MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

Climate Risk Maps
Zomba District

December 2022

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1. Introduction

a Geography of Zomba

Zomba district is located in the southern highlands of Malawi (Fig.1), with the highest altitude of 2087 meters above sea level at Zomba plateau. The district covers an area of 2363 square kilometres and according to the Housing and Population Census (2018), Zomba has a population of 746,724 that fall in the following 11 traditional authorities: TA Kuntumanji with population of 48,079; TA Mwambo 151,997; TA Mkumbira 6,211; TA Chikowi 63,831; TA Mbiza 85,311; TA Malemia 82,320; TA Mlumbe 127,300; STA Nkagula 51,548; STA Ntholowa 50,738; STA Ngwelero 34,034; and STA Nkapita 45,355.

The main agricultural activities of the district are farming of tobacco and cotton cash crops, while the main food crops grown are maize, sorghum, rice, beans and sweet potatoes. Farming is heavily dependent of rainfall during summer. Fishing is also a major economic activity mainly on Lake Chilwa.

b Climate and common hazards in Zomba

The annual rainfall ranges from 600mm to 1900mm across the district. Zomba is prone to both floods and droughts/dry spells and some of the worst floods occurred in January 2015, May 2019, January 2022 and March 2022. (GOM, 2015; GOM, 2019). For example, the 2019 floods ranked Zomba the fifth worst hit district and the accumulated damages and losses were about USD 15 million (~ MWK 15,393,075,000), GOM, 2019. The district is also prone to recurrent pests that destroy crops. These pests are often times due to the prolonged dry spells. Strong winds that damage buildings and crops are also common in the district.

c Objective of the study

The objective of this project is to develop the climate risk maps for Zomba District. The analyses are done using data from 1981 to 2020. The climate risk maps 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.

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 Tab. 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

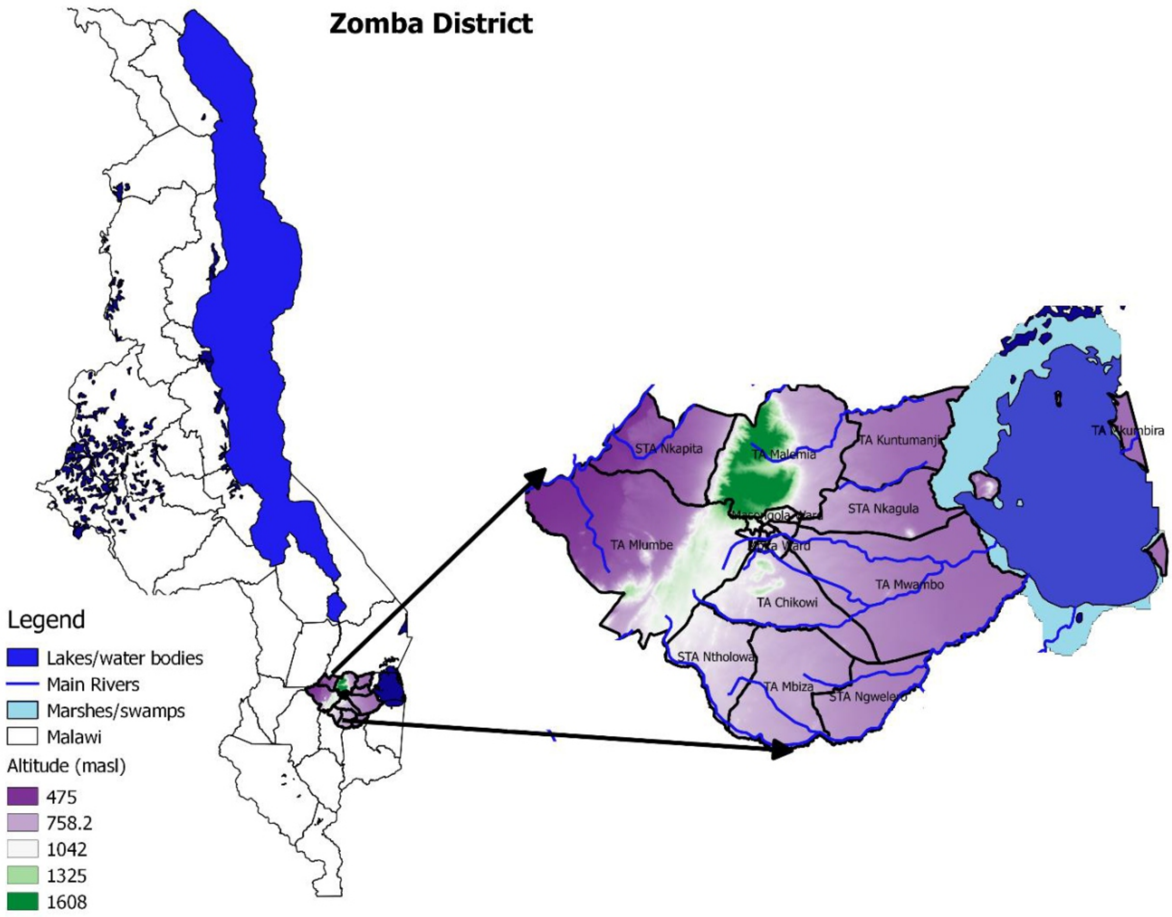

Figure 1 Zomba District, traditional authorities (TAs), rivers and topography

2. Climate Risk Maps

a. Rainfall Trend

Rainfall is significantly decreasing in Zomba district as is indicated in Fig.2 at various locations in TA Malemia, TA Mlumbe, TA Chikowi, TA Mbiza and TA Mwambo.

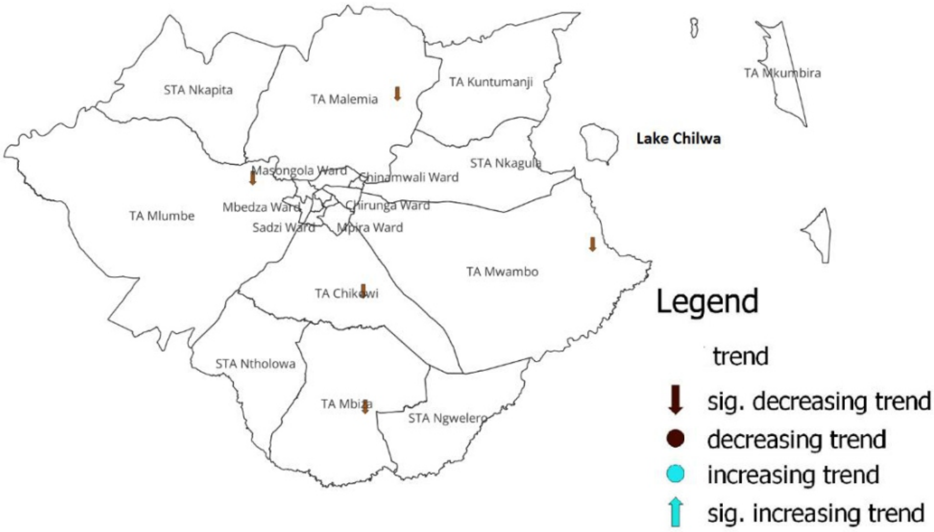

Figure 2 Rainfall trend in Zomba District. The significance of the trends is based on p-value < 0.05

b. Extreme Rainfall

Though the rainfall is decreasing in the district, the study also looked at the highest rainfall received in the district in 24 hours. The extreme rainfall represents the highest rainfall amounts ever recorded in a 24-hour period from the historical rainfall records. From the map above, it can be seen that areas in Zomba experienced extreme rainfalls which range from 146mm to 296mm. This implies, most areas in Zomba have a possibility of receiving such extreme amounts of rainfall in just a day.

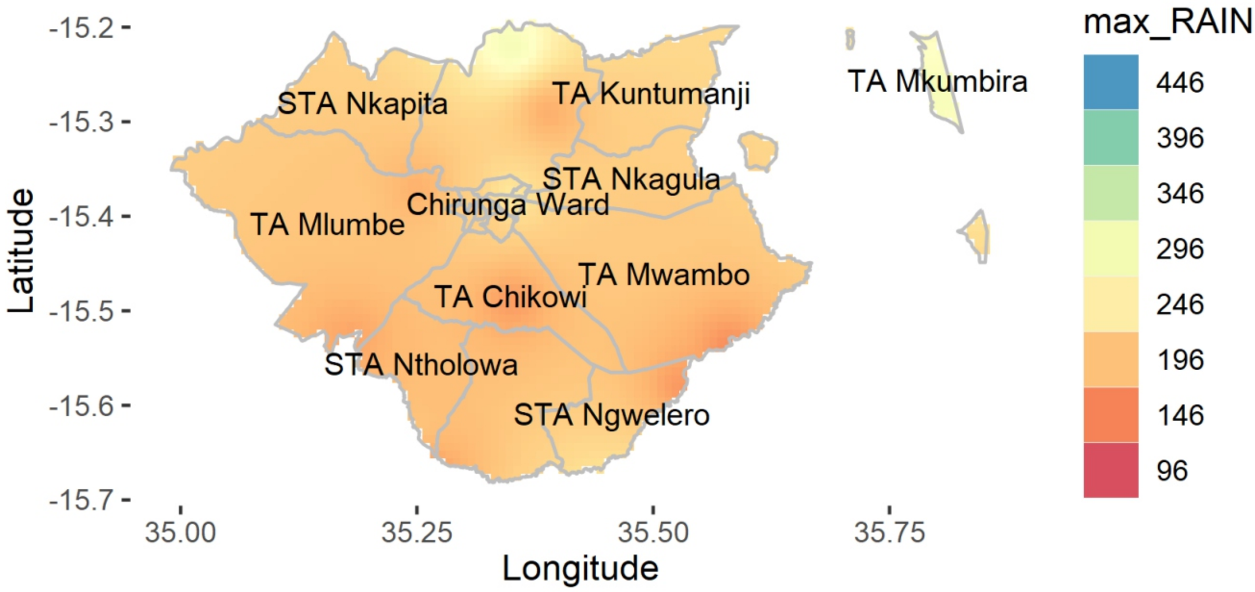

Figure 3 Absolute maximum rainfall in Zomba district

c. Heatwaves (high temperatures)

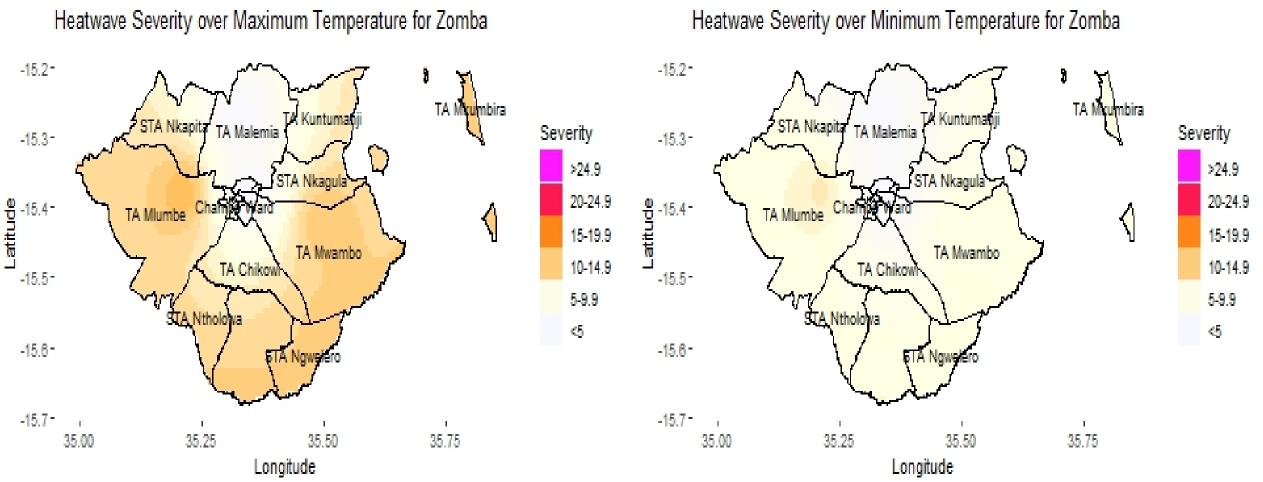

Figure 4 The heatwave based on maximum temperature (left) and minimum temperature (right)

Heat waves are a climate risk for some areas in Zomba. The heat severity index is significant in areas of TA Mwambo, TA Mlumbe, STA Ngwelero, TA Ntholowa and TA Mbiza. This implies, these areas are most likely to experience heat waves.

d. Dry spells

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

The dry spells at the beginning of rainfall season are presented in Fig. 5 below. The months considered are October-November-December (OND) and the figure (5a) is the frequency of the dry spells of more than 7 days and (5b) is the frequency of dry spells of more than 14 days from 1981 to 2020 in Zomba district.

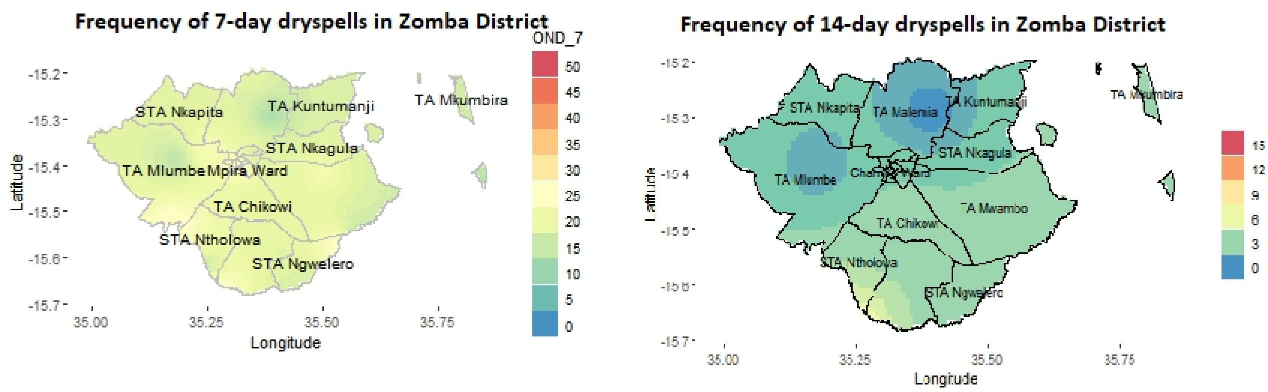

Figure 5 The frequency of dry spells of more than 7 days (a) and more than 14 days (b) in Zomba district

The 7-day dry spells at the beginning of rainfall season in October-November-December (OND) are common in Zomba district. The frequency of these dry spells ranges from 10 to 20 between 1981 to 2020 which is the probability between 25 to 50%.

The frequency of prolonged dry spells beyond 14 days at the beginning of rainfall season is less in the district with majority of Traditional Authorities having a frequency of 3 and parts of Traditional Authority Mlumbe and Traditional Authority Malemia never experienced such dry spells during 1981 to 2020. The highest frequency of 6 is observed in southern parts of Traditional Authority Ntholowa and Sub Traditional Authority Ngwelero.

ii. Frequency of dry spells during the season

The dry spells are also common during the rainfall season from January to March. The frequency of 7-day dry spells ranges from 10 to 25 (25 to 65% probability) in January, 15 to 35 (40 to 90%) in February and almost certain in March (Fig. 6). March has the worst dry spells but probably is also due to the fact that March is the onset of the cessation of rainfall season in this district. The most frequent dry spells are in TA Mlumbe, Sub Traditional Authorities Ngwelero and Ntholowa and southern areas of Sub Traditional Authority Nkagula (Fig.6 Upper-panel).

The 14-day dry spells in Zomba are also worse in March compared to January and February, where the frequency for January reaches 6 and the worst affected Sub Traditional Authorities are Ntholowa and Ngwelero. In February, the highest frequency for dry spells is recorded in Sub Traditional Authority Ngwelero and southern areas of Sub Traditional Authority Nkagula. The 14-day spells in March are more frequent in Sub Traditional Authorities Nkagula, Ngwelero and Ntholowa as compared to northern and western areas in the district under Traditional Authorities Mlumbe, Kuntumanji, Chikowi and Sub Traditional Authority Nkapita (Fig.6 lower-panel).

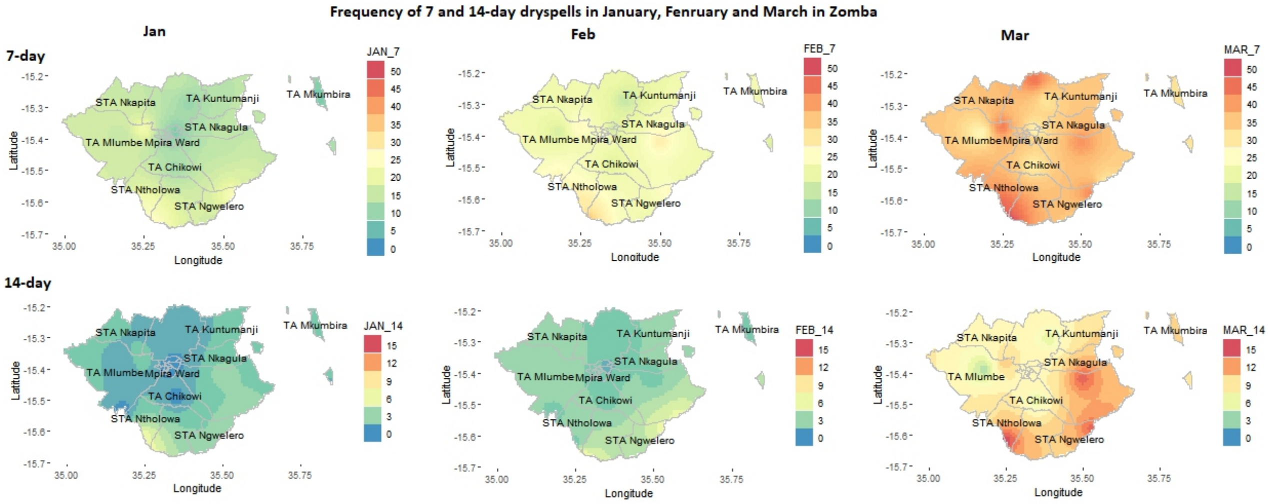

Figure 6 The 7-day (upper-panel) and 14-day (lower-panel) dry spells in January, February and March in Zomba district

iii. Dry spell likelihood, impact and risk maps

The likelihood, impact and risk of 7-day and 14-day dry spells combined are presented in Fig. 7. The spatial distribution is generally uniform across all the TAs in the district for the 7-day dry spells. The likelihood is generally frequent on likelihood scale for the majority of areas with exception of the central areas (Zomba Boma) of the district which the likelihood is probable. The impact of the 7-day spells is moderate in all areas of the district which results into high-risk of 7-day dry spells in the district except Zomba Boma where the risk is medium (Fig. 7 upper panel).

For the combination of 7 and 14-day dry spells are presented in Fig. 7 (lower panel). The majority of areas fall under the probable-likelihood except Zomba Boma and TA Chikowi which has occasional-likelihood. The impact is significant in TAs Mwambo, Ngwerelo and Ntholowa but moderate in the rest of the district. While the risk is extremely high in the same TAs Mwambo, Ngwerelo and Ntholowa but medium in the rest of the TAs in the district (Fig. 7 lower panel).

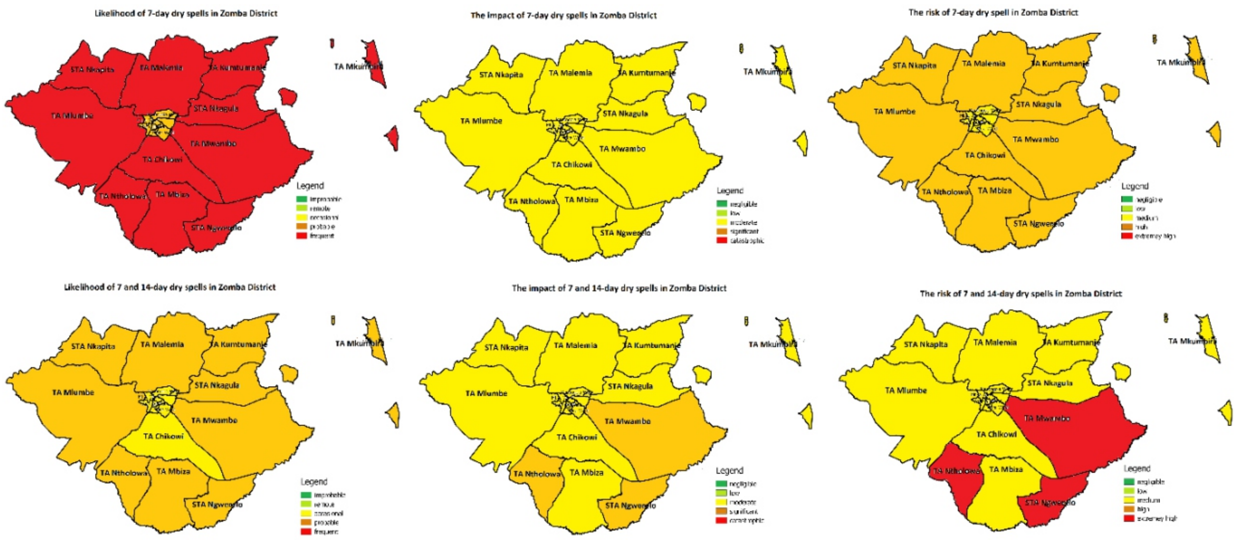

Figure 7 The overall likelihood, impact and risk of dry spells (from left to right respectively) per TA. The 7-day dry spells are in upper panel and the combination of 7-day and 14-dry spells are presented in lower panel. The impact of dry spells is estimated based on the proportion of people affected. The scales are explained in Section 1d.

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 climatological parameters. The estimation of drought 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 Tab. 2. The moderately dry −1 ≤ SPEI ≤ −1.49 is defined as moderate drought, severely dry −1.5 ≤ 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 four locations in the district from 1981 to 2020. The figure shows that droughts are common in Zomba district. For example, Chingale experienced 24 drought events during this period. While Makoka, Malosa and Zomba Agriculture experienced 20 events (Red in the figures).

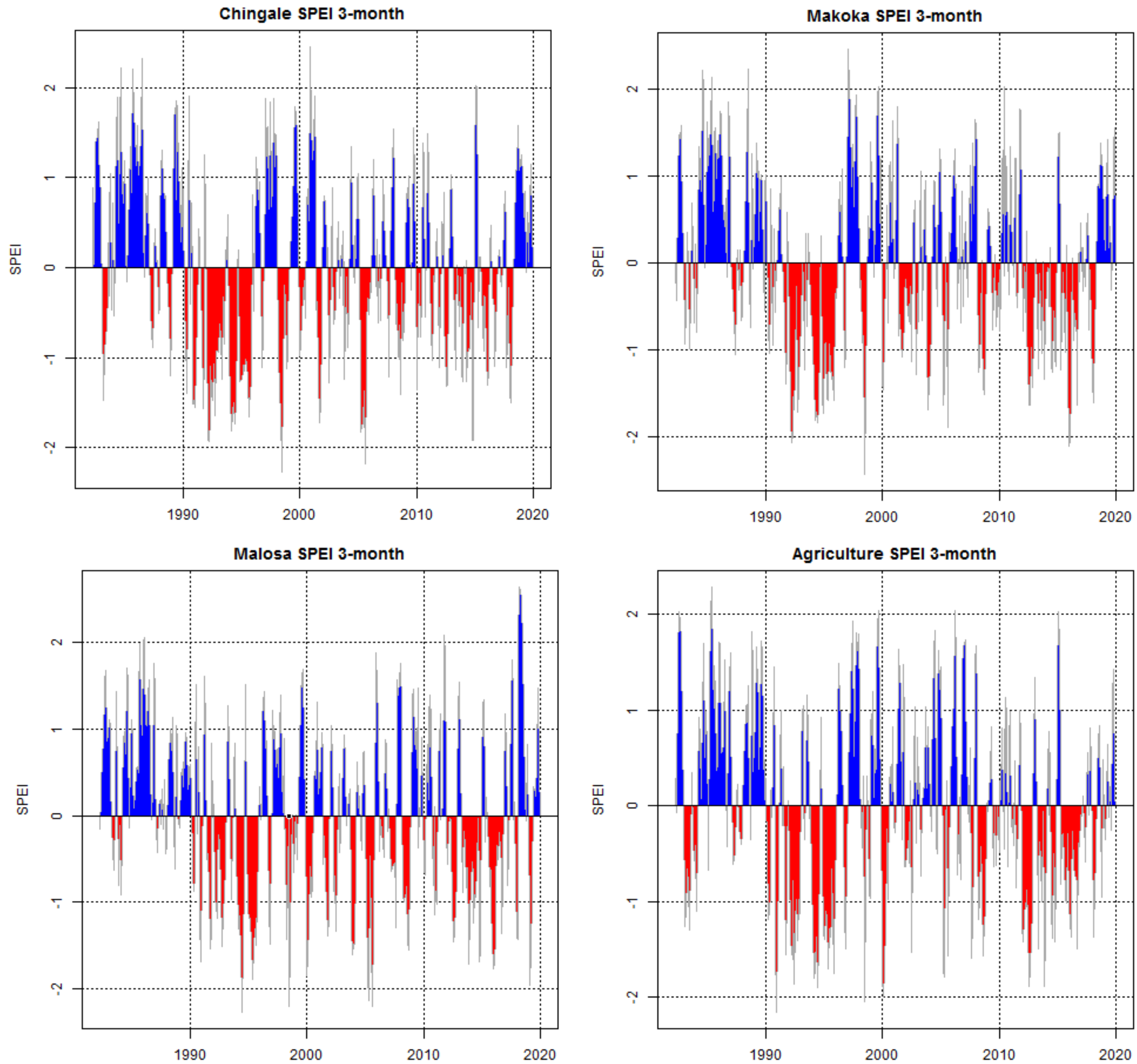

Figure 8 The drought series (red) from 1981 to 2020 at Chingale (upper-left), Makoka (upper-right), Malosa(lower-left) and Zomba Agrilcuture (lower-right). The drought starts when SPEI<-1 and ends when SPET>0.

In space (Fig. 9), the drought events range from 15 to 27 in Zomba district with the duration of 5 and 7 months on average per event. Shorter and higher frequent droughts are generally on the western side of the district in TA Mlumbe, SC Mbiza and TA Chikowi while longer drought events are experienced in TA Malemia, TA Mkumbira, TA Mwambo and areas around lake Chilwa. On average, the droughts experienced are severe in terms of intensity with parts of TA Malemia having moderate intensity drought events. It is also shown that drought intensity is increasing in Zomba district, Fig.10 which is significant in many places in the district.

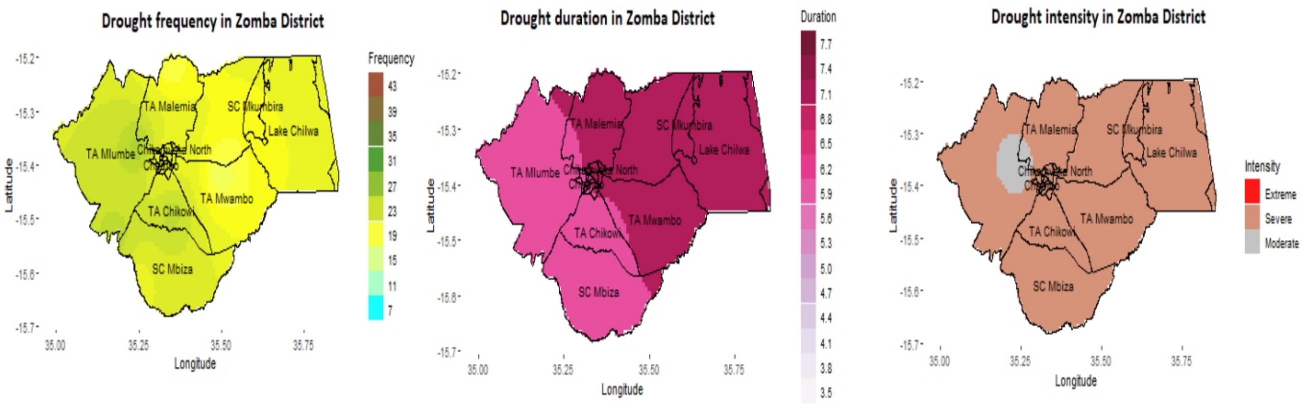

Figure 9 Drought frequency (number of drought years, left), duration in months (middle) and intensity (right)

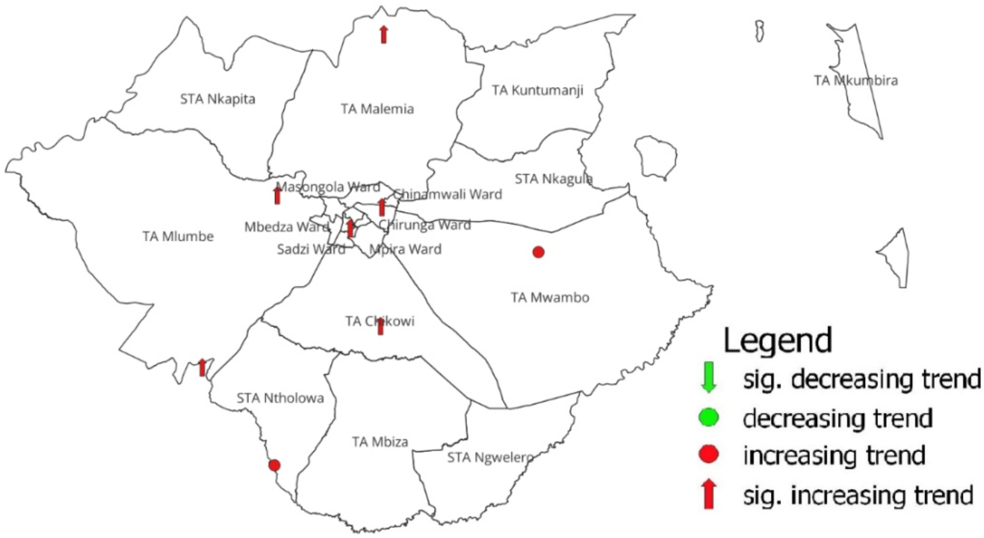

Figure 10 Drought trend in Zomba district sampled at selected locations. The significance of the trends is based on p-value < 0.05

There is a frequent-likelihood of droughts (on likelihood scale) in Zomba district (Fig.11 left) with moderate impact in TA Mlumbe, TA Chikowi and TA Ntholowa (Fig.11 middle). The significant drought impacts are experienced in STA Nkapita, STA Ngwerelo, STA Nkagula, TA Malemia, TA Kumtumanje, TA Mkumbira, TA Mwambo and TA Mbiza, Fig. 11-Middle. The majority of the TAs in the district fall under the high-risk as regards to drought and extremely high risk in STA Nkapita, STA Ngwerelo, STA Nkagula, TA Malemia, TA Kumtumanje, TA Mkumbira, TA Mwambo, Mbiza and Zomba Boma (Fig. 11 right).

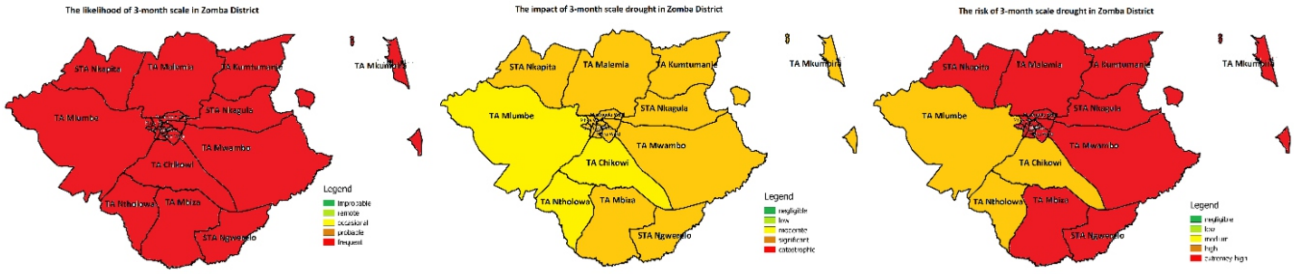

Figure 11 The likelihood, impact and risk of drought (from left to right respectively) per TA. The impact of droughts is estimated based on the proportion of people affected. The scales are explained in Section 1d.

f. Flood events

The flood probability, impact and risk are calculated based on the records from the Department of Disaster Management Affairs (DODMA) from 1981 to 2020. The impact is estimated from the proportion of people affected per TA, Fig. 12. The likelihood of floods is lowest in TAs Ntholowa, Mbiza and Zomba Boma. However, it is highest in TAs Mwambo and Kumtumanje where the likelihood is frequent. However, the impact of floods is negligible in TAs Malemia, Chikowi, Mwambo, Ntholowa, Mbiza, Ngwerelo and Zomba Boma. While it is low in TAs Nkapita, Kumtumanje and Nkagula and medium in TA Mlumbe. The risk therefore, is medium in TAs Mlumbe and Kumtumanje; low in TAs Nkapita, Chikowi, Mwambo and Nkagula and negligible in the rest of the TAs.

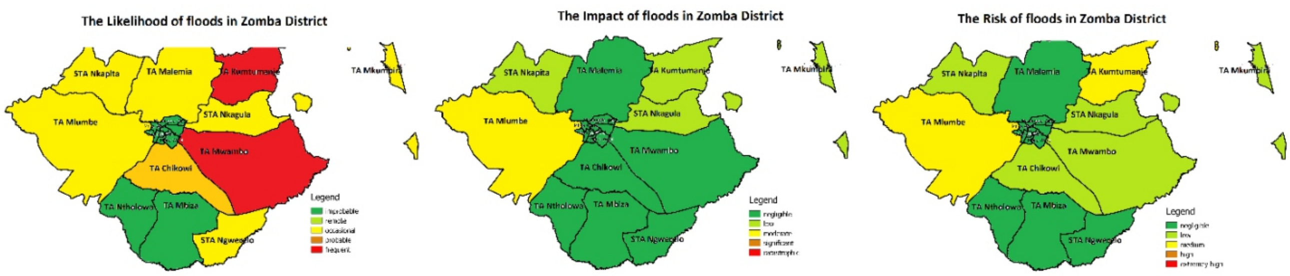

Figure 12 The likelihood, impact and risk of floods (from left to right respectively) per TA. The impact of floods is estimated based on the proportion of people affected. The scales are explained in Section 1d.

g. Overall climate risk

Fig. 13 summarises the dry spell, floods and drought risks in Zomba district. In general, the climate risk is medium for most of the areas in Zomba. However, the highest climate risk is in TA Kumtumanje and TA Mwambo with high-risk. While the rest of the TAs have medium-risk of climate extremes.

Tab. 3 is ranking the risk by TA from the most vulnerable to the least based dry spells, floods and drought. TA Kumtumanje is at the most risk mainly due to droughts but also both the floods and dry spells are at medium-risk. The second and third are TAs Mwambo and Ngwelero respectively with the extremely high-risk of dry spells and droughts. The rest of the TAs have an overall medium-risk and the worst climate extreme is drought.

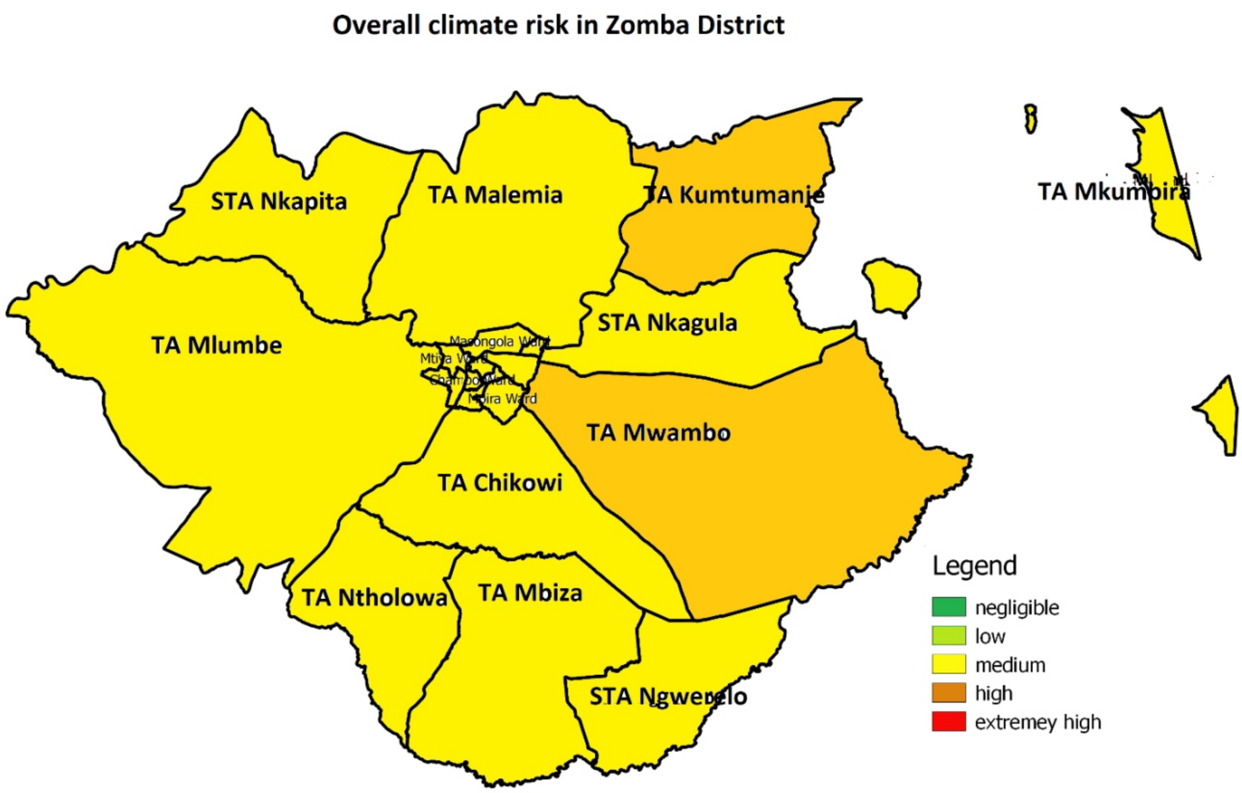

Figure 13 Overall climate risk in Zomba district per TA (summary of dry spells, drought and floods)

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	Kumtumanje	Medium	Extremely high	Medium	High
2	Mwambo	Extremely high	Extremely high	Low	High
3	Ngwerelo	Extremely high	Extremely high	Negligible	Medium
4	mkumbira	Medium	Extremely high	Low	Medium
5	Nkagula	Medium	Extremely high	Low	Medium
6	Nkapita	Medium	Extremely high	Low	Medium
7	Mlumbe	Medium	High	Medium	Medium
8	Malemia	Medium	Extremely high	Negligible	Medium
9	Mbiza	Medium	Extremely high	Negligible	Medium
10	Ntholowa	Extremely high	High	negligible	Medium
11	Boma	Medium	Extremely high	Negligible	Medium
12	Chikowi	Medium	High	Low	Medium

3. Conclusion

The objective of the study was to delineate the climate risk hot spots in Zomba District. The analysis has looked at absolute rainfall, heatwaves, dry spells, drought events and floods. The risk maps of each hazard are presented. The overall summary shows that the highest climate risk is in TA Kumtumanje followed by TA Mwambo where the overall risk is high. The rest of the TAs such STA Ngwelero, TA Mkumbira, TA Nkagula, STA Nkapita, TA Mlumbe, TA Malemia, TA Mbiza, TA Ntholowa, Zomba Boma and TA Chikowi have an overall medium-risk. It also shows that the district has the high risk of droughts compared to dry spells and floods. Although floods do occur in the district, the risk is not high. But still, it is concluded that the entire Zomba District is vulnerable to climate extremes. Therefore, climate change adaptation and measures to reduce the impacts of these climate hazards is paramount in Zomba district.

4. References

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