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THE VULNERABILITY IMPACT ASSESSMENT AND HOTSPOT MAPPING FOR THE CHALINZE DISTRICT COUNCIL, TANZANIA

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ABSTRACT

This study comparatively quantified the way and extends to which different areas within Chalinze district are vulnerable to the impacts of climate change, and consequently mapped the hotspot. It used both quantitative and qualitative primary and secondary data. Quantitative secondary data were collected from various sources, including the National Bureau of Statistics (NBS) and Tanzania Meteorological Authority (TMA). Qualitative data were collected using Participatory Rural Appraisal (PRA), Focus Group Discussion (FGD) and a stakeholder workshop. Assessment results on Exposure, Sensitivity and Adaptive capacity indicated that; the central parts of Chalinze District Council, specifically, Kimange, Msata, Talawanda and Miono wards had the highest Exposure to the associated climate change impacts. On Sensitivity assessment, the findings indicated that Msata and Ubenazomozi wards and some villages in Talawanda, Pera, Vigwaza and Mkange were the most sensitive. On Adaptive capacity, it was found that two wards of Bwilingu and Mandera hada high Adaptive capacity compared to the rest of the wards. The overall vulnerability determined through averaging of the rescaled values from exposure, sensitivity, and lack of adaptive capacity indicates that Talawanda and Kimange wards were the most vulnerable wards. The need for the government, development partners and other stockholders in promoting livelihoods diversifications across the districts to relieve pressure on environment and natural resources were recommended. This will help to reduce community vulnerability and upset impacts of climate change and environmental degradation

1. INTRODUCTION

Climate change and variability are among the biggest challenges of the 21st century (IPCC, 2014) facing the international communities. Currently, most regions in the world, particularly in Africa are already overwhelmed by the impacts of increasing climate variability. According to IPCC, (2012,

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2013, 2018, 2019), global warming has already reached 1.00C above pre-industrial levels and the warming trend is escalating fast. It is projected that if we continue with business as usual scenario-warming trend will reach 1.50C by between 2030 and 2052 (IPCC, 2018, 2019). The IPCC reports also indicate a projected slight decline in precipitation in some areas and increase in others. However, there is good agreement in model simulation that the frequency and intensity of heavy precipitation are projected to increase (Gwambene, 2017, IPCC, 2018). Extreme weather and climate events including droughts and floods are projected to increase in frequency and magnitude (Kahimba et al., 2015; Irish Aid, 2018). The projected climate change will significantly impact food production in various parts of the world including agro-ecological zones and river basins (IPCC, 2019). Generally, climate change poses a serious risk to poverty reduction efforts and threatens to undo decades of development efforts of many countries including Tanzania. This challenge is more evident in Chalinze District, located within the Coastal region of Tanzania. The District like any other coastal areas are faced with immediate climate change threats such as frequent and prolonged droughts, severe floods, rise of sea level and coastal storms (Neumann et al, 2015; Irish Aid, 2018). In recent years, there has been a great shift in climatic seasons in Chalinze District, which have strongly affected the community' livelihoods, especially the rain-fed agriculture, which is the mainstay of the majority of community members (CAN Tanzania, 2016). Unfortunately, in spite of all these challenges not much has been done to comprehensively assess and quantify the vulnerability of different parts of the districts to the impacts of climate change, which is a pre-requisite information for designing appropriate and effective adaptation strategies. Vulnerability assessment is, therefore, an important instrument to reveal the patterns, and the extent of the impacts of climate change on the environment and society, and identifying hotspot regions of climate change and facilitate the formulation of appropriate adaptation measures.

In most countries in Africa including Tanzania, limited or lack of high-resolution climate datasets has been one of the main constraints in climate change studies including in vulnerability assessment (Kahimba et al., 2015). Lack of high-resolution climate data has also constrained the assessment of climate change vulnerability for Chalinze District Council. As it stands currently, the district does not have sufficient weather stations, only use climate data observed from the nearby weather stations.. Lack of these specific climate data, particularly rainfall and temperature hinders comprehensive assessment of mesoscale climate patterns and for detailed climate change vulnerability assessment. This Vulnerability Impact Assessment and Hotspot Mapping for the Chalinze District Council study used multiple datasets to fills the data gaps challenge and to ensure adequate characterization of the vulnerability.

The results from this study will play crucial role in informing planning and decision making in various development agenda in the context of a changing climate, and in the manner that ensure enhanced community resilience and embracing national and international development policies such as the Tanzania Vision 2025, The National Climate Change Strategy of 2012 and Sustainable Development Goals (Agenda, 2030).

2. MATERIALS AND METHODS

2.1 Study area

Chalinze District Council (CDC) was established on 25th September 2015 under the terms of the provisions of sections 7, 9, 10, 11 and 12 of the Local Government (District Authorities) Act of 1982. The Council, being one among nine District Councils in Pwani region is located between 37^0 and 39^0

East and between 6^0 and 7^0 South of the Equator. It is found 75 Km away from Pwani Region Headquarters. The Chaplains District Council is a junction which linking roads to Bagamoyo district and Tanga region in the Southern part and bordered by Handeni District and Pangani districts of Tanga region in the northern side. In the East, it is bordered by Kibaha district of Pwani region and by the Morogoro District on the West. The climate of CDC is characterized by bimodal rainfall distribution with a peak in October –December, normally known as short rains or *Vuli* in the Swahili language, and March-May, normally known as Long rains or *Masika* in Swahili language. January to February is normally a transition period, and June to September is relatively a dry season. The district occasionally experiences heavy and intermittent rainfall, which sometimes causes loss of live, severe impacts to properties and infrastructure including destruction of roads and bridges. The annual rainfall ranges from 800mm to 1200mm with a mean of around 1000mm. Temperature ranges between 13°C and 30°C with the highest Temperature being recorded in September. Cool-weather is experienced in the months of June to August with temperature ranging between 15°C and 20°C.

As per the 2012 national population and housing census, CDC has an estimated population of 214,080 out of which 105,595 are males and 108,485 are females. It has a total of 42,218 households with an average family size of 5 persons. The life expectancy is 45 years and the average population growth rate per year being 2%. With an estimated area of 8,042 Km^2, CDC has 68 villages and 437 hamlets. It is made of five (5) Divisions namely; Msata, massage, Collins, Kwaruhombo and Miono. The CDC is composed of fifteen (15) wards as shown in the Figure 1.

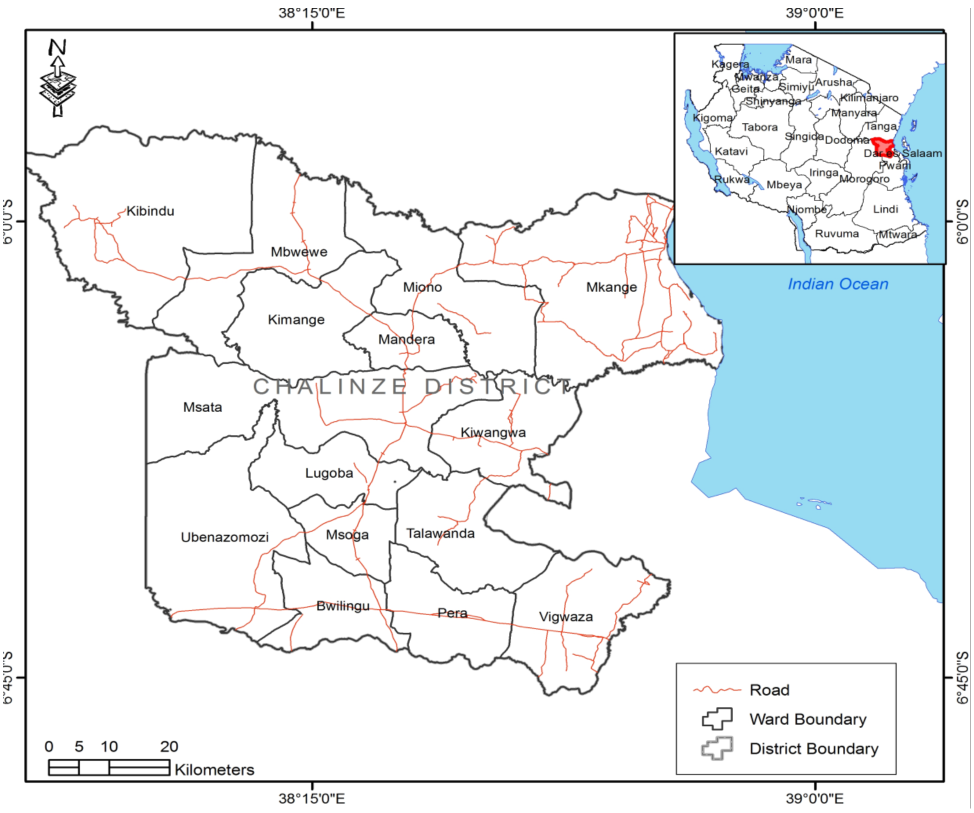

Figure 1: Location and Administrative structure of Chalinze District Council.

2.2 Data Collection Approach and tools

This assessment made use of both primary and secondary quantitative and qualitative data respectively obtained multiple data sources. To complement and address the lack of high-resolution climate data sets due to low station density, the study also used satellite-based data. Climate data sets from nearby stations were obtained from TMA, and other High-resolution rainfall and temperature data were made available from FEWSNET and CHIRPS. Other relevant socioeconomic data were obtained from NBS and other sources as indicated in Table 1. Qualitative data were strategically collected during stakeholder workshop. The three main vulnerability components of exposure, sensitivity and adaptive capacity were properly addressed and indicator was assigned a specific code that was later used in the R statistical package for processing climate change components and vulnerability analysis. The detailed description of the datasets used and their respective sources are provided in Table 1 and the main steps that were followed in this assessment have been presented under Figure 2.

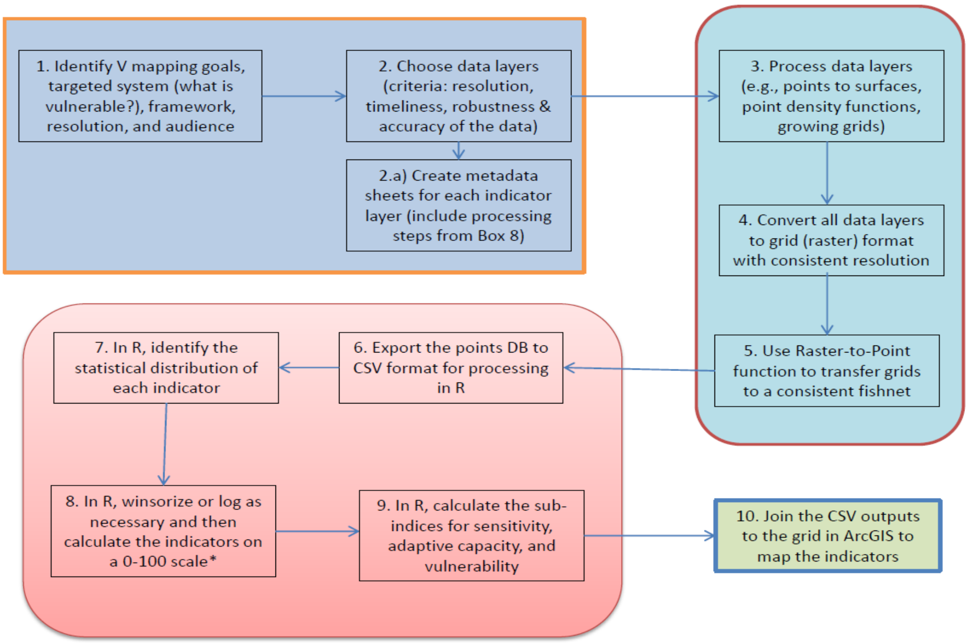

Figure 2: Steps for Vulnerability Mapping.

Source: SERVIR (2017).

2.2.1 Data Sources and Mapping Approach

Different data including the main data layers were gathered from various sources, analyzed, mainstreamed in the overall data set and mapped using various units. Under the three vulnerability components (exposure, sensitivity and adaptive) indicators were collected. For exposure, indicators included rainfall/ precipitation trends, maximum temperature trends, Land use land cover change, land productivity and flood frequency. The sensitivity indicators entailed a population density, land productivity, organic soil carbon, poverty and malaria prevalence. Adaptive capacity was related to the three assessed indicators includes access to improved water sources, markets and health facilities.

Rainfall: Average monthly rainfall data were derived from Climate Hazards Group Infrared Precipitation with Station Data (CHIRPS) for the year 1981-2016. It is a 30+year quasi-global rainfall dataset. The resolution of the data is 0.05°, it is a gridded rainfall time-series obtained by merging satellite imagery with in-situ station data.

Table 1: Vulnerability Data indicators and sources

Component	Data Layer	Indicator code	Data source
Exposure	Rainfall	Pcv	CHIRPS/TMA
	Floods frequency	Flood	UNEP GRID model
	Average maximum temperature (day time temperatures)	Temp	FEWSNET
	Precipitation trends (change)	Ptrend	CHIRPS/TMA
Sensitivity	Malaria prevalence	Mala	MALA/AfriPop
	Land use land cover	Lulc	Interpretation from Landsat/Sentinel data
	Land productivity	Crop	RCMRD/FEWSNET
	Poverty	Pov	National Bureau of Statistics
	Organic soil carbon	Soc	UNFCCD/JRC
	Population density	Pop	National Bureau of Statistics
Adaptive capacity	Access to improved water sources	Wacc	National Bureau of Statistics
	Access to markets	Mark	JRC
	Access to health facilities	Health	National Bureau of Statistics

Temperature: Average maximum temperature (day time temperatures) data were acquired from FEWSNET ITE temperature (1981-2012). FEWS NET's remote sensing products and datasets are available through the U.S. Geological Survey (USGS) FEWS NET Data Portal <http://earlywarning.usgs.gov/fews> and the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center Data Portal <http://www.cpc.ncep.noaa.gov/products/international/>. The products include weather forecasts and seasonal outlooks highlighting trends, hazards, and anomalies, as well as geospatial data and mapping related to vegetation, rainfall, and water use. The data have a coarse resolution of 0.1 degrees

Flood frequency: The flood frequency (events/100 years) data were derived from UNEP GRID (2009). This data set includes an estimate of flood frequency. It is based on three sources: 1) A GIS modelling using a statistical estimation of peak-flow magnitude and a hydrological model using HydroSHEDS dataset and the Manning equation to estimate the river stage for the calculated discharge value. 2) Observed flood from 1999 to 2007, obtained from the Dartmouth Flood Observatory (DFO). 3) The frequency was set using the frequency from UNEP/GRID-Europe PREVIEW flood dataset. In the area where no information was available, it was set to 50 years returning period. The unit is expected average number of events per 100 years. This product was designed by UNEP/GRID-Europe for the Global Assessment Report on Risk Reduction (GAR). It was modelled using global data. The Chalinze district council has a flood frequency value of 0 t0 10 as minimum and maximum values respectively.

Land use land cover change: Land use land cover change data were derived from Land use land cover change (2000-2010) from Regional Center for Mapping of Resources for Development (RCMRD). The data were developed using Landsat images for the year 2000 and 2010 with 30m resolution. The data contained nominal data and categories of the change were directly assigned a value between 0-100 depending on the relationship between the change and the perceived importance of supporting livelihoods and the health of water resources. For instance, changes from vegetated categories in bare land were assigned 100 representing most sensitive categories (due to the perceived sensitivity of open soil to erosion, high evaporative capacity and lack of sufficient soil moisture and organic matter to support vegetation or crop growth) while Forested areas were assigned a value of 0.

Land productivity: Land productivity dynamic is a continuous variable, which represents land cover through vegetation density and vigor. Land productivity can indicate the land's ability to support and sustain life and is useful for identifying land degradation. Data for this indicator was acquired from the Joint Research Center (JRC) for the year 2014. It has five classes, i.e. Declining productivity, early signs of decline Stable, but stressed, Stable, not stressed and increasing productivity. It has a pixel size of 0.0027777777 by 0.0027777777 degrees, the data were then resampled to 0.01 degrees mapping unit.

Malaria prevalence: This refers to the Malaria endemicity index. It was acquired from the Malaria Atlas project (2010). It is all about the spatial distribution of Plasmodium falciparum malaria endemicity. The data were collected in the year 2010 globally. The tabular data set was converted to a 0.01 raster resolution-mapping unit and later subset to Chalinze boundary extent using the ArcGIS Extract by Mask tool. The malaria endemicity index for Chalinze district is 12 and 23 as minimum and maximum values respectively

Poverty: The Poverty indicator in terms of Poverty index (%) i.e., persons living below USD 2/day, was acquired from the National Bureau of Statistics (NBS) for the year 2016. The raster dataset of the poverty index was derived from the Water Resources Integration Development Initiative (WARIDI) under Climate change vulnerability mapping. The maximum and minimum values were 0.85 and 0.19 respectively.

Organic soil carbon: Soil organic matter is generally associated with higher crop yields and greater soil moisture retention, thus making areas with higher soil organic matter more resilient to climate variability and change. Data were derived from SoilGrids250m (Dec 2016 version) and IPCC (2006) Tier I methodologies for compiling National Greenhouse Gas Inventories with the pixel resolution of 0.0027777777 degrees. Extraction of data for Chalinze district was done in ArcGIS software and then resampled to 0.01 degrees pixel resolution as the mapping unit. Chalinze has a Soil Organic value of 2 to 30 tons per hectare.

Population density: Population for Chalinze district council was obtained from the National Bureau of statistics from Population and housing census 2012 at the village level. The population density per village was calculated by dividing the total population by area. The maximum density value was 771.269 and minimum value 2.61896. The data were then converted to raster format with a resolution of 0.01 degrees pixel size.

Access to improved water sources: Access to water for domestics use data were obtained from the water department at the Chalinze district council. These data were in point form showing the distribution of water points within the district council. These data were then integrated into GIS by calculating the Euclidian distance from the water point where a low and high value signifies high and poor access to water services respectively.

Access to markets: An extensive literature shows that road networks and market accessibility play an important role in development and access to health care and other social services. Greater spatial isolation is assumed to produce higher sensitivity to climate stressors. It is computed using a cost-distance algorithm that computes the "cost" (in units of time) of travelling between two locations on a regular raster grid. The raster grid cells contain values that represent the cost required to travel across them; hence, this raster grid is often termed a friction-surface. The friction-surface contains information on the transport network as well as environmental and political factors that affect travel times between locations. The data were acquired from the Joint Research Center (JRC) World travels time map for the year 2015. Clipping was done in ArcGIS software to get the Access to market data for Chalinze. The output indicates the maximum value is 981 and minimum value of 21.

Access to health facilities: Data for access to health services was obtained from the health department Chalinze district council. The data were in point form showing the distribution of health facilities, including dispensaries, health centres and hospital within the district council. The data were then integrated into GIS by calculating the Euclidean distance from the health facility, whereby low and high values signify high and poor access to health services respectively.

2.3 Data analysis

In order to analyze the collected data, a SERVIR (2017) methodology was adopted. Generally, a percentile version of the raw data was created, maintaining the original data distribution. The temporal reference for the baseline vulnerability mapping is the year 2010, though individual indicators are base-lined between the years 2000 and 2015. Several indicators had highly skewed distributions on the raw data, such data layer includes the location of health facilities, average annual precipitation, temperature, land productivity, population, and access to clean water. In this case, guided scientific decision was required in processing a number of these indicators, including development of continuous surfaces for two-point data sets (population and health infrastructure). The main procedures include converting all the original (raw) spatial data layers into grids, Inverting and Rescaling of indicators and Development of composite component indices and overall vulnerability map.

All the original (raw) spatial data layers were converted into grids at a common 30 arc-second (approximately 1 sq. km) resolution. This grid cell size was chosen because it was the highest-resolution, in which the data sets could achieve a better representation of spatial variability. Most data were in raster format except for the location of health facilities, land productivity, land cover land-use change and population. Prior to conversion, grids were converted to tabular comma-separated values (CSV) - format files using a common grid referencing system. Regular grids (fishnet) size of 0.01 degrees were created and used to extract values from the raster files of indicators. All data transformations and aggregations were performed in the R- statistical package and the data were re-exported to ArcGIS for mapping.

Each indicator under the assessment had its value attributed either low or high. Underthese circumstances, an indicator with high value in the raw data indicated low vulnerability and vice versa. Data such as rainfall (exposure), soil organic carbon (sensitivity) and location of health centers (adaptive capacity) indicates low vulnerability despite its high value. All indicators were given equal weights, assuming that all indicators have an equal contribution to vulnerability in Chalinze District Council. The development of aggregate indices required rescaling of the raw data values on a 0-100 scale, where 0 equates to lower vulnerability and 100 equate to high vulnerability. Indicators were then averaged to produce indicator maps for exposure, sensitivity, and adaptive capacity. The adaptive capacity was changed to “lack of adaptive capacity” for the mapping in order to retain the standard meaning across all indicators, in which higher values equate to high vulnerability.

Since the ranges of scores in the resulting indicators significantly varied, the resulting indicator scores were rescaled so that they range from 0 to 100, to give proper inclusion of data. The three indicators (exposure, sensitivity and lack of adaptive capacity) were averaged to create an overall vulnerability map. Indicator scores 0 equates to lower vulnerability and 100 equates to high vulnerability.

3. RESULTS

3.1 Exposure Component

The exposure indicators as presented in figure 3 included rainfall trends, maximum temperature trends, land productivity and flood frequency. The results showed that, categorized under high exposure, where those areas characterized by declining rainfall trends, an increasing trend in maximum temperature and increasing flood frequencies (Figure 3). Apparently, the analysis showed that the central parts of Chalinze District Council area is highly exposed to the associated climate change impacts. Specifically, Kimange, Msata, Talawanda and Miono wards fall under this category.

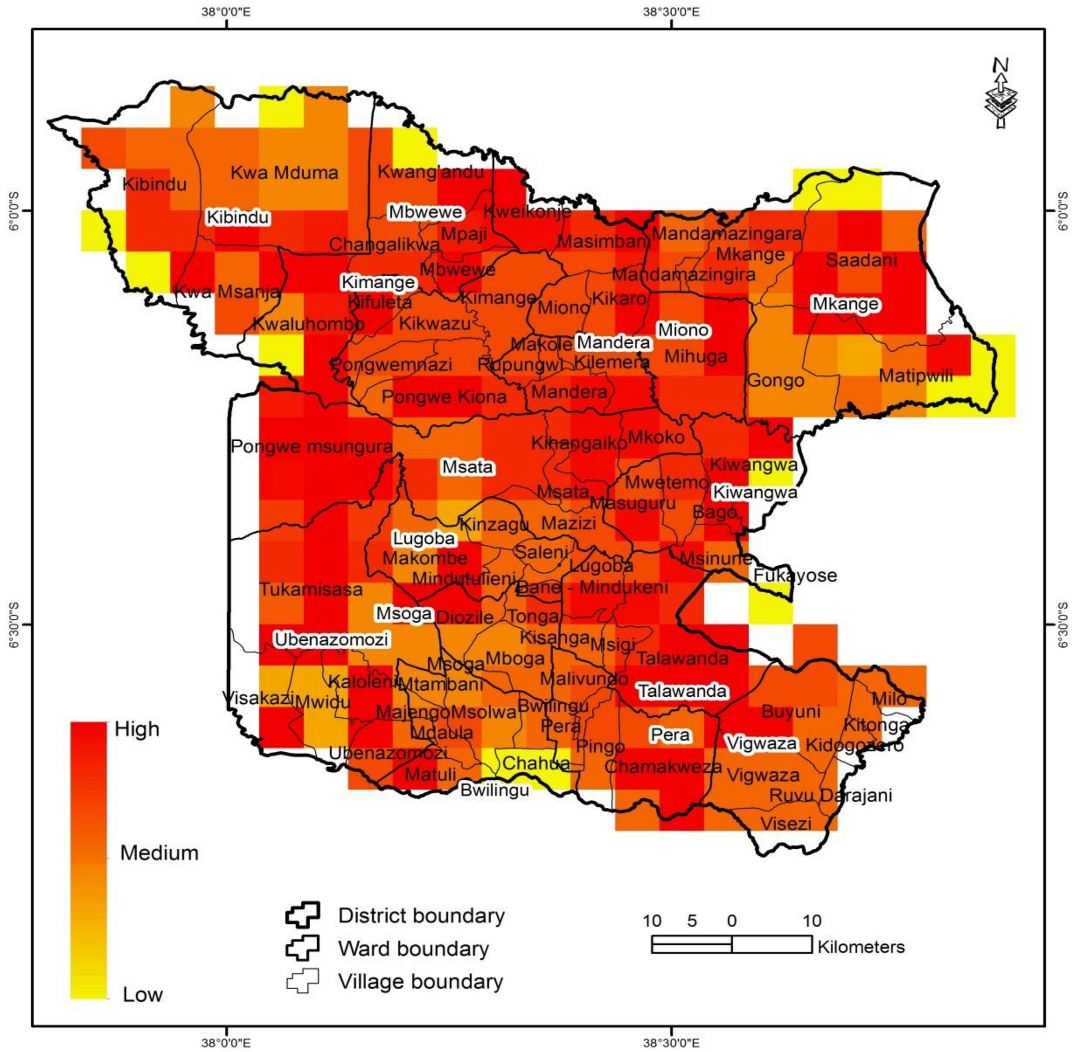

Figure 3: Exposure Component Map

3.1.1 Trends of the Exposure Indicators

The trends of the main exposure indicators including rainfall, maximum temperature and flood frequency are described in figure 4. The result shows that there has been a consistent decline in rainfall and the increase in temperatures over the past 30 years, while the frequency and intensity of floods have been increasing along the Wami –Ruvu River crossing Chalinze District, especially in

Mkange, Miono and Mandera wards.

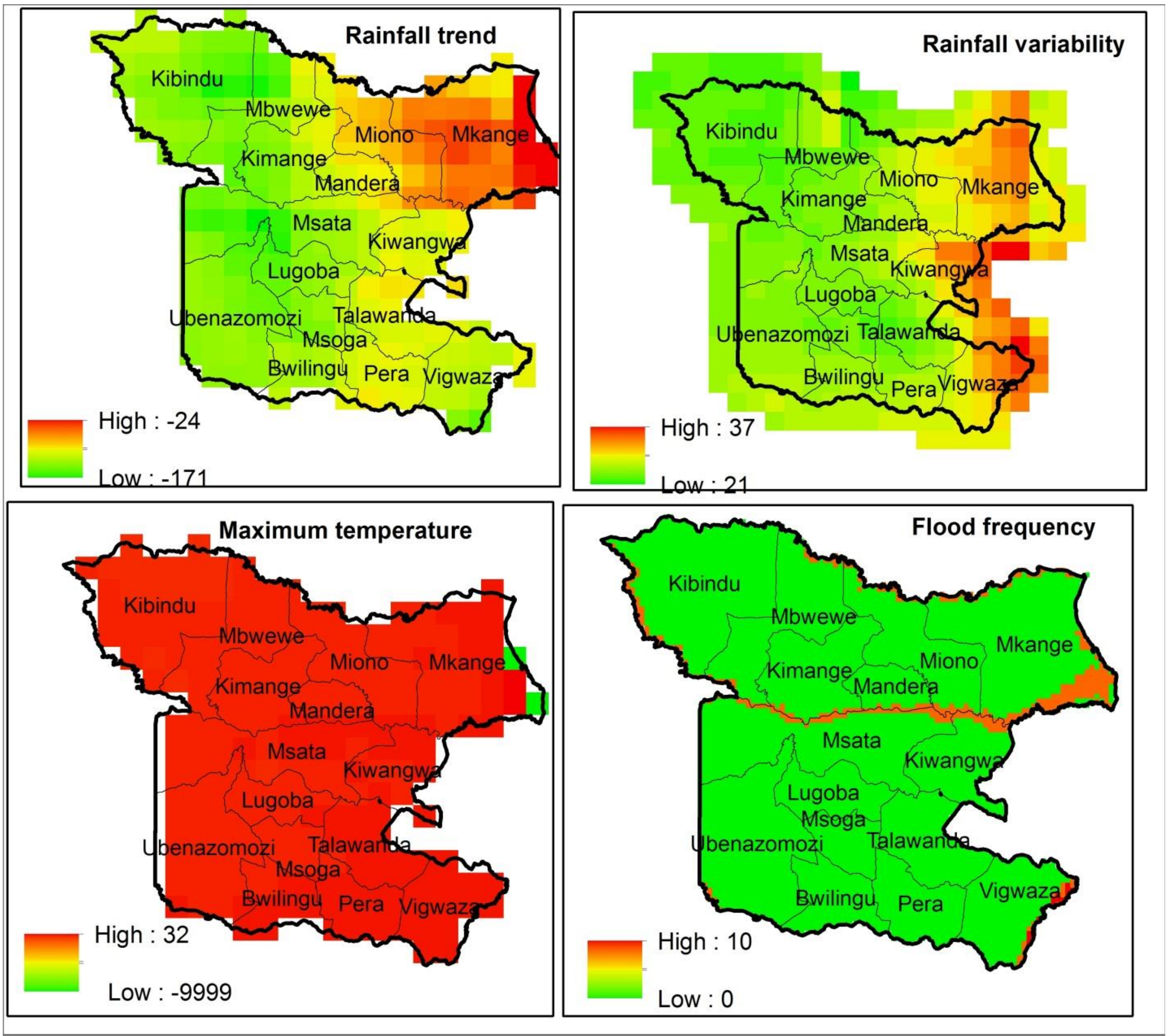

Figure 4: Spatial representation of the trend in Exposure Indicators

3.2 Sensitivity Component

The analysis of sensitivity component considered population density, malaria prevalence, income, poverty, soil organic carbon land use/ land cover change, and land productivity indicators. In general terms, the results indicate that the most sensitive areas have been and are those areas located in Msata and Ubena zomozi wards and some villages in Talawanda, Pera, Vigwaza and Mkange wards (Figure 5).

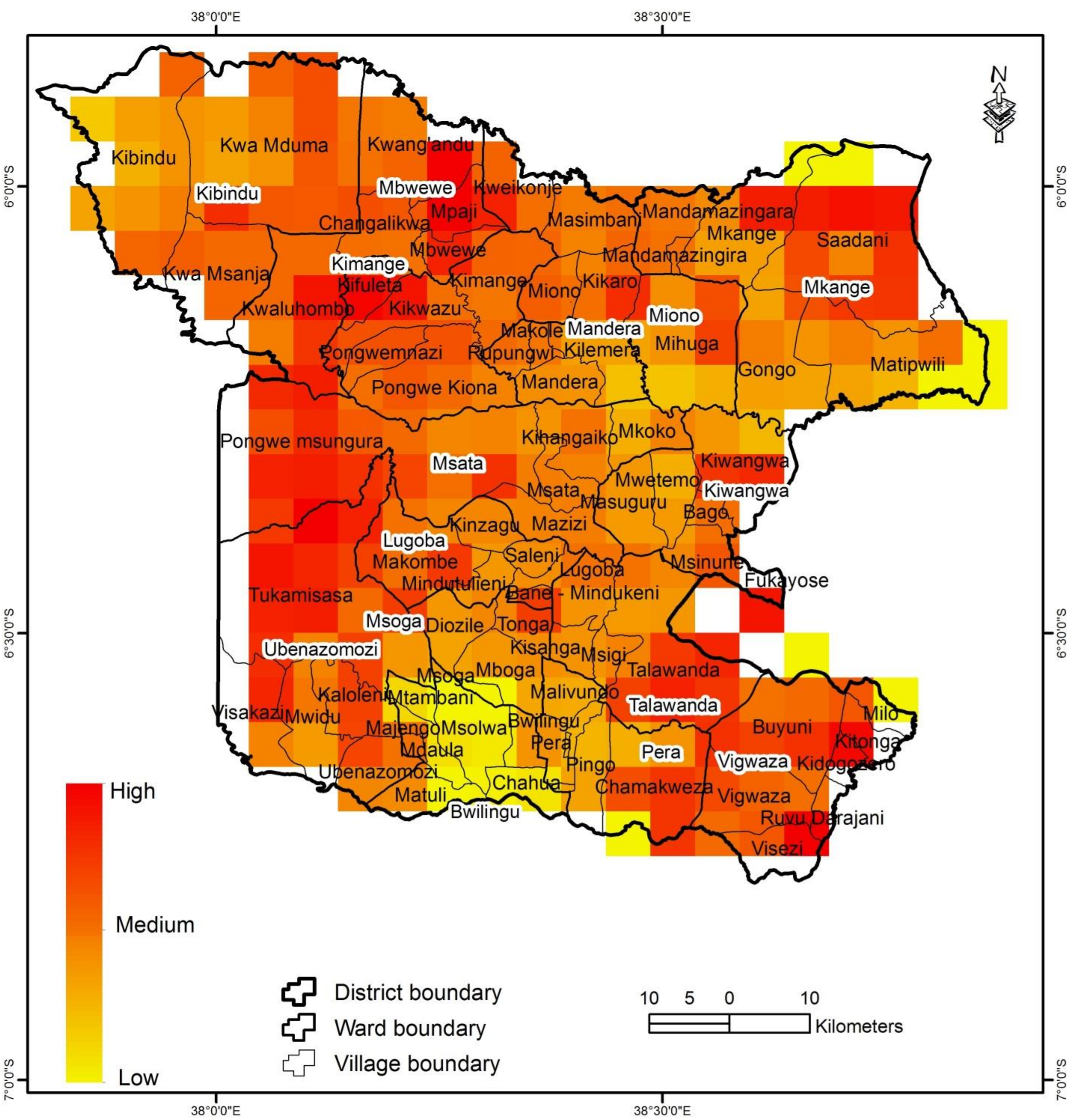

Figure 5: Spatial representation of Sensitivity levels

3.2.1 Detailed characterization of Sensitivity Indicators

The main indicators used in characterizing sensitivity levels include population, poverty, soil organic carbon, malaria prevalence, land cover/use change and land productivity. Specific maps have been presentedin Figure 6. The results indicate that high population density areas were located in villages found at Msoga, Mbwewe, Bwilingu and Lugoba wards. **Poverty** was high in villages located at Ubena Zomozi and Kibindu wards**.**

Soil organic carbon was mainly low on the eastern part of the district, covering villages found in

Mkange and Vigwaza wards. The central part, on the other hand, indicated high soil organic carbon. Malaria prevalence was higher in Mkange and Vigwaza wards followed by Ubena zomozi, Talawanda, Pera and Bwilingu. Villages in Kibindu ward had the least cases of malaria. The result indicates that the most highly affected areas are those found along the Wami and Ruvu river basins. Land cover and land-use change were mainly influenced by human economic activities such as sand and stone mining; and deforestation for charcoal making and expansion of agricultural lands. The moderately affected wards were Mbwewe, Ubenazomozi, Kimange, Lugoba, Msata, Miono and Vigwaza.

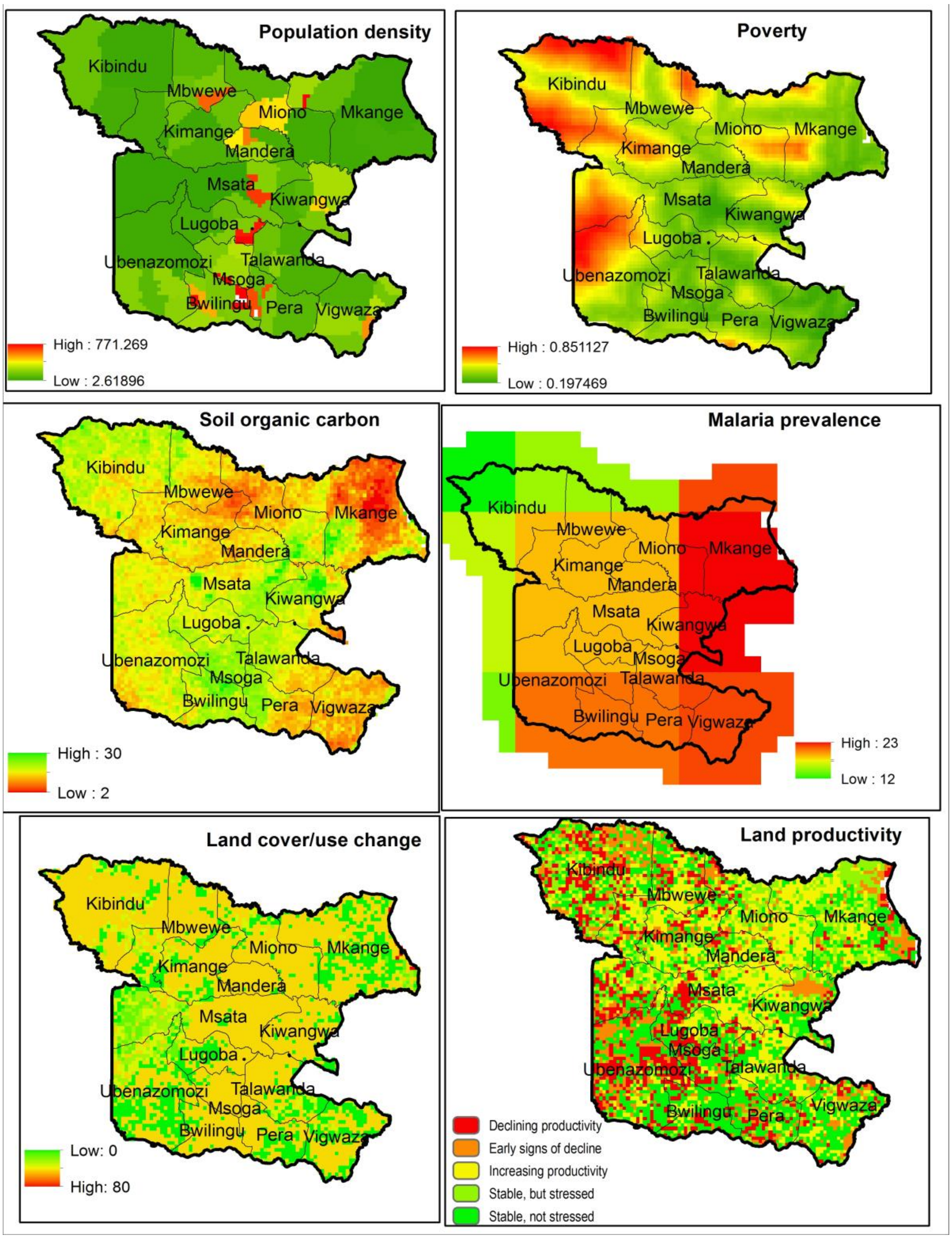

Figure 6: Sensitivity Indictor Maps

3.3 Adaptive Capacity Component

Three indicators related to adaptive capacity were used in this assessment. The indicators included access to improved water sources, access to markets and access to health facilities (Figure 7). Two wards of Bwilingu and Mandera had a higher adaptive capacity compared to the rest of the wards in the district.

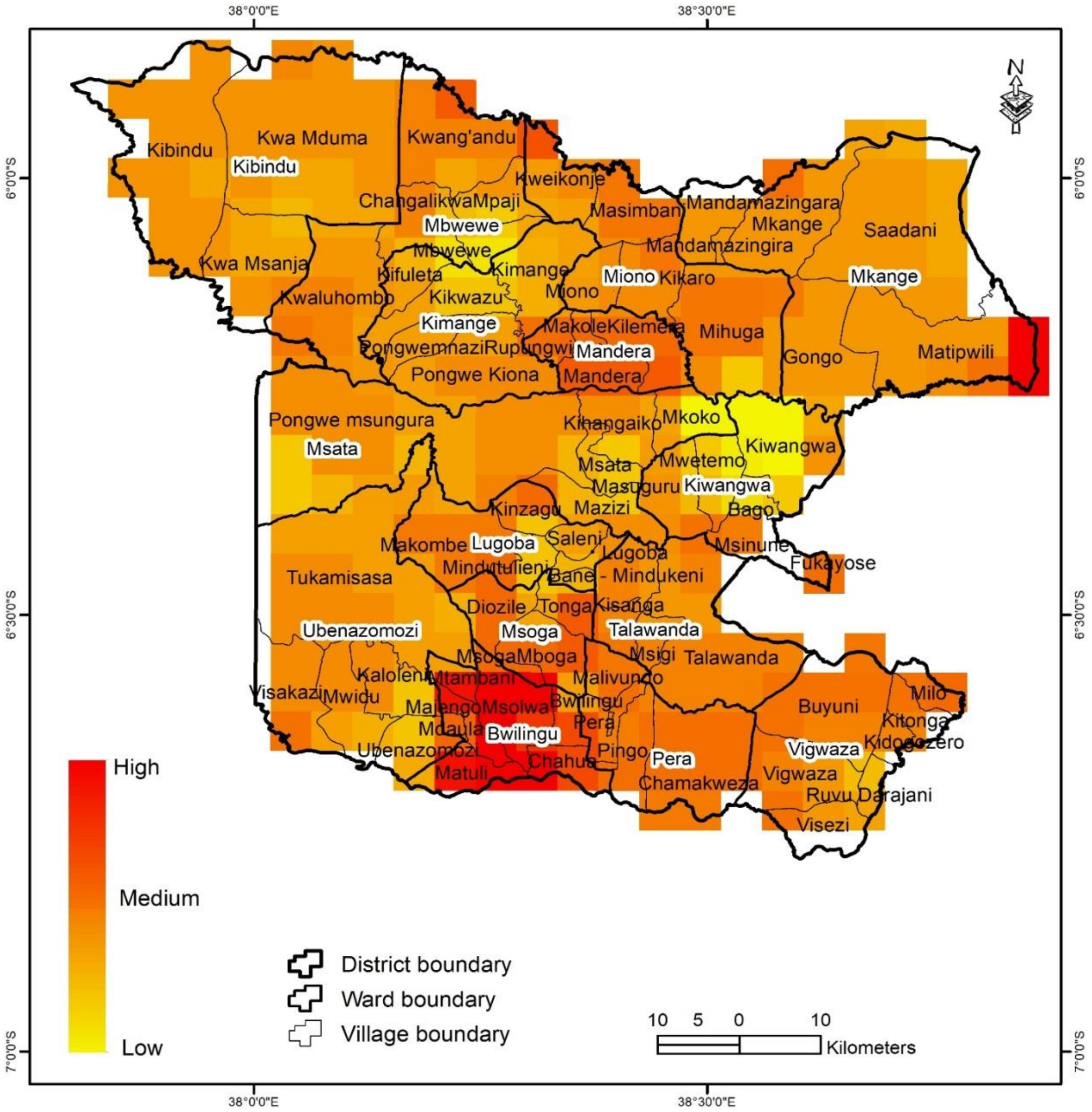

Figure 7: Spatial representation of the different levels of Adaptive Capacity.

3.3.1 Adaptive Capacity Indicators

This section provides the detailed assessment result of adaptive capacity component indicators (Figure 8), which include; access to markets, water and health services as follows:

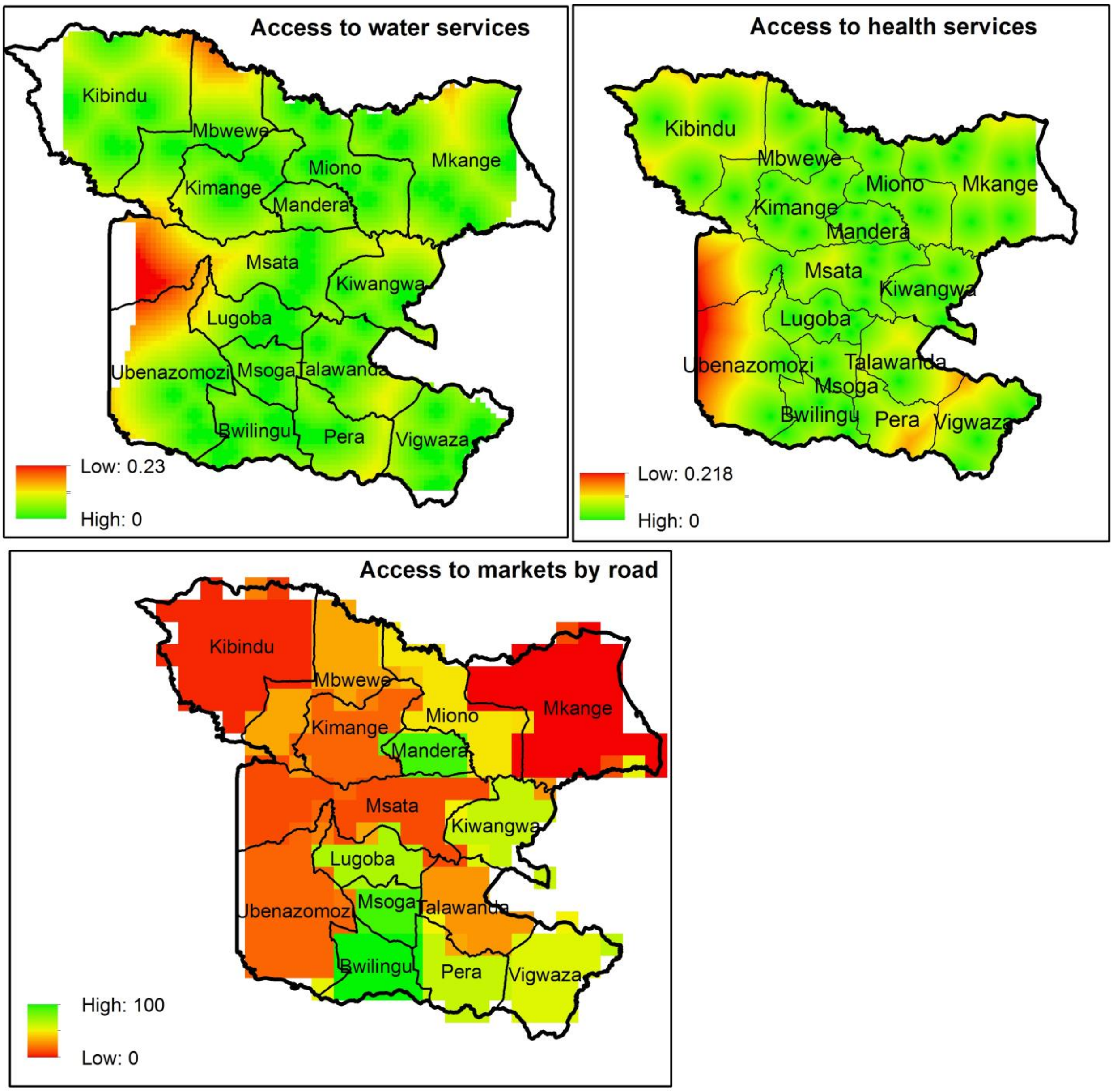

Figure 8: Adaptive Capacity Indicator Maps

With regard to access to markets, the assessment has considered the distribution of road infrastructure that facilitates communities' access to and time spent to access markets available in the CDC. On the other hand, access to health facilities and water services has considered the distribution of such services in the CDC and the way they can be accessed/reached. This approach is also articulated in similar studies on climate change vulnerability impact assessment conducted in Tanzania and Mali (MALI, 2014; WARIDI, 2017). With regard to accessing the markets, the assessment indicates that areas with low adaptive capacity are; Kibindu and Mkange wards and some villages in Msata and Ubenazomozi wards.

Water accessibility assessment shows that CDC is fairly supplied with water for domestic use through the piped Wami River water scheme under the Chalinze Water Supply and Sanitation Authority (CHALIWASA) and the boreholes. Areas of Ubenazomozi ward in the western part of CDC, the western parts of Msata ward, Kiwangwa ward and Talawanda wards in the eastern parts, as well as Kibindu wards, Mkange and Mbwewe wards in the northern parts, are faced with limited access to water.

Assessment results, on **access to health services,** indicated that, most of the communities in the CDC access health services from dispensaries, health centers, and district hospital, which accounts for 89%, 9%, and 2% respectively. It is worth noting that, these health service facilities are owned by the government, faith-based organisations and individuals/ institutions. Unfortunately, most wards, which depicted inadequacy of water supply, have exhibited a similar situation with regard to the distribution of health services. These wards include Ubenazomozi, Msata, Talawanda, Kibindu, Mkange and Mbwewe wards.

3.4 Overall Vulnerability

The overall vulnerability was determined through averaging of the rescaled values from exposure, sensitivity, and lack of adaptive capacity indicators. The overall vulnerability assessment indicates that some parts of Chalinze District Council wards exhibit a significant degree of vulnerability; with Talawanda and Kimange wards being the most vulnerable. However, there are several villages in the CDC, which are also portraying similar nature of severe vulnerabilities as shown under Figure 9. On the other hand, some villages in Bwilingu, Msoga, Kiwangwa and Kibindu wards are considered to be least vulnerable to the impacts of climate change as per the assessed vulnerability indicators.

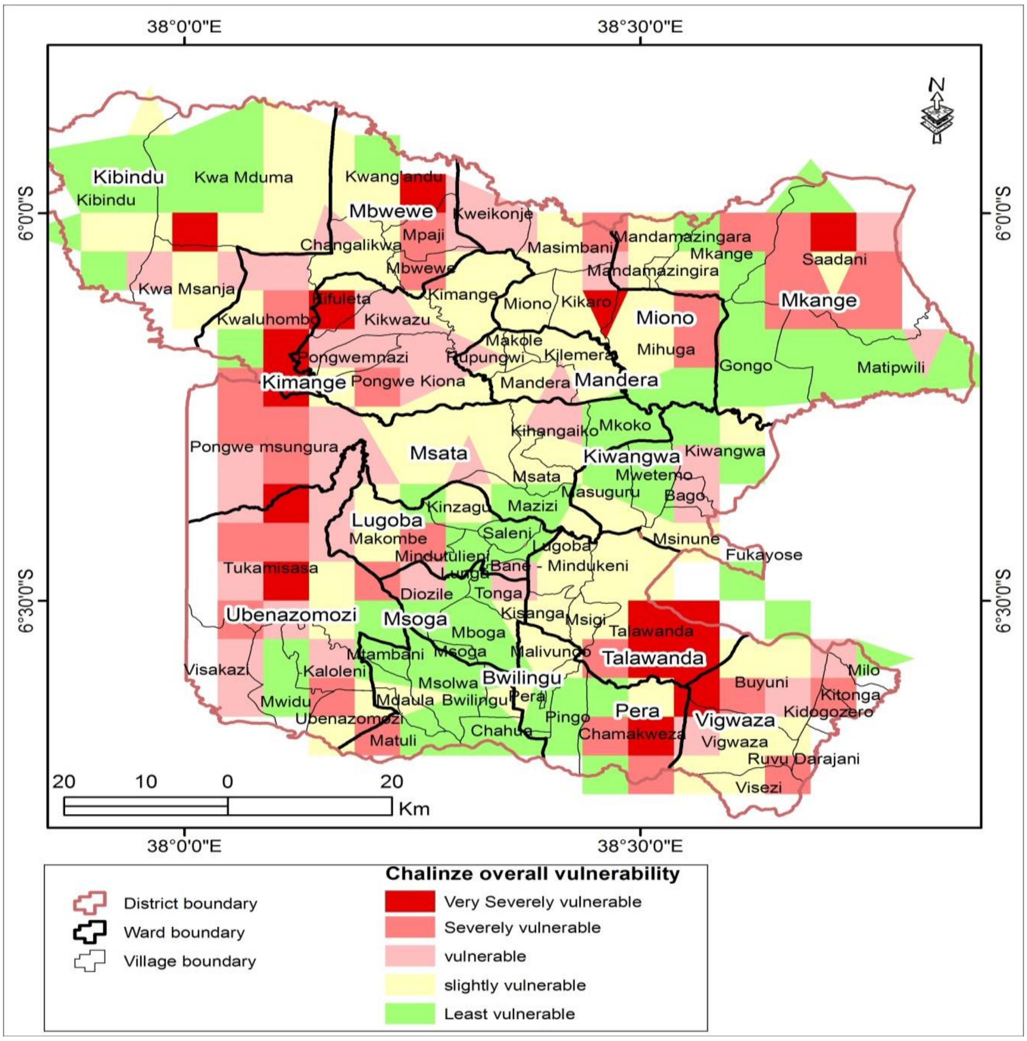

Figure 9: Overall Vulnerability Map.

4. DISCUSSIONS

This section provides a discussion in relation to the findings presented in section 3. The main focus of the discussion is on the vulnerability components (exposure, sensitivity and adaptive capacity) and the overall vulnerability assessment results.

4.1 Exposure Component

The results from trend analysis have indicated the declining rainfall trends across the study area. These results are consistent with the observed rainfall trends in most parts of the country and across the region (Kahimba et al., 2015; Muzuka et al., 2015; IPCC, 2018; Irish Aid, 2018). As it is in most part of the world and in most parts of the country the declining rainfall trends are normally not statistically significant highlighting the major uncertainties associated with rainfall analysis and even projection. Considering the facts that majority of the people relies on rain-fed agriculture for their livelihoods, the declining rainfall trends have severe socio-economic and even ecological consequences (Kahimba et al., 2015; Gwambene, 2017; Irish Aid, 2018). This decline in rainfall has negatively impacted various communities' livelihood systems as well as compromised economic development of the district council (Gwambene and Karata, 2019). According to the stakeholders consulted, the declining rainfall trend has negatively impacted water availability, survival of livestock, agricultural productivity and the base of the general ecosystem. There has been frequent food support from the government and other development partners in the district, due to inadequate productivity attributed to inadequate rainfall.

The trends analysis on maximum temperature data sets clearly depicts increasing trends across the district. This increasing temperature trend is widespread across the country and is in most cases statistically significance underlying the robustness, certainties and confidence in the observed trends, which is also consistent with the global patterns (IPCC, 2018). However, during stakeholder's consultation, it was noted that there were some different perspectives on the rate and severity of temperature trends depending on topography and altitude of a location. The presence of Sadani Nature Forest Reserve in the eastern part and Zigua mountain forests in the western parts of the Council contributes to relatively cooler temperatures as compared to the lowlands. It was also noted, the impacts from increasing temperature and decreasing rainfall are much compounded by recurring severe droughts, which cause severe socio-economic impacts (For instance, in 2014, most of the villages suffered massive water shortages due to drought leading to death of livestock, crop failures and decline of water sources.

As noted in the results section, the frequency of flood is increasing so are the impacts. This observation is consistent with the latest findings from the Intergovernmental Panel on Climate Change (IPCC, 2014, 2018, 2019), which indicates that, on a global scale, the frequency and intensity of heavy precipitation which normally leads to flooding are observed to increase. The studies by Kahimba et al (2015); Gwambene and Karata (2019) revealed changes in climate patterns denoted by rising of maximum and minimum temperatures, increased variability of rainfall, and increased frequency and severity of extreme events. These studies indicate that the onset and cessation of rainy seasons are highly variable and fluctuating and posse significant impacts on rural livelihoods. Such changes are projected to increase further, especially in tropical areas including in most parts of Tanzania and East Africa (Irish Aid, 2018). Floods and droughts are the leading climate extremes responsible for the majority of the natural disaster s globally and across the region.

4.2 Sensitivity Component

The assessment indicated that the most sensitive areas include Msata and Ubena Zomozi wards. Higher sensitivity is attributed to a combination of factors including high population density; low land productivity, poverty coupled with a sustained increase in malaria prevalence. Increase in malaria prevalence is triggered by changes in climate patterns and proximity of the respective areas to mosquito breeding sites. The observed increase in malaria prevalence is consistent with the general trends in most parts of the country, whereby due to increase in temperature, even places where there was no significant problem of malaria are now becoming malaria prevalent. Shemsanga, et al (2010) noted that malaria is the most important public health concern in Tanzania, especially so in children under five years of age and among pregnant women.

The observed high population density and high-income poverty are also compounded by increased climate variability and changes in climate system which severely affects livelihoods activities, particularly in rural settings whereby majority of local communities depend on natural resources and rain-fed agricultural activities for their livelihoods. This is evident from the observed widespread declining trends of rainfall and increasing trend of temperature. The sensitivity is much further compounded by the struggle of the local communities to explore natural resources, including charcoal making, expansion of agricultural areas, sand and stone mining in an attempt to reduce income poverty (Gwambene and Karata, 2019). Unfortunately, these lead to increasing land cover change and increasing rate of deforestation and ultimately leading to aggravating the sensitivity indicators.

The observed decline in land productivity is attributed to the changes in the climate system including environmental degradation. The production and productivity of crops such as maize have been noted to decline due to declining rainfall trends and increasing temperature, which triggers enhanced evapotranspiration and thus depriving moisture availability for crop growth. Unfortunately, the future model's scenario indicates further negative impacts on food security on a global scale and particularly in low latitudes. The latest assessment report from IPCC indicates that all four pillars of food security including Availability, Accessibility, Utility and Stability will significantly affected by climate change (IPCC, 2019). These will have consequential implications to livelihoods and socio-economic development especially, for local communities such as Chalinze.

4.3 Adaptive Capacity Component

In addressing the challenges of climate change, Adaptation is a major priority for Tanzania, Africa and most of the developing countries. The focus of this study was to assess potential vulnerability indicators in Chalinze District Council. Like in most part of the countries the area has already experienced impacts of climatic changes due to a weak economy and low adaptive capacity (Excellensia Consulting, 2010).

This study used adaptive capacity component indicators which include; access to markets, water and health services to assess the community adaptive capacity. The results indicated that infrastructure facilities such as communication and services (access to market, hearth, and water) are important in improving adaptive capacity. The area with low adaptive capacity were those with poor access to the markets, limited access to water and have exhibited a similar situation with regard to the distribution of health services. Therefore, the results from this assessment are consistent with regional and national patterns as most of the wards are characterized with medium to low adaptive capacity in relation to the three assessed indicators (Access to water, market and health facilities). Also the results are in line with other studies who discussed on vulnerability and adaptation capacity (Excellensia Consulting, 2010; Hepworth, 2010; Muzuka et al., 2015 and Gwambene, 2018). The results from this assessment provide a very important observation that coordinated efforts need to be employed to enhance adaptive capacity with the view of maximizing benefits.

4.4 Overall Vulnerability

The overall vulnerability characterizes the propensity or predisposition to be adversely affected by the impacts of climate change. In the assessment of the overall vulnerability, five categories or levels were used in this study. The categories of vulnerability included: least vulnerable, slightly vulnerable, vulnerable, very vulnerable and extremely vulnerable. Comparatively, developing countries including most of the African countries, Tanzania inclusive are considered to be very vulnerable to the impacts of climate change due to a combination of factors including low adaptive capacities, exposure and high sensitivity to climate change (SERVIR, 2017; Irish Aid, 2018).

In this study, some of the villages in Msoga and Kibindu wards have been quantified with least vulnerability compared to other villages in Talawanda and Kimange wards, which are characterized as very vulnerable to the impacts of climate change. Nature and extent of vulnerabilities also depends on the nature of climate change impacts such as floods, droughts and strong winds. Such observed results are in line with other climate change impacts and adaptation studies (Shemsanga et al., 2010; Kahimba et al., 2015; Gwambene, 2018). These studies further discussed on the impact of climate variability, environmental changes and locally specific vulnerability that are hard to predict.

The least vulnerable villages have been observed to experience better social services, improved economic activities and productive lands compared to other villages. Assessment of climate change vulnerability is thus very critical for designing and implementing effective adaptation strategies and can also provide valuable contributions to the planning and development of various socio-economic activities at districts such as Chalinze.

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

This vulnerability assessment and hotspot mapping is an essential exercise for informed climate change adaptation intervention in Chalinze District Council. It is also an important tool for informed climate change adaptation planning, policy formulations and decision-making process across levels and scales. The assessment can assist planners to make useful and crucial decisions for appropriate and right interventions for the socio-economic development in the context of a changing climate. The set up the GIS - the database will assist in attracting funding and another technical assistance from interested individuals and organisations within and outside the country and hence enables the council to achieve its set vision and mission.

5.2 Recommendation

It is highly recommended for the district to consider having strategies for enhancing observation and monitoring capacity of climate by enhancing observing networks, particularly of rainfall and temperature by installing appropriate meteorological instruments in Chalinze district and link with the national designated authority, the Tanzania Meteorological Authority for sustainability.

It is essential for government and other stockholders including development partners to promote livelihoods diversifications across the districts to relieve pressure on the environment and natural resources. This will help to reduce community vulnerability and upset impacts of climate change environmental degradation.

There is a need for conducting CDC vulnerability awareness raising and capacity building sessions with stakeholders across levels and scale to enhance understanding of the current situation and stimulate usage of the report findings in decision making at various levels. This need to include facilitating regular detailed assessment of each component after 5-10 years to help understand how the situation has been changing across various indicators. Alongside, the use of the research findings at all levels should be promoted to increase community and other stakeholder awareness thus, ameliorate the negative impact and reduce vulnerability components.

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Conflict of interests

The authors declare no conflict of interest.

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