



MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE

# DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

## Climate Risk Maps Phalombe District

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## TABLE OF CONTENTS

1. Introduction .....	2
a. <b>Geography</b> .....	2
b. <b>Climate and common hazards in Phalombe District</b> .....	2
c. <b>Objective of the study</b> .....	2
d. <b>Methods</b> .....	2
2. Climate Risk Maps .....	4
a. <b>Rainfall trend in Phalombe District</b> .....	4
b. <b>Extreme rainfall</b> .....	4
c. <b>Heatwaves (high temperatures)</b> .....	5
d. <b>Dry spells</b> .....	6
i. Frequency of dry spells at the beginning of the season .....	6
ii. Frequency of dry spells during the season .....	6
iii. Dry spell likelihood, impact and risk maps .....	7
e. <b>Drought events</b> .....	8
f. <b>Flood maps</b> .....	12
g. <b>Overall climate risk</b> .....	13
3. Conclusion .....	13
4. References .....	14
5. Acknowledgement .....	14

## **1. Introduction**

### **a. Geography**

Phalombe District lies in the southern region of Malawi and it covers 1,323 square kilometres. Phalombe district has a population of 429,450 (National Statistical Office, 2019) that spread in 6 traditional authorities (TAs). From the northern side of the district, the TAs are Chiwalo which has a total population of 43,933; Jenala 88,237; Kaduya 79,357; Nazombe 60,745; Mkhumba 110,623; and Nkhulambe 40,313 and Phalombe Boma 6,242. Phalombe District is within the Shire Highlands at an altitude range from 623 to 786 meters above sea level. Phalombe makes boundary with Lake Chirwa over the north in TA Chiwalo and Jenala Fig.1. The main crops that are grown in Phalombe are maize, millet, sorghum, rice, sweet potatoes, beans and cotton. Most of the farming activities rely on rain during summer while winter cultivation is largely based on irrigation along the main rivers in the district. Phalombe district has a lot of livestock such as cattle, goats, sheep and chickens.

### **b. Climate and common hazards in Phalombe District**

The climate in Phalombe district is mainly cool to warm where the mean maximum temperatures is about 32 degrees Celsius in summer and mean minimum is 10 degrees Celsius in winter. The annual rainfall ranges from less than 630mm to 1540mm. Phalombe is prone to both floods and droughts/dry spells and some of the worst floods occurred in January 2015, March 2019, January 2022 and March 2022 (GOM, 2015; GOM, 2019). Phalombe district was ranked second most affected district during 2019 floods with loss and damages amounting to 26 million US dollar (~ MWK 26,681,330,000) (GOM, 2019). The district is also prone to recurrent pests that destroy crops. These pests often times are prominent during 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 Phalombe 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**

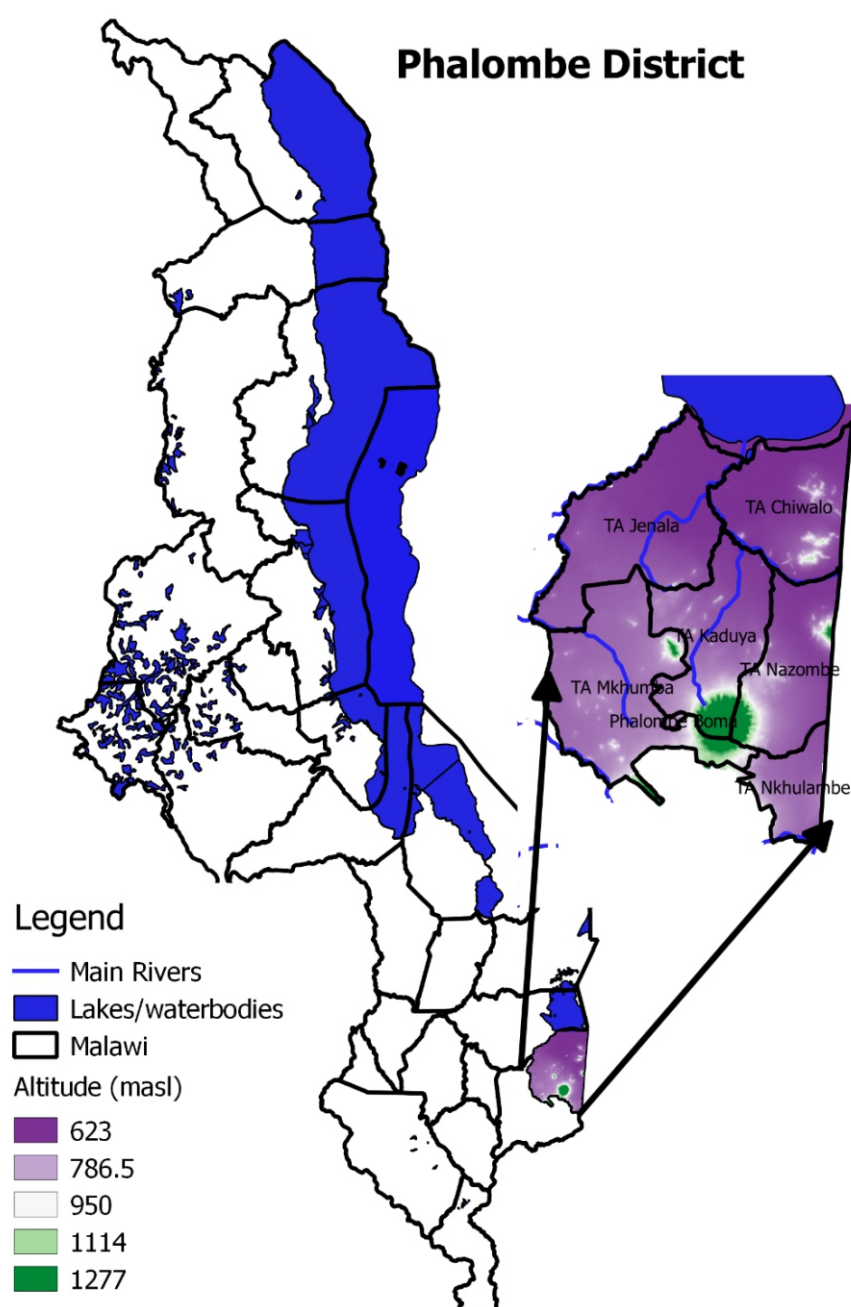
The development of risk maps follows the definition below, where the **Risk** is the product of **Likelihood** and **Impact**.

**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 1 The 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

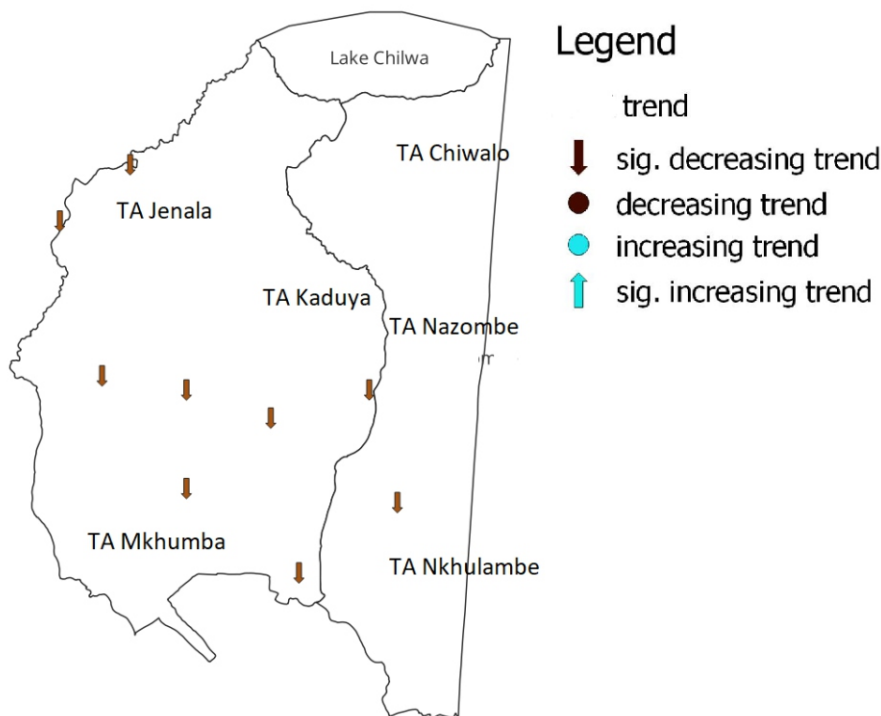


*Figure 1 Phalombe District, traditional authorities (TAs), rivers and topography*

## 2. Climate Risk Maps

### a. Rainfall trend in Phalombe District

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



*Figure 2 Rainfall trend in Phalombe district at selected locations. 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 absolute rainfall amounts ever recorded in the district to provide a picture of pattern of rainfall extremes in Phalombe. The maximum absolute rainfall (highest recorded in 24 hours) ranges from 110 to 310 mm in the district. Areas in southern TA Chiwalo, TA Nazombe and TA Mkhumba ever experienced rainfall exceeding 300mm in just a day. In most areas, rainfall of greater than 155mm has ever been observed, Fig.3.



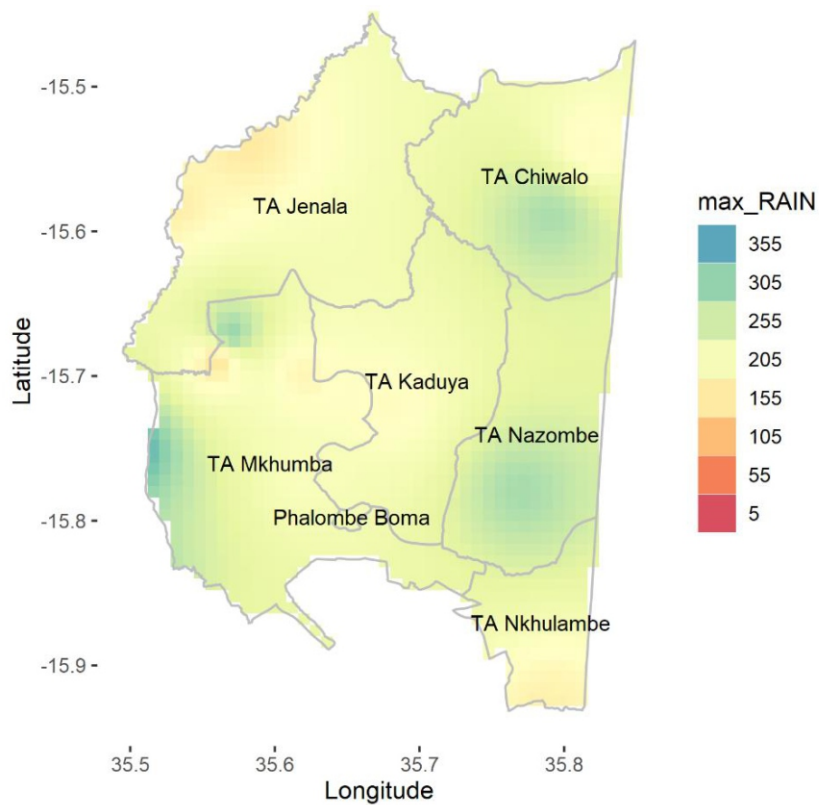


Figure 3 Absolute maximum rainfall in Phalombe district

### c. Heatwaves (high temperatures)

The severe heatwaves are likely in areas within TA Chiwalo spreading into TA Jenala and some parts of TA Mkhumba, Fig.4.

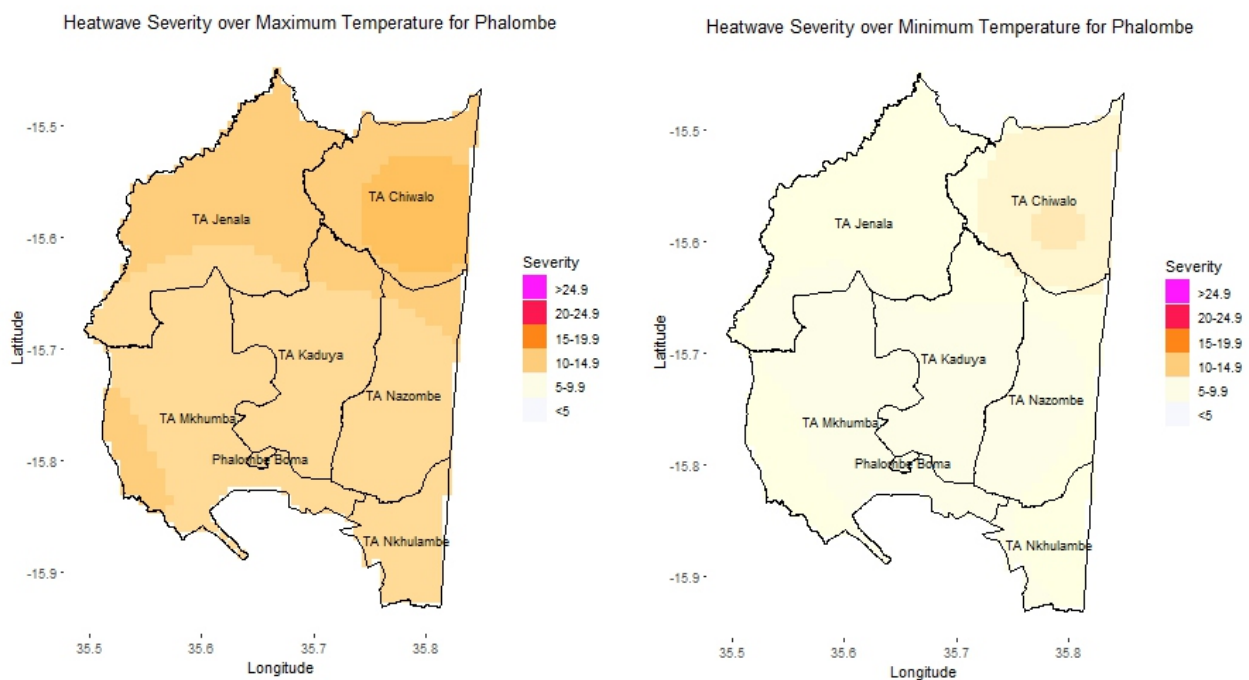


Figure 4 The heatwave based on maximum temperature (left) and minimum temperature (right)

#### d. Dry spells

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

The dry spells at the beginning of rainfall season are presented in Fig. 5. 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 Phalombe district.

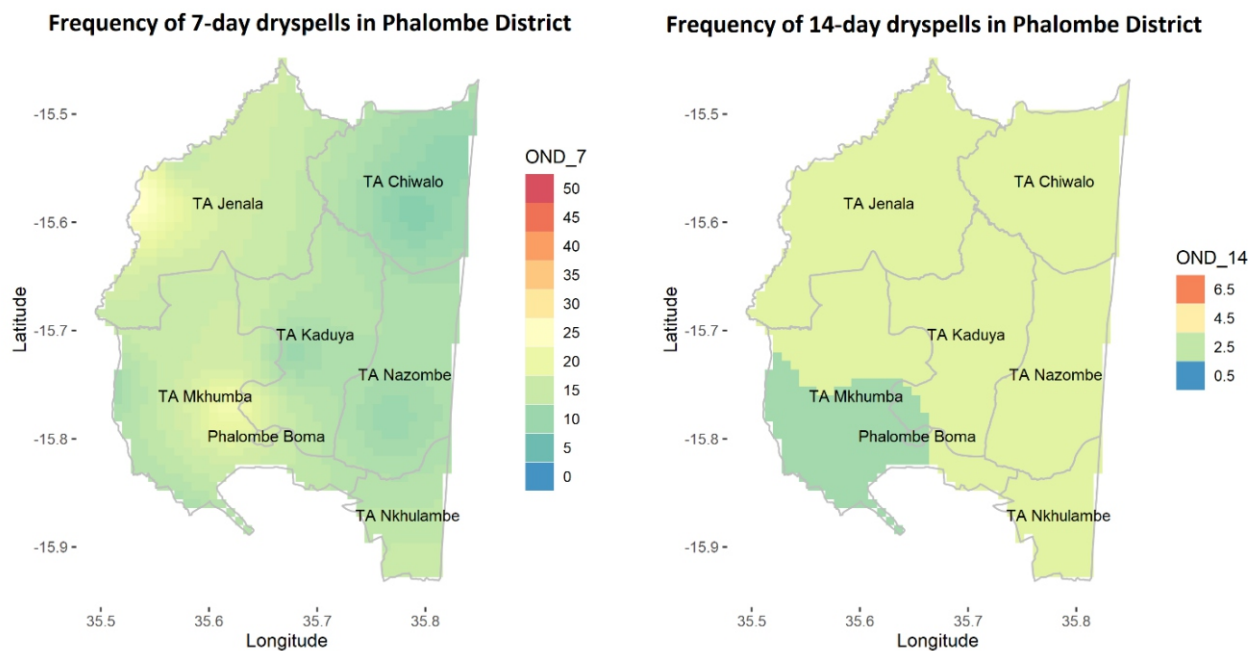


Figure 5 The frequency of dry spells of more than 7 days (a) and more than 14 days (b) in Phalombe district

The 7-day dry spells at the beginning of rainfall season in October-November-December (OND) are most common in TAs Jenala and Mkhumba. The frequency of these dry spells ranges from 20 to 30 which is the probability between 40 to 60% while the rest of the district ranges from 5 to 15 thus the probability between 10 to 30%.

The prolonged dry spells beyond 14 days at the beginning of rainfall season are less common in Phalombe with only 3 of such events ever occurred since 1981.

##### ii. Frequency of dry spells during the season

The dry spells are also common during the rainfall season, especially in the months of January, February and March. The frequency of 7-day dry spells ranges from 9 (22% probability) in January in TA Chiwalo to 18 (45%) for the rest of the district. For February this ranges between 10-20 (25-50%) over TA Chiwalo, Kaduya, Nazombe and Nkhulambe. The month of March is also affected by dry spells over most areas in Phalombe. The frequency

is greater than 20 spells over the district. March also marks the cessation of rainfall season (Fig. 6 upper-panel).

The 14-day dry spells in Phalombe are most frequent in February and March compared to January, where the frequency in March ranges from 10 to 12 (25 to 30% probability) in TAs Jenala, Kaduya, Mkhumba, Nazombe and Nkhulambe while in TA Chiwalo, frequency ranges from 4 to 6 which represents 10% to 15% probability. In February, the highest frequency for dry spells is in TA Jenala where the frequency is up to 6 (15% probability). The least frequent dry spells in January are in TA Chiwalo with only one 14-day spell event to have ever occurred.

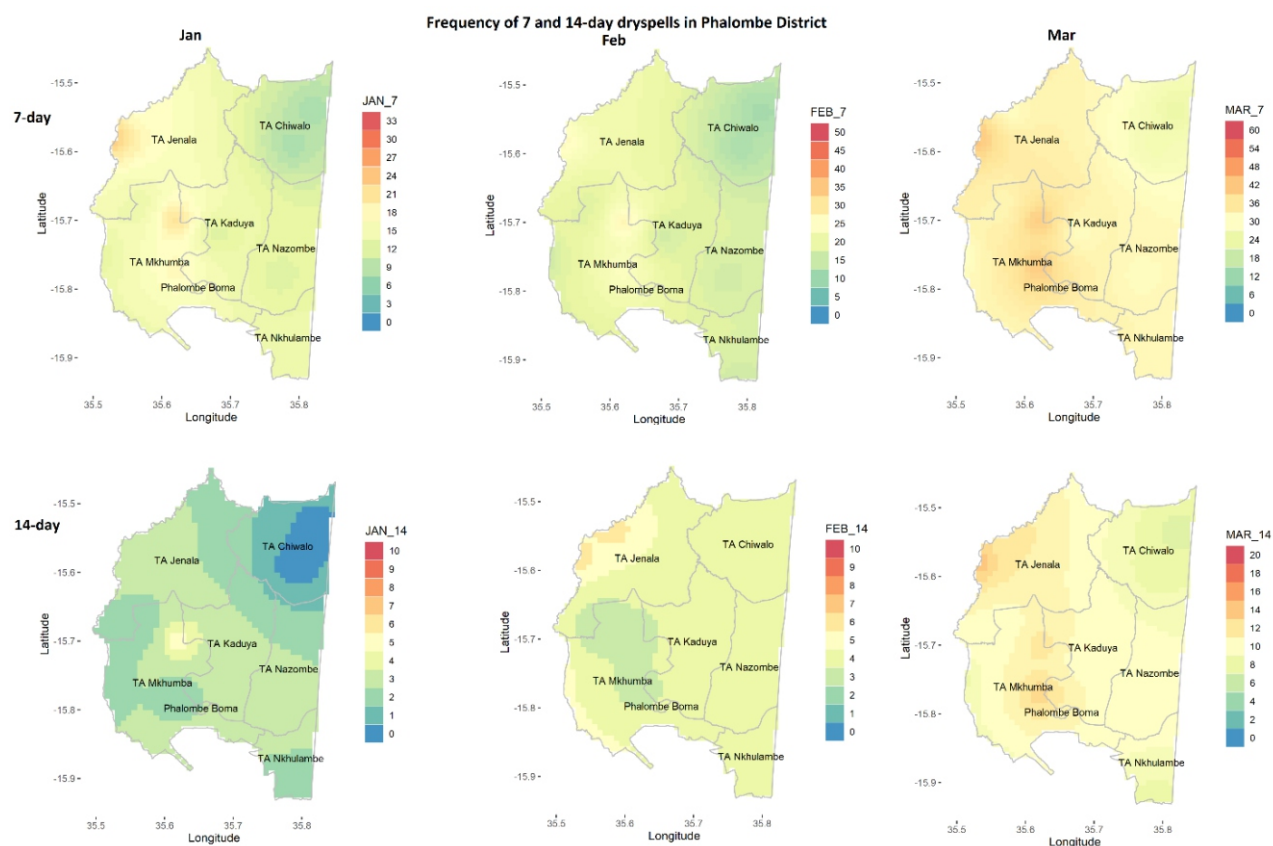


Figure 6 The 7-day (upper panel) and 14-day (lower panel) dry spells in January, February and March in Phalombe district

### 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 western side of the district has a frequent-likelihood (on likelihood scale) of 7-day dry spells in TA Jenala, TA Mkhumba and Phalombe Boma. While the eastern part of the district has a probable-likelihood (Fig.7 upper-panel (right)). The impacts are generally moderate over the western side of the district in TA Mkhumba, TA Jenala, TA Kaduya, Phalombe Boma and TA Nkhulambe, while low-impact is noted in TAs Chiwalo and TA Nazombe, Fig.7 upper-



panel (middle)). The risk is high in TA Jenala, TA Mkhumba and Phalombe Boma but medium in the rest of the TAs, Fig. 7 upper-panel (right).

When the 7 and 14-day dry spells are combined (Fig. 7 lower panel), the likelihood of dry-spells is probable in TA Jenala, TA Mkhumba and Phalombe Boma; and occasional in the rest of the TAs. While the impact is moderate category on impact scale over TAs Jenala, Kaduya, Mkhumba and Phalombe boma and the rest of the district has low-impact. The risk is medium at TA Jenala, TA Mkhumba, Phalombe boma, TA Kaduya and TA Nkhulambe compared to the rest of the district which has low-risk (Figure 7 lower panel (right)).

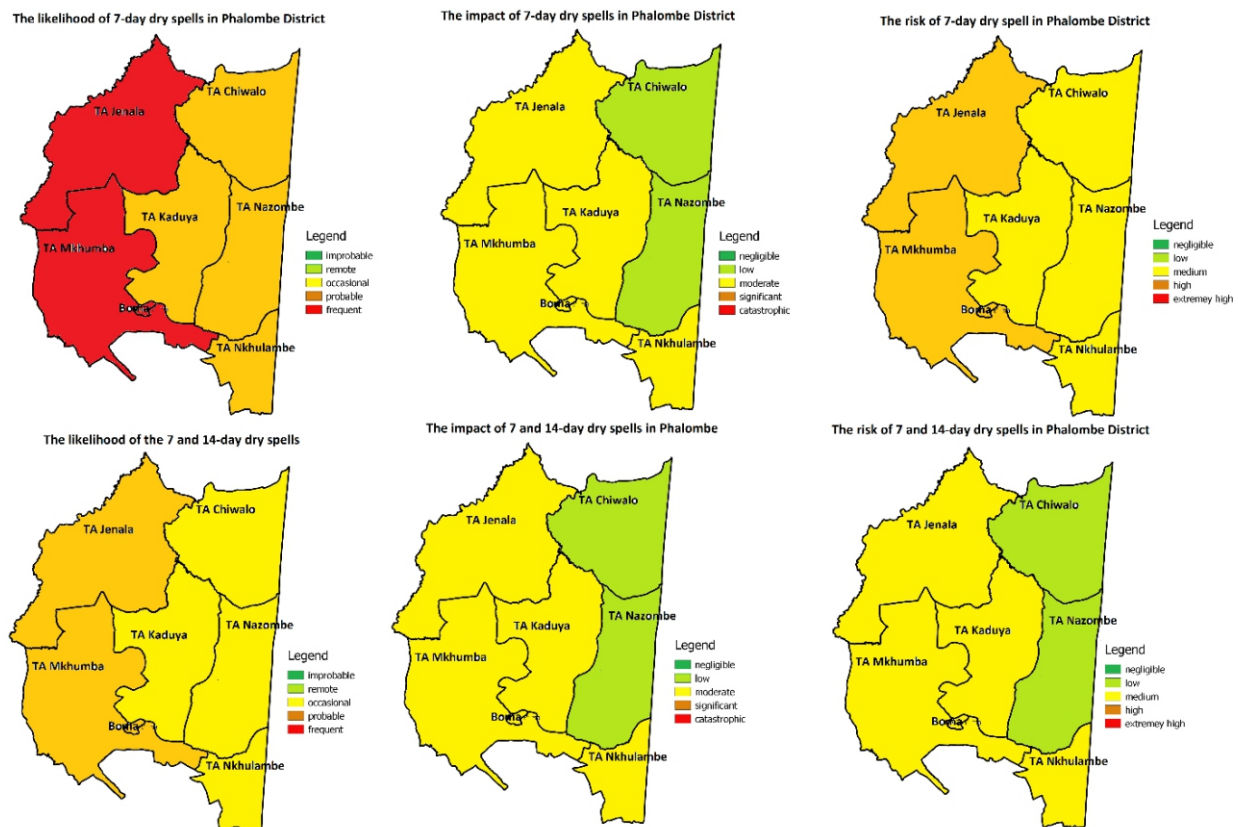


Figure 7 The overall likelihood, impact and risk of dry spells (from left to right respectively) per TA. The 7-day dry spells are in upper panel and the combination of 7-day and 14-dry spells are presented in lower panel. The impact of dry spells is estimated based on the proportion of people affected. 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 and other climatological factors. 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  $-1 \leq \text{SPEI} \leq -1.49$  is defined as moderate drought, severely dry  $-1.5 \leq \text{SPEI} \leq -1.99$  is a severe drought and extremely dry  $\text{SPEI} \leq -2$  is an extreme drought. The SPEI calculation is based on 3-month scale.

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

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

Fig. 8 are the time series of drought events at various locations in the district from 1983 to 2020. The figure shows that droughts are common in Phalombe district. For example, Naminjiwa experienced 24 drought events during the period, Tamani 17, Migowi 15 while Nkhulambe experienced 14 events (Red in Fig.8). It is also noted that the drought intensity is increasing in Phalombe district, Fig.9. Almost all the points sampled in the district are showing that the drought intensity is increasing significantly with only two points at Namasoko and Waluma where the increase is there but not significant.

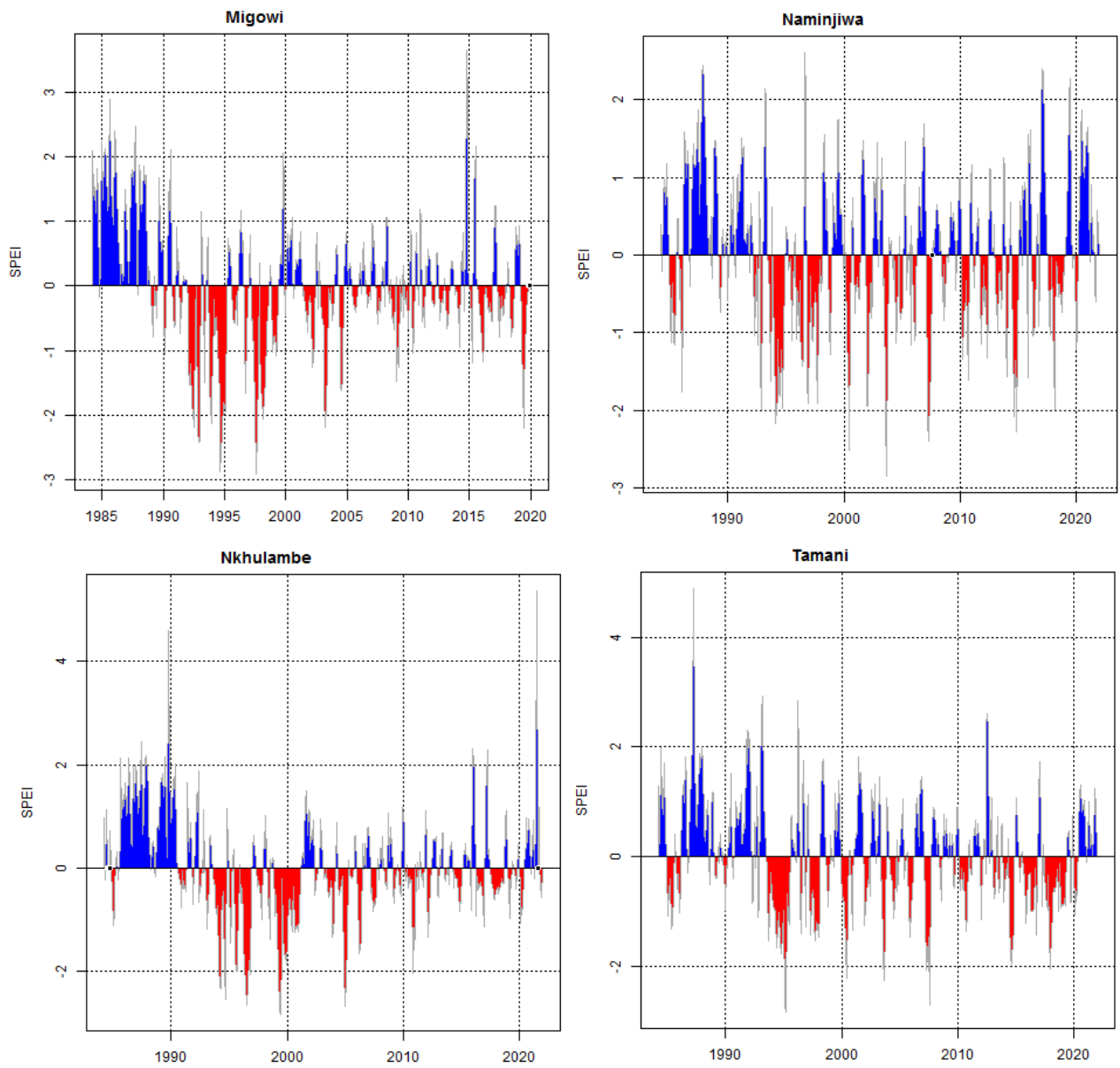


Figure 8 The drought series (red) from 1981 to 2020 at Migowi (upper-left), Naminjiwa (upper-right), Nkhulambe (lower-left) and Tamani (lower-right). The drought starts when  $SPEI < -1$  and ends when  $SPET > 0$ .

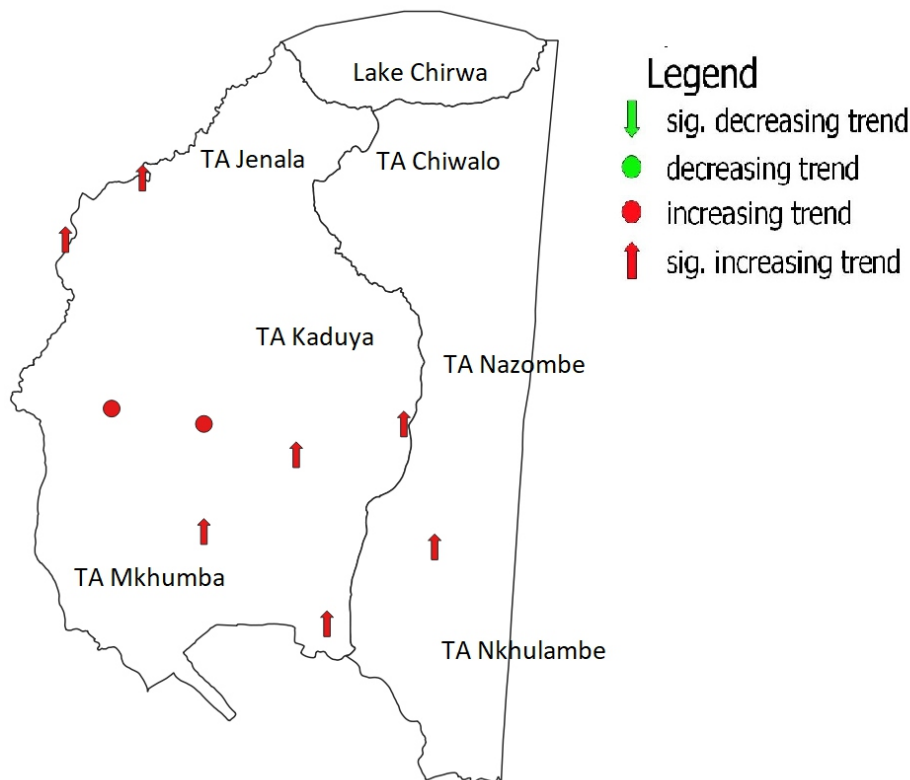


Figure 9 Drought trend in Phalombe district. The significance of the trends is based on  $p\text{-value} < 0.05$

From Fig. 10, it can be noted that the drought events range from 15 to 23 with the duration range of 4 to 7 months per event. The shorter drought events are generally in TA Mkhumba, TA Chiwalo, TA Jenala and Phalombe Boma, while longer drought events are experienced in TA Nazombe, TA Nkhulambe and to the North Western part of TA Jenala. Though the duration differs but the intensity is similar across the district where the droughts are generally severe (Fig. 10 right).

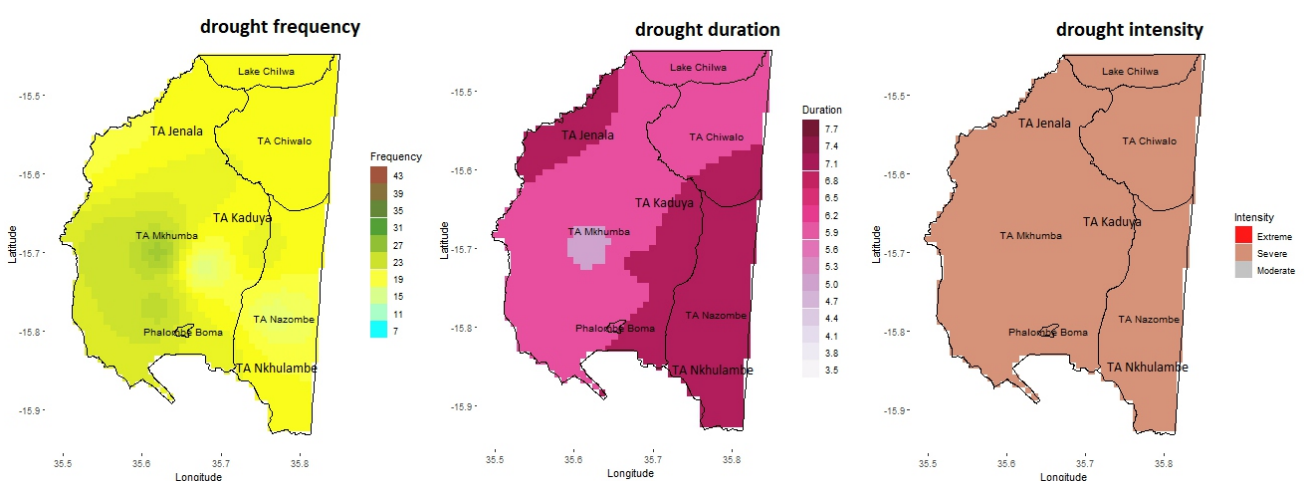


Figure 10 Drought frequency (number of drought years, left), duration (months, middle) and intensity (right)

The likelihood of drought is probable in TA Chiwalo, TA Kaduya and TA Nazombe while it is frequent over TA Jenala, TA Mkhumba, Phalombe boma and TA Nkhulambe. The pattern is

similar to that of dry spells where the highest likelihood probabilities are to the western side of the district. The impact and risk of droughts are uniform across the whole district, where the impact is significant and risk is extremely high, Fig.11.

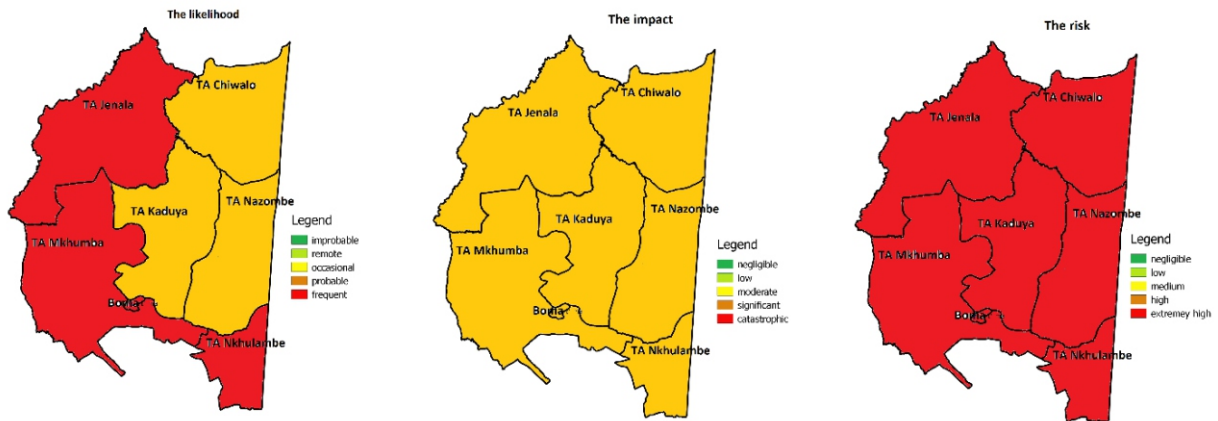


Figure 11 The likelihood, impact and risk of drought (from left to right respectively) per TA. The impact of droughts is estimated based on the proportion of people affected. The scales are explained in Section 1d.

#### f. Flood maps

The flood probability, impact and risk are calculated based on the frequency of flood episode from 1981 to 2020 from the records from the Department of Disaster Management Affairs. The impact of floods is based on the proportion of population affected per TA. The likelihood of floods is occasional in all the TAs in the district. However, the impact is moderate in TAs Chiwalo, Jenala and Mkhumba; low in TAs Nazombe and Nkhulambe and negligible in TA Kaduya and Phalombe Boma (Fig. 12 (middle)). The risk is medium in TAs Chiwalo, Jenala and Mkhumba; low in TAs Nazombe and Nkhulambe but negligible in TA Kaduya and Phalome Boma (Fig. 12 (right)).

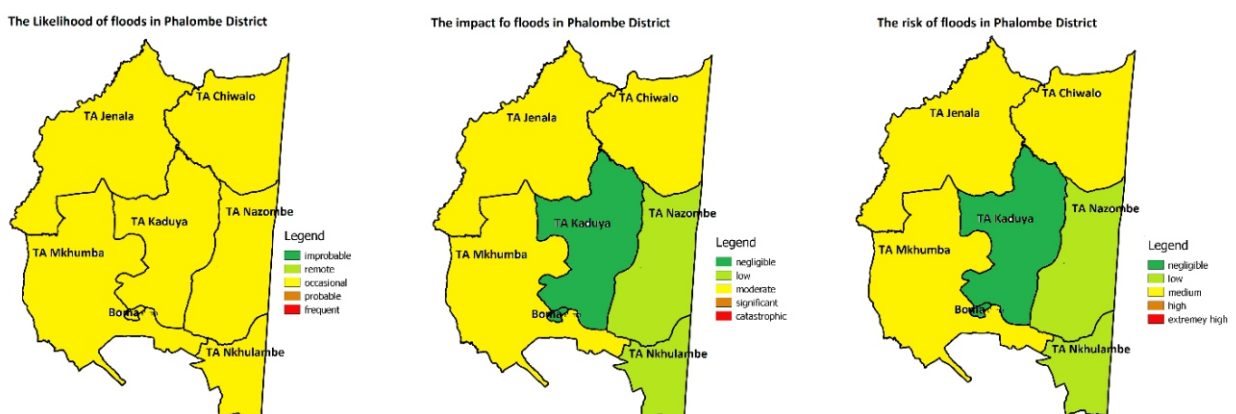


Figure 12 The likelihood, impact and risk of floods (from left to right respectively) per TA. The impact of floods is estimated based on the proportion of people affected. The scales are explained in Section 1d.



### g. Overall climate risk

Fig. 13 is summarising the dry spell, drought and flood risk in Phalombe district. The high-risk is over the western side of the district in TAs Jenala and Mkhumba while medium-risk is in the rest of the TAs including the Phalombe Boma. Tab. 3 is ranking the TAs from highest risk to lowest. TA Jenala has topped the list with high-risk of climate extremes, followed by TA Mkhumba. TA Nkhulambe is third while Phalombe Boma is fourth. The TA with least risk is TA Nazombe where the risk of both floods and dry spells is low. It is however noted that drought risk is extremely high for the whole district.

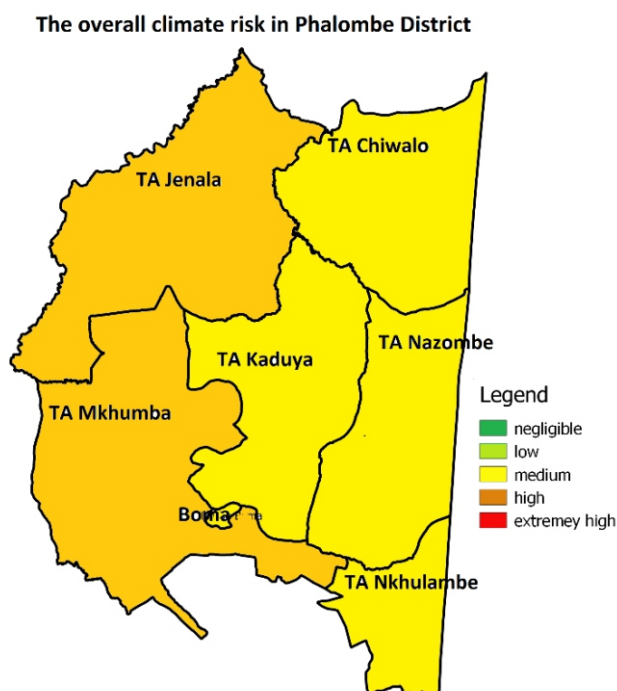


Figure 13 Overall climate risk in Phalombe district per TA (summary of dry spells, drought and floods)

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	Jenala	Medium	Extremely high	Medium	High
2	Mkhumba	Medium	Extremely high	Medium	High
3	Nkhulambe	Medium	Extremely high	Low	Medium
4	Boma	Medium	Extremely high	Negligible	Medium
5	Chiwalo	Low	Extremely high	Medium	Medium
6	Kaduya	Medium	Extremely high	Negligible	Medium
7	Nazombe	Low	Extremely high	Low	Medium

### 3. Conclusion

The objective of the study was to delineate the climate risk hot spots in Phalombe 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 TAs Jenala and Mkhumba have high-risk of climate extreme. Both TAs are highly affected by floods, droughts and dry spells. Still more, the overall climate risk of the rest of the district is medium, indicating that the entire district is vulnerable. Climate change adaptation and measures to reduce the impacts of these climate hazards is paramount in Phalombe district.

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