MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE

DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

Climate Risk Maps
Mulanje District

December 2022

The page is intentionally left blank……

TABLE OF CONTENTS

1. Introduction

a. Geography

Located in the southern region of Malawi (Fig.1), Mulanje district covers an area of 2,056 km² and has a population of 684,107 at an annual growth rate of 2.6% (National Statistical Office, 2019). The district is covered by 9 Traditional Authorities (TA) and these are TA Mabuka with a population of 108,442; TA Laston Njema 91,742; TA Chikumbu 87,148; TA Nthiramanja 51,108; Nkanda/ Mulanje Mountain Reserve 128,376 ; TA Juma 109,821; STA Sunganinzeru 68,585; STA Tombondiya 24,103; and Mulanje Boma 14,782. The district which lies in the shire highlands, is at an altitude of 500 to 3000 meters above the mean sea level.

Mulanje has an agro-based economy with the main cash crop being tea grown in industrial size farms. Main food crops grown are maize, groundnuts, beans, soya beans, pigeon peas and other pulses. The district also grows horticultural crops like pineapples and bananas which are exported to other districts in the country. Mulanje district also indulges in livestock production such as cattle, goats and chickens.

b. Climate and common hazards in Mulanje District

The climate in Mulanje district is warm to hot with mean maximum temperatures of around 32 degrees Celsius in summer and average minimum of 13 degrees in winter. The annual rainfall ranges from 600mm to 1600mm. Mulanje 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, 2019; GOM, 2015). Mulanje district was one of the districts that were most affected during the 2019 floods where the total damage and loss was at 8.2 million US dollars (~MWK 8,414,881,000) and the worst sector was housing that covered over half of the effects (GOM, 2019). The district is also prone to recurrent pests that destroy crops. These pests are often times due to 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 Mulanje 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

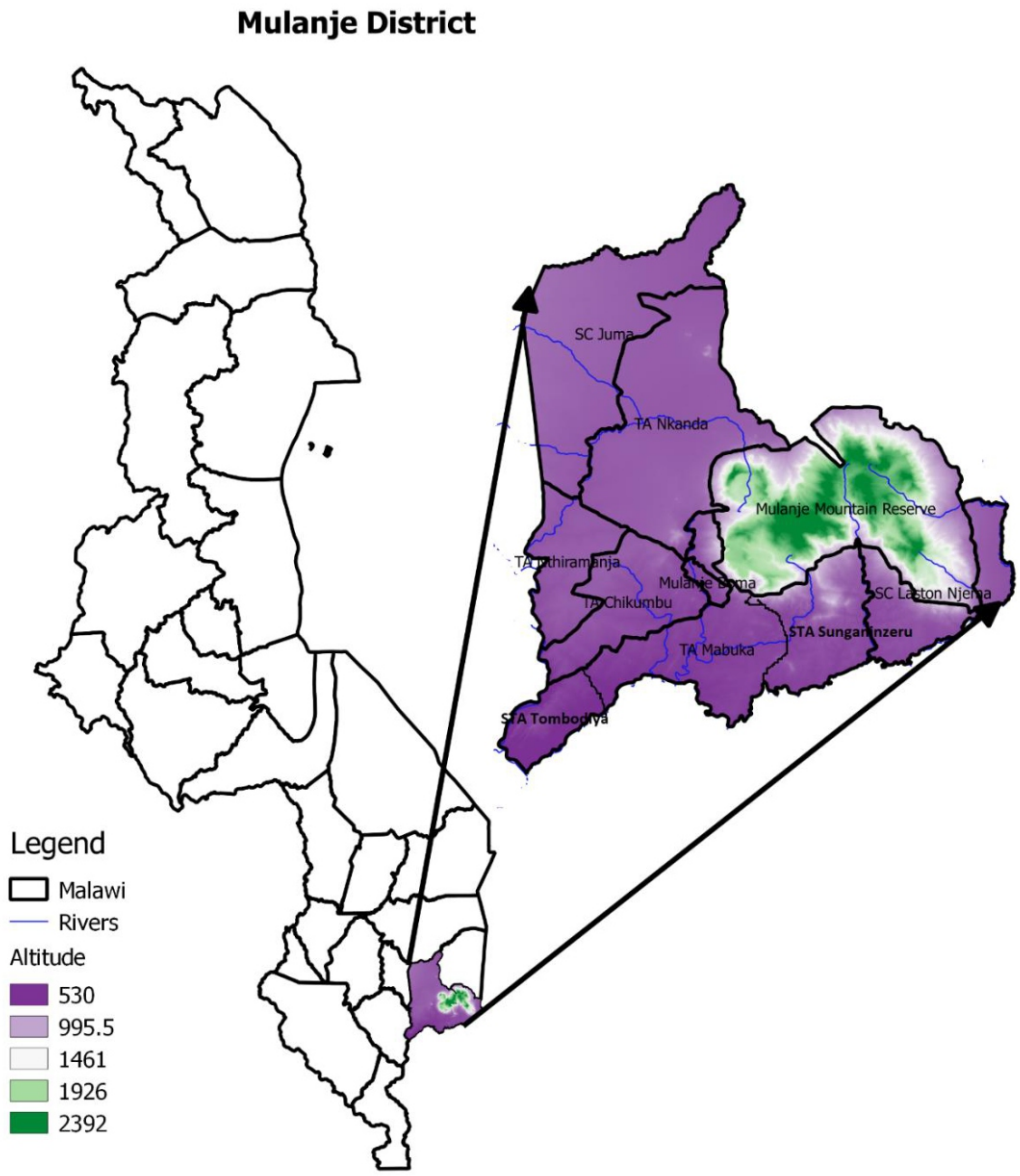

Figure 1 Mulanje District, traditional authorities (TAs), rivers and topography

2. Climate Risk Maps

a. Rainfall trend in Mulanje District

There is a significant reduction of rainfall in Mulanje district during 1981-2020 period as is shown from various points sampled in the district, Fig. 2. Further rainfall analysis of Mulanje also shows that there is a significant downward trend of winter rainfall which is affecting winter cropping.

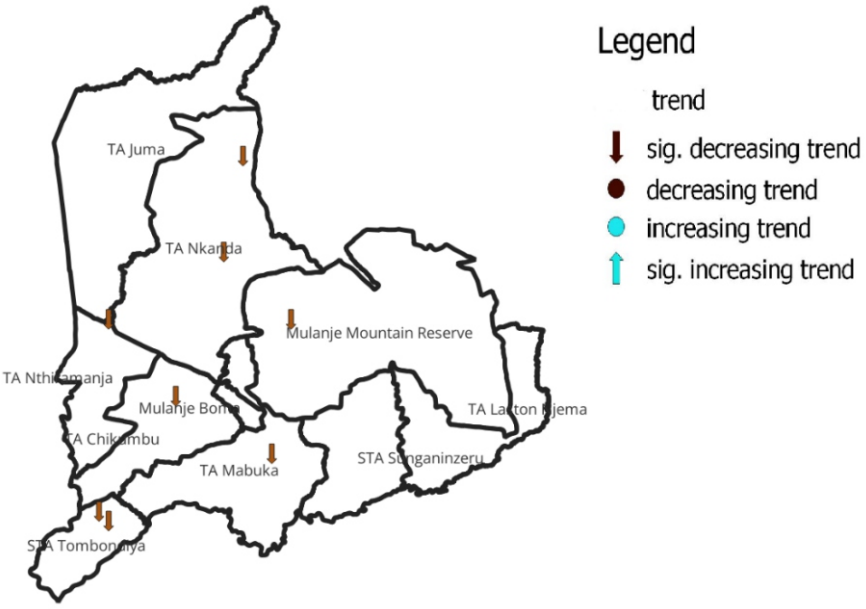

Figure 2 Rainfall trend in Mulanje District. The significance of the trends is based on p-value < 0.05

b. Extreme rainfall

Though the rainfall is decreasing in the district, the study further analysed the extreme rainfall received in the district from 1980 to 2020 and are presented in Fig.3. The figure is a summary of maximum absolute rainfall (highest ever recorded in 24 hours) in mm during the rainfall season for the period of 1981 to 2020 in Mulanje. Generally, the spatial distribution is even as it ranges from 150 to 250mm with the exception of TA Nkanda and TA Ndanga having maximum absolute rainfall amounts of 300 to 350mm. all this indicating the possibility for the district to receive rainfall above 150mm in 24 hours.

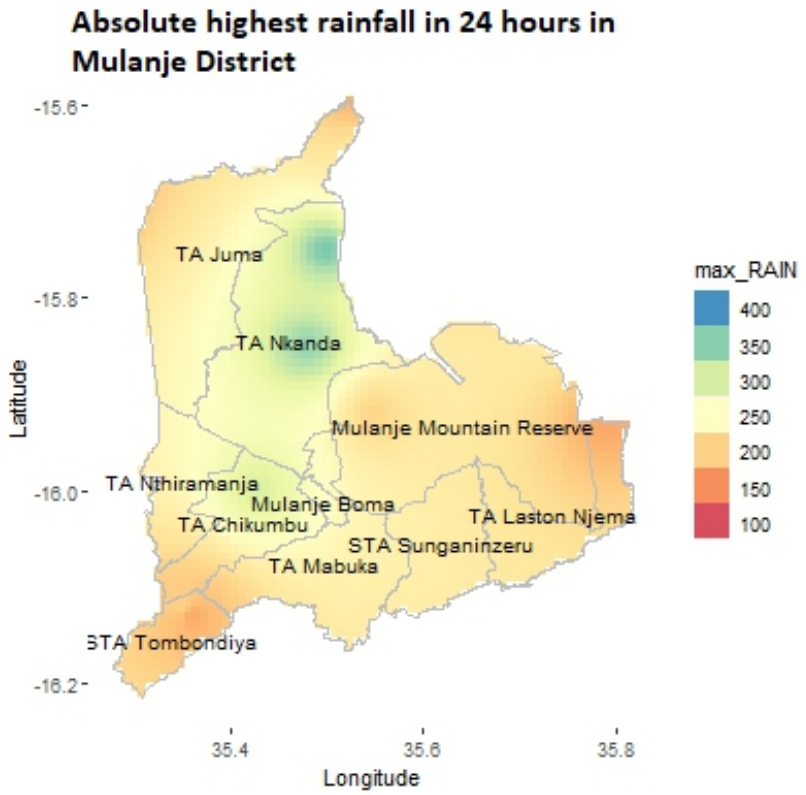

Figure 3 Absolute maximum rainfall in Mulanje district

c. Heatwaves (high temperatures)

A heatwave is an extended period of hot weather relative to the expected conditions of the area at a certain time of year. Global climate change is likely to be accompanied by an increase in the frequency and intensity of heatwaves as well as by warmer summers and milder winters. Heatwaves can burden health, that can even lead to deaths.

The areas to the western side of Mulanje district are at a higher risk of heatwave and extremely hot temperatures. These areas are such as TA Juma, TA Nkanda, TA Nthiramanja, TA Chikumbu and STA Tomboniya (Fig. 4). As heat waves have the capacity to exacerbate droughts and wildfires, which can lead to negative impacts on the agricultural sector, these areas are at a high risk of food and livelihood insecurity if people lose their crops or livestock due to the extreme heat.

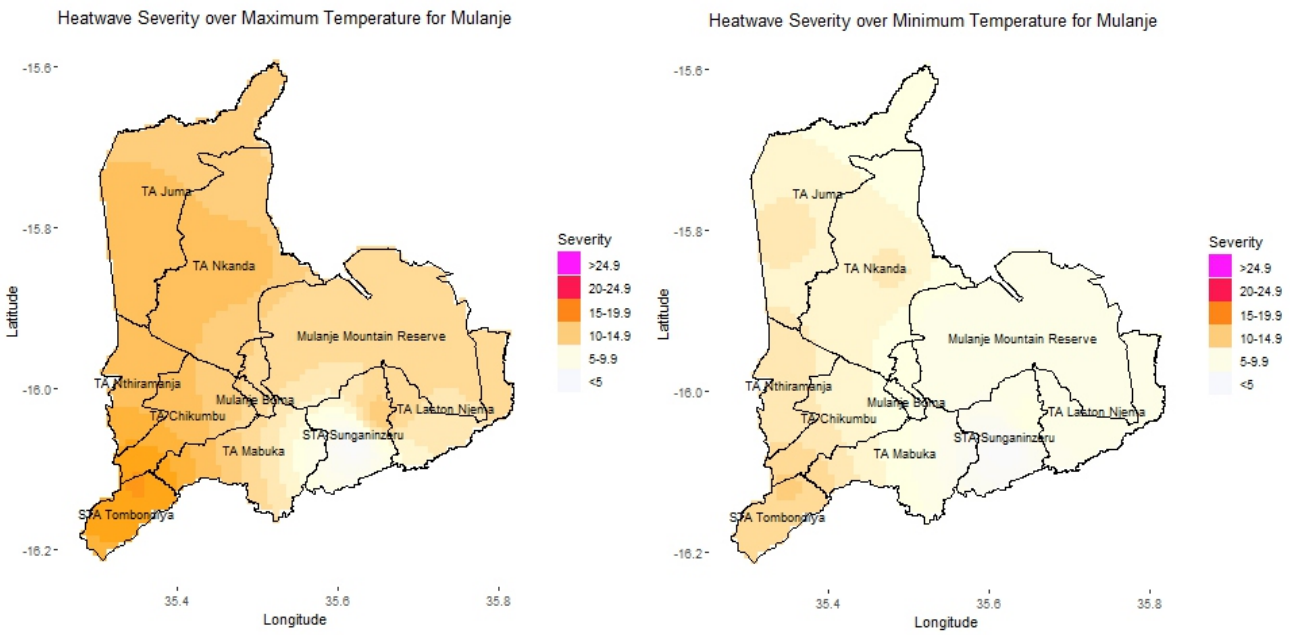

Figure 4 The heatwave based on maximum temperature (left) and minimum temperature (right)

d. Dry spells

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

Climatologically, Malawi's rainfall season starts from October to March in Southern Region. October to December are months in which the onset of rains generally occurs. During this time there have been occurrences of dry spell and prolonged dry spells at times. This in turn affects the planting dates as well as the duration of rainfall season. Fig. 5 depicts the frequency of more than 7-day (5a) and that of more than 14-day (5b) dry spells respectively. The months in consideration are October to November (OND) for the period of 1981 to 2020.

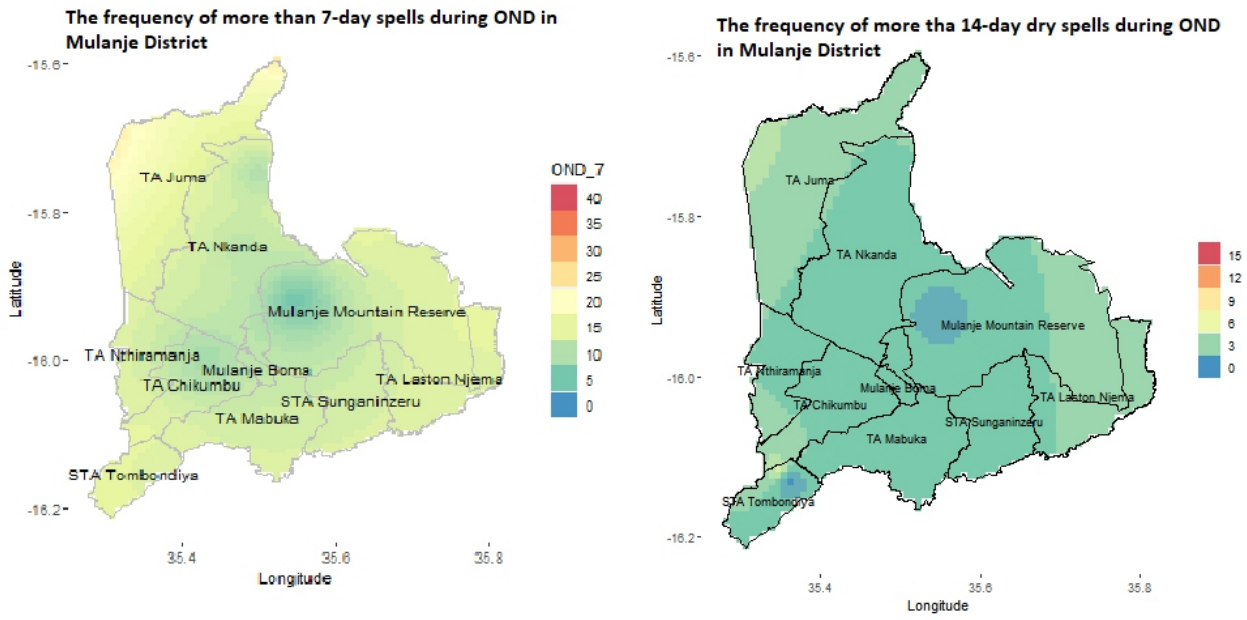

Figure 5 The frequency of dry spells of more than 7 days (a) and more than 14 days (b) in Mulanje district during the October-November-December season

From the figure above it is evidenced that the 7-day dry spells that occur at the start of rainfall season are common in Mulanje. The frequency of these dry spells ranges from 10 to 20 times (40-53% probability of occurrences) during 1981-2020 with the Mulanje Mountain reserve having lowest number dry spells of 5 days. On the other hand, the occurrences of prolonged dry spells beyond 14 days are less common in Mulanje district except areas of TA Laston Njema, TA Juma and south west of TA Chikumbu and TA Tombondiya in which the frequency is in the range of 3 to 6 representing 8 to 13% probability.

ii. Frequency of dry spells during the season

During the rainfall season from January to March, dry spells are common. As shown in Fig.6, the frequency of 7-day dry spells ranges from 15 to 25 (55 to 71% probability) in January and February respectively. In March, there is a higher frequency of 30 to 40 (80 to 100%), (Fig.6 upper panel). 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 Mulanje District. The 14-day dry spells in the district are also worse in March compared to January and February (Fig.6 lower panel) where the frequency ranges from 6 to 12 (30 to 70% probability). In January, the frequency of the dry spells of more than 14-days is least except west of TA Juma and central Mulanje reserve in which the frequency range is 3 to 6 times.

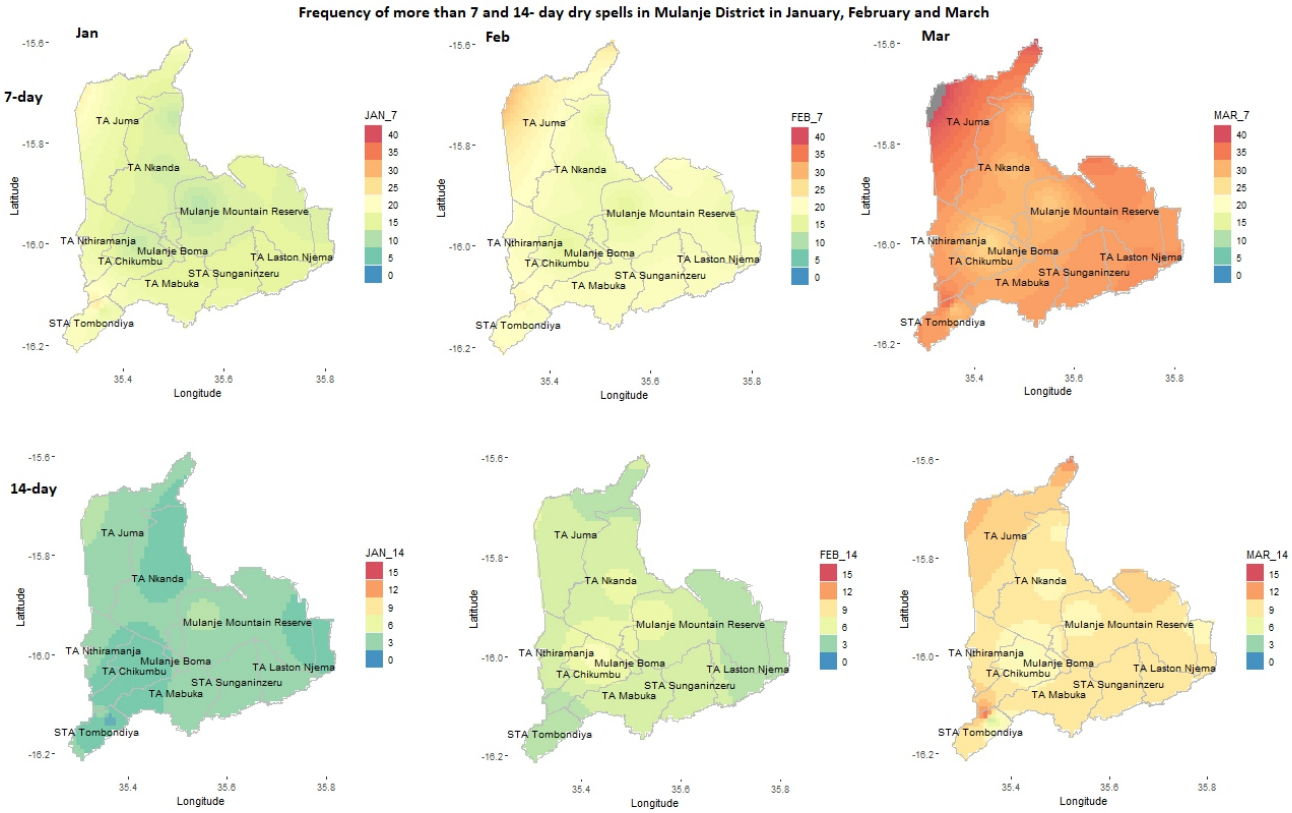

Figure 6 The 7-day (upper panel) and 14-day (lower panel) dry spells in January, February and March in Mulanje district

iii. Dry spell likelihood, impact and risk maps

The spatial distribution of the likelihood, impact and risk of 7-day and 14-day dry spells combined are displayed in Fig. 7. The likelihood of 7-day dry spell is frequent excluding areas around Mulanje mountain reserve, Mulanje boma as well as TA Chikumbu which is probable on likelihood scale. The impact of the 7-day dry spell is moderate and is distributed uniformly across the entire district (Fig. 7 -upper-panel middle), while the risk is high except Mulanje boma and TA Chikumbu in which the risk is medium (Fig. 7 -upper-panel right).

The analysis in Fig. 7 (lower-panel) has considered all the rainfall season from October to March and also both 7-day and 14-day dry spells which in some instances the effects may offset each other. The likelihood of dry spells is probable in the district except TA Chikumbu and Mulanje Boma. The impact and the risk of these dry-spells is moderate and medium across the district respectively, except for STA Tombodiya where the impact is significant and the risk is extremely high (Fig.7 lower panel (middle and left)).

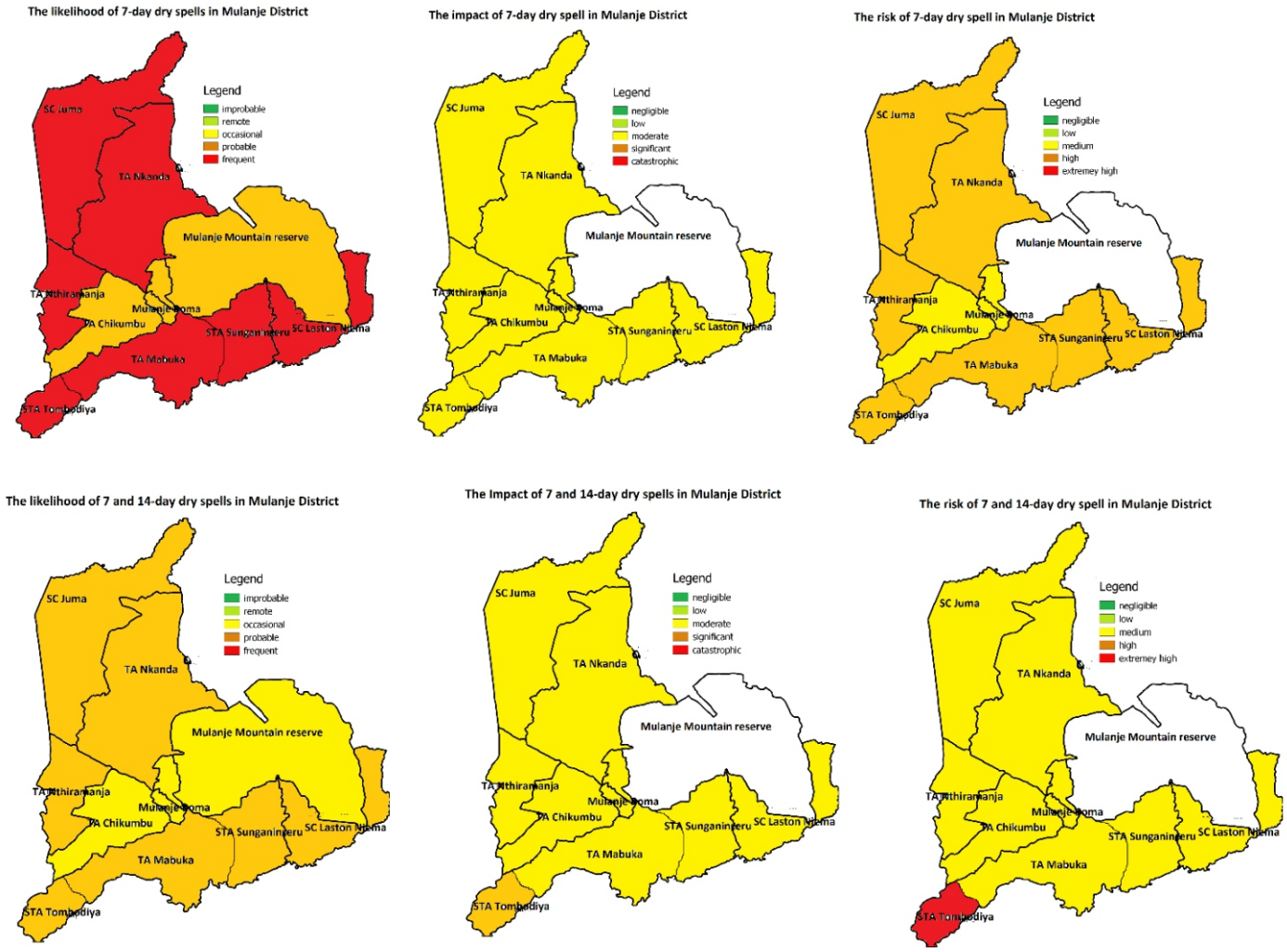

Figure 7 The overall likelihood, impact and risk of dry spells (from left to right respectively) per TA. The 7-day dry spells are in upper panel and the combination of 7-day and 14-dry spells are presented in lower panel. The scales are explained in Section 1d. The impact of dry spells is estimated based on the proportion of people affected. So Mulanje Mountain Reserve is not included 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 in some instances. 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 $-1 \leq SPEI \leq -1.49$ is defined as moderate drought, severely dry $-1.5 \leq SPEI \leq -1.99$ is a severe drought and extremely dry $SPEI \leq -2$ 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 Mulanje district. For example, Mimosa and Chisitu experienced 26 drought episodes each during the period, while Chambe and Nkanda had 21 events each (Red in the figures).

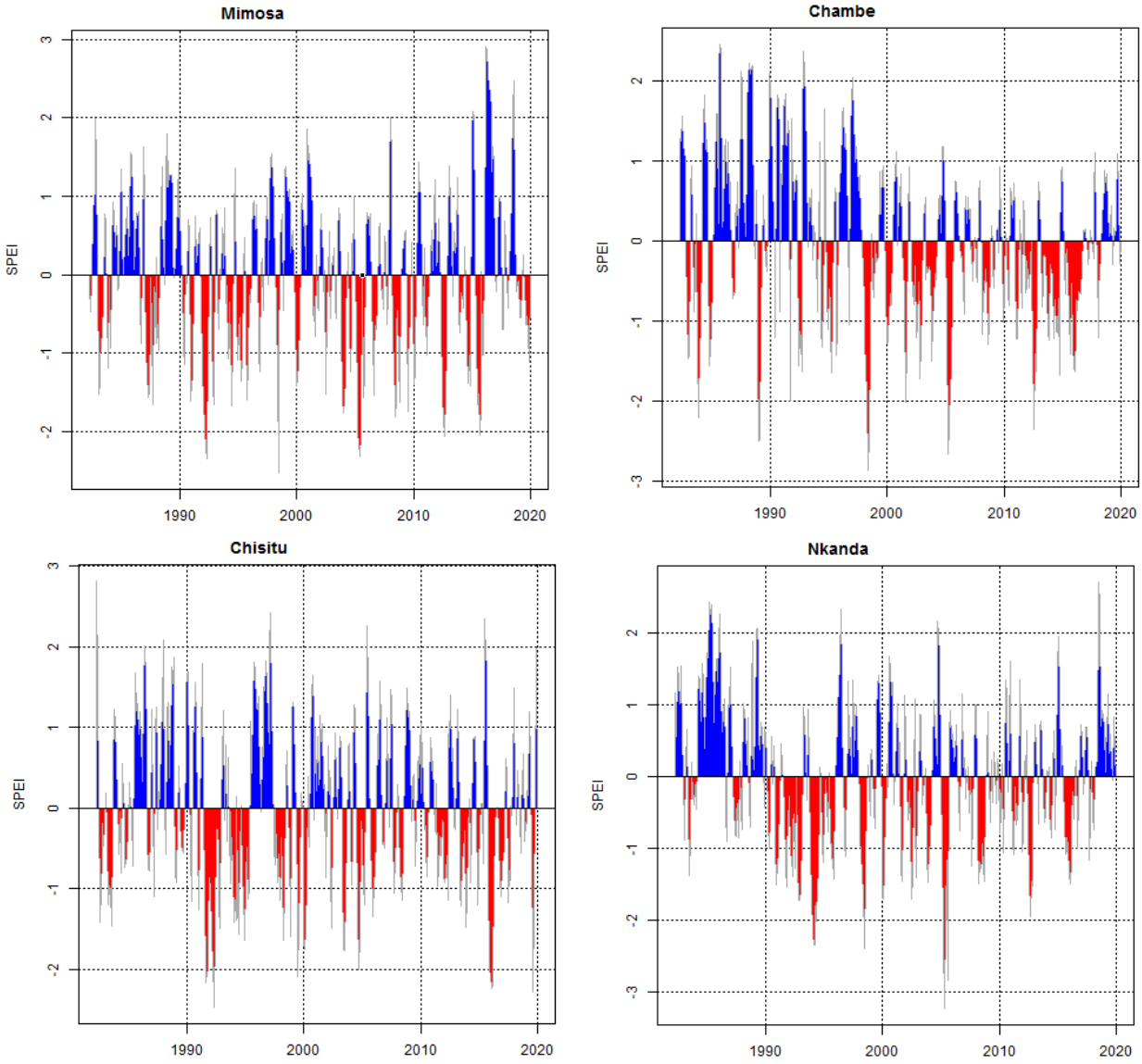

Figure 8 The drought series (red) from 1981 to 2020 at Mimosa (upper-left), Chambe (upper-right) and Chisitu (lower-left) and Chinyama (lower-right). The drought starts when SPEI<-1 and ends when SPET>0.

In space (Fig. 9), the drought frequency ranges from 23 to 27 events in Mulanje district with the duration of 5 and 7 months on average. More frequent but shorter droughts are generally experienced in SC Laston Njema and North of SC Juma while longer drought events are experienced in the rest of the district. However, the drought intensity is severe and uniform across the district. In summary, it also shows that drought intensity is significantly increasing in Mulanje District as is shown from various points sampled in the district, Fig. 10

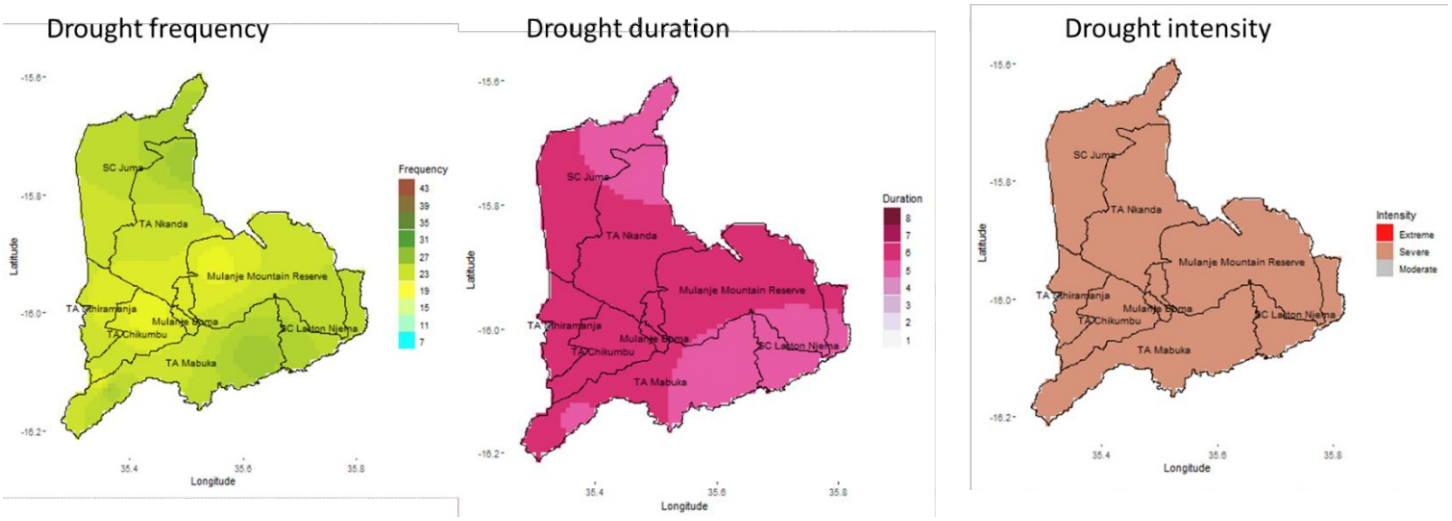

Figure 9 Drought frequency (number of drought years, from 1983 to 2020, left), duration in months (middle) and intensity (right)

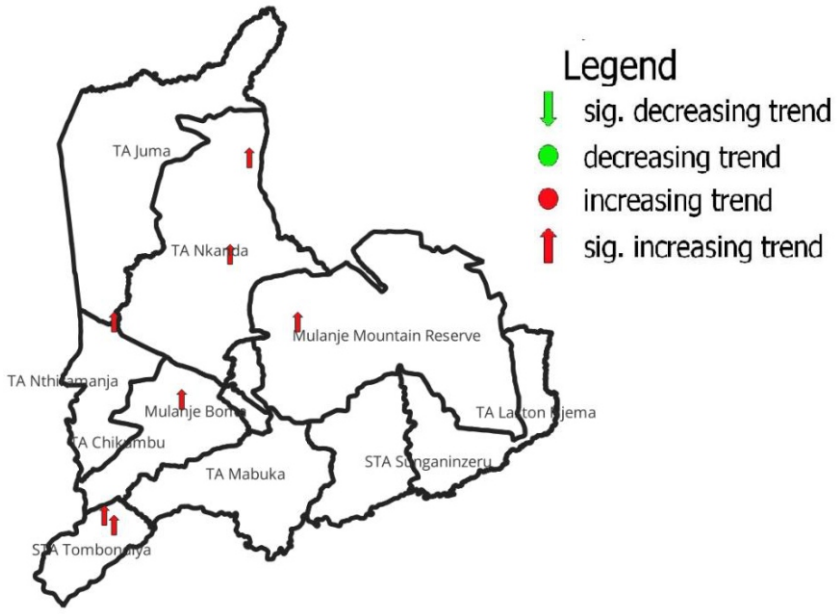

Figure 10 Drought trend in Mulanje district sampled at selected locations. The significance of the trends is based on p-value < 0.05

While the likelihood of drought events is high over SC Juma and TA Nkanda to the north of the district, and SC Laston Njema to the south (Fig. 11 (left)), the impacts of these events

when they occur are significant and uniform across the entire district (Fig. 11 (Middle)). The population living in the areas of SC Juma, TA Nkanda, STA Sunganinzeru and SC Laston Njema are at extremely high risk of these impacts while the rest of the district remains at moderate-risk Fig. 11 (right).

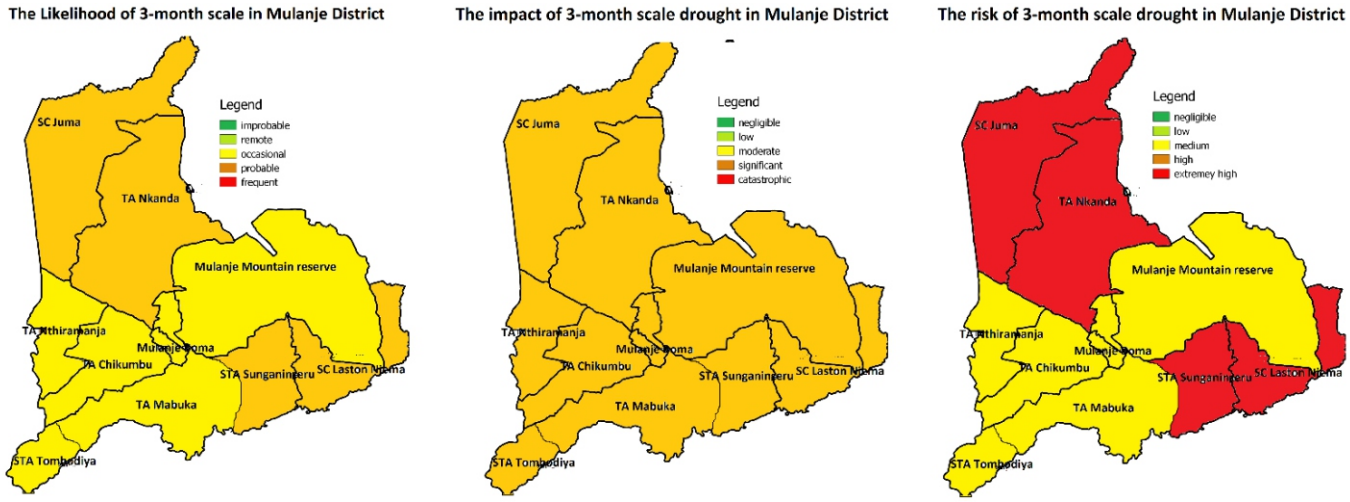

Figure 11 The likelihood, impact and risk of the 3-month scale drought (from left to right respectively) per TA. The impact of droughts is estimated based on the proportion of people affected. The scales are explained in Section 1d.

f. Flood maps

Mulanje is one of the districts in which recurring of flood episodes affect the lives of people. The floods are due to rivers which burst its banks after heavy rainfall. Fig.12 presents an analysis of likely flood prone areas for the district. Overall, STA Thomboya is the most likely flood prone area followed by TA Mabuka.

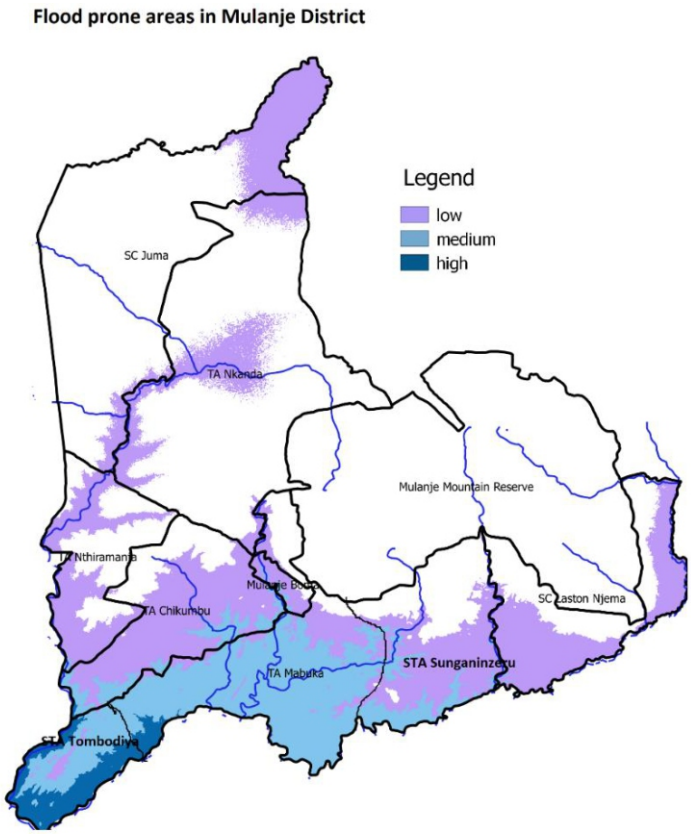

Figure 12 Flood prone areas in Mulanje district

The flood probability, impact and risk are also analysed based on the frequency of flood events for the same time period 1981 to 2020. The likelihood and impact of floods are estimated based on the records from the Department of Disaster Management Affairs. Impact considers the proportion of population affected by floods per TA. The analysis has established probable-likelihood of floods over TAs Tombondiya, Mabuka and Sunganinzeru, and remote-likelihood in TA Chikumbu and Mulanje Boma while it is occasional in the rest of the TAs (Fig. 13-left). The flood impact is low in many TAs and negligible in TA Chikumbu, Fig. 13-middle. While the risk is medium in TAs Tombondiya, Mabuka and Sunganinzeru; low in many TAs except TA Chikumbu which is negligible, Fig. 13-right.

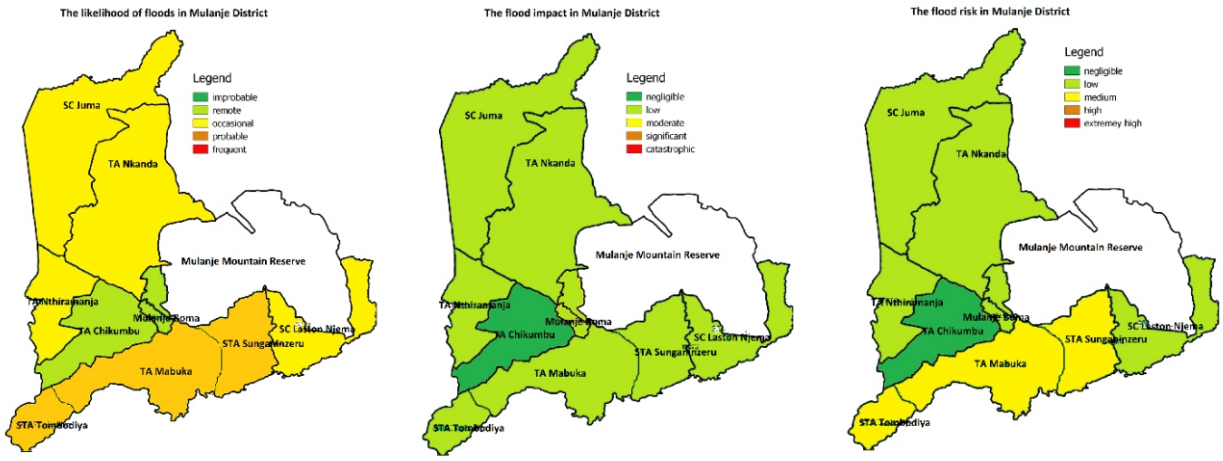

Figure 13 The likelihood, impact and risk of floods (from left to right respectively) per TA. The impact of floods is estimated based on the proportion of people affected. The scales are explained in Section 1d.

g. Overall climate risk

Fig. 14 is summarising the dry spell, drought and flood risk in Mulanje district. The district is entirely at medium-risk. Tab. 3 is ranking the risk by TA from the most vulnerable to the least. Though all the TAs are at the medium-risk of climate extreme events, TA Tombondiya is at the most risk mainly due to dry spells which are at extremely high-risk while droughts and floods are at medium-risk. TA Tombondiya is followed by TA Sunganinzeru which is at extremely-high risk of droughts and medium-risk of dry spells and floods. TAs Juma, Nkanda and Laston Njema are also at extremely high risk of droughts, medium-risk of dry spells but low-risk of floods. TA Mabuka is at medium-risk of all the three hazards, while TA Nthiramanja and Mulanje Boma are at medium-risk of dry spells and droughts while floods are at low-risk. TA Chikumbe has medium-risk of dry spells and droughts and low-risk of floods.

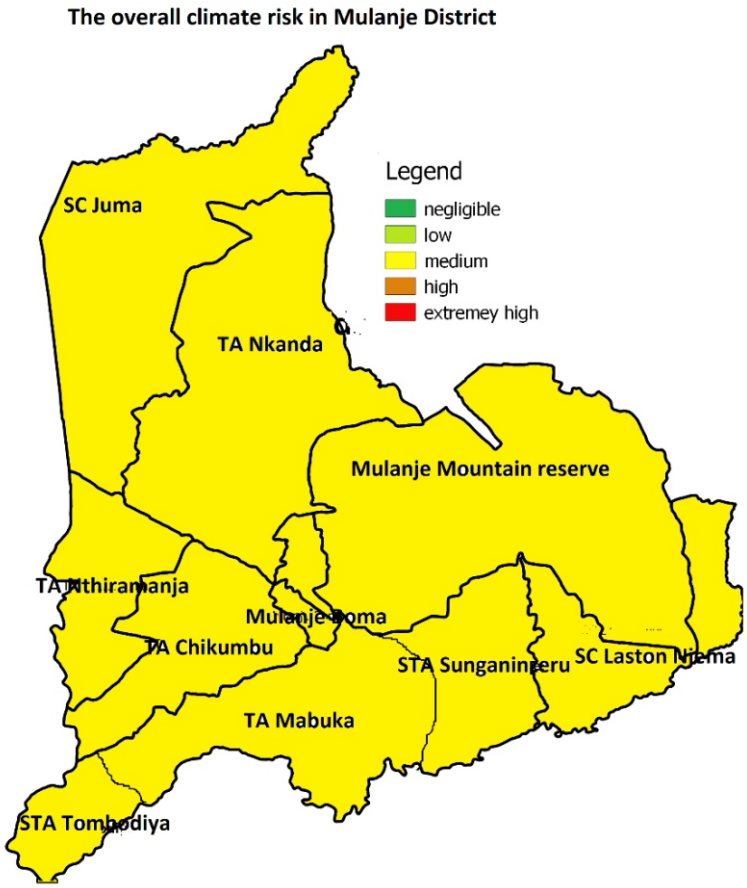

Figure 14 Overall climate risk in Mulanje district per TA (summary of dry spells, drought and floods)

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	Tombondiya	Extremely high	Medium	Medium	Medium
2	Sunganinzeru	Medium	Extremely high	Medium	Medium
3	Juma	Medium	Extremely high	Low	Medium
4	Nkanda	Medium	Extremely high	Low	Medium
5	Laston Njema	Medium	Extremely high	Low	Medium
6	Mabuka	Medium	Medium	Medium	Medium
7	Nthiramanja	Medium	Medium	Low	Medium
8	Mulanje Boma	Medium	Medium	Low	Medium
9	Chikumbu	Medium	Medium	Negligible	Medium

3. Conclusion

The objective of the study was to delineate the climate risk hot spots in Mulanje 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 is that all the TAs in the district are at medium-risk of climate extremes, however, TA Tombondiya is affected most and worst hazard is dry spells, while droughts are highly affecting TAs Sunganinzeru, Nkanda, Juma and Laston Njema. TA Chikumbu is ranked the lowest.

Climate change adaptation and interventions for the management of climate risks to reduce the impacts of these climate hazards is paramount in Mulanje district.

4. References

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