MINISTRY OF FORESTRY AND NATURAL RESOURCES AND CLIMATE CHANGE

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

Climate Risk Maps
Chikwawa District

December 2022

The page is intentionally left blank……

TABLE OF CONTENTS

1. Introduction

a. Geographical position of Chikwawa District

Chikwawa district is located in the southern region of Malawi. Its total land area is 4892km^2 (489,769 ha) which is about 15% of the total of southern region and 5.04% of the Malawi surface area (Chikwawa district physical development planning). The district has a population of about 564,684 (National Statistical Office, 2019) that spread in eleven traditional authorities (TAs) and these are Kasisi, Chapananga, Katunga, Maseya, Lundu, Makhwira, Mililima, Ndakwera, Ngokwe, Masache and Ngabu. Chikwawa has a farming community and the main cash crops grown are cotton, maize, millet, sorghum, rice, sweet potatoes, beans, soya beans and pulses. The district also contains sugarcane plantations along the Shire River. Chikwawa district is also famous for livestock farming (cattle stocking communities) that supply meat to most parts of Malawi. Most of the farming activities that take place in uplands rely on rain during summer while areas along the river banks also cultivate during winter. Malawi's electricity is hydro-based and some of the hydropower stations are also located in district along the Shire River. The other economic activity in the district is fishing mainly on Shire River. The Lengwe National Park and Majete Game reserve are the protected areas found in this district. Chikwawa shares borders with Mozambique both to the east and to the west, Figure 1.

b. Climate and common hazards in Chikwawa District

Chikwawa district is generally hot and dry between September and November where temperatures vary from around 20°C (minimum) to 35°C (maximum) but can go beyond 42°C in November. The mean annual temperature is around 30°C. Being in the valley, Chikwawa district frequently experiences severe floods and some of the worst floods occurred in January 2015, March 2019, January 2022 and March 2022 (GOM, 2015; GOM 2019). For example, 2019 floods that came due to tropical cyclone Idai resulted to losses and damages of about USD25 million (~ 25,655,125,000) and the district was ranked the third worst hit (GOM, 2019). However, the district is also prone to droughts. The prolonged dry spells during the rainfall season are also common. Over 90 percent of rainfall received in the district fall during the hot and wet season (November-April). Distribution of these seasonal rains is poor and on average ranges between 400-600mm annually.

c. Objective of the study

The objective of this project is to develop the climate risk maps for Chikwawa District. The climate risk maps in this study cover extreme rainfall, rainfall trend, heatwaves (extreme maximum and minimum temperature), dry spells, drought events and floods. Due to unavailability of daily maximum wind speed, the maps of wind hazard are not generated. The production is made based on 1981 to 2020 period.

d. Methods

The development of risk maps follows the definition below, where the **Risk** is the product of **Likelihood** and **Impact.**

Risk = Likelihood X Impact

Therefore, the analysis involves the estimation of likelihood and impact in order to generate the risk of dry spells, droughts and floods. The classification of likelihood, impact and risk as used in this project are presented in Table 1 below.

Table 1The Classification of Likelihood, Impact and Risk by colour

Likelihood	Impact	Risk
improbable	negligible	negligible
remote	low	low
occasional	moderate	medium
probable	significant	high
frequent	catastrophic	extremely high

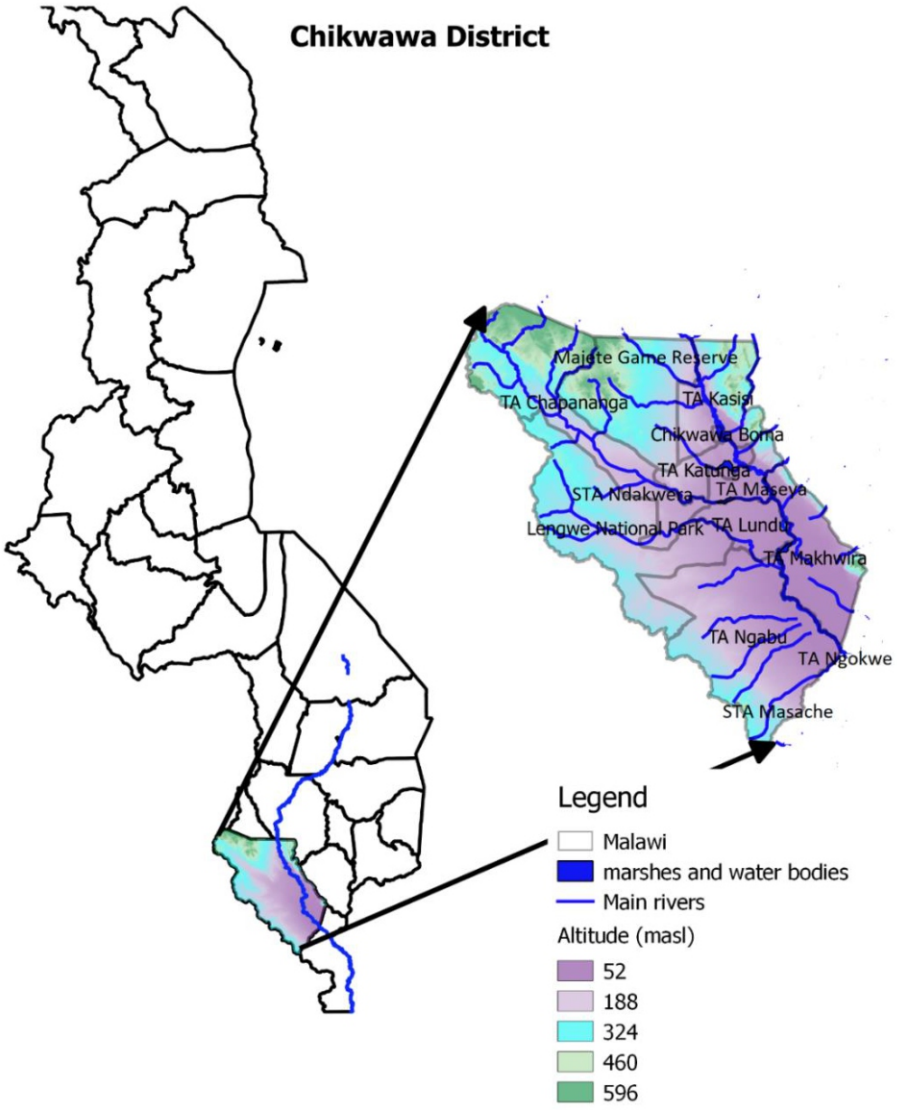

Figure 1 Chikwawa District, traditional authorities (TAs), rivers and topography

2. Climate Risk Maps

a. Rainfall trend in Chikwawa District

There is a significant reduction of rainfall in Chikwawa district during 1981-2020 period as is shown from various points sampled in the district, Fig. 2.

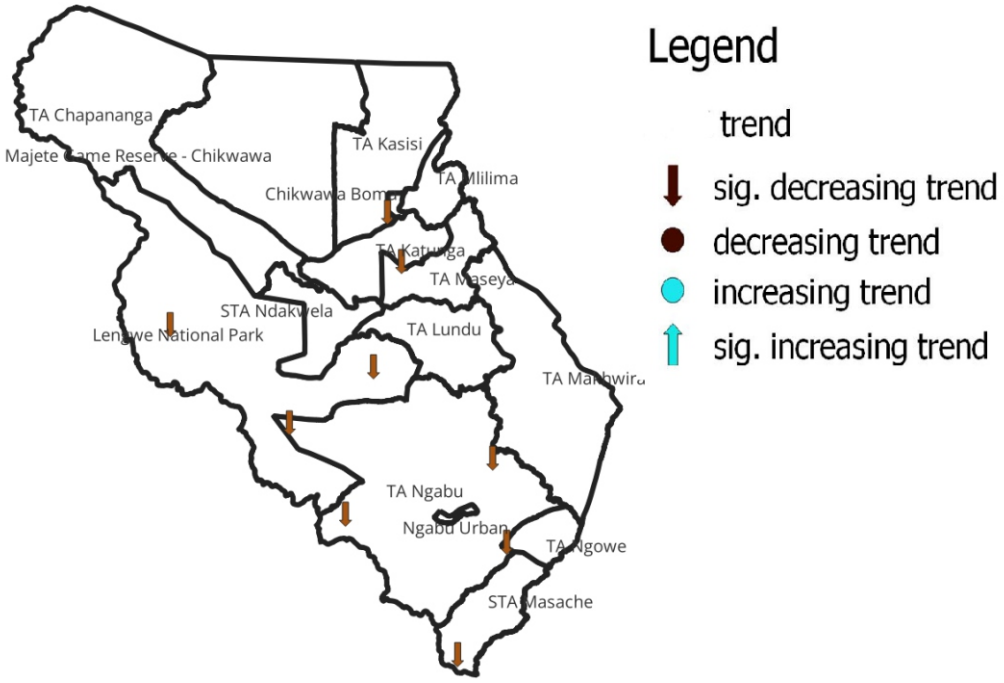

Figure 2 Rainfall trend in Chikwawa District. The significance of the trends is based on p-value < 0.05

b. Extreme rainfall

Though the rainfall is decreasing in the district, the study also analysed the extreme rainfall ever recorded in the district from 1980 to 2020. Figure 3 is a map of absolute maximum rainfall (highest ever recorded in a single day) during the rainfall season for the period 1981 to 2020 in Chikwawa. The figure shows that rainfall extremes can exceed 200mm in a day in the district. These extreme rainfalls are potential for floods in the district.

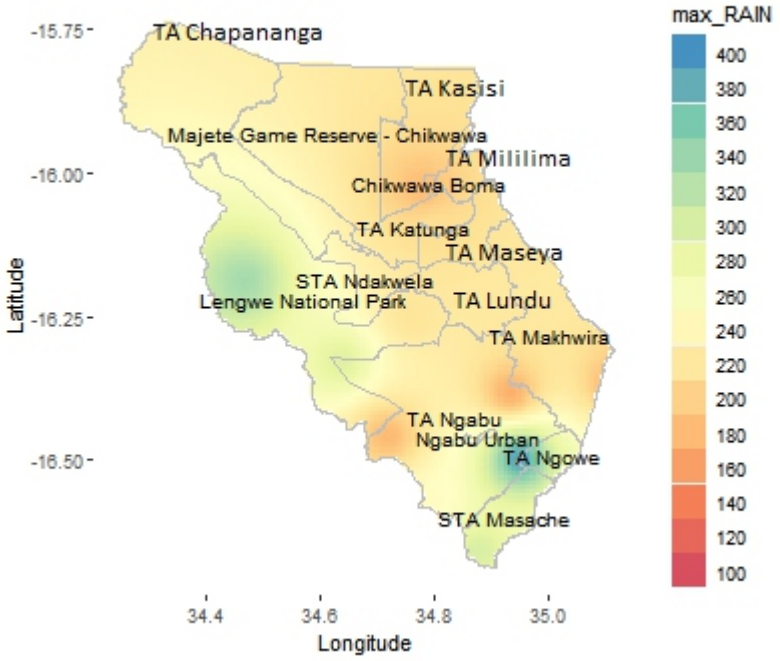

Figure 3 Absolute maximum rainfall in Chikwawa district

c. Heatwaves (high temperatures)

Chikwawa usually experiences high temperatures and heatwaves are also common in the district, especially during summer months. The heatwaves are also catalysts to drought if they are associated with low rainfall amounts.

Analysis of temperature in the district shows that heatwave severity is higher over highlands than in low lying areas. Figure 4 shows that the western parts of the district experience severe heatwaves compared to the rest of the district with parts of Lengwe National Park and TA Ngabu being the epicentre of the severity.

Severity for minimum temperature contribution to heatwave is high in TA Ngabu, parts of TA Ndakwera, TA Lundu, TA Maseya and few parts of TA Mlilima. Nonetheless, TA Ngabu still experiences severe heat as compared to all the other area in the district as shown by Figure 4.

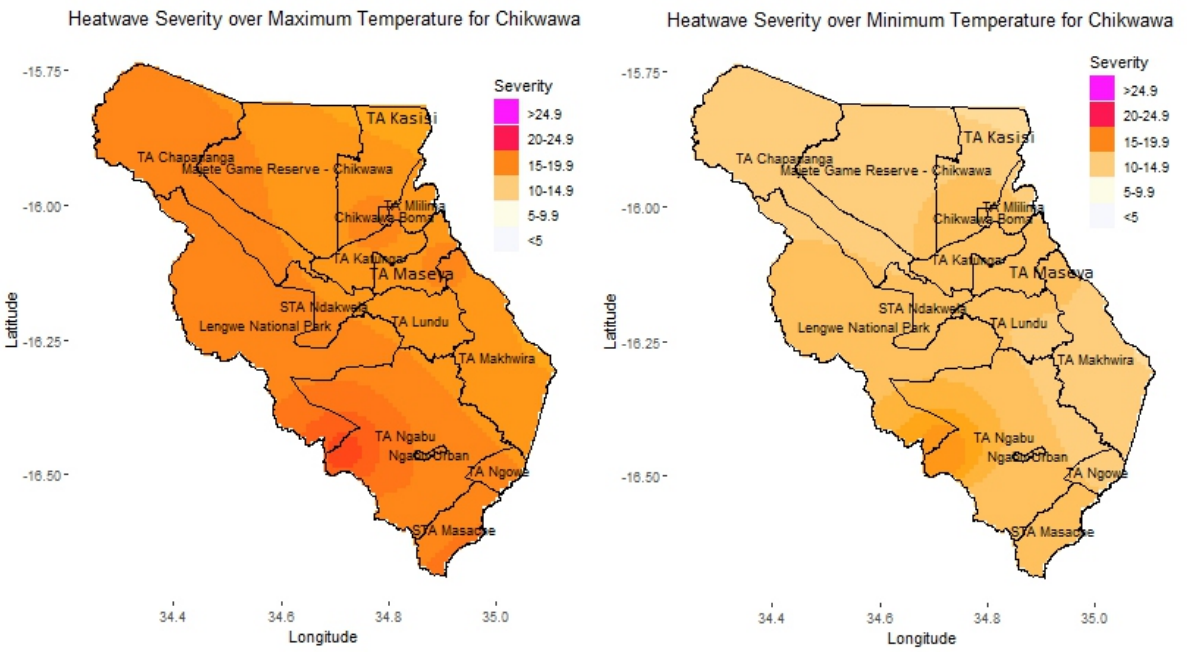

Figure 4 The heatwave based on maximum temperature (left) and minimum temperature (right)

d. Dry spells

i. Frequency of dry spells at the beginning of the season

Chikwawa district experiences dry spells at the beginning of the season as presented in Figure 5. The beginning of the season in this study refers to October-November-December (OND). The frequency of the dry spells during this period for 7-day and 14-day dry spells are presented in Figure 5a and 5b respectively from 1981-2020.

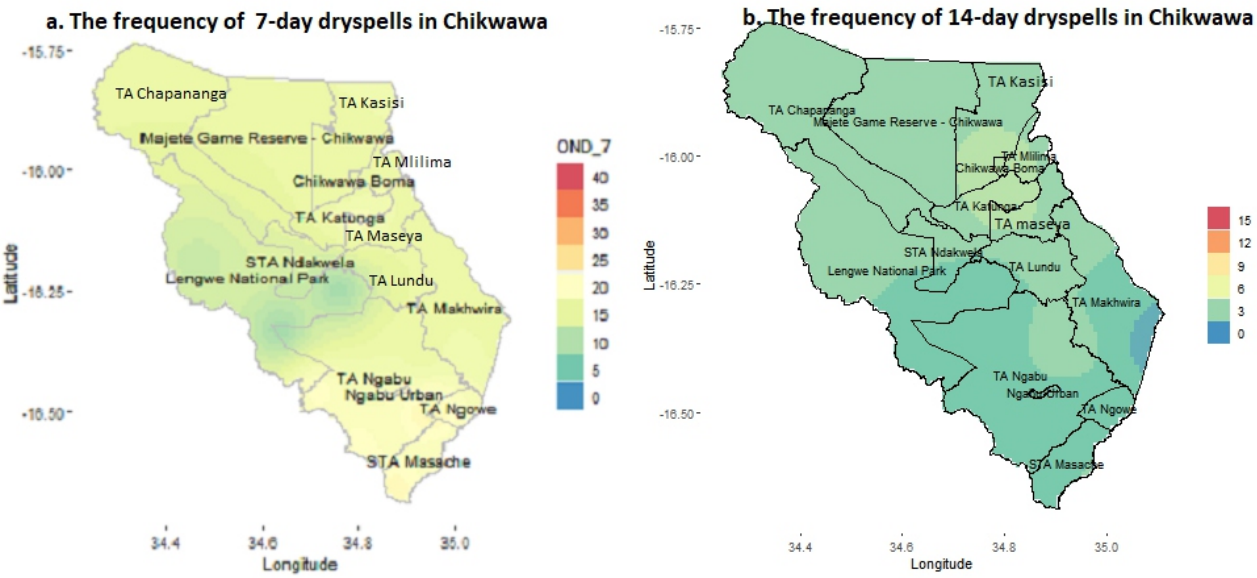

Figure 5 The number of dry spells of more than 7 days (a) and more than 14 days (b) in Chikwawa district between 1981-2020

Chikwawa district experiences dry spells at the beginning of season that is October-November-December (OND). During 1981-2020, the areas in TA Ndakwela and Lengwe National Park had dry spells between 5-10

times, while most areas in TAs Chapangana, Kasisi, Majete Game Reserve-Chikwawa, Mlilima, Katunga, Maseya, Lundu, Makhwira, Ngabu, Ngokwe and STA Masache experienced dry spells about 15-20 times, Figure 5a. The 14-day dry spells occurred 6 times in areas around TA Mlilima, Chikwawa Boma, TA Katunga and parts of TA Maseya. Other TAs which include TA Chapananga, TA Kasisi, STA Ndakwera, Lengwe National Park and TA Lundu experienced dry spells 3 times while the rest of the TAs did experience less than 3 dry spell events exceeding the 14-days during this period, Figure 5b.

ii. Frequency of dry spells during the rainy season

During the months of January-February-March (JFM), the following TAs Chapananga, Kasisi, Katunga, Maseya, Lundu, Makhuwira, Ngabu and STA Ndakwela experienced 7-day dry spells in the ranges of 20-25 times during the month of January between 1980 and 2020. In February most TAs experienced the 7-day dry spells frequency ranging from 25-30 and in March the frequency of the 7-dry dry spells range was between 30-35 in all TAs and areas around Majete Game Reserve and Lengwe National Park, Figure 6 (upper panel). The 14-day dry spells in January were experienced 3 times in TAs Chapananga, Kasisi, Katunga, Maseya, Lundu, Makhuwira, Majete Game Reserve, Chikwawa Boma and STA Masache. But higher frequencies between 6 and 9 times were observed in TA Ngabu and Lengwe National Park during this month. While during the month of February the frequency of 14-day dry spells was from 6-9 times over many places and in March the frequency range was from 9-12 times and of particular interest are areas around Lengwe National Park, south of TA Makhuwira and North East of Ngabu which experienced dry spells from 12-15 times. March has high number of dry spells compared to January and February. This could be because March is also the month the rains start to tail off, Figure 6 (lower panel).

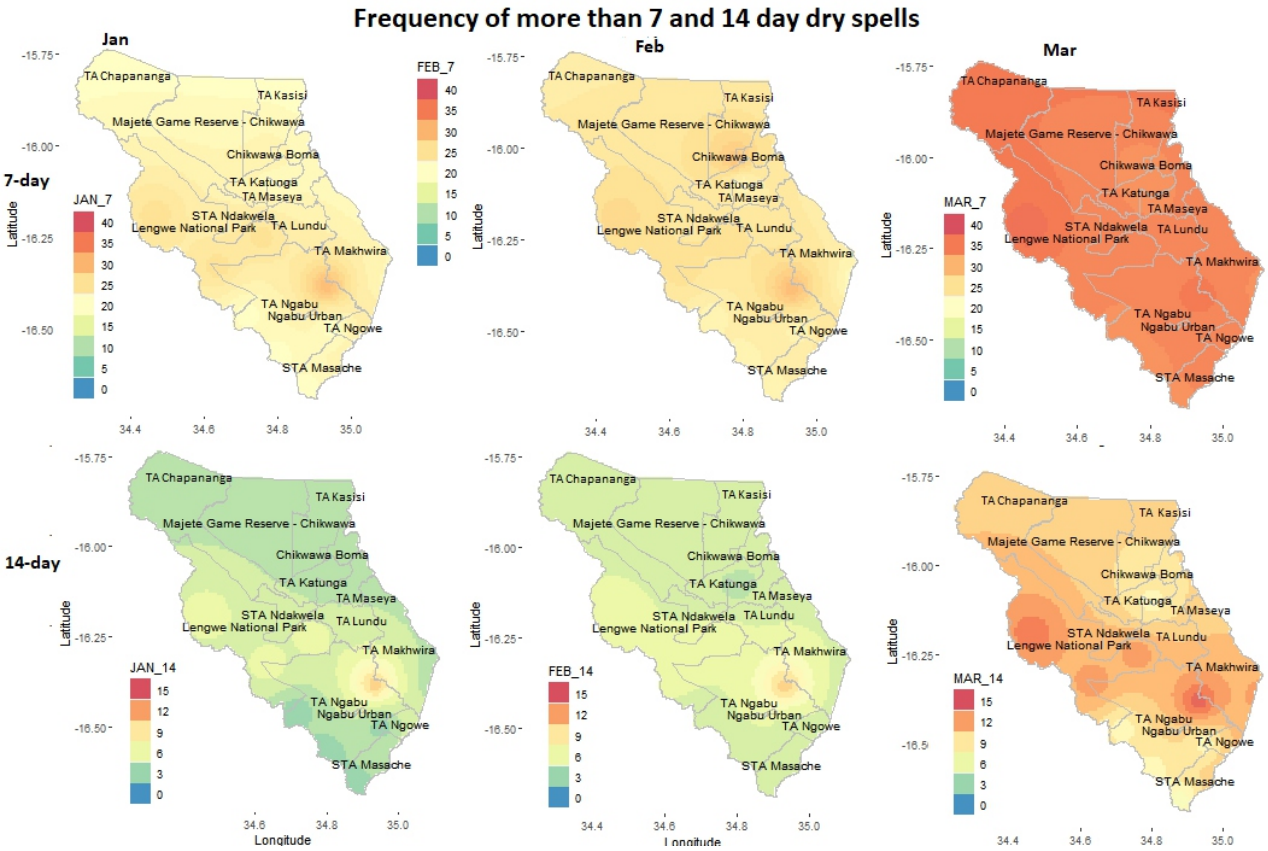

Figure 6 The number of the 7-day (top panel) and 14-day (lower panel) dry spells in January, February and March in Chikwawa district

iii. Dry spell likelihood, impact and risk maps

The 7-day dry spell likelihood is frequent (likelihood scale, Figure 7-top panel (left)) in Chikwawa district and this covers all the TAs and protected areas i.e., game reserve and a national park. But the impact of these 7-day dry spells is moderate (impact scale, Figure 7-top panel (middle)); therefore, its risk is high (Risk scale, Figure 7-top panel (right)). While the combination of the 7- and 14-day dry spells makes the likelihood to take the probable category in Chikwawa district in all the TAs (Figure 7-lower panel (left)). But the impact is moderate in many TAs except TA Ngabu and Makhuwira which is significant (Figure 7-lower panel (middle)). This results into extremely high-risk of dry spells in these two TAs, while the rest of the TAs have medium-risk category (Figure 7-lower panel (middle)). The protected areas are not included in the impact analysis because the estimation is based on the number of people exposed and assumption is that there are very few people in these areas.

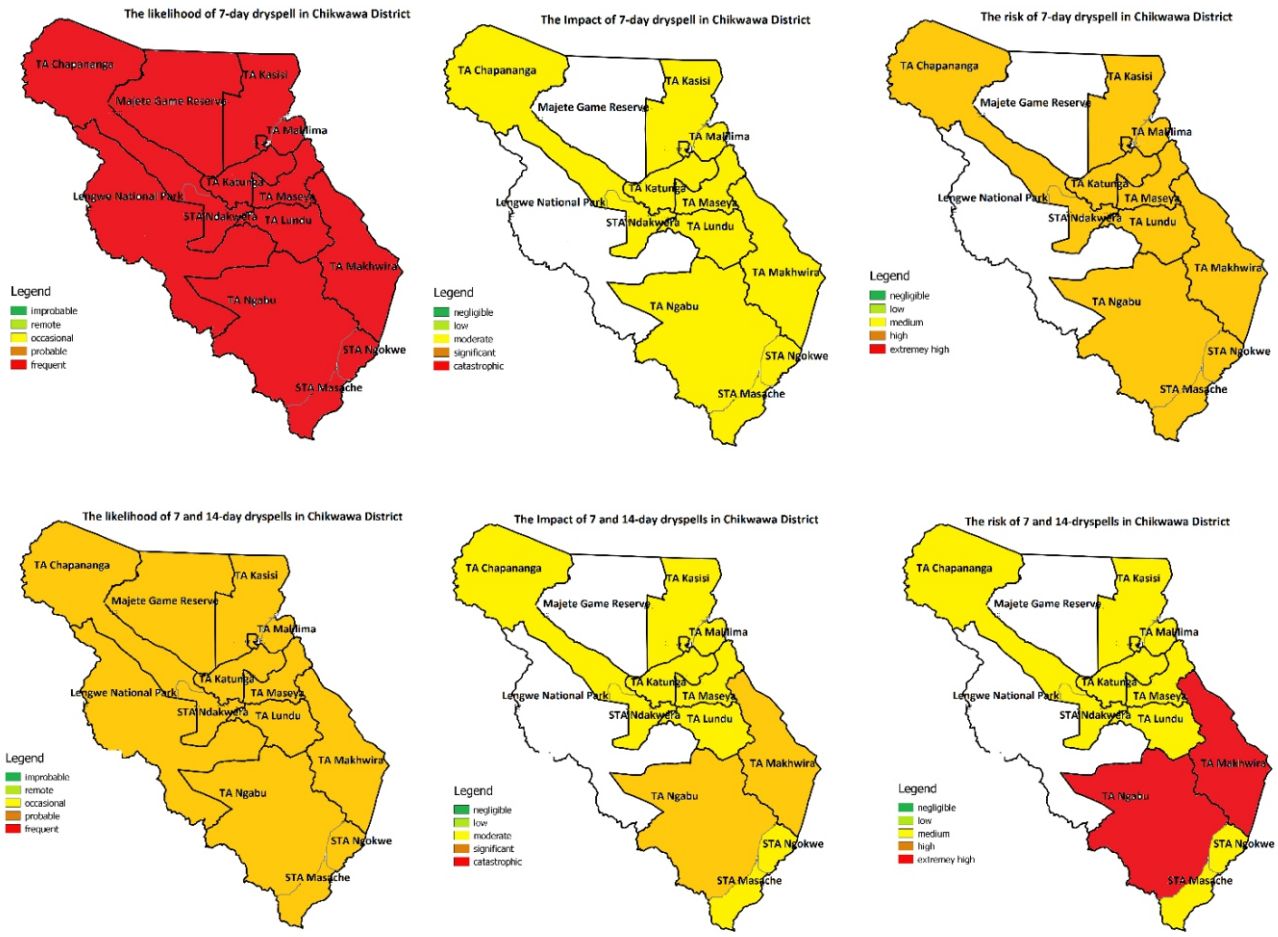

Figure 7 The overall likelihood, impact and risk of dry spells (from left to right respectively) per TA. The scales are explained in section 1d. The 7-day dry spells are in upper panel and the combination of 7-day and 14-dry spells are presented in lower panel. The scales are explained in Section 1d. The impact of dry spells is estimated based on the proportion of people affected. So Lengwe National Park and Majete Game Reserve are not included in impact analysis since very few people live in the reserve.

e. Drought events

Very often the dry spells (ng'amba) are confused with droughts (chilala). However, dry spells are simply a number of successive days without rainfall and this does not take into consideration the amount of rain received. It is possible to have a drought without dry days as drought considers the cumulative amount of rainfall acquired in combination with other climatic factors. The estimation of drought in this project is based on the standardised precipitation and evapotranspiration index (SPEI) (Vicente-Serrano et al., 2010). The project adopts the classification of drought based on Mtilatila et al (2020) as shown in Table 2. The moderately dry $-1 \leq$ SPEI ≤ -1.49 is defined as moderate drought, severely dry $-1.5 \leq$ SPEI ≤ -1.99 is a severe drought and extremely dry SPEI ≤ -2 is an extreme drought. The SPEI calculation is based on 3-month scale.

Table 2 Modified drought classification. Source: Mtilatila et al (2020)

SPEI value	Explanation	Drought intensity
-0.99 to 0.99	Near normal	No drought
-1.0 to -1.49	Moderately dry	Moderate drought
-1.5 to -1.99	Severely dry	Severe drought
< -2	Extremely dry	Extreme drought

Figure 8 is the timeseries of drought events sampled at three locations in the district from 1983 to 2020. The figure shows that droughts are common in Chikwawa. For example, Ngabu experienced 17 drought episodes which lasted at least 6 months on average during the period. Nchalo had 22 drought events that were also 6 months long on average per event, while Chikwawa Boma had only 9 drought events that lasted for 7 months per event on average. But it also shows that the most recent two droughts at Chikwawa Boma and Ngabu were the worst because they lasted 13 and 19 months respectively. The first episode started in February 2016 to February 2017, while the next one was from May 2017 to November 2018, Figure 8.

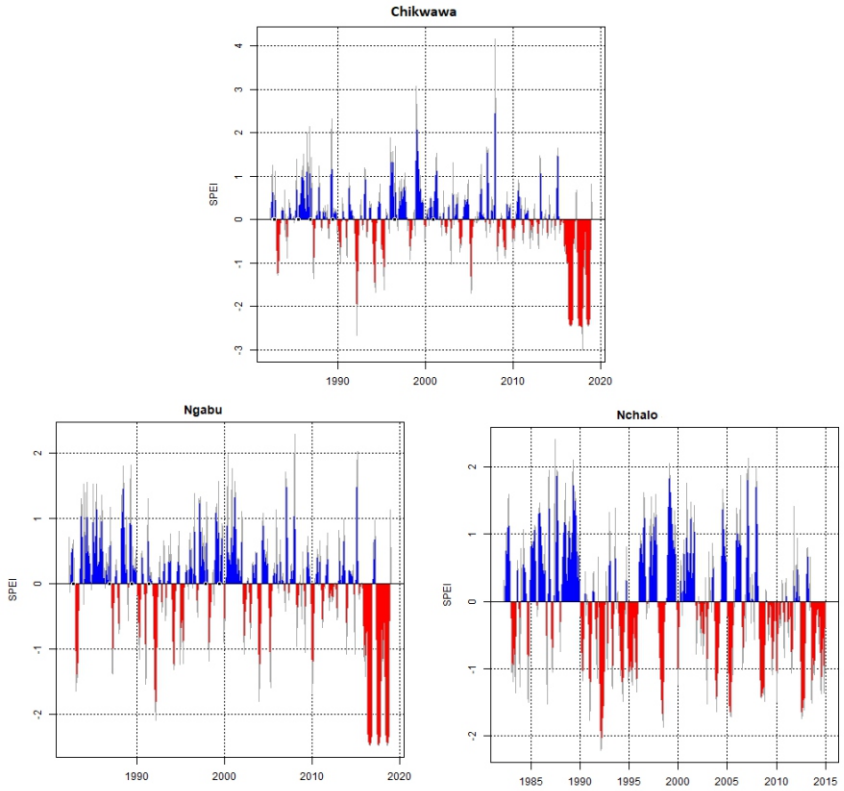

Figure 8 The drought series (red) from 1983 to 2020 at Chikwawa (top), Ngabu (lower-left) and Nchalo (lower-right). The drought starts when SPEI<-1 and ends when SPET>0.

In spatial terms (Figure 9), the drought events range from 6 to 17 in Chikwawa district during 1980 to 2020. The Southern Chikwawa has higher frequency than the north parts (Figure 9-left). The mean duration of these droughts is between 4 and 7 months. Longer droughts are experienced in TAs Kasisi, Katunga, Maseya, Ndakwera, part of TA Ngabu and TA Makhuwira (Figure 9-middle). The intensity of these droughts is generally severe in most TAs except part of TAs Chapananga, Ngabu, Makhuwira, Lundu and Maseya where it is moderate (Figure 9-right). It is also found that droughts are significantly increasing in the district as sampled at various locations in Figure 10.

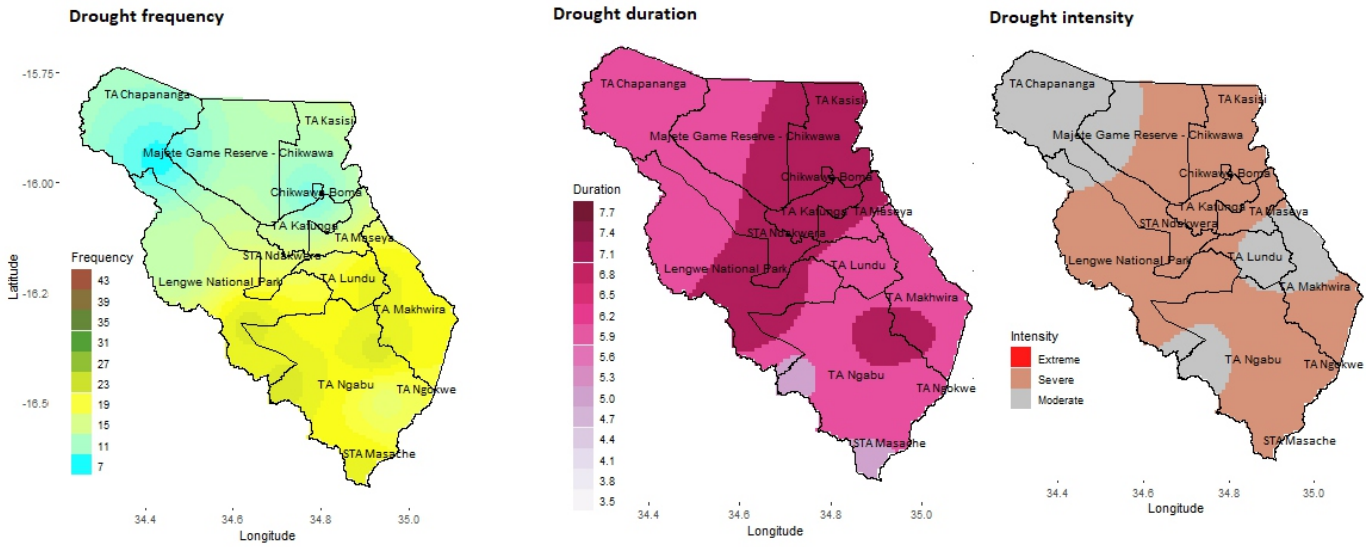

Figure 9 Drought frequency (number of drought events, left), duration in months (middle) and intensity (right)

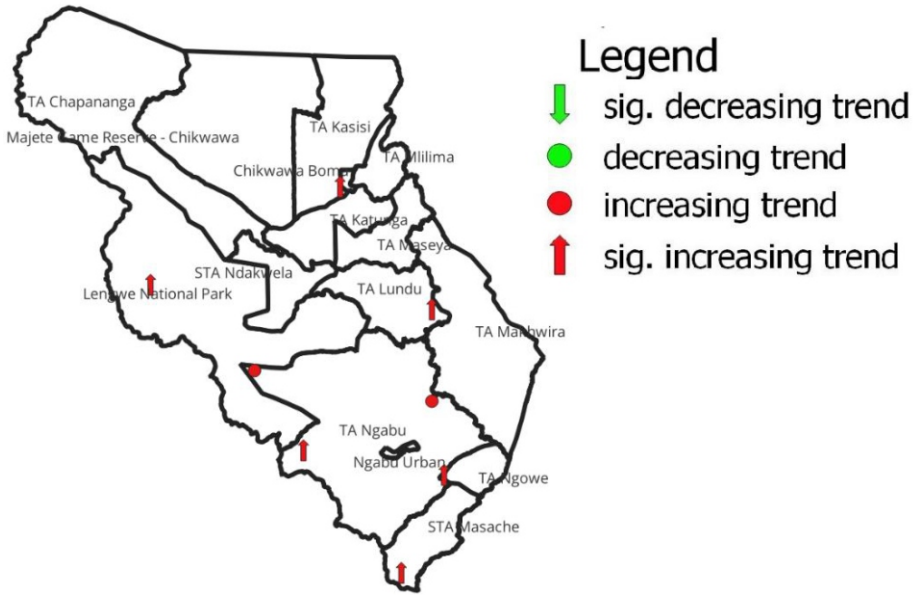

Figure 10 Drought trend in Chikwawa district sampled at selected locations. The significance of the trends is based on p-value < 0.05

The probability of occurrence of drought is frequent (likelihood scale) in TAs Lundu, Makhuwira, and Ngabu. While it is probable in Lengwe National Park, STA Ndakwera, TA Maseya and STA Ngokwe. It is however, occasional-likelihood in the rest of TAs, Figure 11 (left). The impact is significant in all the TAs (Figure 11 (middle)). This results into extremely high-risk in TAs Maseya, Lundu, Makhuwira, Ngabu, Ngokwe and Ndakwera, while the risk is medium in the rest of the TAs Figure 11 (right).

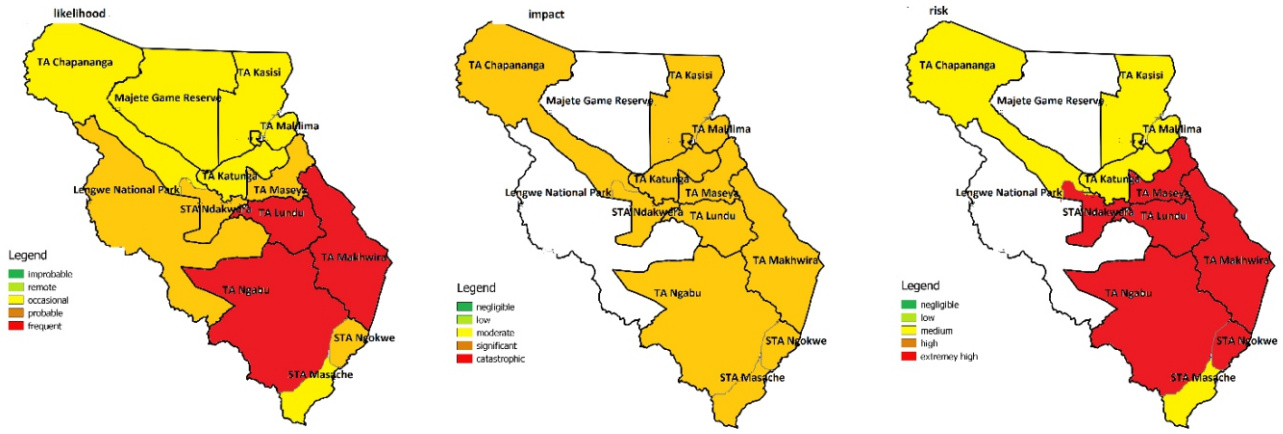

Figure 11 The likelihood, impact and risk of drought (from left to right respectively) per TA. The impact of droughts is estimated based on the proportion of people affected. The scales are as explained in Section 1d.

f. Flood maps

The flood prone areas are mainly over the eastern part of the district (Figure 12). Areas under high flood likelihood lies along the river banks of Shire River as shown by the map. TA Lundu and greater part of TA Ngabu, Ngowe and Makhuwira have highest likelihood that is attributed by the increasing number of rivers that run through the TAs. For instance, TA Makhuwira in the eastern bank of Shire River, apart from Shire River, has also many more small streams that bring water from the Thyolo escarpments and empty into Shire River. Similarly, the western Bank has also some streams that come from the Kirk range and empty into the Shire River. TA Ndakwera experiences floods due to Mwanza and Mkombedzi Rivers.

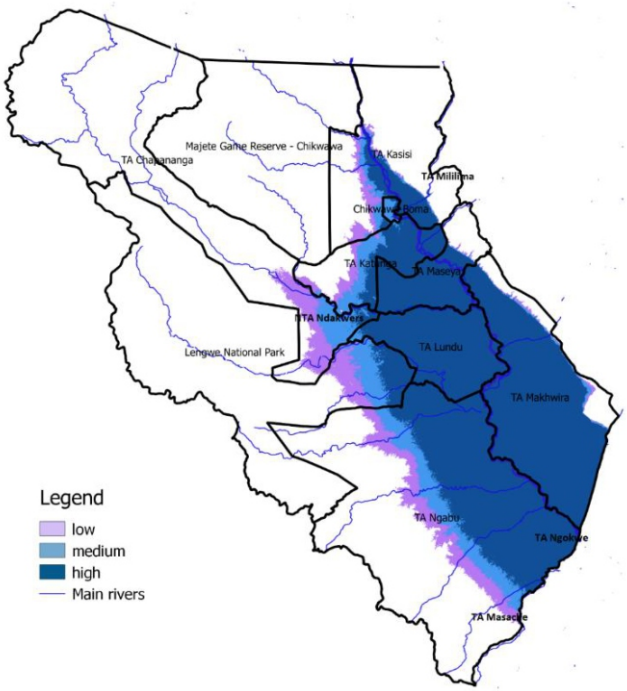

Figure 12 Flood prone areas in Chikwawa district

Based on the records from the Department of Disaster Management Affairs (DODMA), the likelihood of floods is lower in TA Ndakwera which is occasional. But it is probable in TAs Chapananga, Kasisi, Mlilima and

Masache, while it is frequent in TAs Ngabu, Ngokwe, Makhuwira, Lundu, Maseya and Katunga, Figure 13 (left). Again, based on the proportion of people affected per TA, we find that the impact of floods is negligible in TAs Chapananga, Katunga and Ngabu and low in TAs Kasisi, Ndakwera and Masache. The impact is moderate in TAs Maseya, Lundu, Ngokwe and Makhuwira, while the significant-impacts are experienced in TA Mlilima, Figure 13 (middle). The risk therefore, is extremely high in TA Mlilima; high in TAs Ngokwe, Lungu, Makhuwira and Maseya. The risk is medium in TAs Masache and Kasisi, while it is low in TAs Chapananga, Katunga, Ngabu, and STA Ndakwera Figure 13 (right).

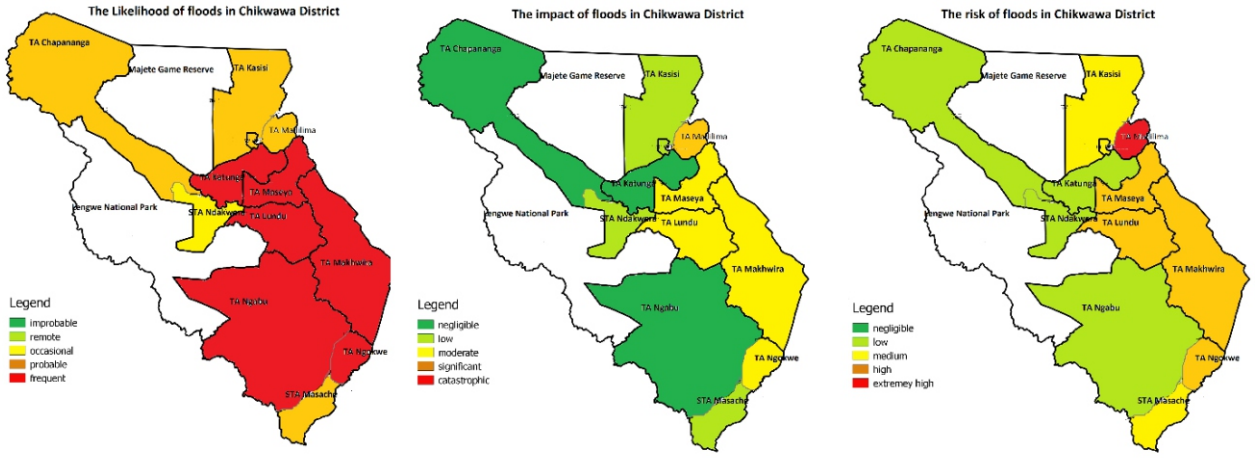

Figure 13 The likelihood, impact and risk of floods (from left to right respectively) per TA. The impact of floods is estimated based on the proportion of people affected. The scales are explained in section 1d.

g. Overall climate risk

The summary of the dry spell, drought and flood risk in Chikwawa district in Figure 14 shows that TA Lundu and TA Makhuwira are at extremely high-risk compared to other TAs in the district. Followed by TA Ngabu and TA Maseya which are at high-risk. Otherwise, the overall risk for the rest of the TAs is medium. Table 3 is ranking the TAs from the most vulnerable TA to least. TA Makhuwira is at extremely high-risk because of all the three hazards; dry spells, droughts and floods. Followed by TA Lundu which has a high risk of droughts and floods while dry spells are at medium-risk. Next is TA Ngabu which has high-risk of dry spells and droughts. TAs Maseya and Ngokwe have high-risk of droughts and floods while dry spells are at medium-risk. Followed by TA Mlilima which is at extremely high-risk of floods, otherwise dry spells and droughts are at medium-risk. TA Ndakwera is at extremely high-risk of droughts while dry spells are at medium-risk. TAs Kasisi and Masache are at medium-risk of dry spells, droughts and floods. At last, TA Chapananga and Katunga are at medium-risk of dry spells and droughts.

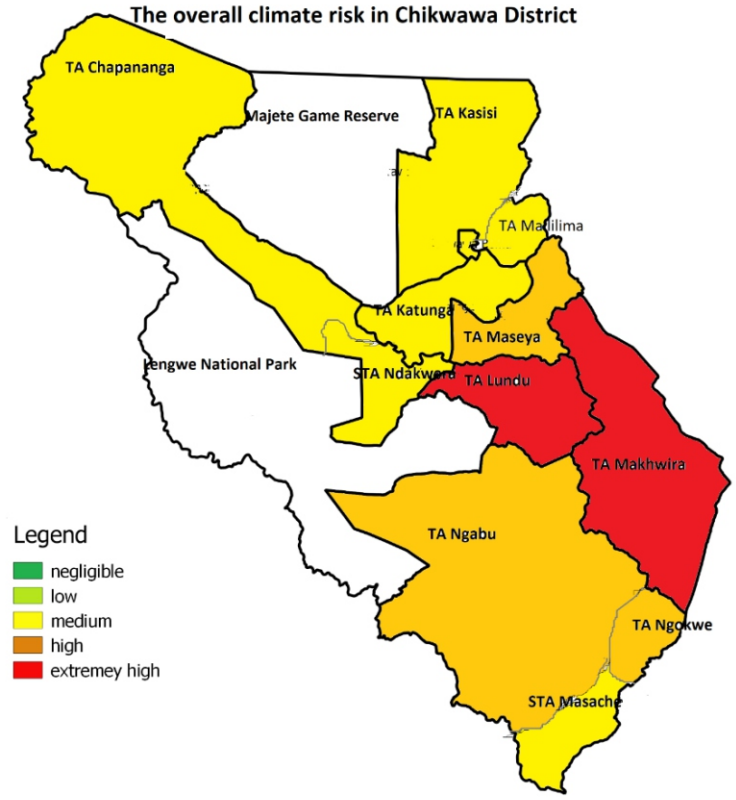

Figure 14 Overall climate risk in Chikwawa district per TA (summary of dry spells, drought and floods)

Table 3 The Traditional Authority ranking based on the dry spell, drought and flood risks. The Risk scale is as defined in Section 1d

Rank	TA	Dry spells	Droughts	Floods	Overall
1	Makhuwira	Extremely high	Extremely high	High	Extremely high
2	Lundu	Medium	Extremely high	High	Extremely high
3	Ngabu	Extremely high	Extremely high	Low	High
4	Maseya	Medium	Extremely high	High	High
5	Ngokwe	Medium	Extremely high	High	High
6	Mililima	Medium	Medium	Extremely high	Medium
7	Ndakwera	Medium	Extremely high	Low	Medium
8	Kasisi	Medium	Medium	Medium	Medium
9	Masache	Medium	Medium	Medium	Medium
10	Katunga	Medium	Medium	Low	Medium
11	Chapananga	Medium	Medium	Low	Medium

3. Conclusion

In conclusion, the study's objective was to develop climate risk hot spots/areas in Chikwawa district. The work has considered absolute rainfall, heatwaves, dry spells, drought events and floods. The results have shown that TA Makhuwira is the most highly affected by climate extremes mainly due to extremely high-risk of dry spells and drought combined with high-risk of floods. TA Lundu follows due to high-risk of drought and floods. TA Ngabu has a high-risk of droughts and dry spells. While TAs Maseya and Ngokwe have also high-risk of dry

spells and droughts. The rest of the TAs have a medium-risk of climate extremes. The overall climate risk of the district is high. Therefore, climate change programs such adaptation, mitigation, intervention and measures to reduce the impacts of these climate hazards are paramount and need to implemented in Chikwawa district. The programmes should consider drought, dry spells and floods.

4. References

Chikwawa district physical development plan, 2020 https://www.svtp.gov.mw/wp-content/uploads/2021/01/CHIKWA-DISTRICT-PHYSICAL-DEVELOPMENT-PLAN-APPROVED-VERSION.pdf

GOM. (2015). *Malawi 2015 Floods Post Disaster Needs Assessment Report*. https://www.ilo.org/global/topics/employment-promotion/recovery-and-reconstruction/WCMS_397683/lang--en/index.htm

GOM. (2019). *Malawi 2019 Floods Post Disaster Needs Assessment Report*. https://www.unicef.org/malawi/sites/unicef.org.malawi/files/2019-12/Malawi 2019 Floods Post Disaster Needs Assessment Report.pdf

Mtilatila, L, Bronstert, A., Bürger, G., & Vormoor, K. (2020). Meteorological and hydrological drought assessment in Lake Malawi and Shire River Basins (1970-2013). *Hydrological Sciences Journal*.

National Statistical Office. (2019). *2018 Malawi Population and Housing Census*. National Statistical Office.

Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. (2010). A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index - SPEI. *Journal of Climate*, 1696–1718.

5. Acknowledgement

Acknowledgement goes to the African Development Bank Group under Multinational Post Cyclone Idai & Kenneth Emergency Recovery and Resilience Building Programme (PCIREP) for funding this work. We also thank the District and Areal Civil Protection Committees for the contributions made during the development of the report.

Department of Climate Change and Meteorological Services

P.O. Box 1808

Blantyre, Malawi.

Tel: +265(0) 1822 014. Fax: +265(0) 1822 215.

Email: metdept@metmalawi.gov.mw

www.metmalawi.gov.mw

AFRICAN DEVELOPMENT BANK GROUP