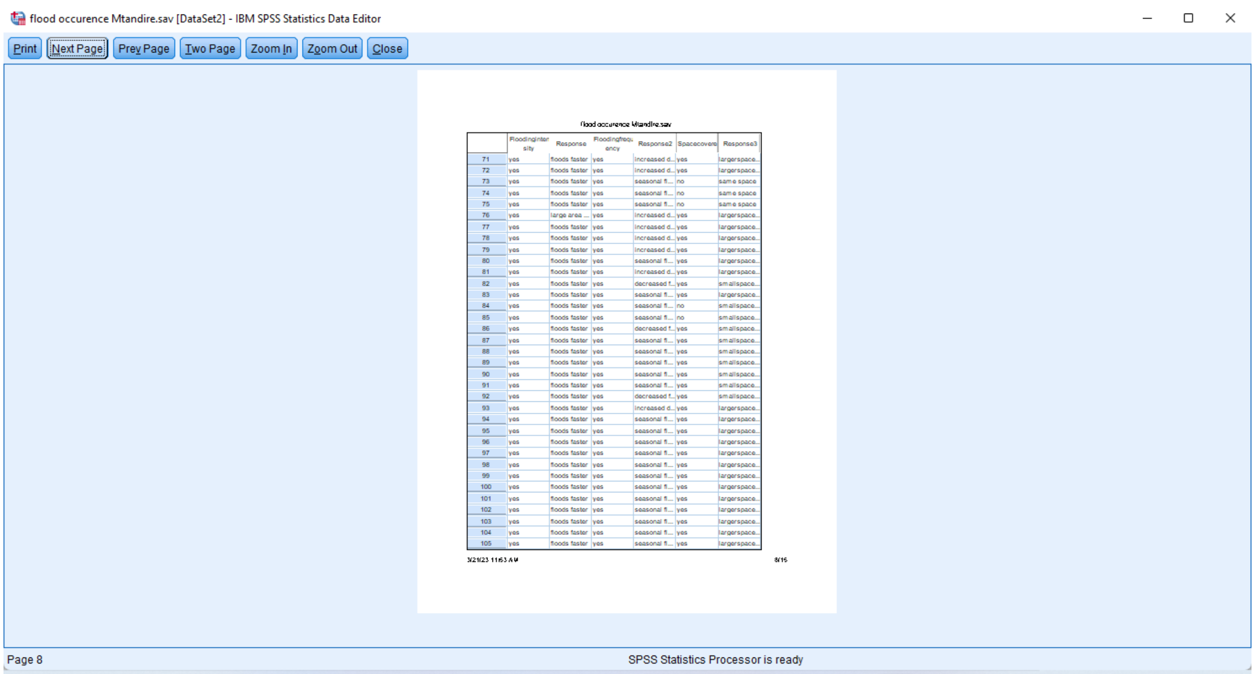

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Floodingintensity	Response	Floodingfrequency	Response2	Spacecovere	Response3
71	yes	floods faster	yes	increased d...	yes	largerspace...
72	yes	floods faster	yes	increased d...	yes	largerspace...
73	yes	floods faster	yes	seasonal fl....	no	same space
74	yes	floods faster	yes	seasonal fl....	no	same space
75	yes	floods faster	yes	seasonal fl....	no	same space
76	yes	large area ...	yes	increased d...	yes	largerspace...
77	yes	floods faster	yes	increased d...	yes	largerspace...
78	yes	floods faster	yes	increased d...	yes	largerspace...
79	yes	floods faster	yes	increased d...	yes	largerspace...
80	yes	floods faster	yes	seasonal fl....	yes	largerspace...
81	yes	floods faster	yes	increased d...	yes	largerspace...
82	yes	floods faster	yes	decreased f...	yes	smallspace...
83	yes	floods faster	yes	seasonal fl....	yes	largerspace...
84	yes	floods faster	yes	seasonal fl....	no	smallspace...
85	yes	floods faster	yes	seasonal fl....	no	smallspace...
86	yes	floods faster	yes	decreased f...	yes	smallspace...
87	yes	floods faster	yes	seasonal fl....	yes	smallspace...
88	yes	floods faster	yes	seasonal fl....	yes	smallspace...
89	yes	floods faster	yes	seasonal fl....	yes	smallspace...
90	yes	floods faster	yes	seasonal fl....	yes	smallspace...
91	yes	floods faster	yes	seasonal fl....	yes	smallspace...
92	yes	floods faster	yes	decreased f...	yes	smallspace...
93	yes	floods faster	yes	increased d...	yes	largerspace...
94	yes	floods faster	yes	seasonal fl....	yes	largerspace...
95	yes	floods faster	yes	seasonal fl....	yes	largerspace...
96	yes	floods faster	yes	seasonal fl....	yes	largerspace...
97	yes	floods faster	yes	seasonal fl....	yes	largerspace...
98	yes	floods faster	yes	seasonal fl....	yes	largerspace...
99	yes	floods faster	yes	seasonal fl....	yes	largerspace...
100	yes	floods faster	yes	seasonal fl....	yes	largerspace...
101	yes	floods faster	yes	seasonal fl....	yes	largerspace...
102	yes	floods faster	yes	seasonal fl....	yes	largerspace...
103	yes	floods faster	yes	seasonal fl....	yes	largerspace...
104	yes	floods faster	yes	seasonal fl....	yes	largerspace...
105	yes	floods faster	yes	seasonal fl....	yes	largerspace...

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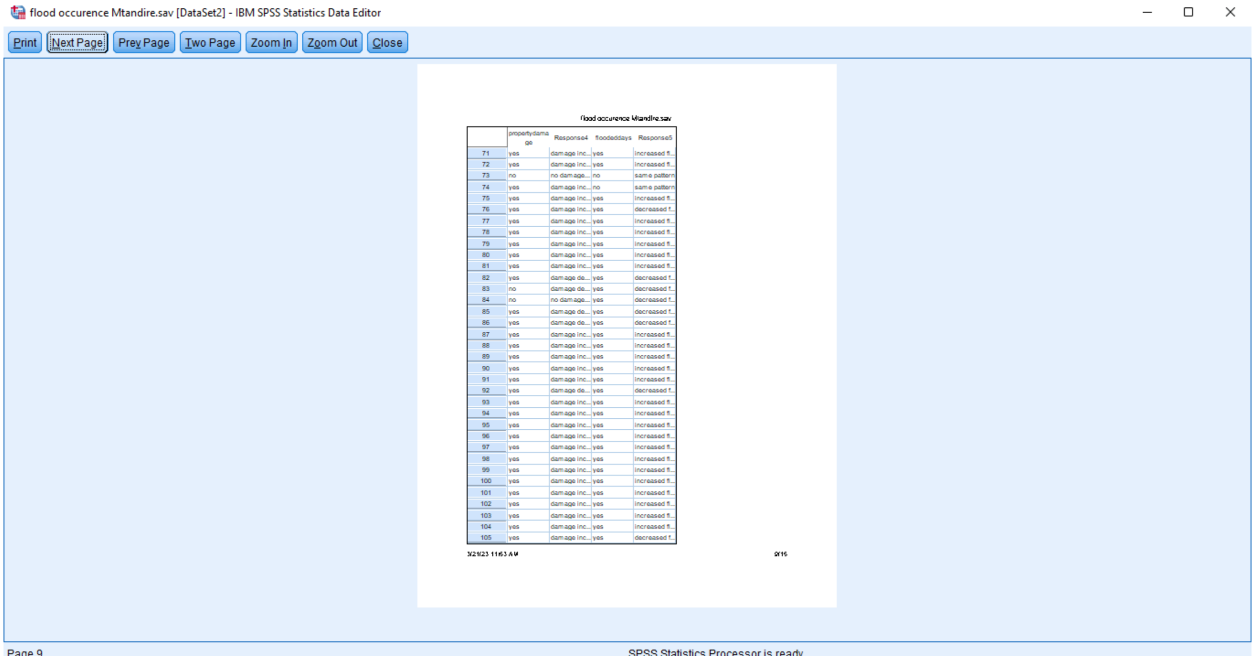

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	propertydamage	Response4	floodeddays	Response5
71	yes	damage inc...	yes	increased fl...
72	yes	damage inc...	yes	increased fl...
73	no	no damage...	no	same pattern
74	yes	damage inc...	no	same pattern
75	yes	damage inc...	yes	increased fl...
76	yes	damage inc...	yes	decreased f...
77	yes	damage inc...	yes	increased fl...
78	yes	damage inc...	yes	increased fl...
79	yes	damage inc...	yes	increased fl...
80	yes	damage inc...	yes	increased fl...
81	yes	damage inc...	yes	increased fl...
82	yes	damage de...	yes	decreased f...
83	no	damage de...	yes	decreased f...
84	no	no damage...	yes	decreased f...
85	yes	damage de...	yes	decreased f...
86	yes	damage de...	yes	decreased f...
87	yes	damage inc...	yes	increased fl...
88	yes	damage inc...	yes	increased fl...
89	yes	damage inc...	yes	increased fl...
90	yes	damage inc...	yes	increased fl...
91	yes	damage inc...	yes	increased fl...
92	yes	damage de...	yes	decreased f...
93	yes	damage inc...	yes	increased fl...
94	yes	damage inc...	yes	increased fl...
95	yes	damage inc...	yes	increased fl...
96	yes	damage inc...	yes	increased fl...
97	yes	damage inc...	yes	increased fl...
98	yes	damage inc...	yes	increased fl...
99	yes	damage inc...	yes	increased fl...
100	yes	damage inc...	yes	increased fl...
101	yes	damage inc...	yes	increased fl...
102	yes	damage inc...	yes	increased fl...
103	yes	damage inc...	yes	increased fl...
104	yes	damage inc...	yes	increased fl...
105	yes	damage inc...	yes	decreased f...

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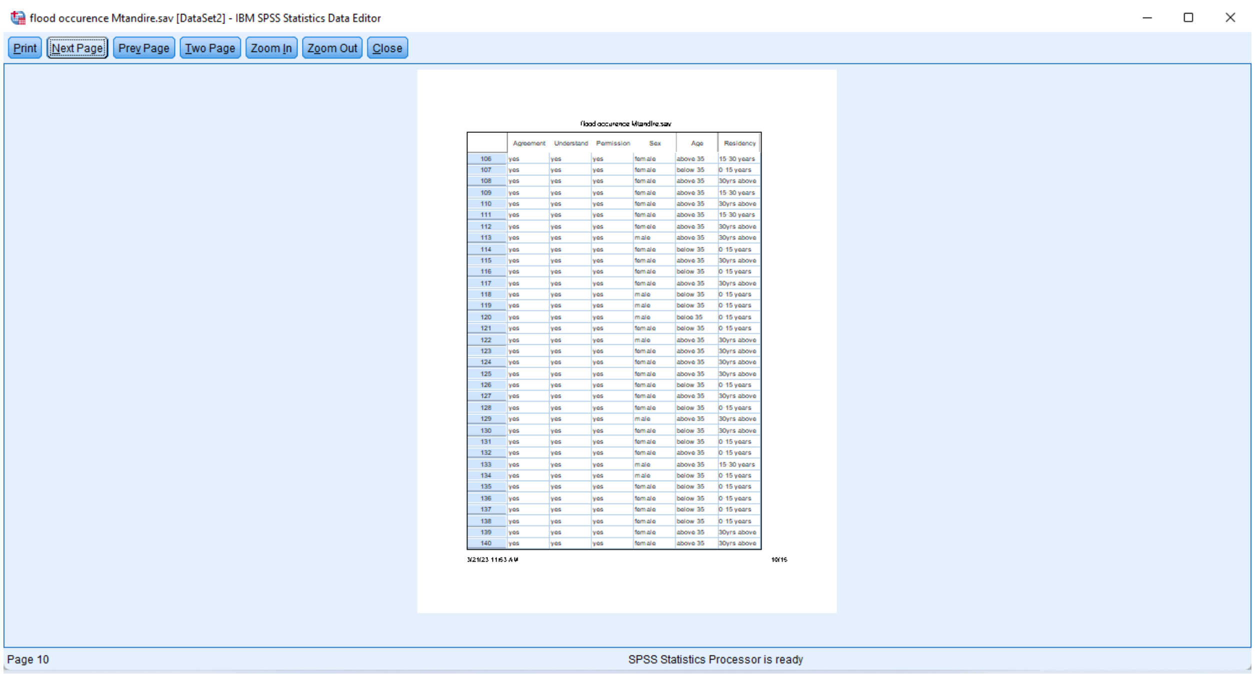

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Residency
106	yes	yes	yes	female	above 35	15-30 years
107	yes	yes	yes	female	below 35	0-15 years
108	yes	yes	yes	female	above 35	30yrs above
109	yes	yes	yes	female	above 35	15-30 years
110	yes	yes	yes	female	above 35	30yrs above
111	yes	yes	yes	female	above 35	15-30 years
112	yes	yes	yes	femele	above 35	30yrs above
113	yes	yes	yes	male	above 35	30yrs above
114	yes	yes	yes	female	below 35	0-15 years
115	yes	yes	yes	female	above 35	30yrs above
116	yes	yes	yes	female	below 35	0-15 years
117	yes	yes	yes	female	above 35	30yrs above
118	yes	yes	yes	male	below 35	0-15 years
119	yes	yes	yes	male	below 35	0-15 years
120	yes	yes	yes	male	beloe 35	0-15 years
121	yes	yes	yes	female	below 35	0-15 years
122	yes	yes	yes	male	above 35	30yrs above
123	yes	yes	yes	female	above 35	30yrs above
124	yes	yes	yes	female	above 35	30yrs above
125	yes	yes	yes	female	above 35	30yrs above
126	yes	yes	yes	female	below 35	0-15 years
127	yes	yes	yes	female	above 35	30yrs above
128	yes	yes	yes	female	below 35	0-15 years
129	yes	yes	yes	male	above 35	30yrs above
130	yes	yes	yes	female	below 35	30yrs above
131	yes	yes	yes	female	below 35	0-15 years
132	yes	yes	yes	female	above 35	0-15 years
133	yes	yes	yes	male	above 35	15-30 years
134	yes	yes	yes	male	below 35	0-15 years
135	yes	yes	yes	female	below 35	0-15 years
136	yes	yes	yes	female	below 35	0-15 years
137	yes	yes	yes	female	below 35	0-15 years
138	yes	yes	yes	female	below 35	0-15 years
139	yes	yes	yes	female	above 35	30yrs above
140	yes	yes	yes	female	above 35	30yrs above

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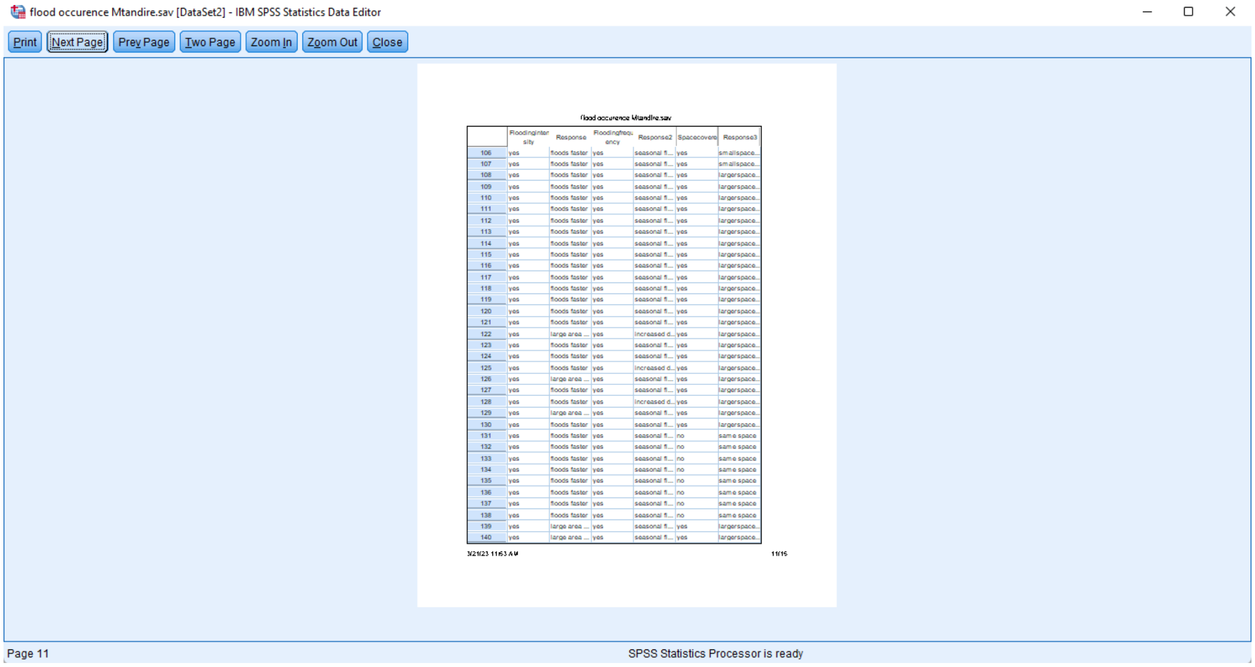

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Floodingintensity	Response	Floodingfrequency	Response2	Spacecovere	Response3
106	yes	floods faster	yes	seasonal fl...	yes	smallspace...
107	yes	floods faster	yes	seasonal fl...	yes	smallspace...
108	yes	floods faster	yes	seasonal fl...	yes	largerspace...
109	yes	floods faster	yes	seasonal fl...	yes	largerspace...
110	yes	floods faster	yes	seasonal fl...	yes	largerspace...
111	yes	floods faster	yes	seasonal fl...	yes	largerspace...
112	yes	floods faster	yes	seasonal fl...	yes	largerspace...
113	yes	floods faster	yes	seasonal fl...	yes	largerspace...
114	yes	floods faster	yes	seasonal fl...	yes	largerspace...
115	yes	floods faster	yes	seasonal fl...	yes	largerspace...
116	yes	floods faster	yes	seasonal fl...	yes	largerspace...
117	yes	floods faster	yes	seasonal fl...	yes	largerspace...
118	yes	floods faster	yes	seasonal fl...	yes	largerspace...
119	yes	floods faster	yes	seasonal fl...	yes	largerspace...
120	yes	floods faster	yes	seasonal fl...	yes	largerspace...
121	yes	floods faster	yes	seasonal fl...	yes	largerspace...
122	yes	large area ...	yes	increased d...	yes	largerspace...
123	yes	floods faster	yes	seasonal fl...	yes	largerspace...
124	yes	floods faster	yes	seasonal fl...	yes	largerspace...
125	yes	floods faster	yes	increased d...	yes	largerspace...
126	yes	large area ...	yes	seasonal fl...	yes	largerspace...
127	yes	floods faster	yes	seasonal fl...	yes	largerspace...
128	yes	floods faster	yes	increased d...	yes	largerspace...
129	yes	large area ...	yes	seasonal fl...	yes	largerspace...
130	yes	floods faster	yes	seasonal fl...	yes	largerspace...
131	yes	floods faster	yes	seasonal fl...	no	same space
132	yes	floods faster	yes	seasonal fl...	no	same space
133	yes	floods faster	yes	seasonal fl...	no	same space
134	yes	floods faster	yes	seasonal fl...	no	same space
135	yes	floods faster	yes	seasonal fl...	no	same space
136	yes	floods faster	yes	seasonal fl...	no	same space
137	yes	floods faster	yes	seasonal fl...	no	same space
138	yes	floods faster	yes	seasonal fl...	no	same space
139	yes	large area ...	yes	seasonal fl...	yes	largerspace...
140	yes	large area ...	yes	seasonal fl...	yes	largerspace...

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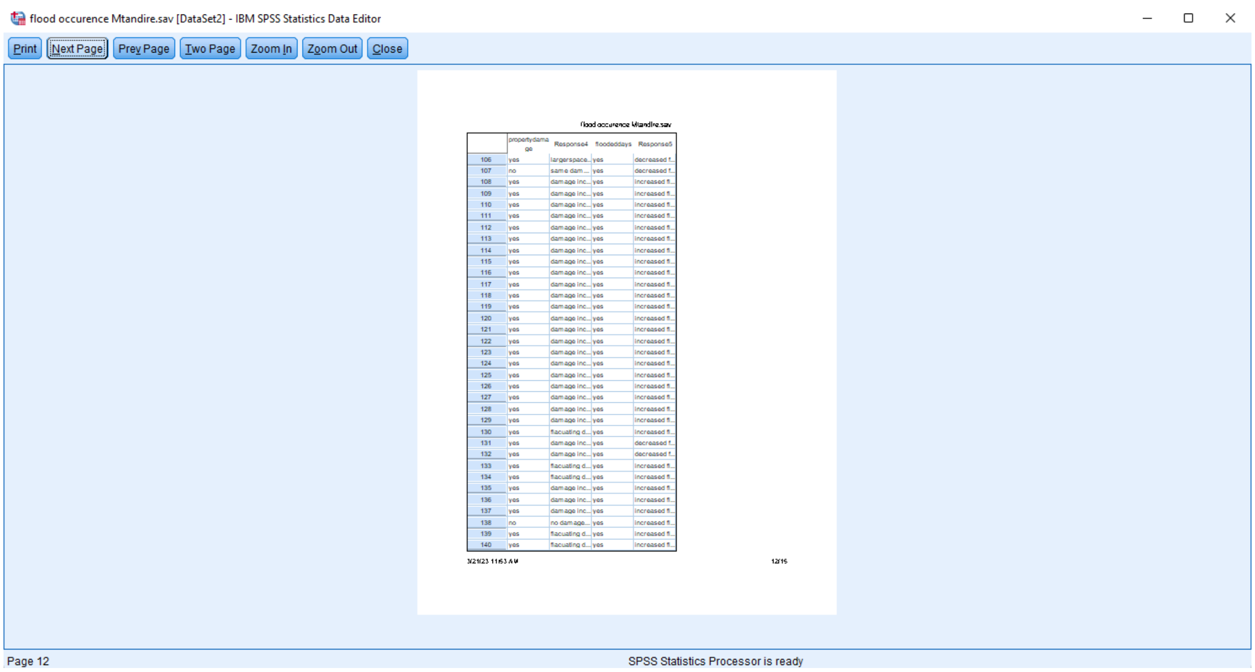

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	propertydamage	Response4	floodeddays	Response5
106	yes	largerspace...	yes	decreased f...
107	no	same dam...	yes	decreased f...
108	yes	damage inc...	yes	increased fl...
109	yes	damage inc...	yes	increased fl...
110	yes	damage inc...	yes	increased fl...
111	yes	damage inc...	yes	increased fl...
112	yes	damage inc...	yes	increased fl...
113	yes	damage inc...	yes	increased fl...
114	yes	damage inc...	yes	increased fl...
115	yes	damage inc...	yes	increased fl...
116	yes	damage inc...	yes	increased fl...
117	yes	damage inc...	yes	increased fl...
118	yes	damage inc...	yes	increased fl...
119	yes	damage inc...	yes	increased fl...
120	yes	damage inc...	yes	increased fl...
121	yes	damage inc...	yes	increased fl...
122	yes	damage inc...	yes	increased fl...
123	yes	damage inc...	yes	increased fl...
124	yes	damage inc...	yes	increased fl...
125	yes	damage inc...	yes	increased fl...
126	yes	damage inc...	yes	increased fl...
127	yes	damage inc...	yes	increased fl...
128	yes	damage inc...	yes	increased fl...
129	yes	damage inc...	yes	increased fl...
130	yes	flacuating d...	yes	increased fl...
131	yes	damage inc...	yes	decreased f...
132	yes	damage inc...	yes	decreased f...
133	yes	flacuating d...	yes	increased fl...
134	yes	flacuating d...	yes	increased fl...
135	yes	damage inc...	yes	increased fl...
136	yes	damage inc...	yes	increased fl...
137	yes	damage inc...	yes	increased fl...
138	no	no damage...	yes	increased fl...
139	yes	flacuating d...	yes	increased fl...
140	yes	flacuating d...	yes	increased fl...

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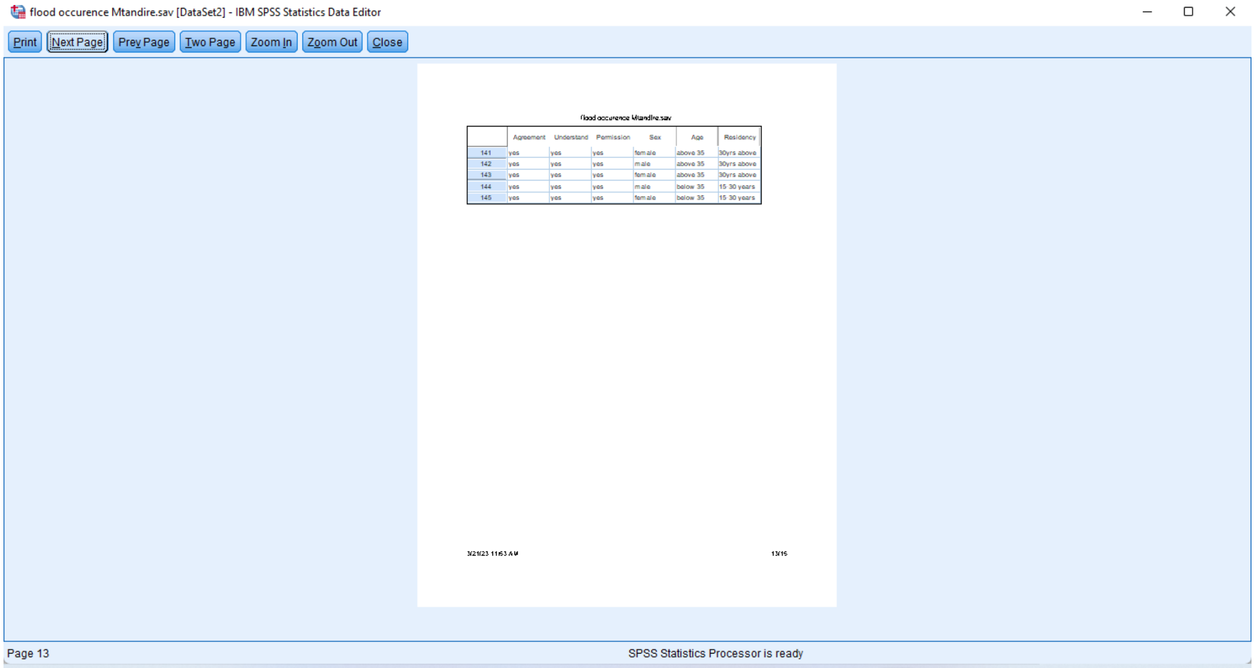

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Agreement	Understand	Permission	Sex	Age	Residency
141	yes	yes	yes	female	above 35	30yrs above
142	yes	yes	yes	male	above 35	30yrs above
143	yes	yes	yes	female	above 35	30yrs above
144	yes	yes	yes	male	below 35	15-30 years
145	yes	yes	yes	female	below 35	15-30 years

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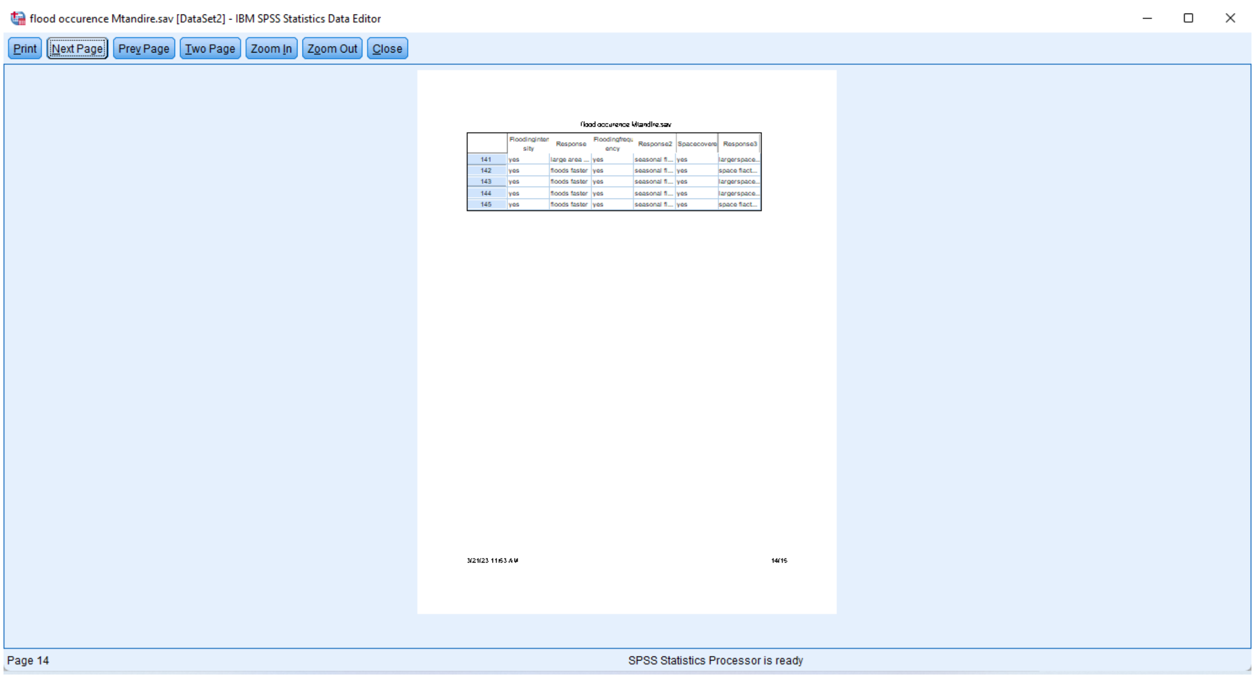

flood occurence Mtandire.sav [DataSet2] - IBM SPSS Statistics Data Editor

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flood occurence Mtandire.sav

	Floodingintensity	Response	Floodingfrequency	Response2	Spacecovere	Response3
141	yes	large area ...	yes	seasonal fl...	yes	largerspace...
142	yes	floods faster	yes	seasonal fl...	yes	space flact...
143	yes	floods faster	yes	seasonal fl...	yes	largerspace...
144	yes	floods faster	yes	seasonal fl...	yes	largerspace...
145	yes	floods faster	yes	seasonal fl...	yes	space flact...

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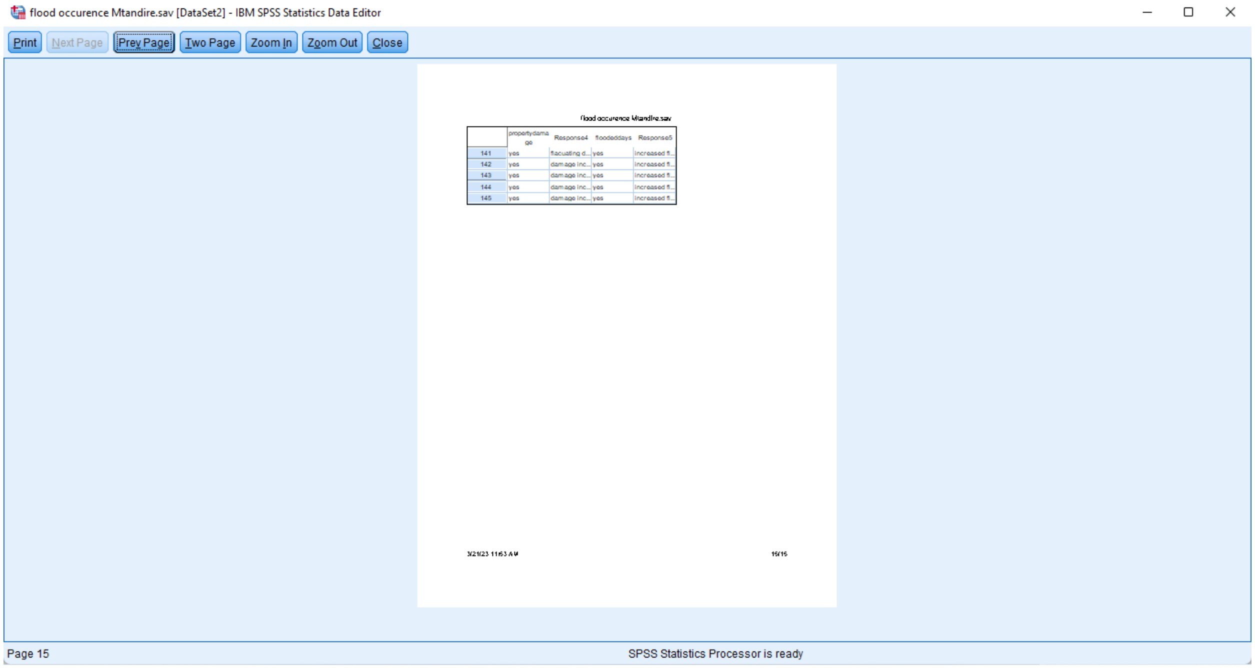

	propertydamage	Response4	floodeddays	Response5
141	yes	flacuating d...	yes	increased fl...
142	yes	damage inc...	yes	increased fl...
143	yes	damage inc...	yes	increased fl...
144	yes	damage inc...	yes	increased fl...
145	yes	damage inc...	yes	increased fl...