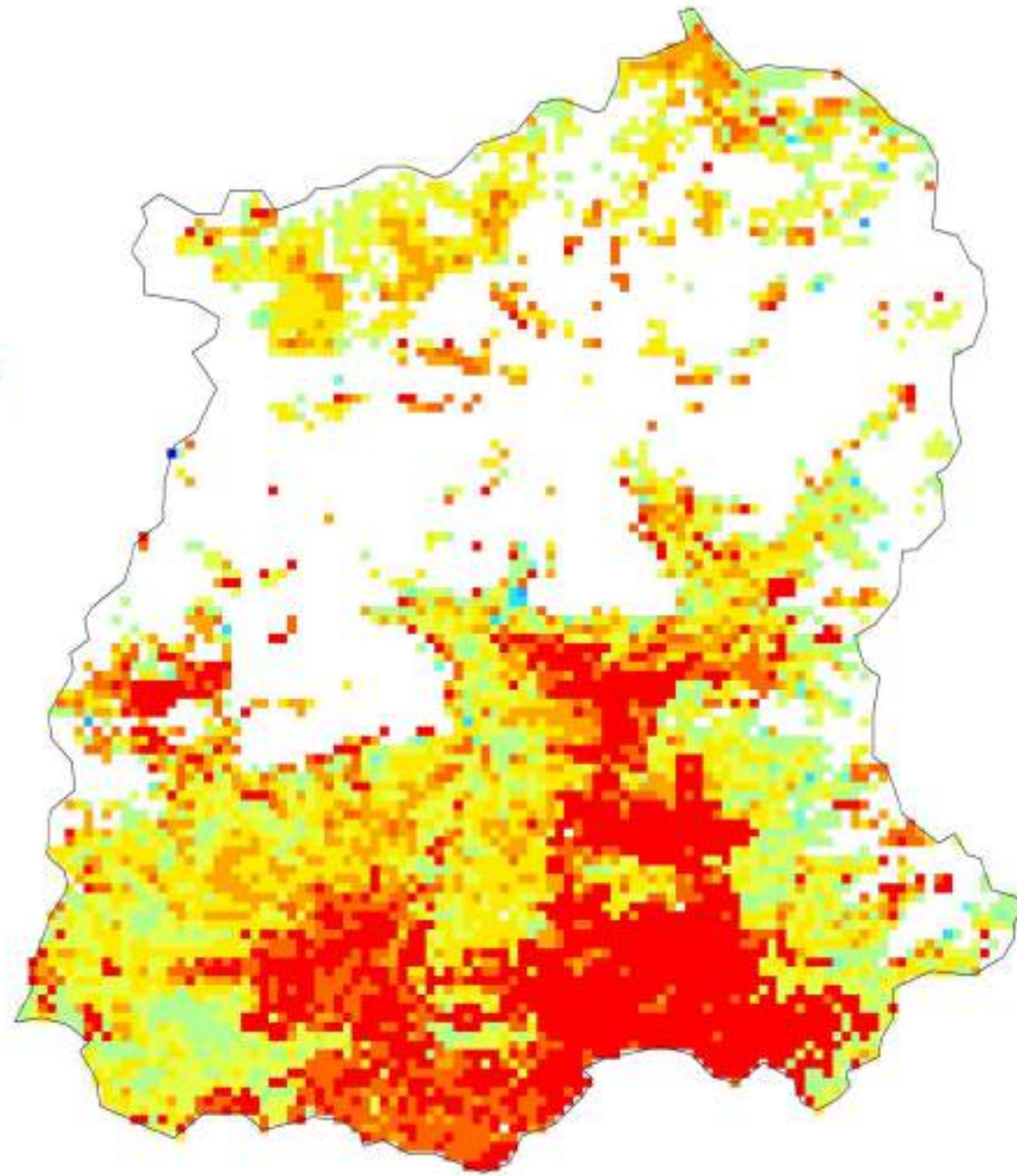
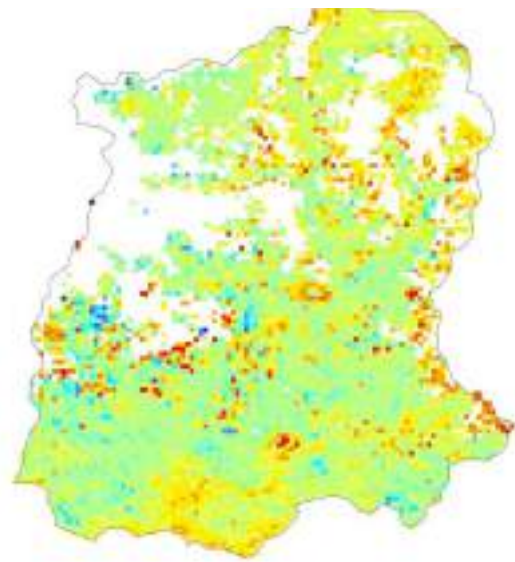


# THE DROUGHT ATLAS OF SIKKIM

Dr. Hemu Kharel Kafle





# The Drought Atlas of Sikkim

Dr. Hemu Kharel Kafle

Center for Water and Atmospheric Research



The Drought Atlas of Sikkim

(Historical monthly drought of Sikkim from 2000-2020)

Dr. Hemu Kharel Kafle

Publisher: Kathmandu Institute of Applied Sciences  
Bagdol, Lalitpur,  
Kathmandu, Nepal.

Figures/Maps: Ms. Soni Khaitu

Edition: First, 2022, January

Price: Rs. 5000.00 (NPR)

ISBN: 978-9937-1-3062-2

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## **Acknowledgement**

The Center for Water and Atmospheric Research (CENWAR) at Kathmandu Institute of Applied Sciences has produced the first edition of the Sikkim Drought Atlas. This Atlas uses a Drought Severity Index (DSI) to highlight the intensity of drought. Descriptive graphs and visuals are used to highlight the drivers and effects of drought in Sikkim.

We would like to thank our collaborators, Prof. Dr. Vimal Khawas from Sikkim University, Sikkim, India for his kind contributions, coordination, and valuable inputs in this atlas of Sikkim.

We are grateful to our technical supervisors Prof. Dr. Yasushi Yamaguchi from Nagoya University and Dr. Shinichi Sobue from GEOGLAM for their advice and inputs in this study. We sincerely thank Asia Pacific Network for Global Change Research (APN) for funding this research work.

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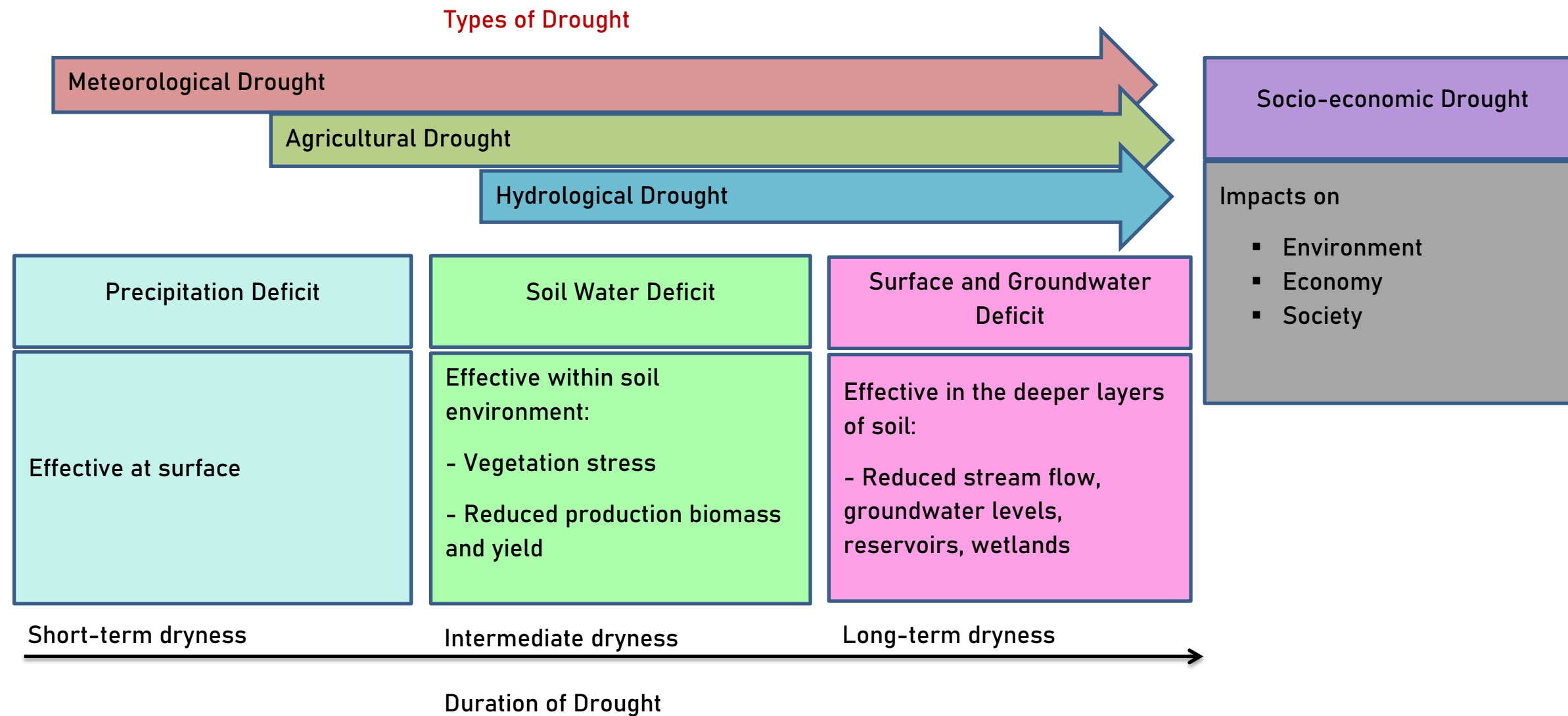


## What is Drought?

Drought is a period of time when there is a lack of water on land. Drought mainly results from abnormally low rainfall leading to water scarcity (Wilhite, 2000b). It is defined as “severe water shortage”.

Drought is a complicated phenomenon, yet one of the least understood of all natural hazards impacting more people than any other disaster (Obasi, 1994). Since the demand for water is increasing along with the population in many parts of the world, water supply interruptions caused by drought can be expected to produce greater impacts (Hewitt, 1997).

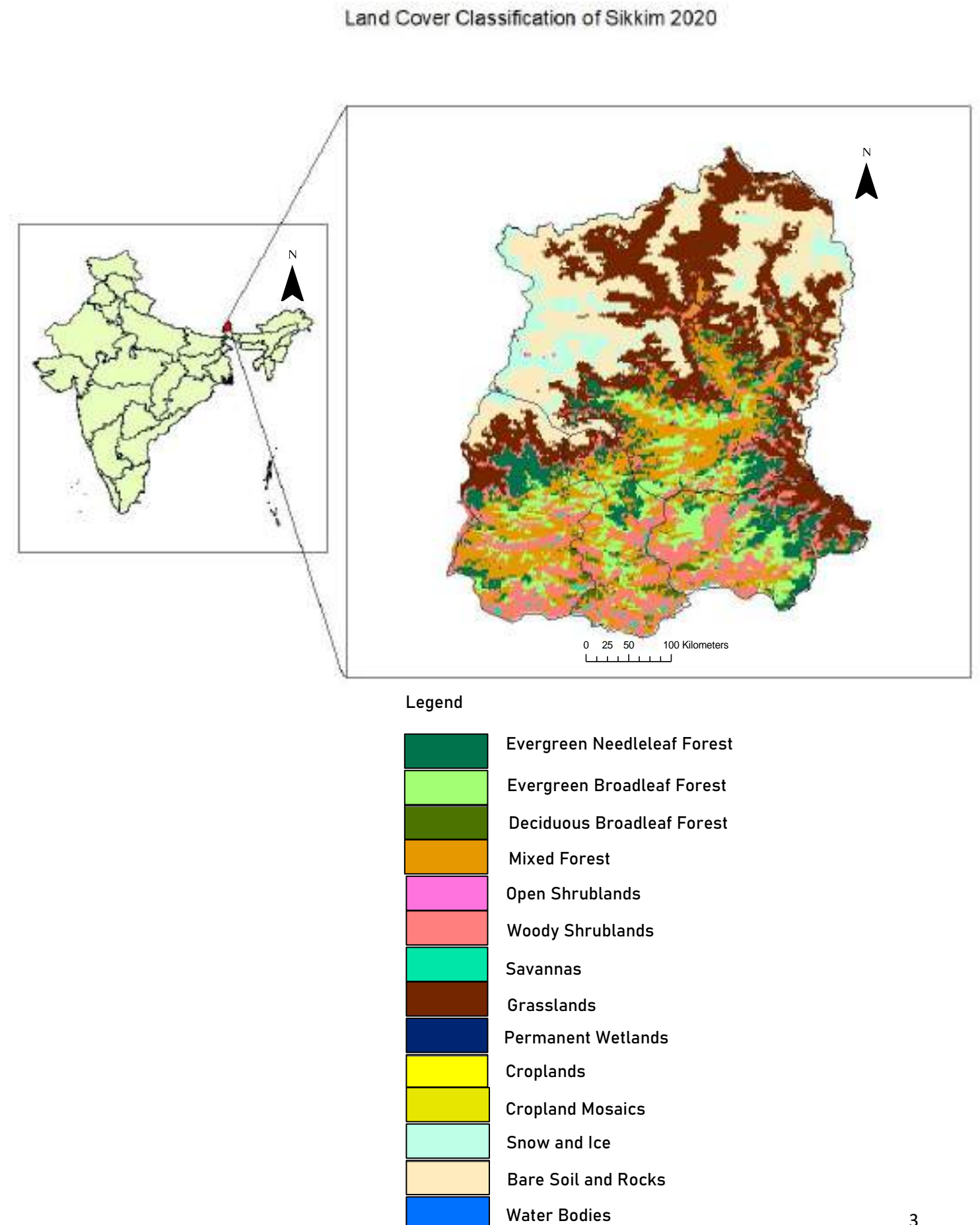
Drought is a global phenomenon; however, their effects are more vulnerable in developing countries because of the lesser potential to mitigate the impacts of such extreme events (Wilhite, 2000).





## Sikkim Overview

Sikkim is a state in northeast India with a land area of 7,096 km<sup>2</sup> and borders Bhutan, Tibet, and Nepal. It is located at latitude 27°31'58.7"N and longitude 88°30'43.98"E. The state of Sikkim is known for its rugged landscape, which is found in the Himalayan highlands. The state is almost entirely hilly, with elevations varying from 280 meters (920 feet) in the south at the border with West Bengal to 8,586 meters (28,169 ft.) in northern peaks near Nepal and Tibet. Because of the steep, precipitous slopes, the terrain is mostly unsuitable for agriculture. Some hill slopes, on the other hand, have been transformed into terrace farms. East Sikkim, North Sikkim, South Sikkim, and West Sikkim are the four districts of Sikkim. Winter, summer, spring, autumn, and monsoon season are the five seasons in the state. The climate in Sikkim varies from subtropical to tundra in the north. The majority of Sikkim's inhabited areas have a temperate climate, with summer temperatures rarely topping 28 °C (82 °F). The average yearly temperature in much of Sikkim is around 18°C (64°F).





## Remotely Sensed Data

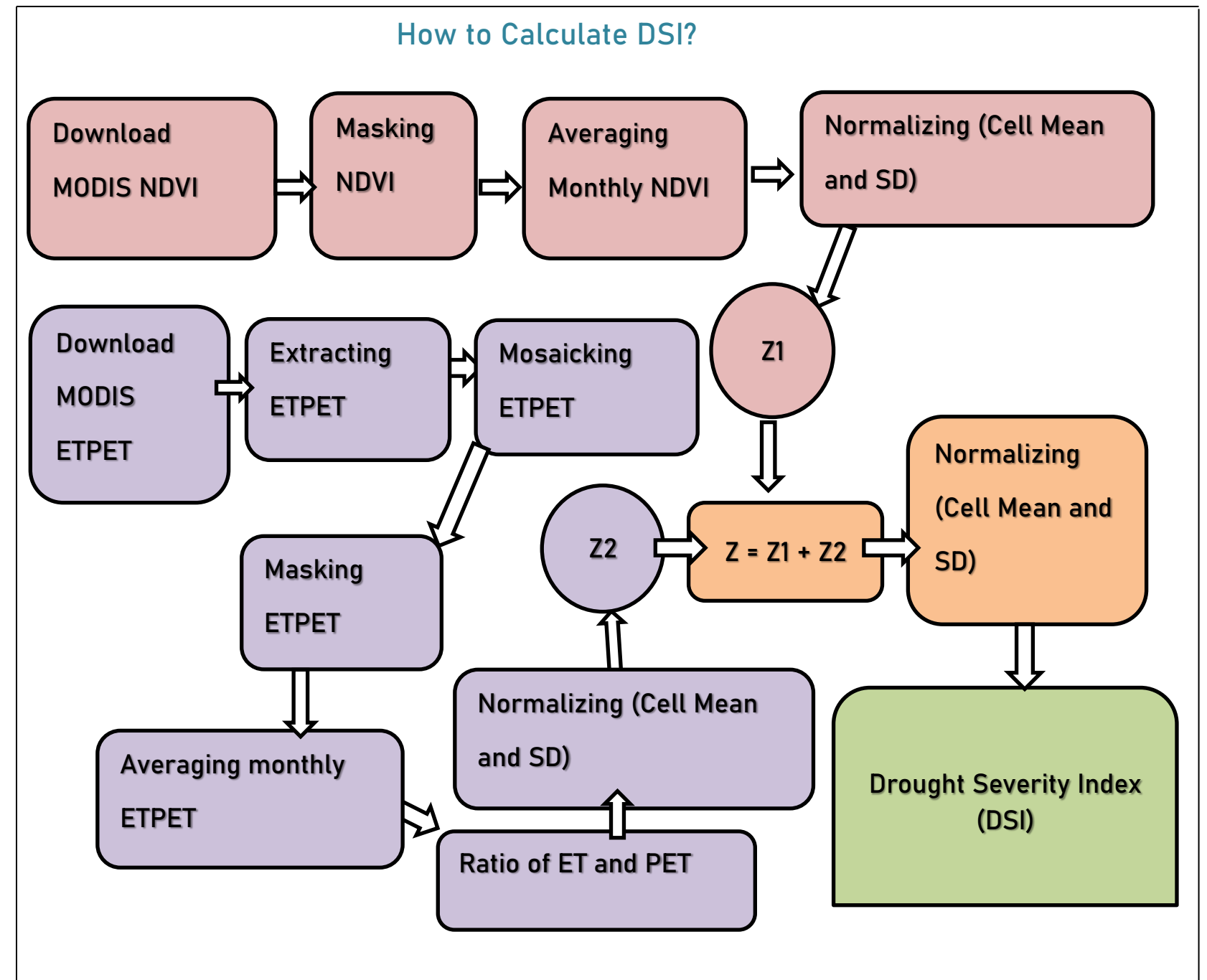
The Moderate-Resolution Imaging Spectrometer (MODIS) is an advanced narrowband-width sensor from which NASA and the USGS allow free composited reflectance data available every eight days via the Earth Resources Observation Systems (EROS) data center (Justice and Townshend, 2002a). MODIS products of Land cover, NDVI and ET/PET have been used for this study.

### MODIS NDVI Data

This data includes MOD13A1 (MODIS/Terra Vegetation Indices 16-Day L3 Global 500m SIN Grid) NDVI products at 500m spatial resolution for twenty one years (2000-2020). Global MOD13A1 data are provided every 16 days at 500-meter spatial resolution as a gridded level-3 product in the Sinusoidal projection i.e obtained from NASA Land Processes Distributed Active Archive Center (LP DAAC, <https://lpdaac.usgs.gov/>).

### MODIS ET, PET

This data set includes 8-day MOD16A2 Gap-Filled ET/PET (MODIS/Terra Net Evapotranspiration Gap-Filled 8-Day L4 Global 500m SIN Grid V006). The MOD16A2GF Version 6 product is a year-end gap-filled 8-day composite dataset produced at 500 meter (m) pixel resolution. The ET/PET datasets are obtained from Earth Data (<https://earthdata.nasa.gov/>).



## Drought Severity Index (DSI)

DSI was chosen to investigate the spatiotemporal variability of droughts across the country using observed satellite products from 2000 to 2020. This newly proposed remote sensing index by Mu et al., 2013 has performed well in many parts of the world. According to Mu et al. (2013), the DSI Index, which combines the NDVI and ET/PET, is calculated as shown in equations (1) to (4). The incorporation of both transpiration and vegetation indicator data in DSI has been regarded as an improvement over other drought index. To study drought in Sikkim, monthly DSI values were calculated over a twenty one year period (2000–2020). Following are the equation systems that were used:

$$Z_{Ratio} = \frac{ET/PET - \overline{ET/PET}}{\sigma_{ET/PET}} \quad (1)$$

$$Z_{NDVI} = \frac{NDVI - \overline{NDVI}}{\sigma_{NDVI}} \quad (2)$$

$$Z = Z_{Ratio} + Z_{NDVI} \quad (3)$$

$$DSI = \frac{Z - \bar{Z}}{\sigma_Z} \quad (4)$$

Where  $Z_{Ratio}$  and  $Z_{NDVI}$  is the standardized value of ET/PET ratio and NDVI respectively.  $\overline{ET/PET}$  and  $\overline{NDVI}$  is mean.  $\sigma_{Ratio}$  and  $\sigma_{NDVI}$  is the standard deviation of ET/PET ratio and NDVI respectively.  $\bar{Z}$  and  $\sigma_Z$  represents the mean and standard deviation of the sum of  $Z_{Ratio}$  and  $Z_{NDVI}$  respectively. Drought Severity Index is represented by the DSI calculated in equation (4). Positive

DSI value indicates wet condition, while negative values indicate dry conditions, Mu et al. (2013) classified DSI, as shown in table.

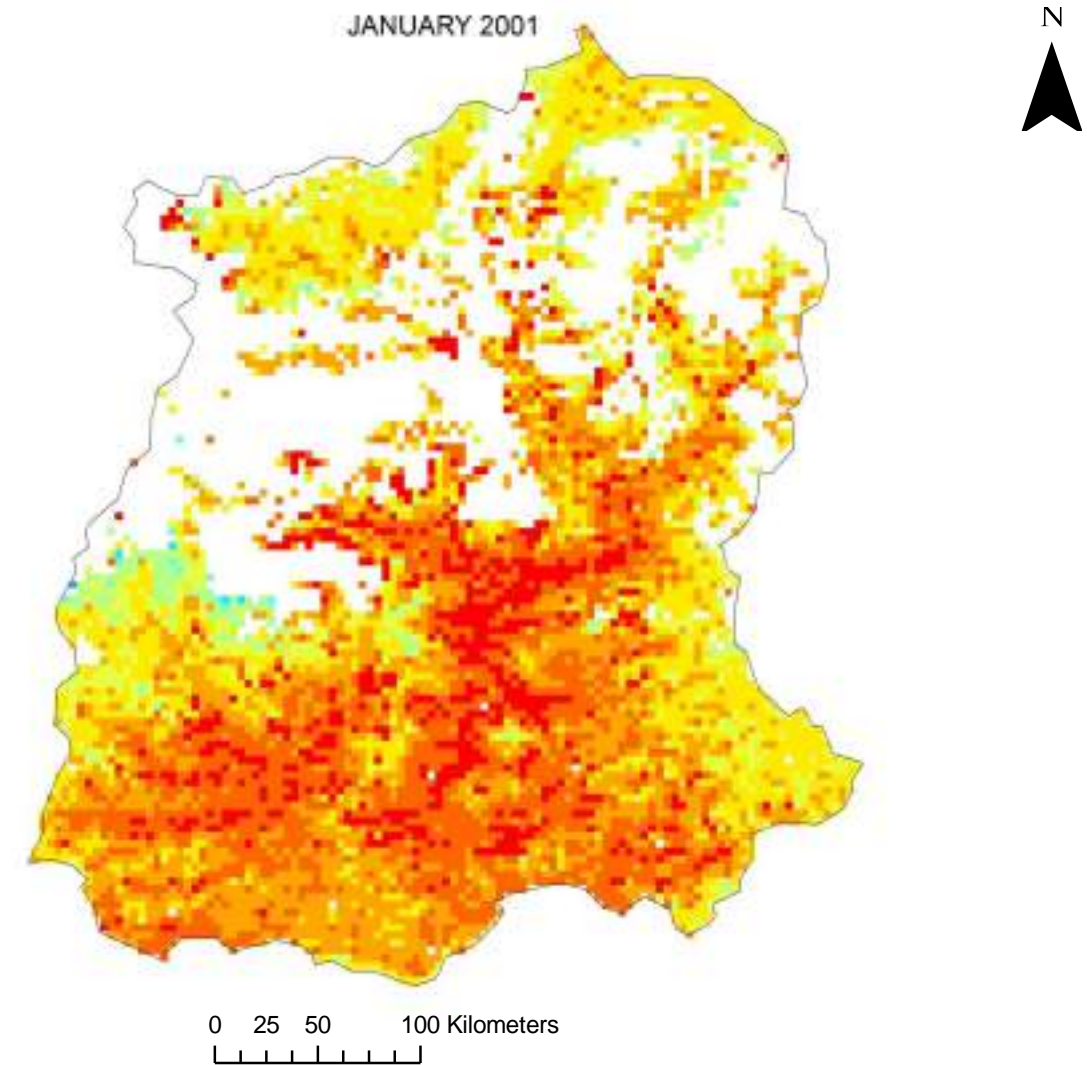
The generate DSI is then imported to ArcGis to export monthly DSI maps i.e displayed in this atlas. In mean monthly DSI maps of Sikkim, extreme dry condition is denoted by Red colour whereas dark blue colour denotes extreme wet condition.

Category	DSI Values	Colour
Extreme Drought	-1.5 or less	Red
Severe Drought	-1.2 to -1.49	Orange
Moderate Drought	-0.9 to -1.19	Yellow-Orange
Mild Drought	-0.6 to -0.89	Yellow
Incipient Drought	-0.3 to -0.59	Light Green
Near Normal	0.29 to -0.29	Green
Incipient Wet Spell	0.3 to 0.59	Light Blue
Slightly Wet	0.6 to 0.89	Cyan
Moderately Wet	0.9 to 1.19	Blue
Very Wet	1.2 to 1.49	Dark Blue
Extremely Wet	1.5 or greater	Dark Blue

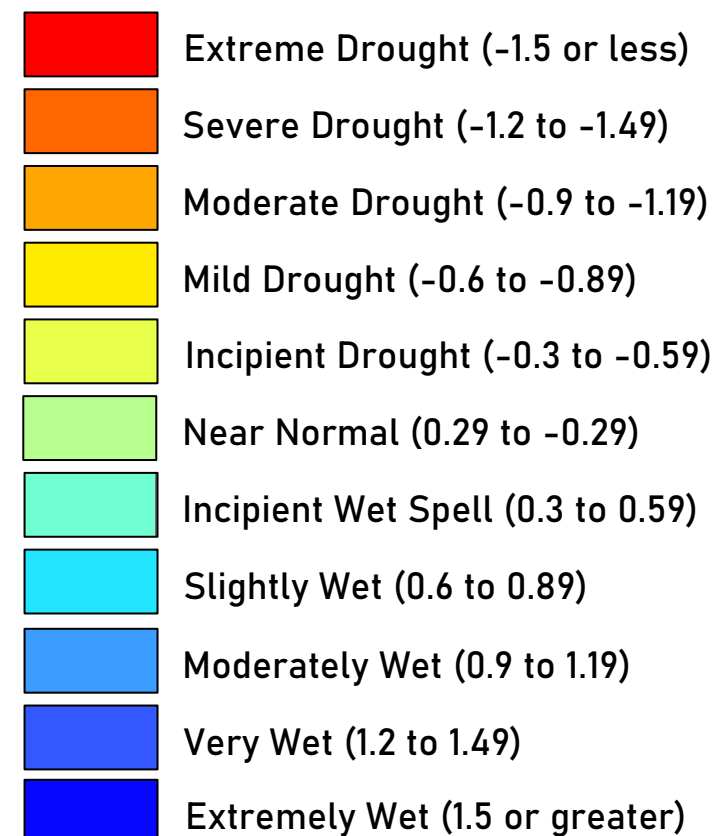
## January DSI Maps

Drought conditions in January typically vary from moderate to incipient drought. The characteristics of this winter month are frequently characterized by moderate to mild drought.

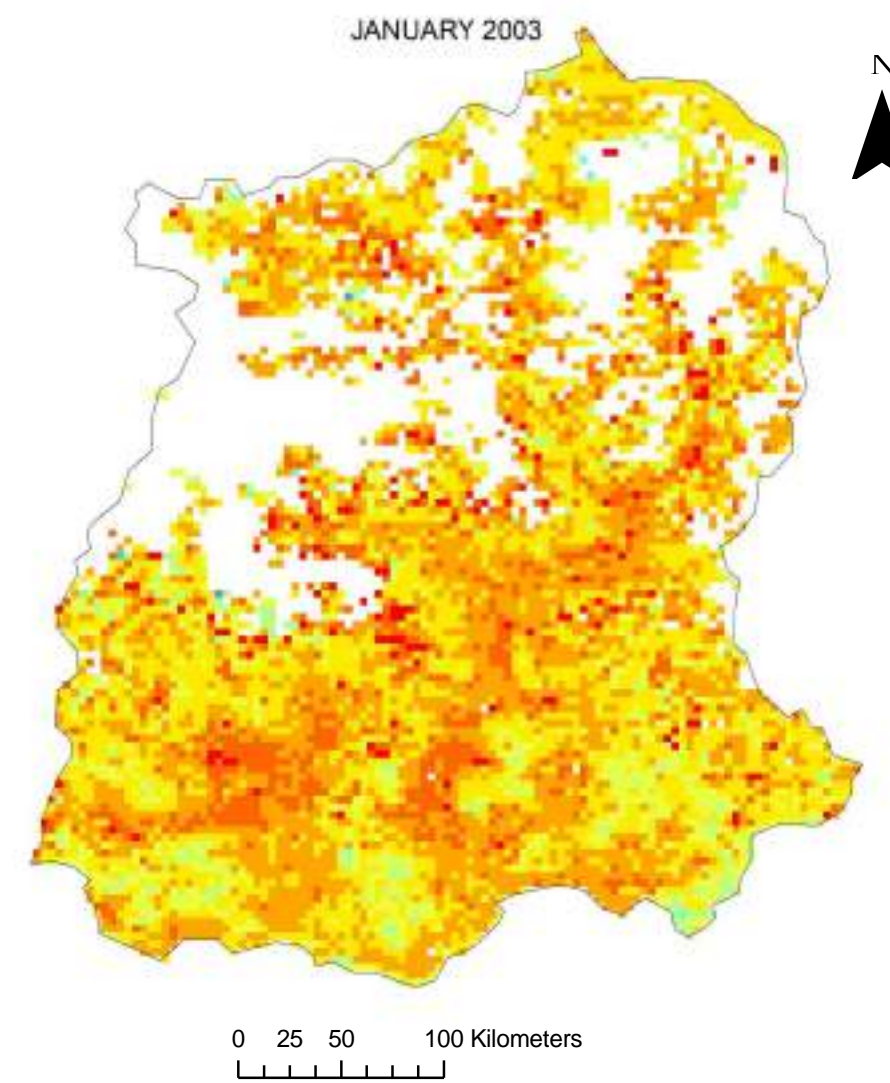
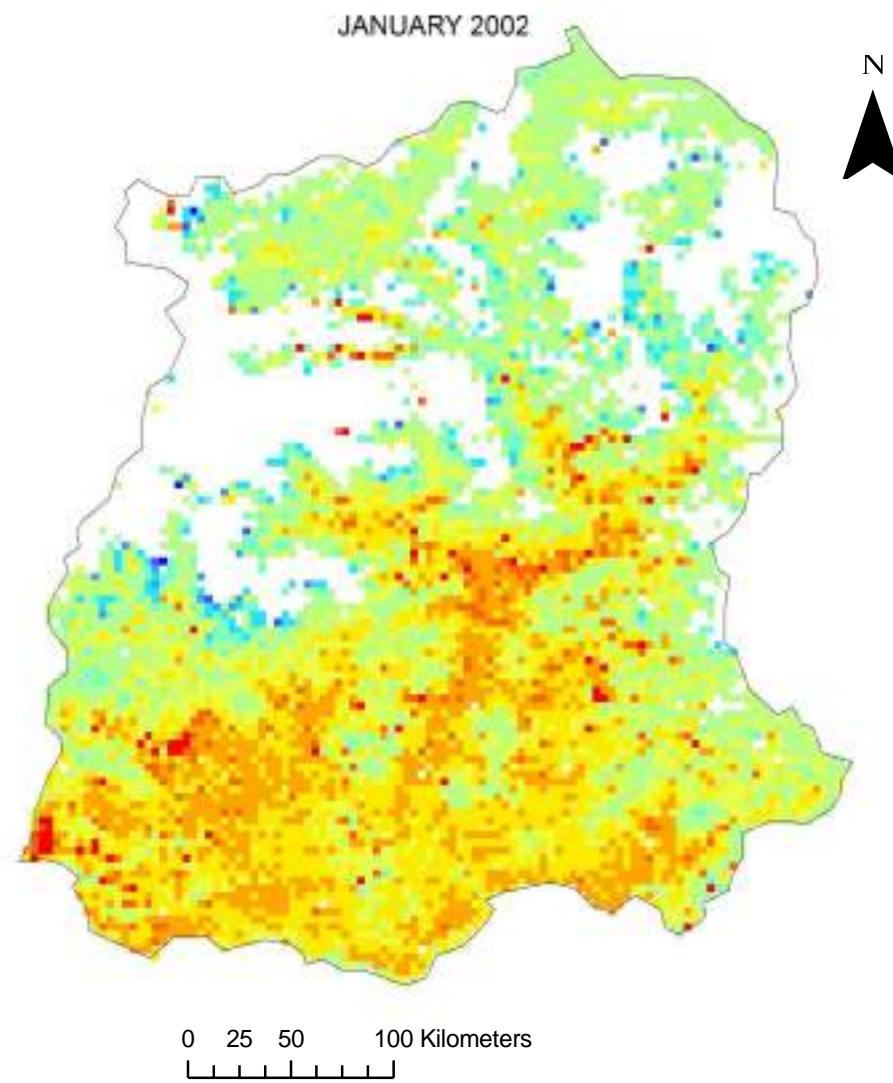
Mean January DSI Values		
Year	DSI Values	Drought Condition
2001	-1.06	Moderate Drought
2002	-0.38	Incipient Drought
2003	-0.92	Moderate Drought
2004	-0.69	Mild Drought
2005	-0.37	Incipient Drought
2006	-0.88	Mild Drought
2007	-0.91	Moderate Drought
2008	-0.60	Mild Drought
2009	-0.92	Moderate Drought
2010	-0.82	Mild Drought
2011	-0.72	Mild Drought
2012	-0.75	Mild Drought
2013	-1.05	Moderate Drought
2014	-0.77	Mild Drought
2015	-1.15	Moderate Drought
2016	-0.70	Mild Drought
2017	-0.96	Moderate Drought
2018	-0.89	Mild Drought
2019	-1.14	Moderate Drought
2020	-0.71	Mild Drought














### Legend

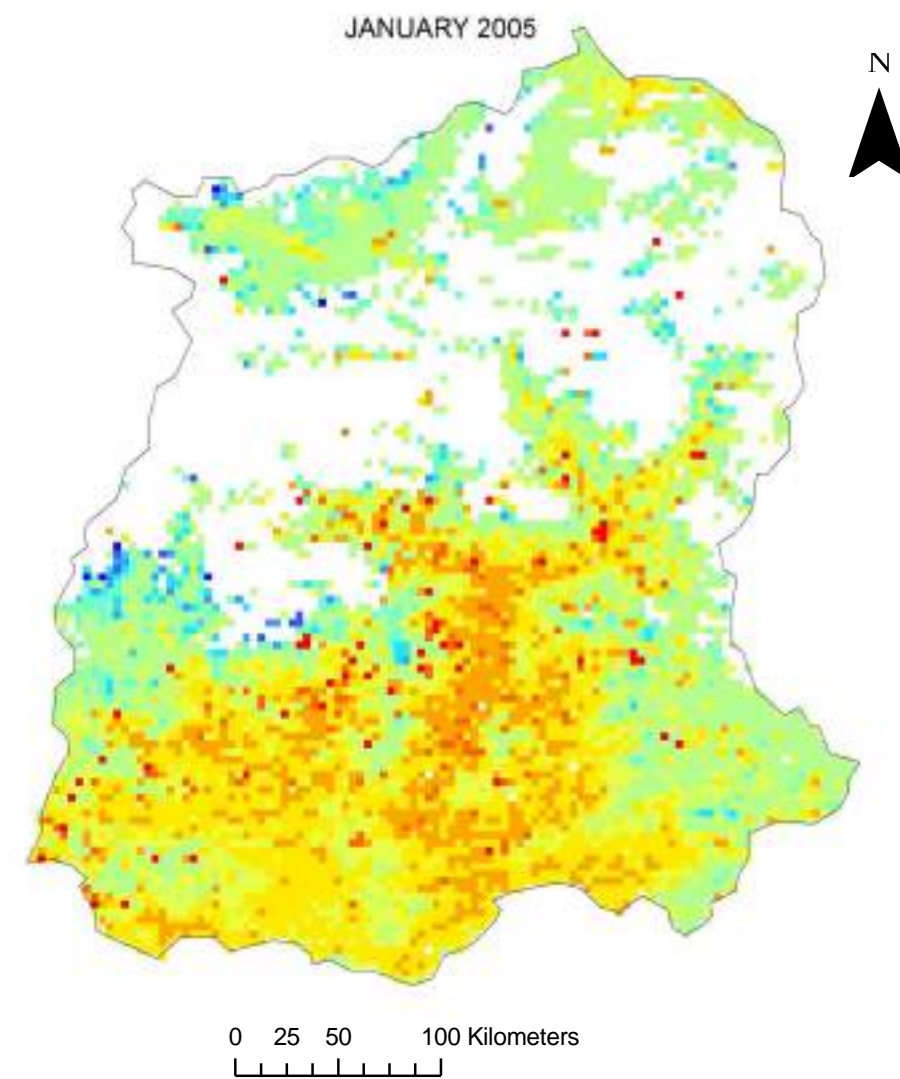
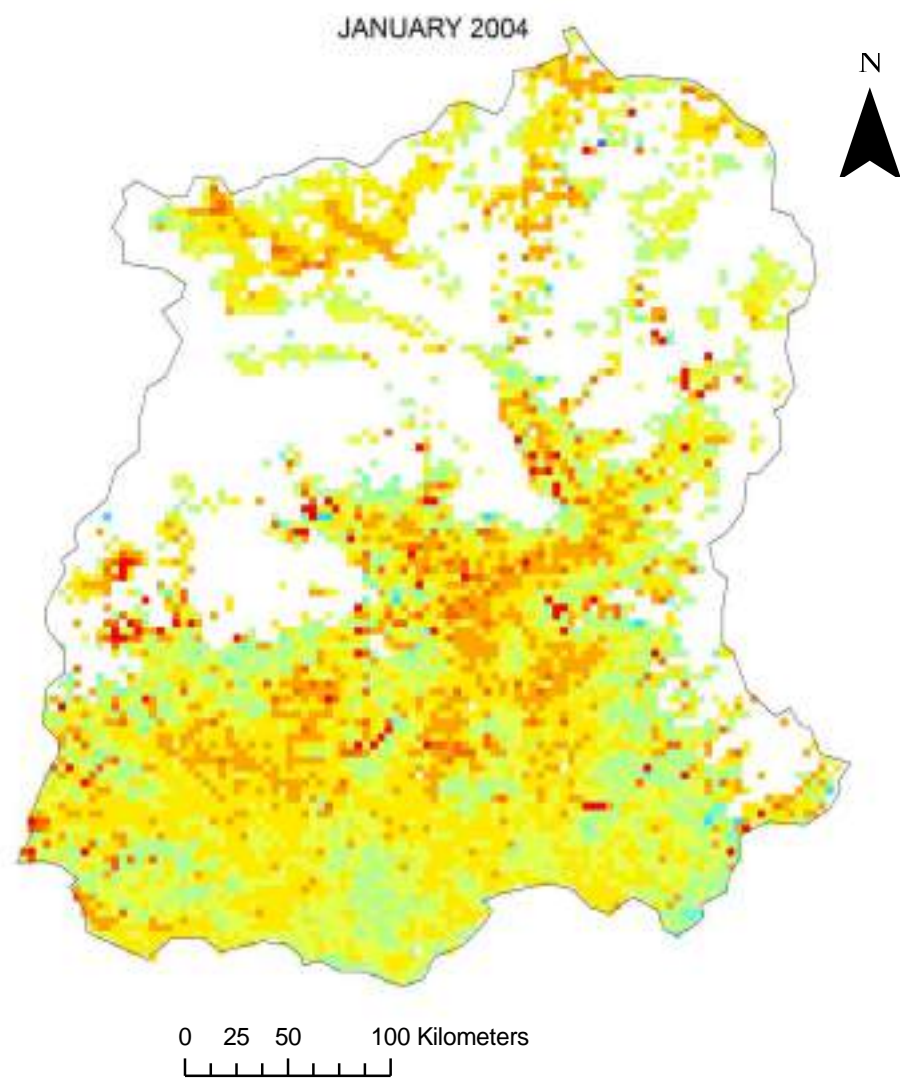






**Legend**

	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		



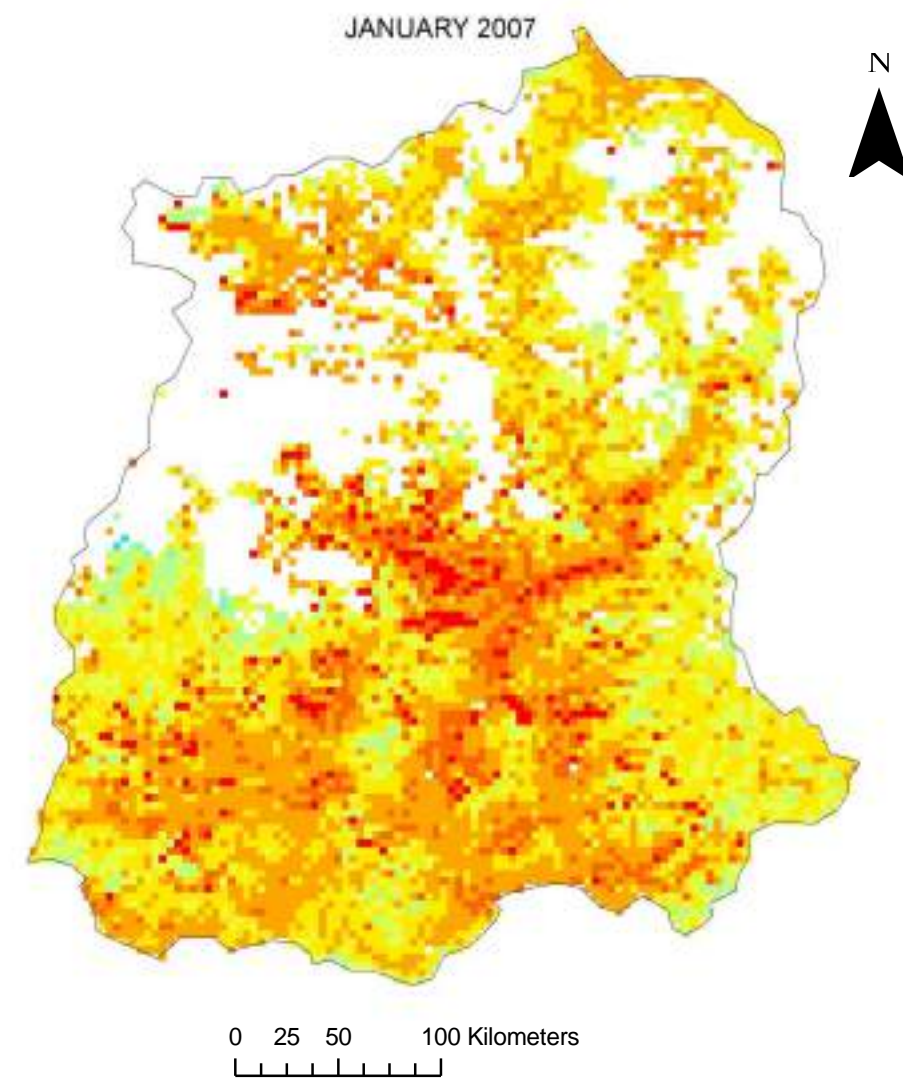
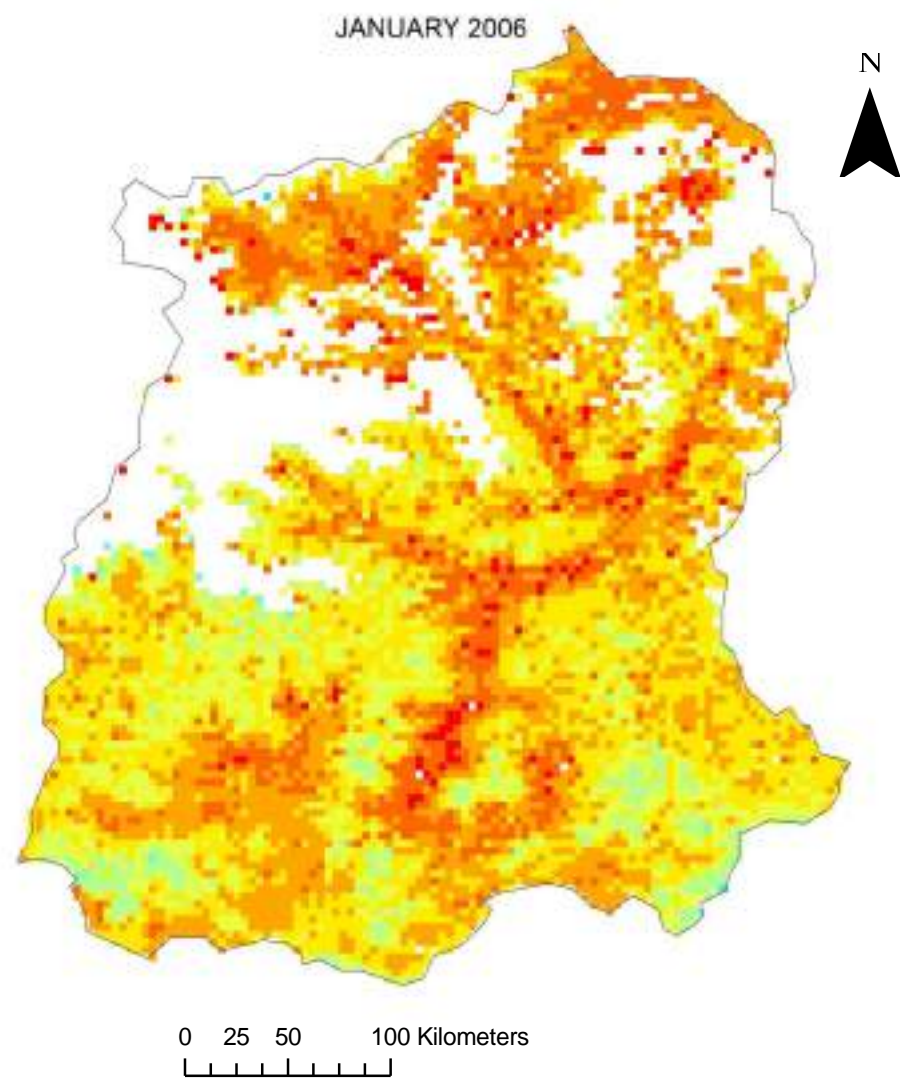
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)





- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)


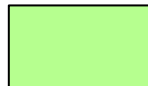


- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)

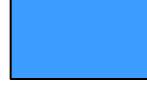






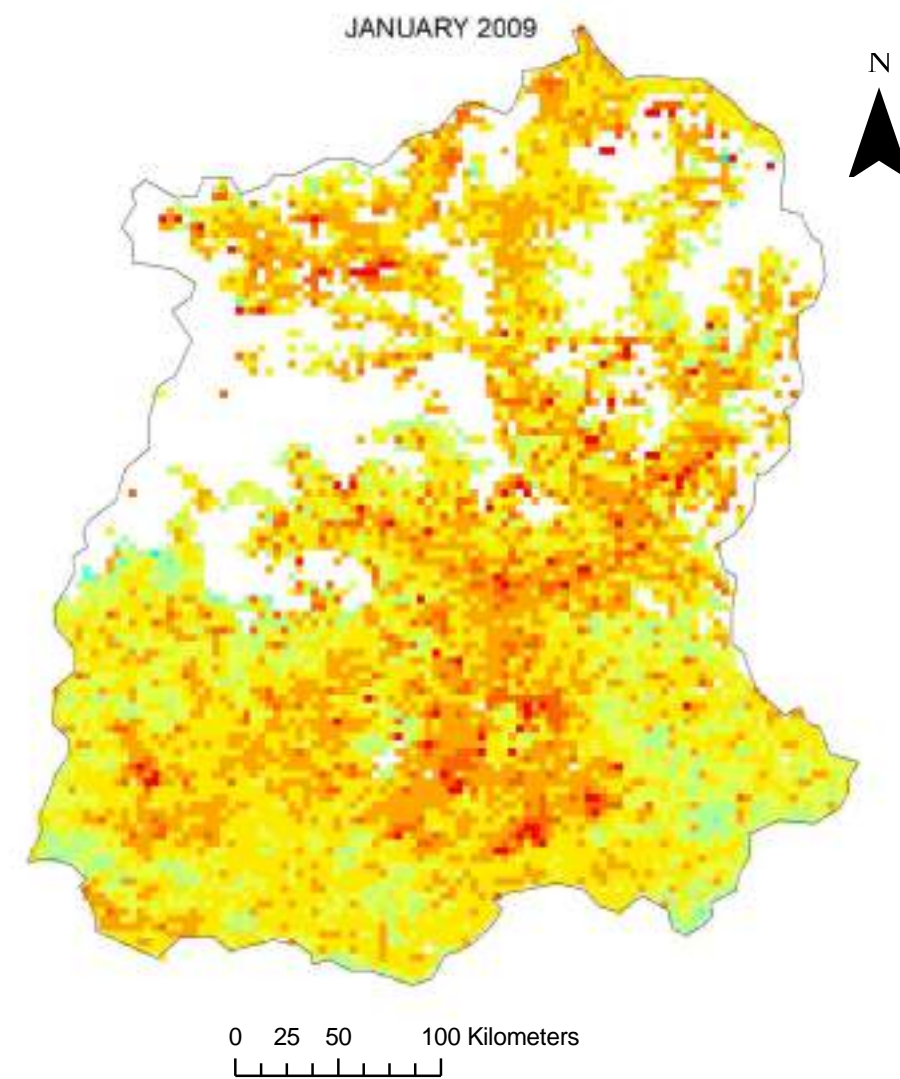
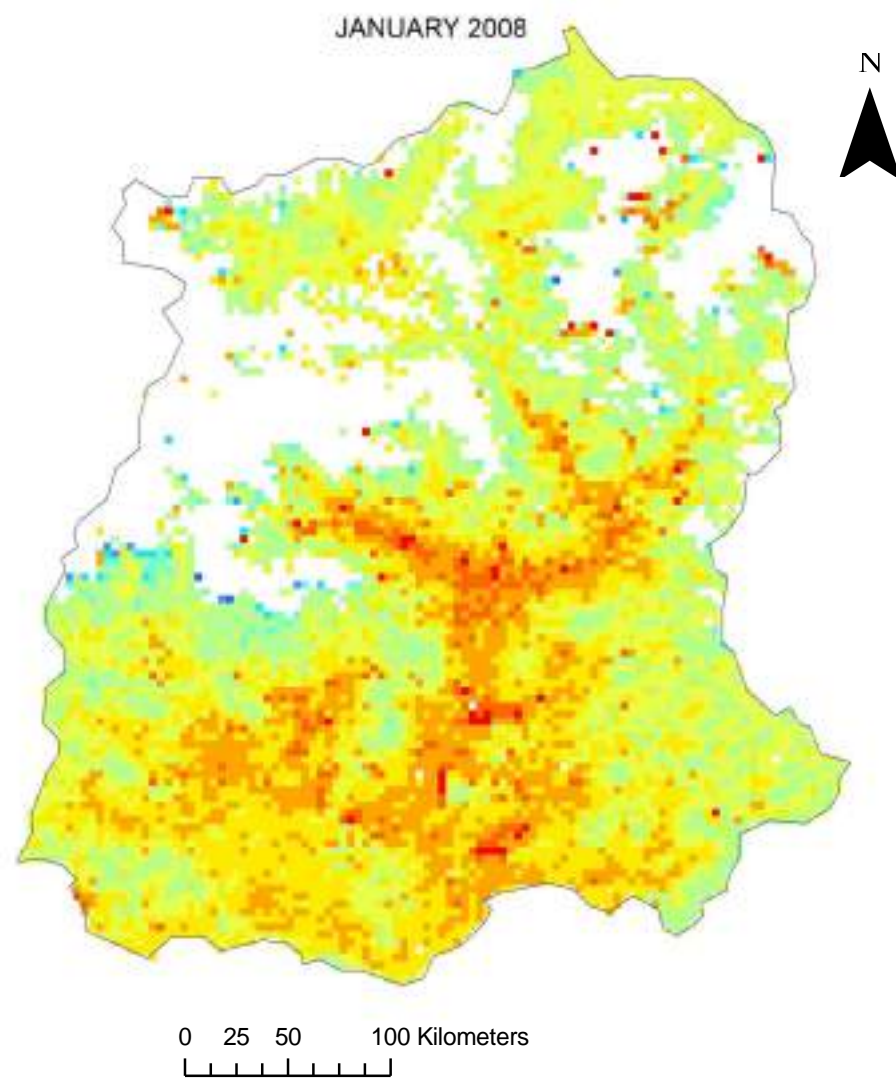
**Legend**

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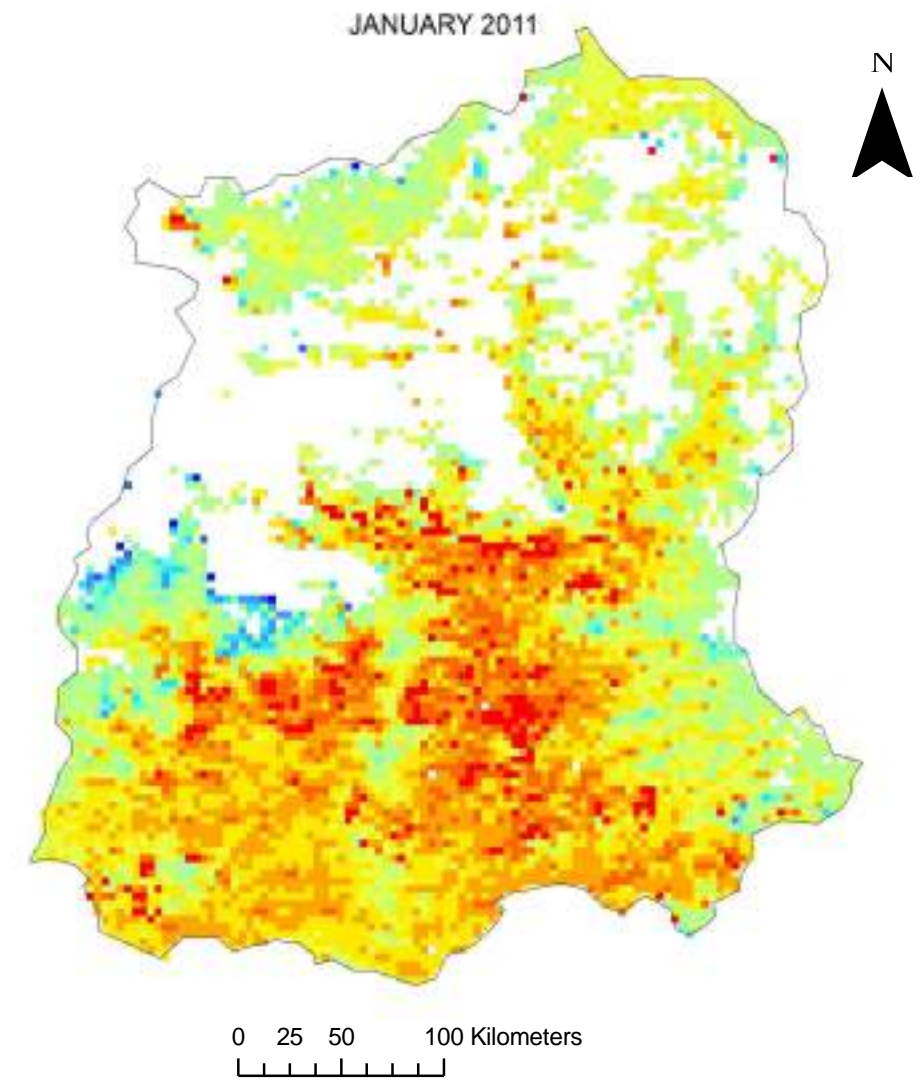
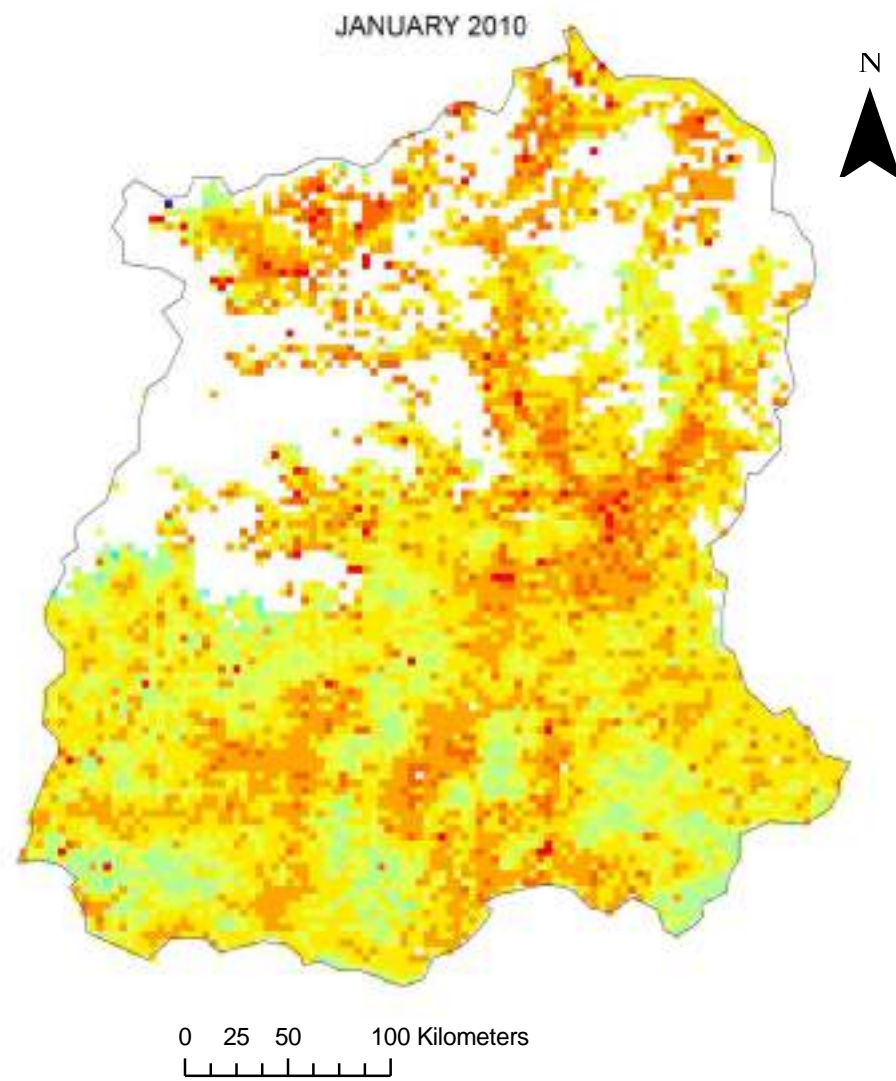


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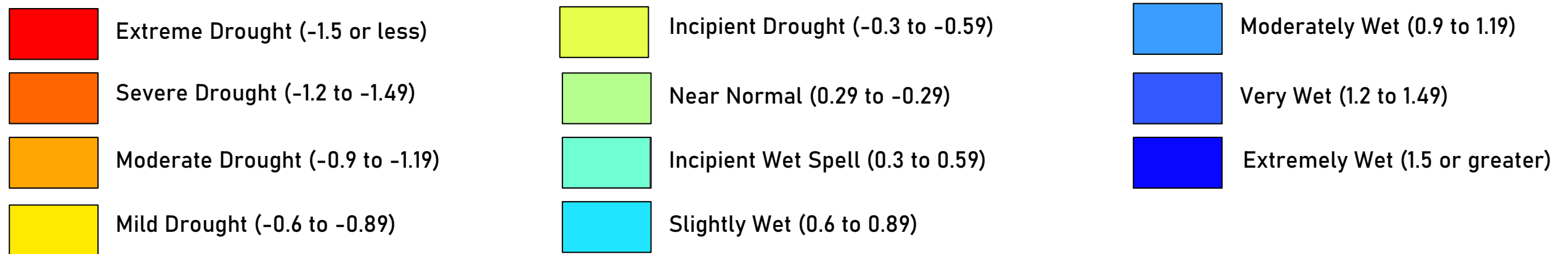
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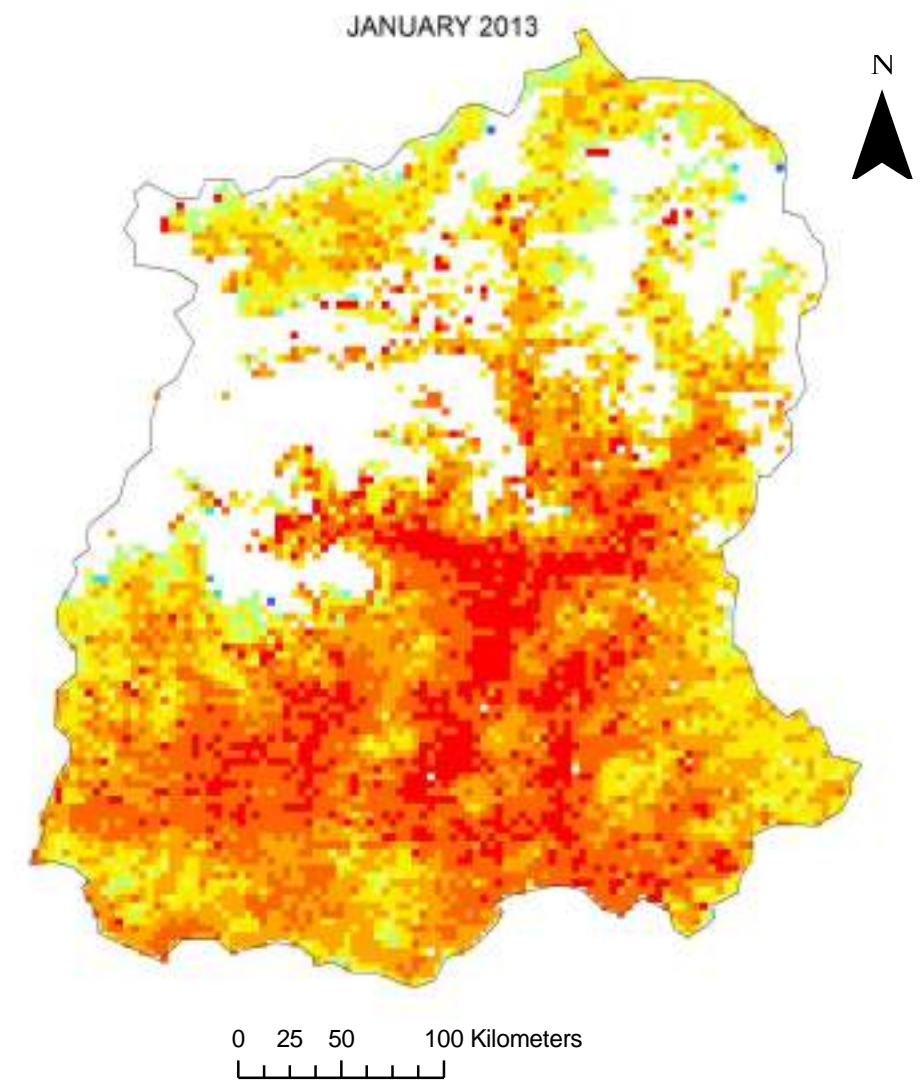
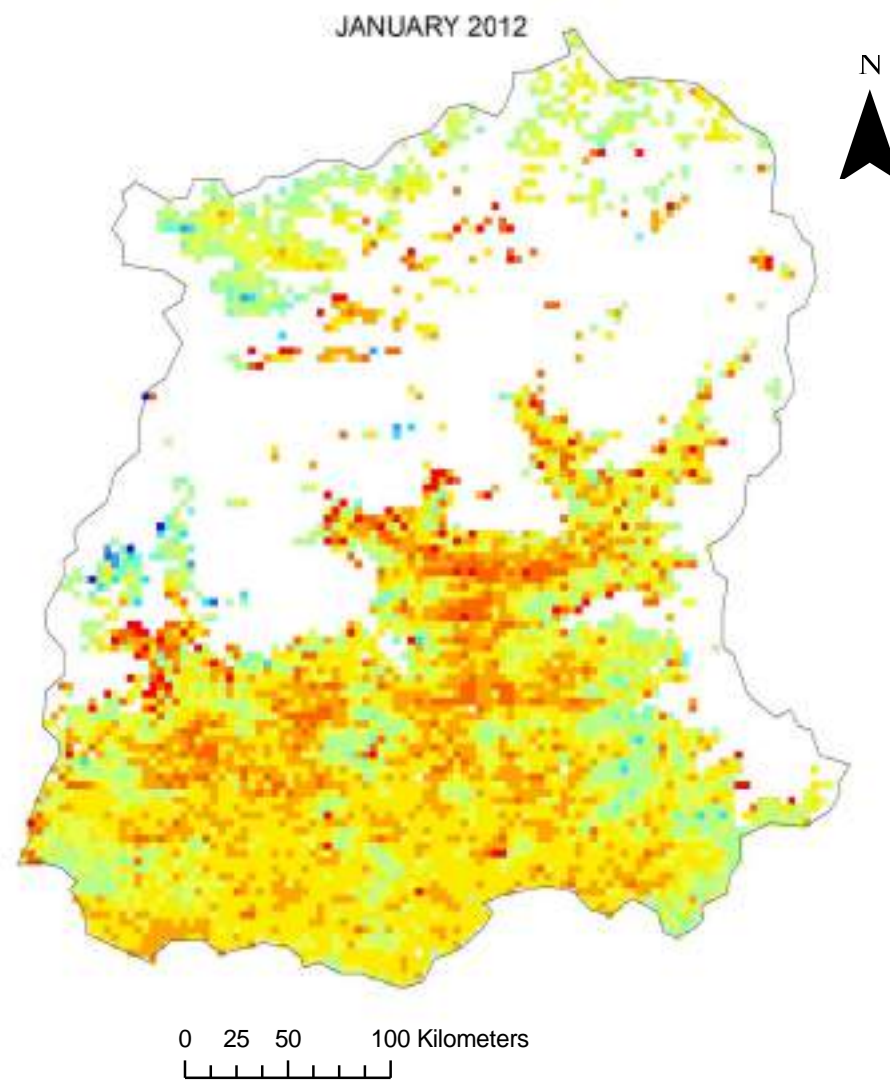
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)














**Legend**

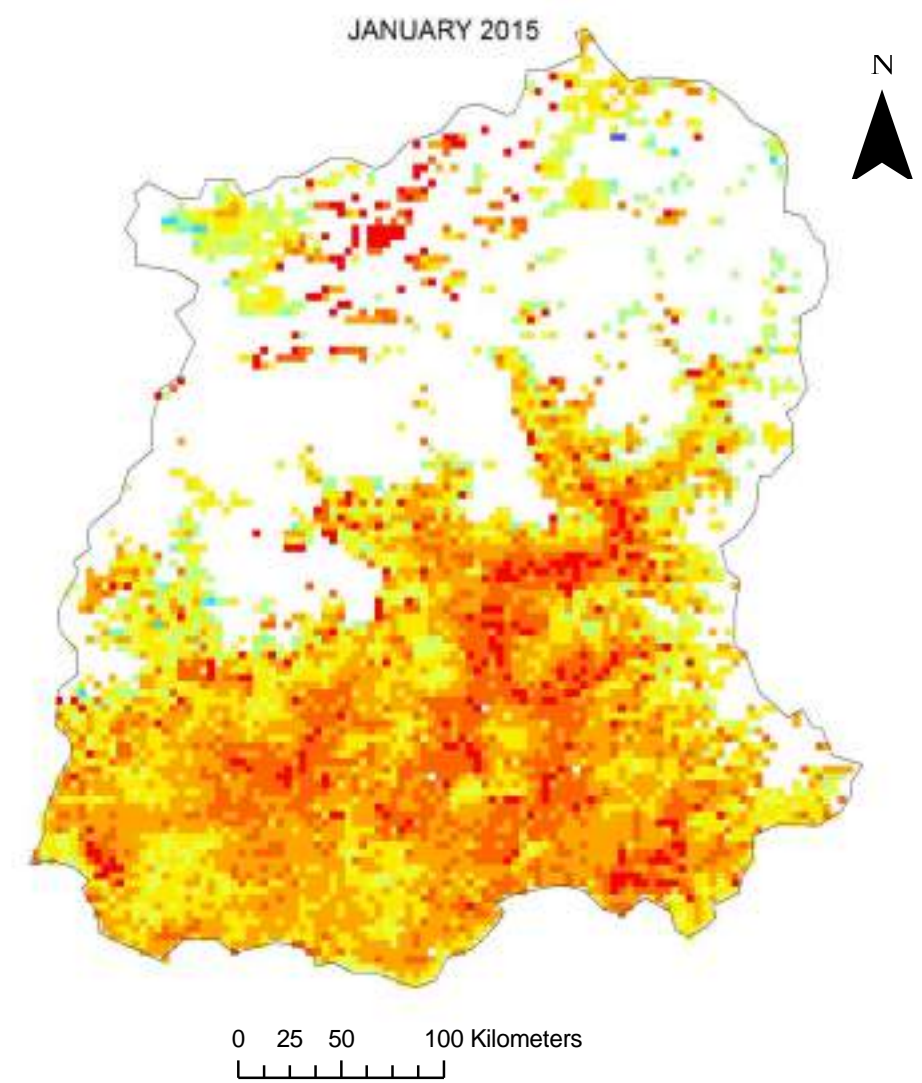
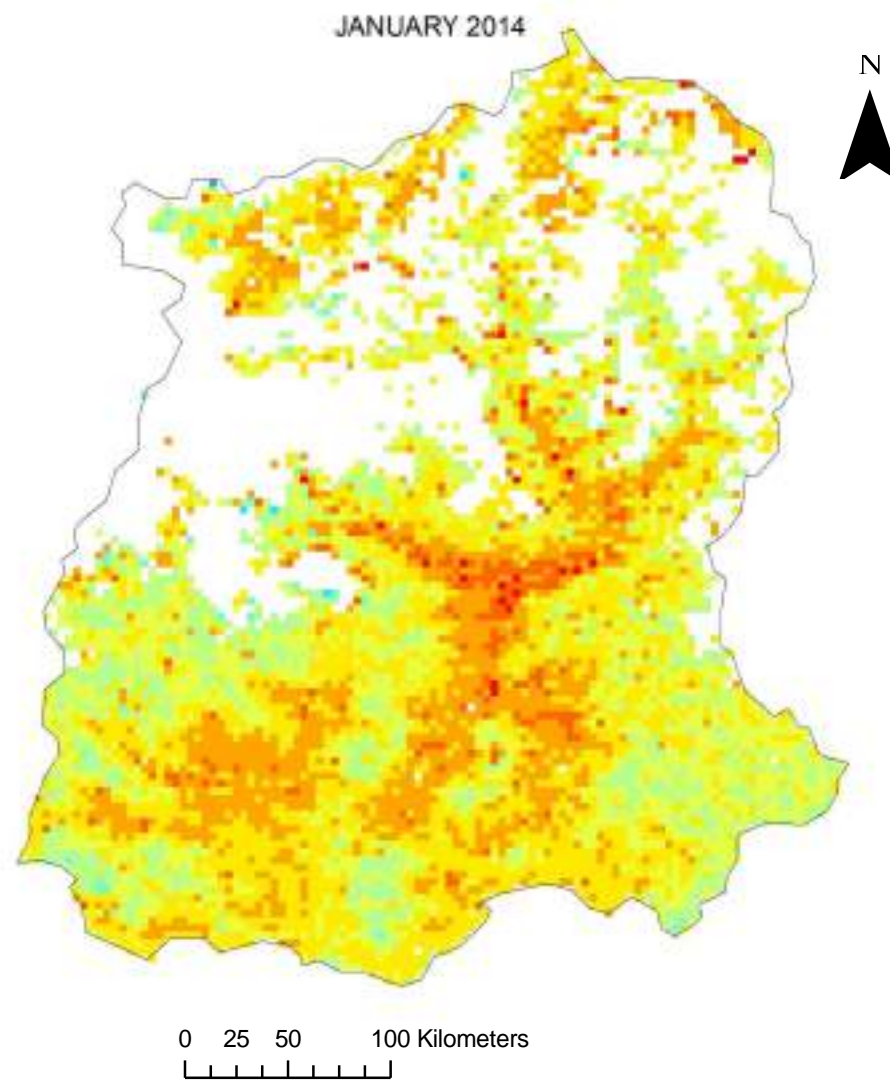

















**Legend**

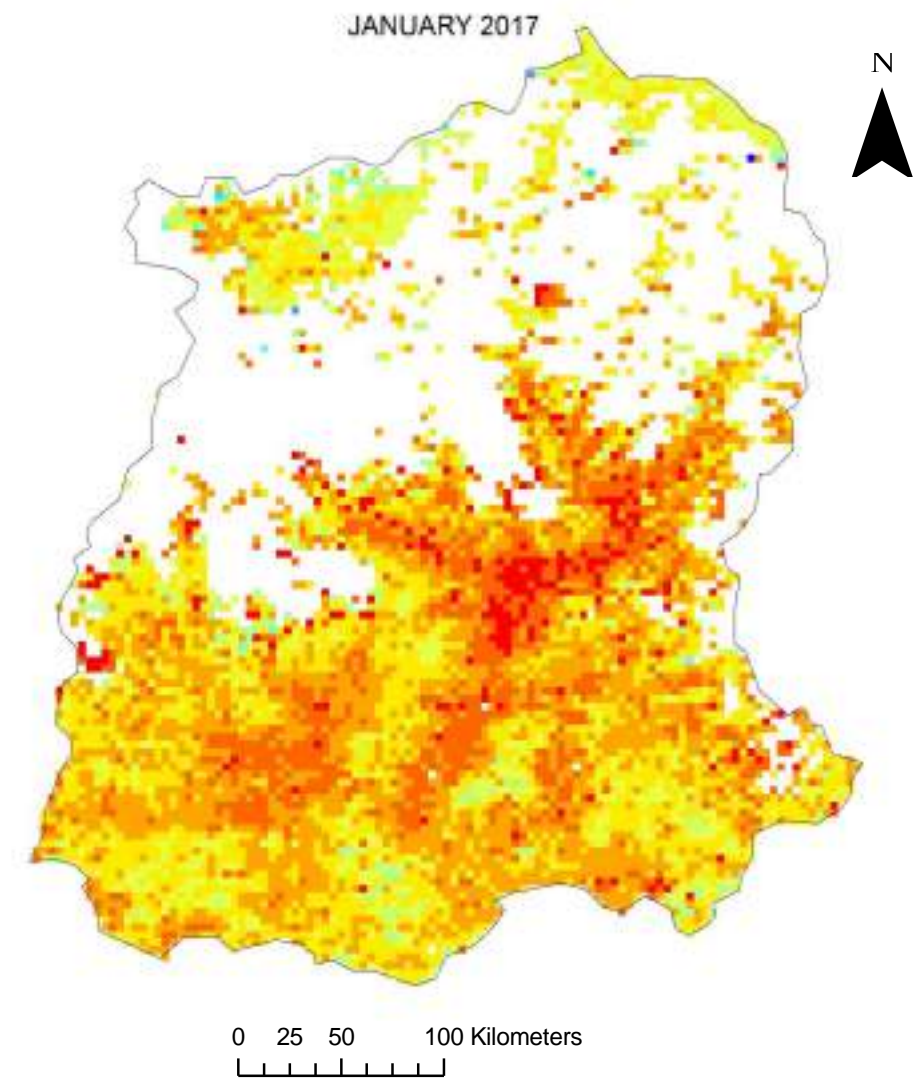
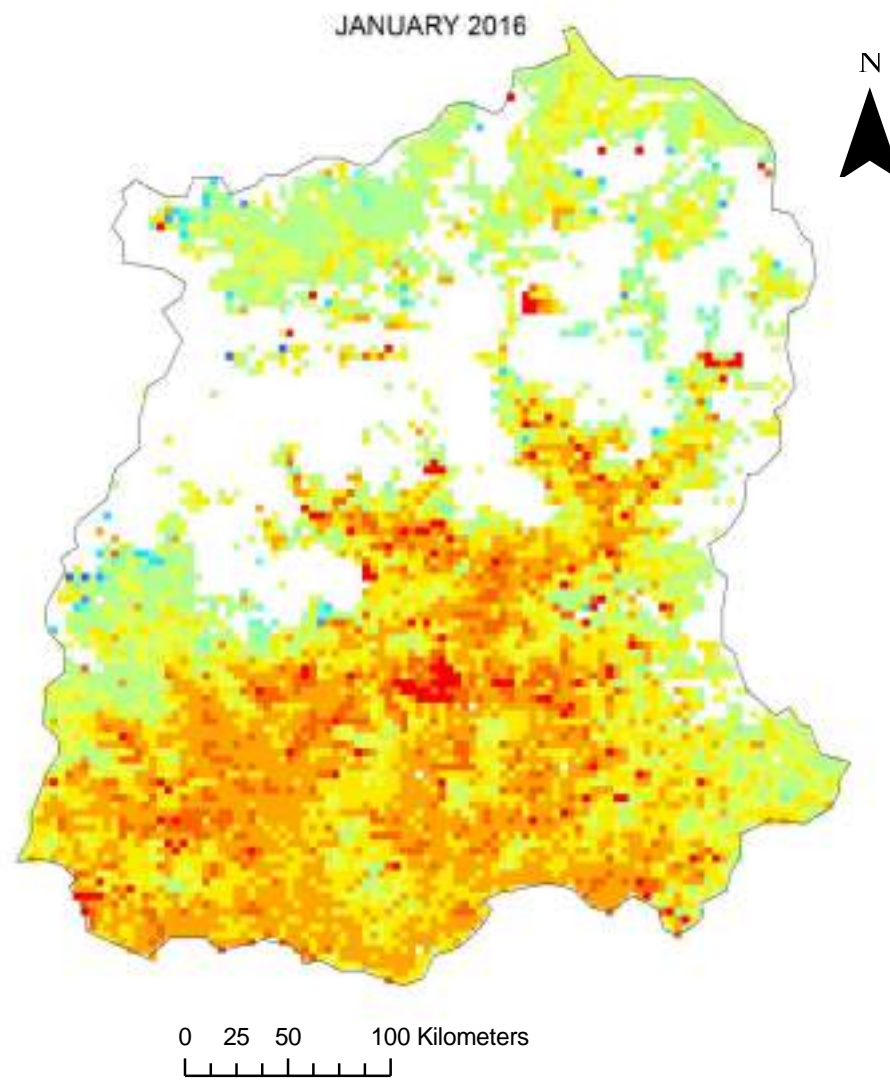
- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



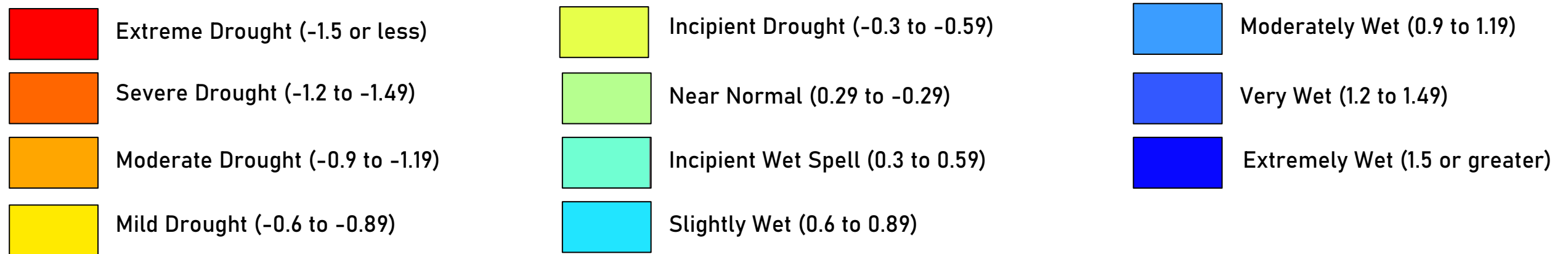
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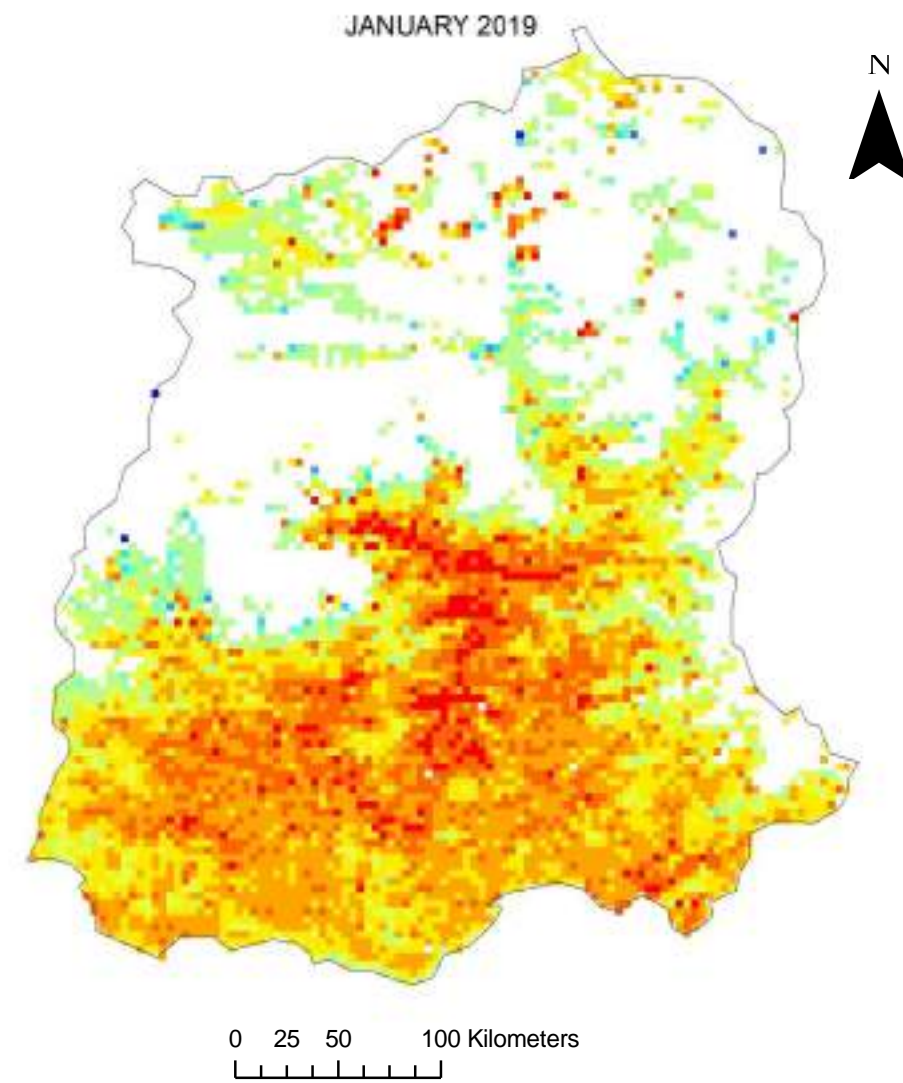
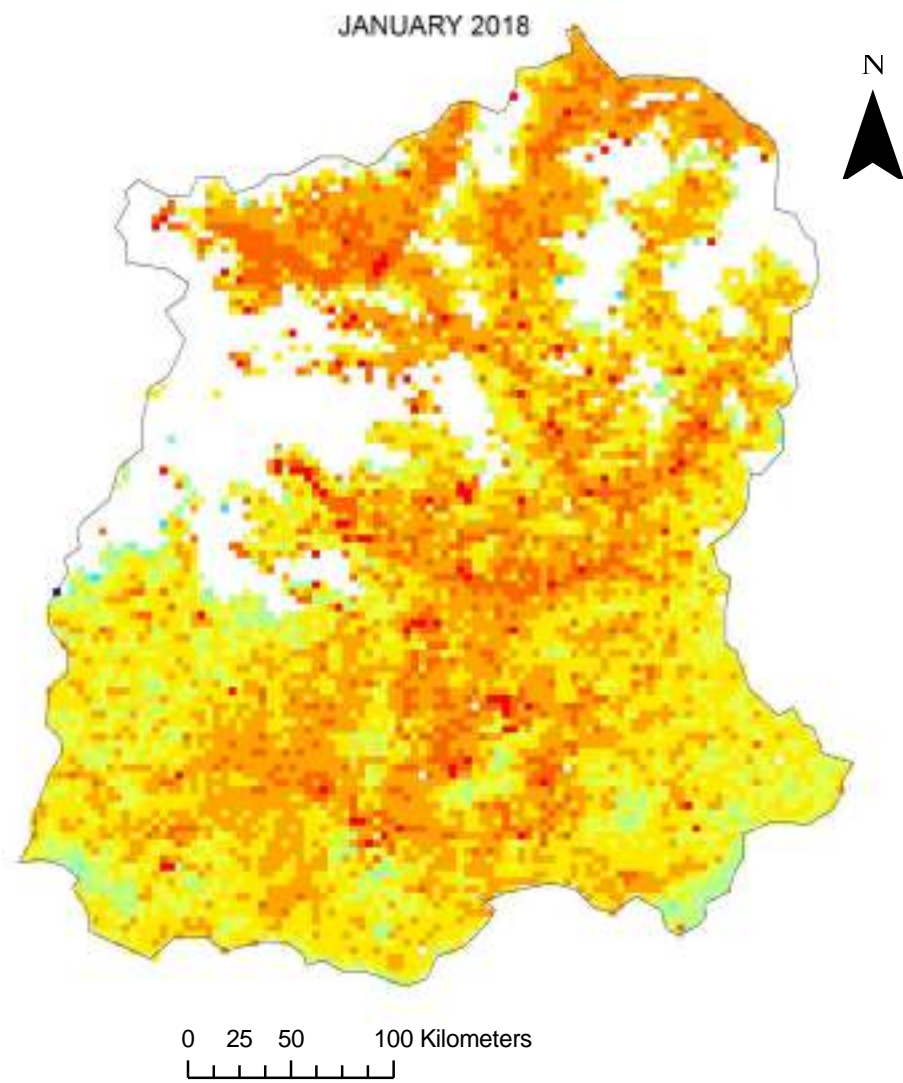
- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
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**Legend**





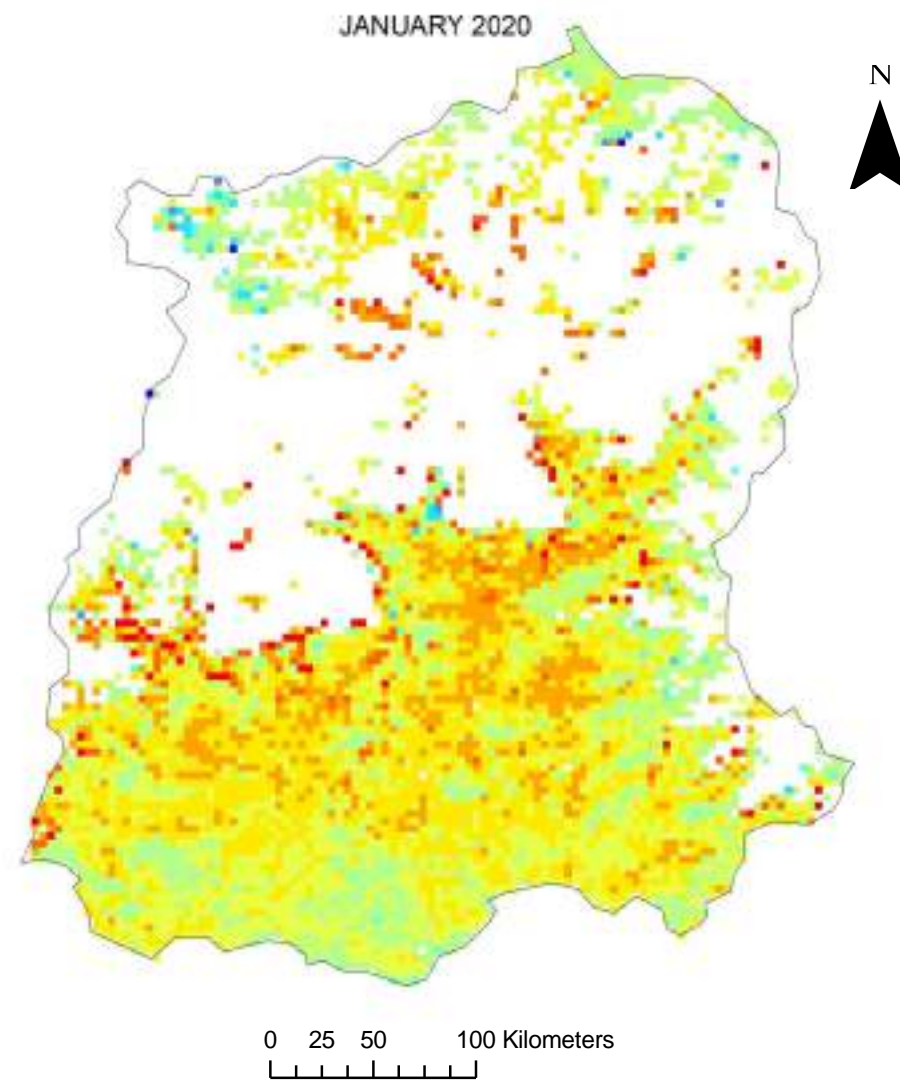
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
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- Mild Drought (-0.6 to -0.89)

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**Legend**

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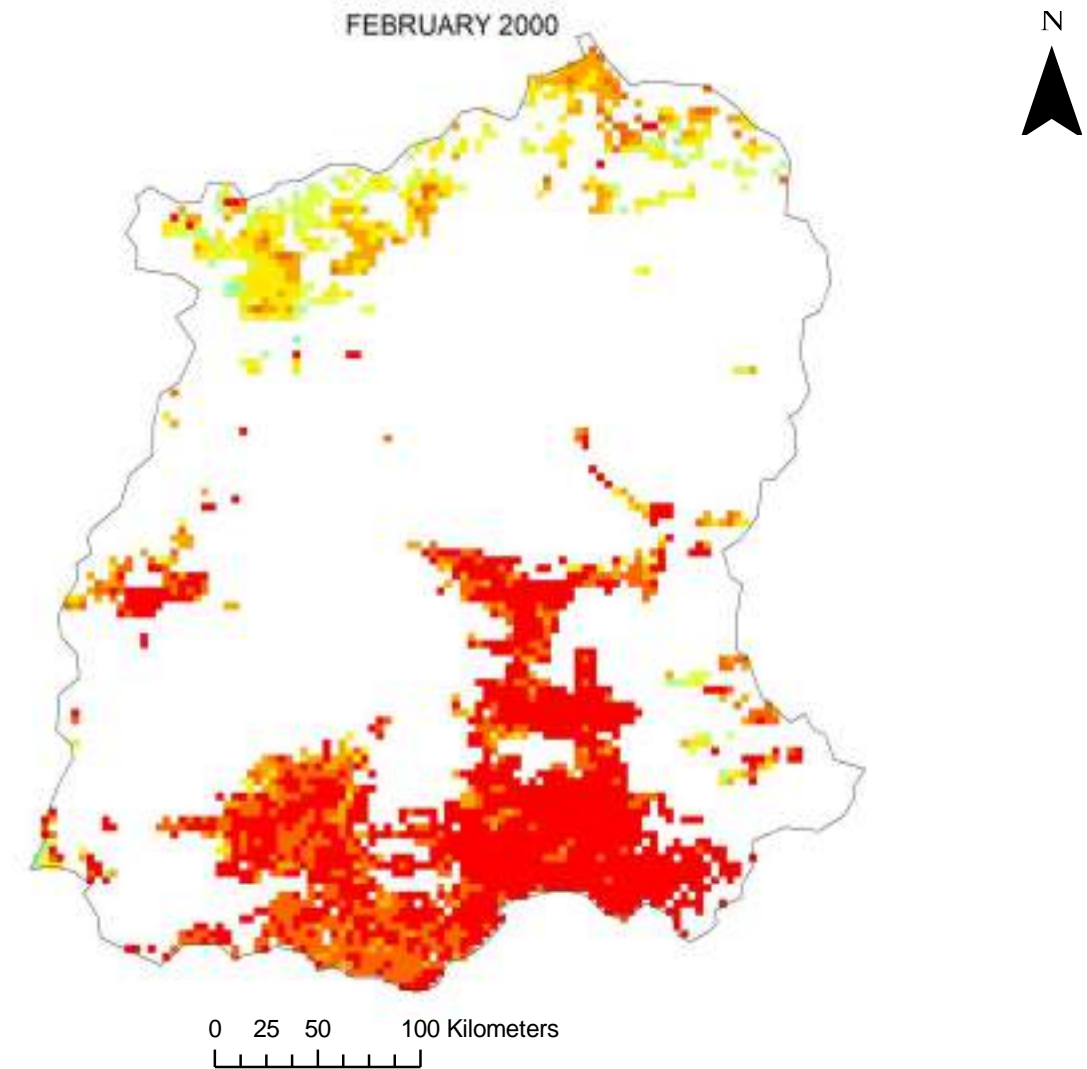
- Incipient Drought (-0.3 to -0.59)
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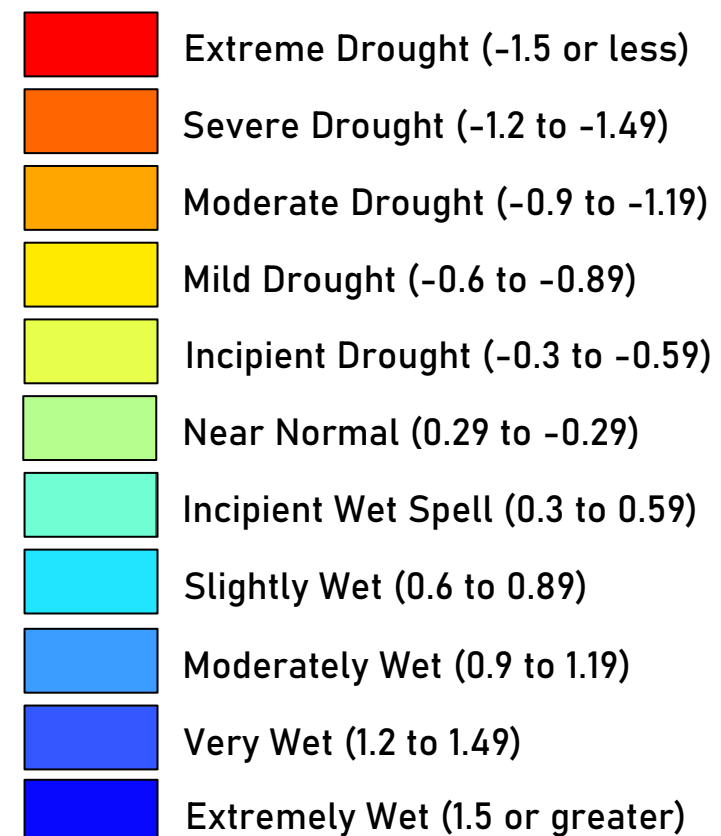
## February DSI Maps

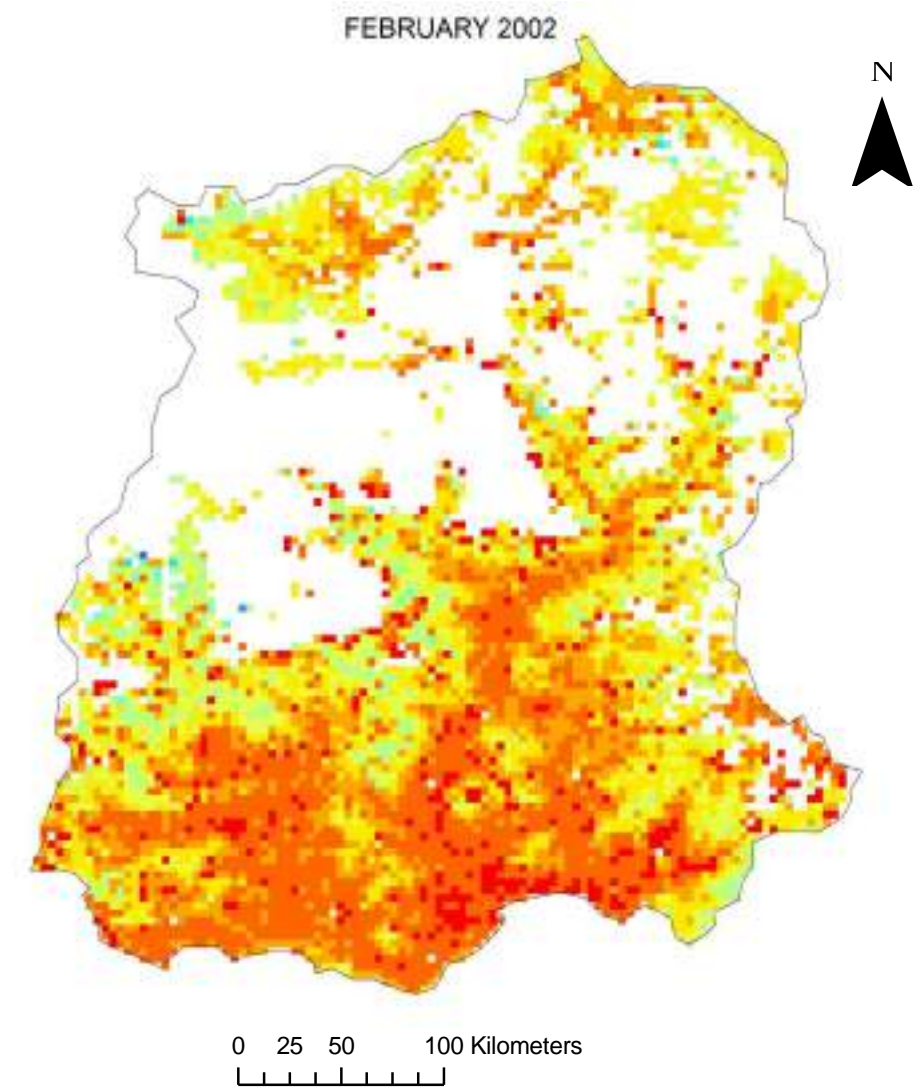
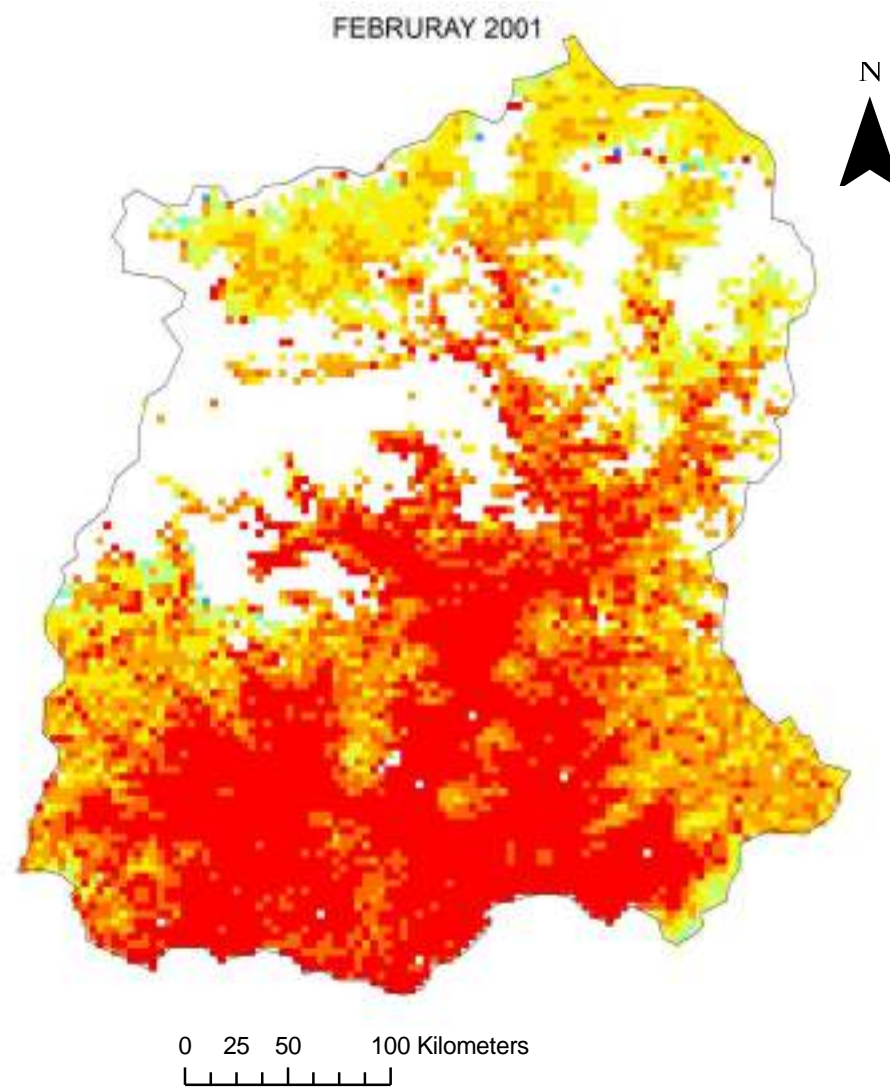
Drought conditions in February range from severe to mild drought. Moderate to mild drought were seen quite often in this cold month. Severe droughts were identified in year 2000, 2001, 2009, 2015, 2017 and 2019.

Mean February DSI Values		
Year	DSI Values	Drought Condition
2000	-1.44	Severe Drought
2001	-1.28	Severe Drought
2002	-0.94	Moderate Drought
2003	-1.10	Moderate Drought
2004	-1.10	Moderate Drought
2005	-0.62	Mild Drought
2006	-1.03	Moderate Drought
2007	-0.75	Mild Drought
2008	-0.97	Moderate Drought
2009	-1.21	Severe Drought
2010	-0.88	Mild Drought
2011	-0.79	Mild Drought
2012	-0.95	Moderate Drought
2013	-1.14	Moderate Drought
2014	-0.75	Mild Drought
2015	-1.20	Severe Drought
2016	-1.08	Moderate Drought
2017	-1.36	Severe Drought
2018	-0.79	Mild Drought
2019	-1.33	Severe Drought
2020	-0.82	Mild Drought














### Legend

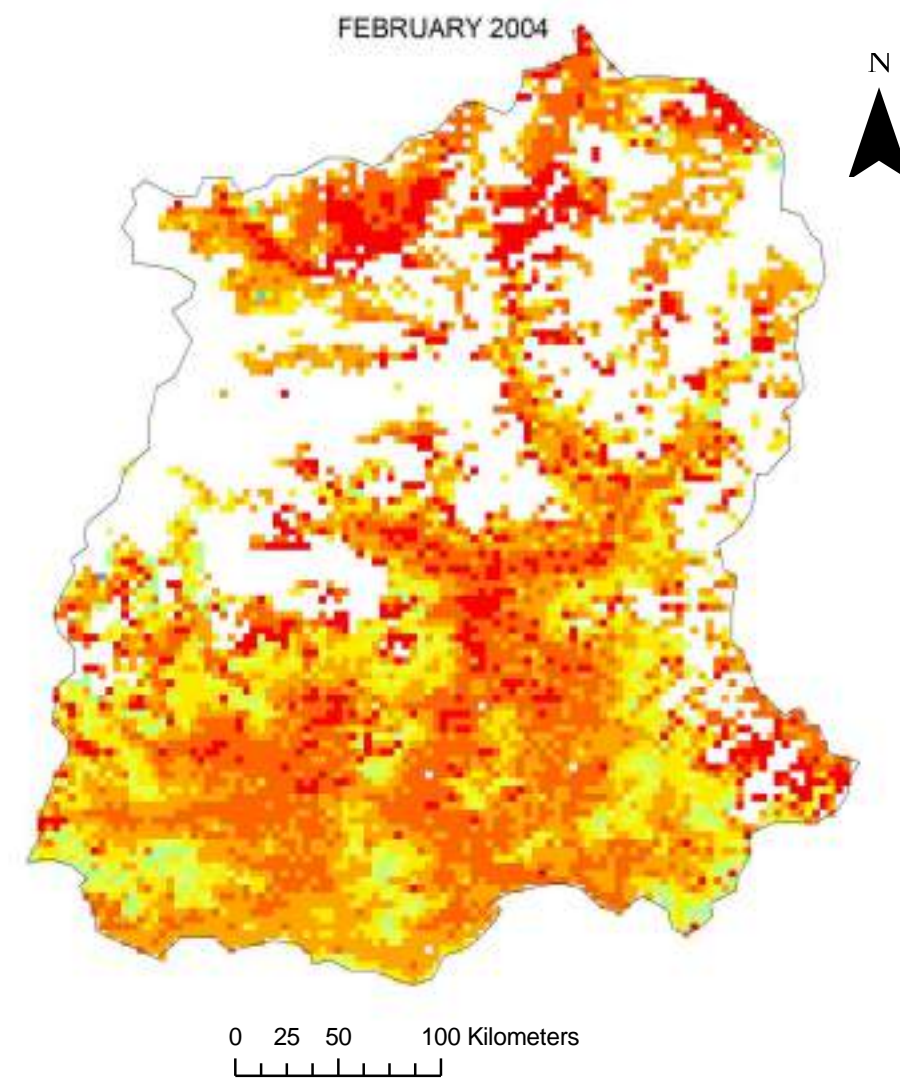
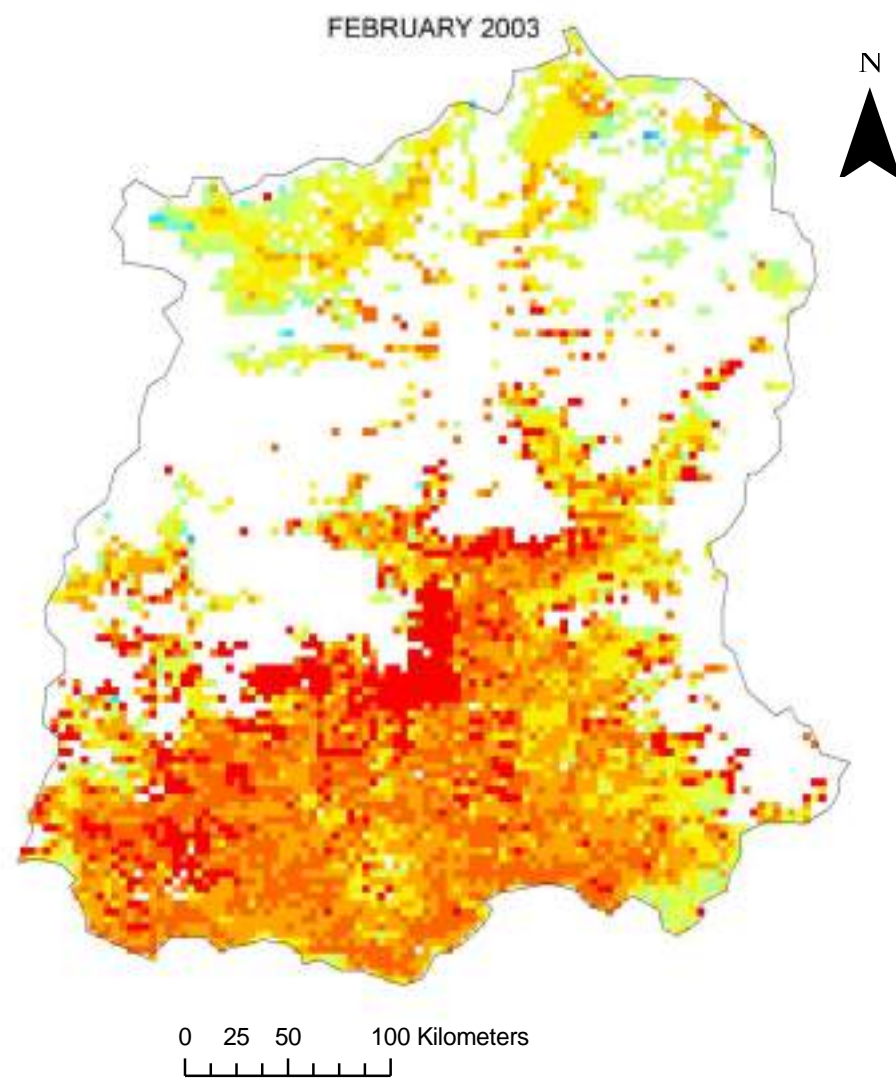




**Legend**

- |  |   |  |
|--|---|--|
|  Extreme Drought (-1.5 or less)   |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19)   |
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|  Mild Drought (-0.6 to -0.89)     |  Slightly Wet (0.6 to 0.89)        |  |



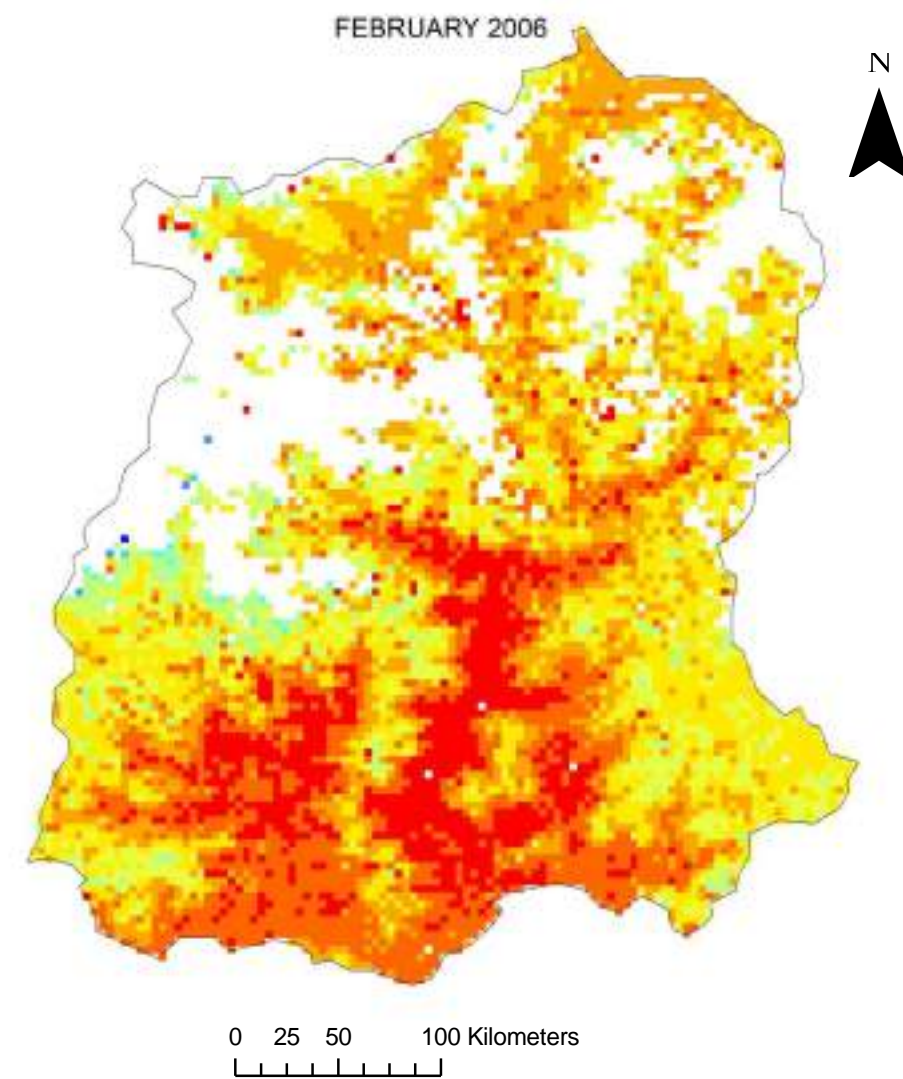
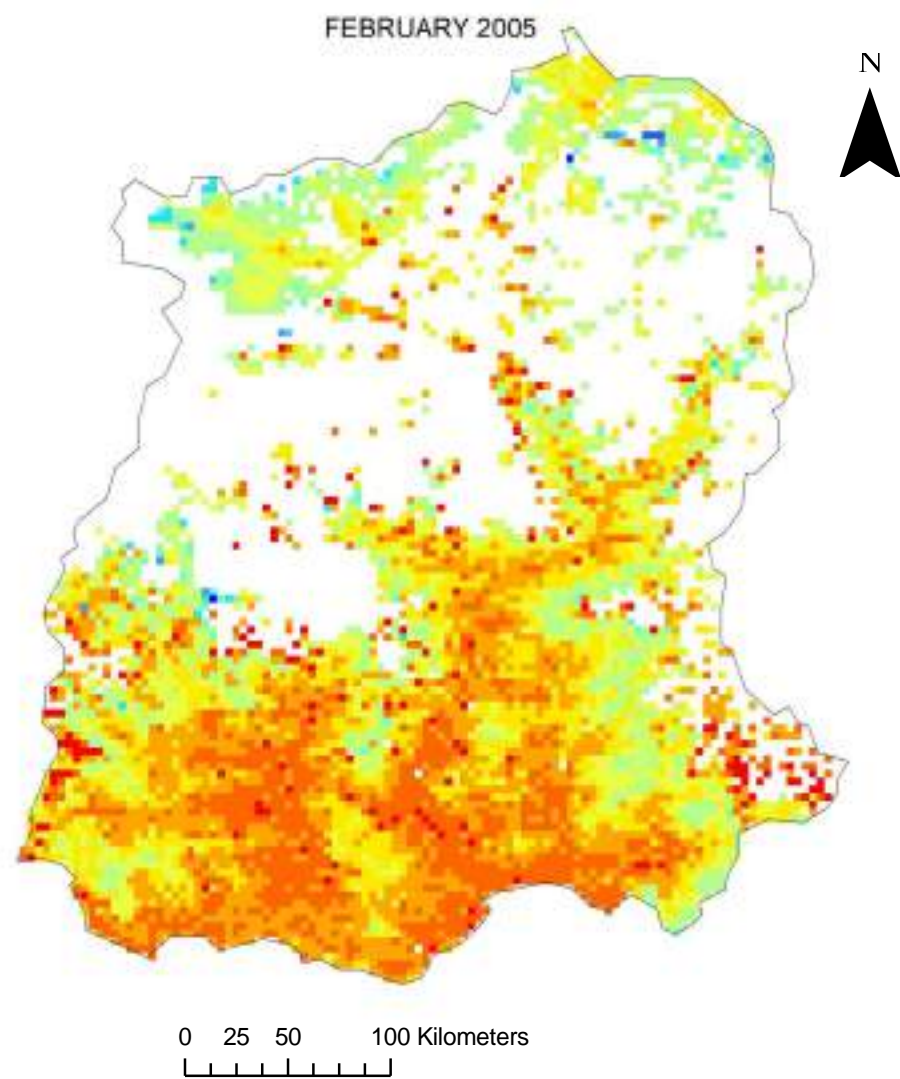


**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
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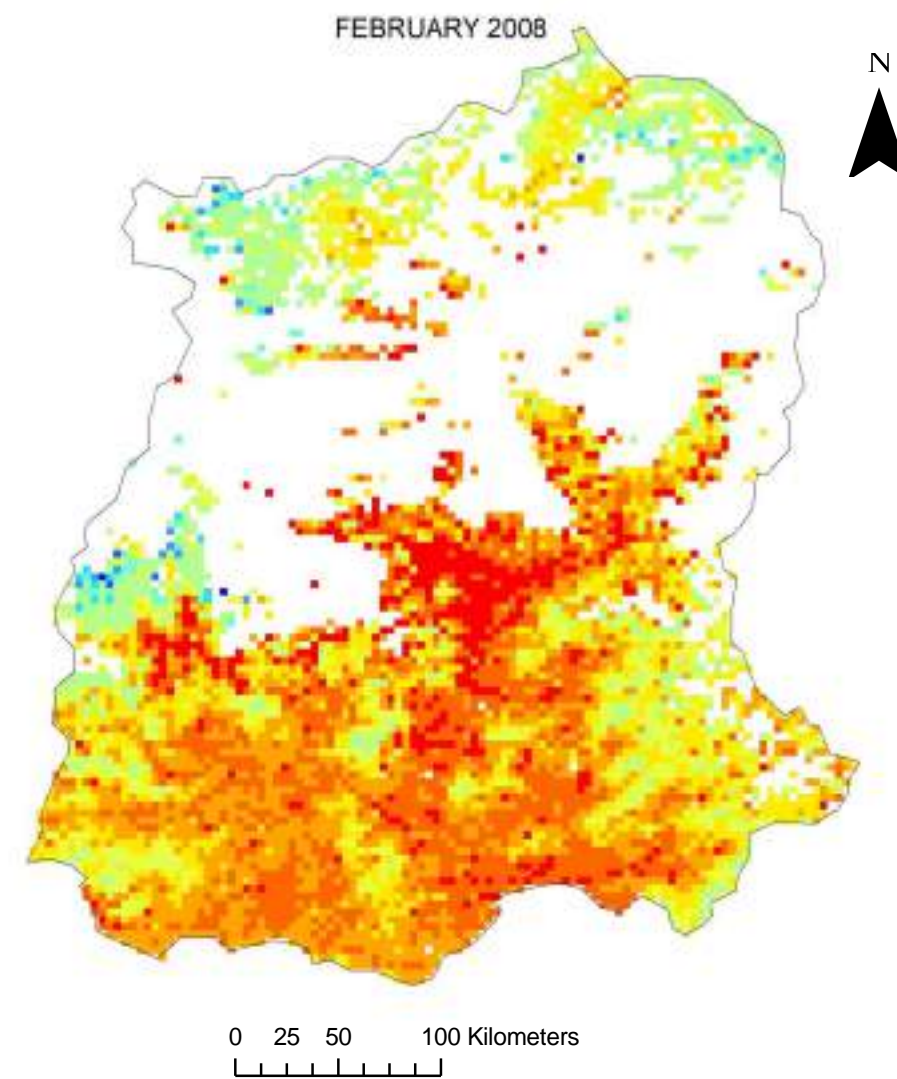
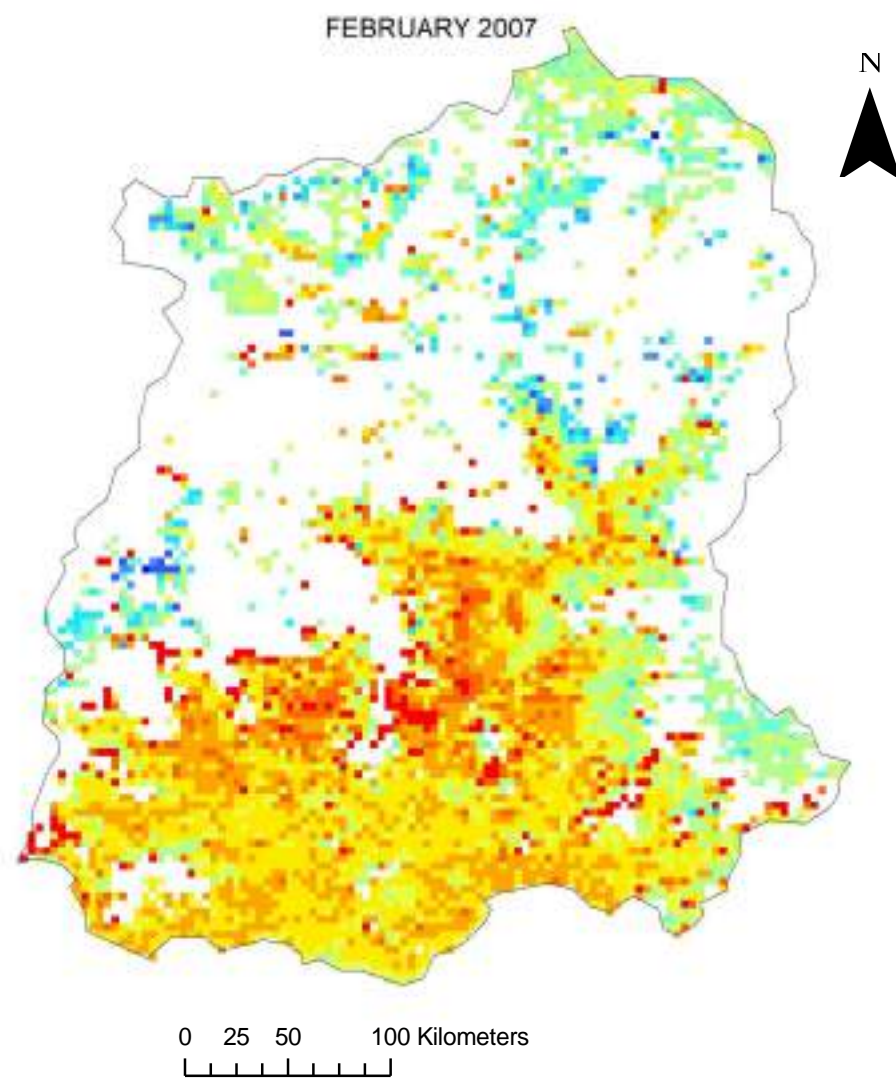
**Legend**

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- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)





- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)


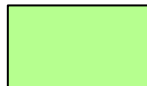


- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)

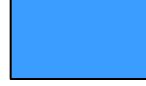






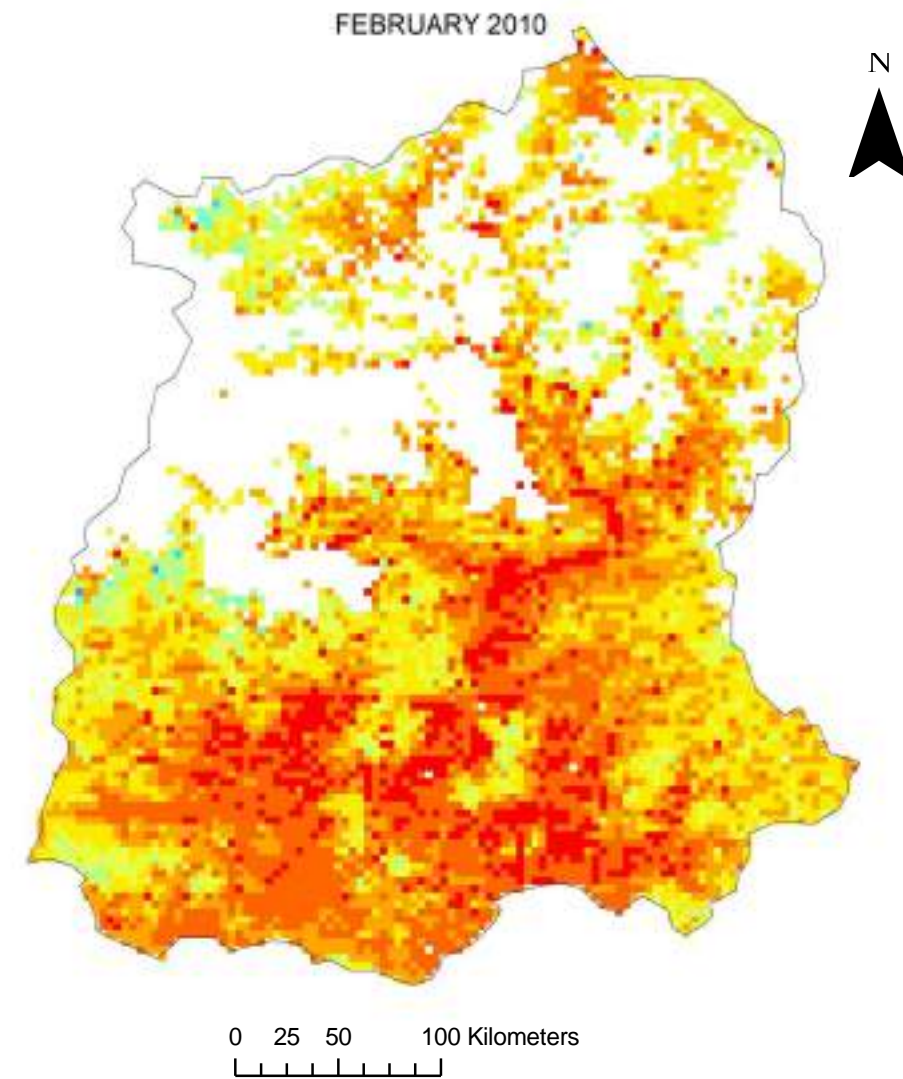
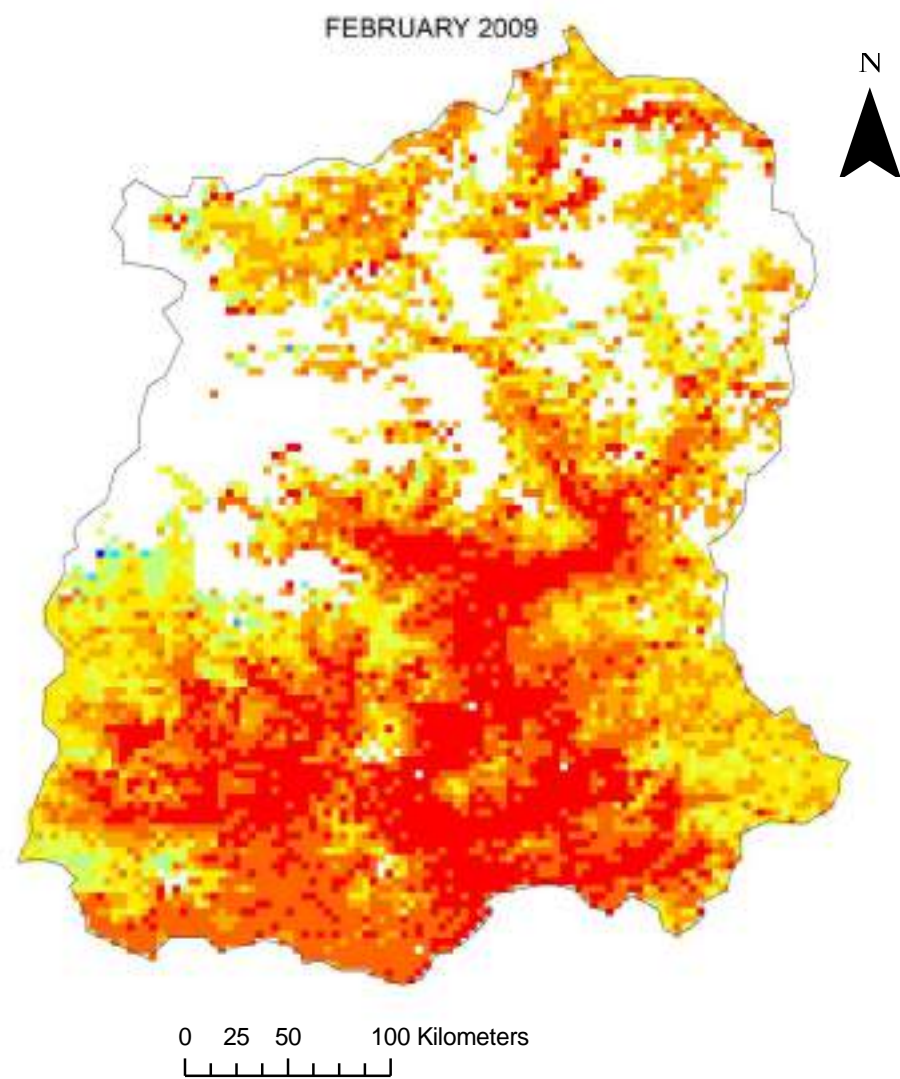
**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)





-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)


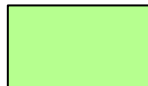


-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)

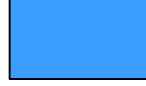




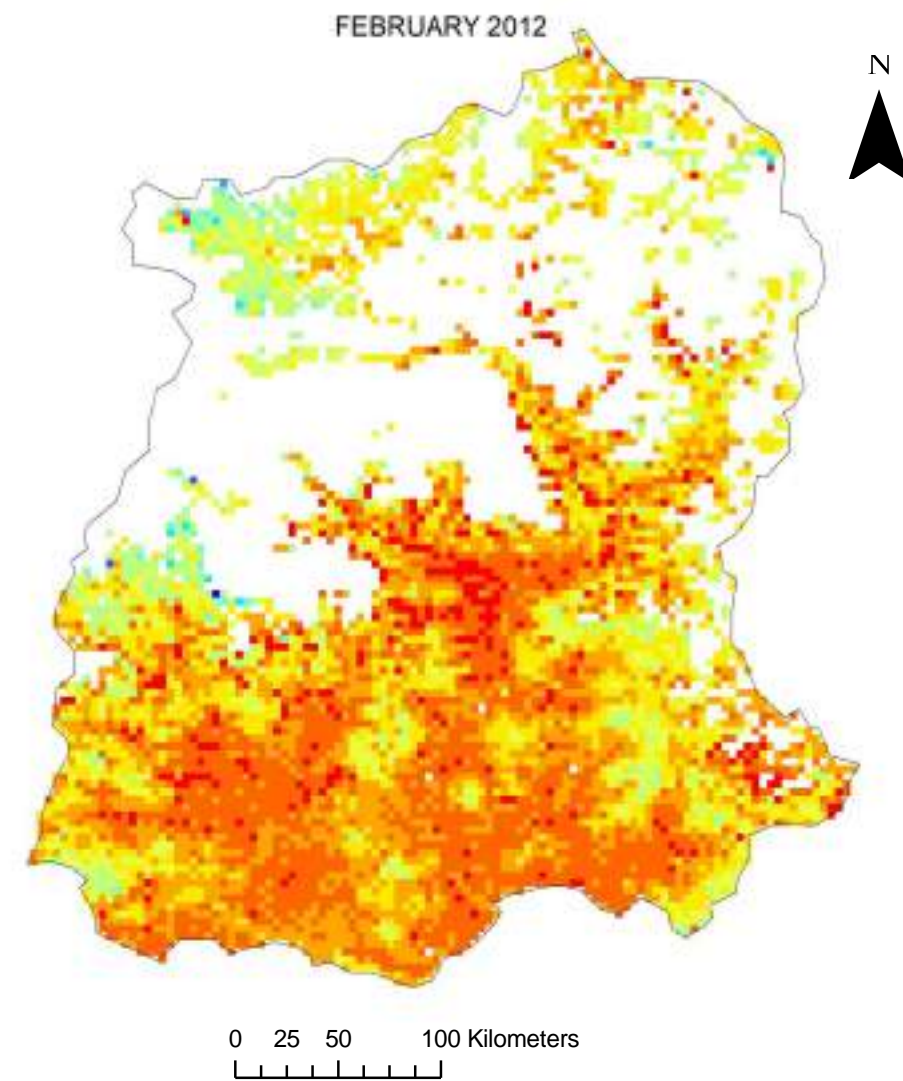
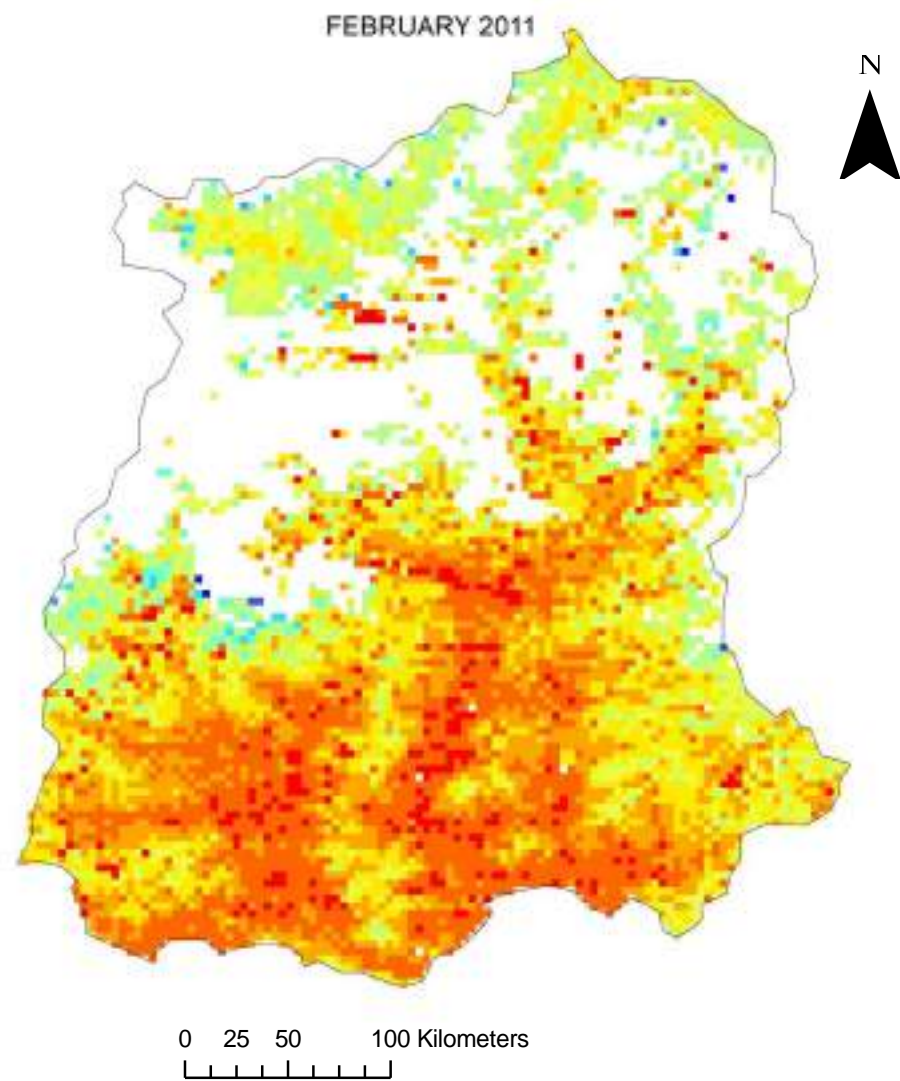


**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
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-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



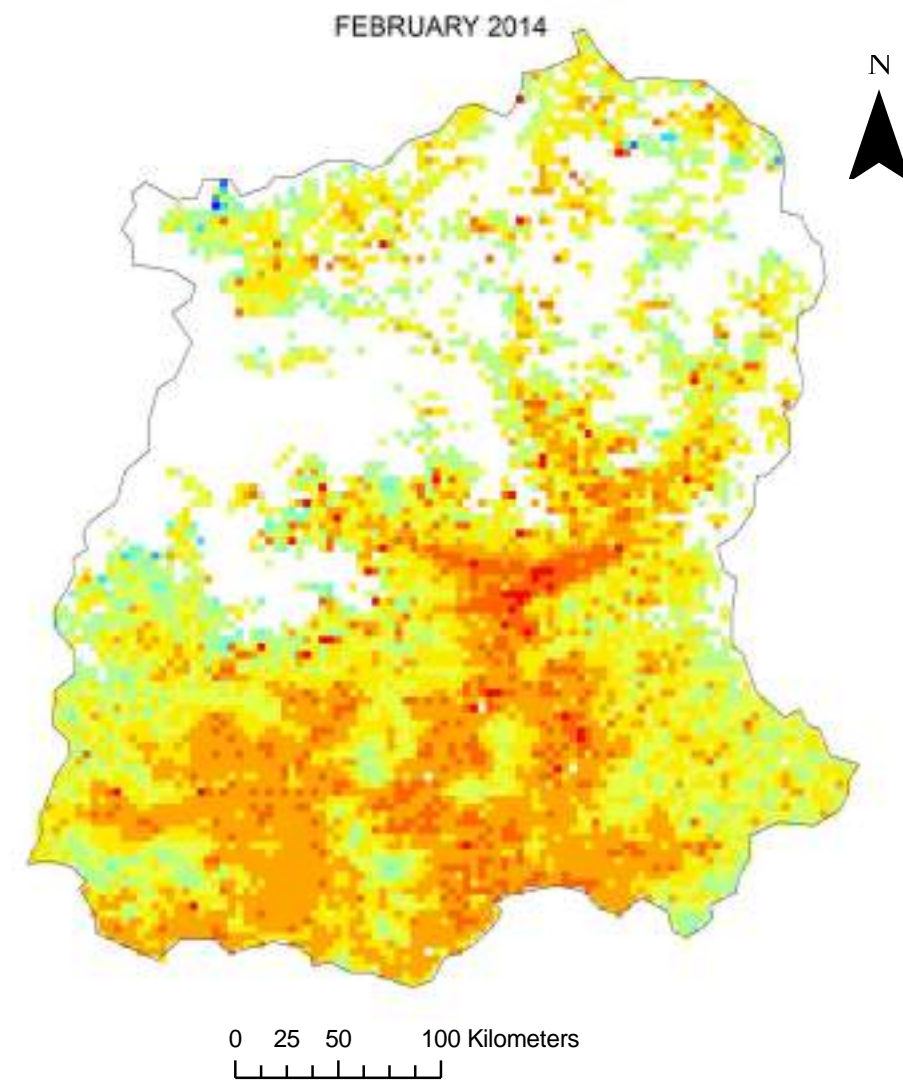
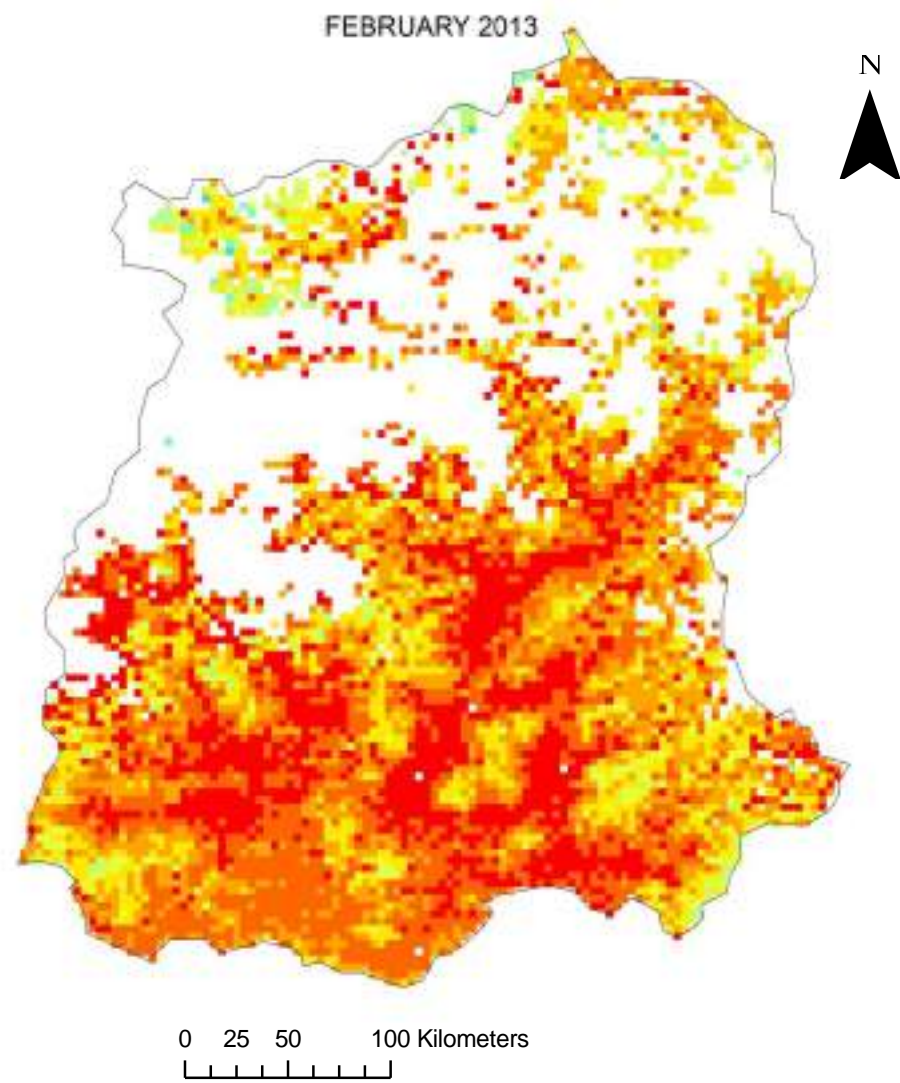
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

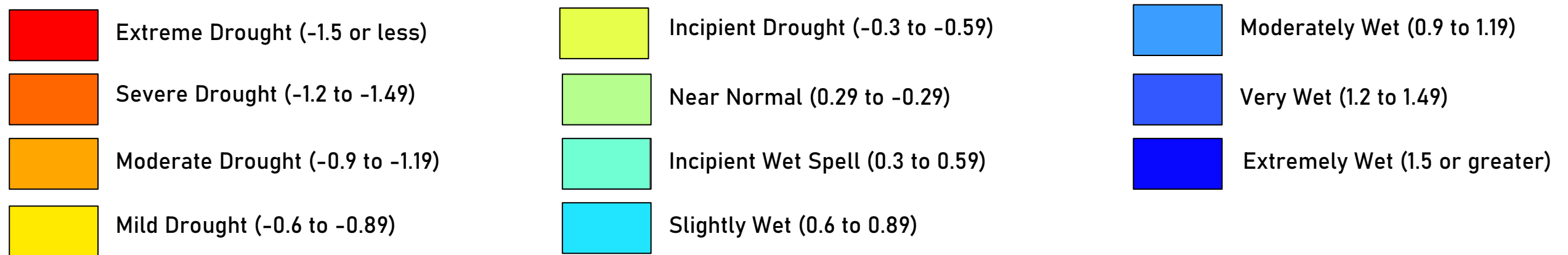
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

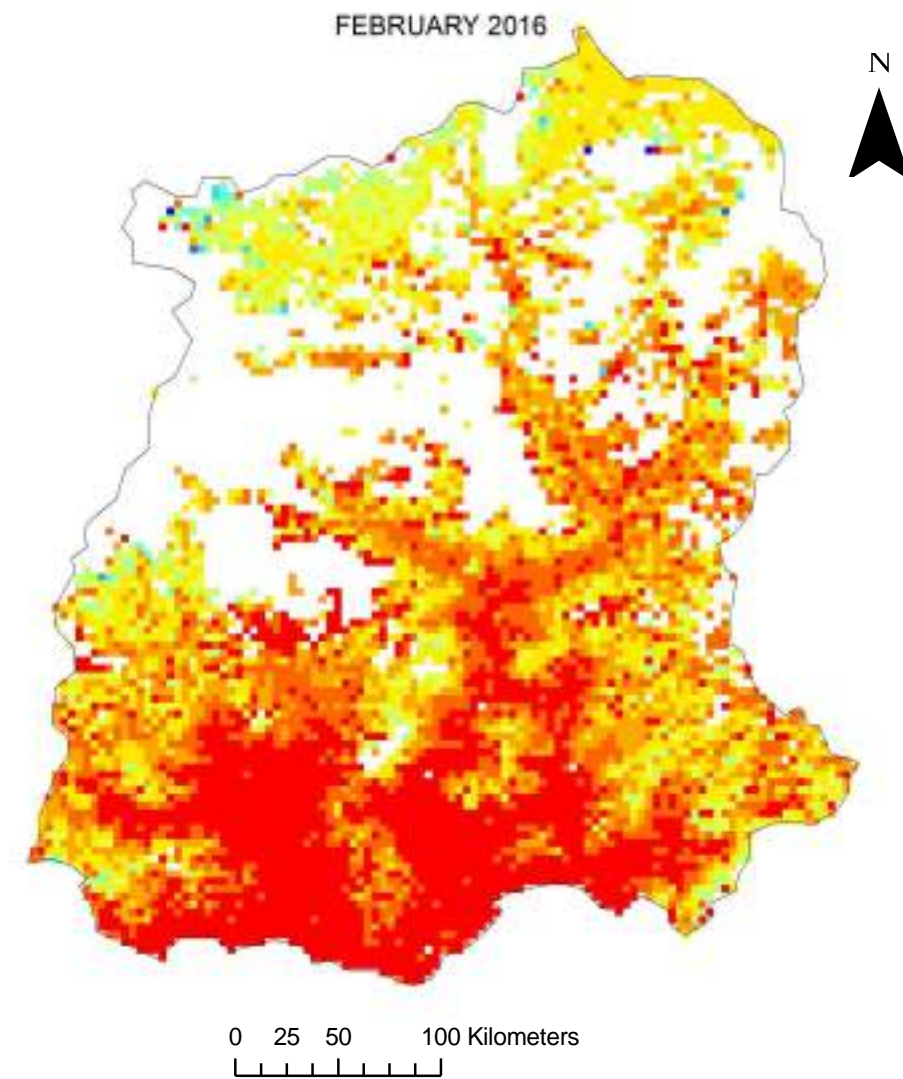
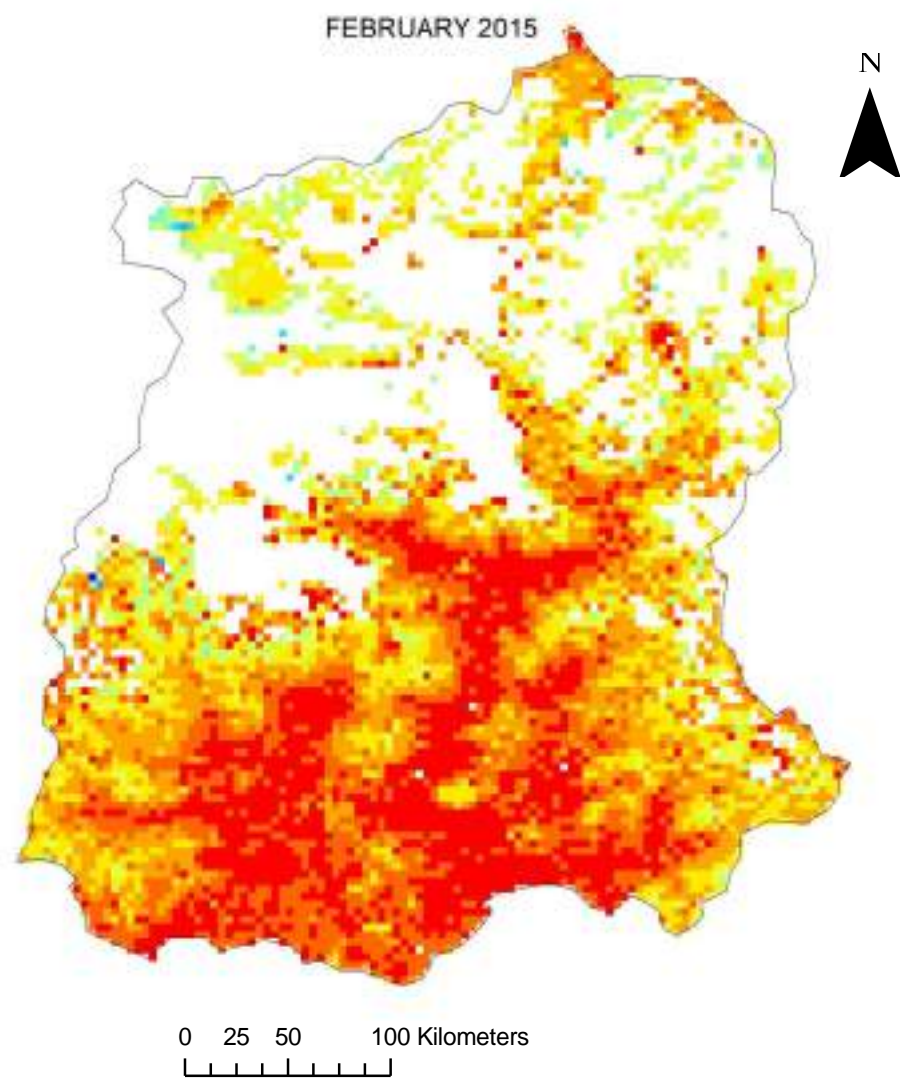
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)










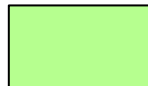


**Legend**

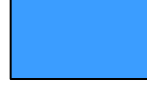






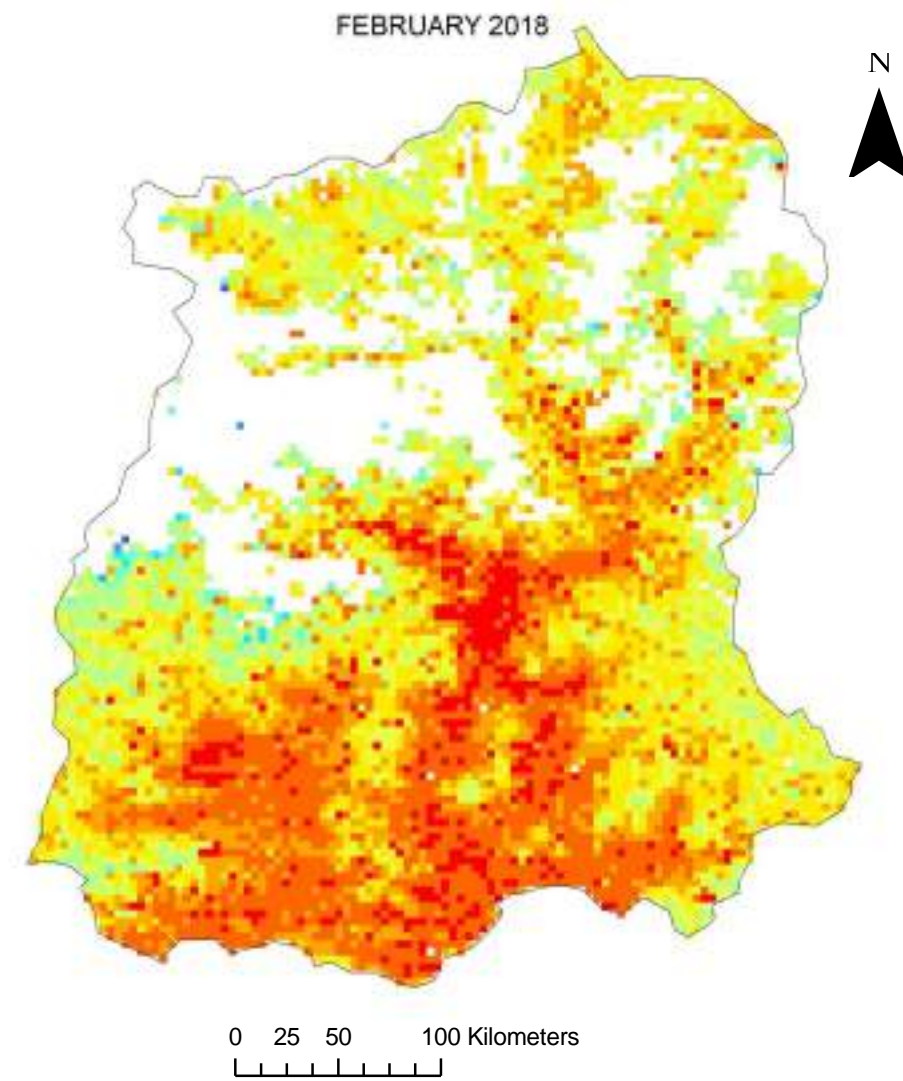
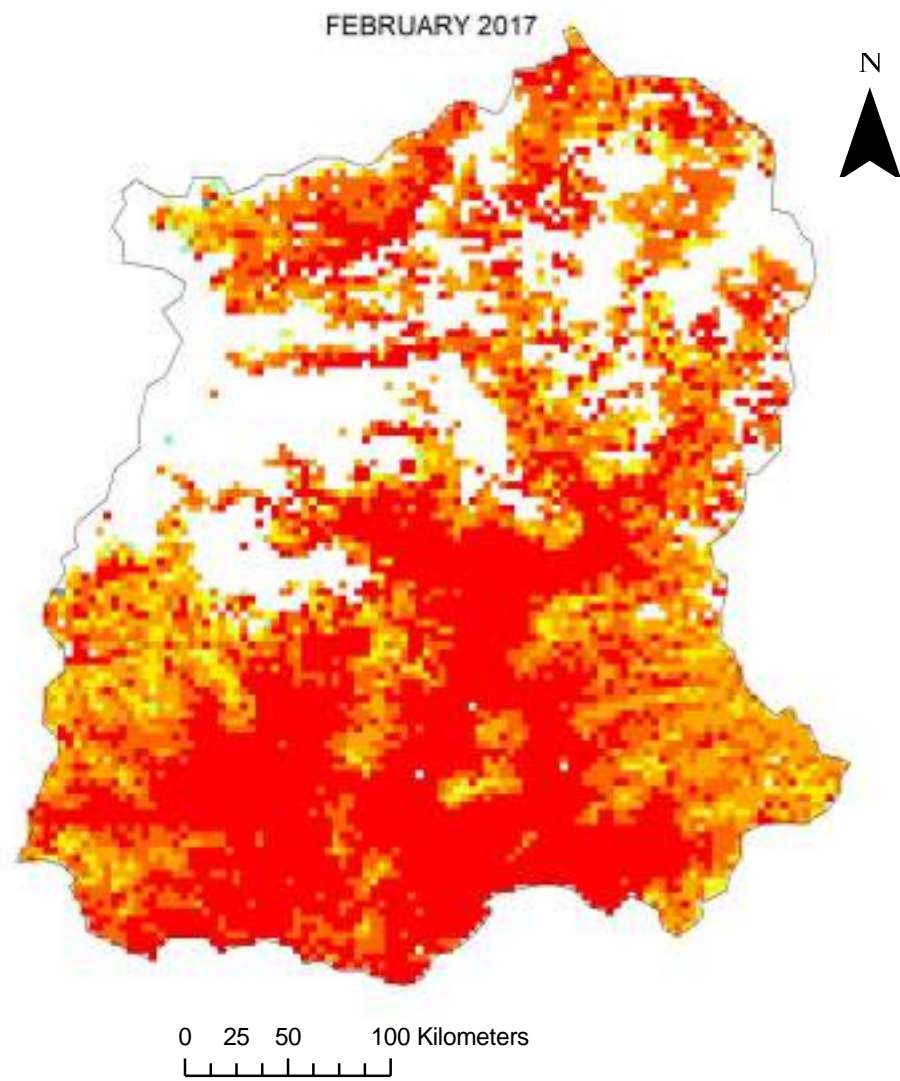
**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)





-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)


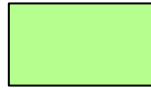


-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)






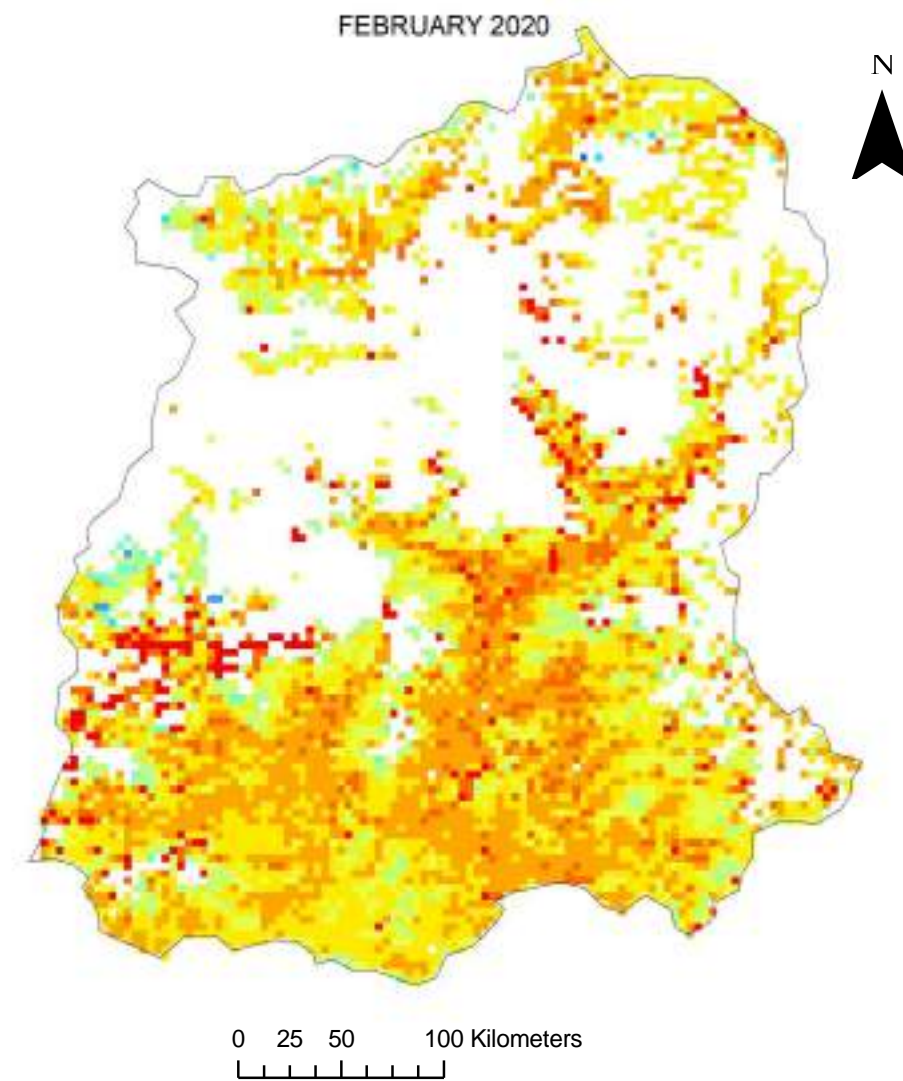
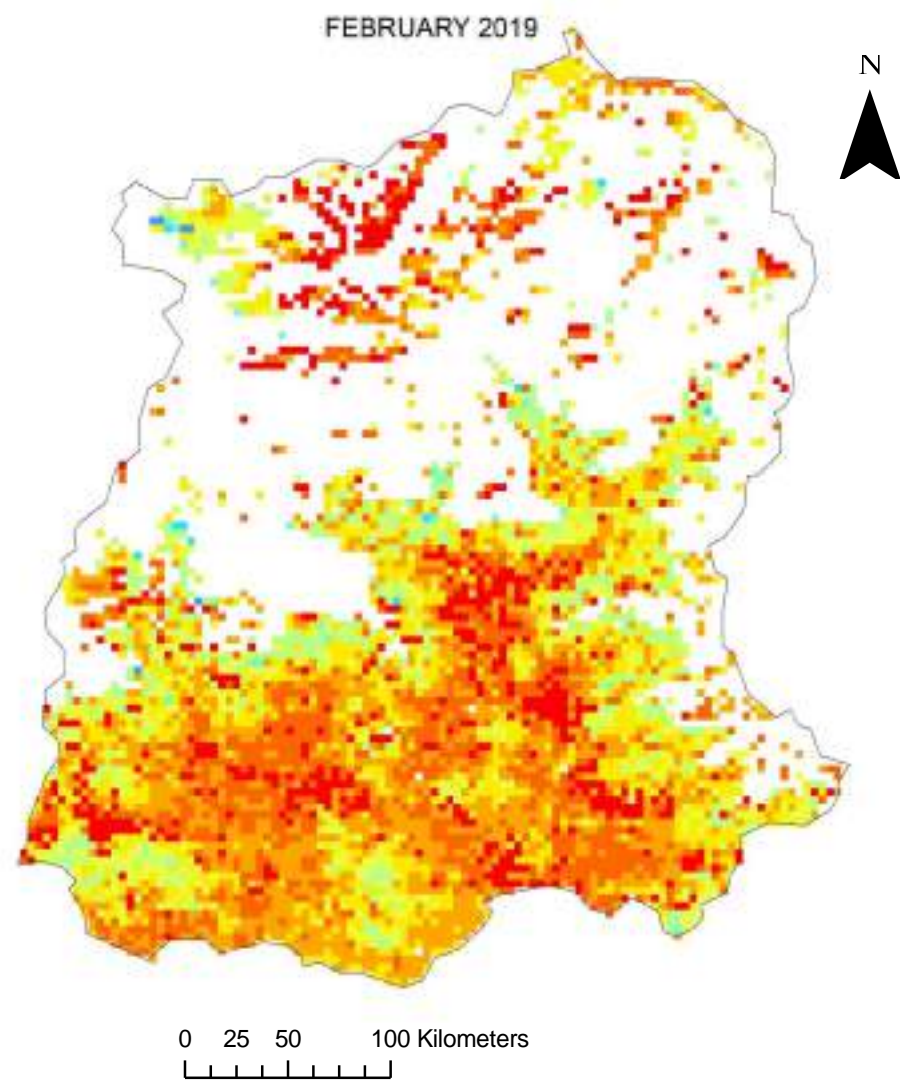


**Legend**





-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
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-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)




-  Moderately Wet (0.9 to 1.19)
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-  Extremely Wet (1.5 or greater)



**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
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-  Near Normal (0.29 to -0.29)
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-  Slightly Wet (0.6 to 0.89)

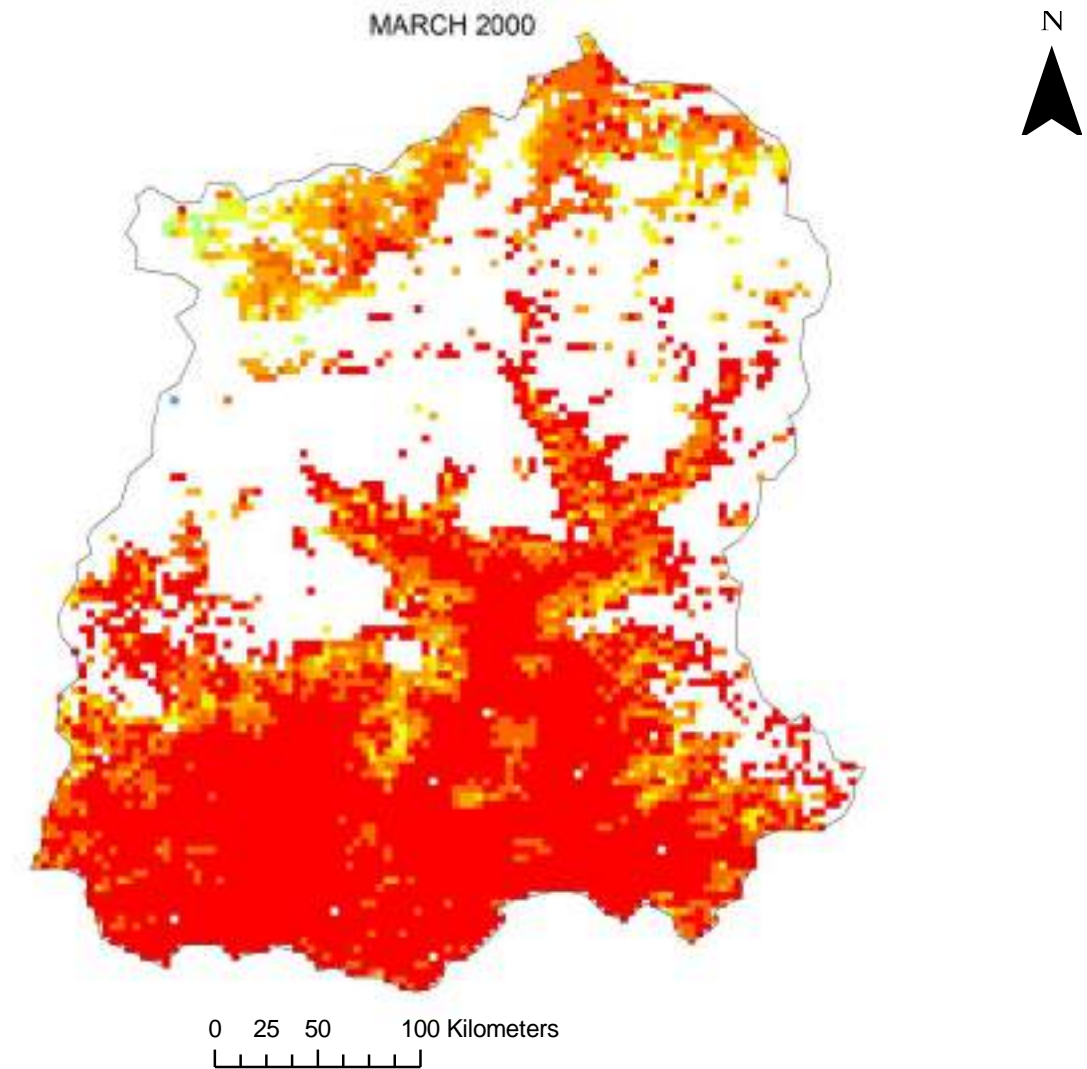
-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



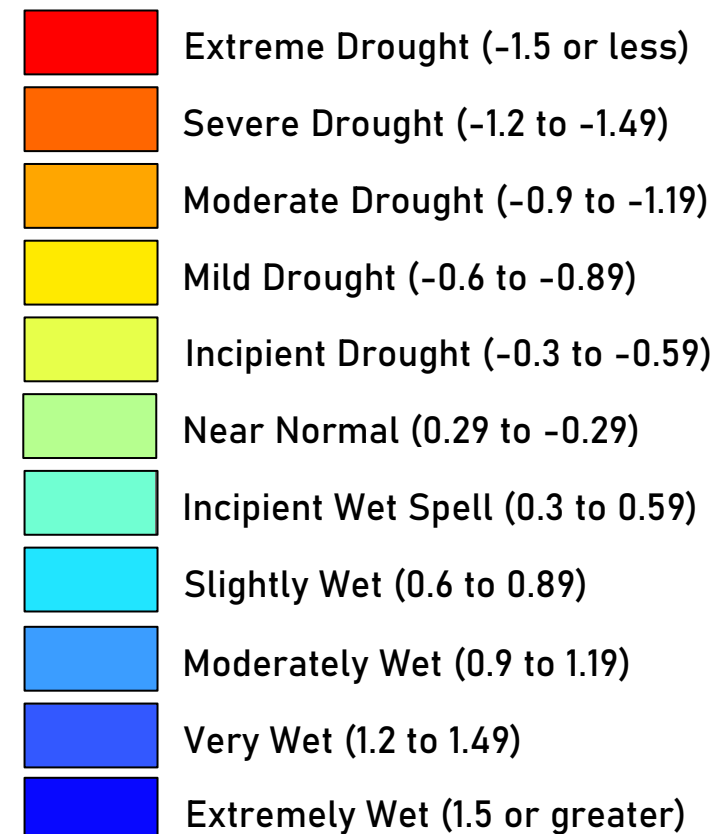
## March DSI Maps

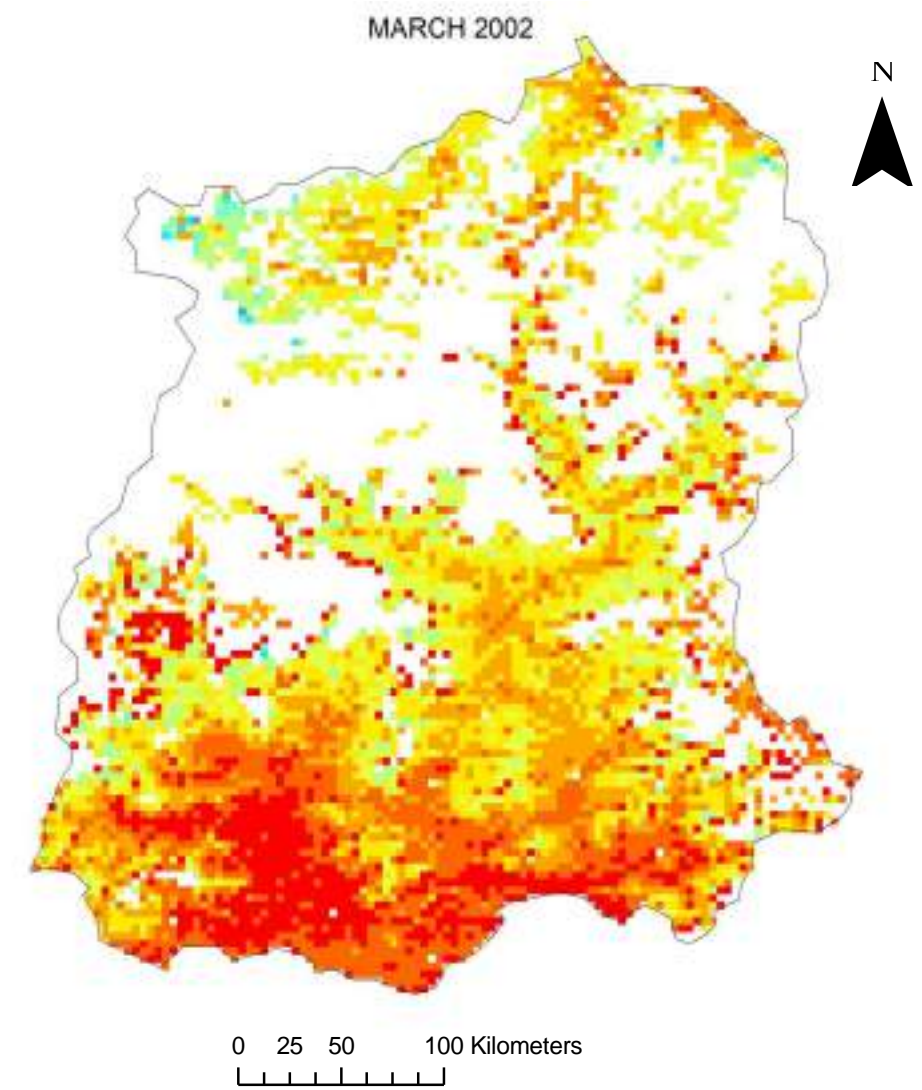
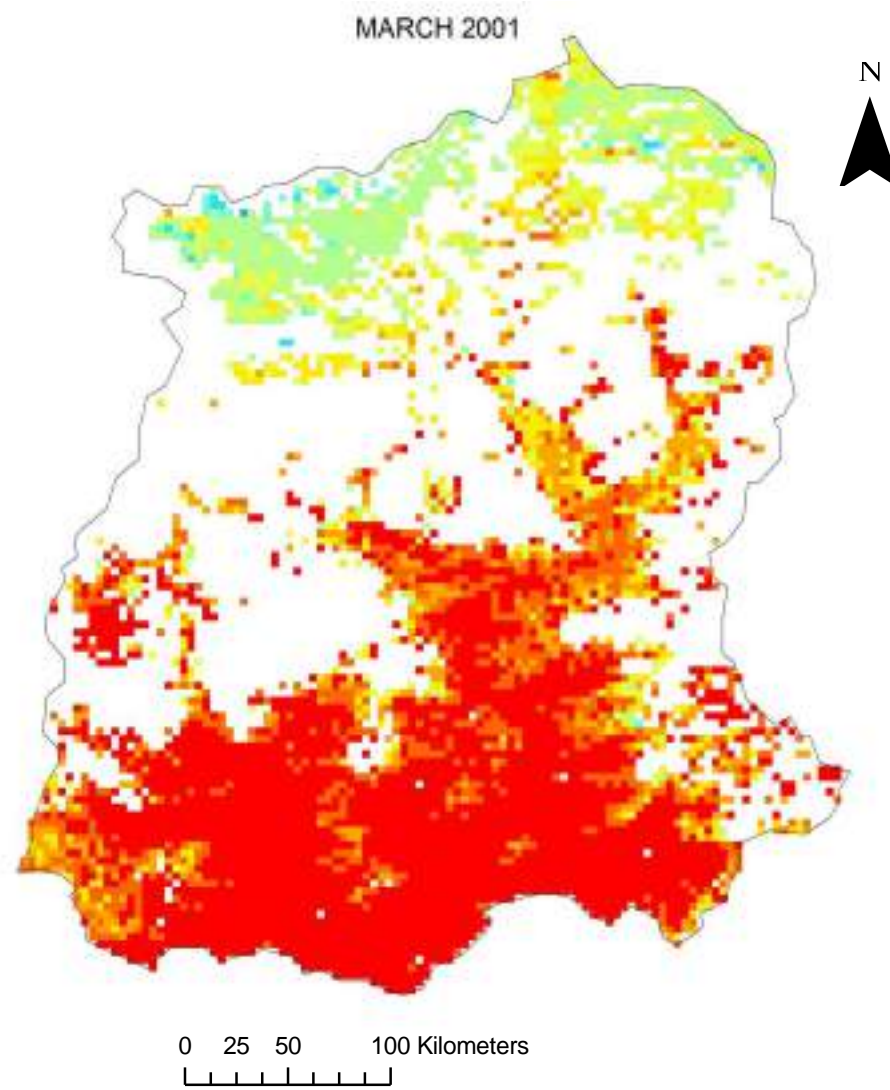
Drought conditions range from extreme to milder in March. Moderate drought was more common than other types of drought. Drought conditions were identified as extreme in the year 2000, and severe in the years 2001, 2007, 2012, and 2015.

Mean March DSI Values		
Year	DSI Values	Drought Condition
2000	-1.53	Extreme Drought
2001	-1.29	Severe drought
2002	-1.03	Moderate Drought
2003	-0.75	Mild Drought
2004	-1.00	Moderate Drought
2005	-0.68	Mild Drought
2006	-0.96	Moderate Drought
2007	-1.34	Severe drought
2008	-0.73	Mild Drought
2009	-1.18	Moderate Drought
2010	-1.02	Moderate Drought
2011	-0.95	Moderate Drought
2012	-1.20	Severe drought
2013	-0.97	Moderate Drought
2014	-0.80	Mild Drought
2015	-1.31	Severe drought
2016	-0.96	Moderate Drought
2017	-1.10	Moderate Drought
2018	-0.85	Mild Drought
2019	-1.15	Moderate Drought
2020	-0.61	Mild Drought













### Legend

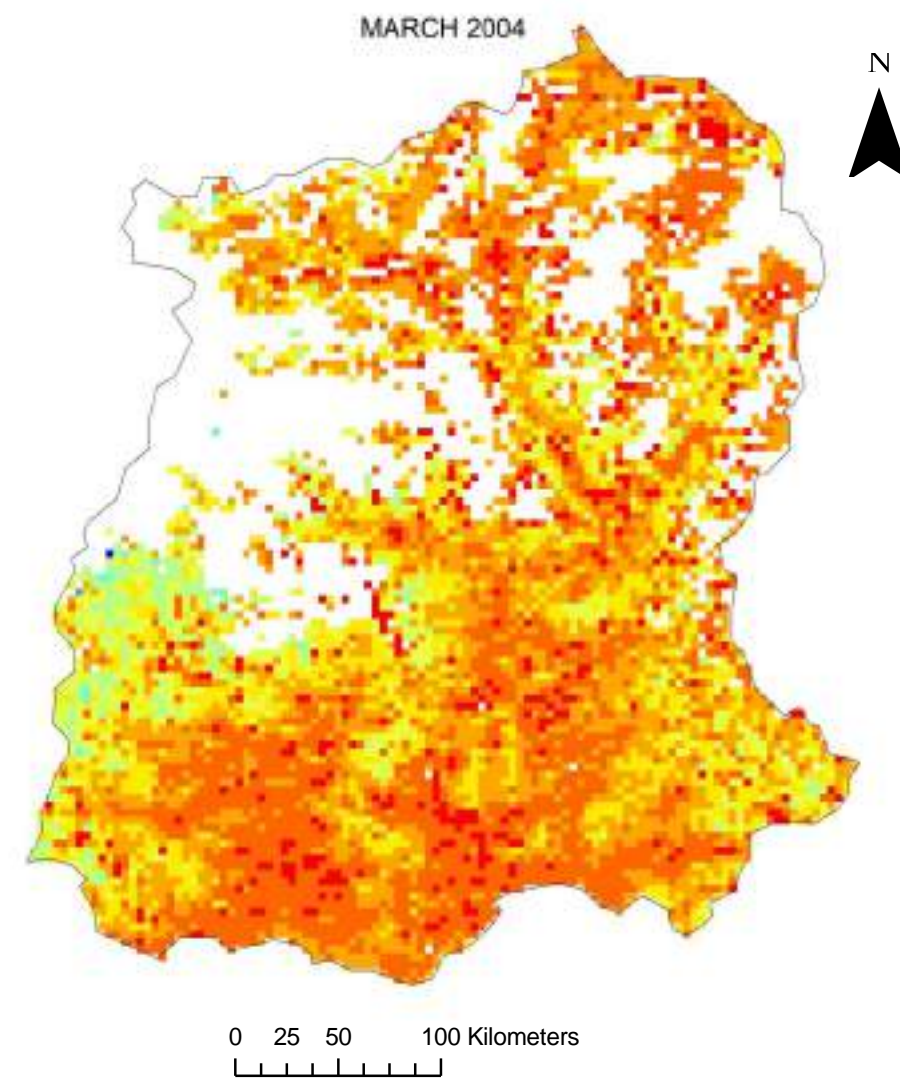
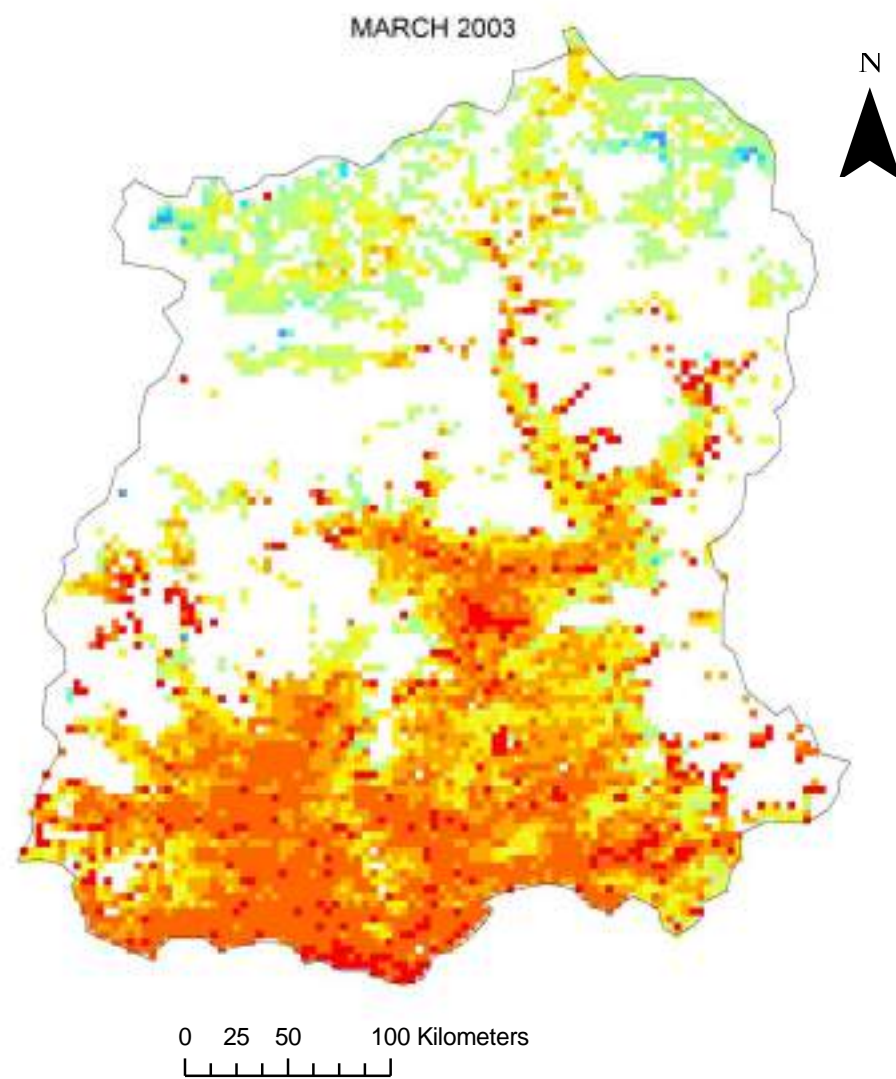




**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |   | Slightly Wet (0.6 to 0.89)        |   |                                |





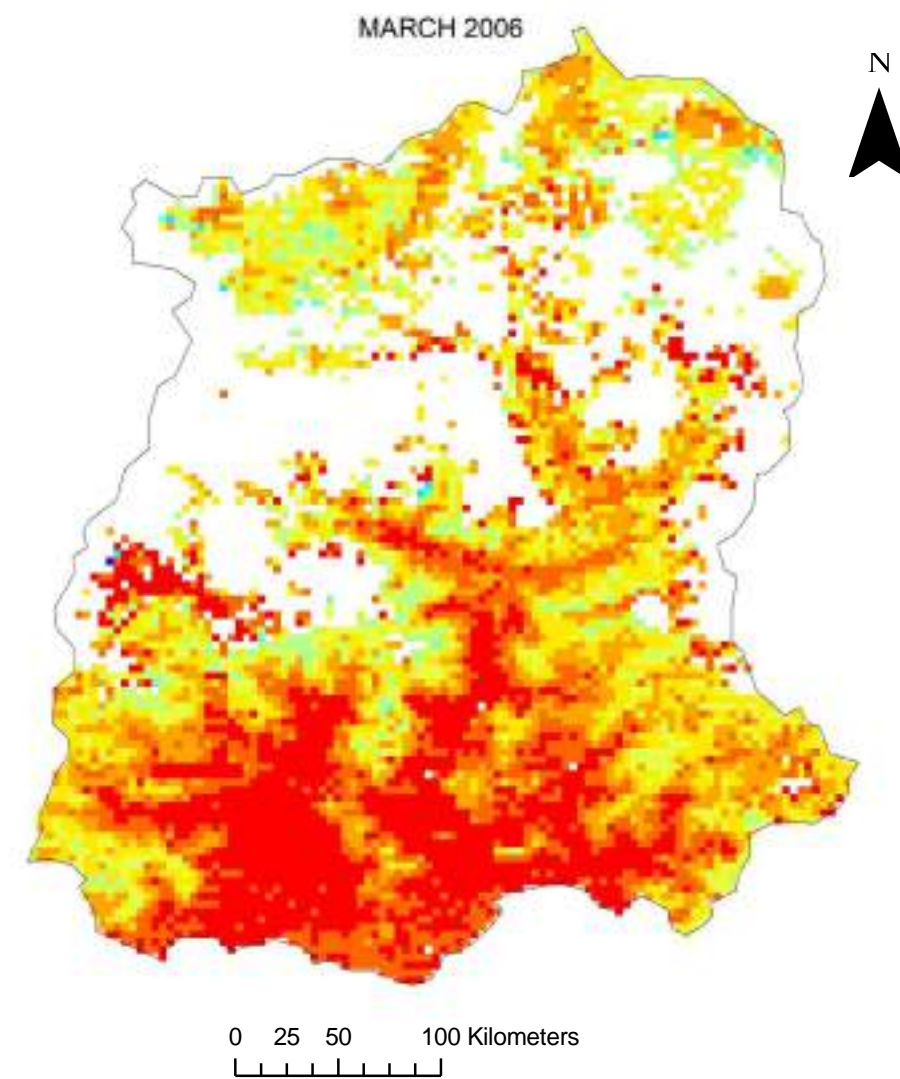
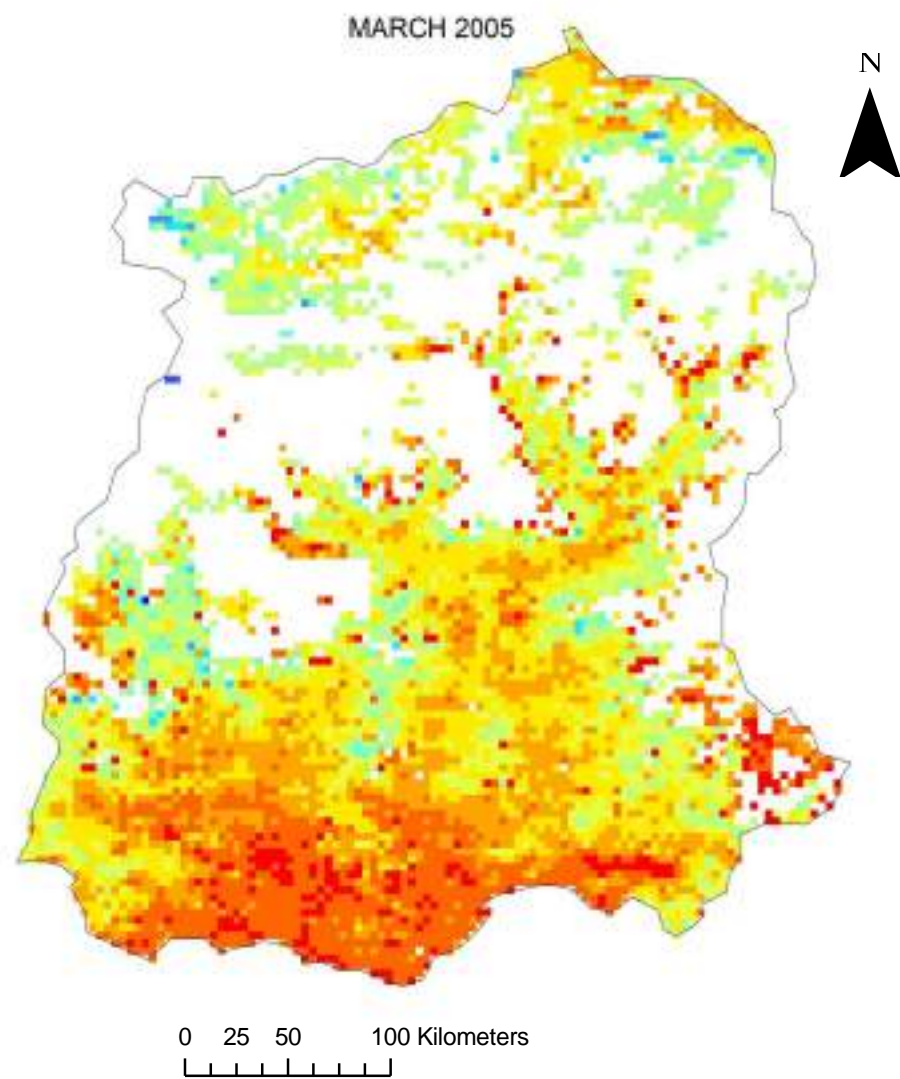
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

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- Near Normal (0.29 to -0.29)
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- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



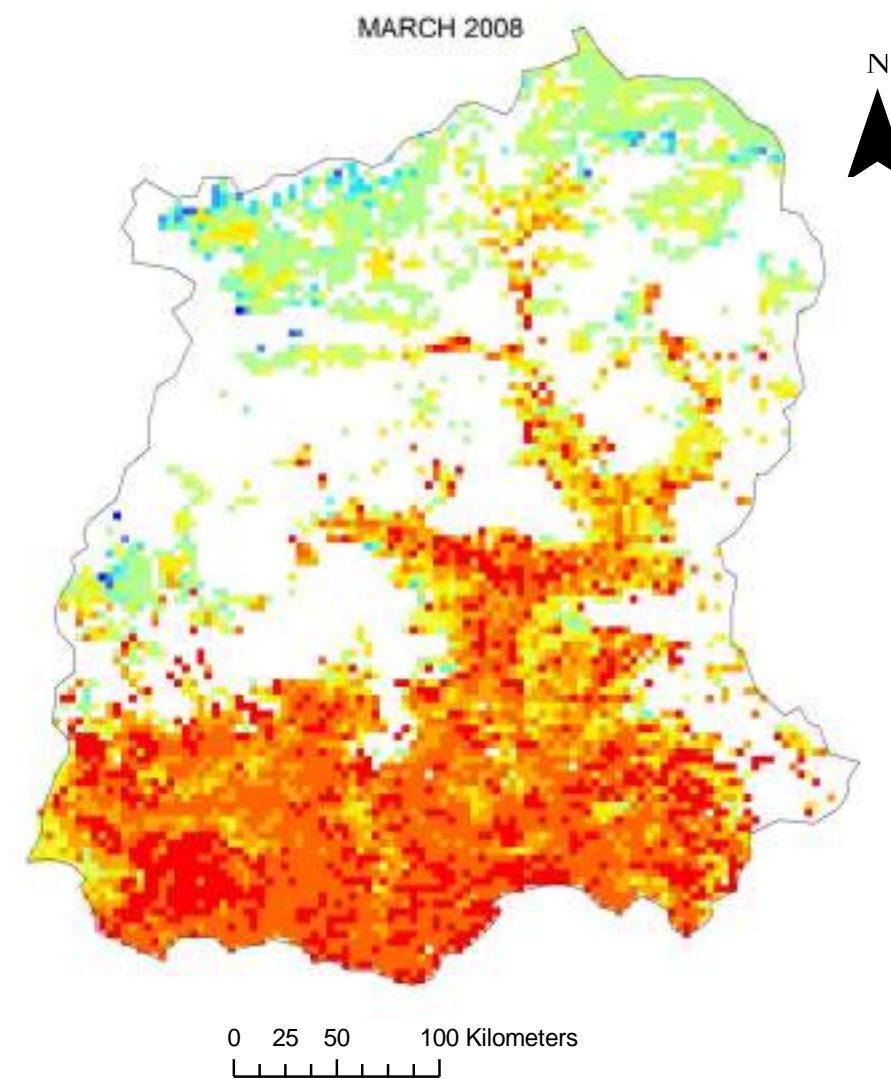
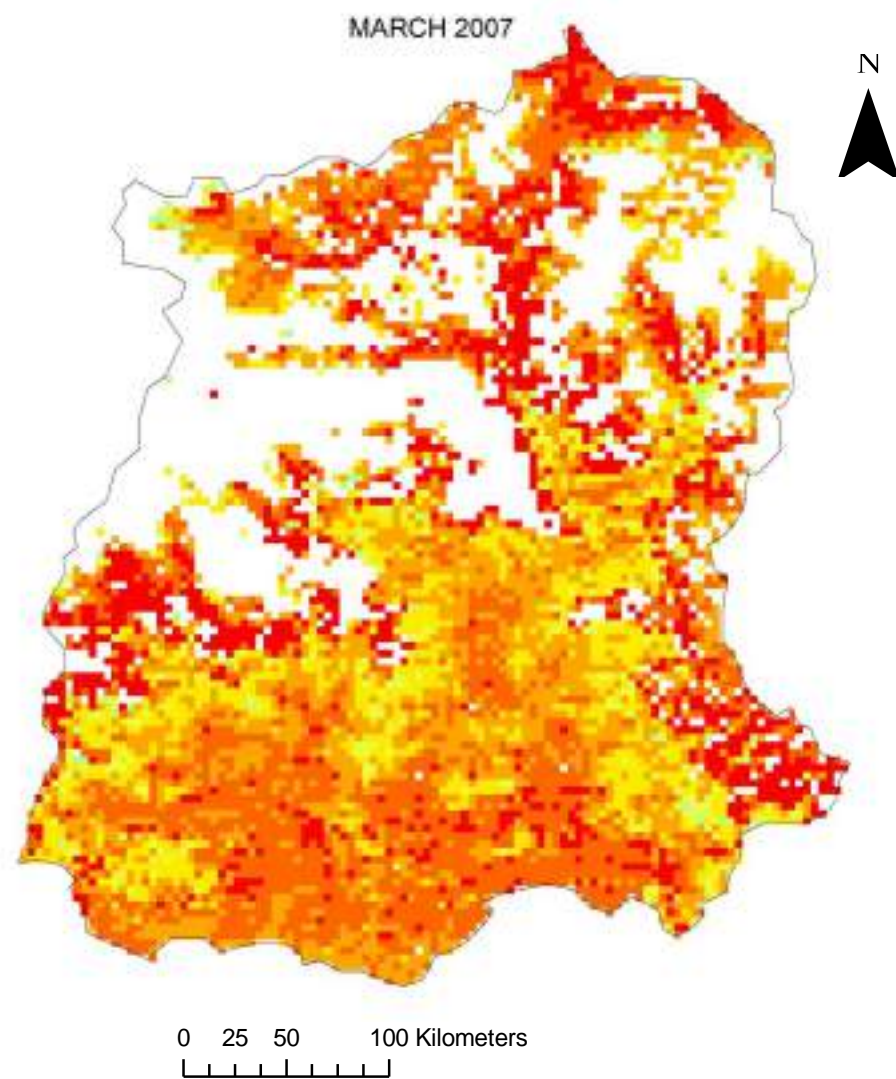


**Legend**

- Extreme Drought (-1.5 or less)
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- Slightly Wet (0.6 to 0.89)

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- Very Wet (1.2 to 1.49)
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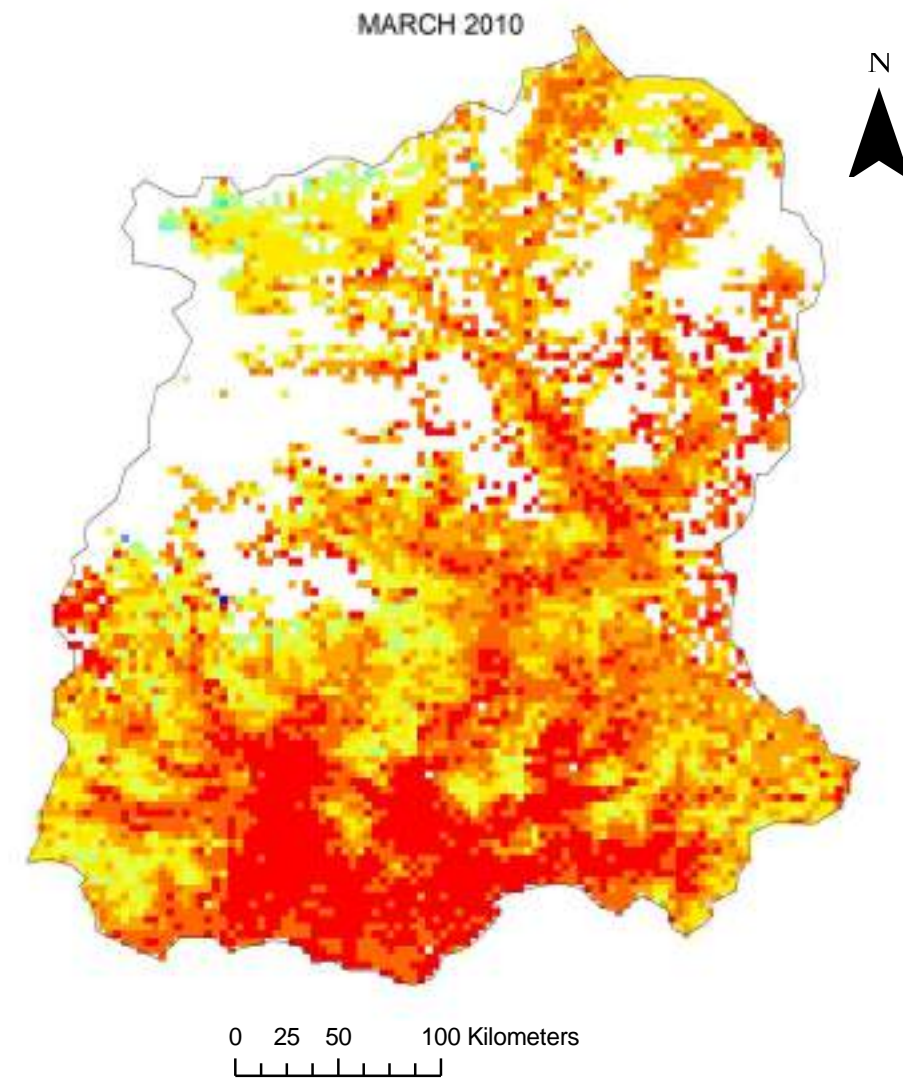
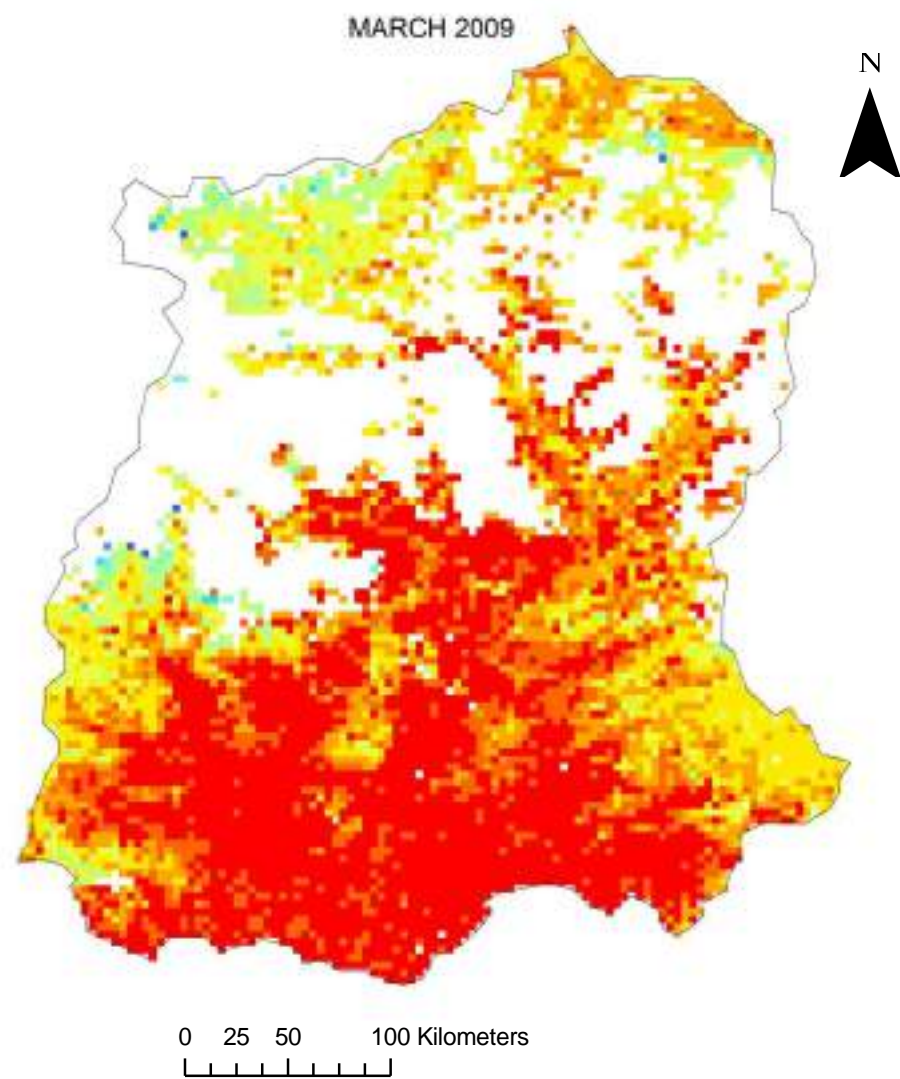
**Legend**

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- Severe Drought (-1.2 to -1.49)
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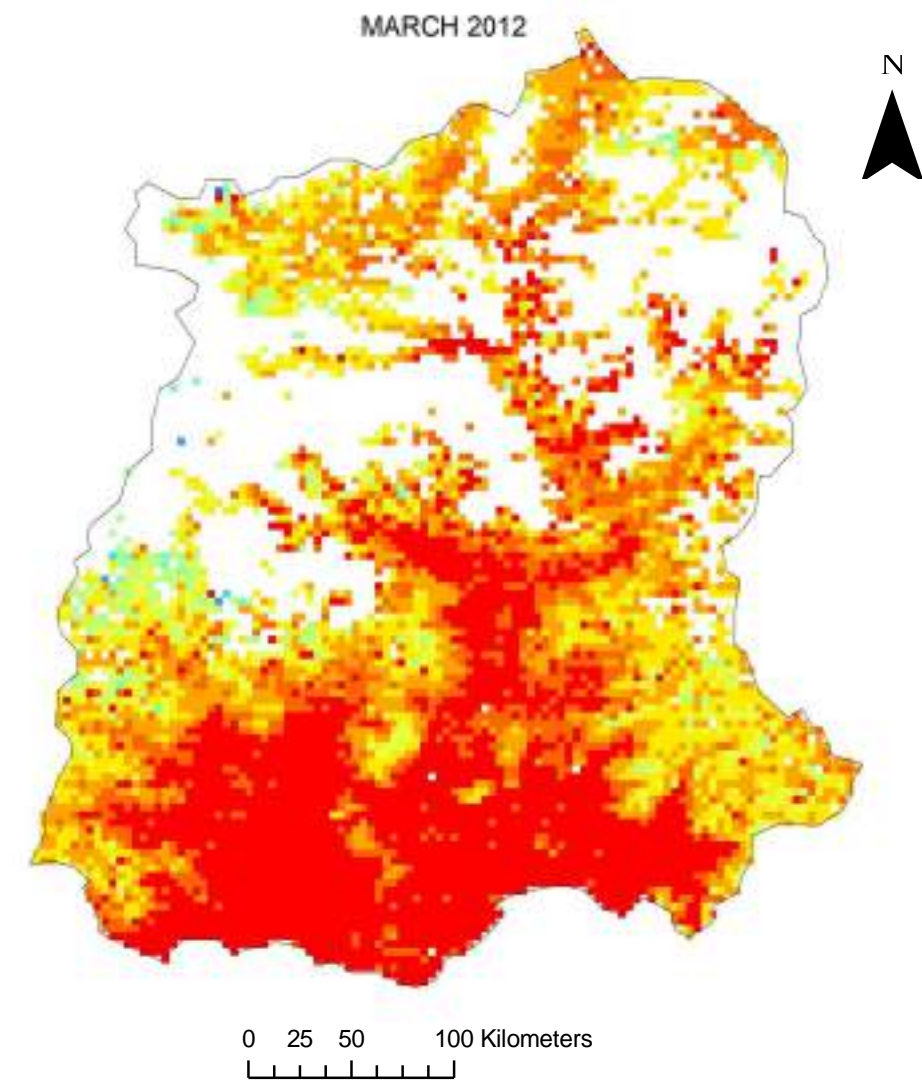
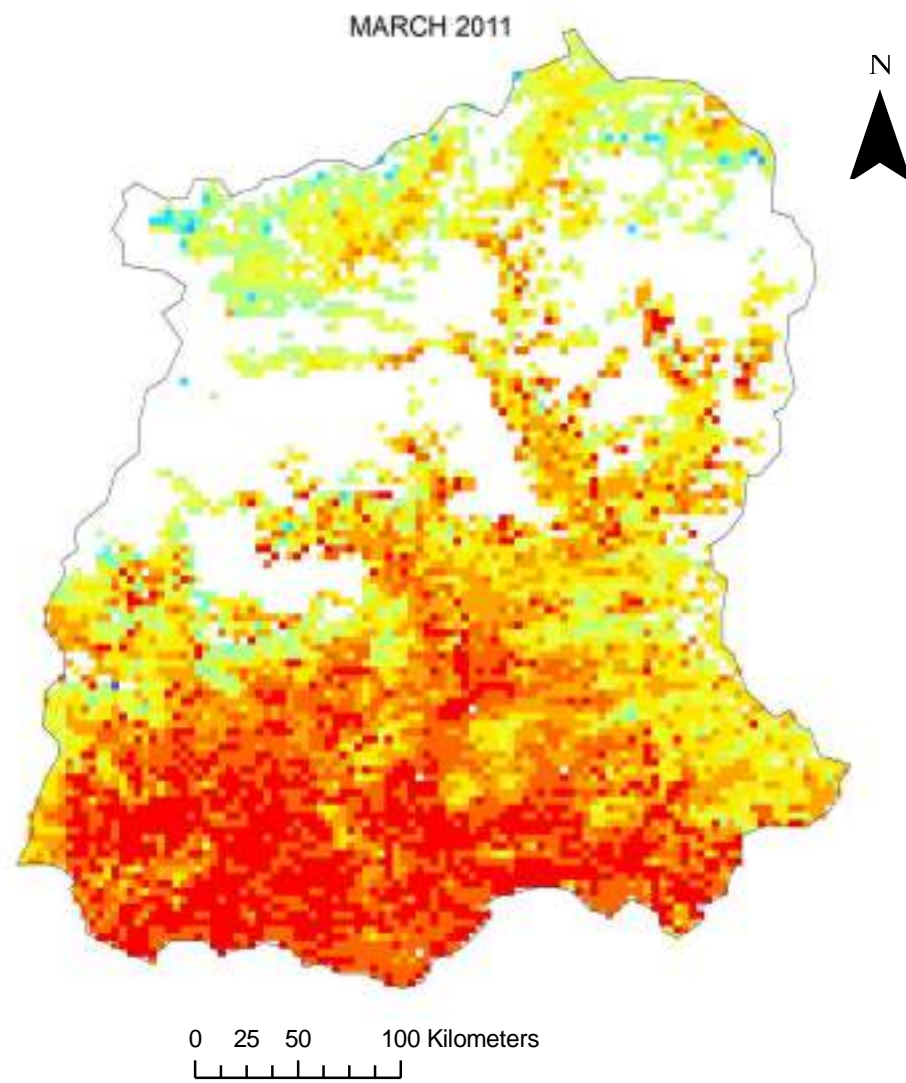
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

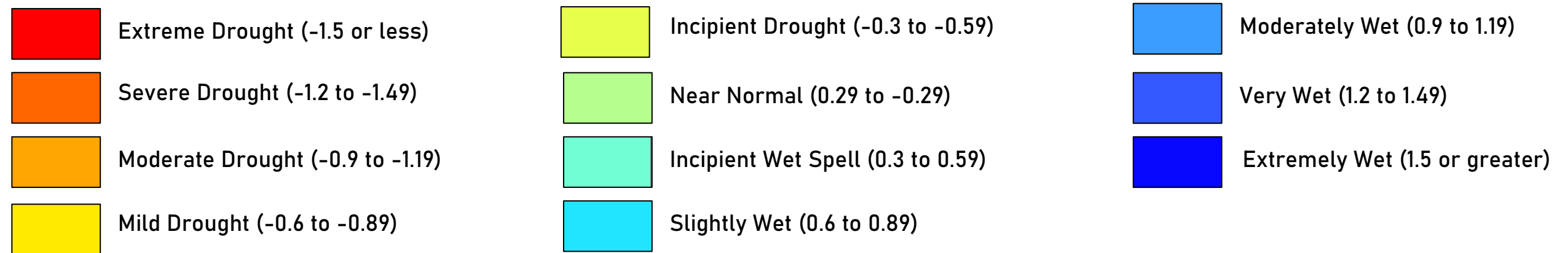
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

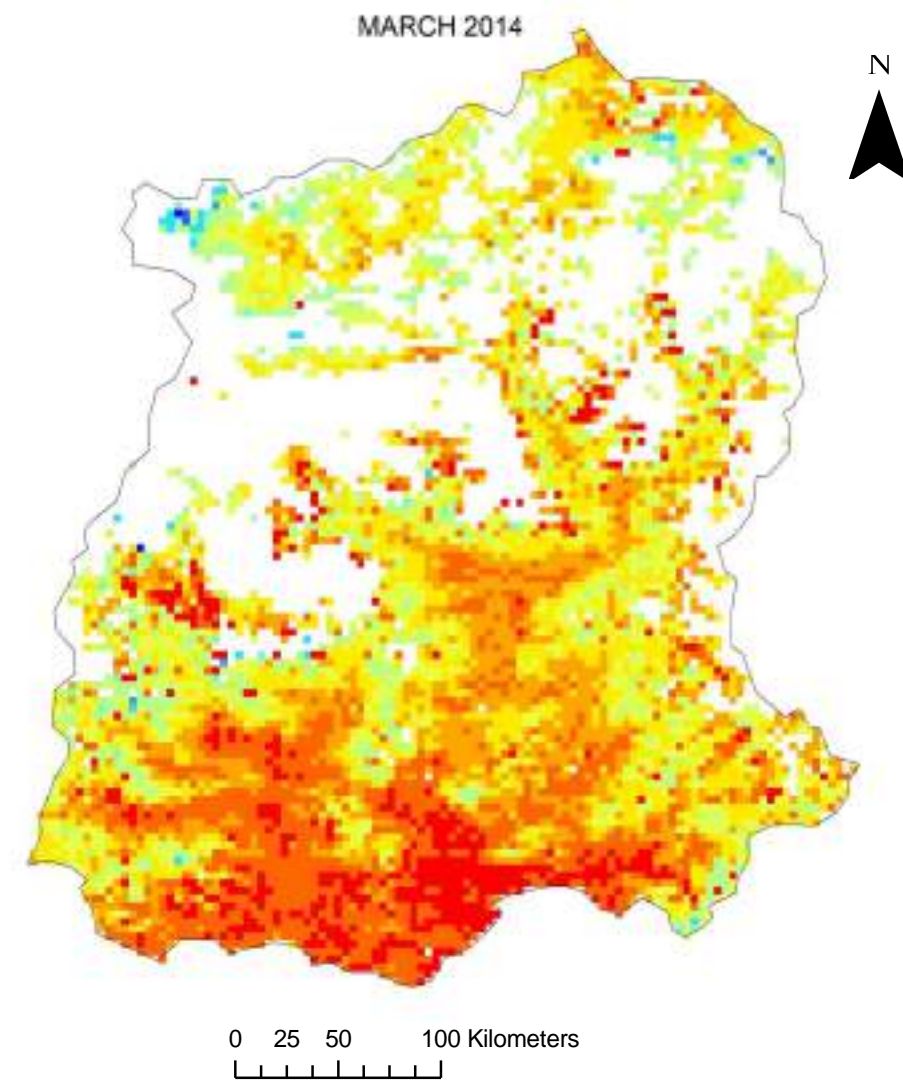
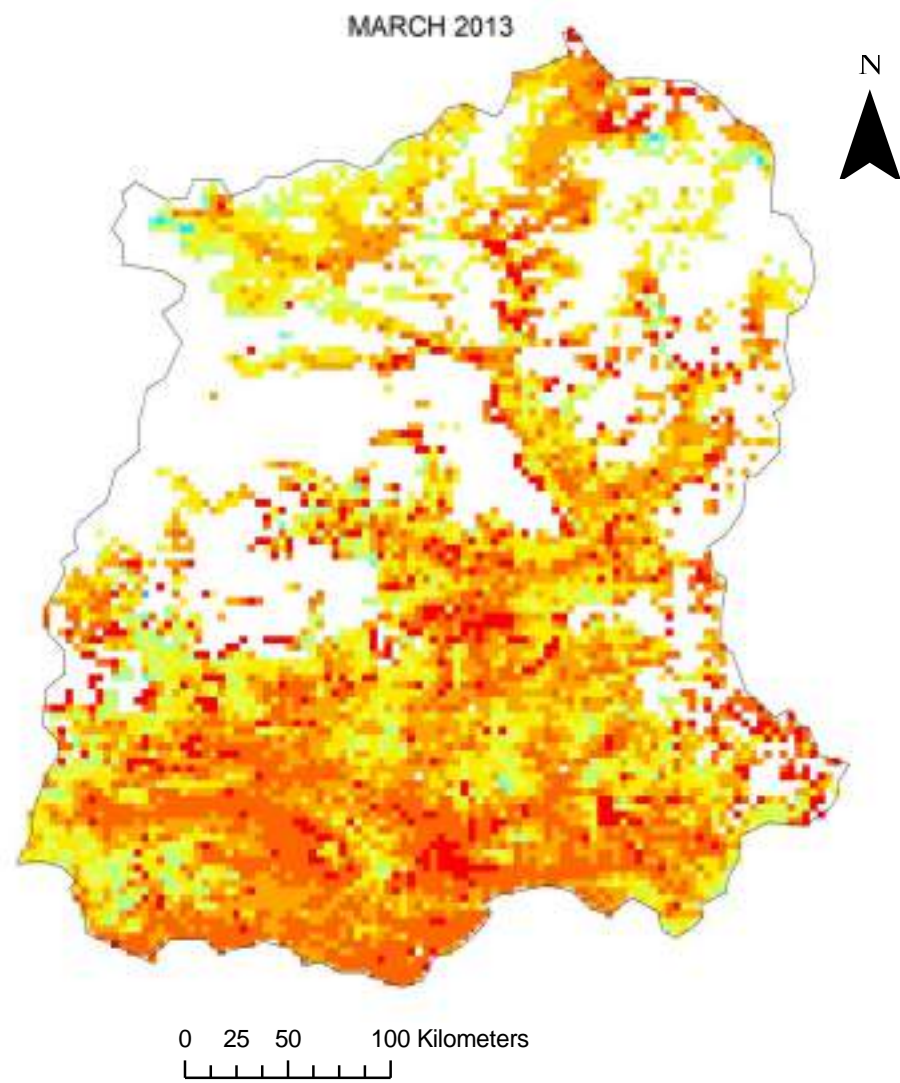
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)













**Legend**

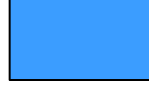






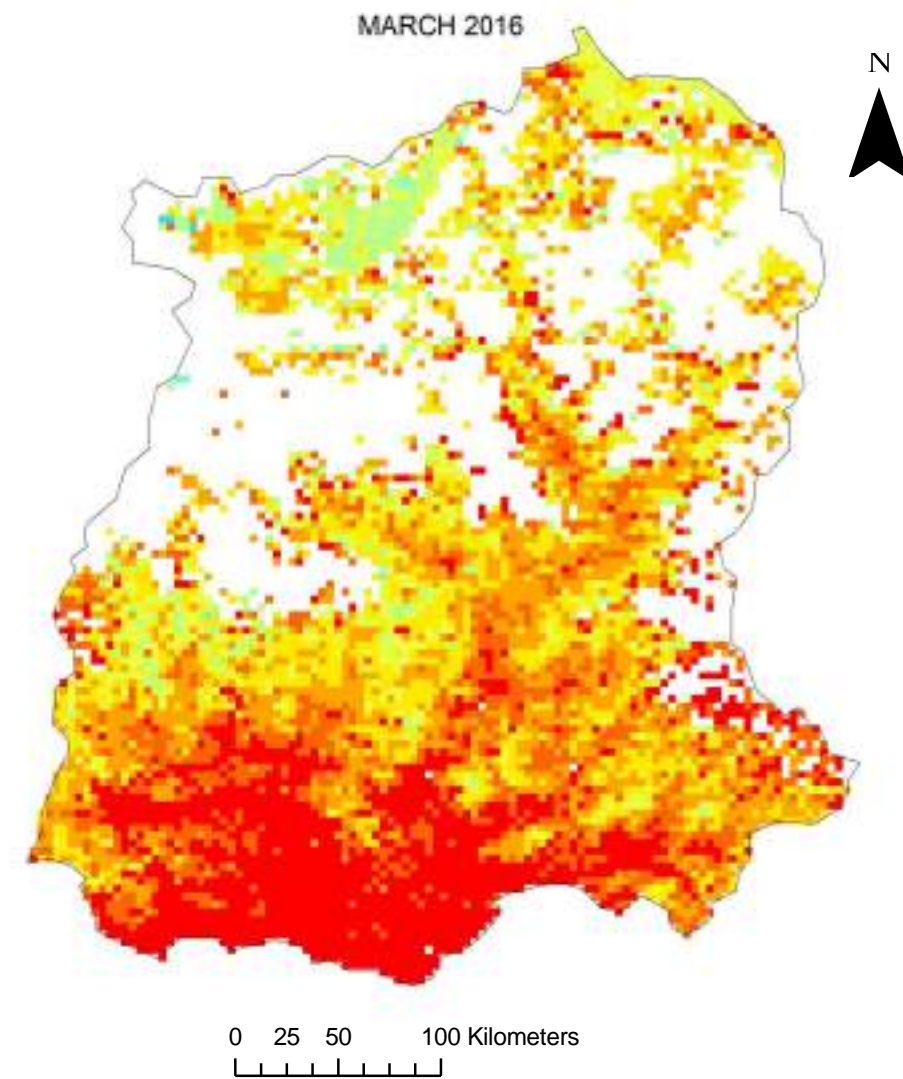
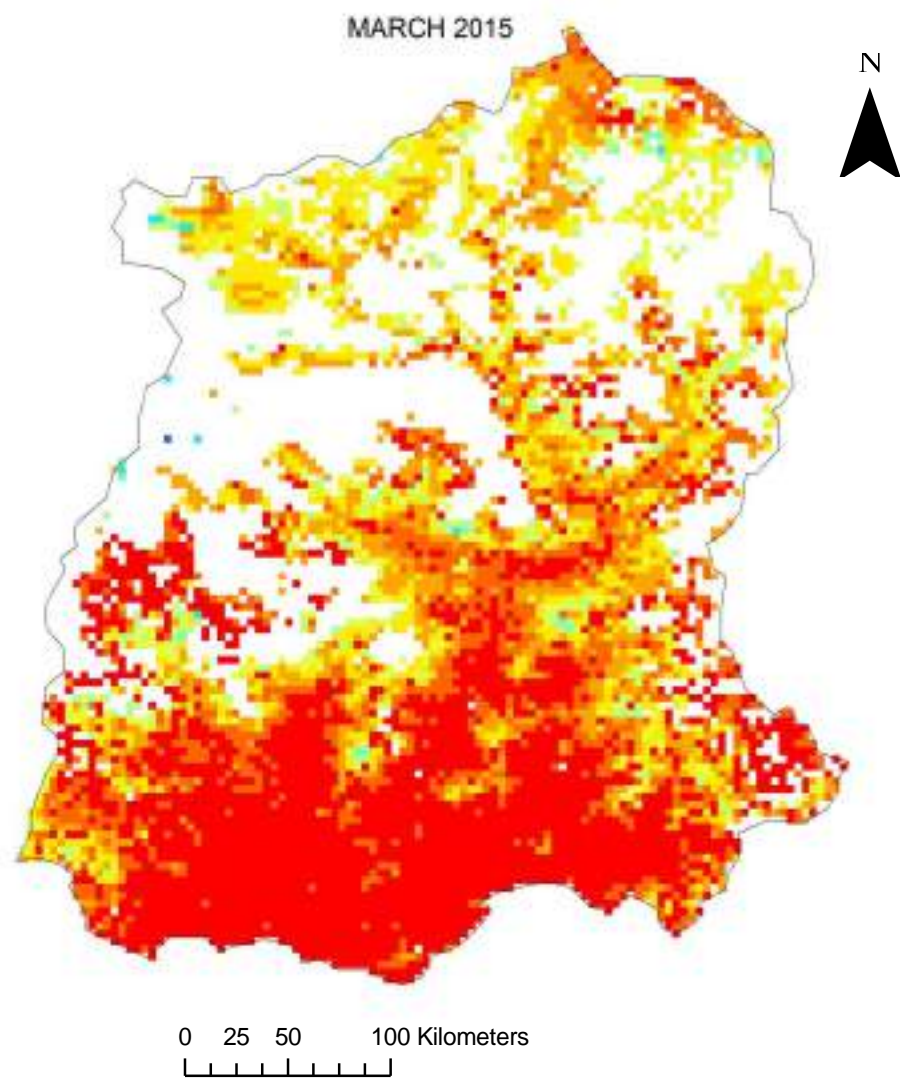
**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
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-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)





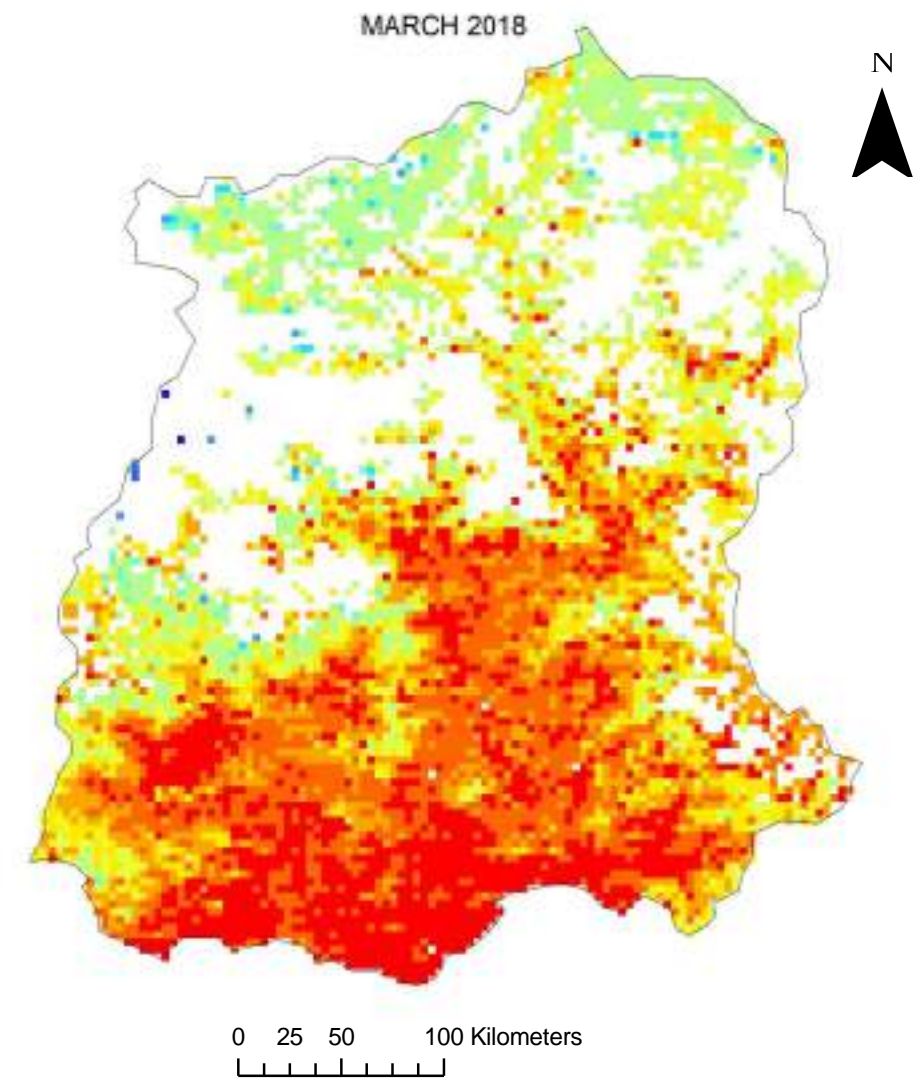
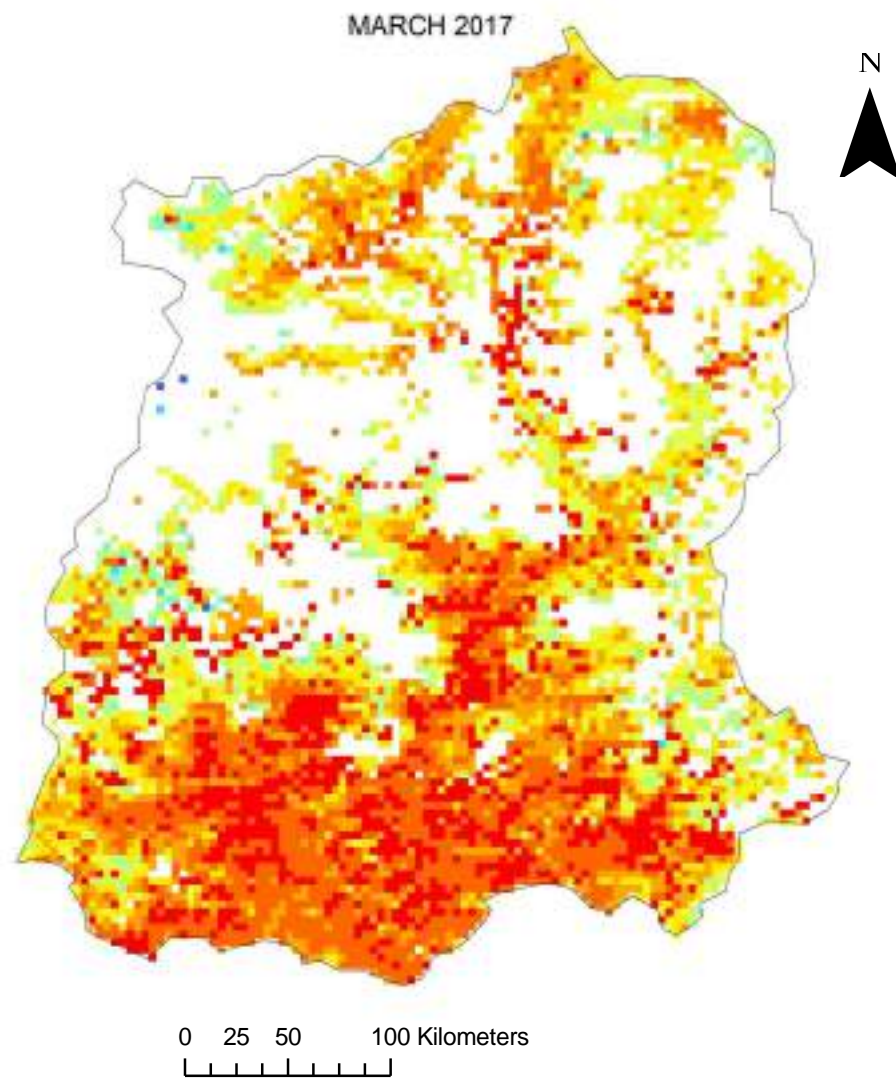
**Legend**

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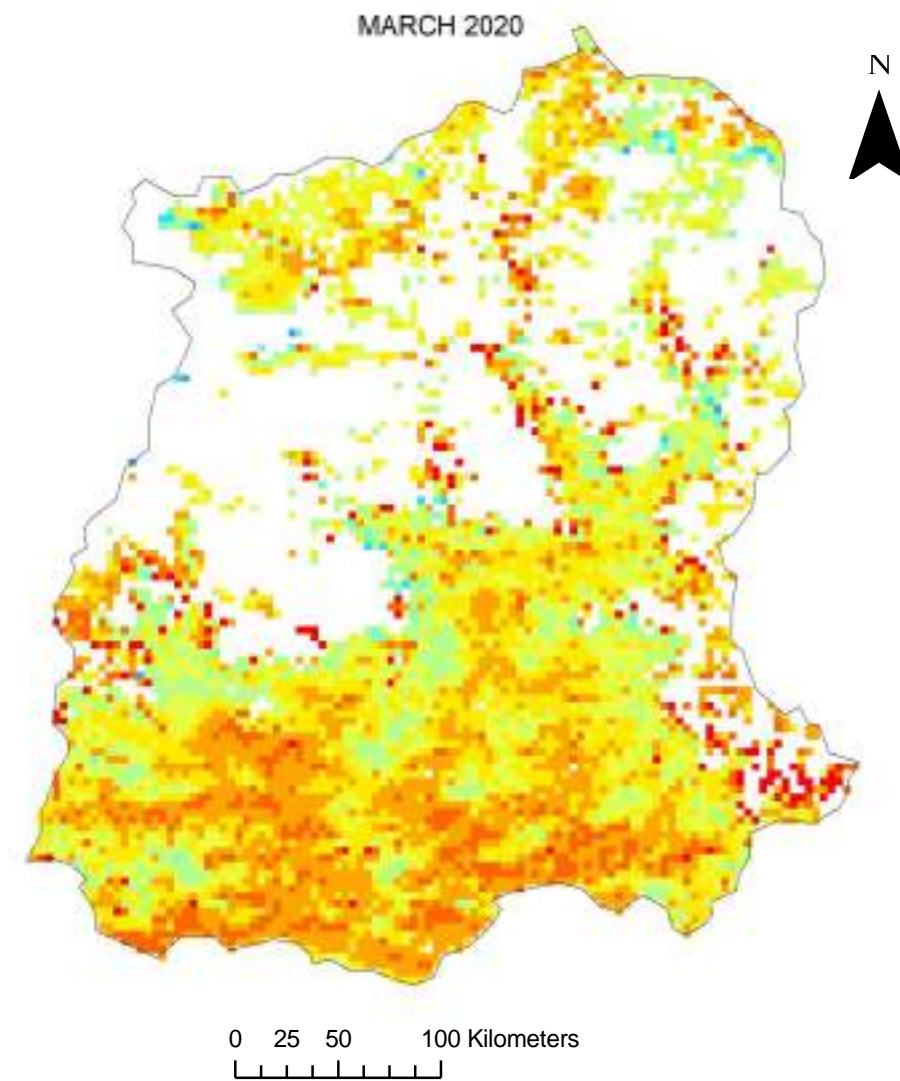
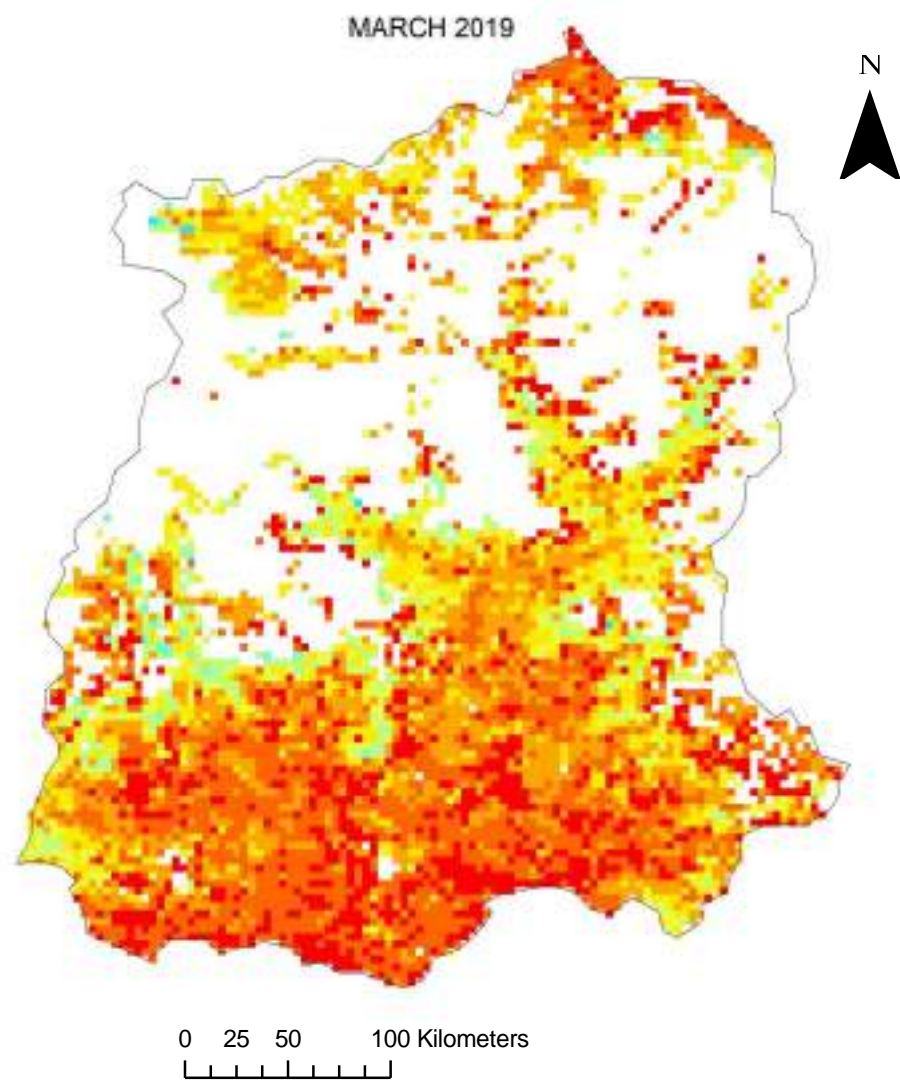


**Legend**





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-  Extreme Drought (-1.5 or less)
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-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

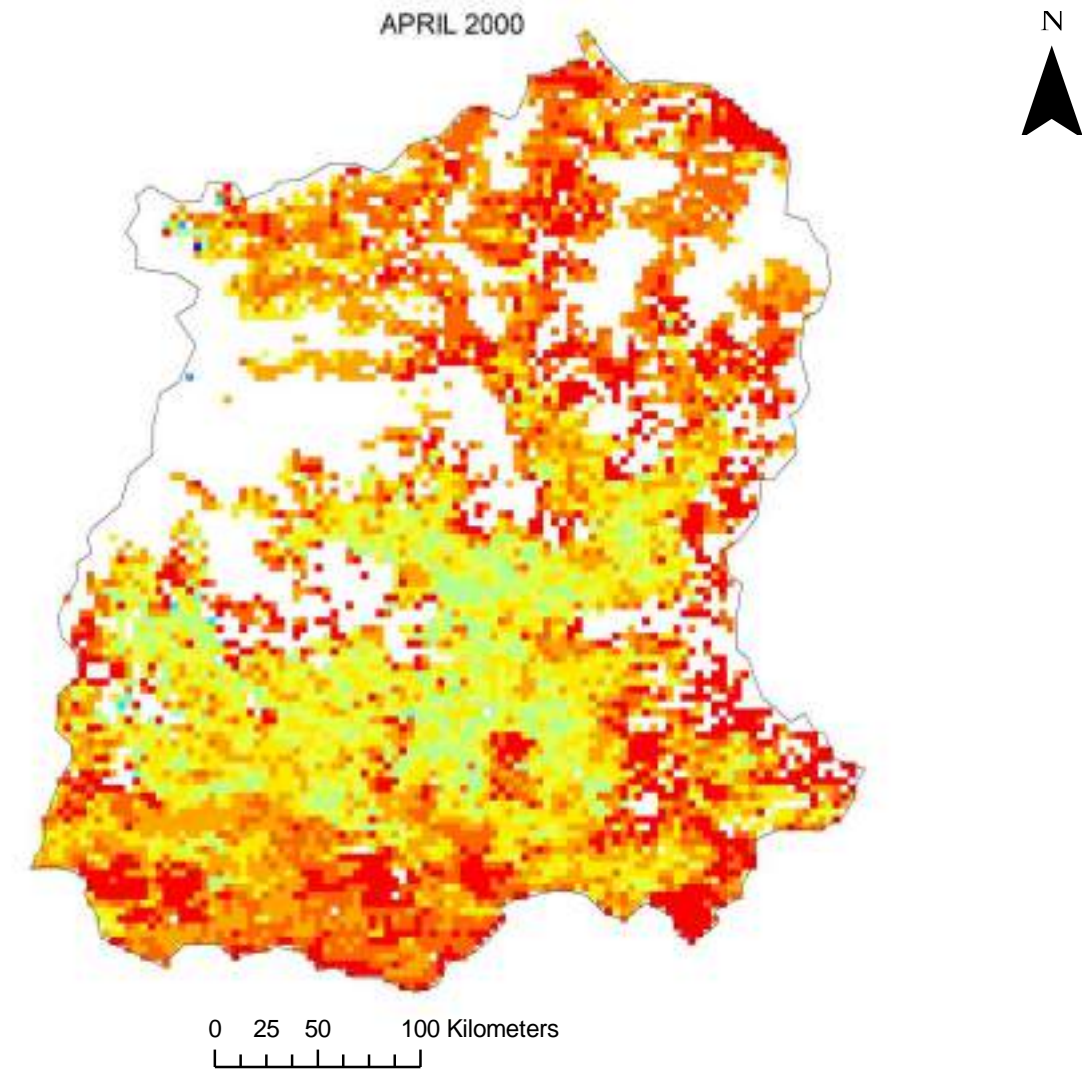
-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



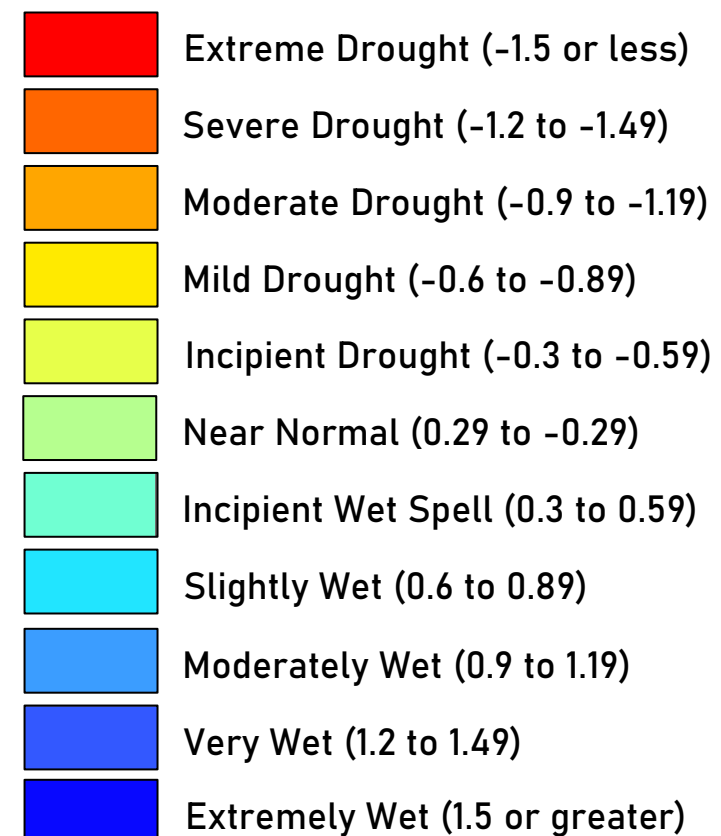
## April DSI Maps

Drought conditions in April typically vary from mild to near normal conditions. The characteristics of this winter month are frequently characterized by incipient drought.

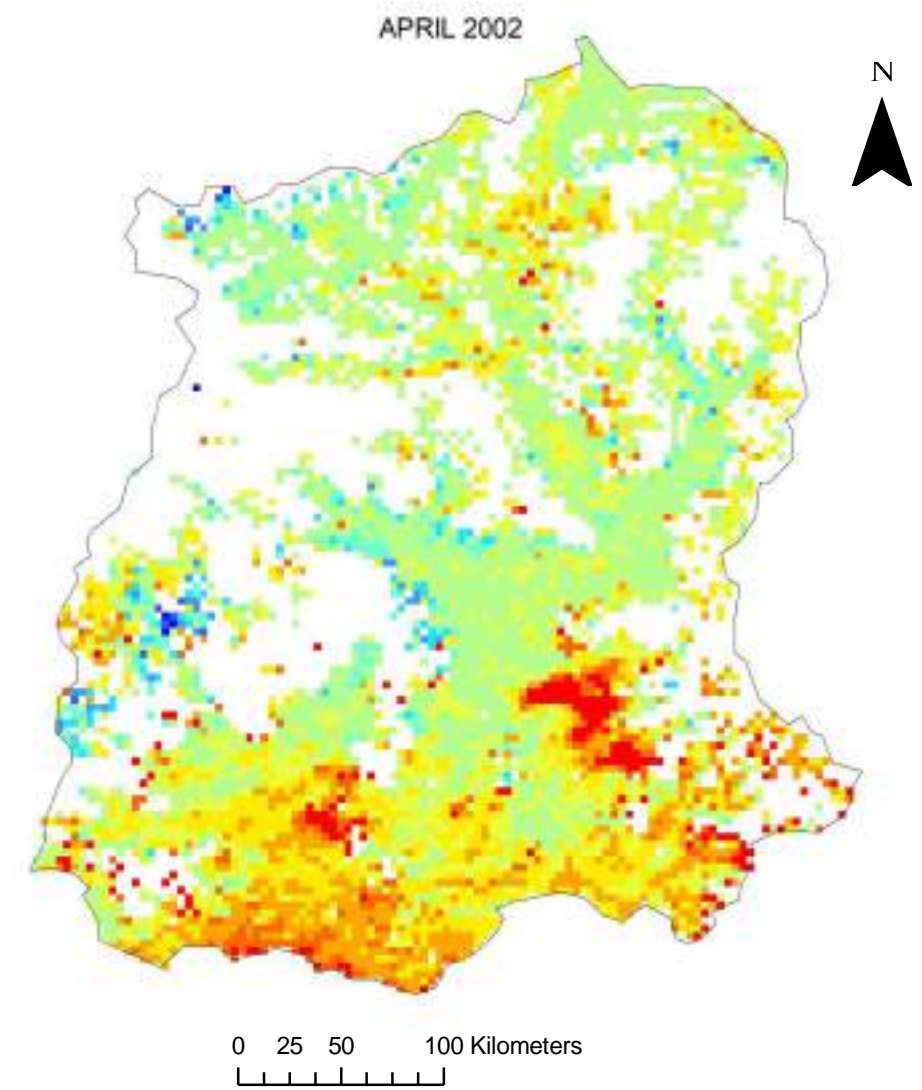
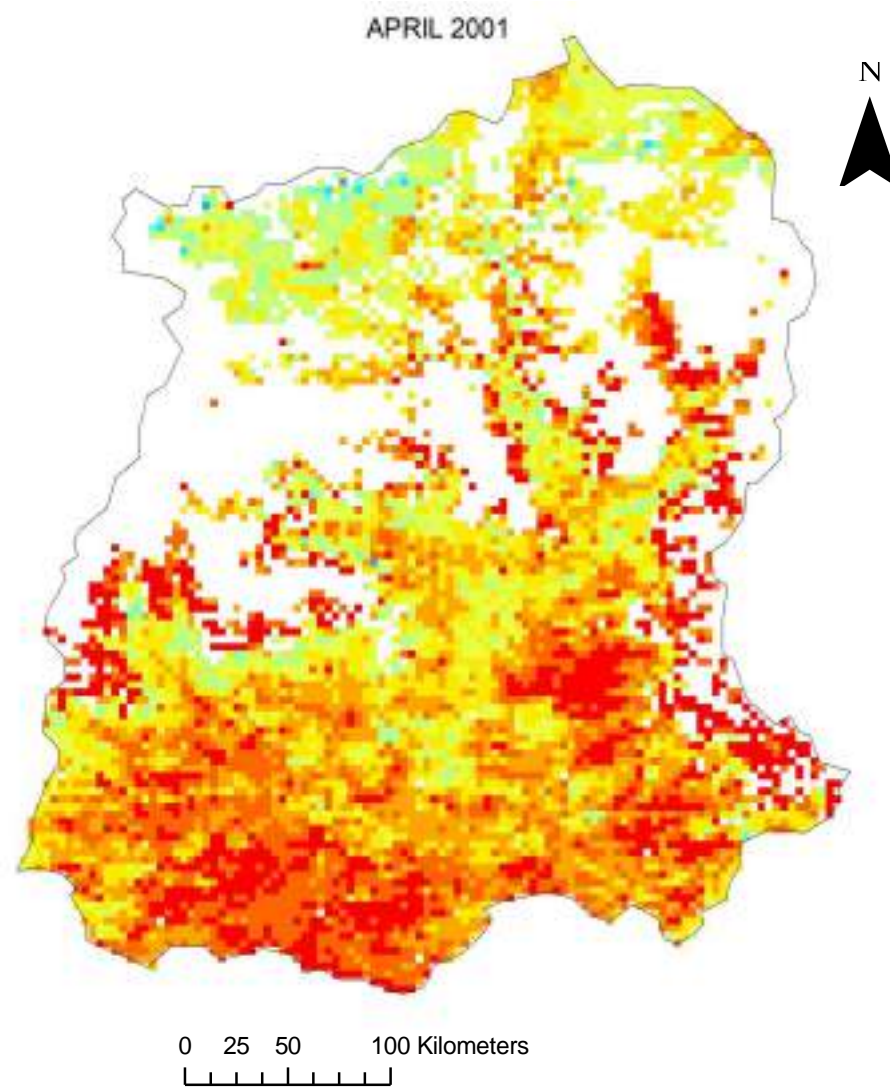
Mean April DSI Values		
Year	DSI Values	Drought Condition
2000	-0.74	Mild Drought
2001	-0.71	Mild Drought
2002	-0.22	Near Normal
2003	-0.55	Incipient Drought
2004	-0.27	Near Normal
2005	-0.33	Incipient Drought
2006	-0.80	Mild Drought
2007	-0.45	Incipient Drought
2008	-0.47	Incipient Drought
2009	-0.87	Mild Drought
2010	-0.54	Incipient Drought
2011	-0.38	Incipient Drought
2012	-0.34	Incipient Drought
2013	-0.46	Incipient Drought
2014	-0.45	Incipient Drought
2015	-0.24	Near Normal
2016	-0.63	Mild Drought
2017	-0.76	Mild Drought
2018	0.21	Near Normal
2019	-0.05	Near Normal
2020	-0.10	Near Normal














### Legend

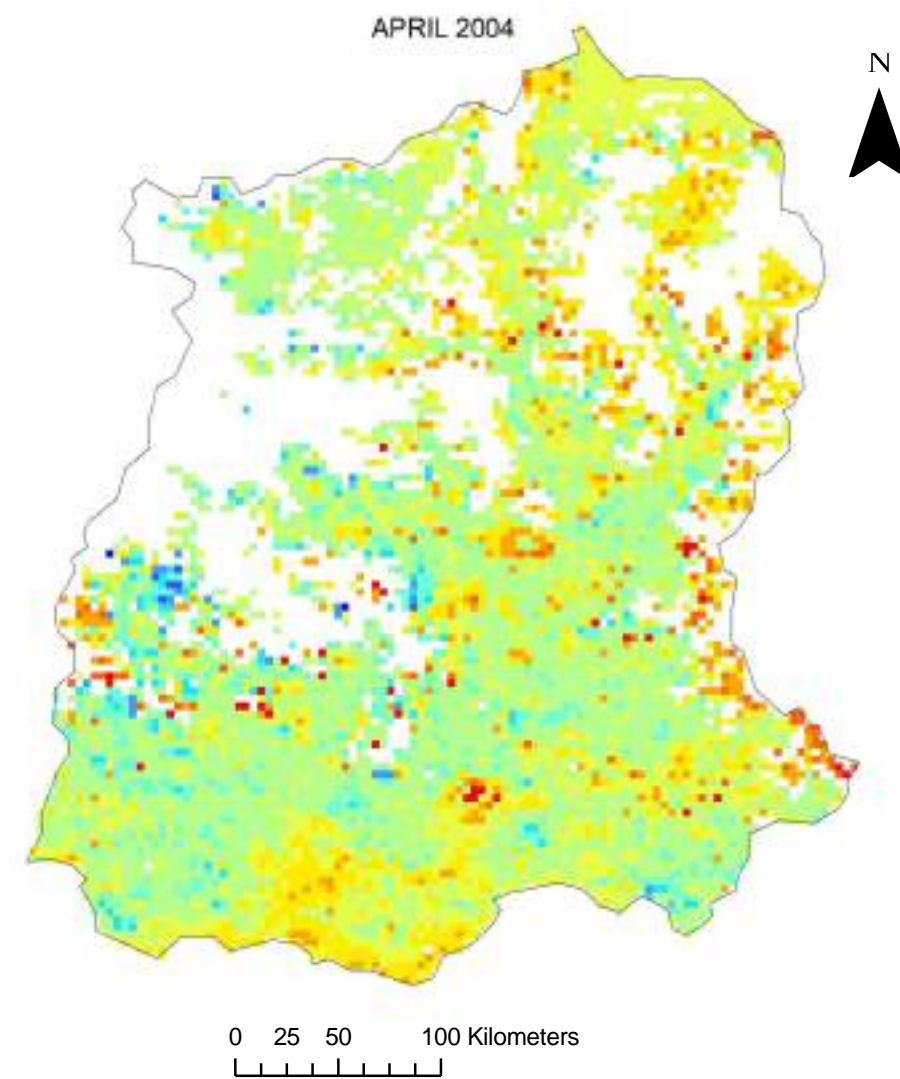
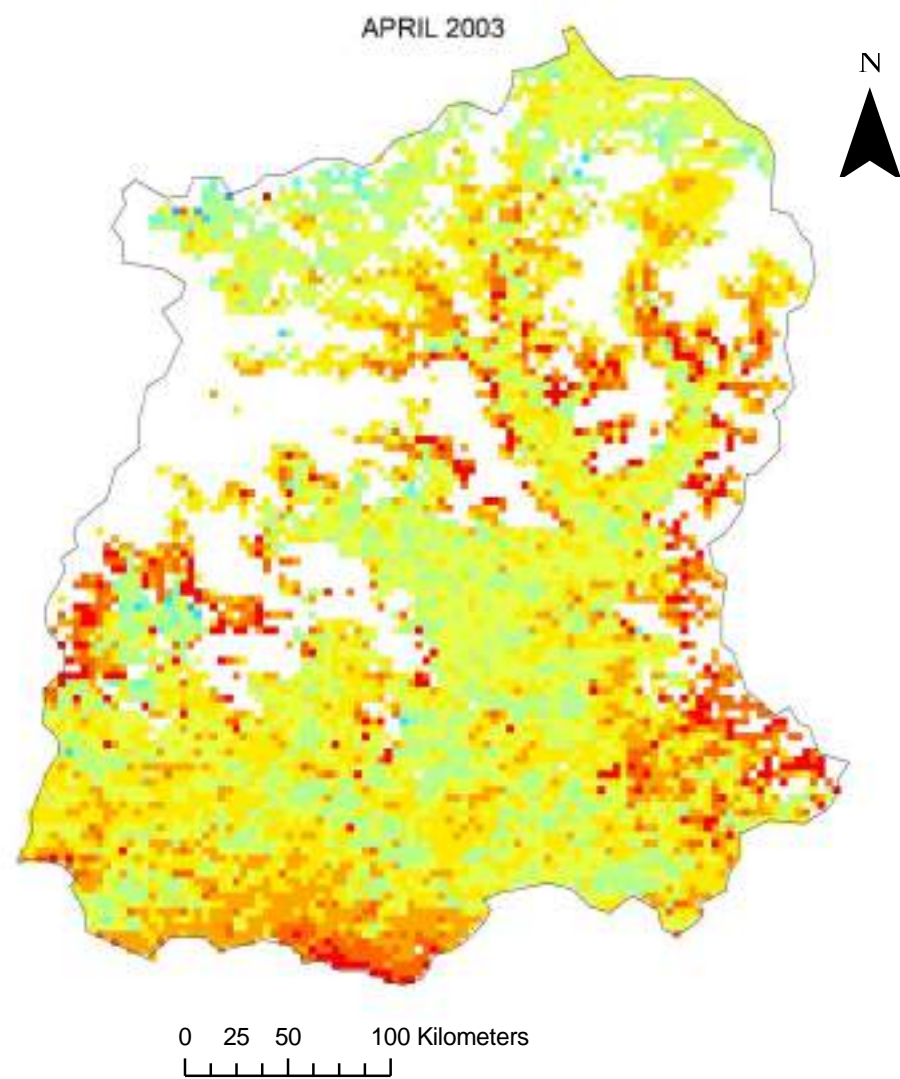






**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



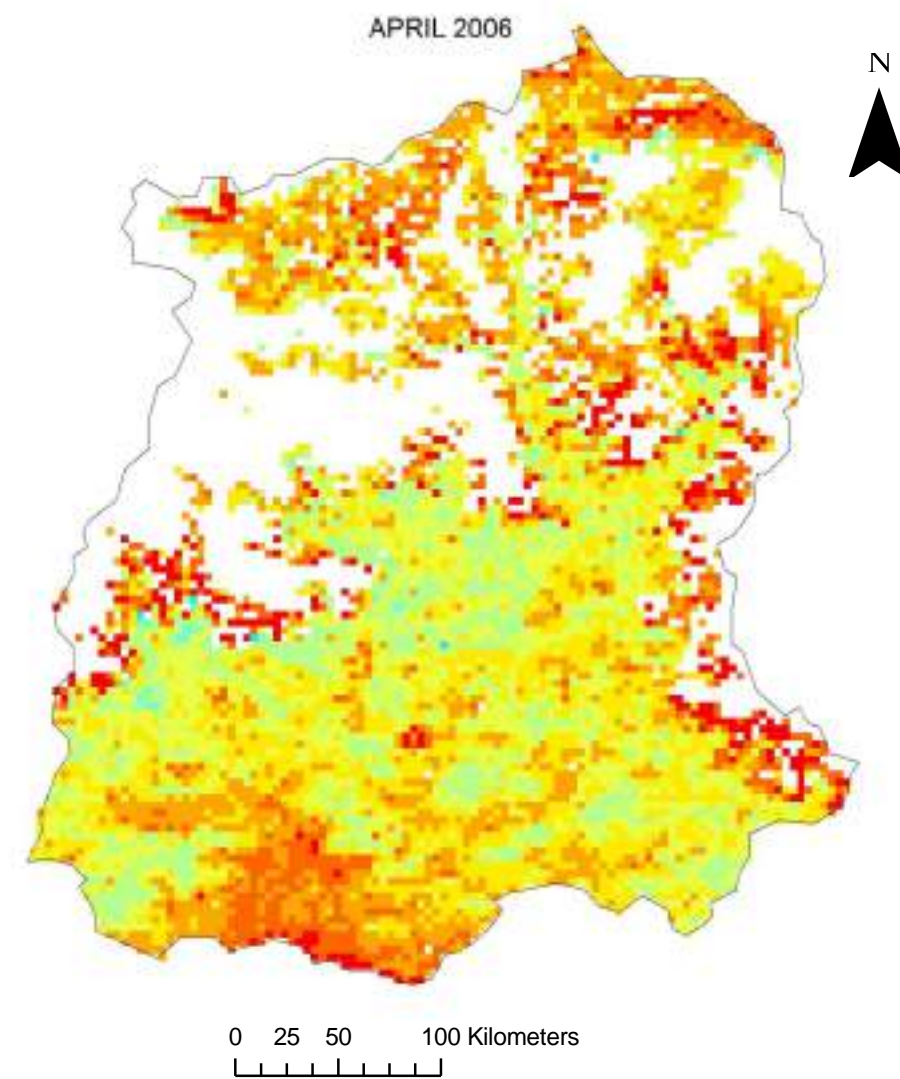
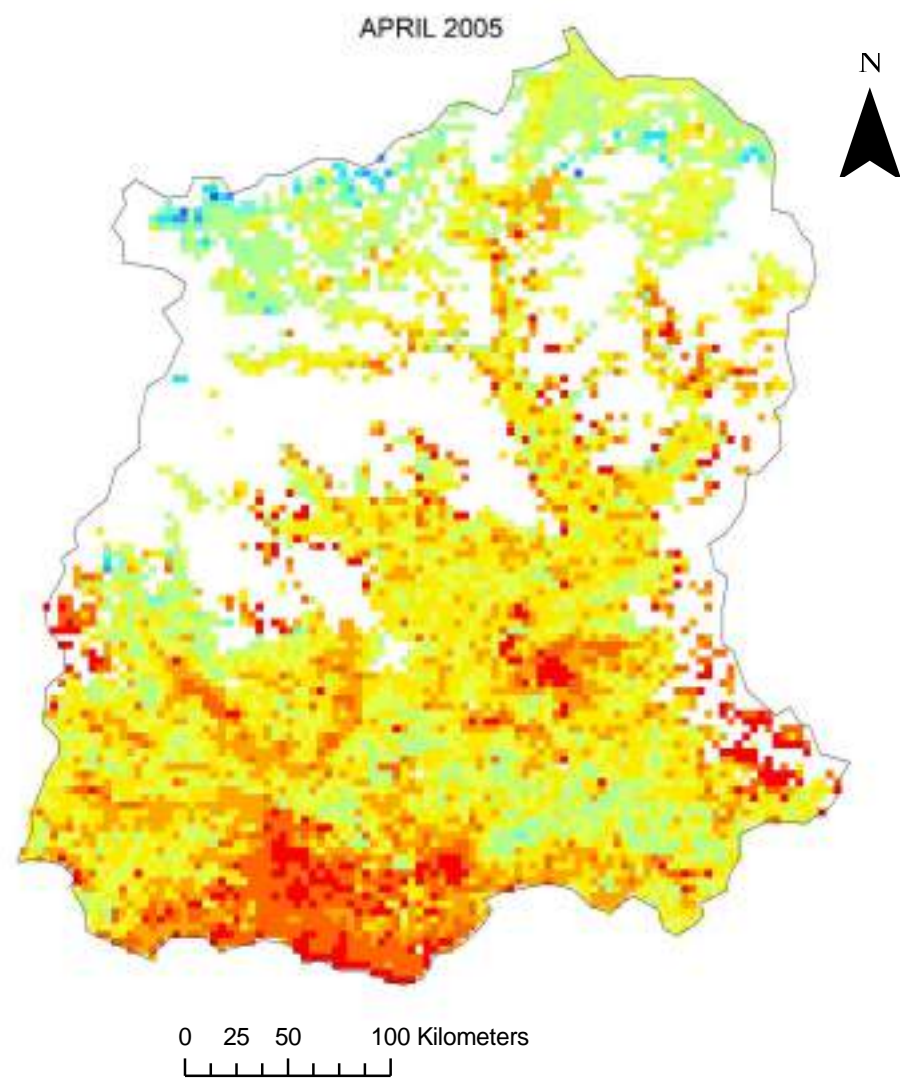
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)





- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)





- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)






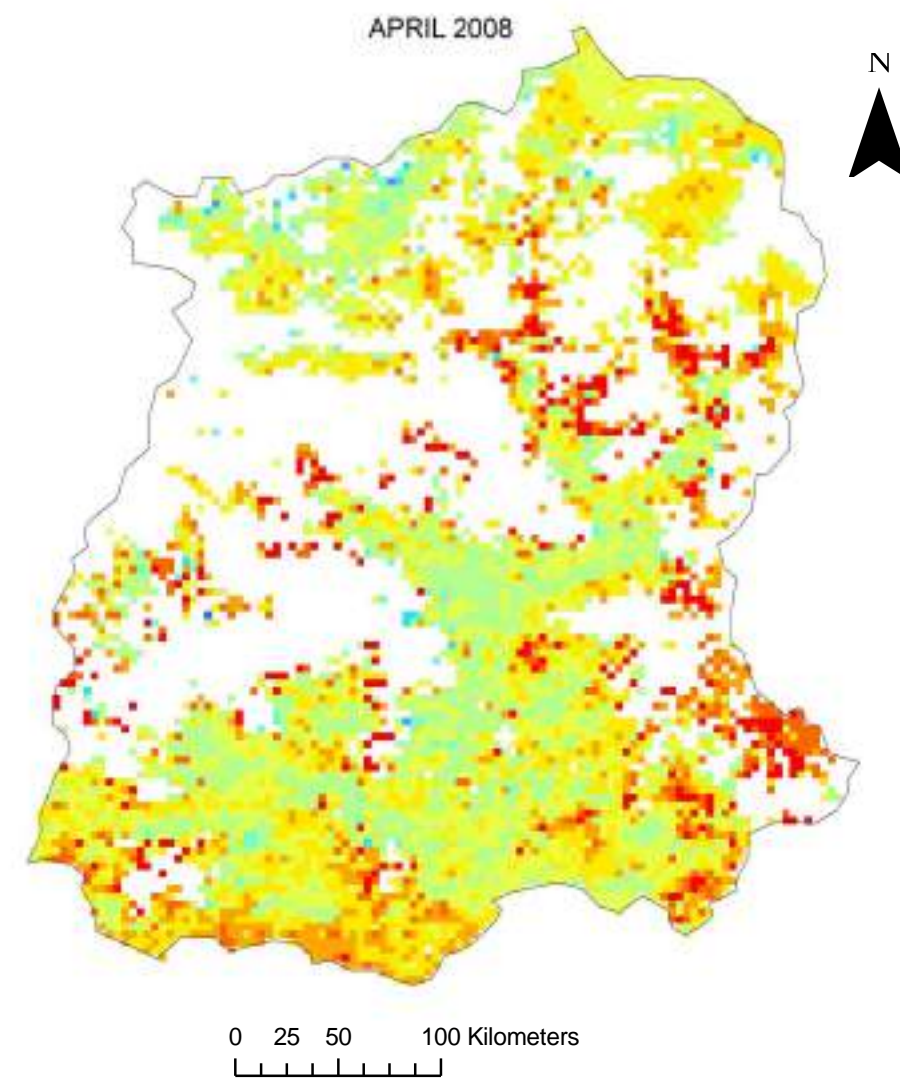
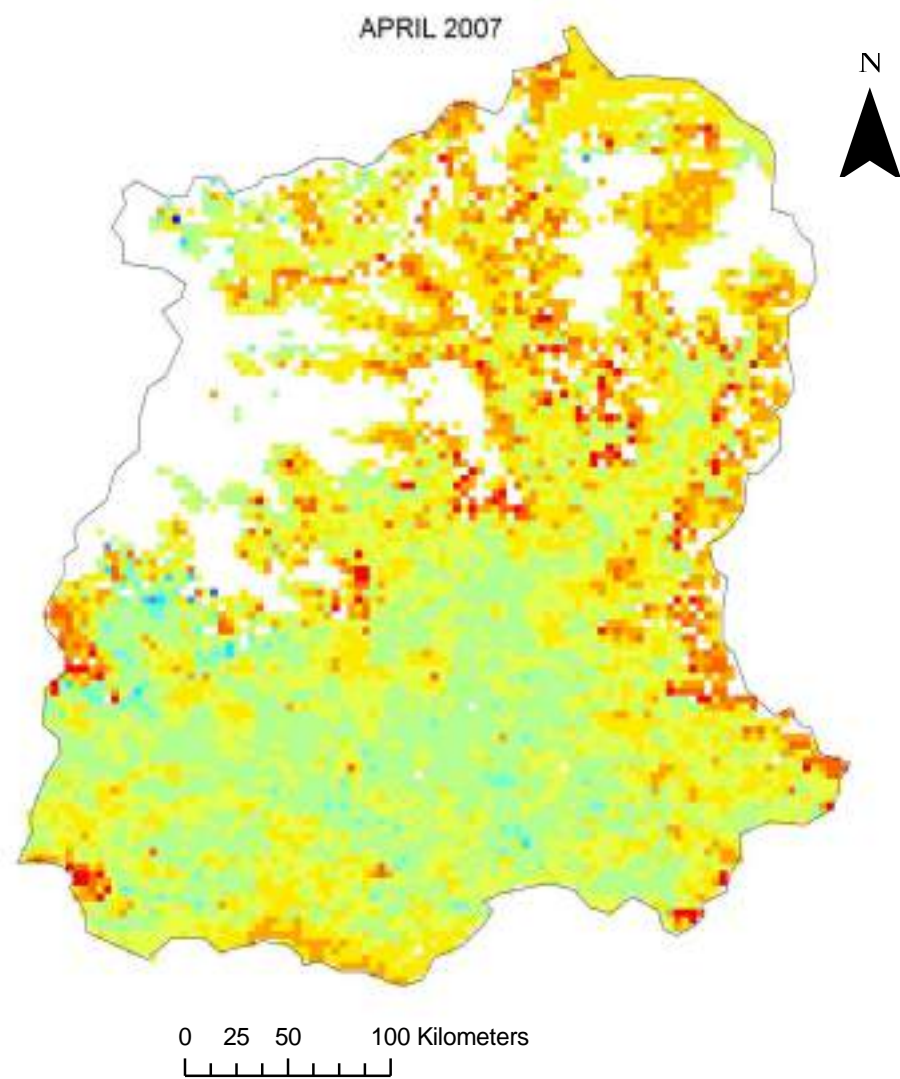


**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



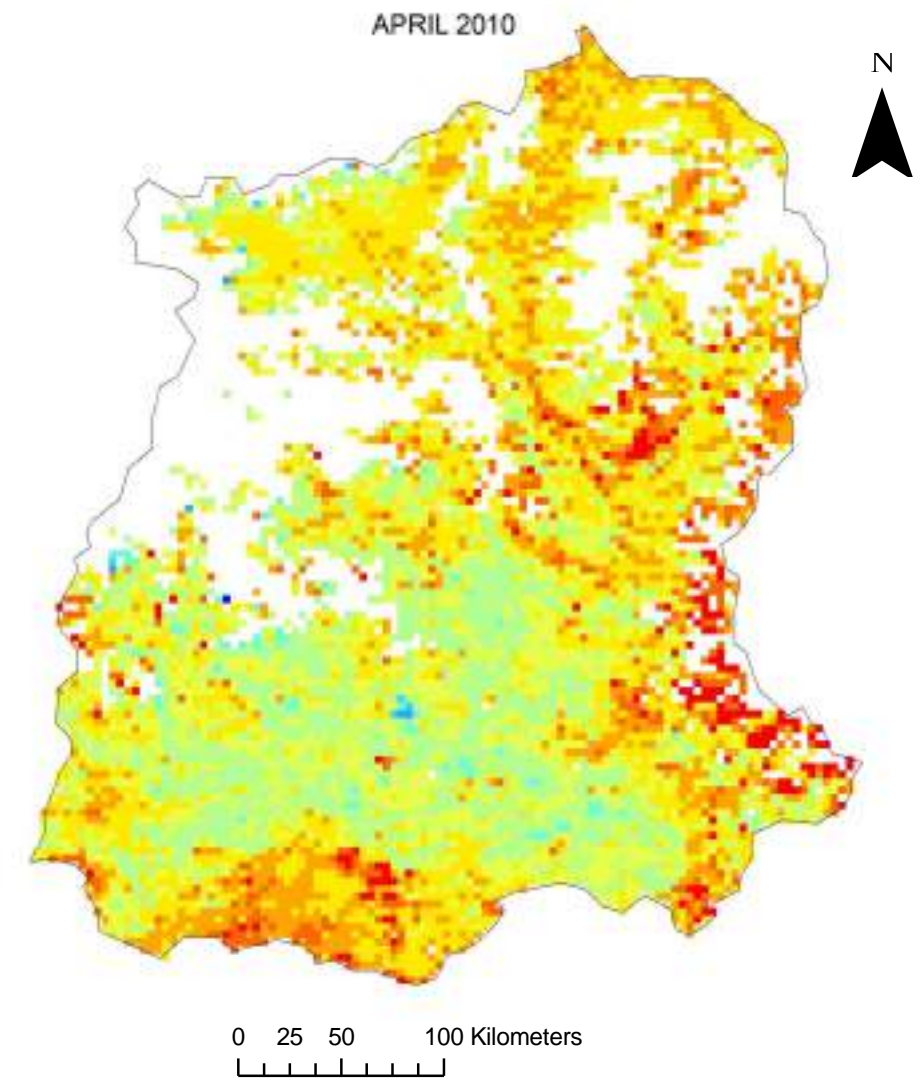
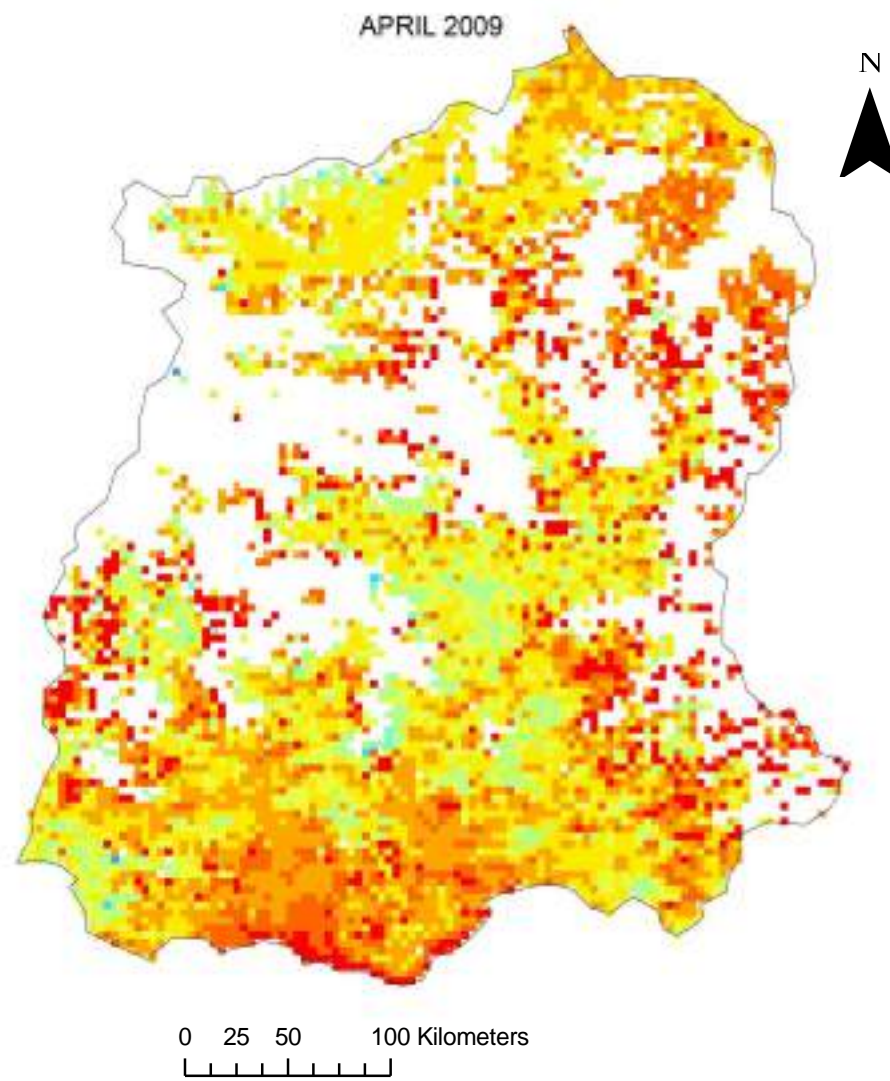
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

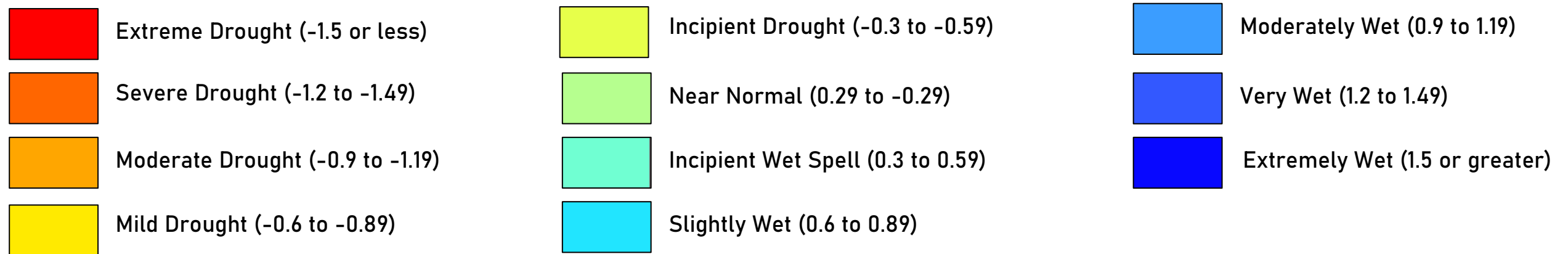
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

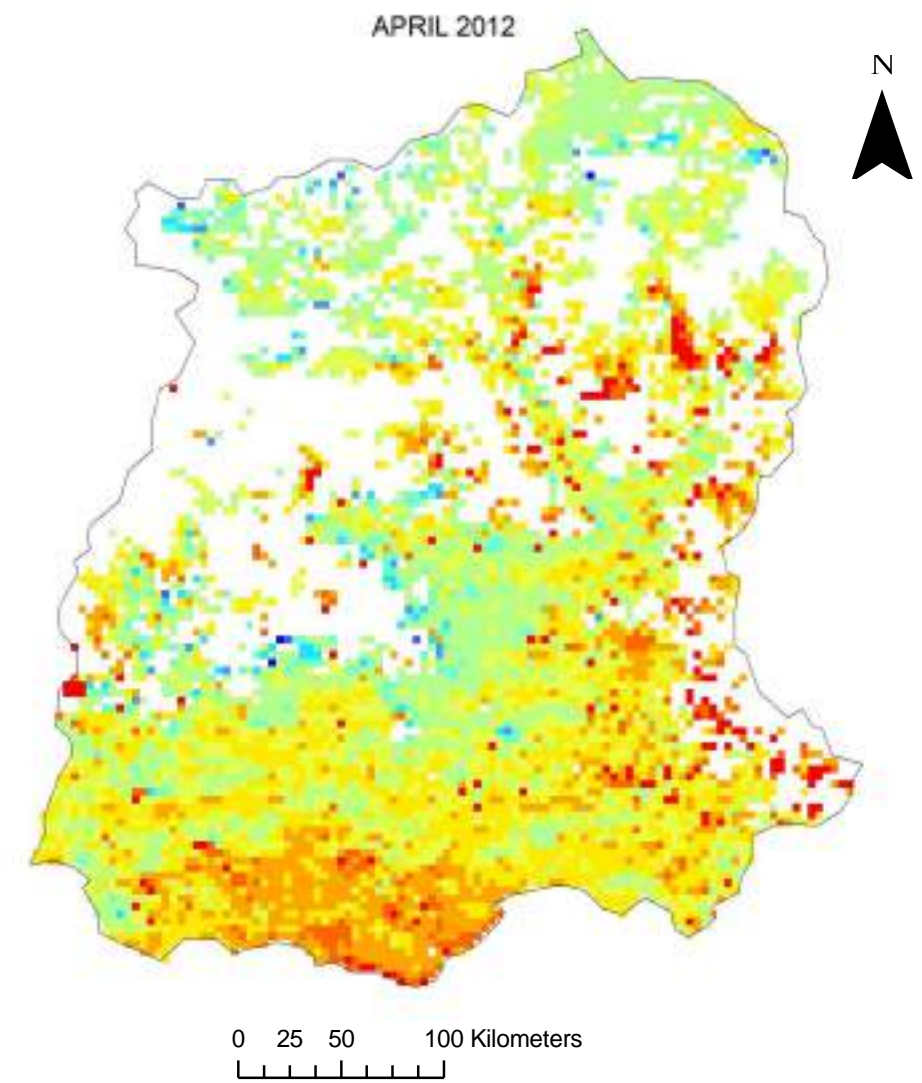
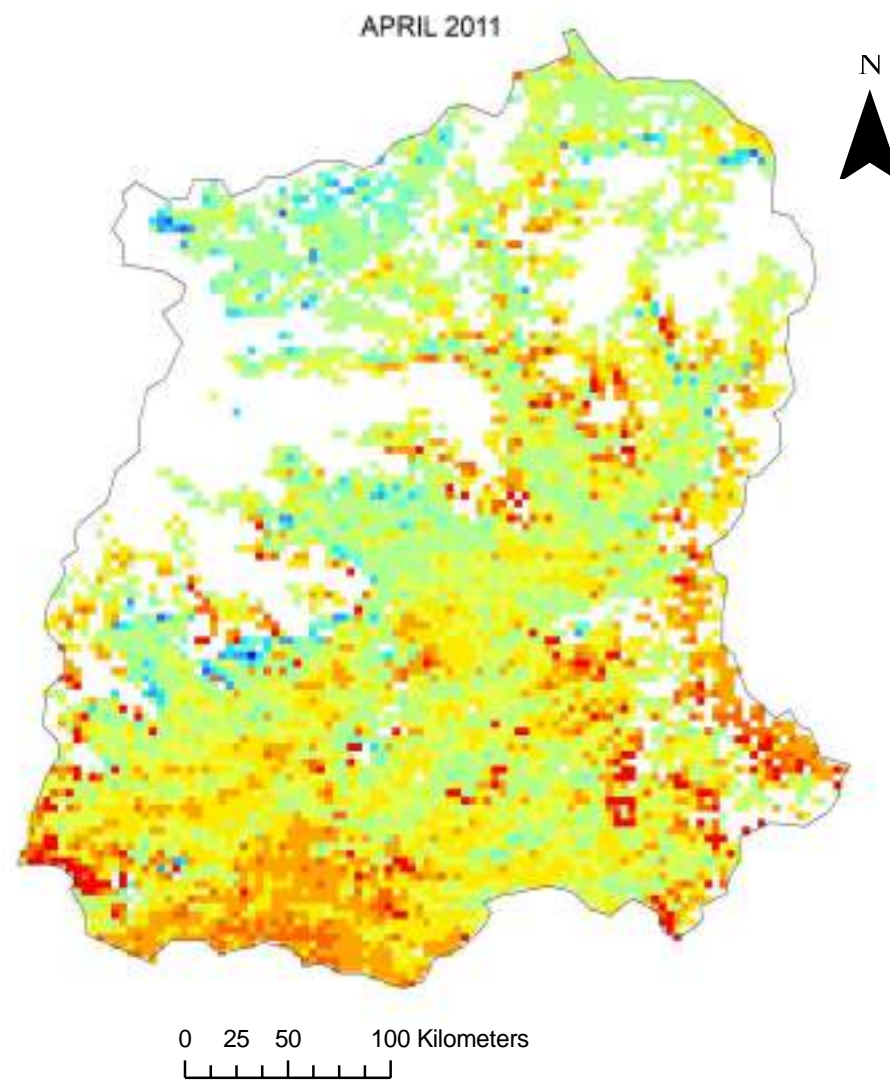
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)
















**Legend**

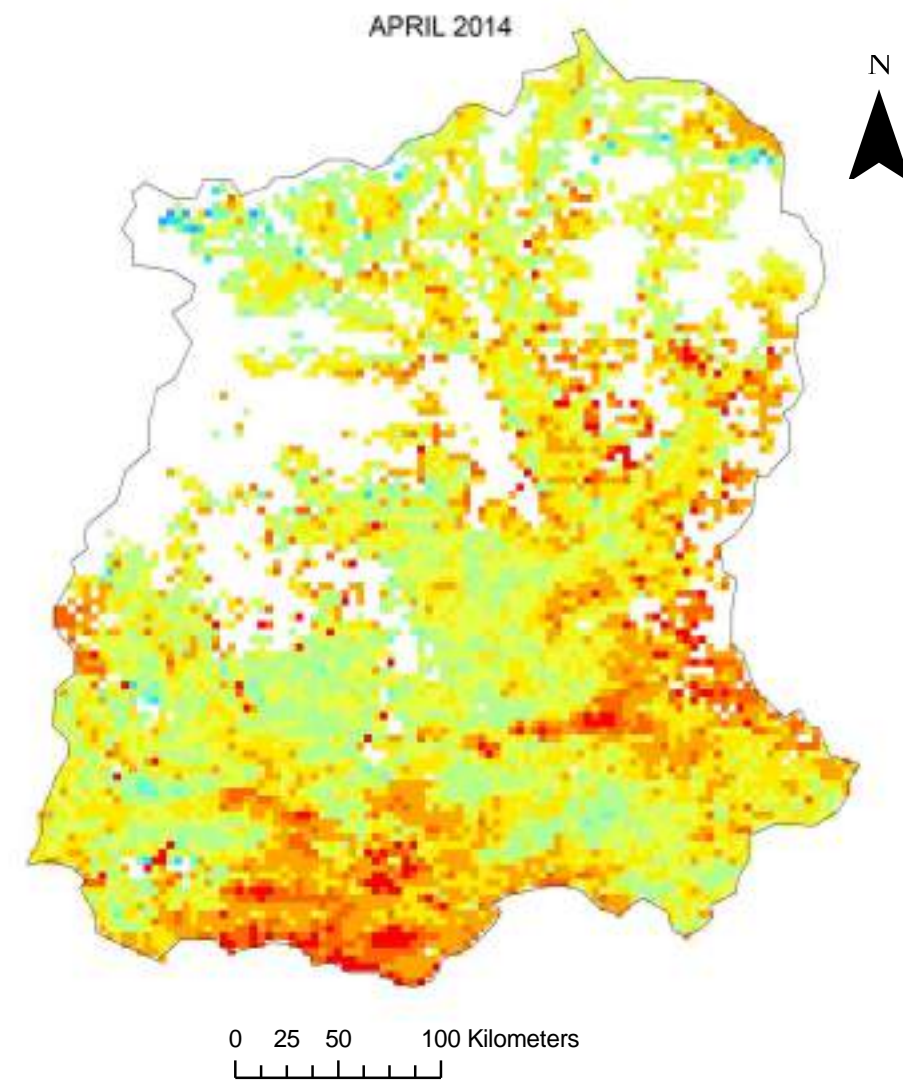
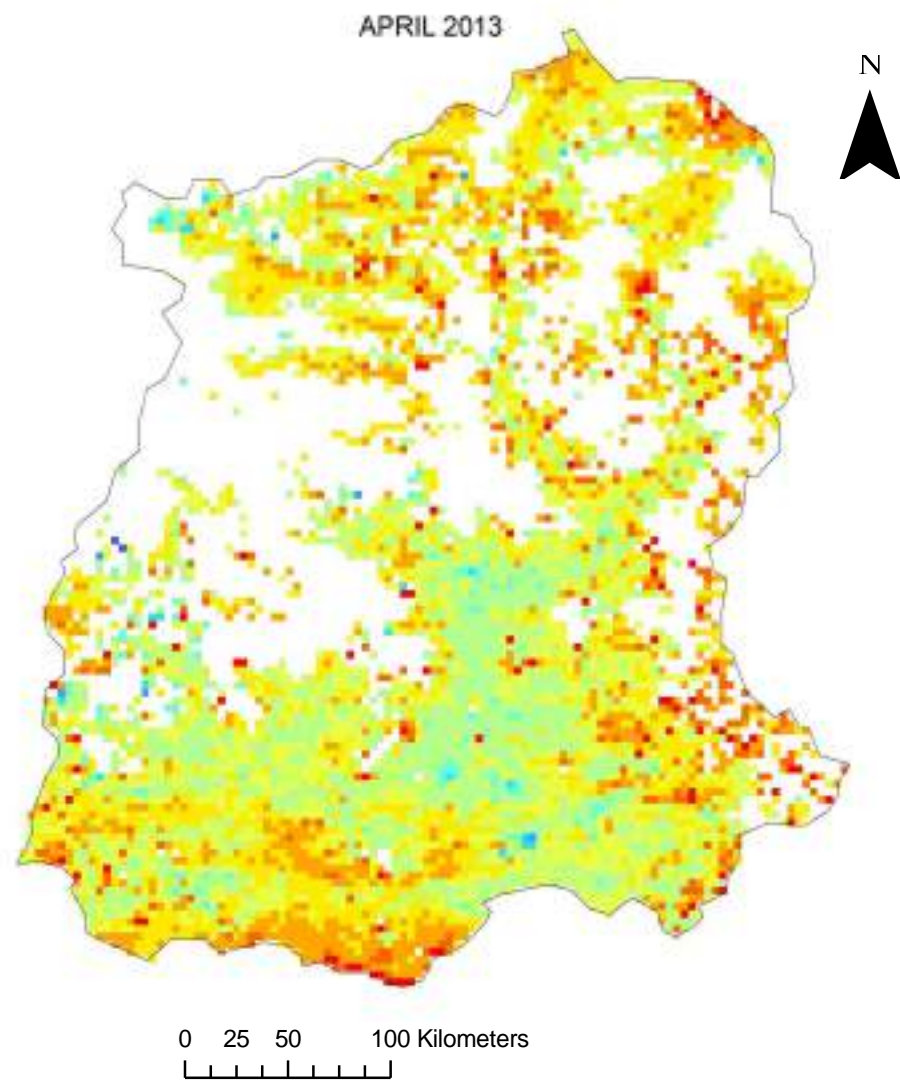








**Legend**





- |  |   |  |
|--|---|--|
|  Extreme Drought (-1.5 or less)   |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19)   |
|  Severe Drought (-1.2 to -1.49)   |  Near Normal (0.29 to -0.29)       |  Very Wet (1.2 to 1.49)         |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89)     |  Slightly Wet (0.6 to 0.89)        |  |

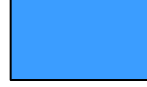




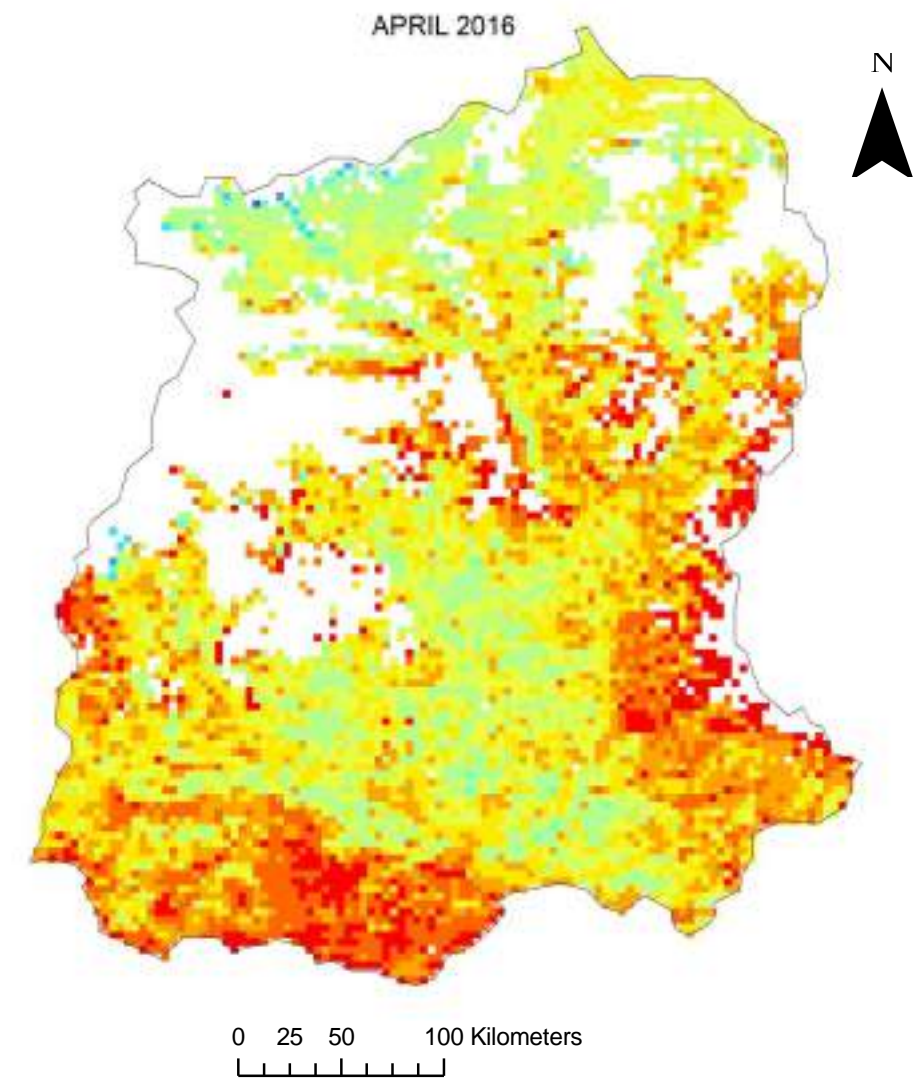
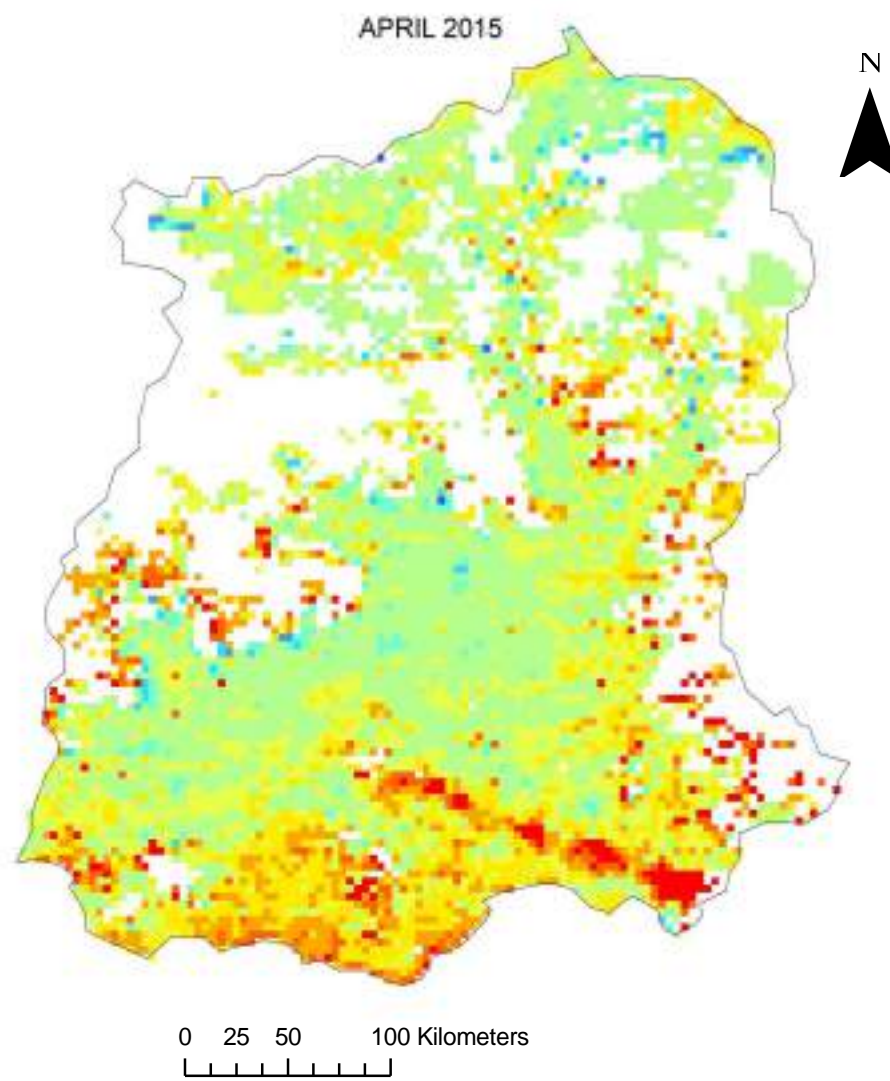


**Legend**












-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

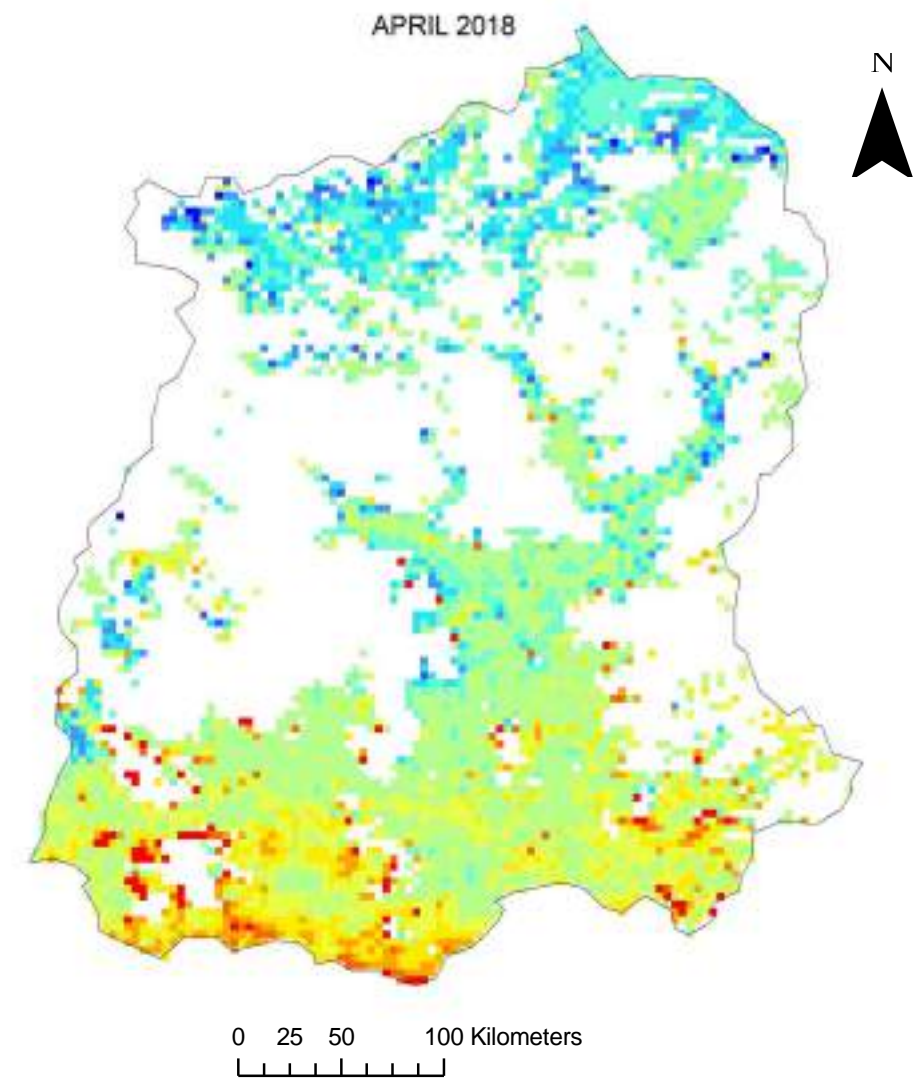
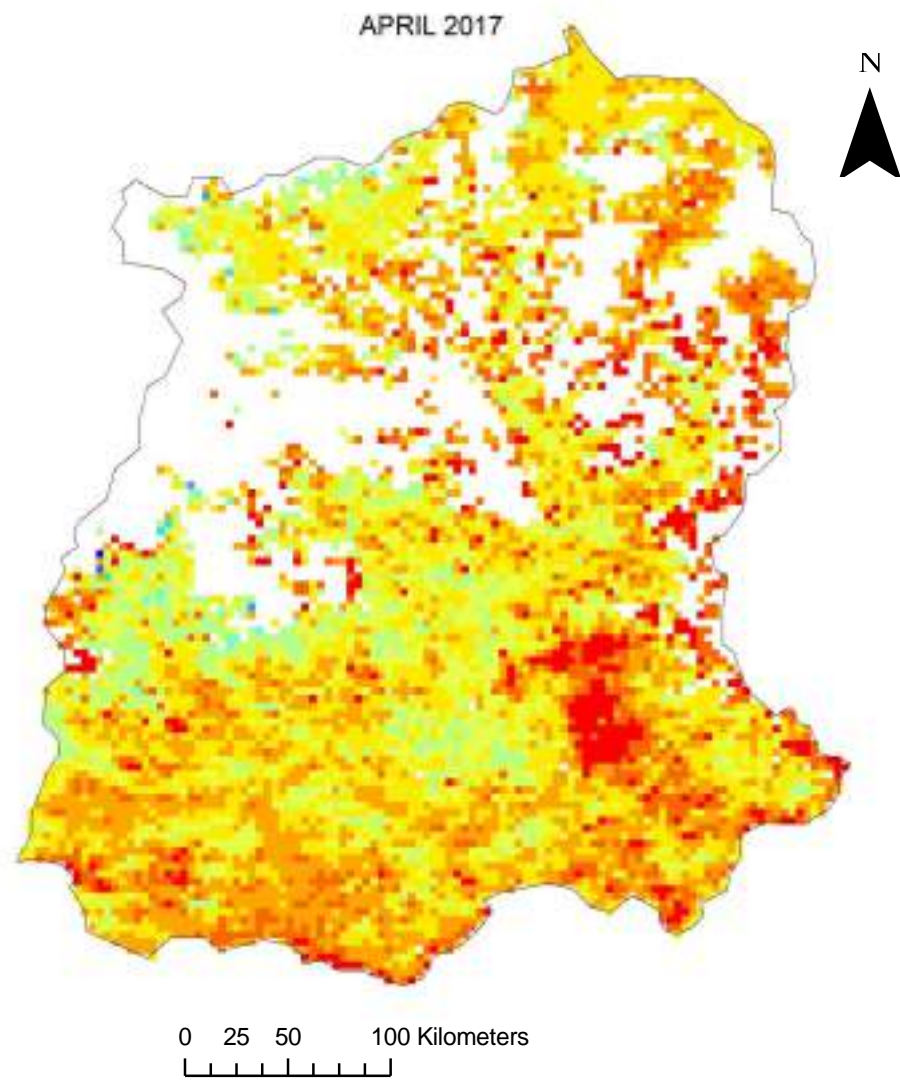
-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



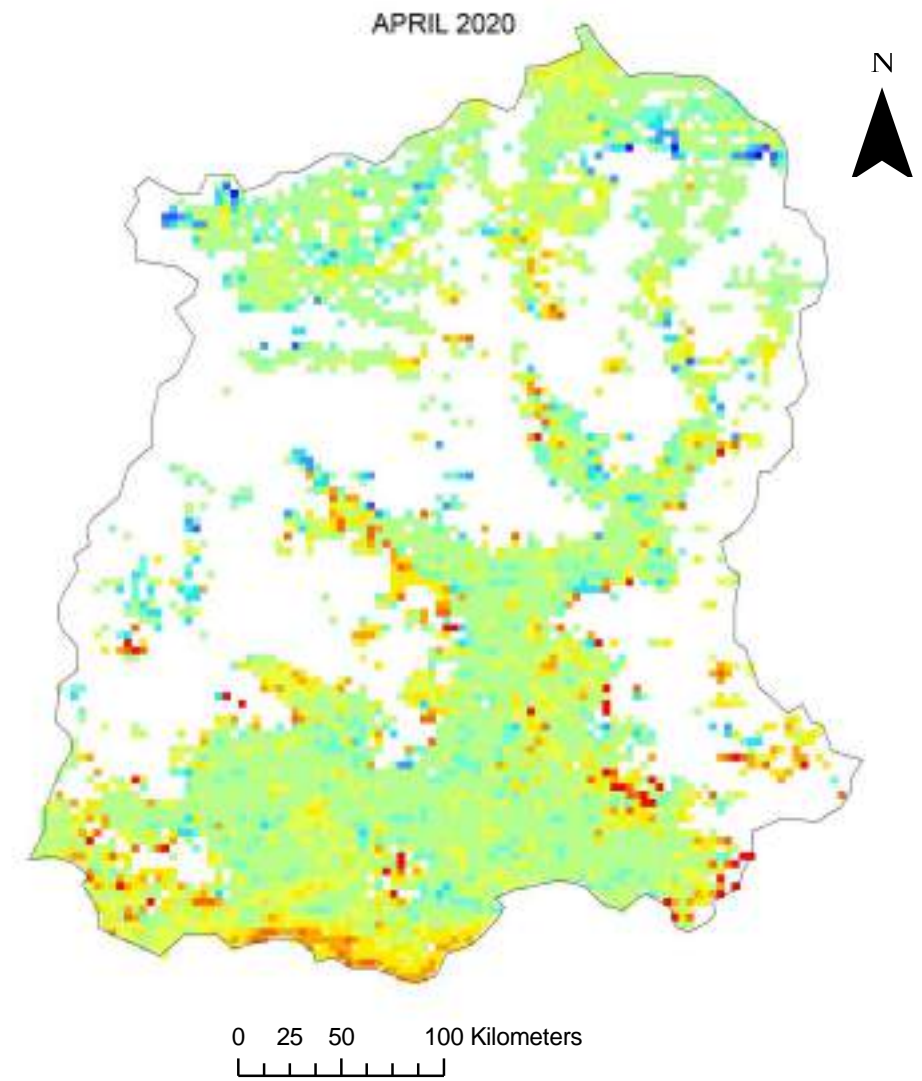
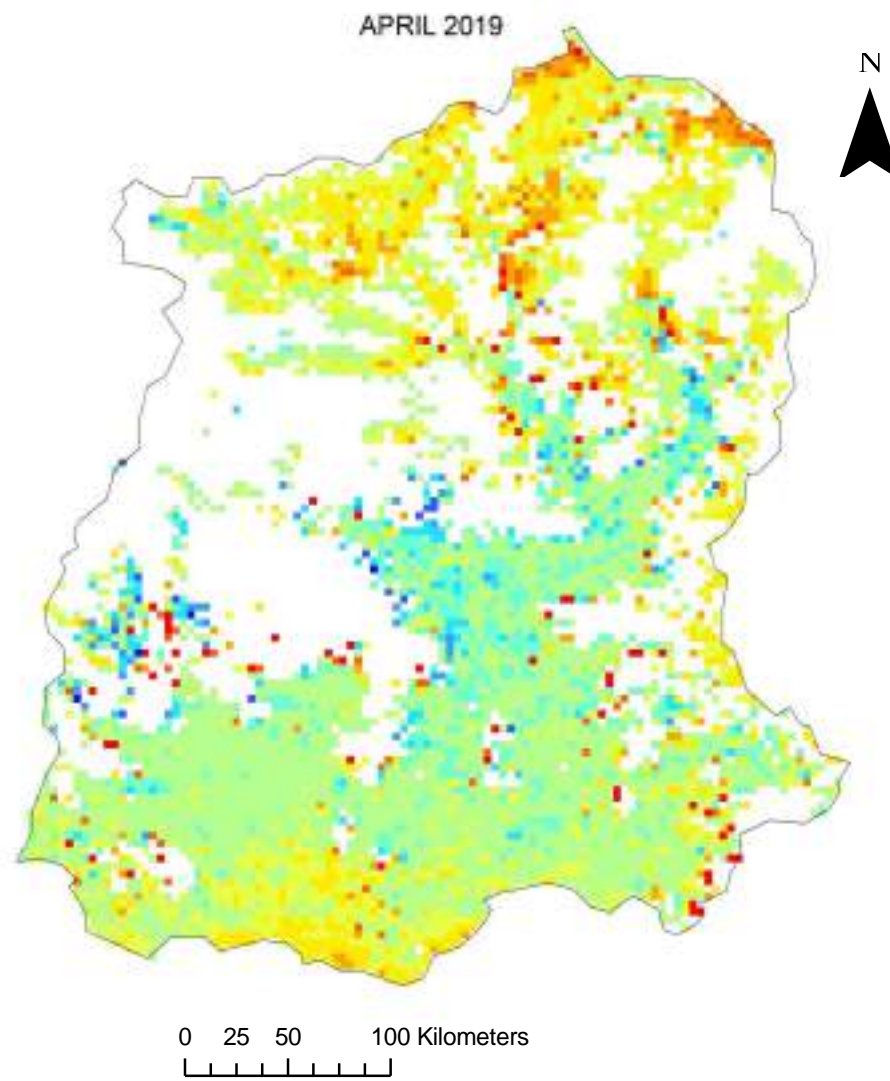


**Legend**





- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)



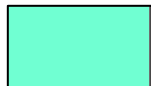

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)




- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

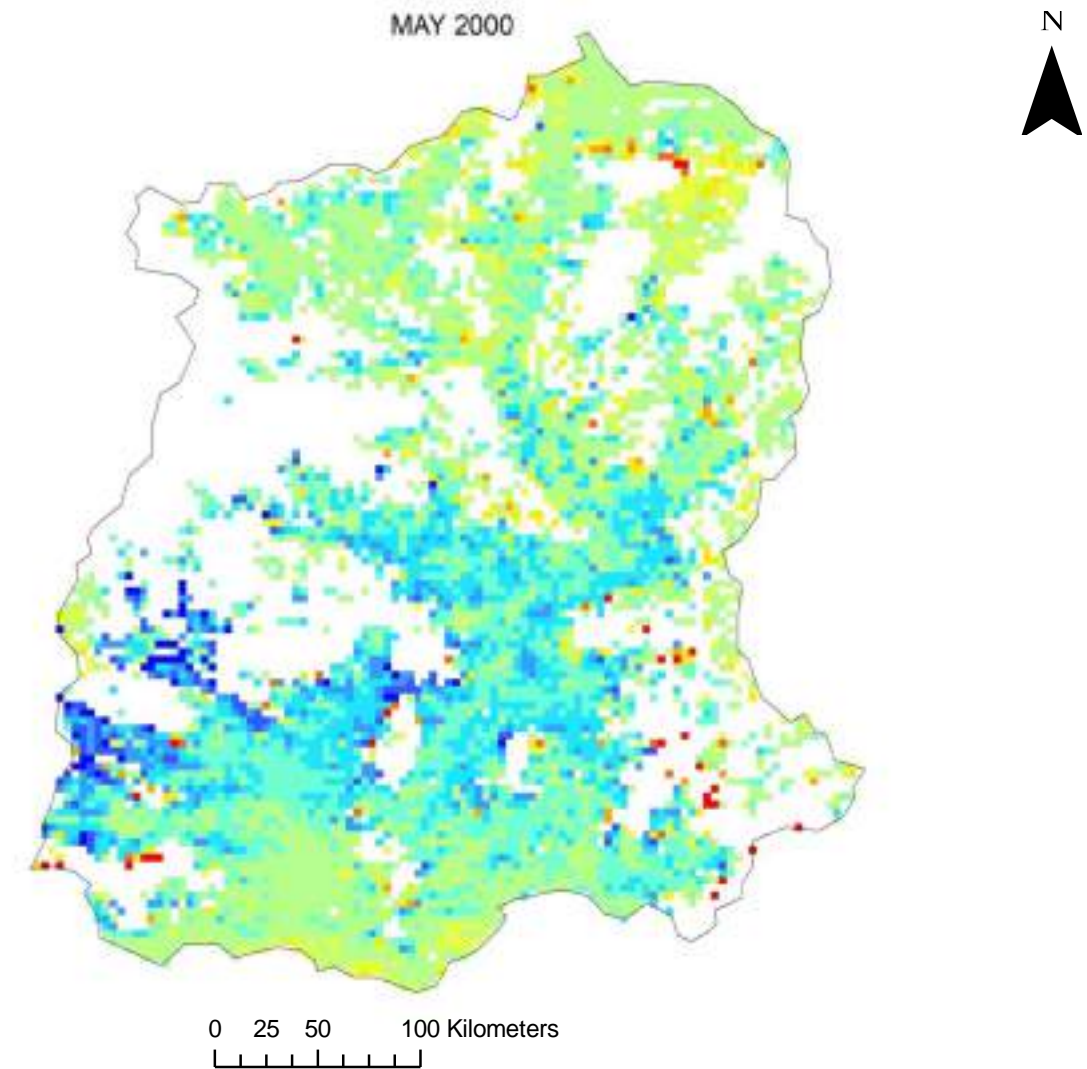
-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



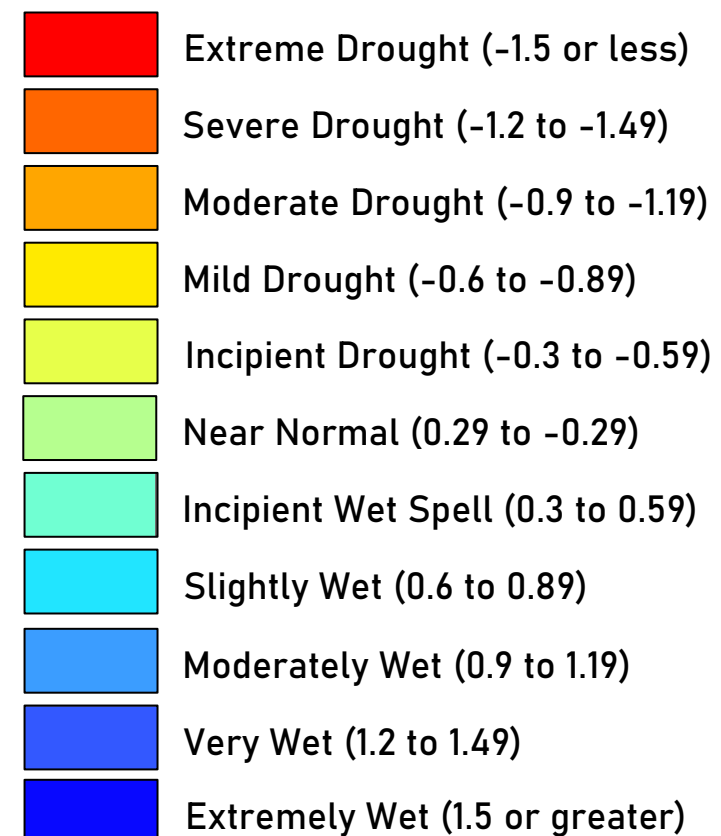
## May DSI Maps

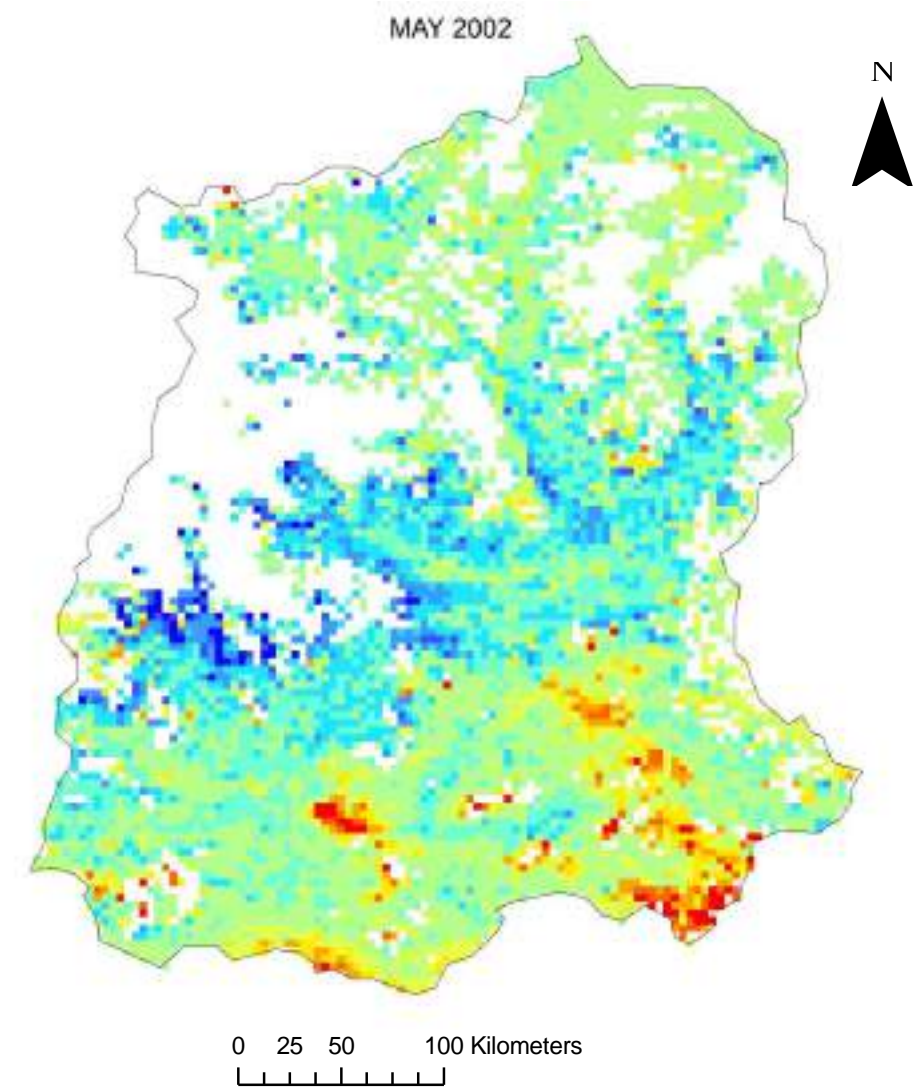
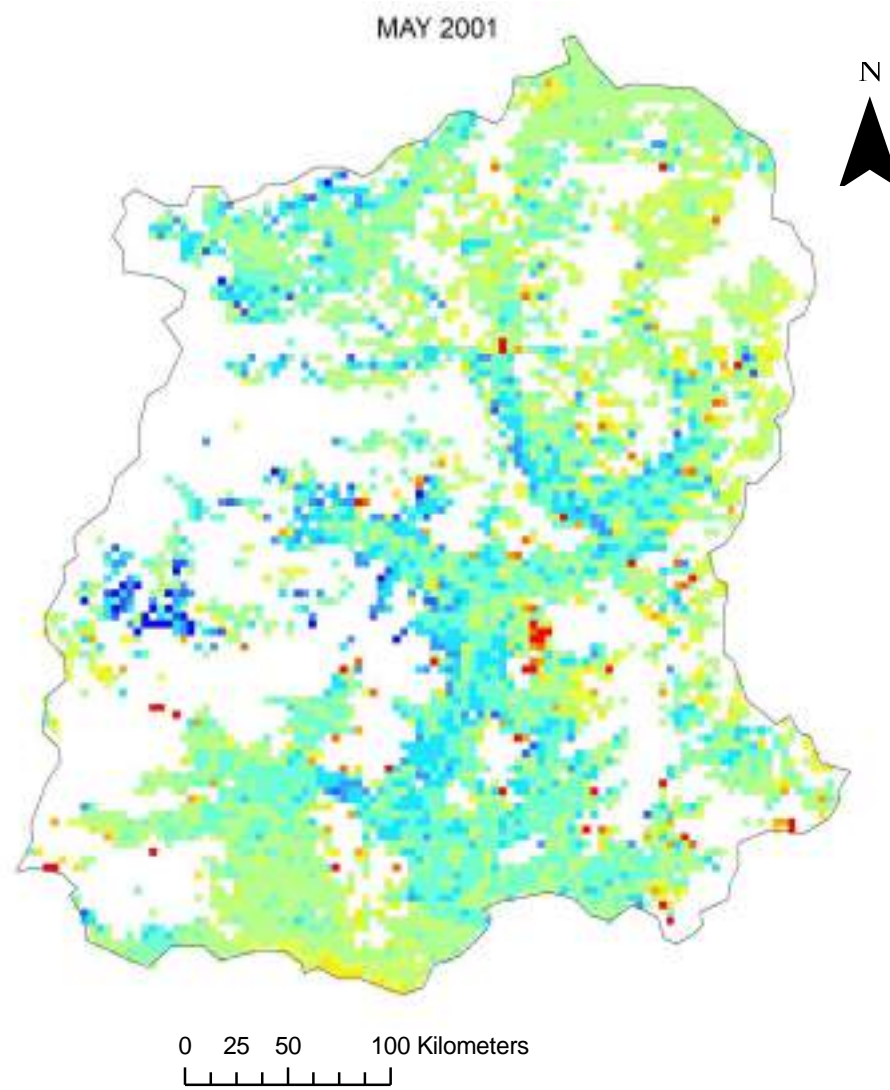
Drought conditions in May usually range from incipient drought to slightly wet. The characteristics of this winter month are frequently characterized by near normal to incipient wet spell conditions.

Mean May DSI Values		
Year	DSI Values	Drought Condition
2000	0.31	Incipient Wet Spell
2001	0.33	Incipient Wet Spell
2002	0.33	Incipient Wet Spell
2003	0.09	Near Normal
2004	-0.32	Incipient Drought
2005	-0.04	Near Normal
2006	0.52	Incipient Wet Spell
2007	0.40	Incipient Wet Spell
2008	0.68	Slightly Wet
2009	0.24	Near Normal
2010	0.39	Incipient Wet Spell
2011	0.41	Incipient Wet Spell
2012	-0.02	Near Normal
2013	-0.53	Incipient Drought
2014	0.25	Near Normal
2015	-0.01	Near Normal
2016	0.25	Near Normal
2017	0.40	Incipient Wet Spell
2018	0.57	Incipient Wet Spell
2019	0.11	Near Normal
2020	-0.05	Near Normal














### Legend

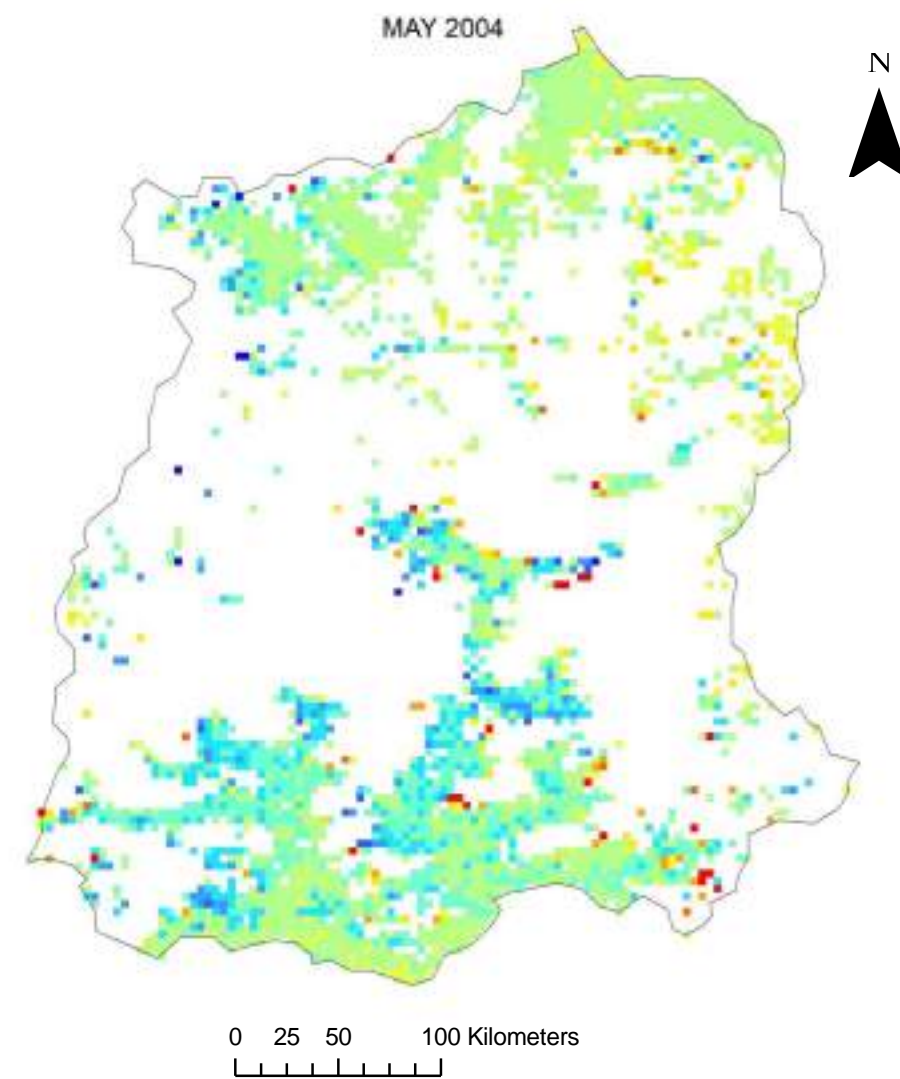
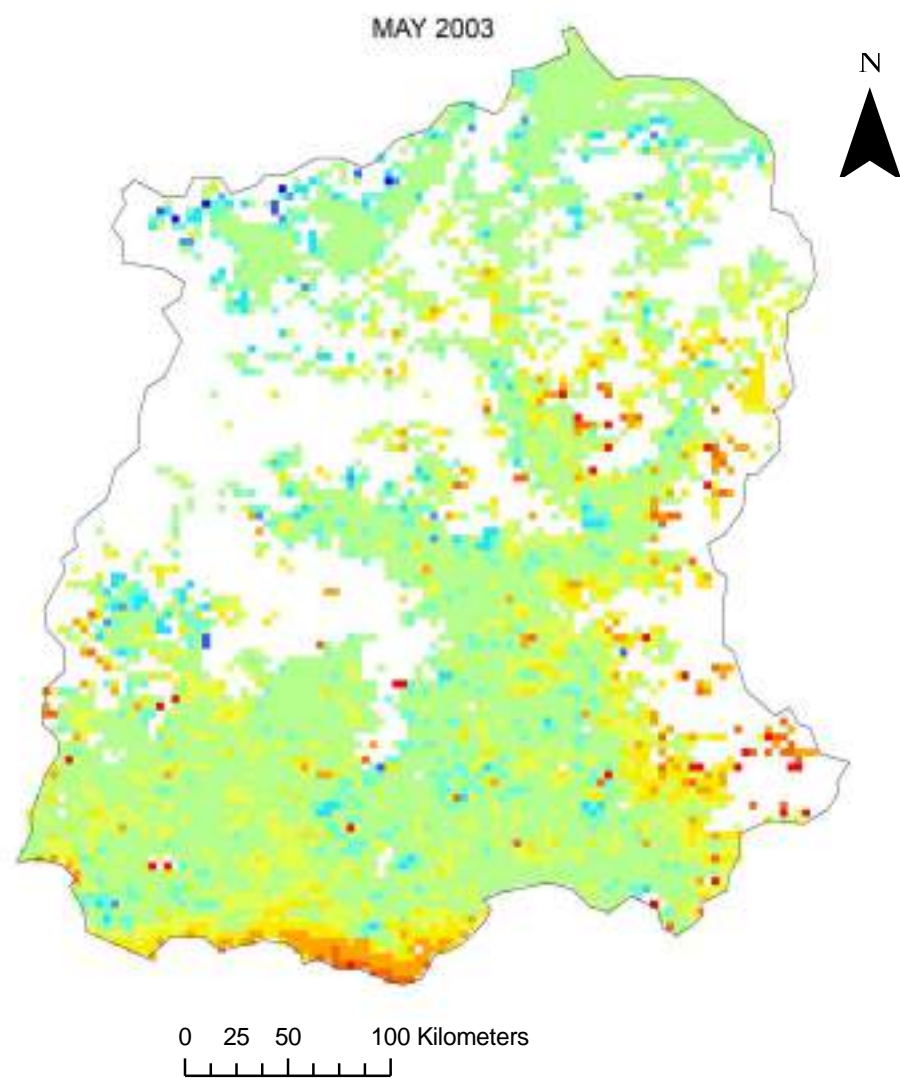








**Legend**


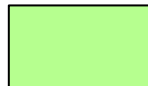


- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |

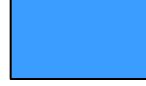




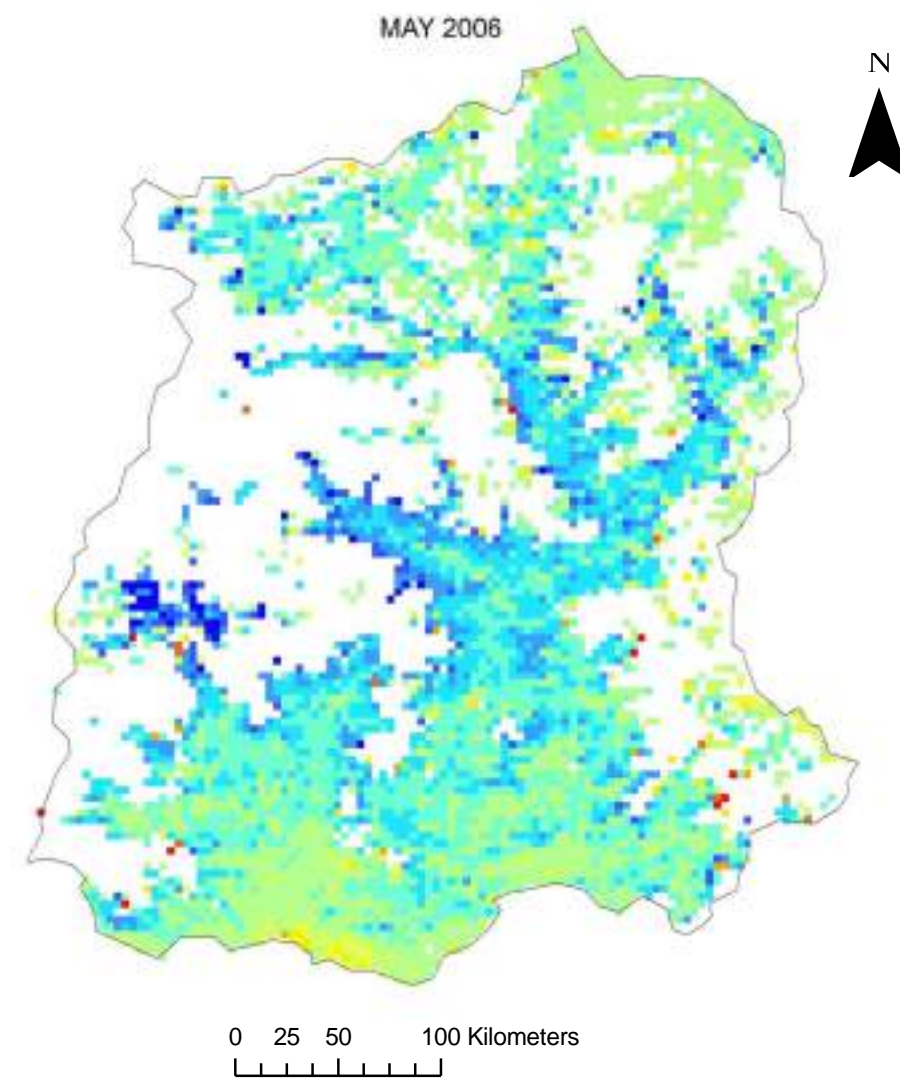
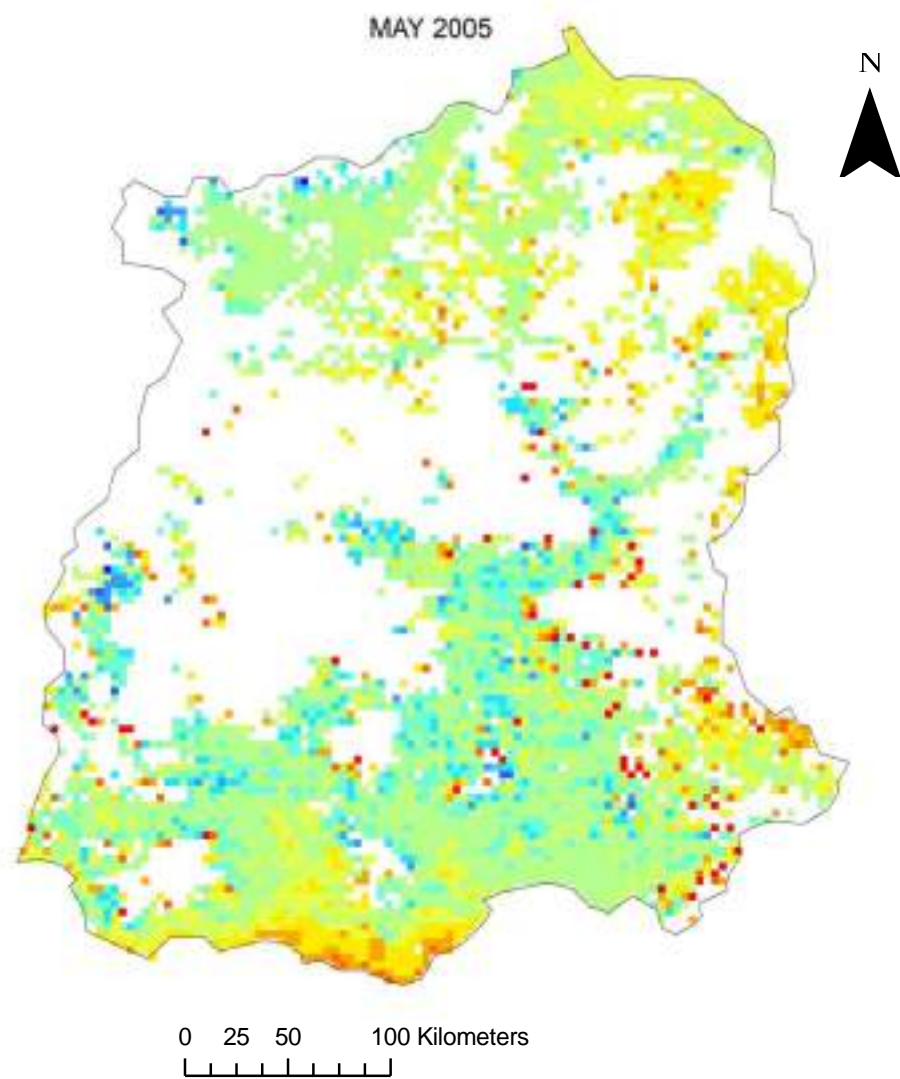


**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



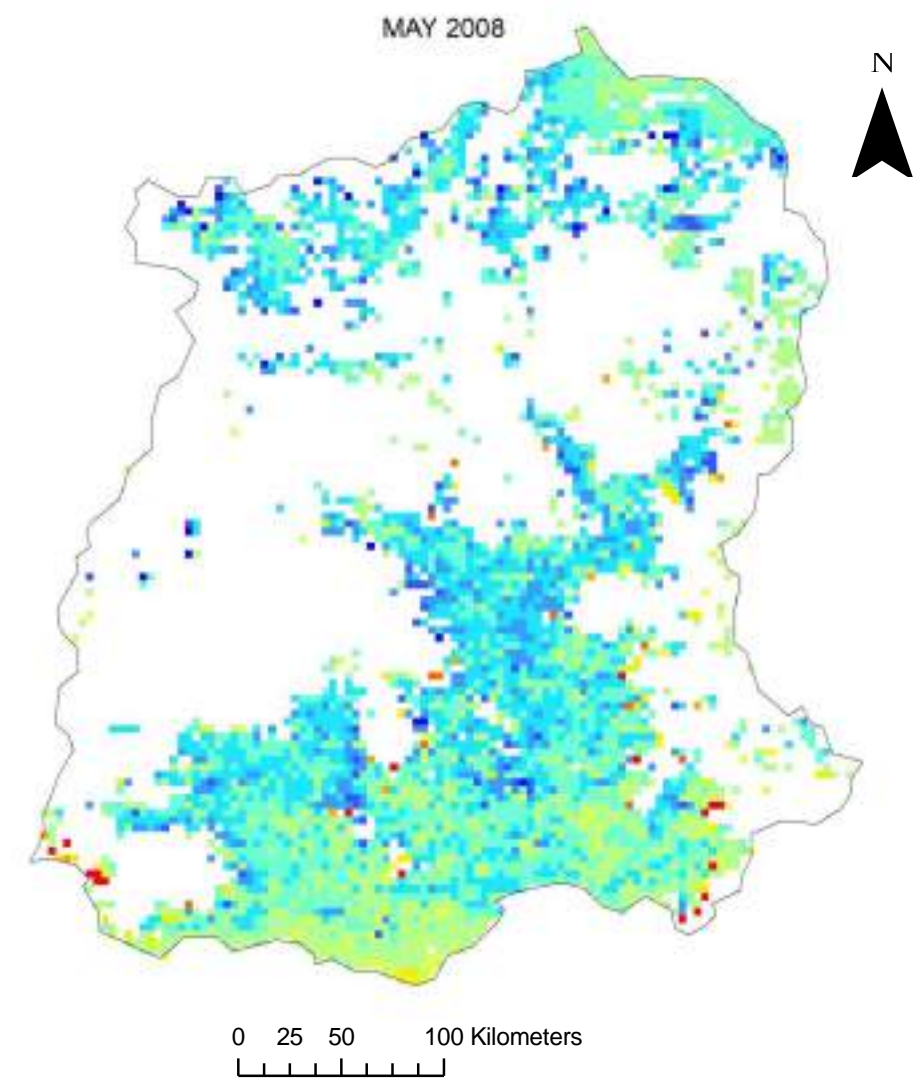
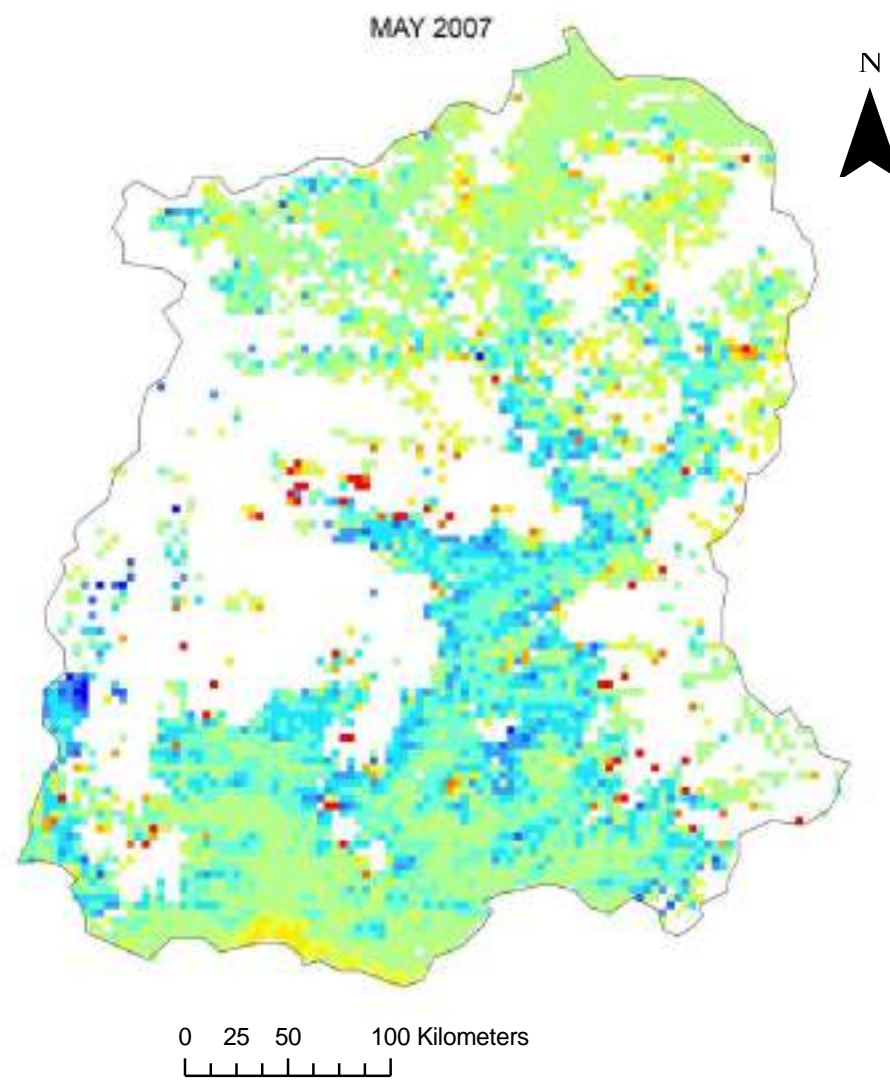
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)








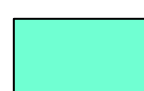



- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

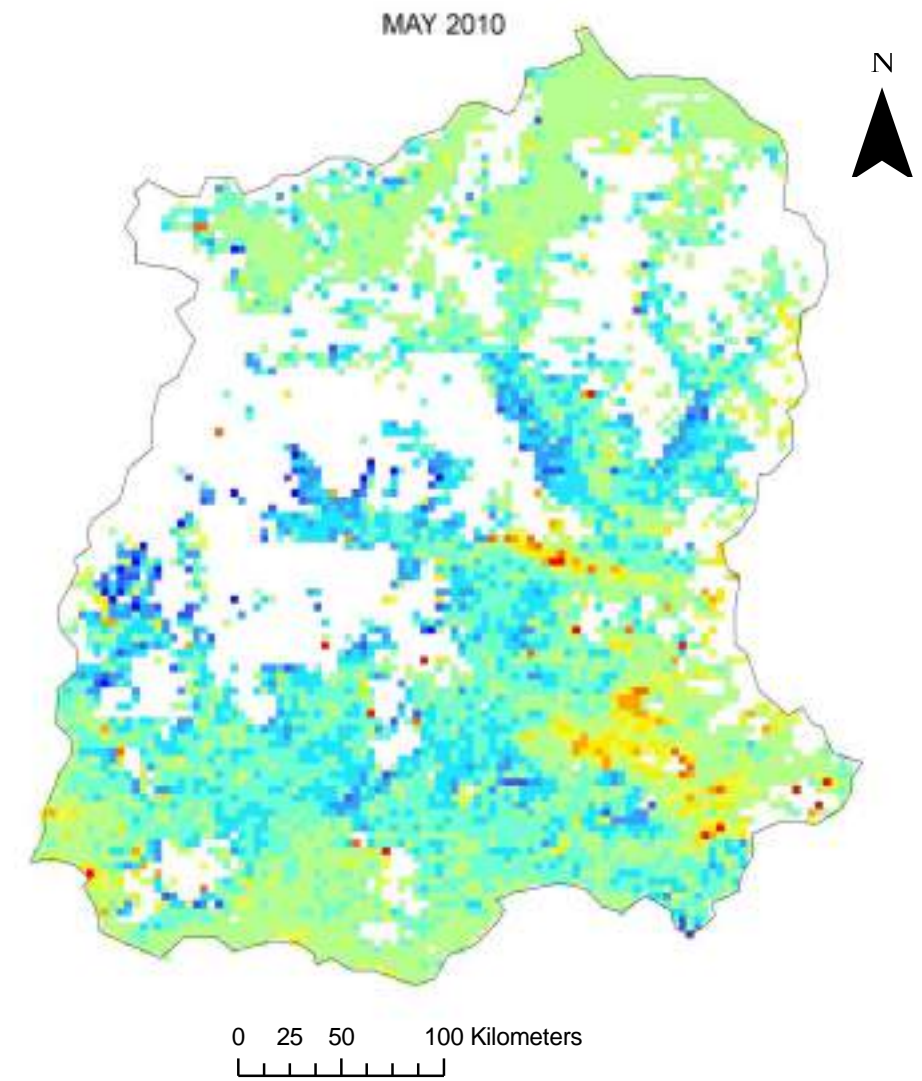
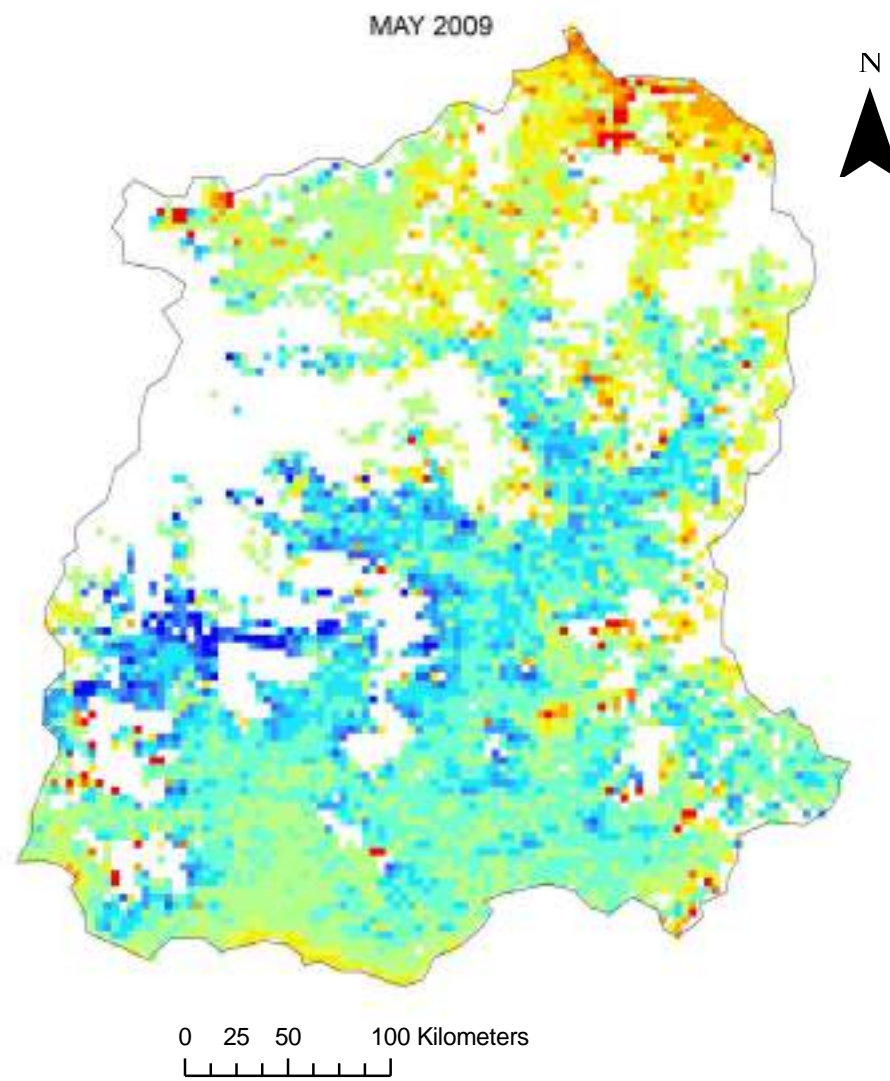
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



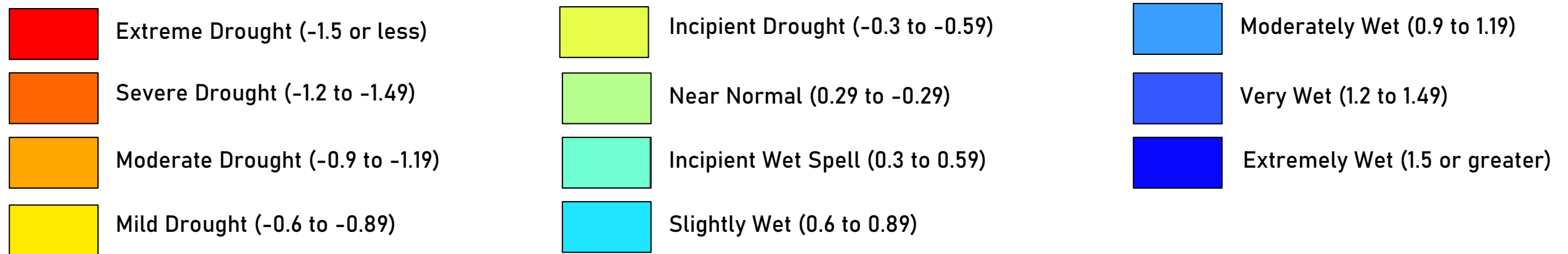


**Legend**

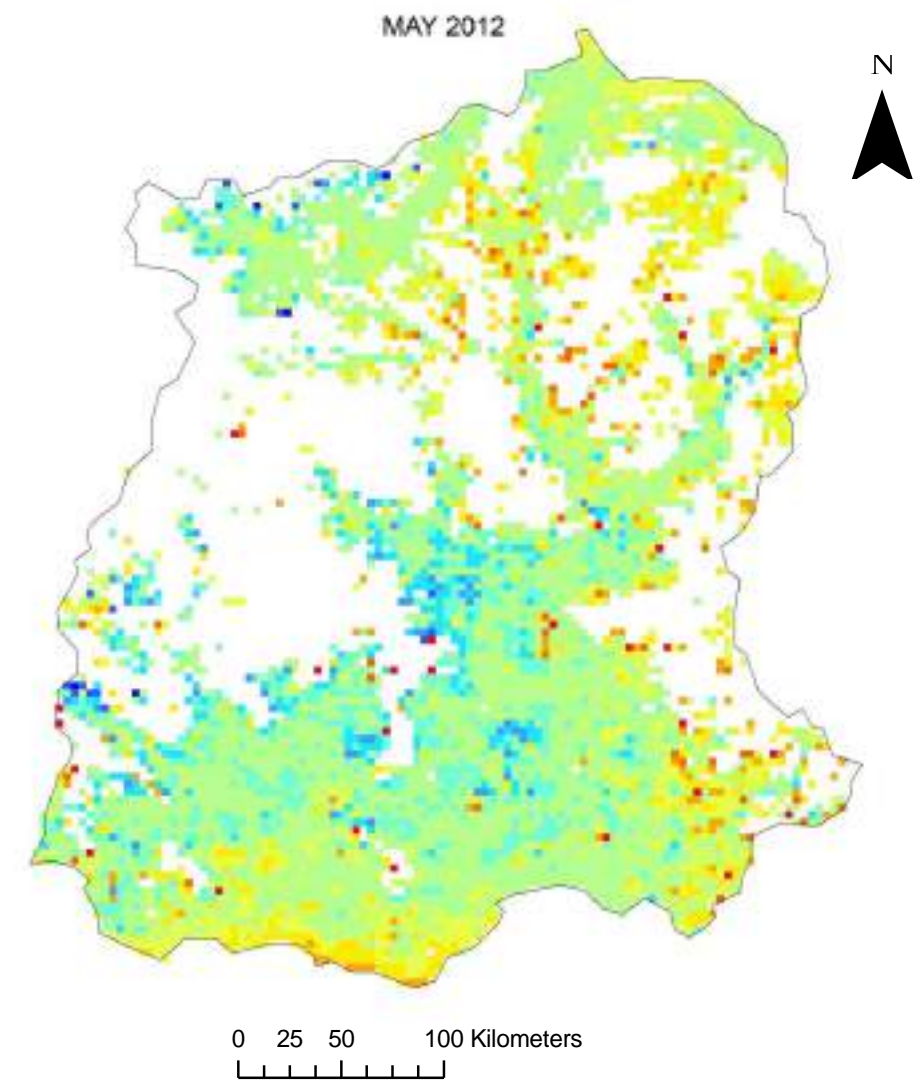
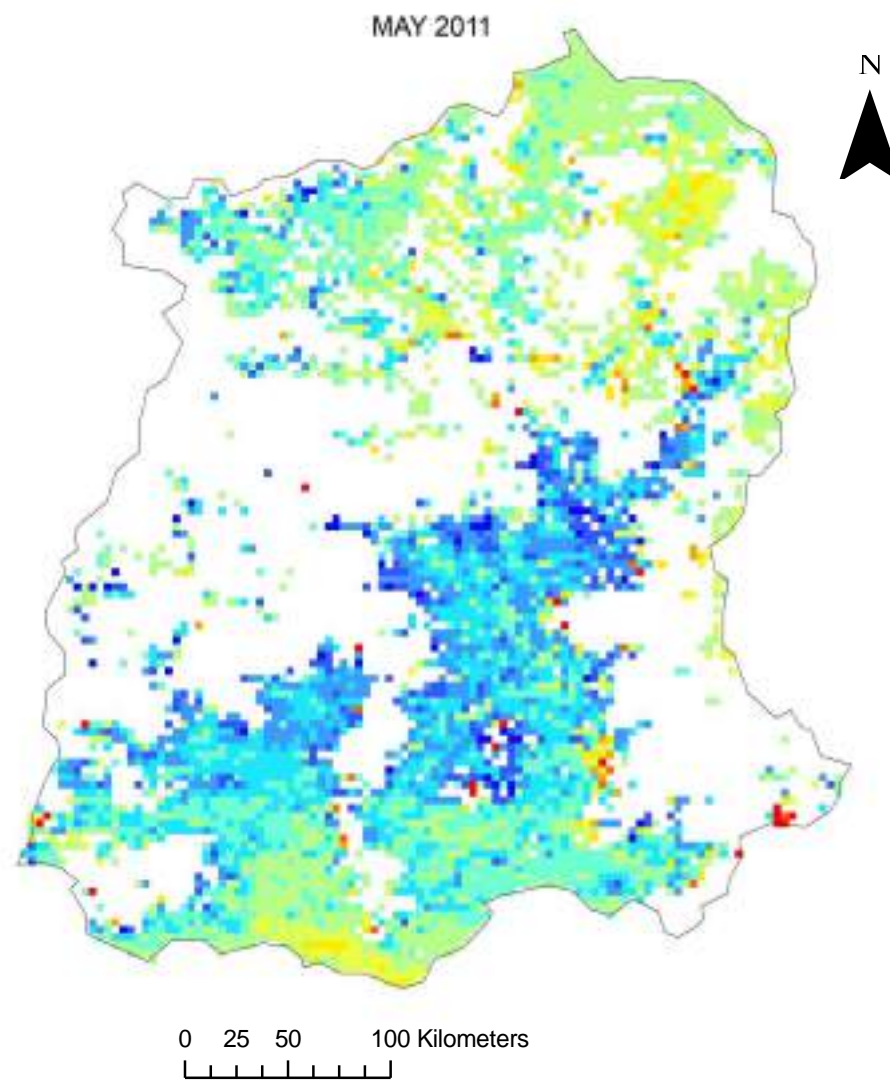
	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		



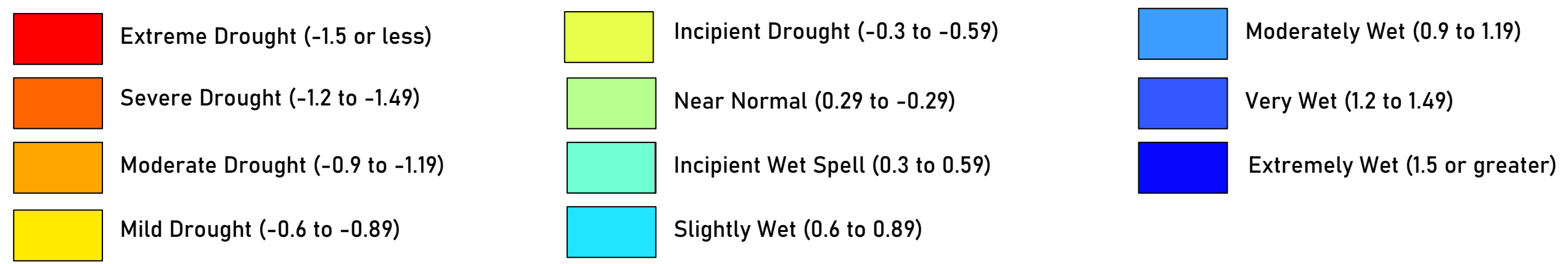
**Legend**

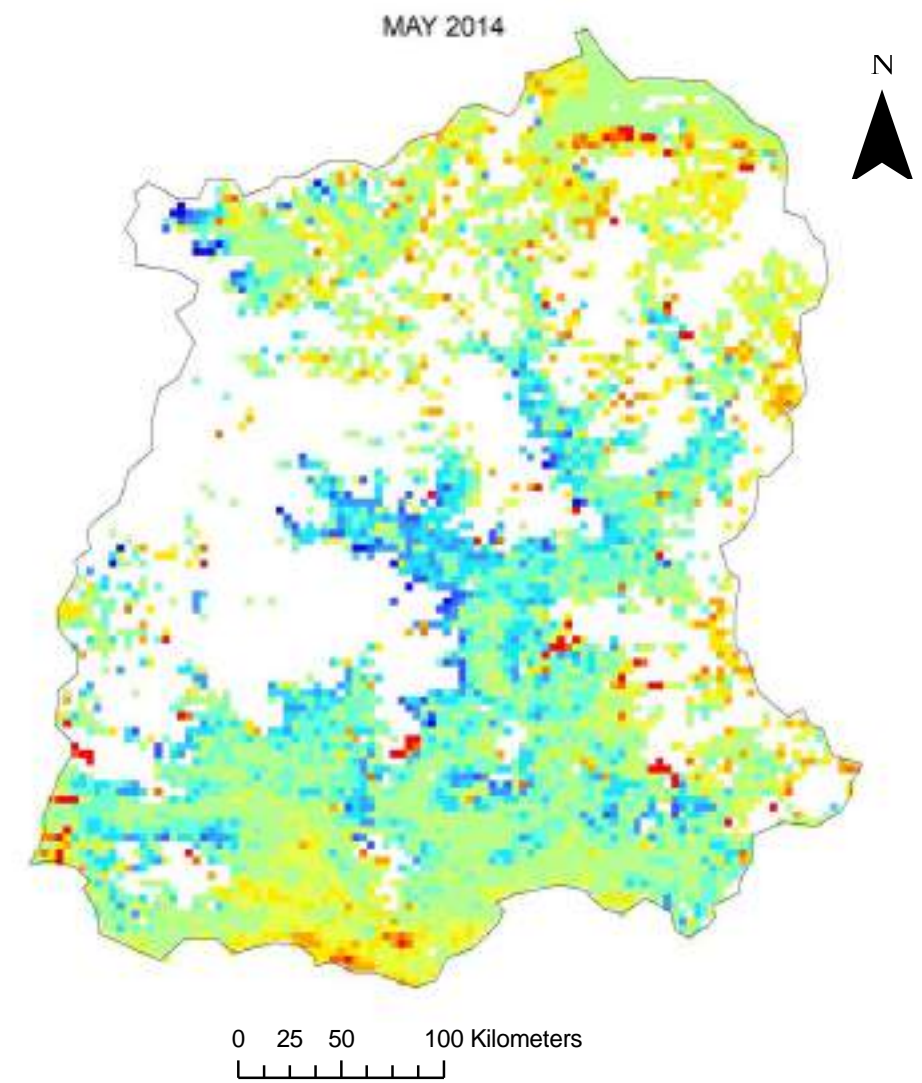
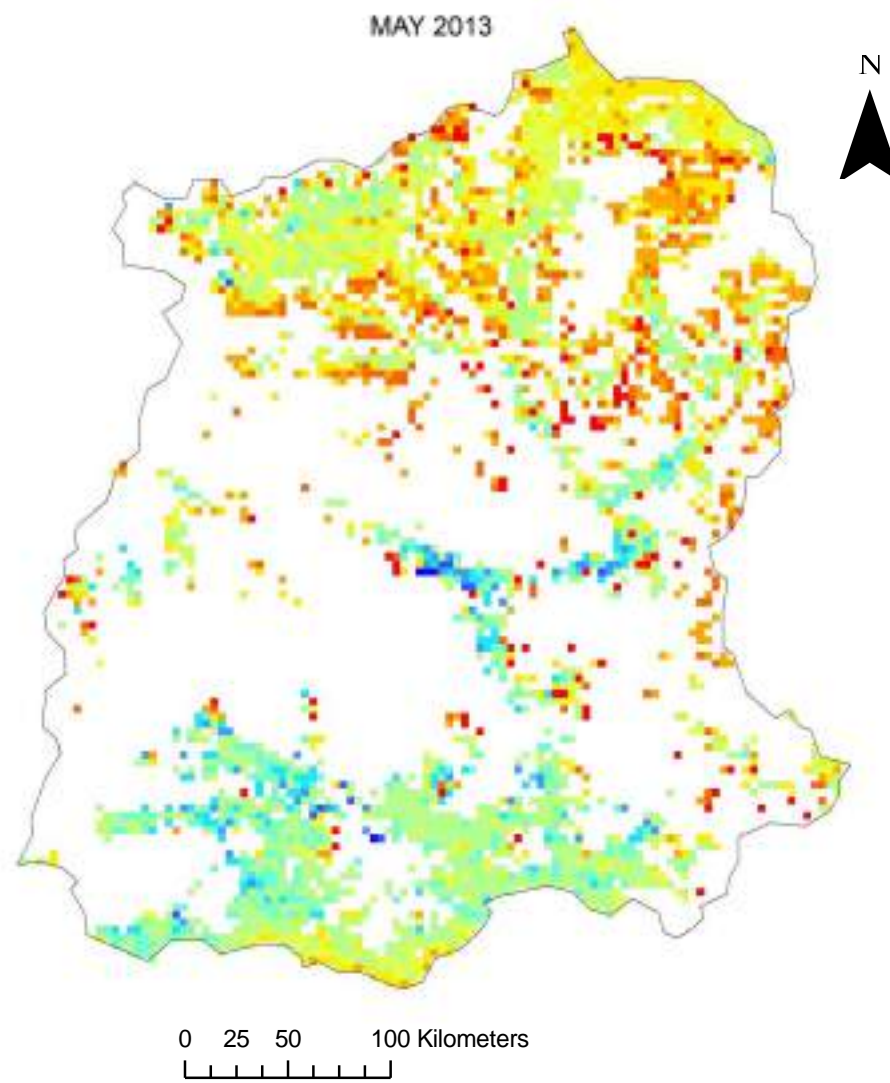

















**Legend**

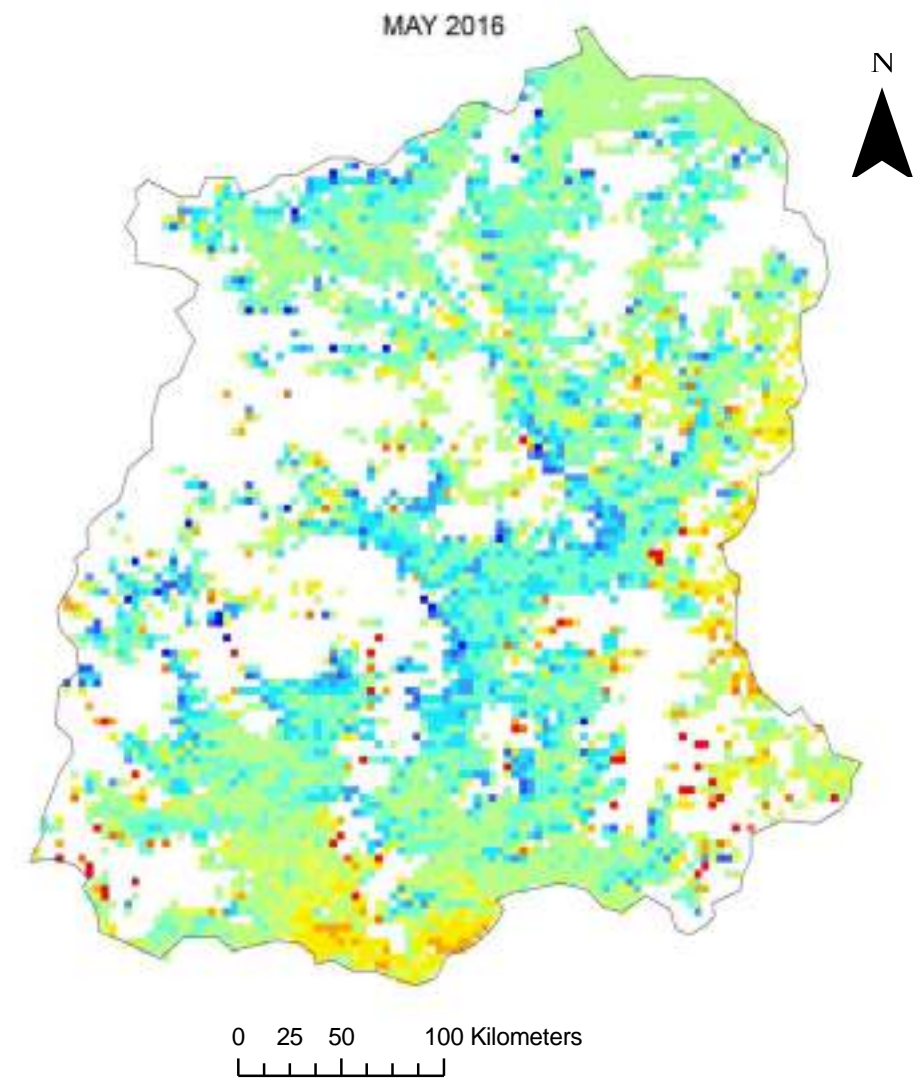
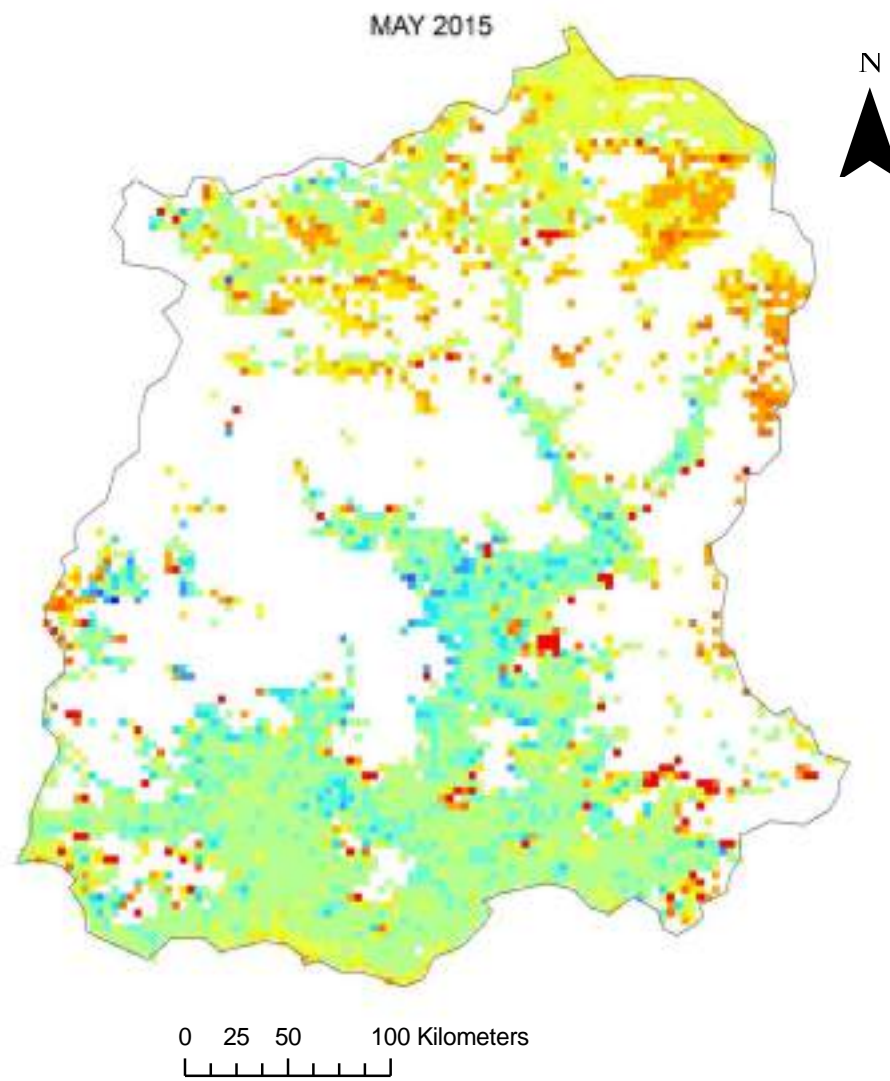








**Legend**





- |  |   |  |
|--|---|--|
|  Extreme Drought (-1.5 or less)   |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19)   |
|  Severe Drought (-1.2 to -1.49)   |  Near Normal (0.29 to -0.29)       |  Very Wet (1.2 to 1.49)         |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89)     |  Slightly Wet (0.6 to 0.89)        |  |

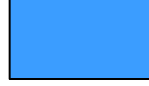




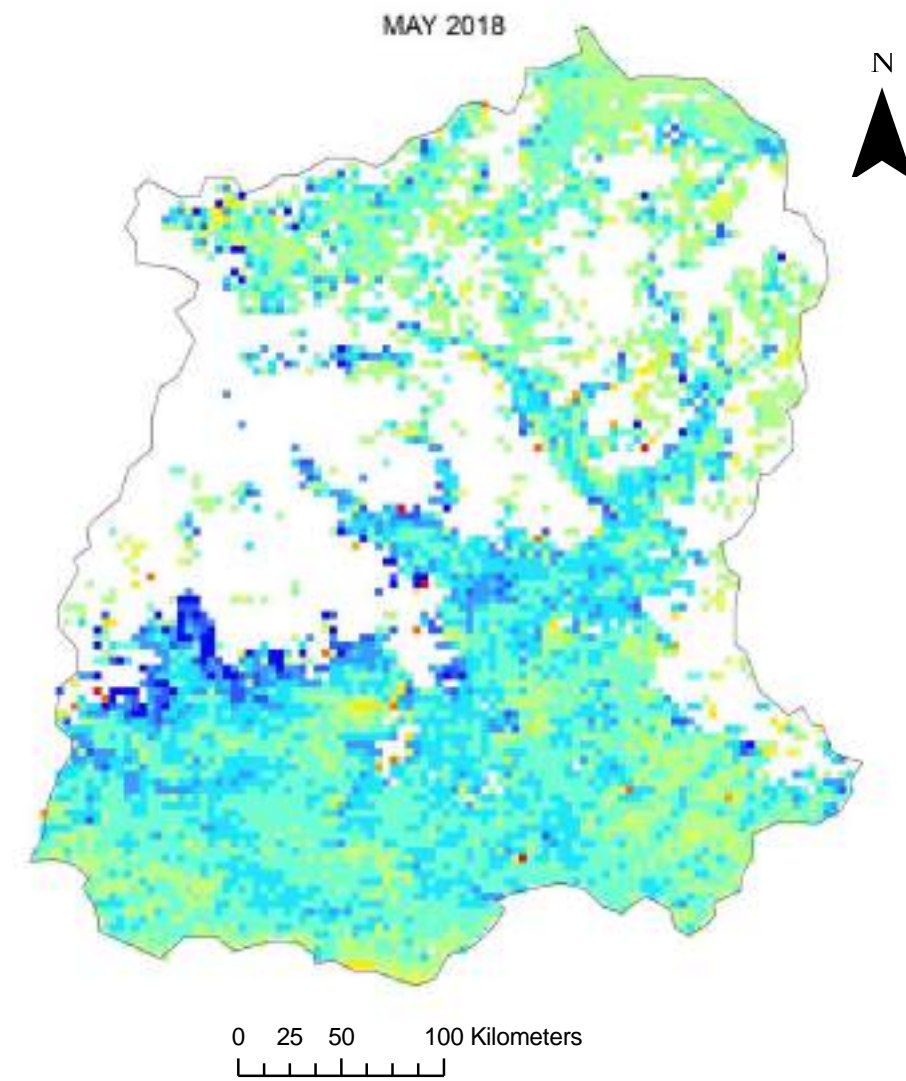
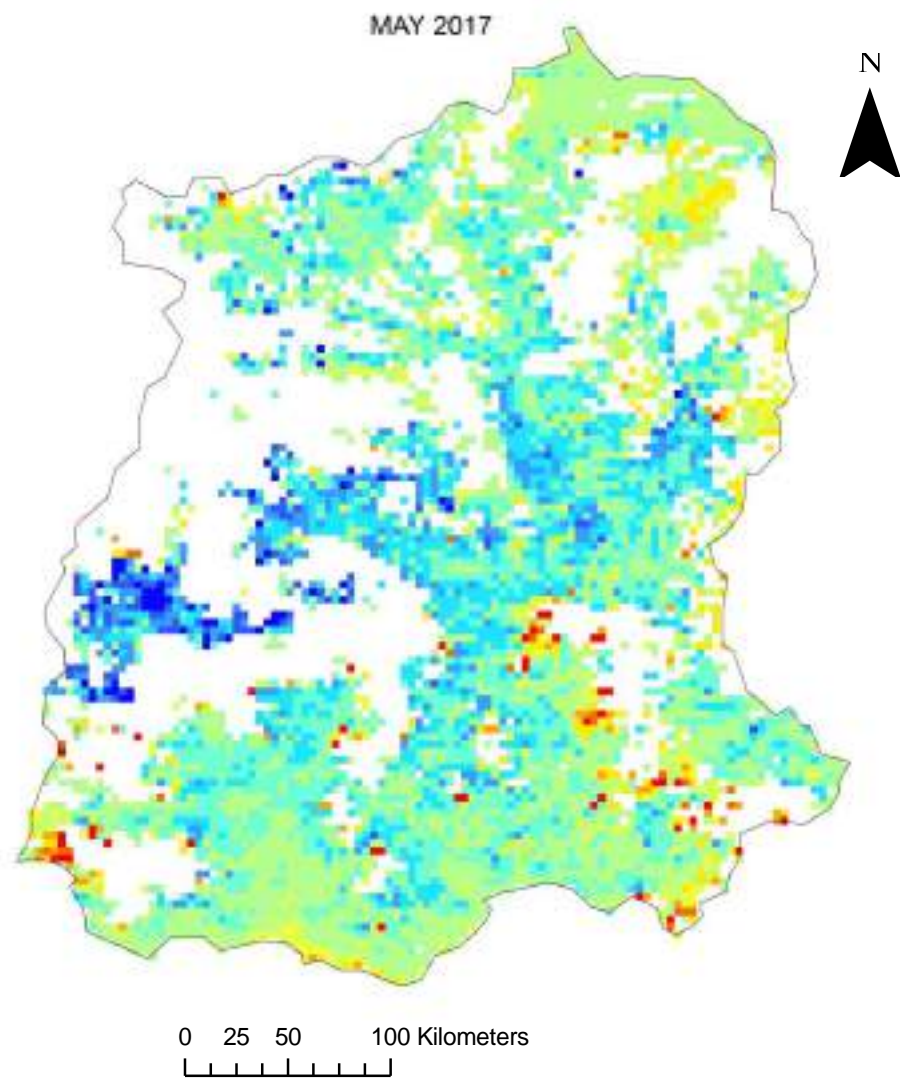


**Legend**

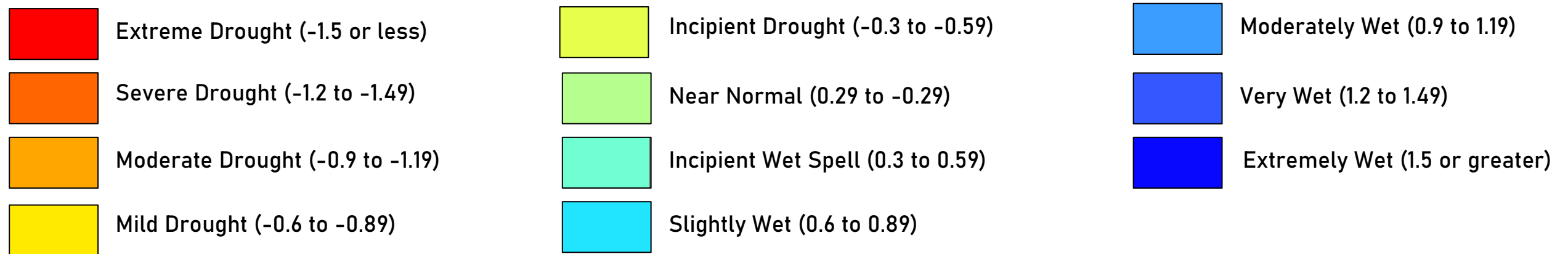
-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

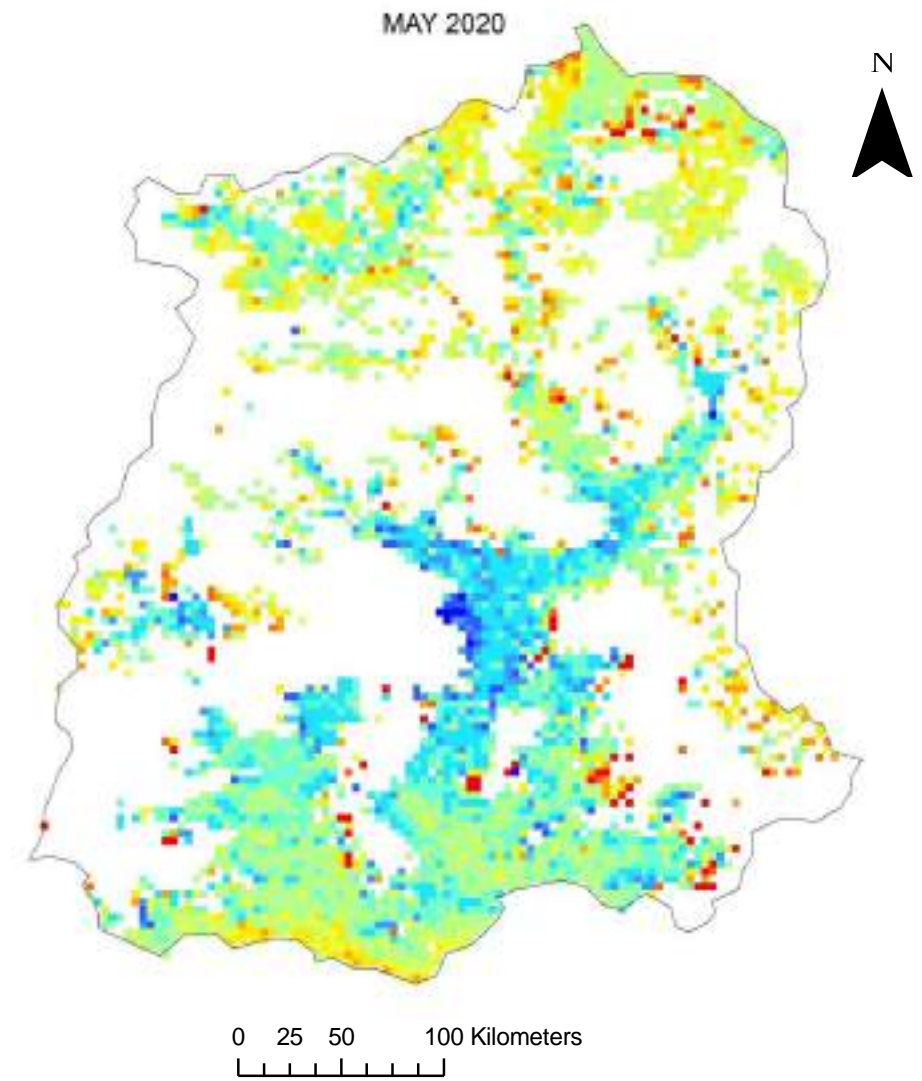
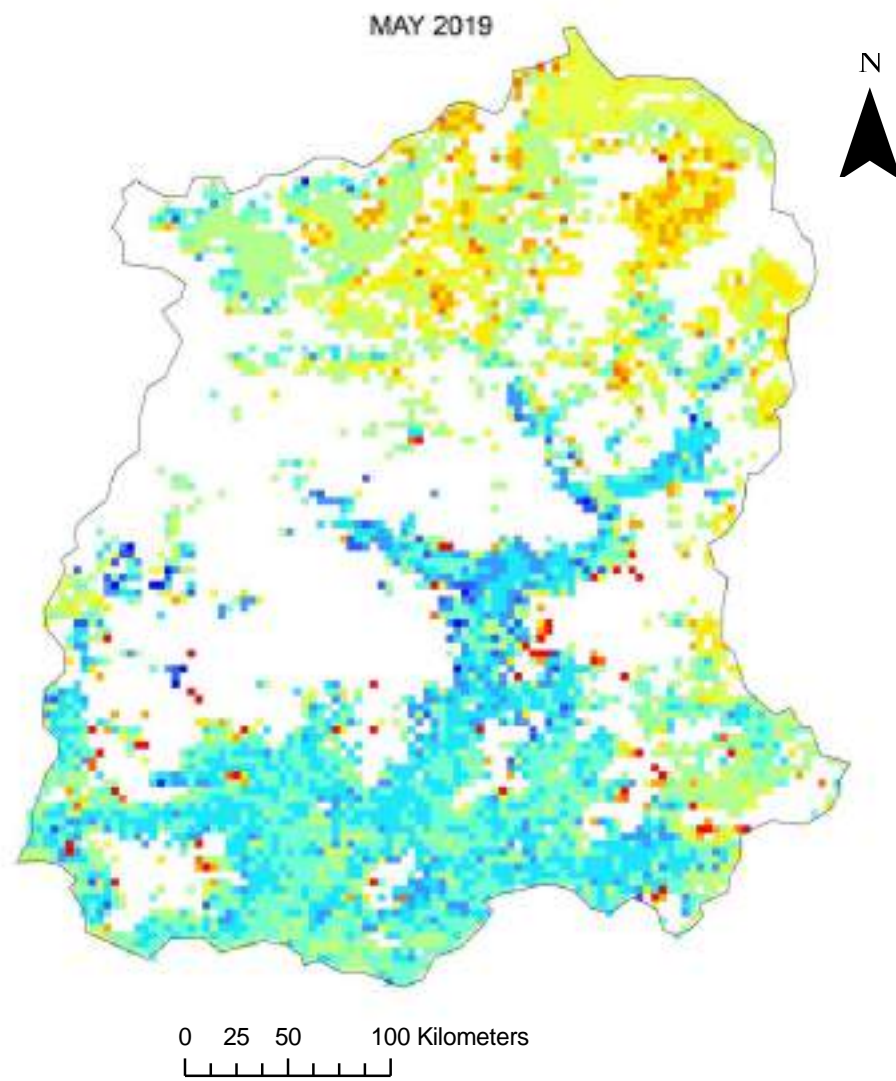
-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



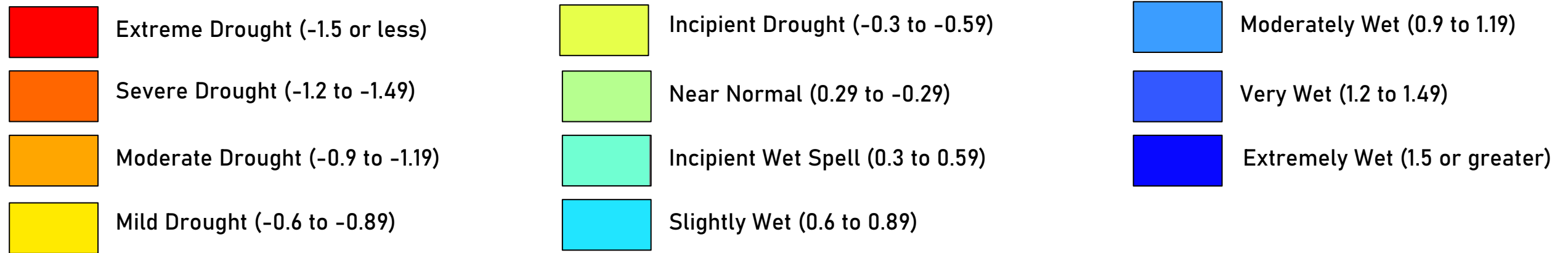
**Legend**







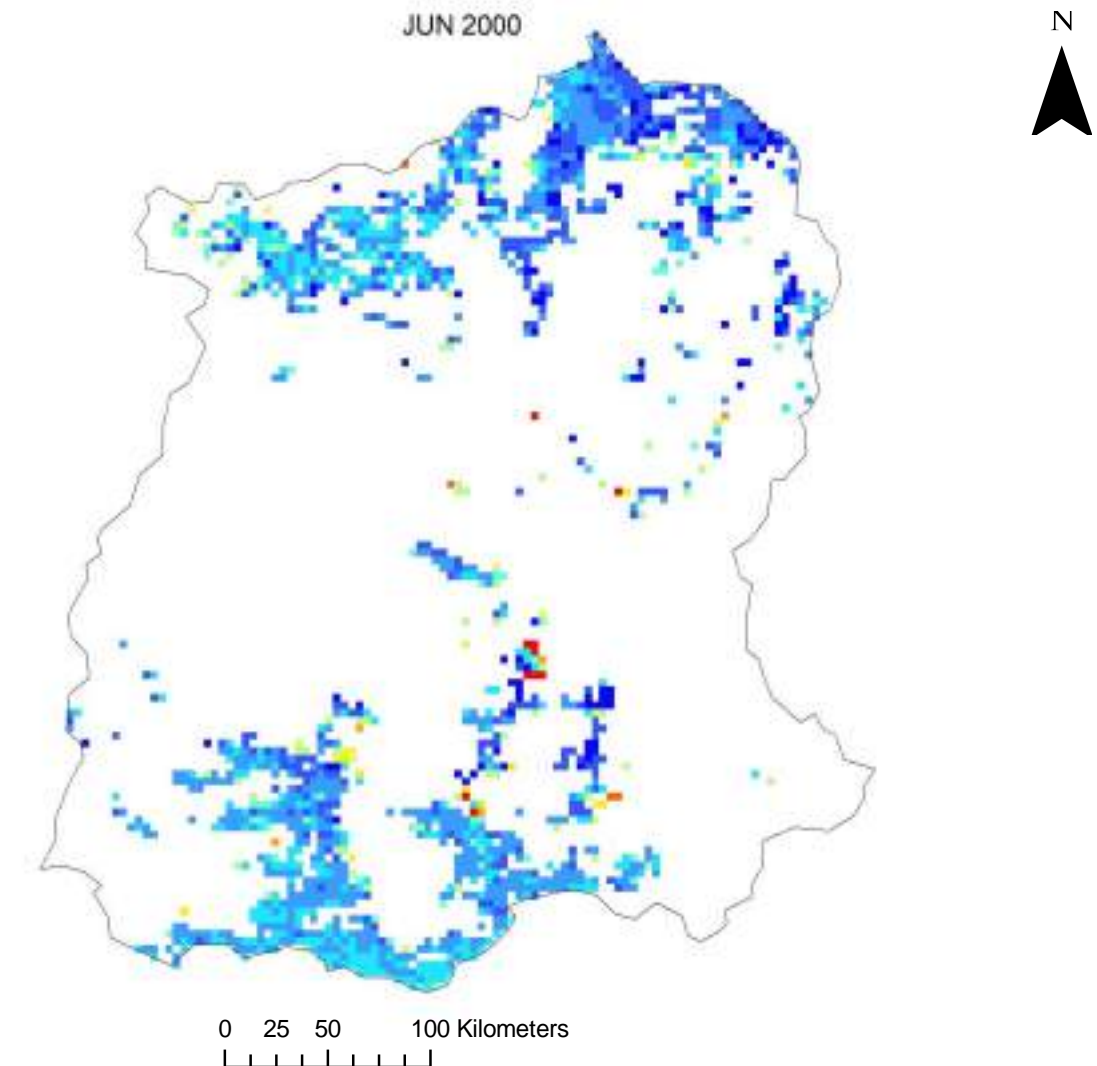
**Legend**



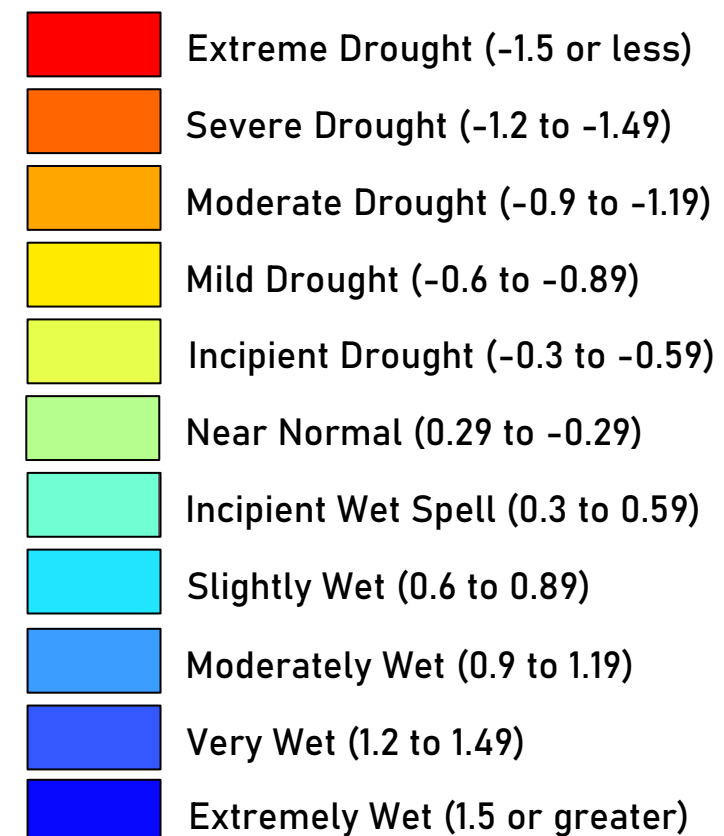
## June DSI Maps

Drought conditions in June vary from incipient wet spell to very wet. This monsoon month is characterized by slightly and moderately wet condition.

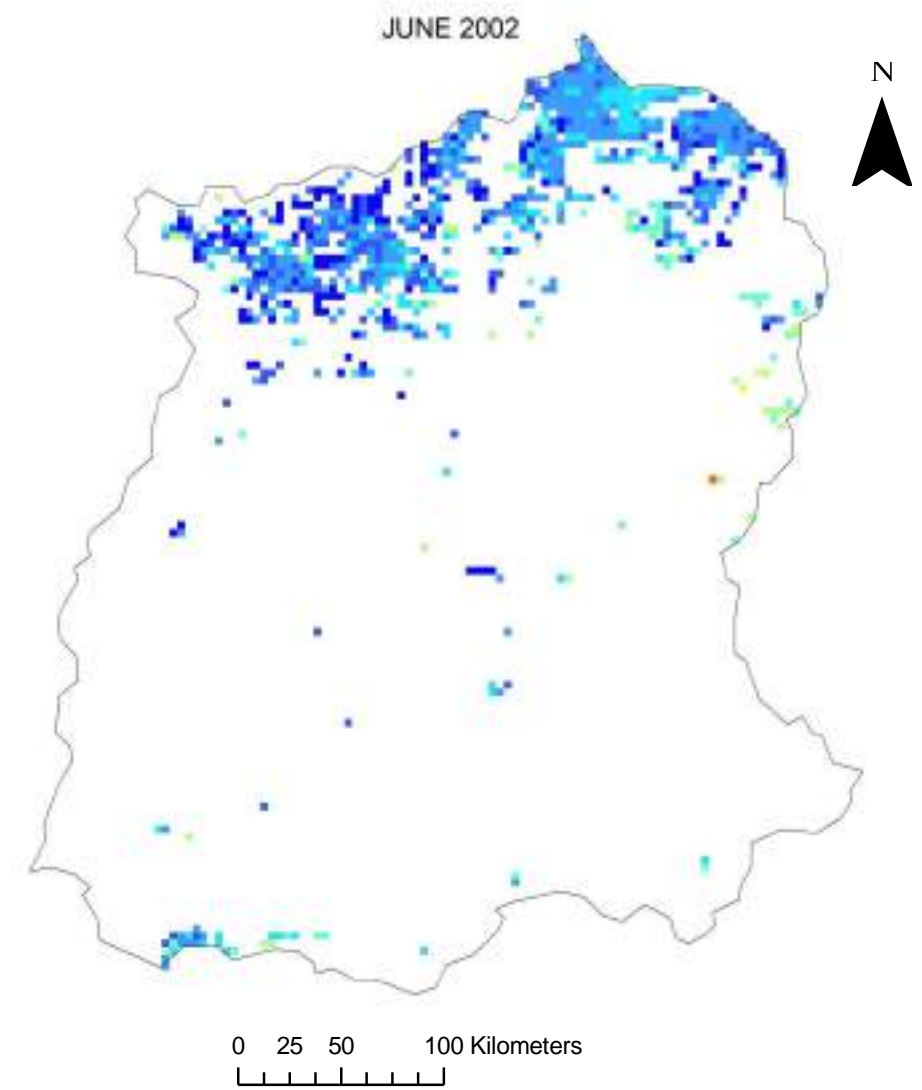
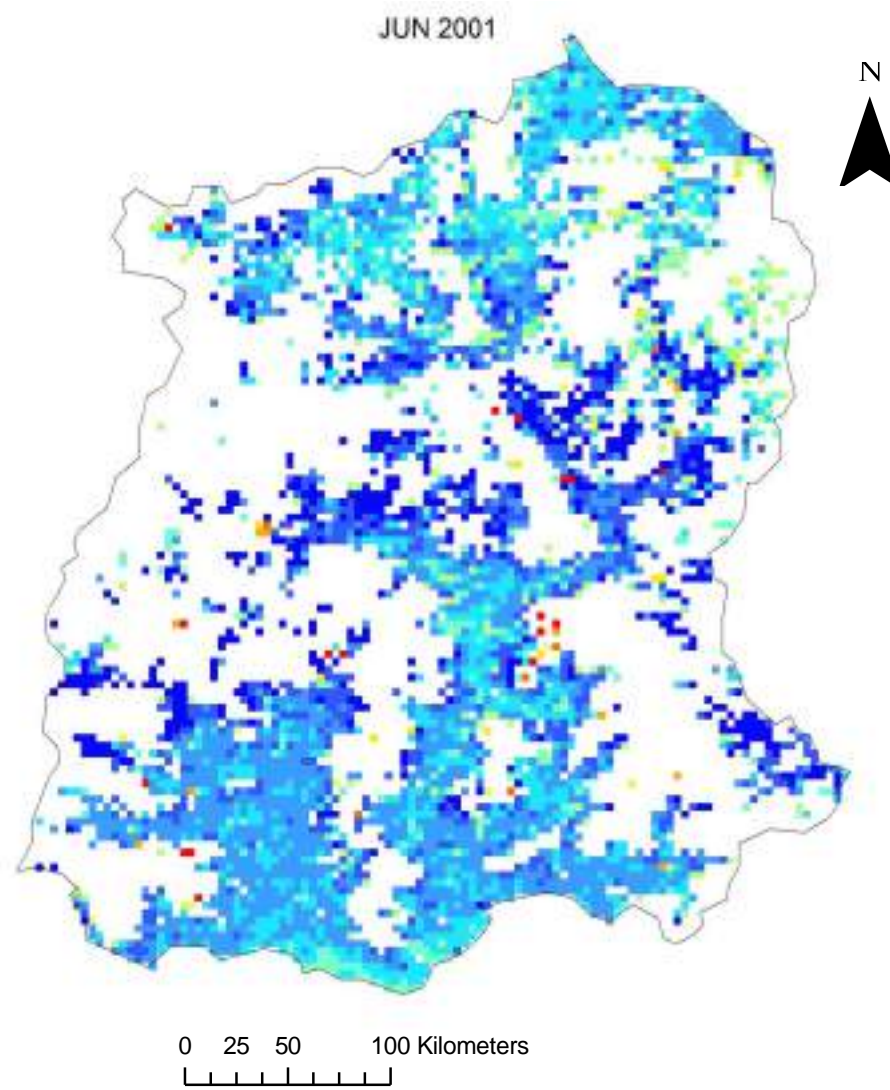
Mean June DSI Values		
Year	DSI Values	Drought Condition
2000	0.65	Slightly Wet
2001	1.19	Moderately Wet
2002	1.06	Moderately Wet
2003	1.18	Moderately Wet
2004	0.86	Slightly Wet
2005	0.87	Slightly Wet
2006	0.98	Moderately Wet
2007	1.28	Very Wet
2008	0.92	Moderately Wet
2009	0.77	Slightly Wet
2010	0.67	Slightly Wet
2011	0.79	Slightly Wet
2012	0.82	Slightly Wet
2013	0.80	Slightly Wet
2014	0.99	Moderately Wet
2015	0.55	Incipient Wet Spell
2016	0.97	Moderately Wet
2017	0.65	Slightly Wet
2018	0.92	Moderately Wet
2019	0.43	Incipient Wet Spell
2020	1.40	Very Wet



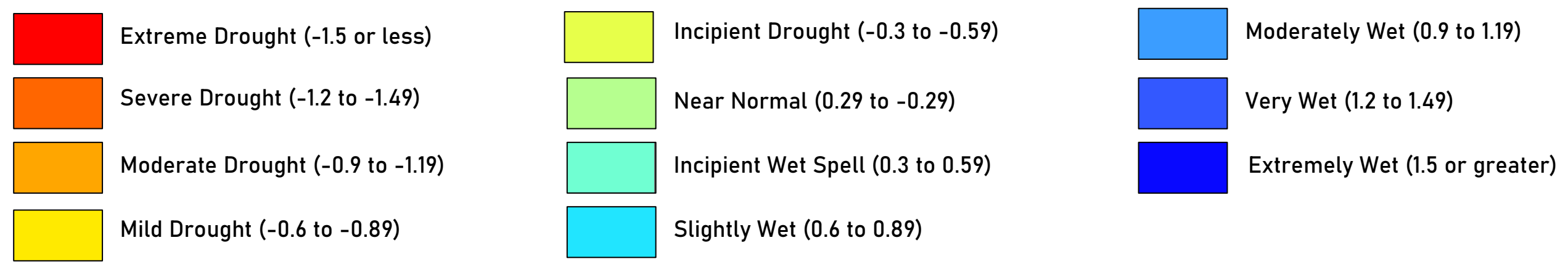
### Legend

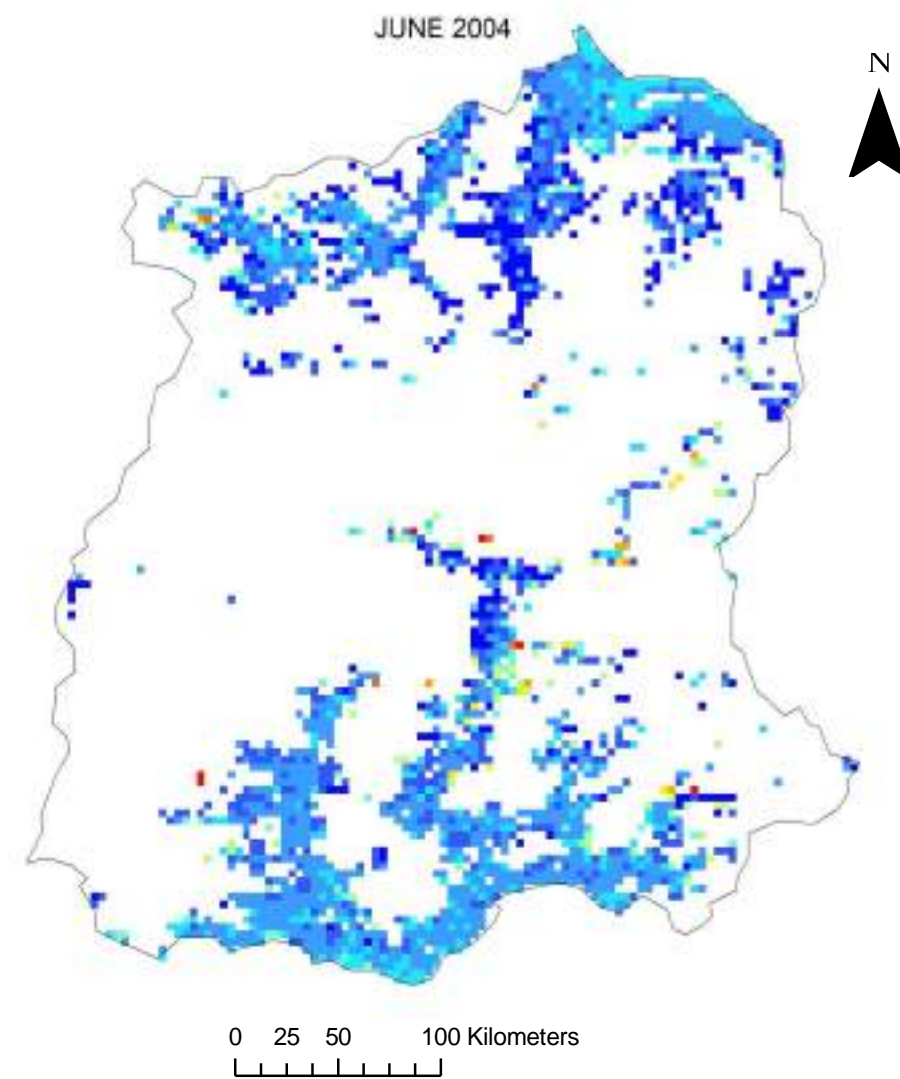
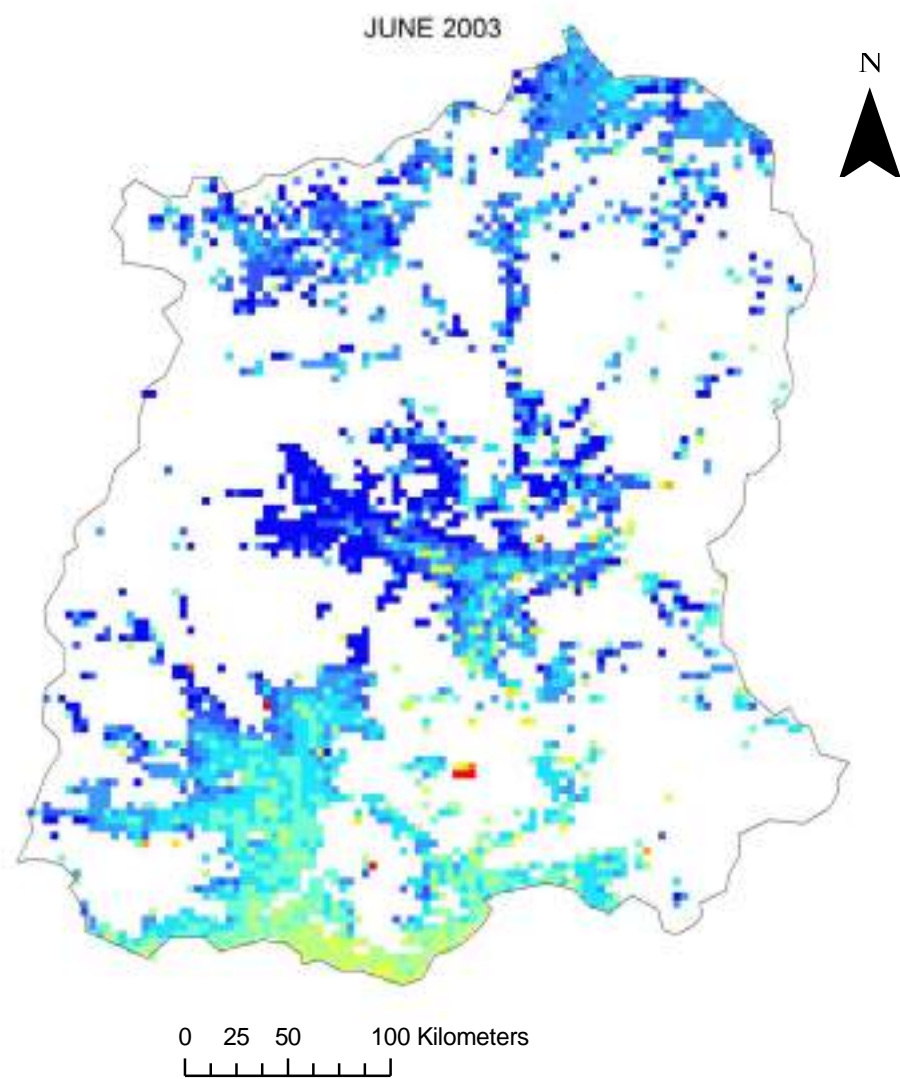











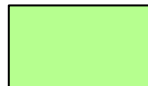


**Legend**

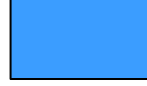






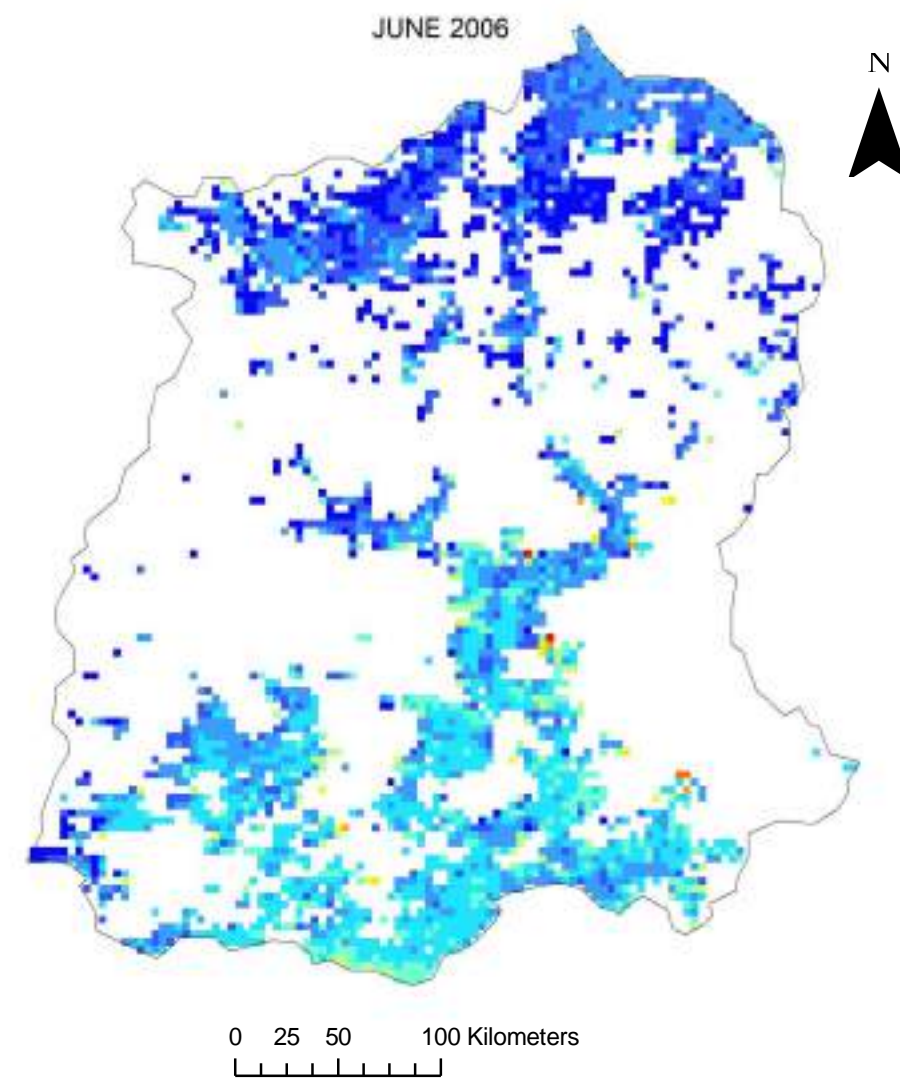
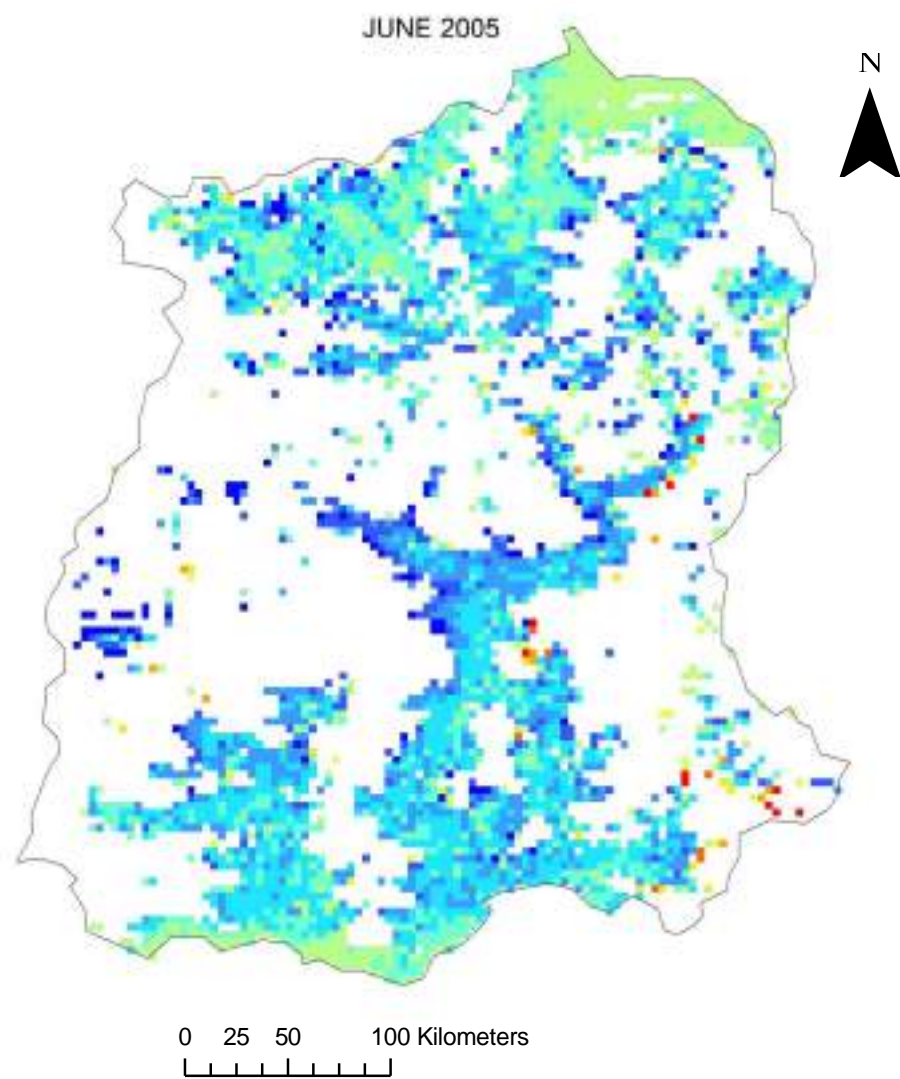
**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



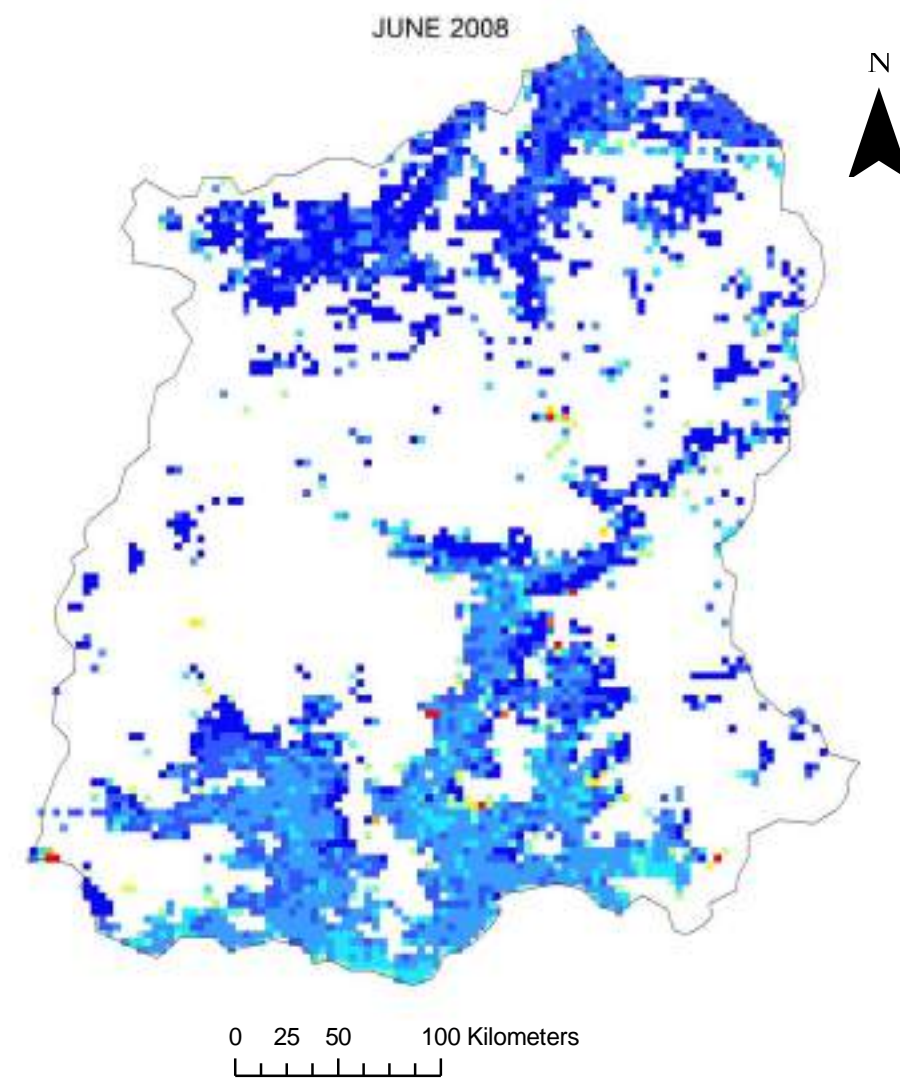
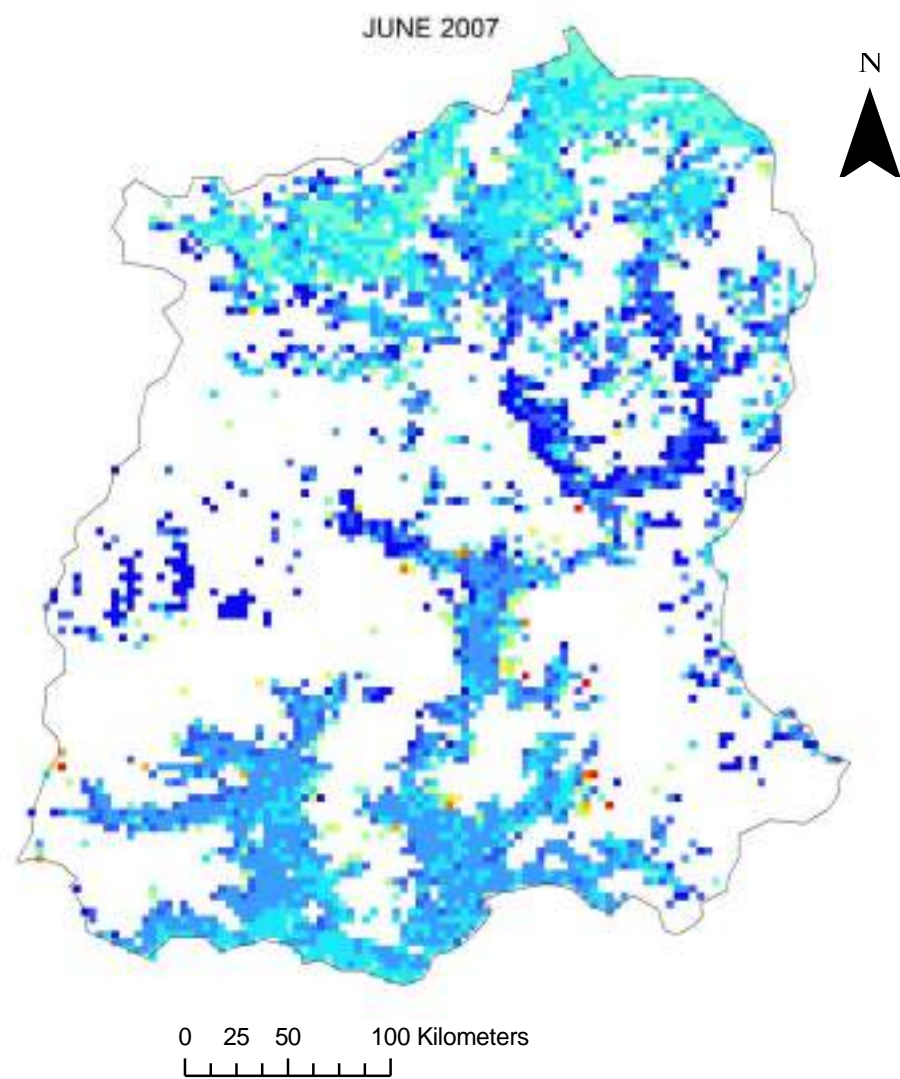


**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



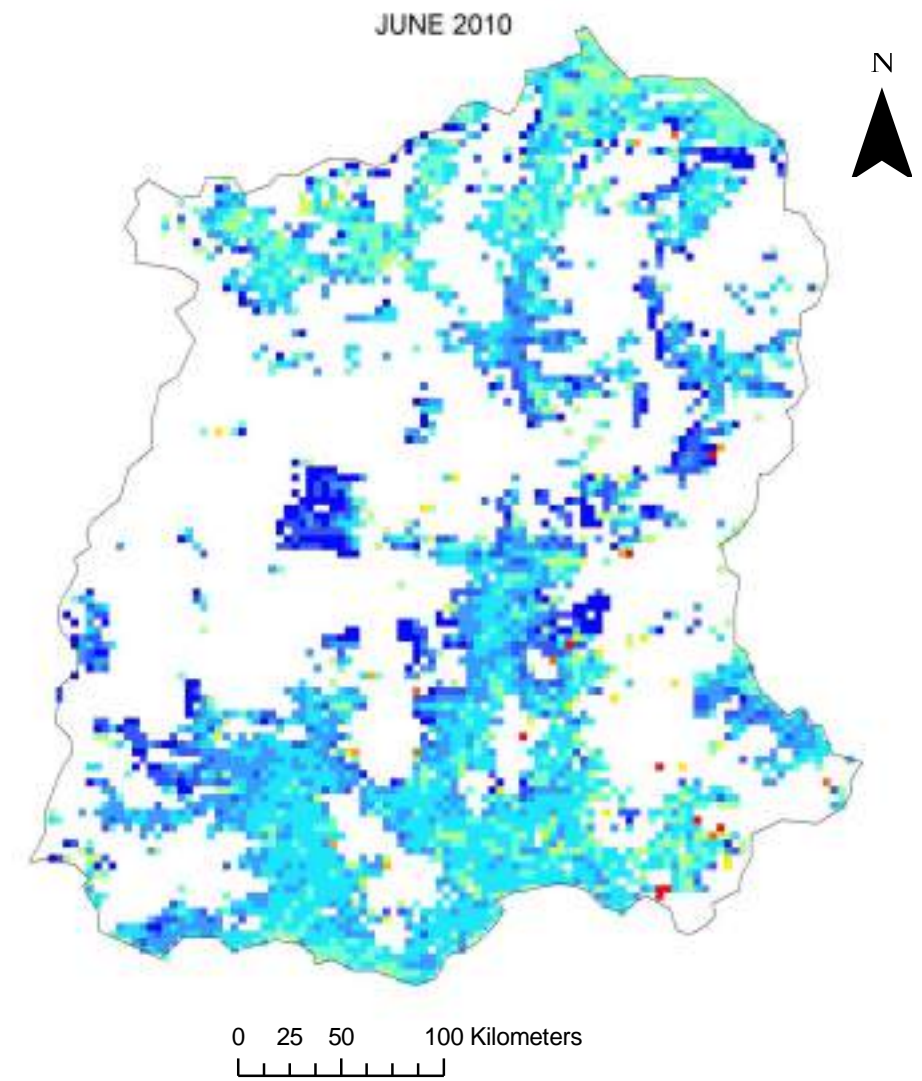
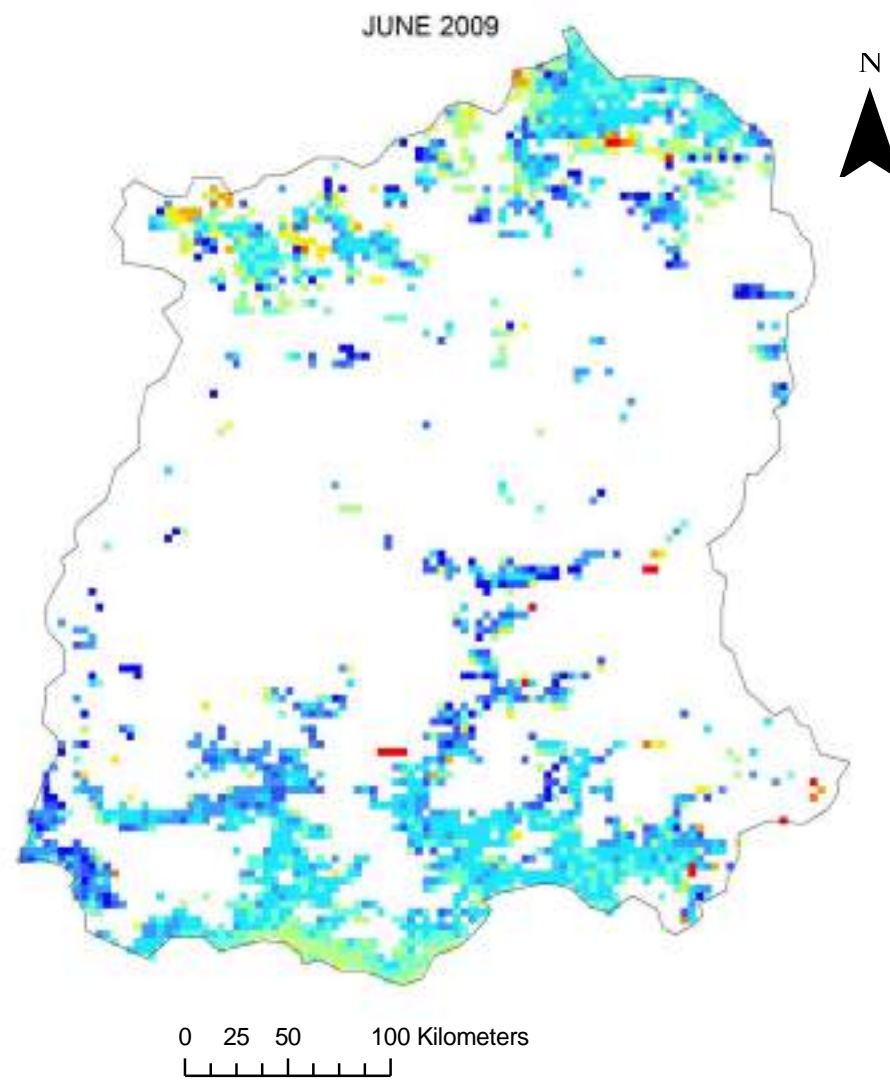
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

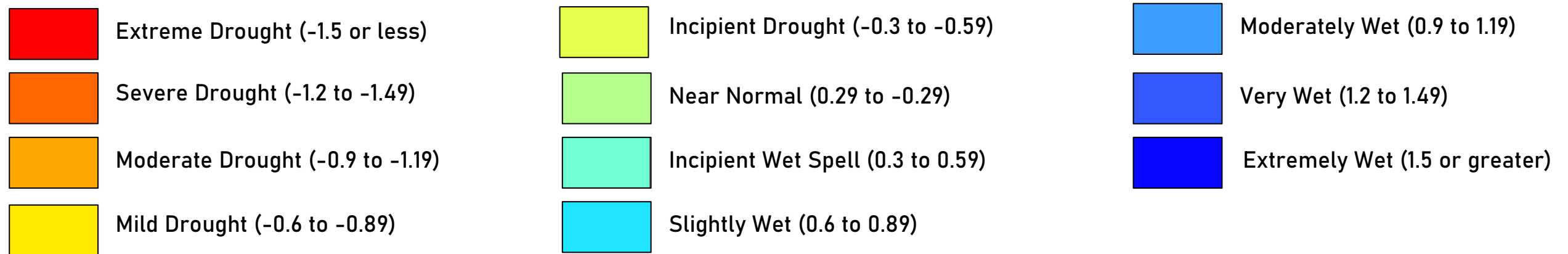
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

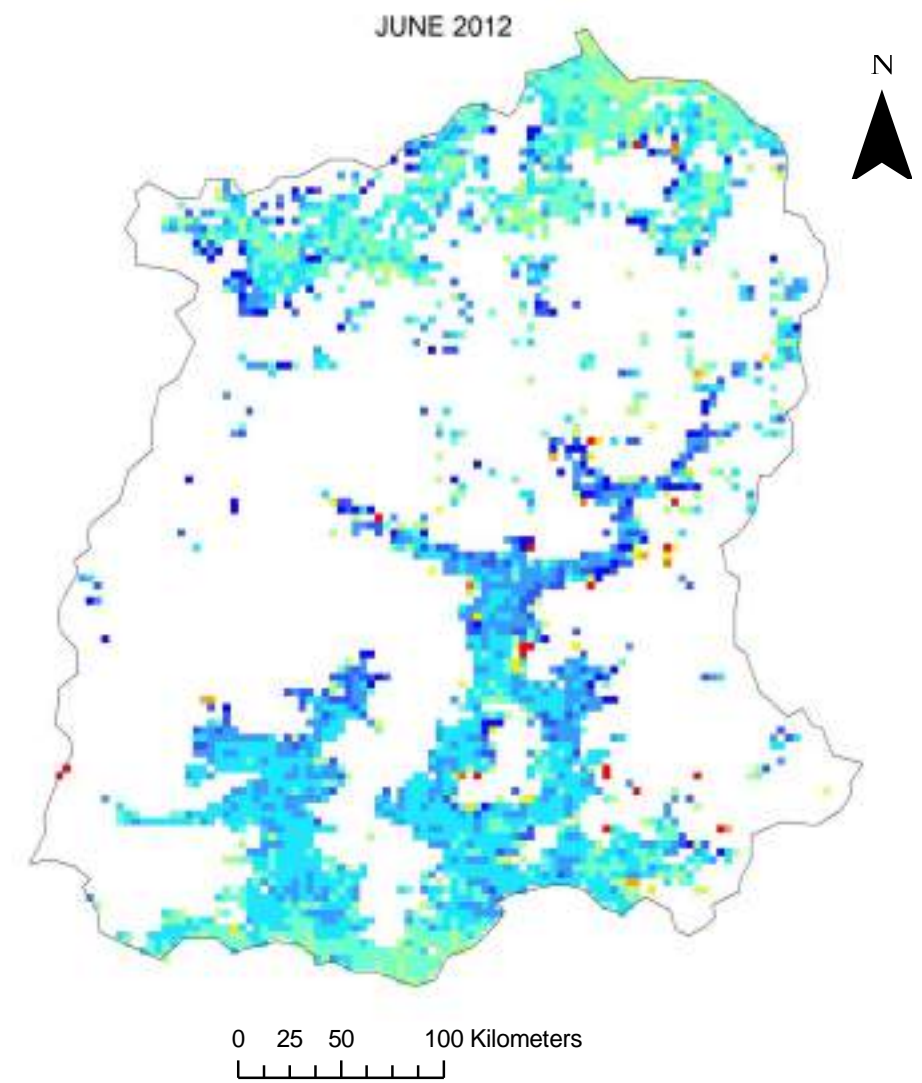
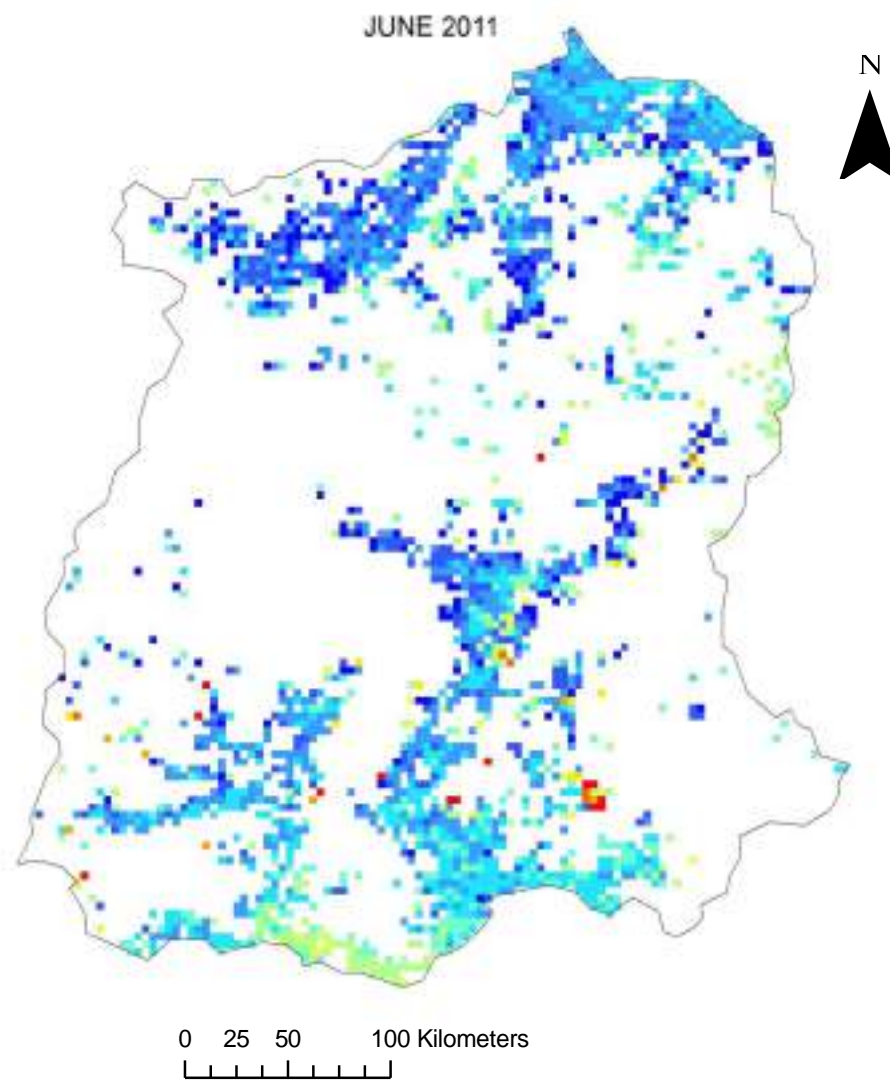
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



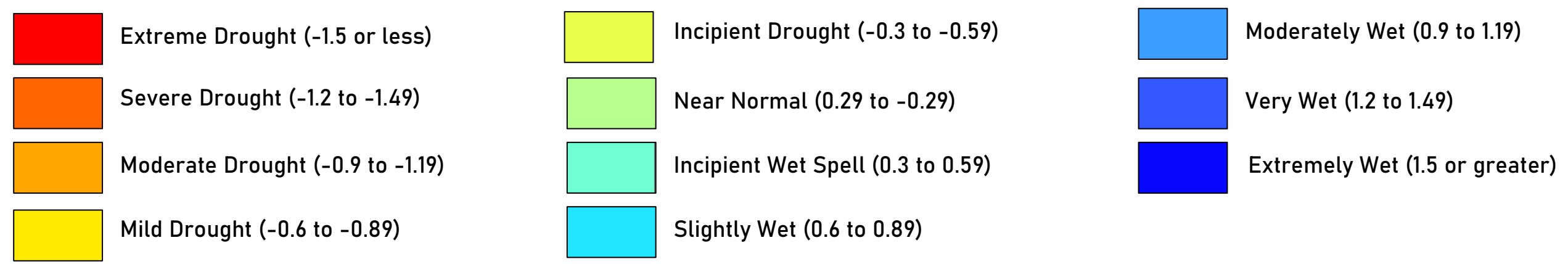


**Legend**

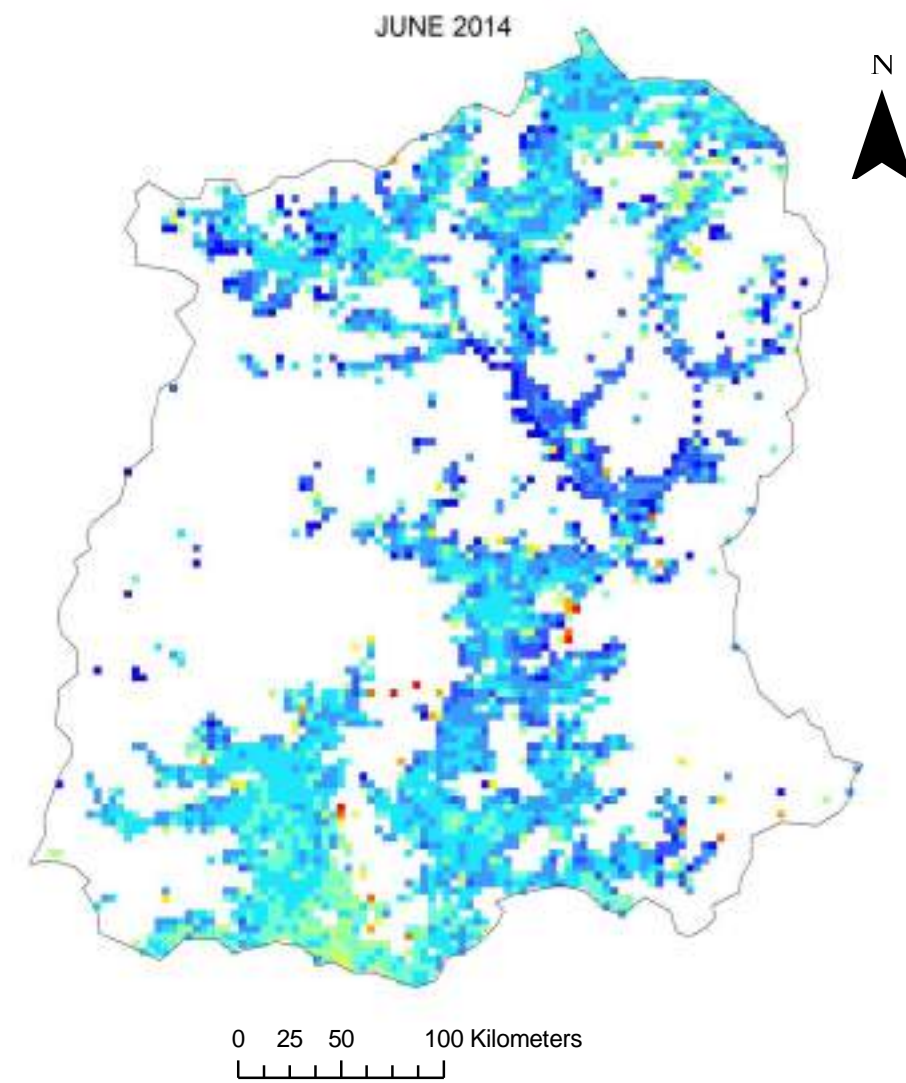
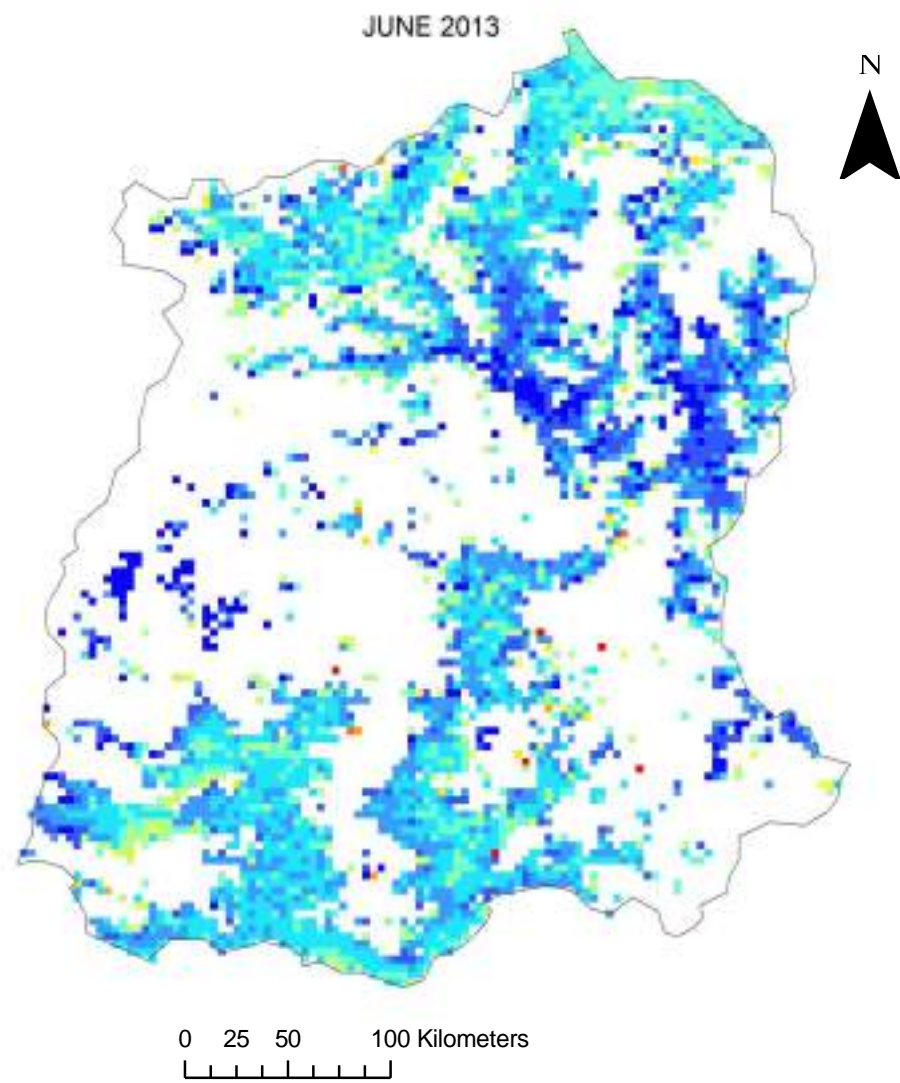




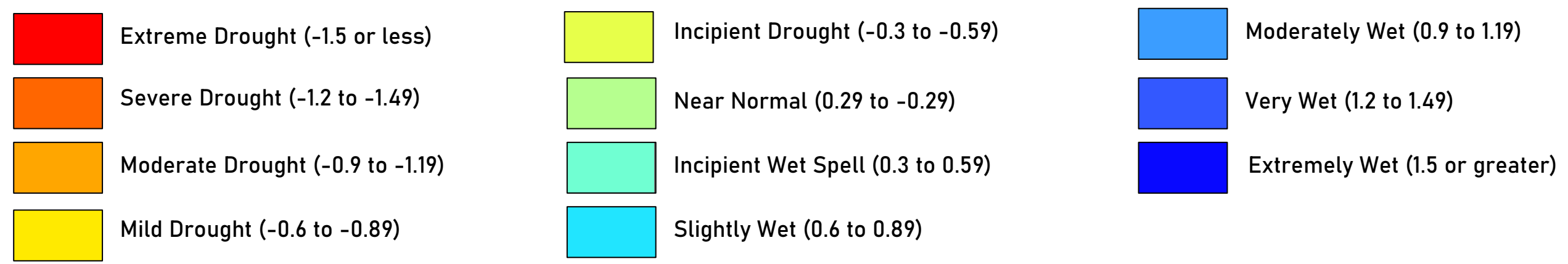
**Legend**

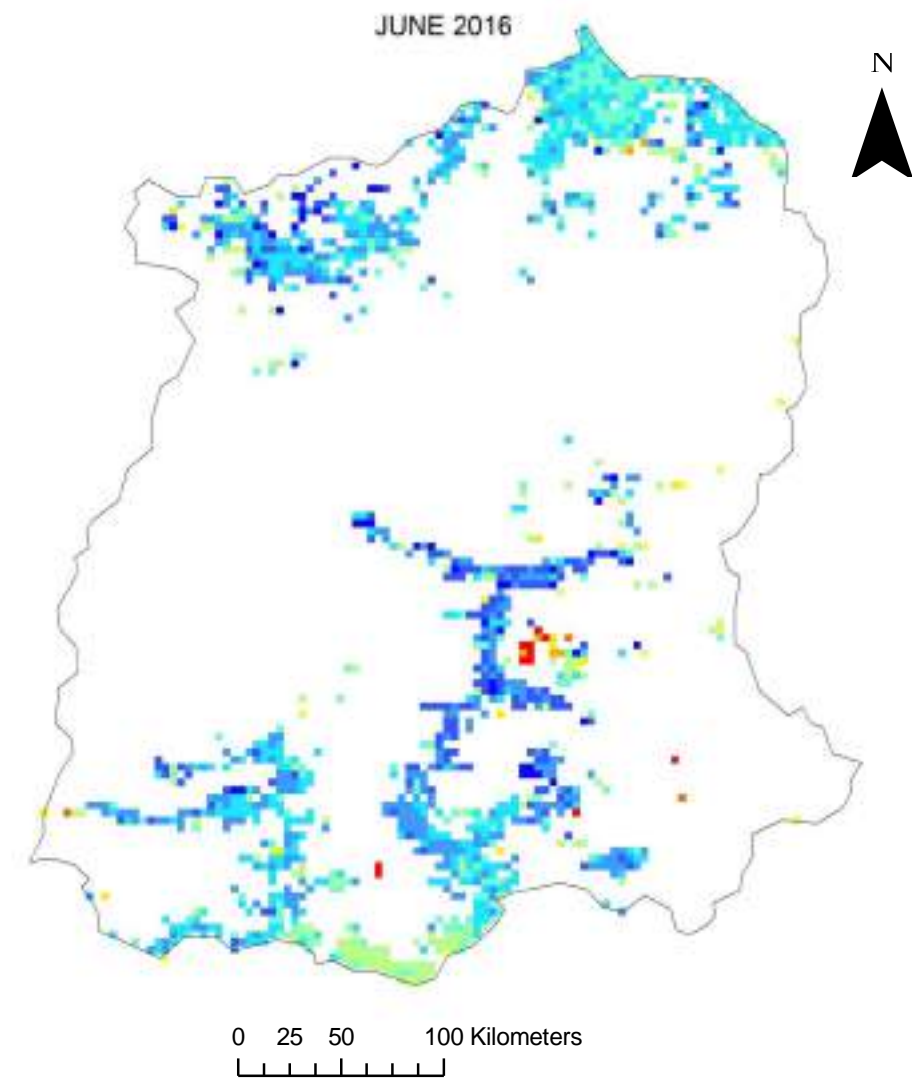
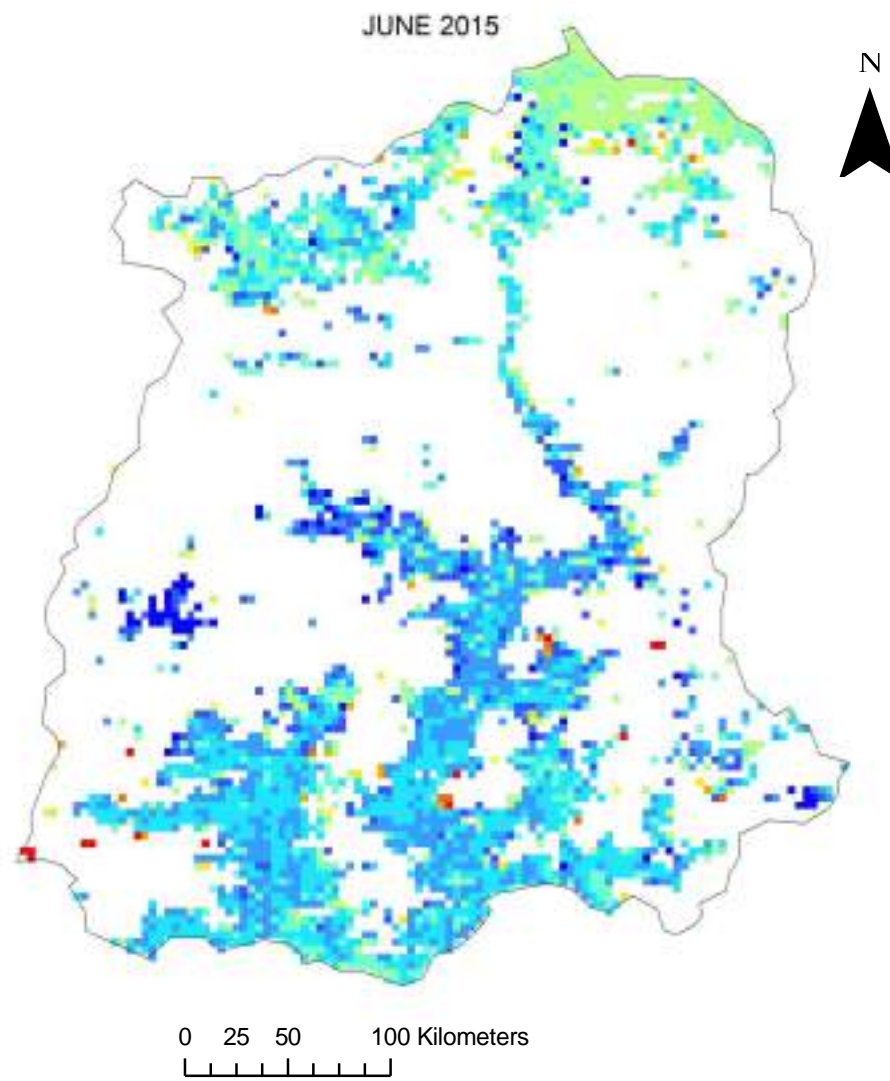




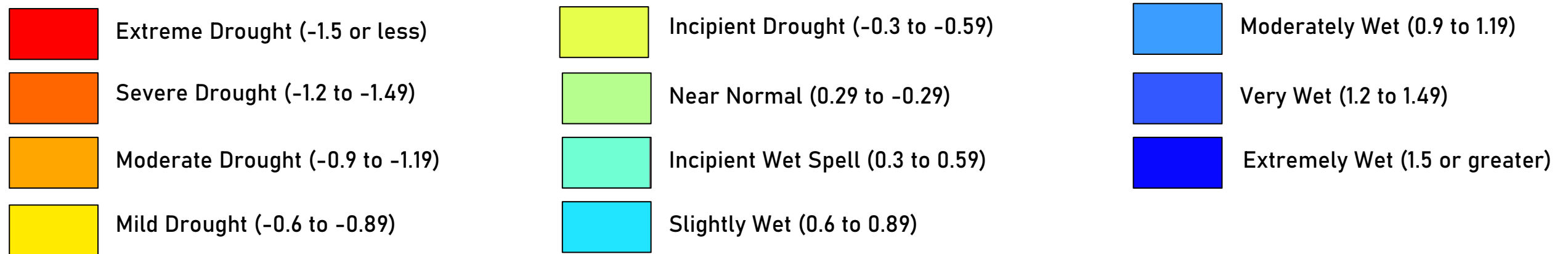


**Legend**

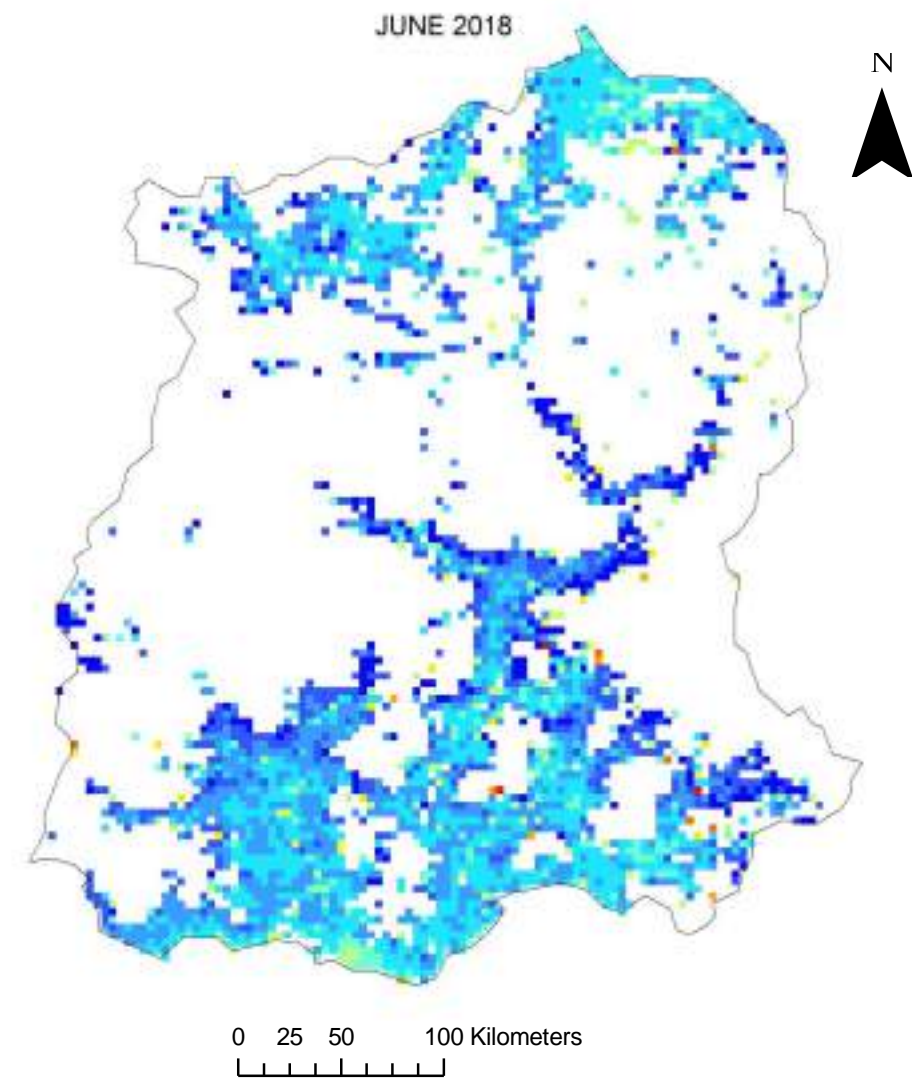
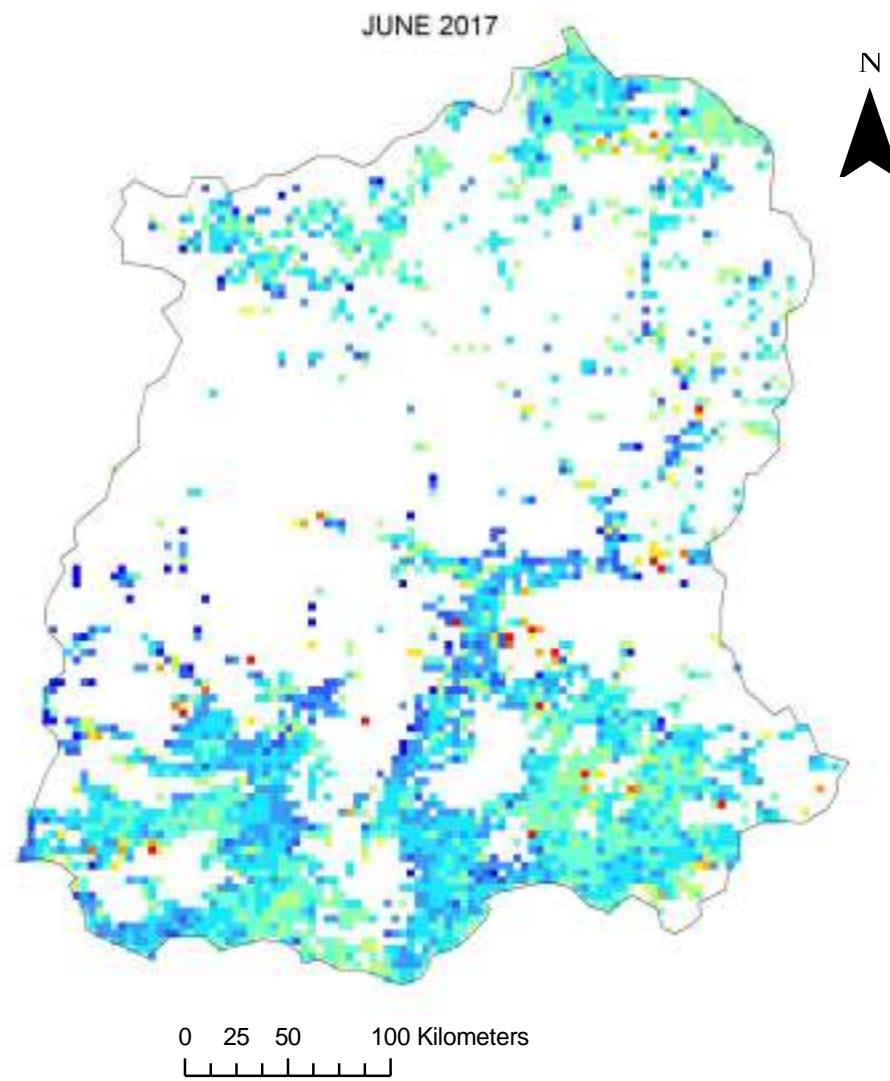




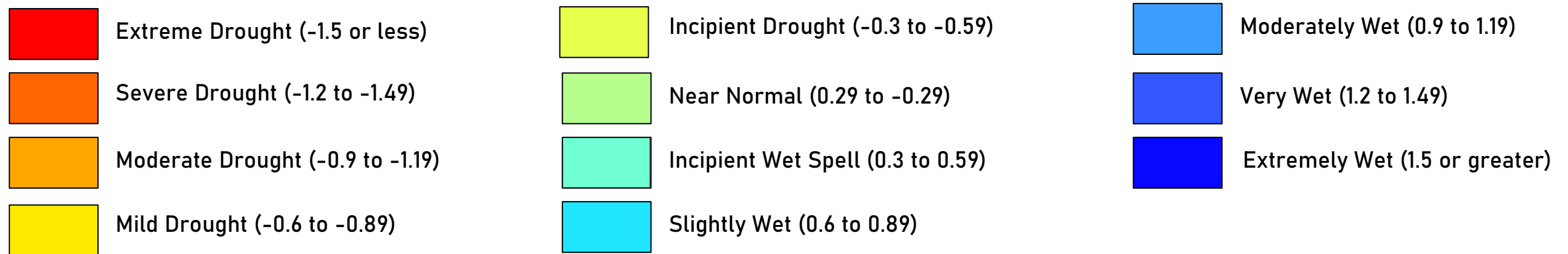
**Legend**

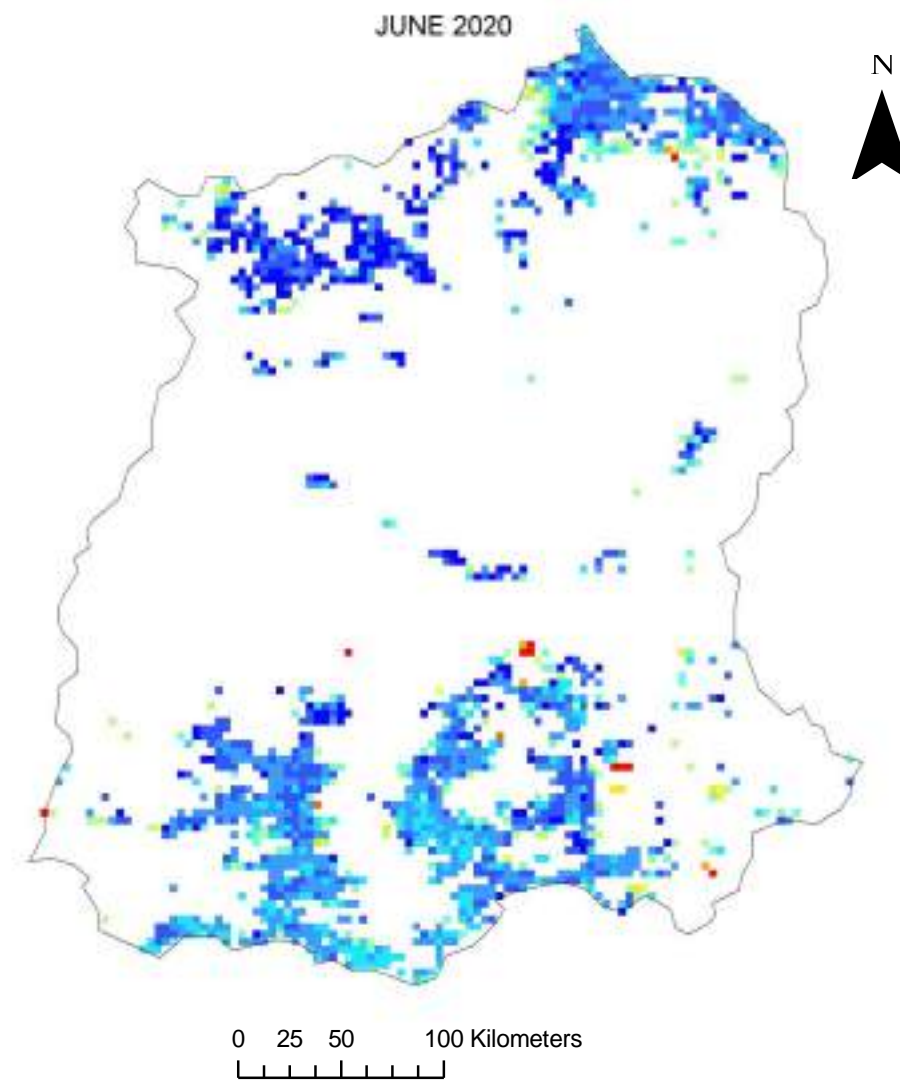
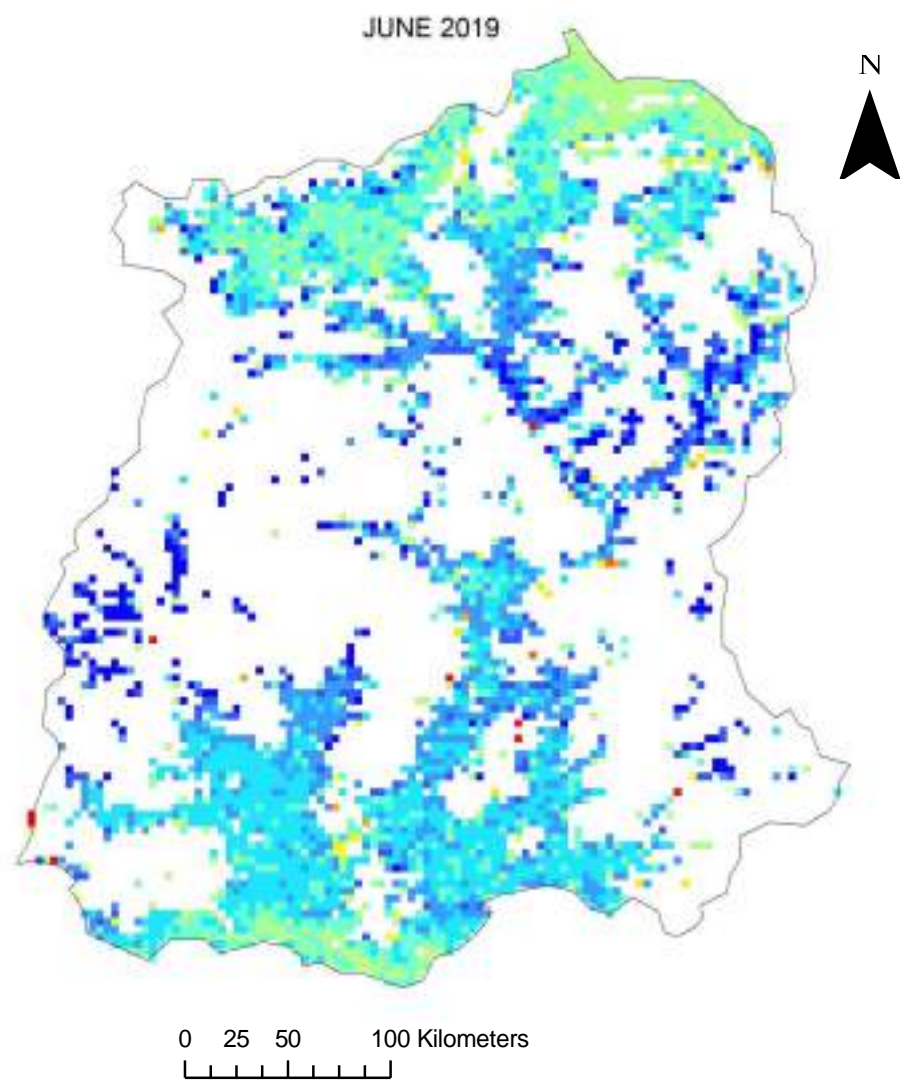






**Legend**





**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

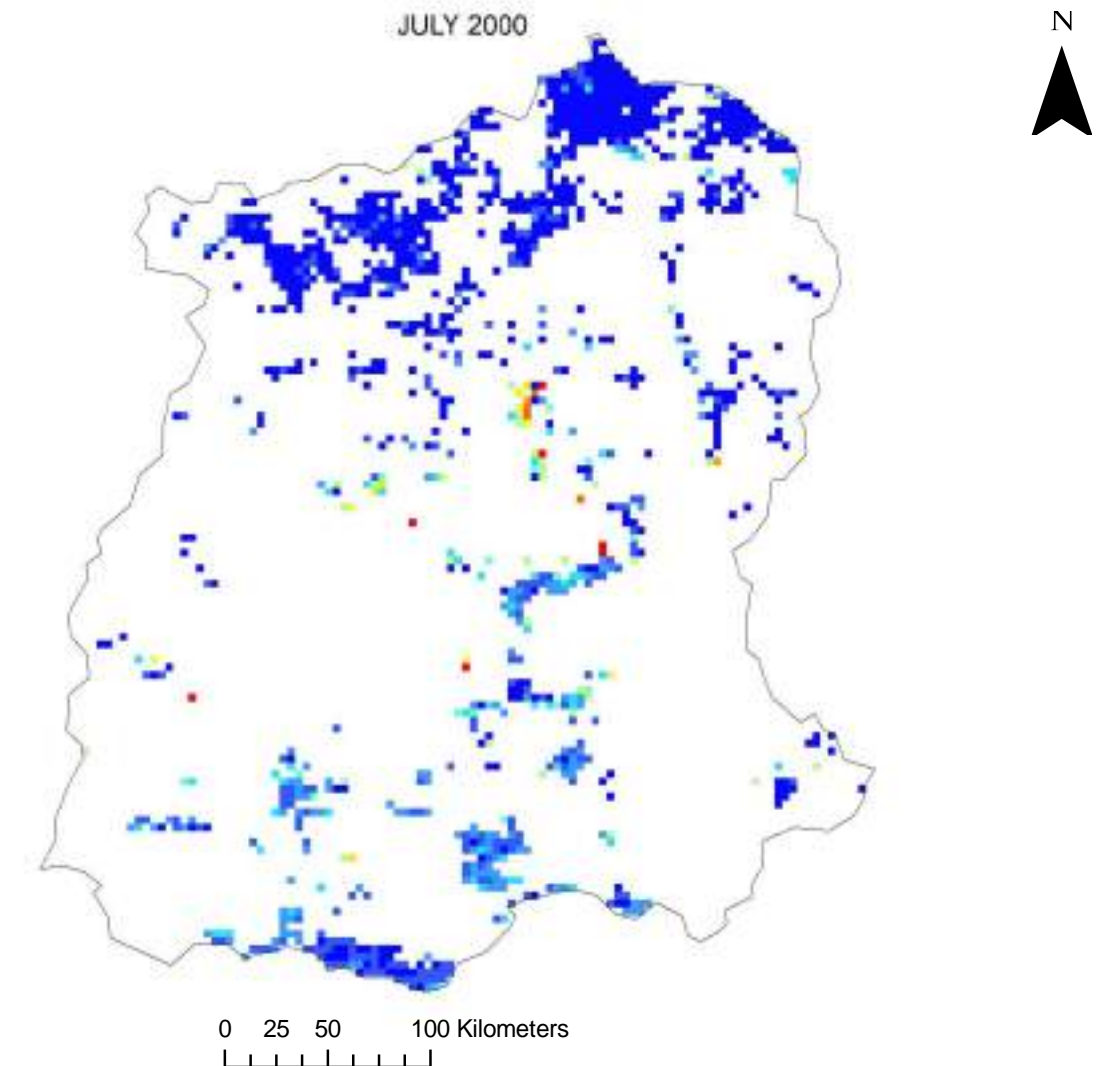
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



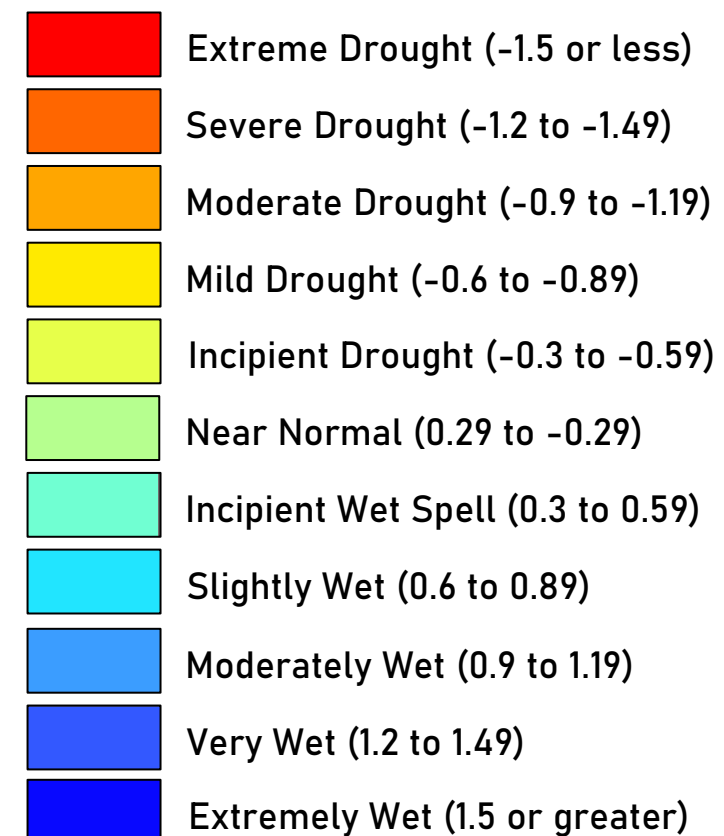
## July DSI Maps

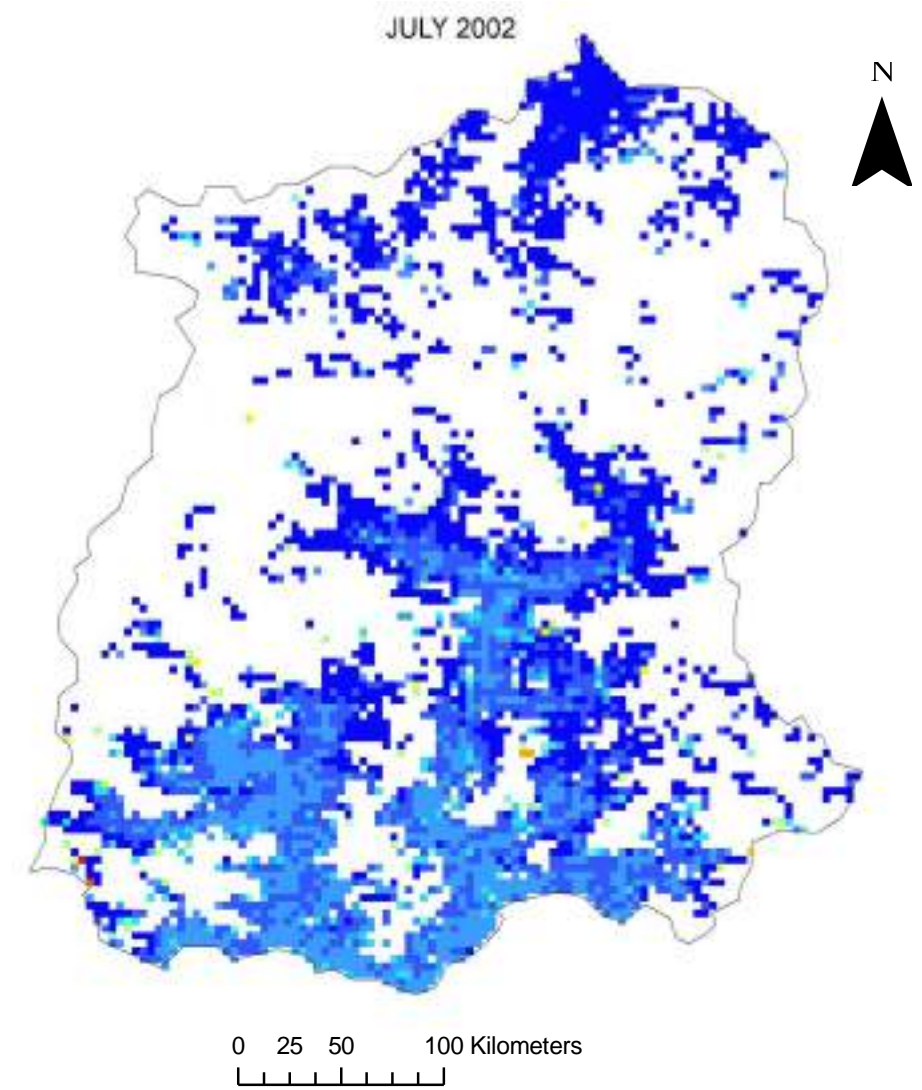
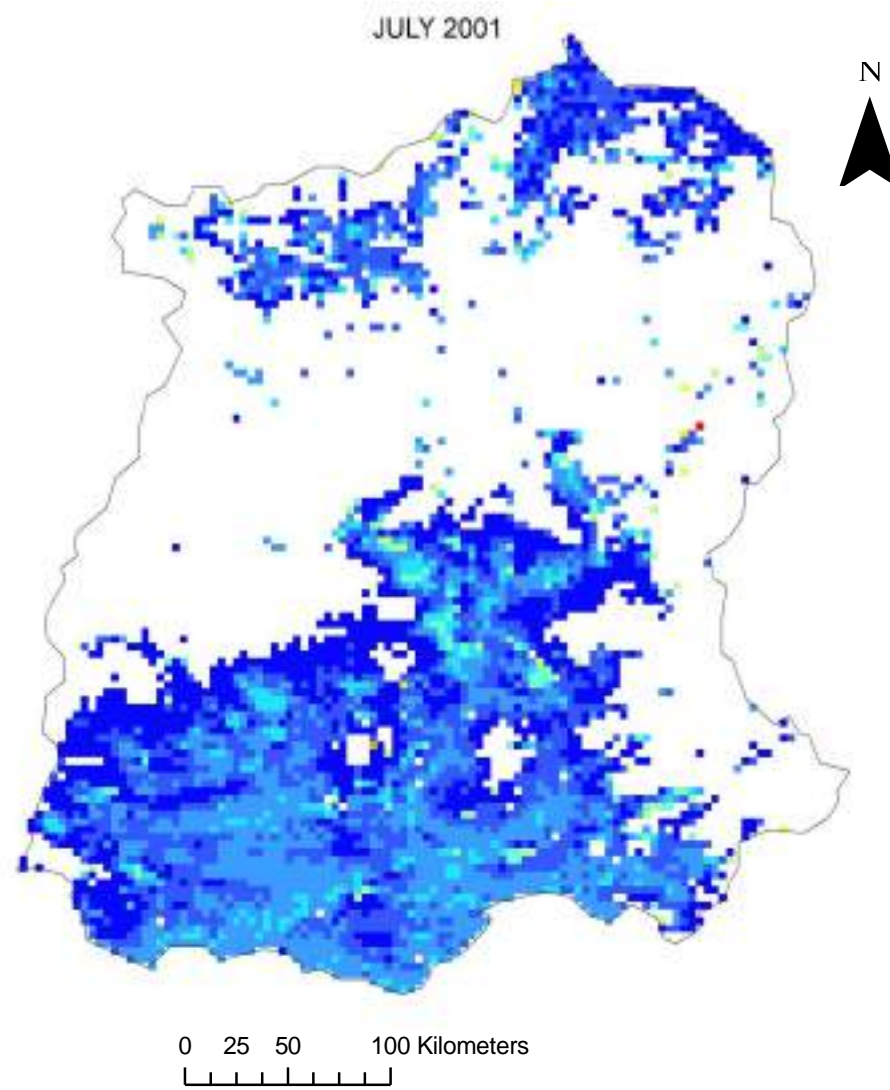
Drought conditions in July vary from incipient wet spell to extremely wet conditions. The characteristics of this monsoon month are frequently characterized by extremely wet condition.

Mean July DSI Values		
Year	DSI Values	Drought Condition
2000	1.65	Extremely Wet
2001	1.33	Very Wet
2002	1.52	Extremely Wet
2003	1.31	Very Wet
2004	1.56	Extremely Wet
2005	1.66	Extremely Wet
2006	1.47	Very Wet
2007	1.03	Moderately Wet
2008	1.60	Extremely Wet
2009	0.43	Incipient Wet Spell
2010	1.50	Extremely Wet
2011	1.58	Extremely Wet
2012	1.63	Extremely Wet
2013	1.76	Extremely Wet
2014	1.29	Very Wet
2015	1.29	Very Wet
2016	1.70	Extremely Wet
2017	1.58	Extremely Wet
2018	1.10	Moderately Wet
2019	1.33	Very Wet
2020	1.64	Extremely Wet














### Legend

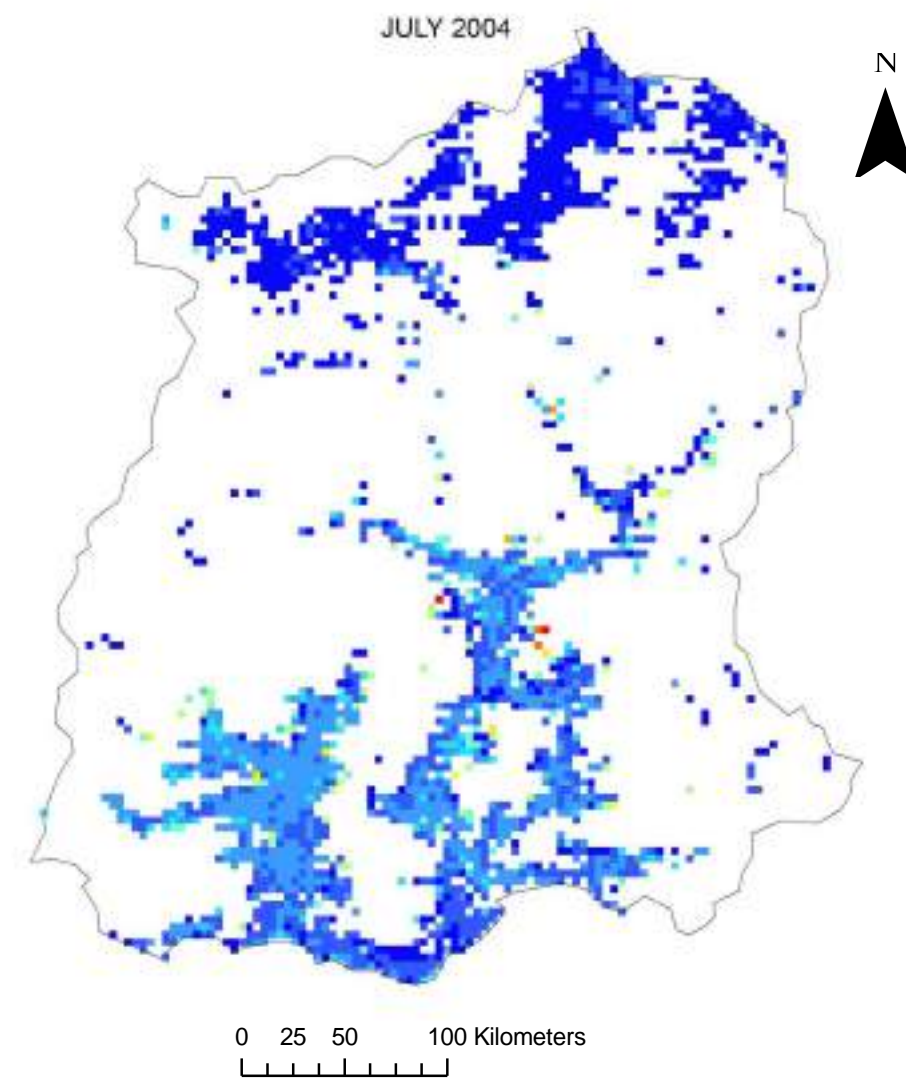
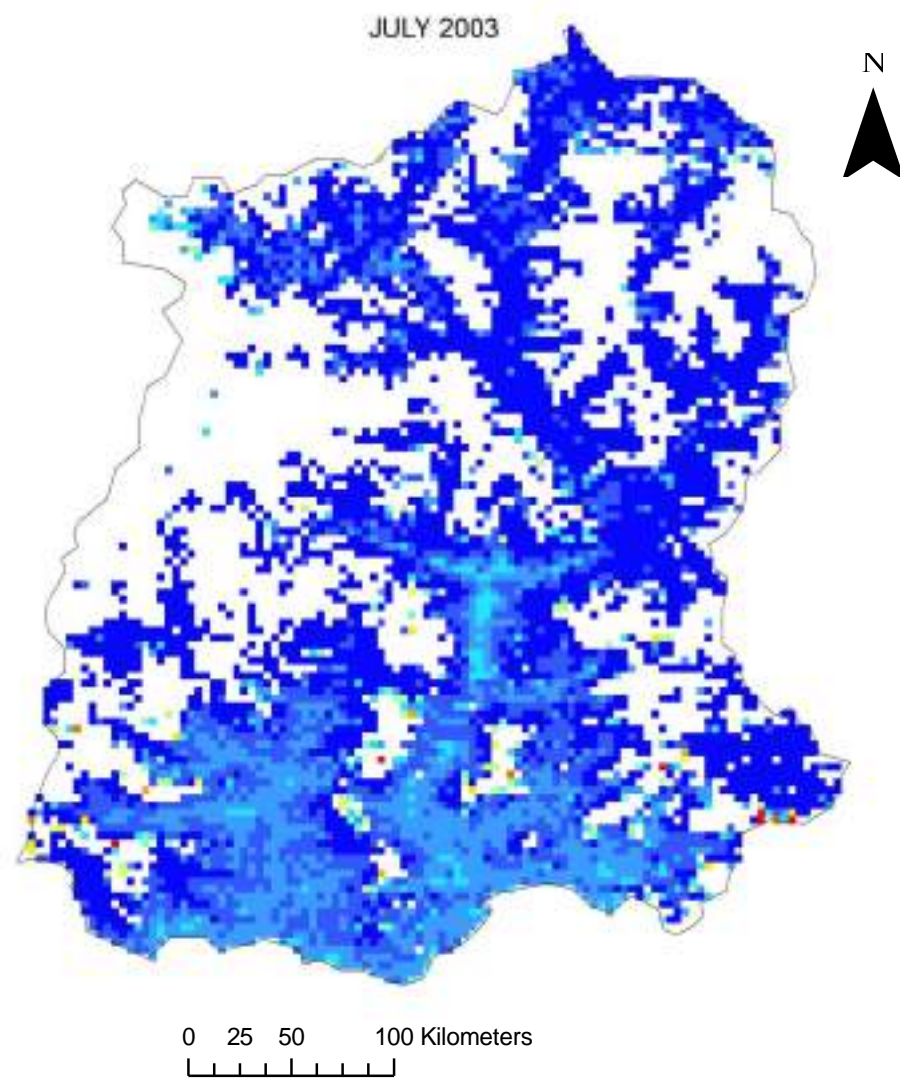




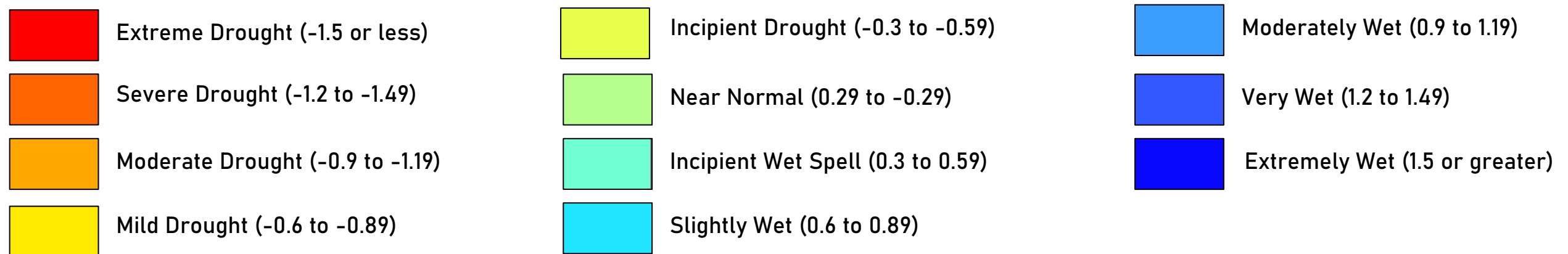
**Legend**

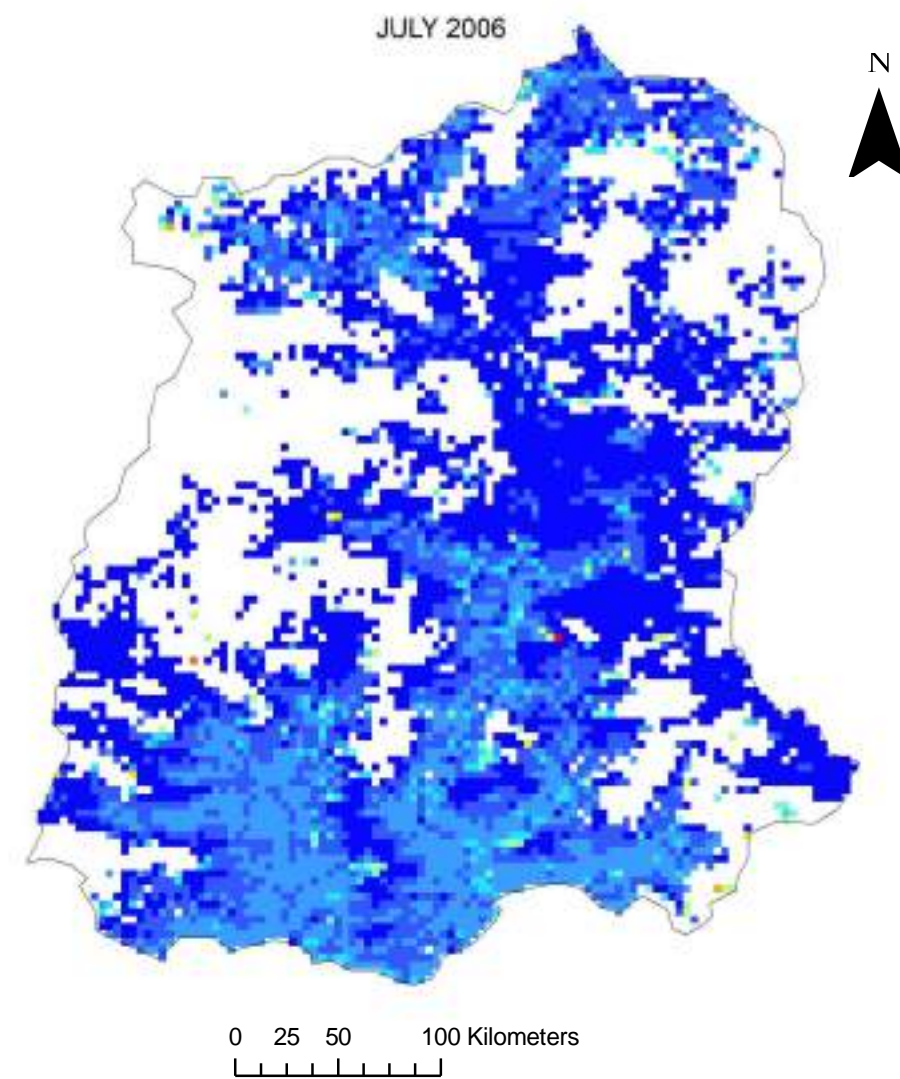
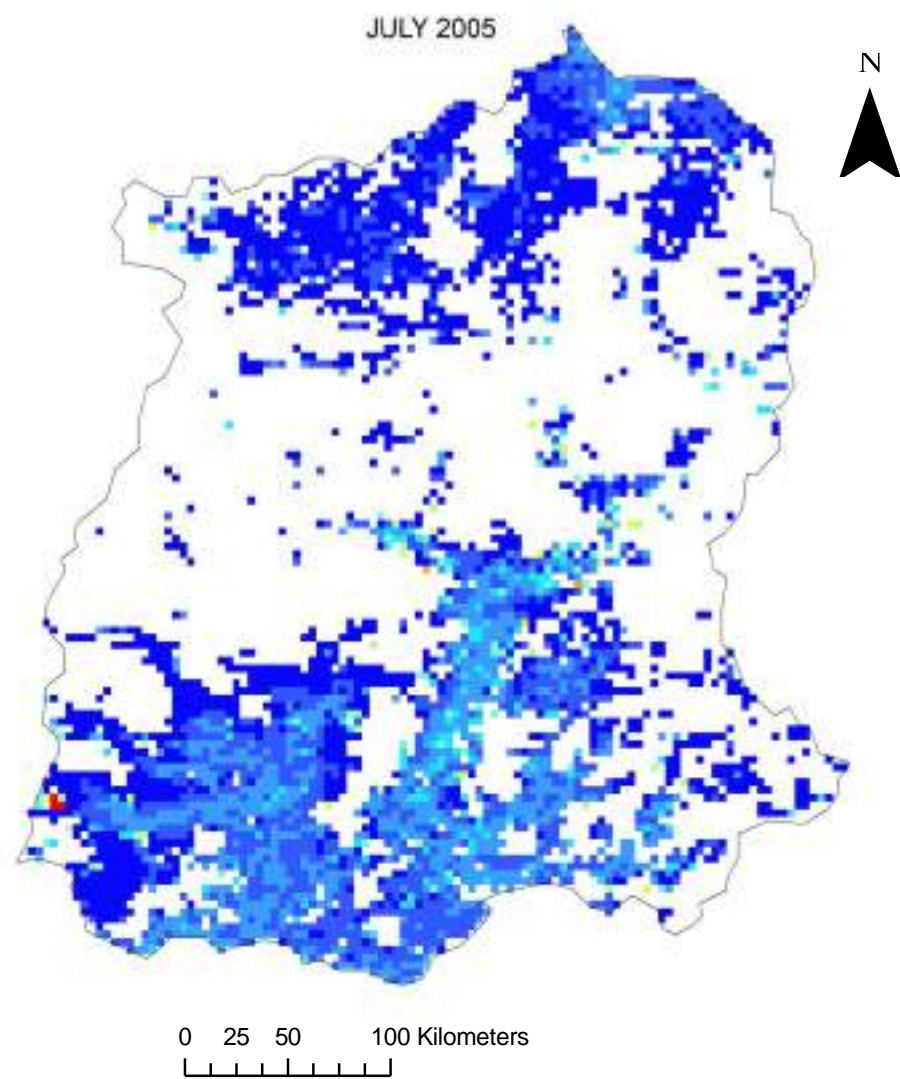
- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



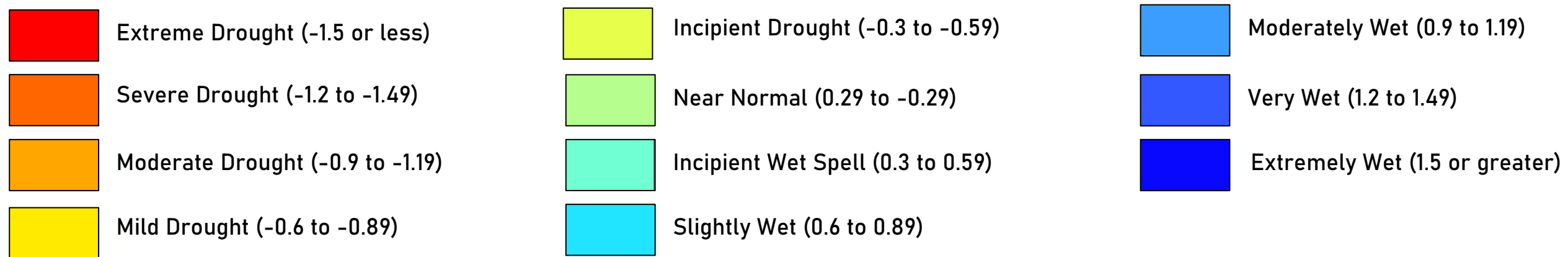


**Legend**

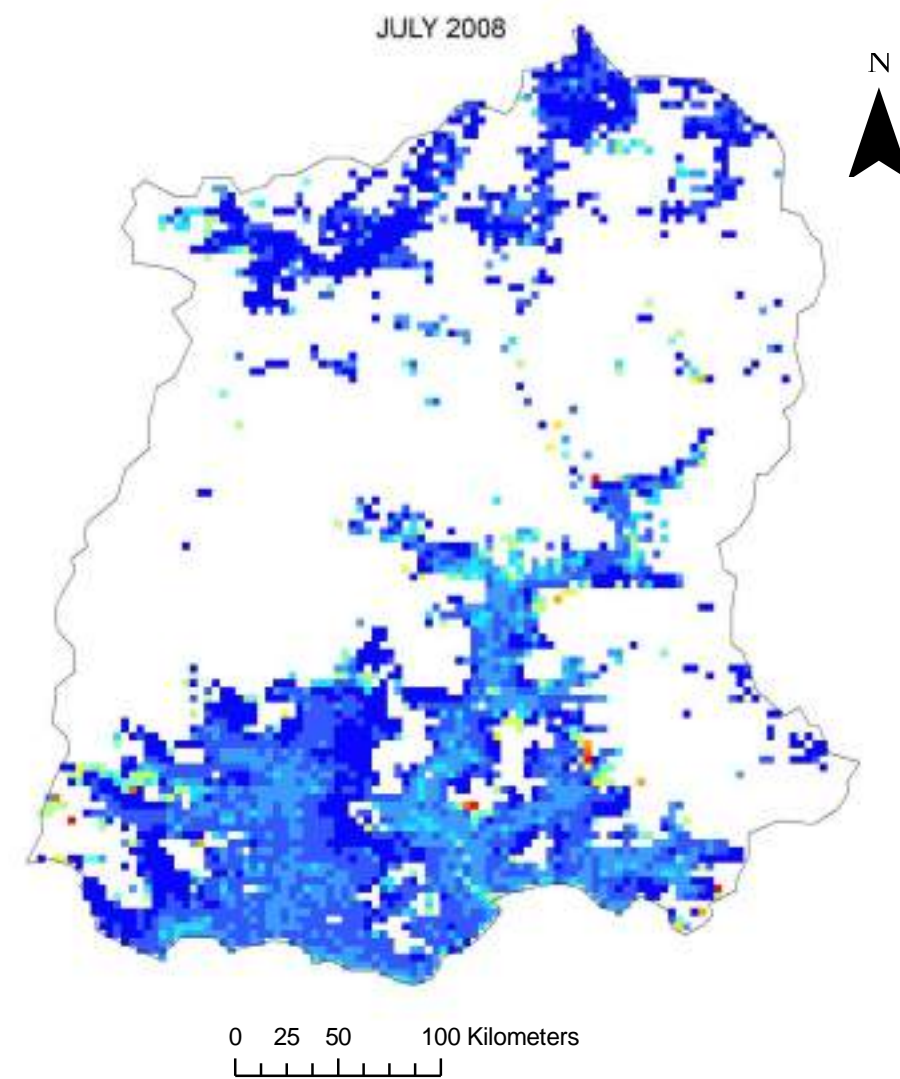
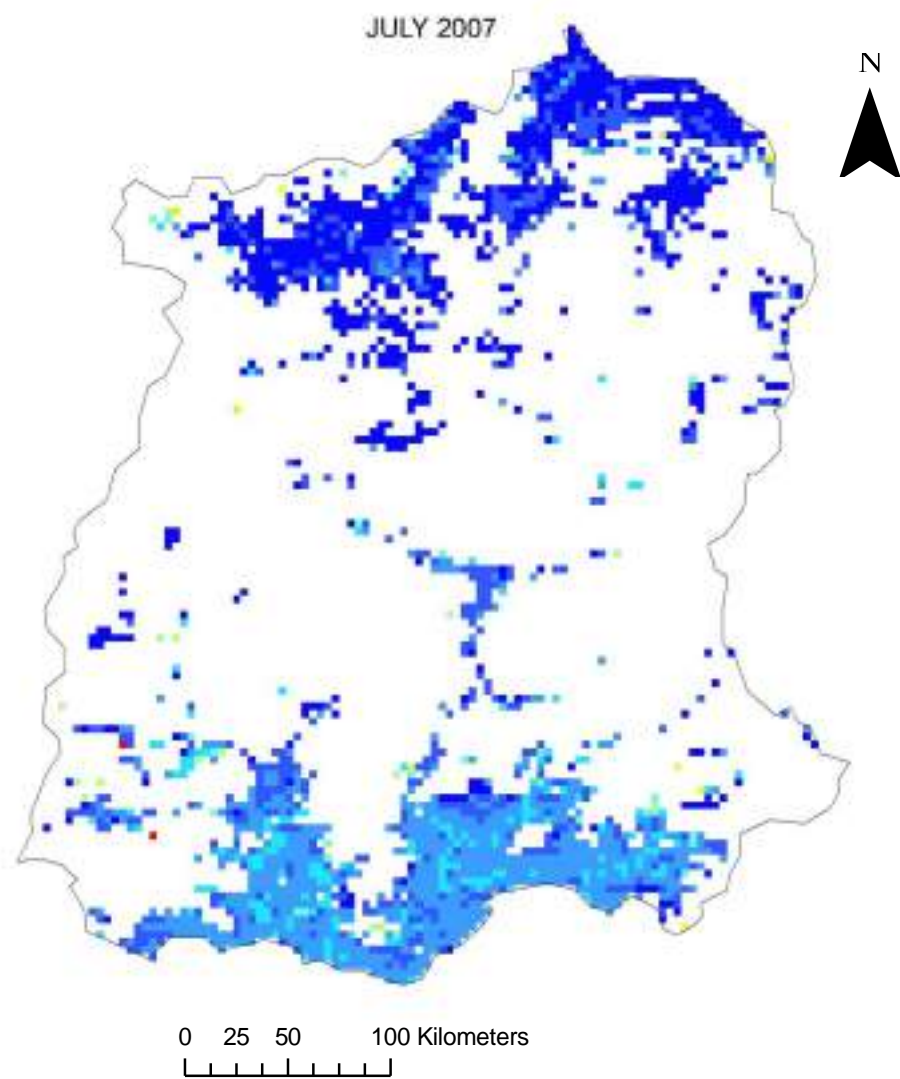




**Legend**





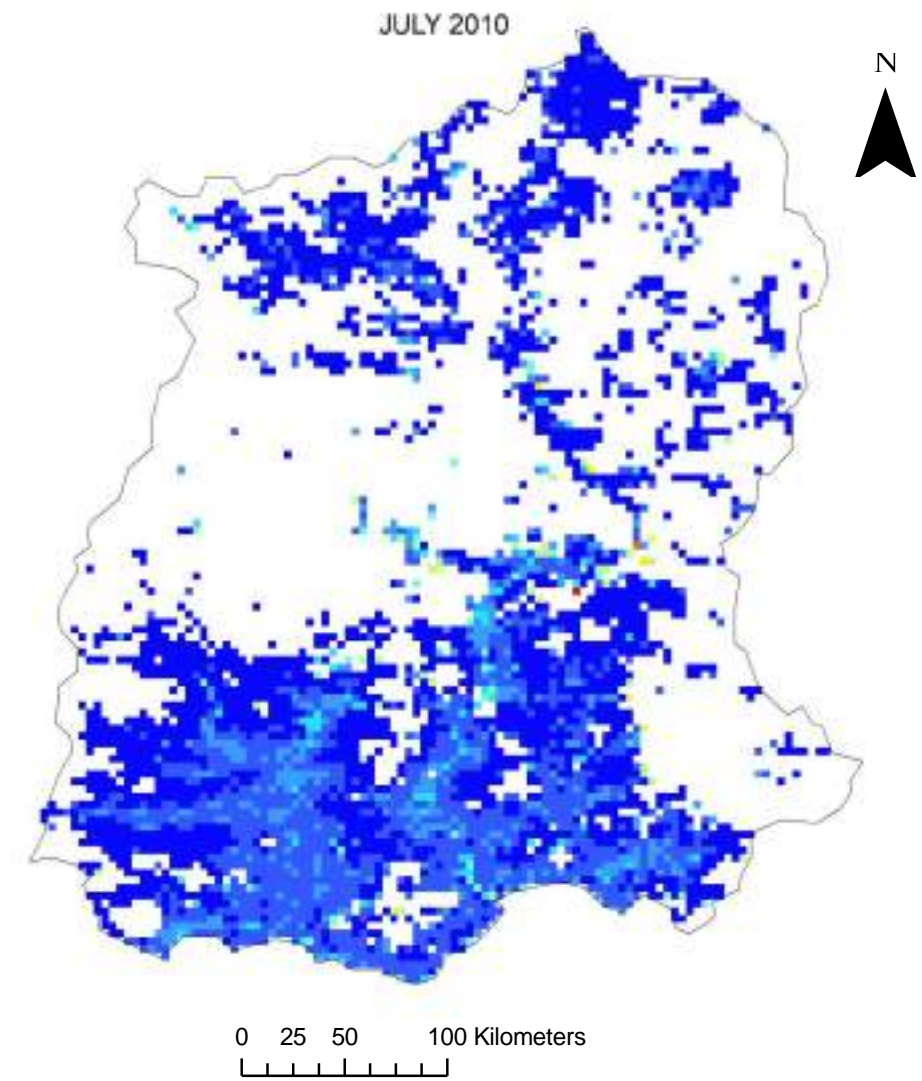
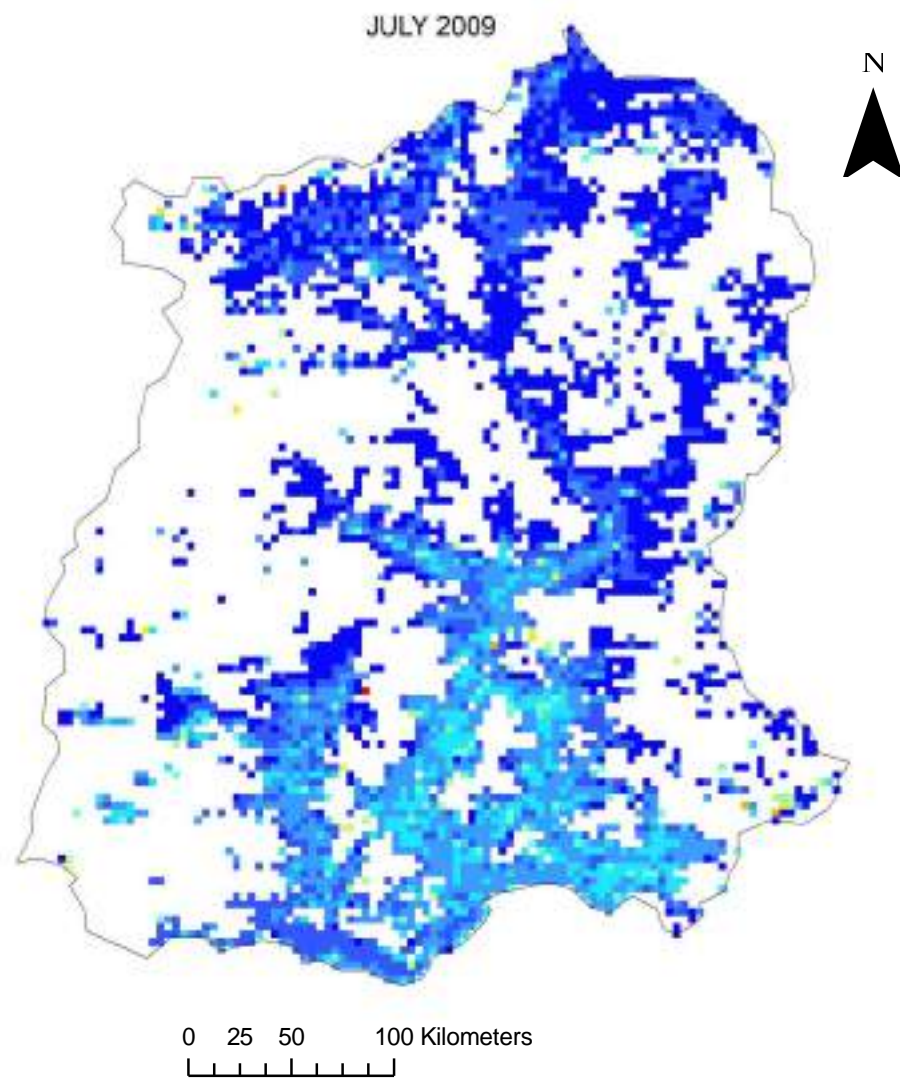


**Legend**

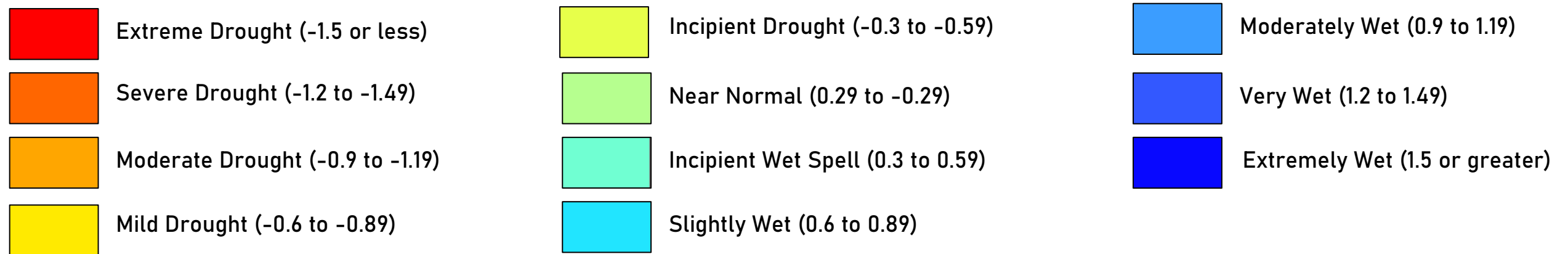
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

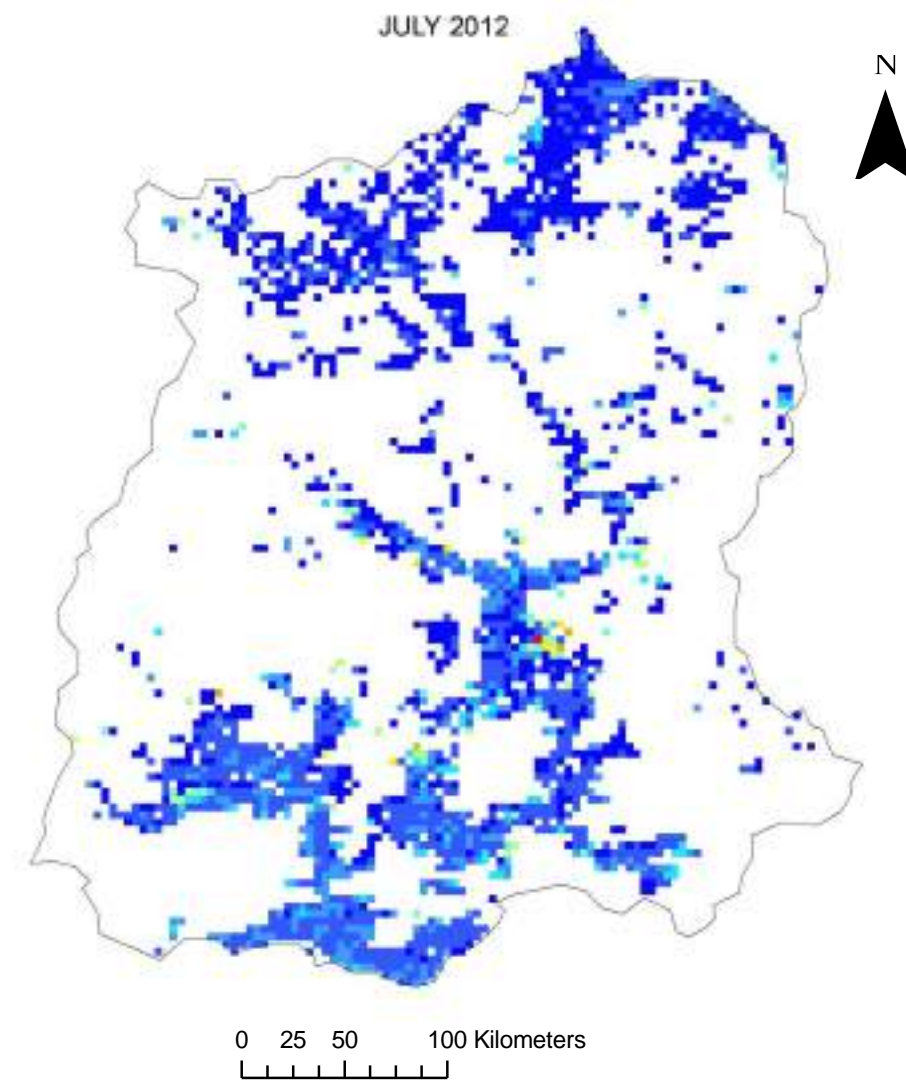
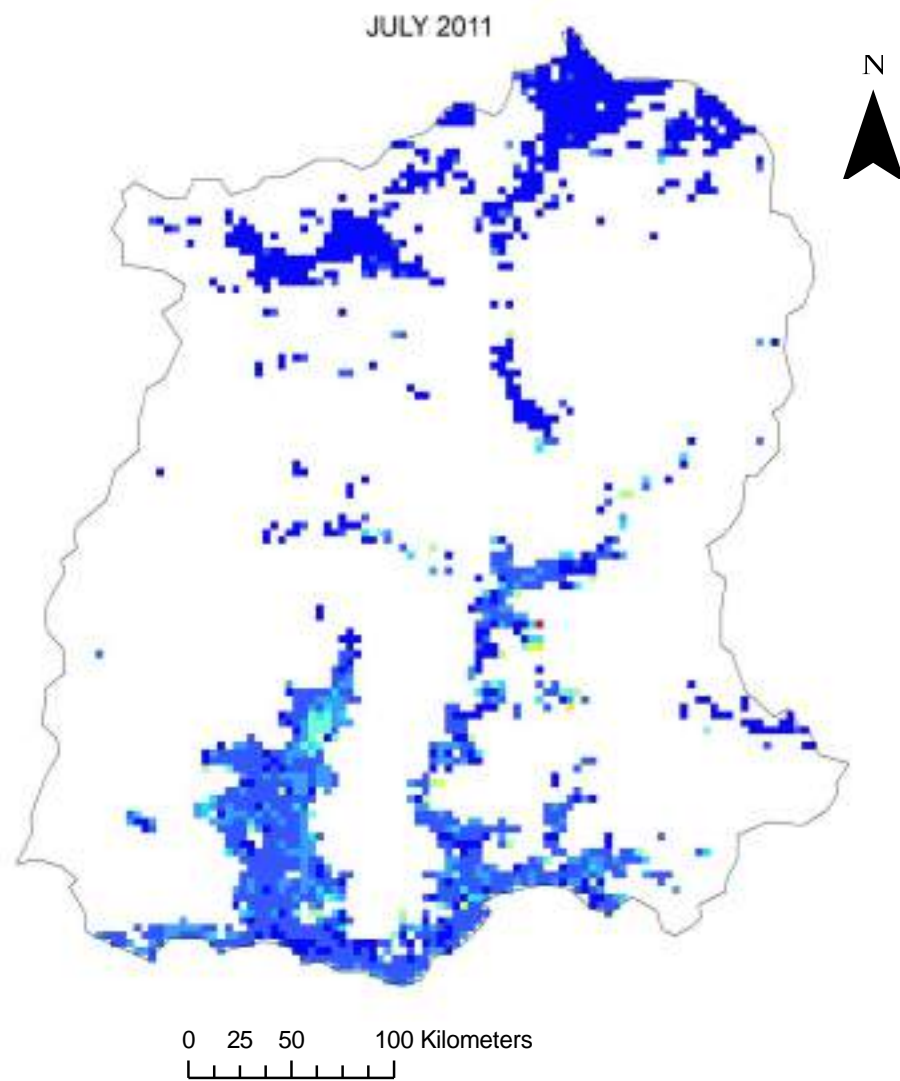
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



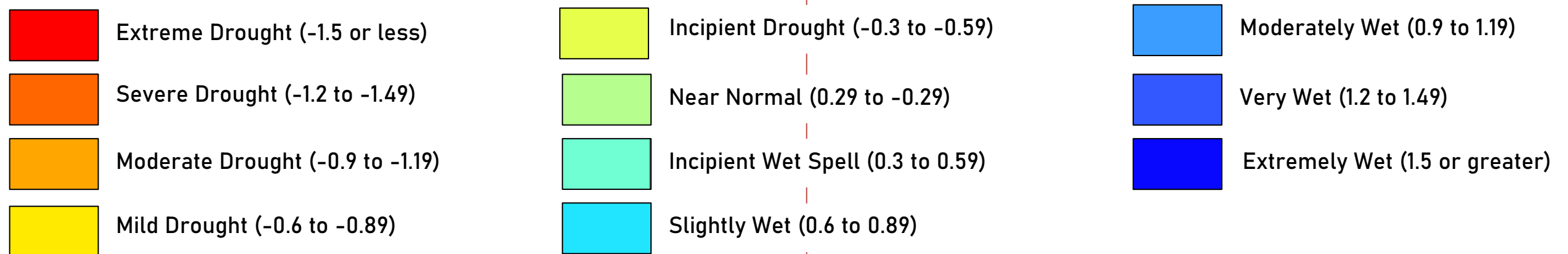
**Legend**

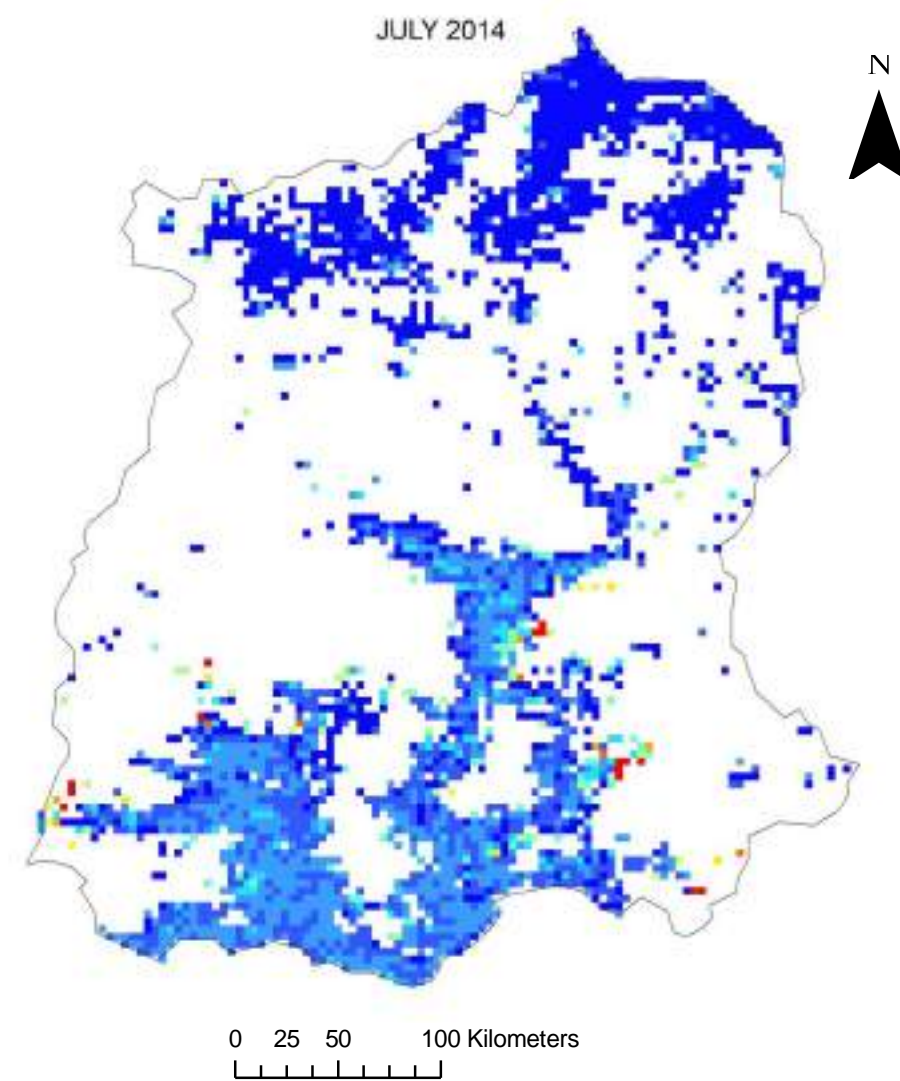
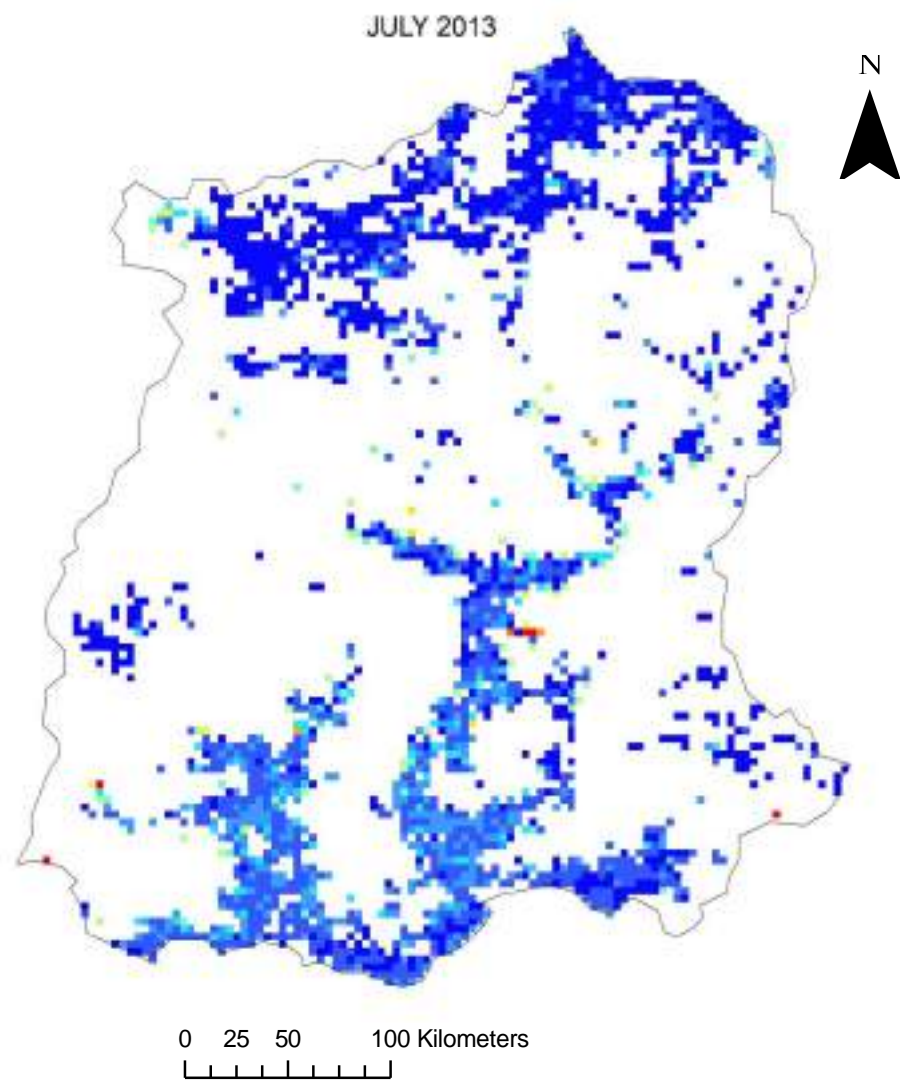






**Legend**





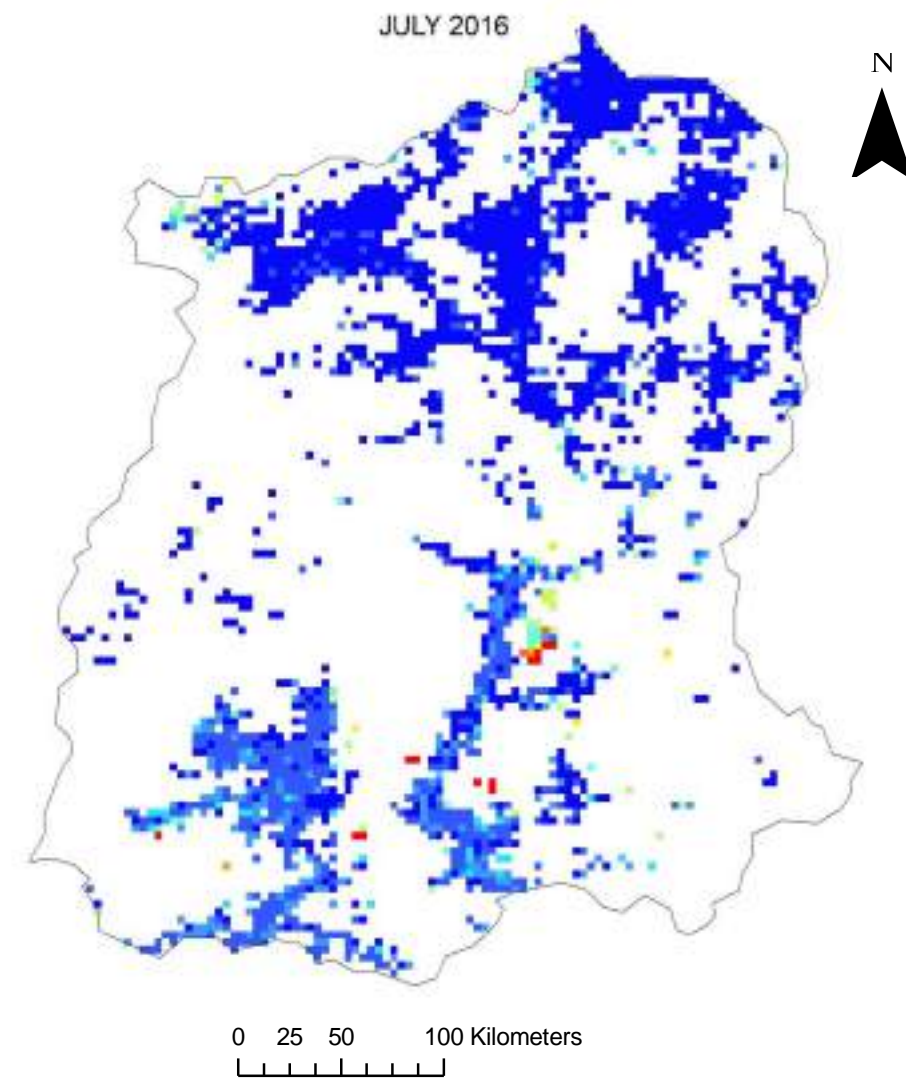
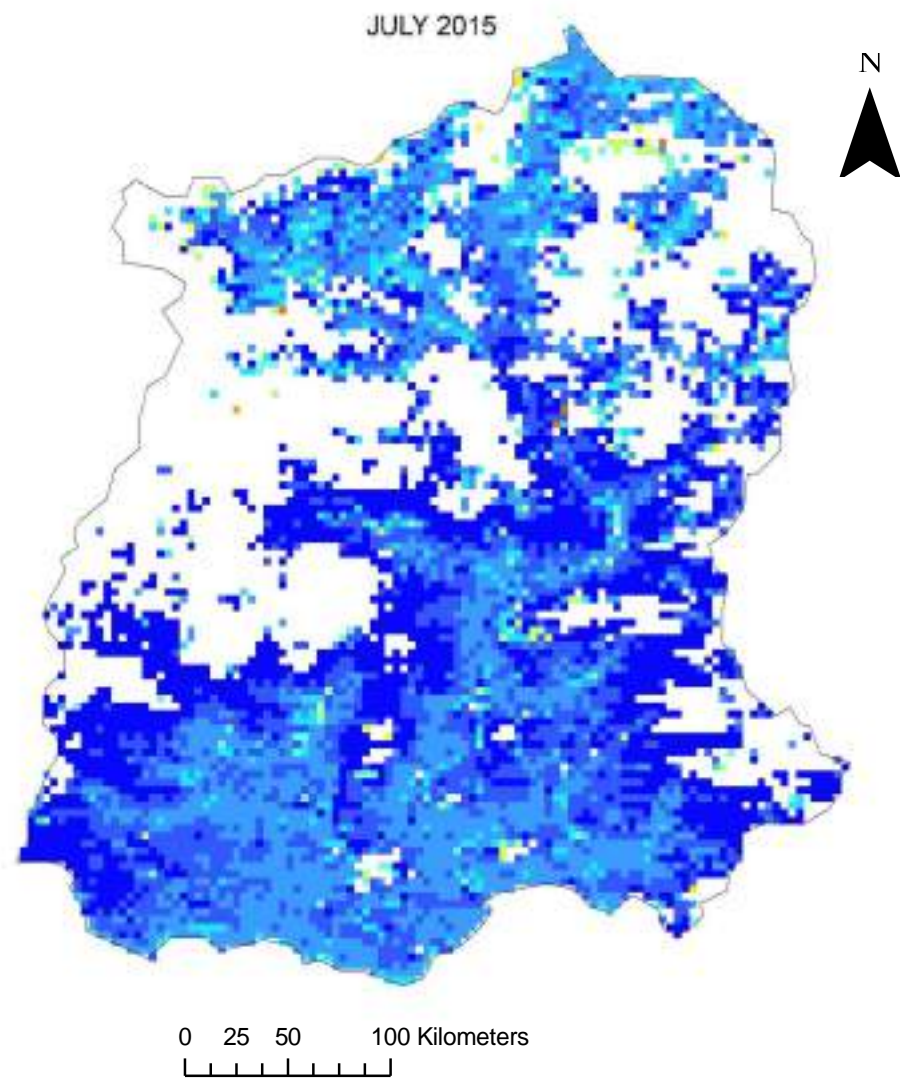
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

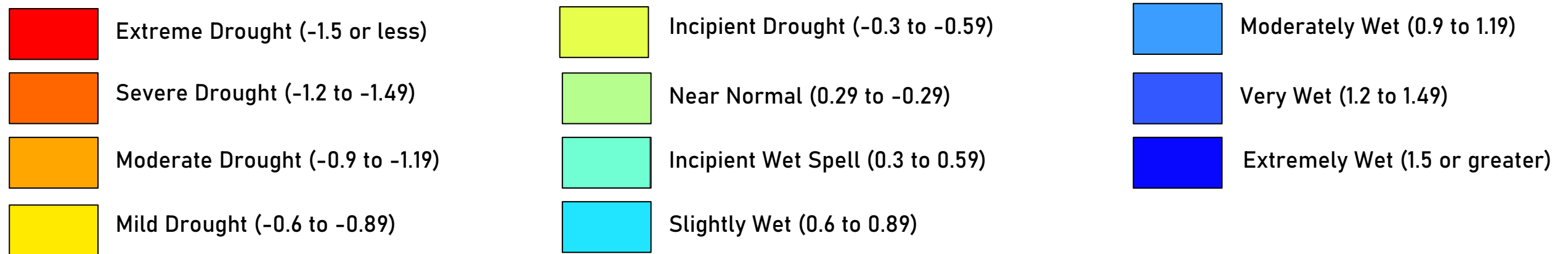
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

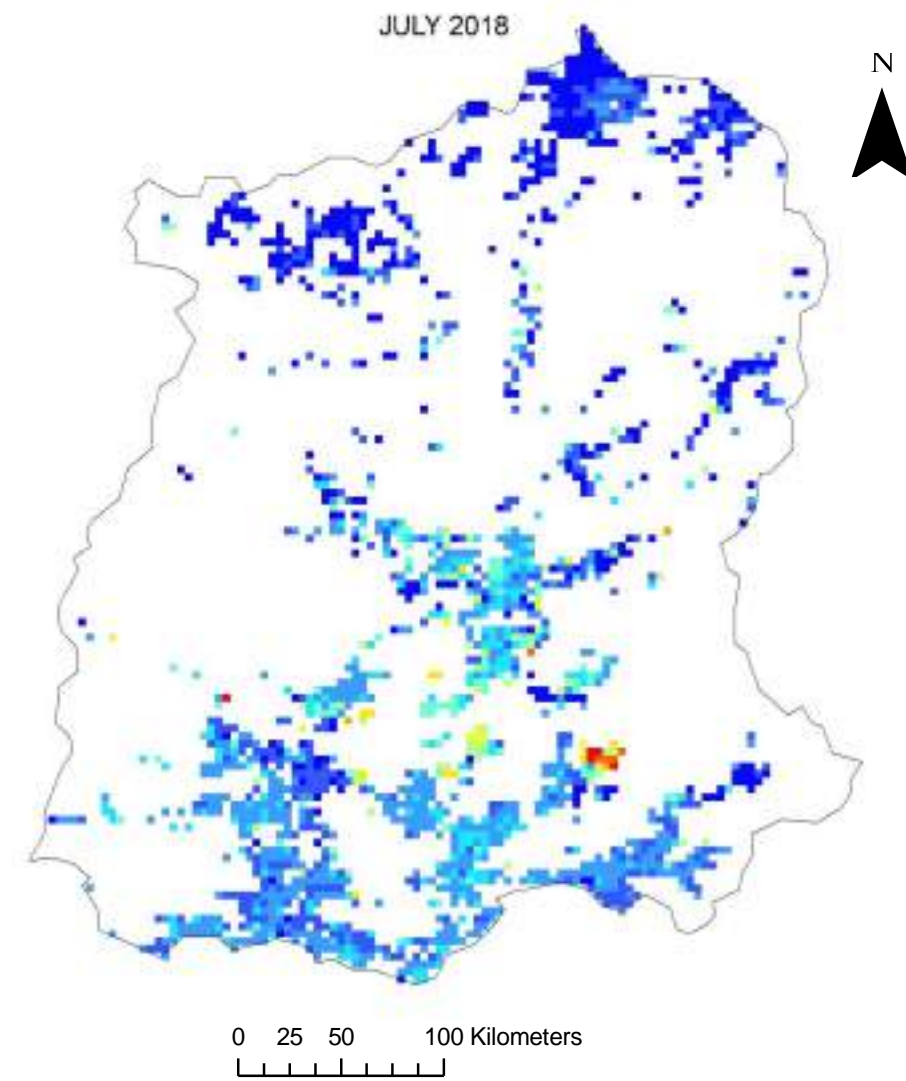
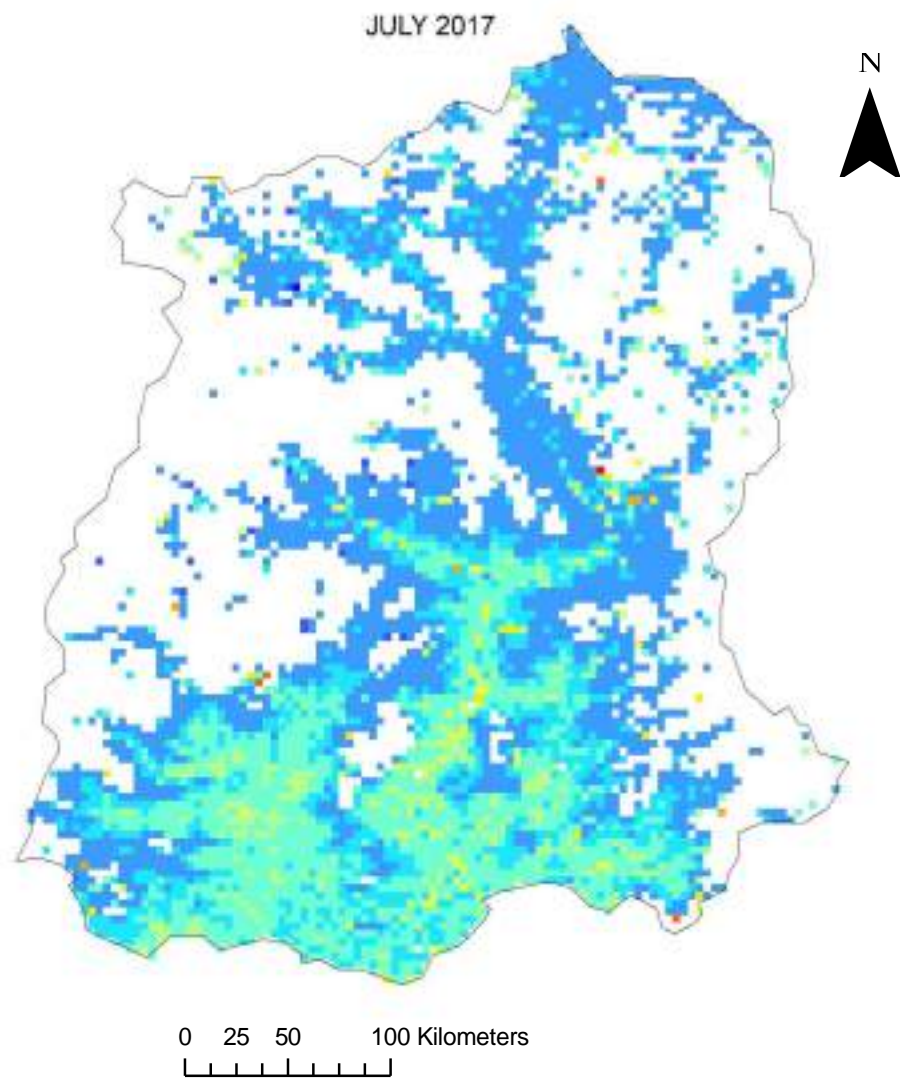
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



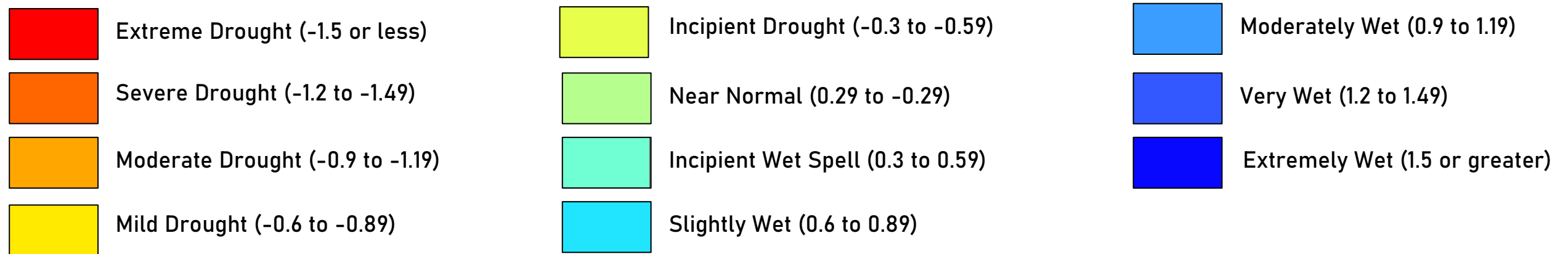


**Legend**

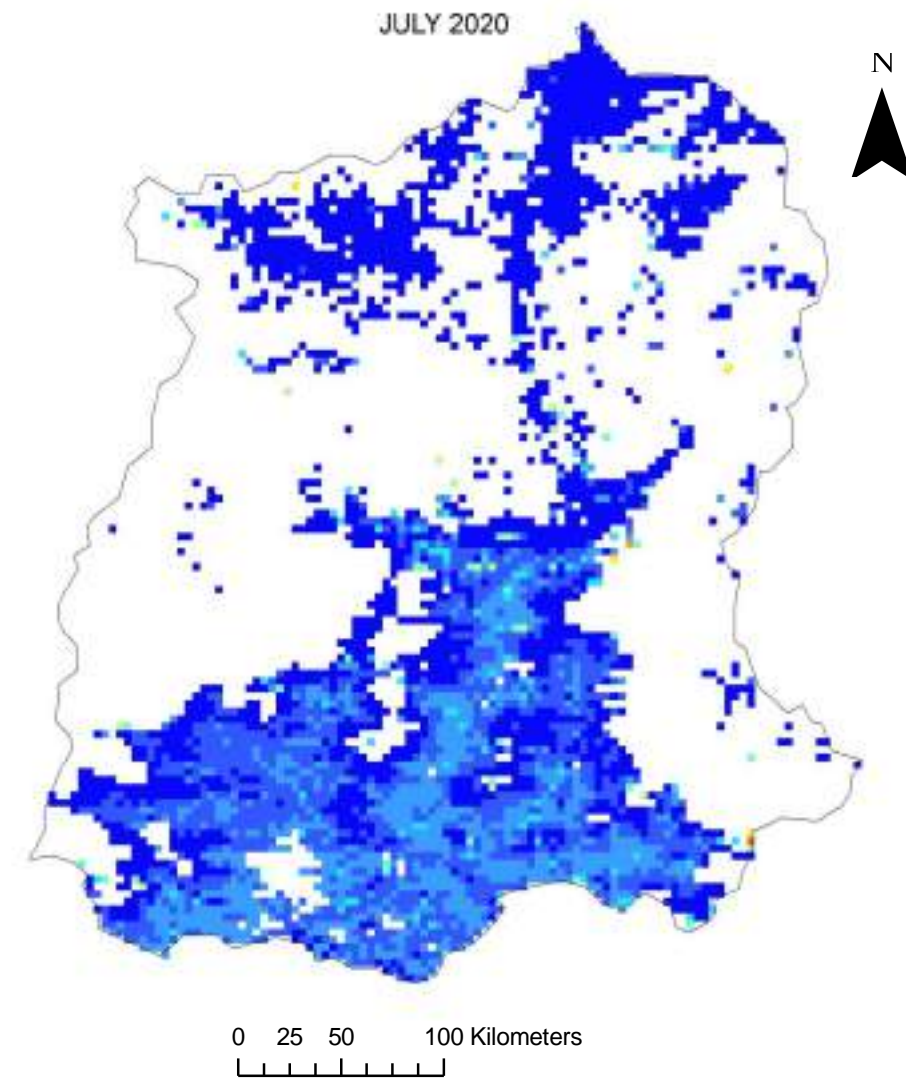
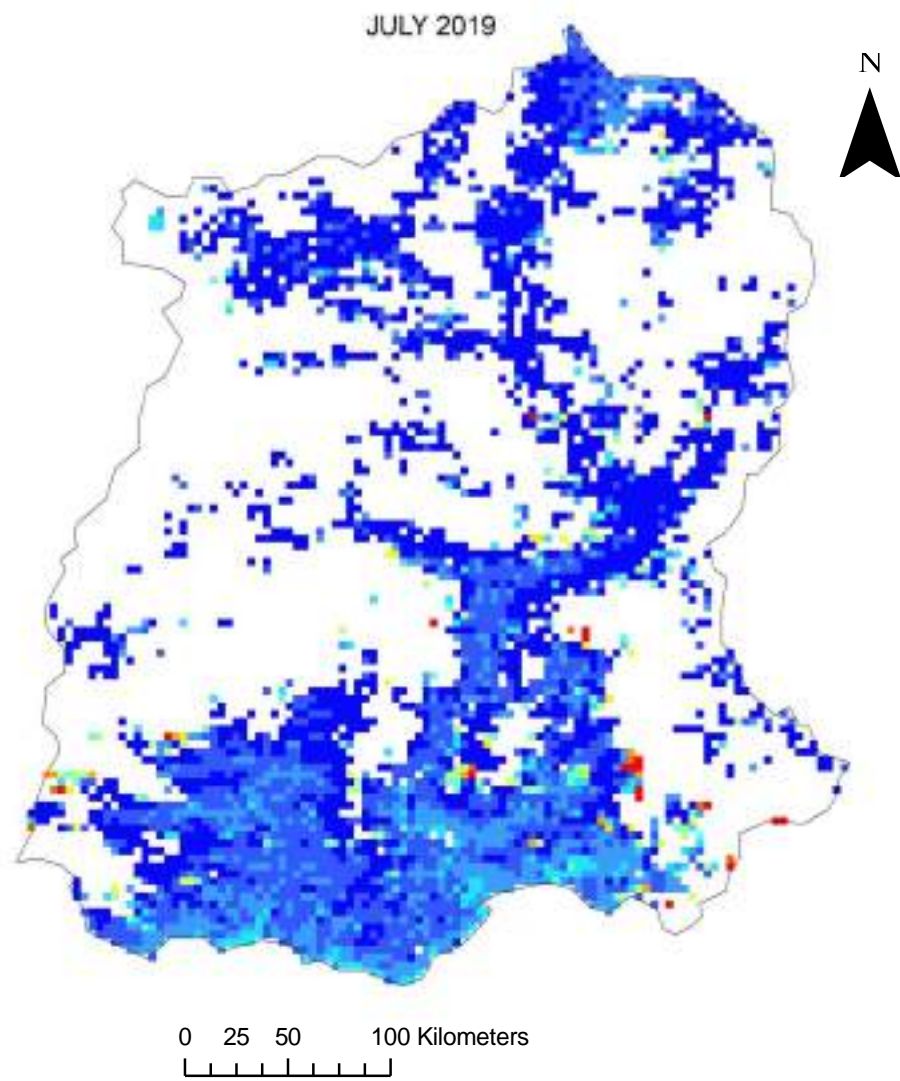




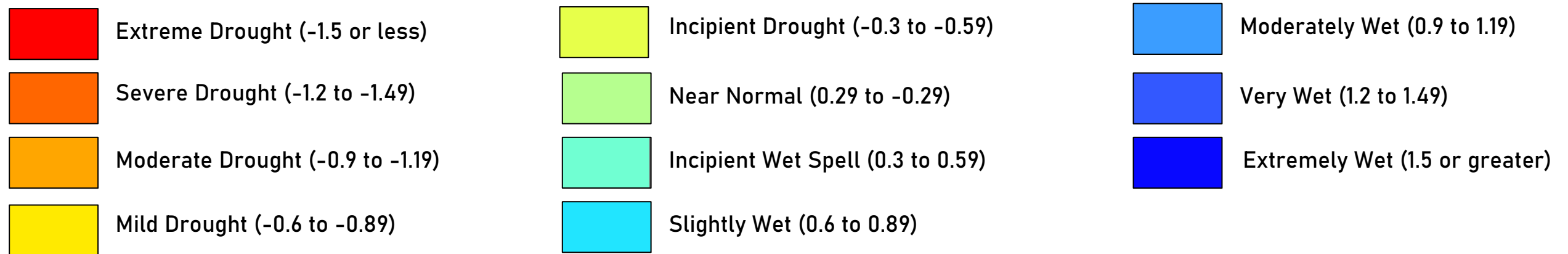
**Legend**







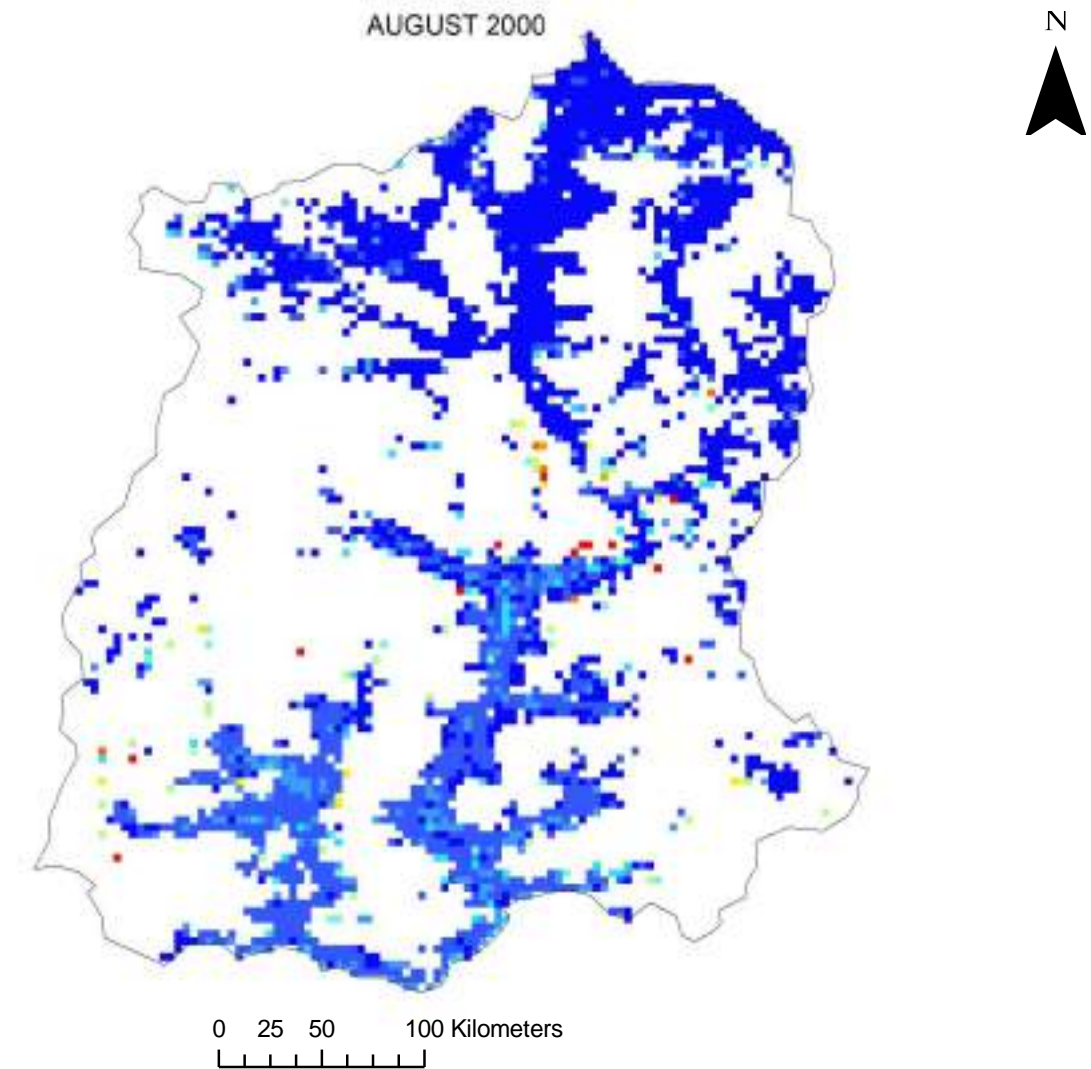
**Legend**



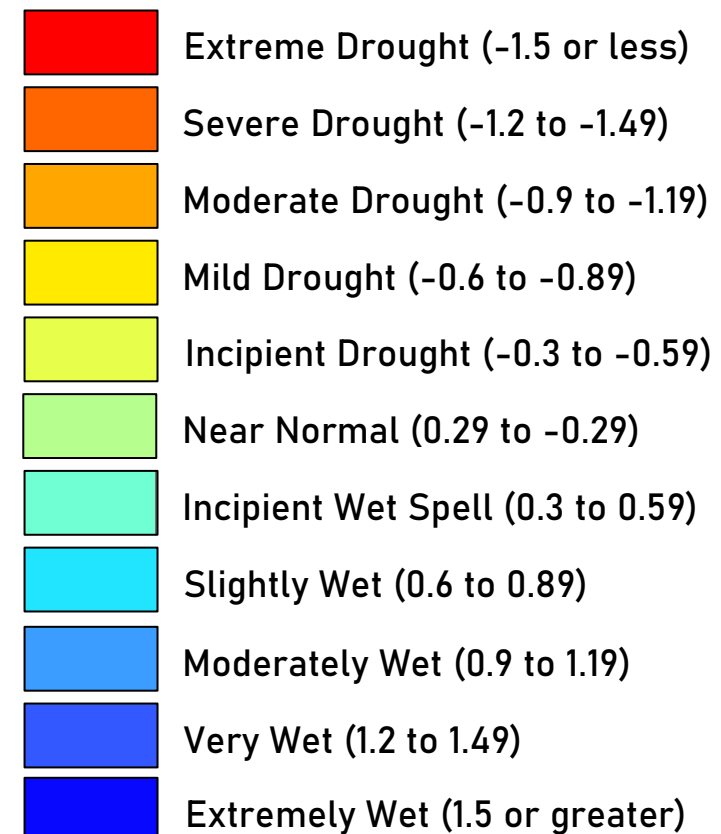
## August DSI Maps

Drought conditions in August vary from moderately wet to extremely wet conditions. Very wet conditions marked this monsoon month.

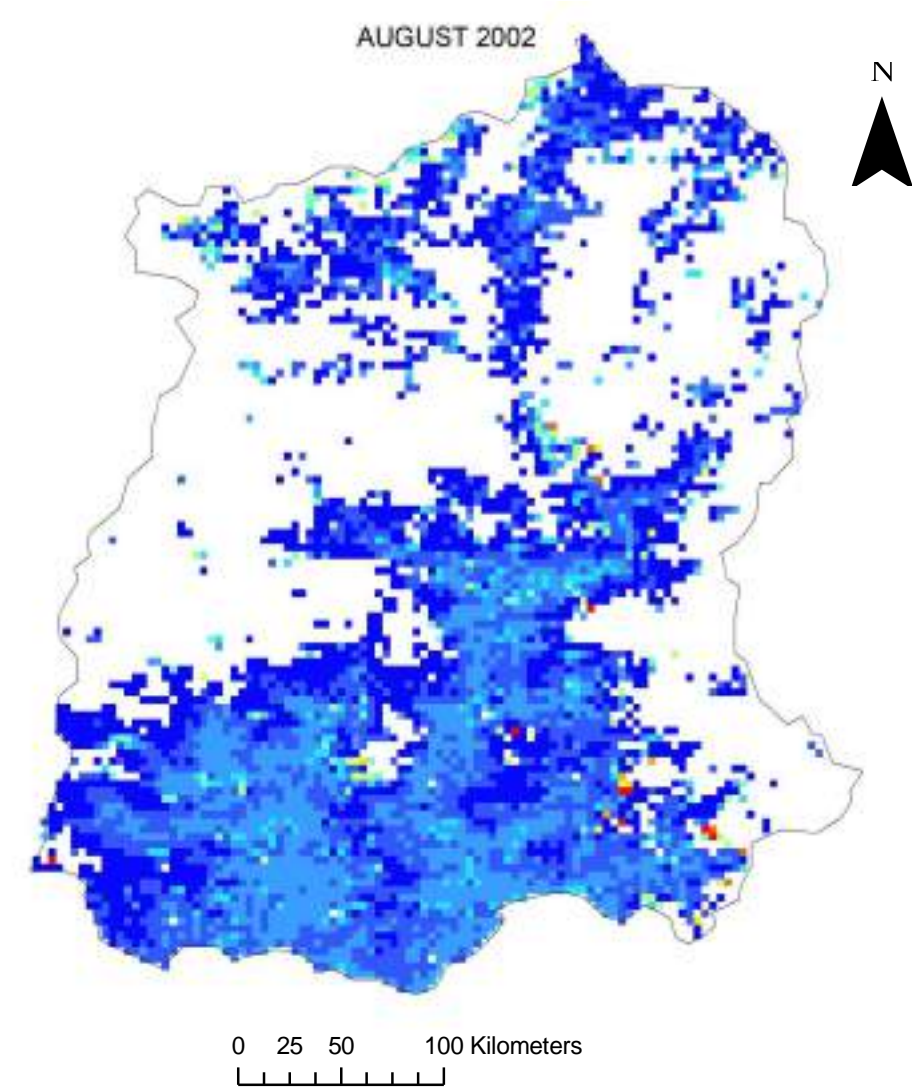
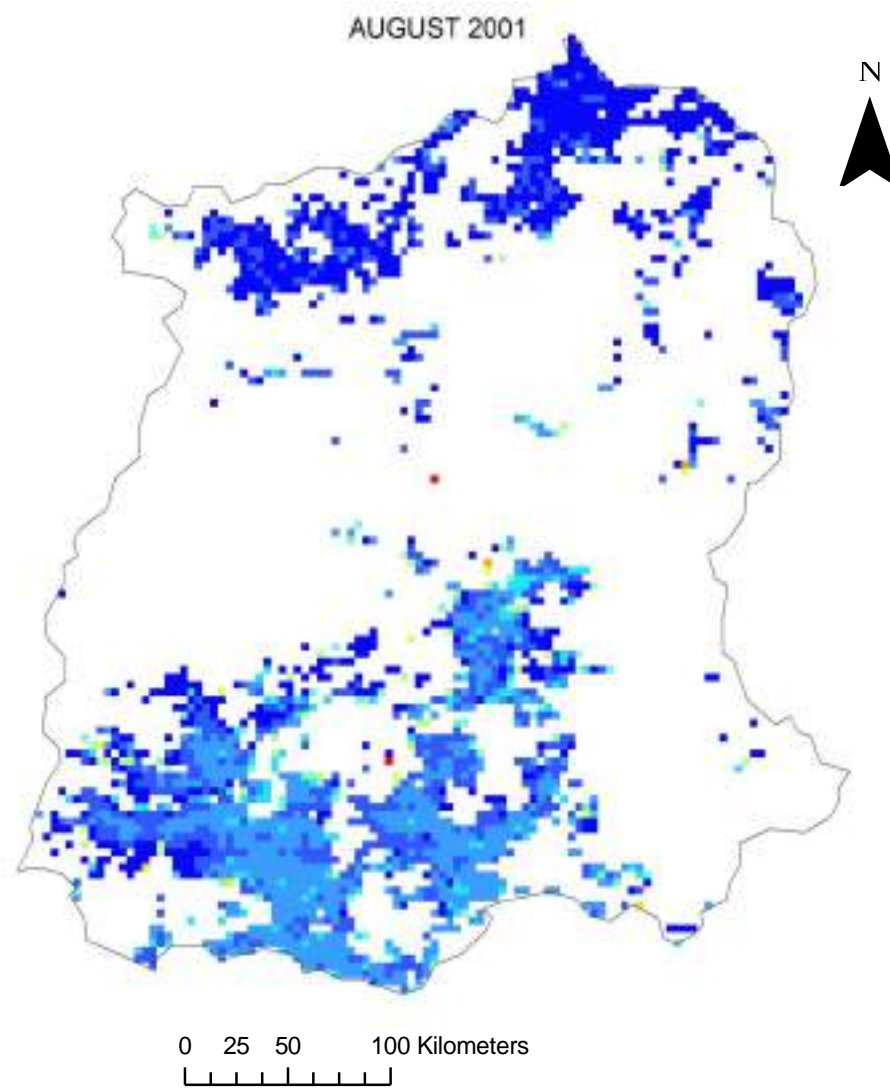
Mean August DSI Values		
Year	DSI Values	Drought Condition
2000	1.66	Extremely Wet
2001	1.38	Very Wet
2002	1.38	Very Wet
2003	1.17	Moderately Wet
2004	1.47	Very Wet
2005	1.81	Extremely Wet
2006	1.60	Extremely Wet
2007	1.27	Very Wet
2008	1.63	Extremely Wet
2009	1.33	Very Wet
2010	1.75	Extremely Wet
2011	1.57	Extremely Wet
2012	1.47	Very Wet
2013	1.43	Very Wet
2014	1.56	Extremely Wet
2015	1.43	Very Wet
2016	1.31	Very Wet
2017	1.25	Very Wet
2018	1.38	Very Wet
2019	1.49	Very Wet
2020	1.25	Very Wet














### Legend

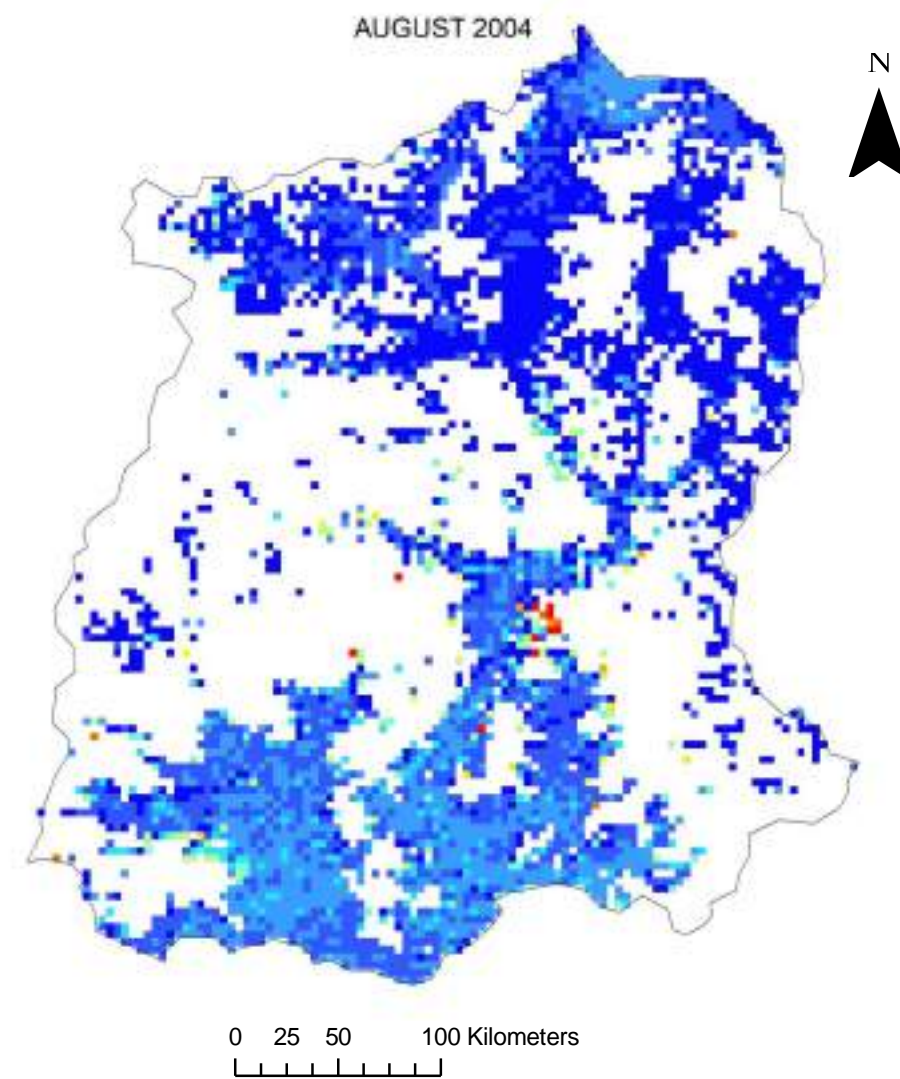
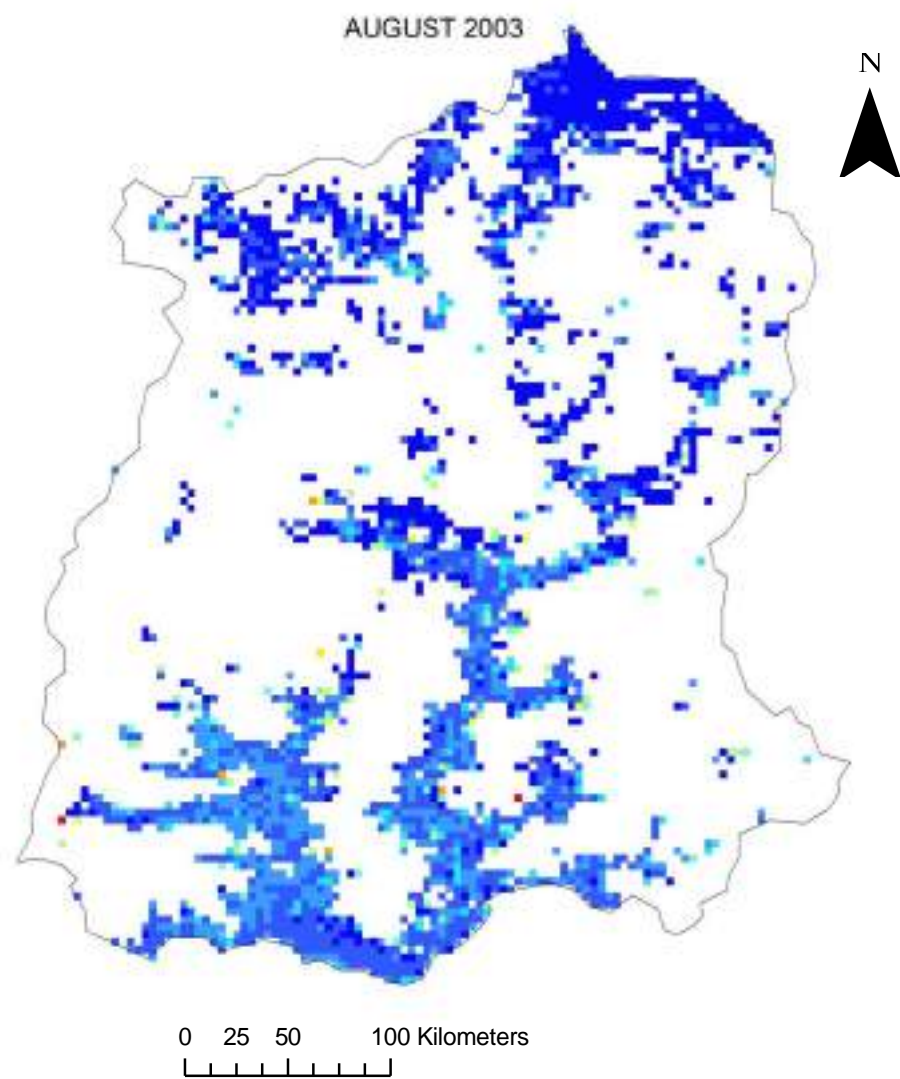




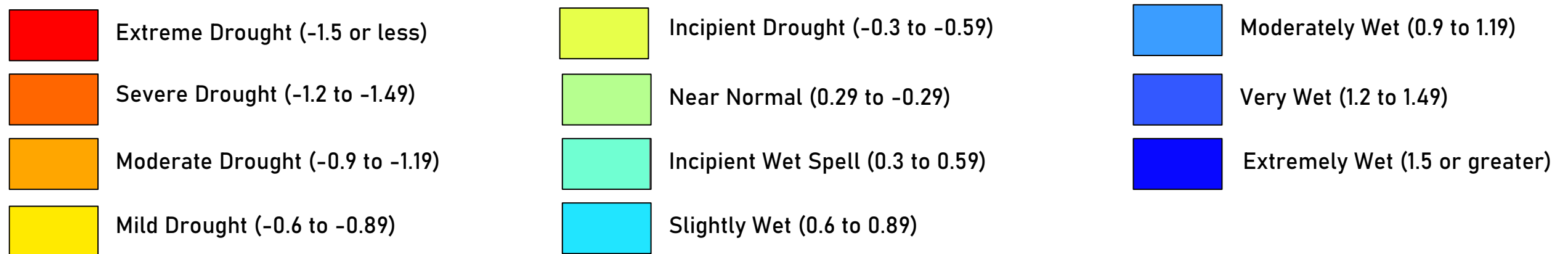


**Legend**

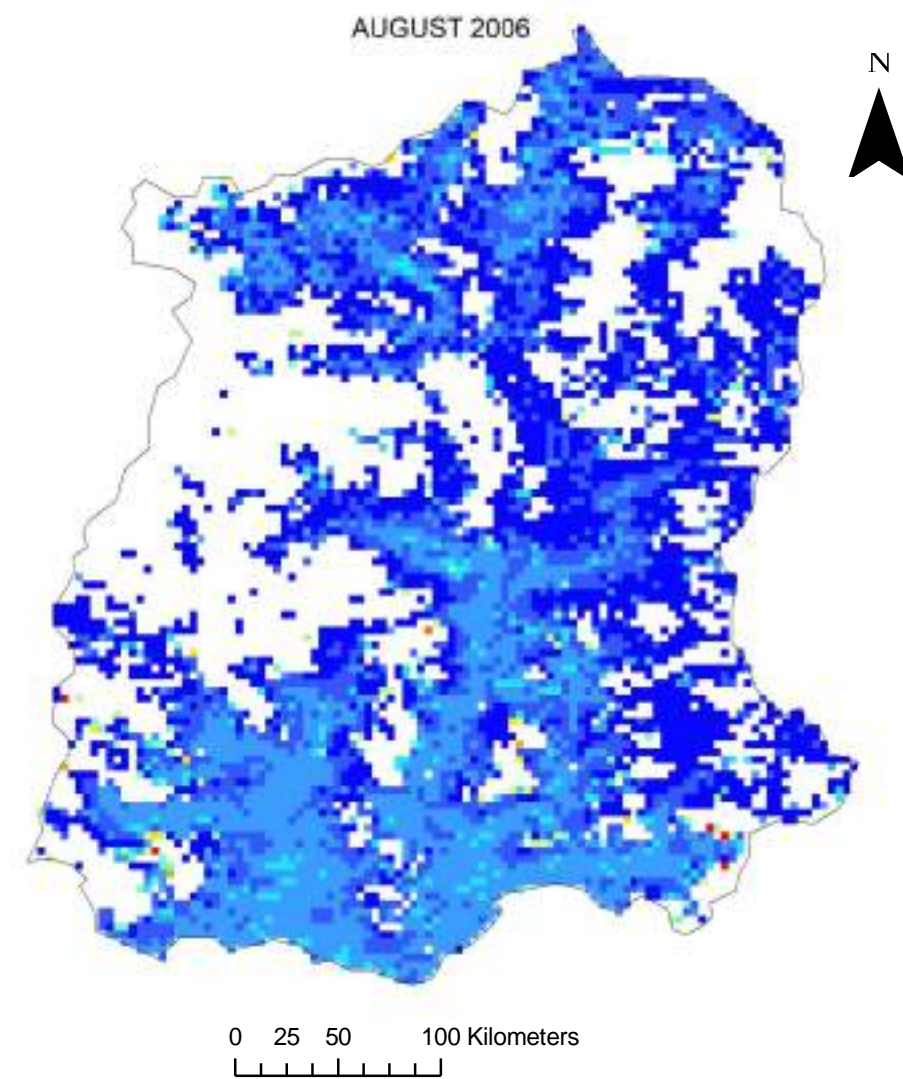
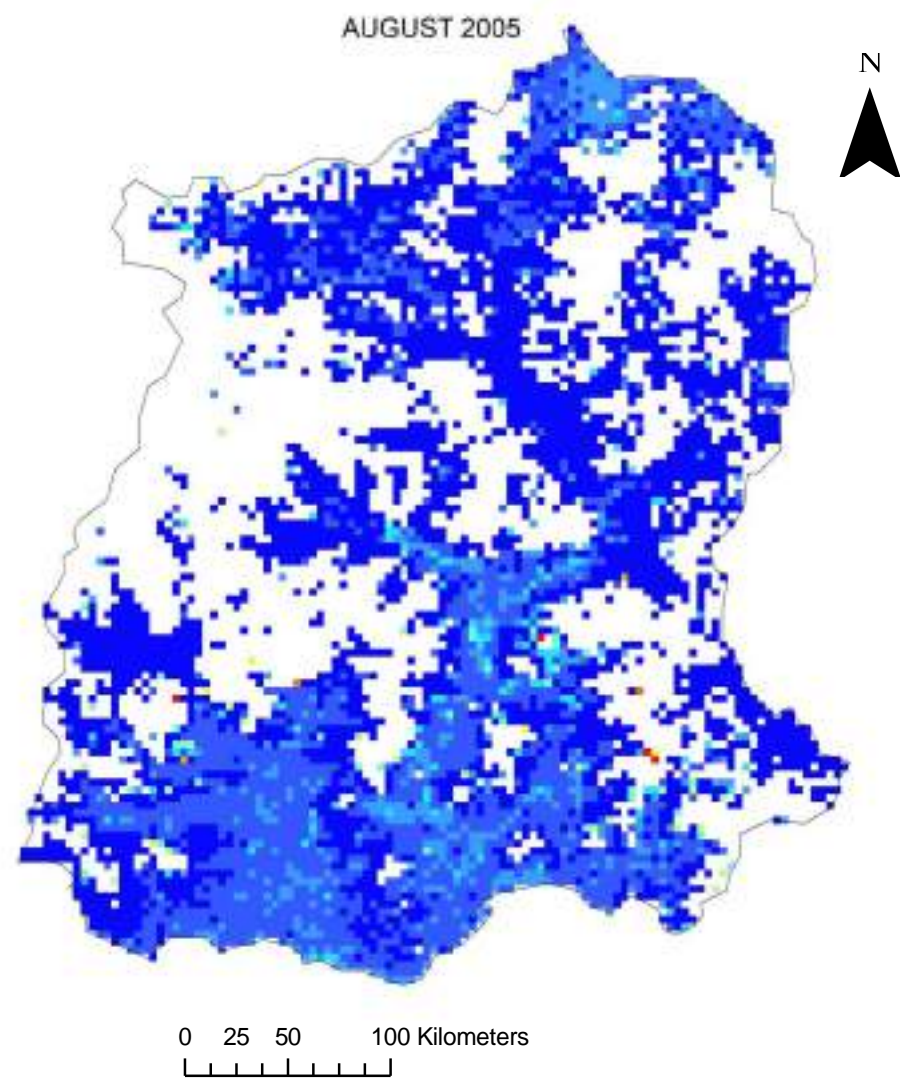
- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



**Legend**





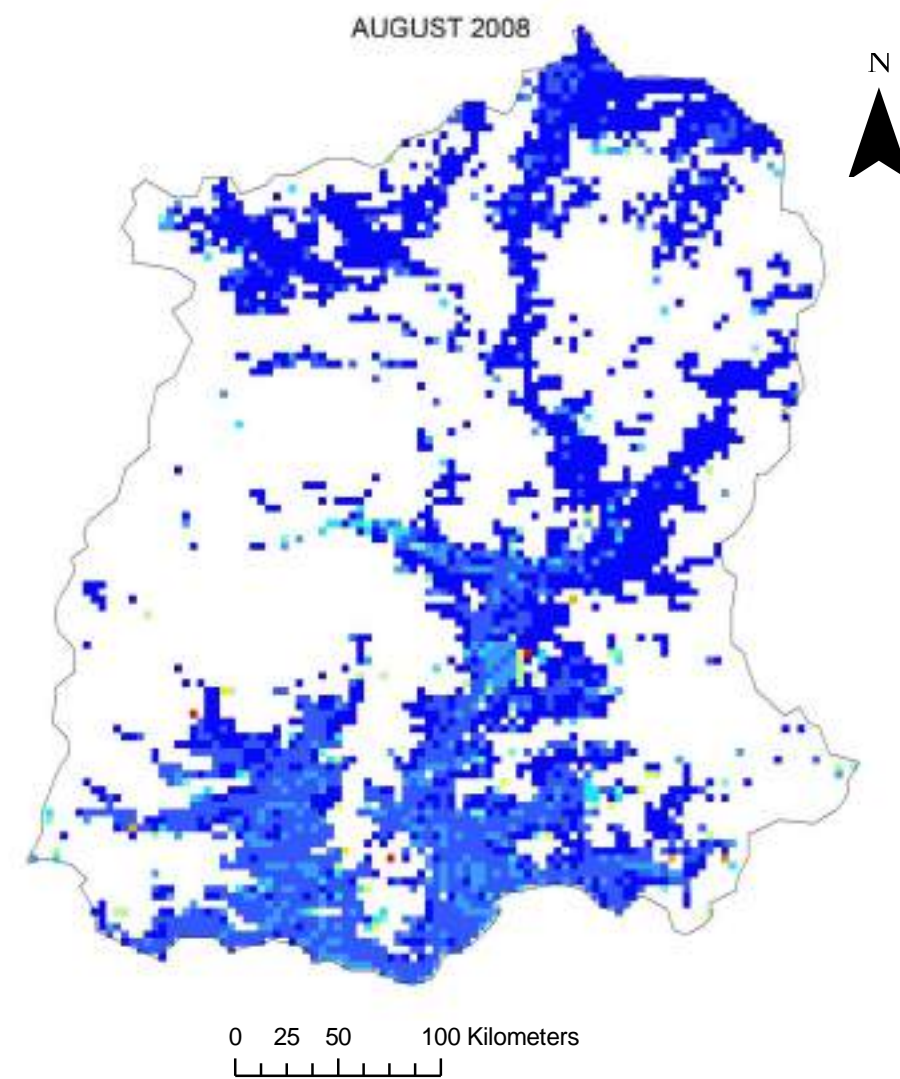
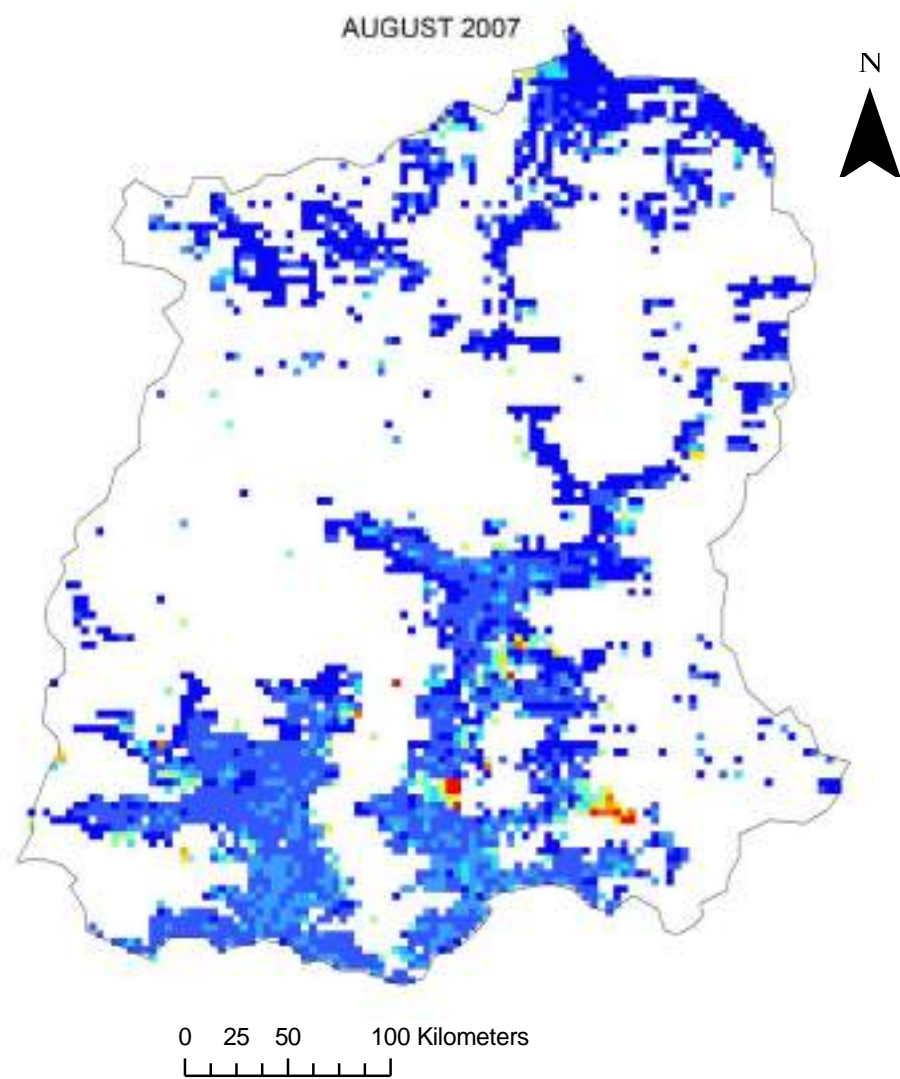


**Legend**





- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)





- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)




- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



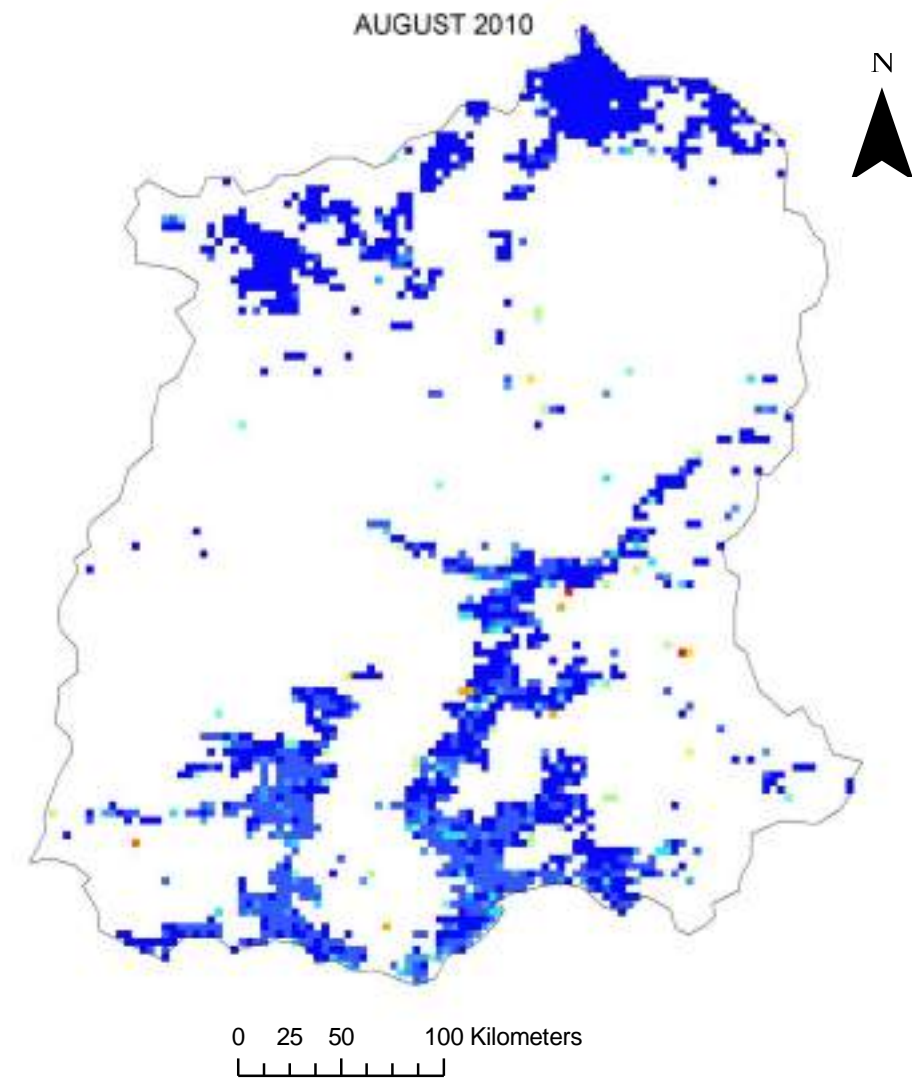
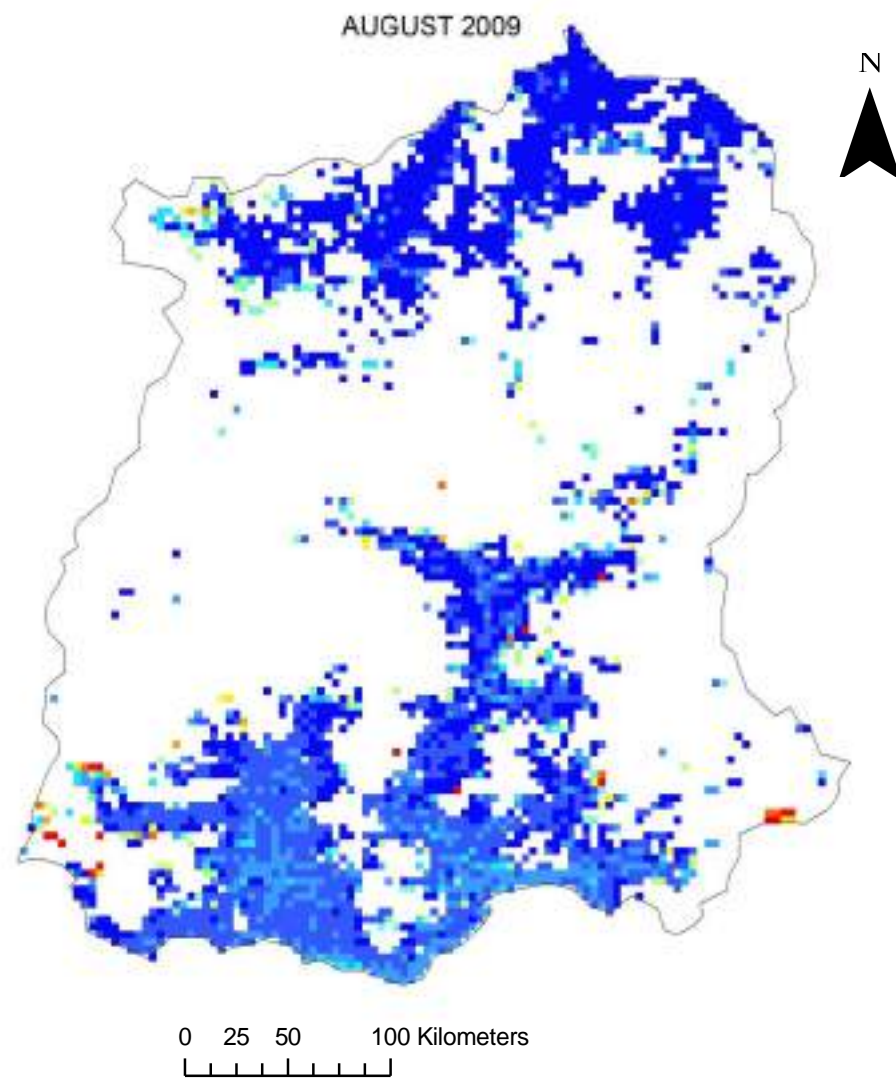
**Legend**

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



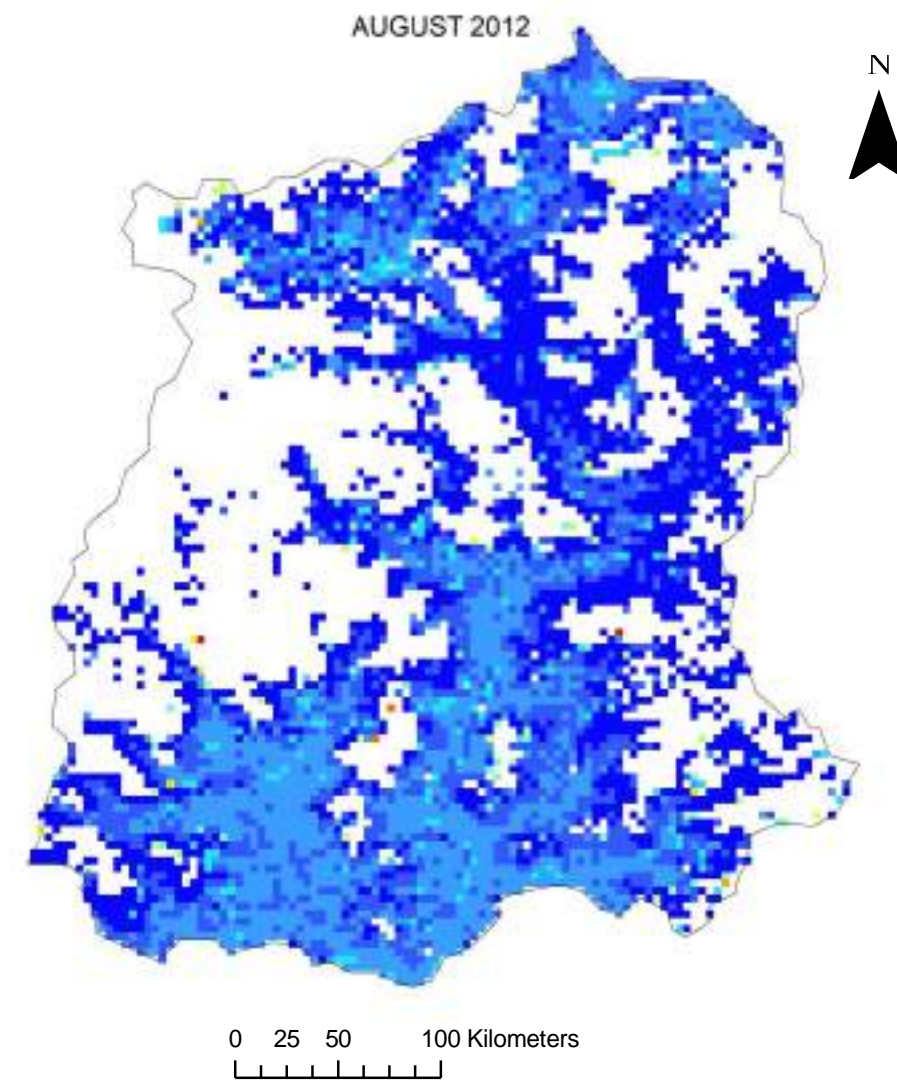
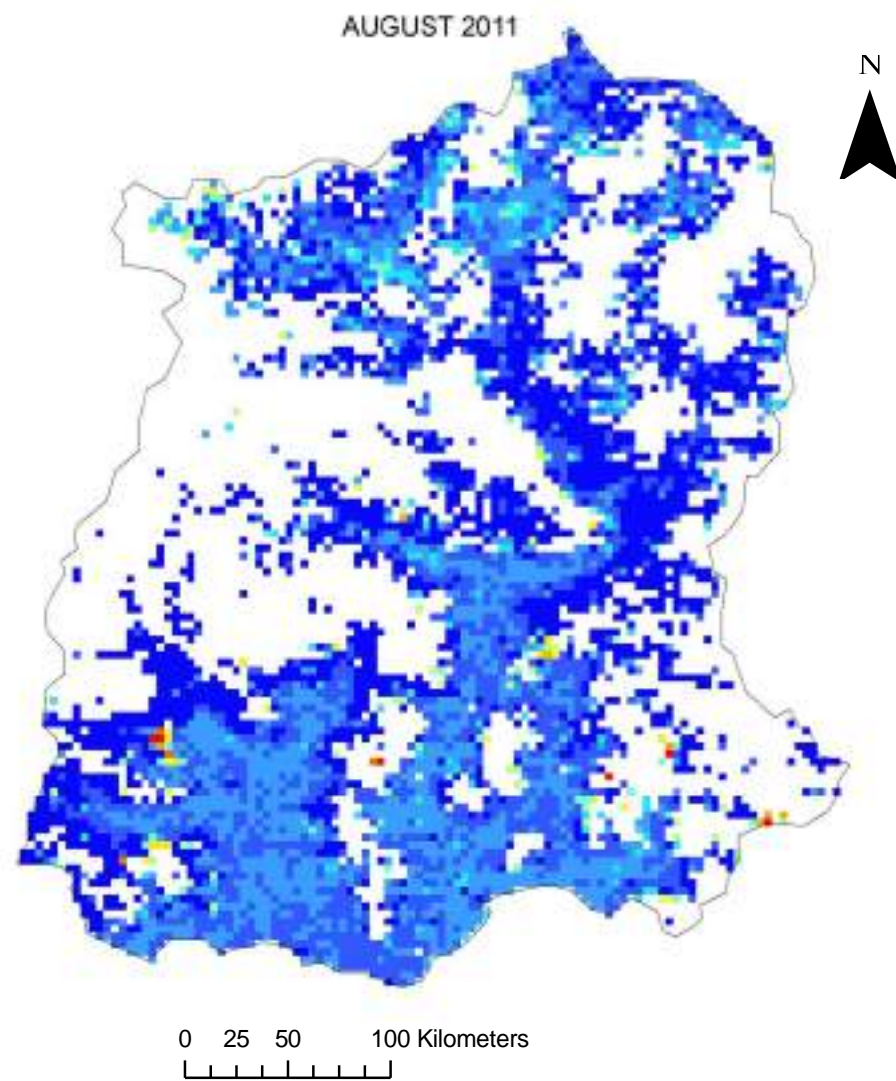


**Legend**

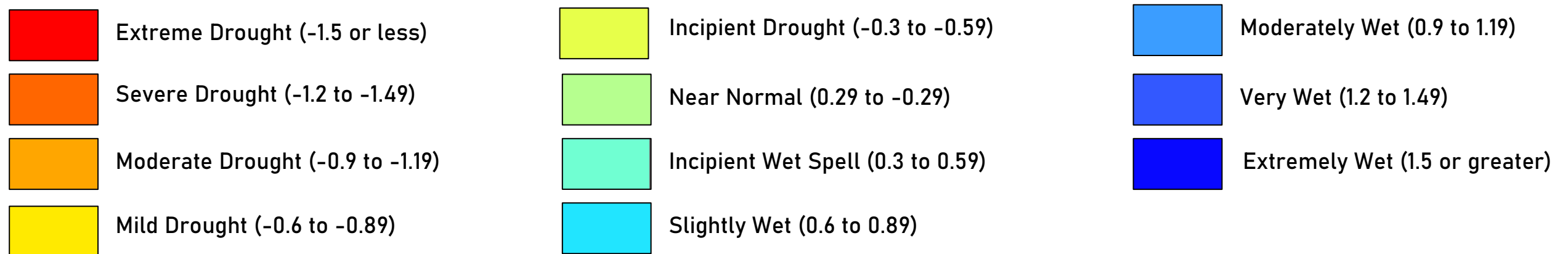
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

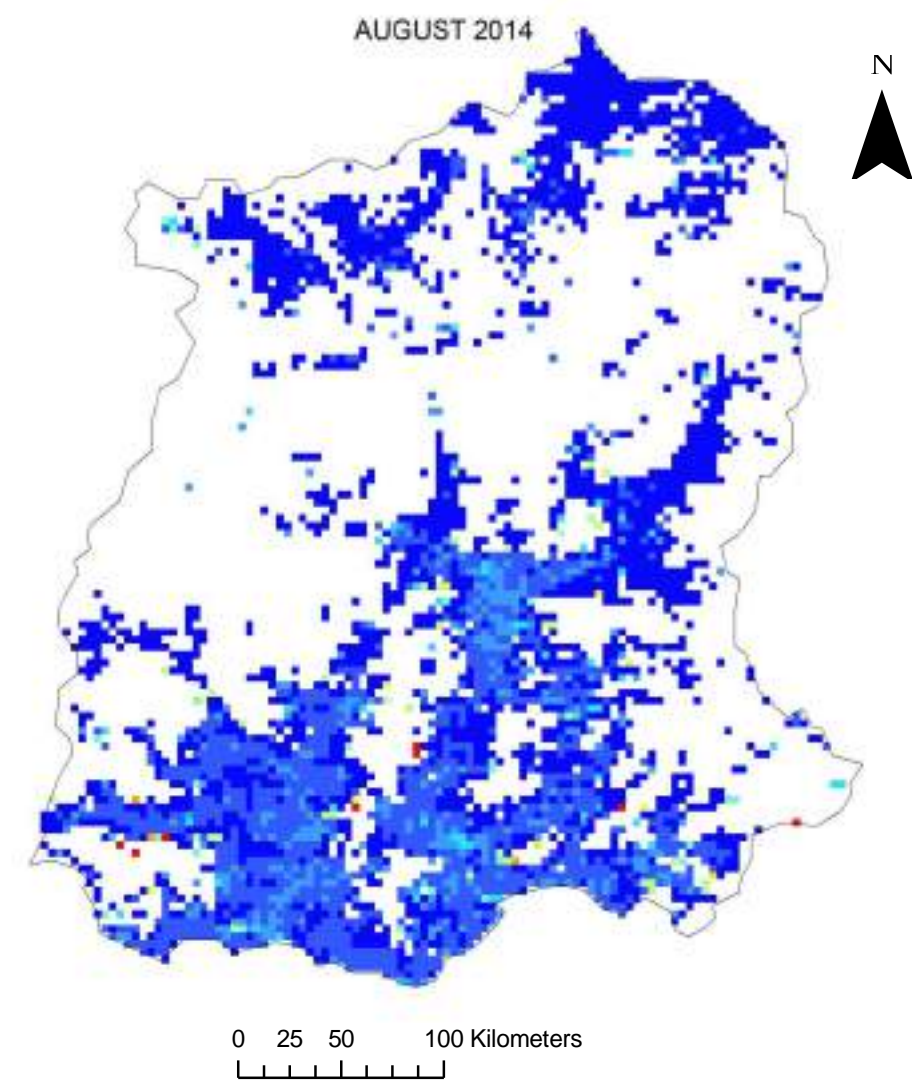
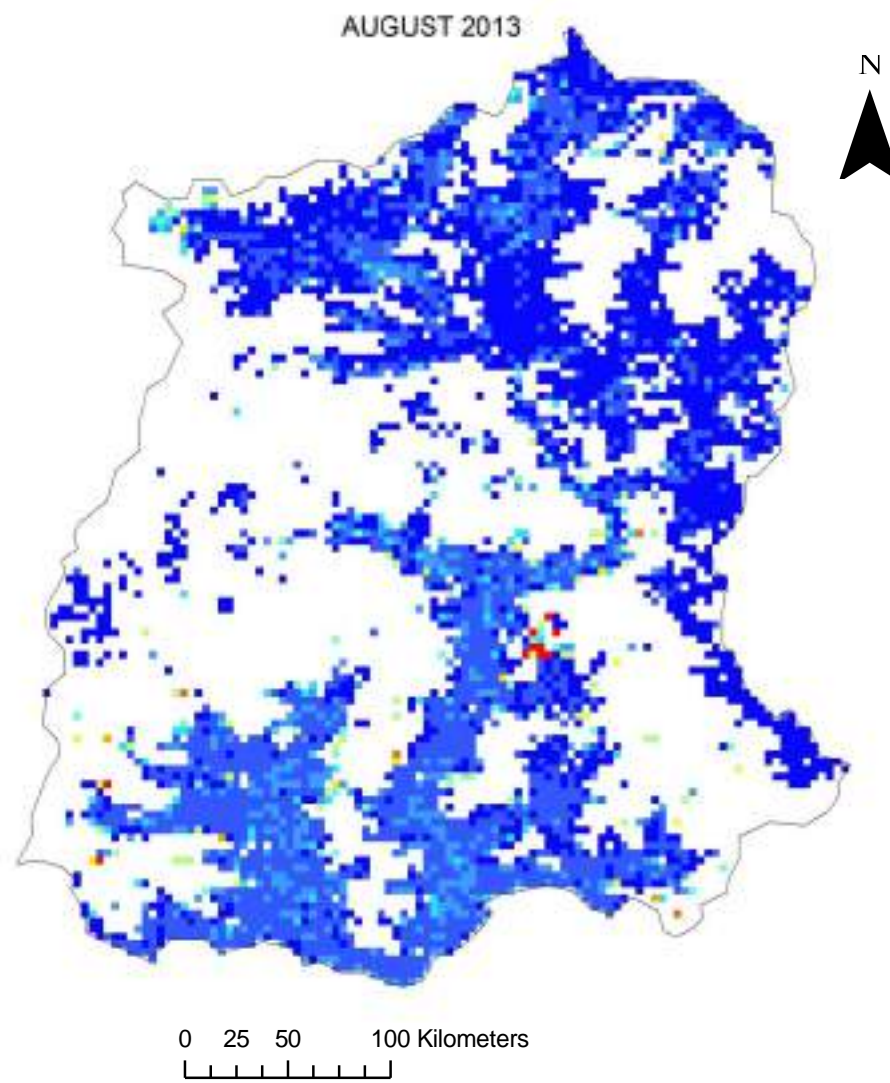
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)














**Legend**

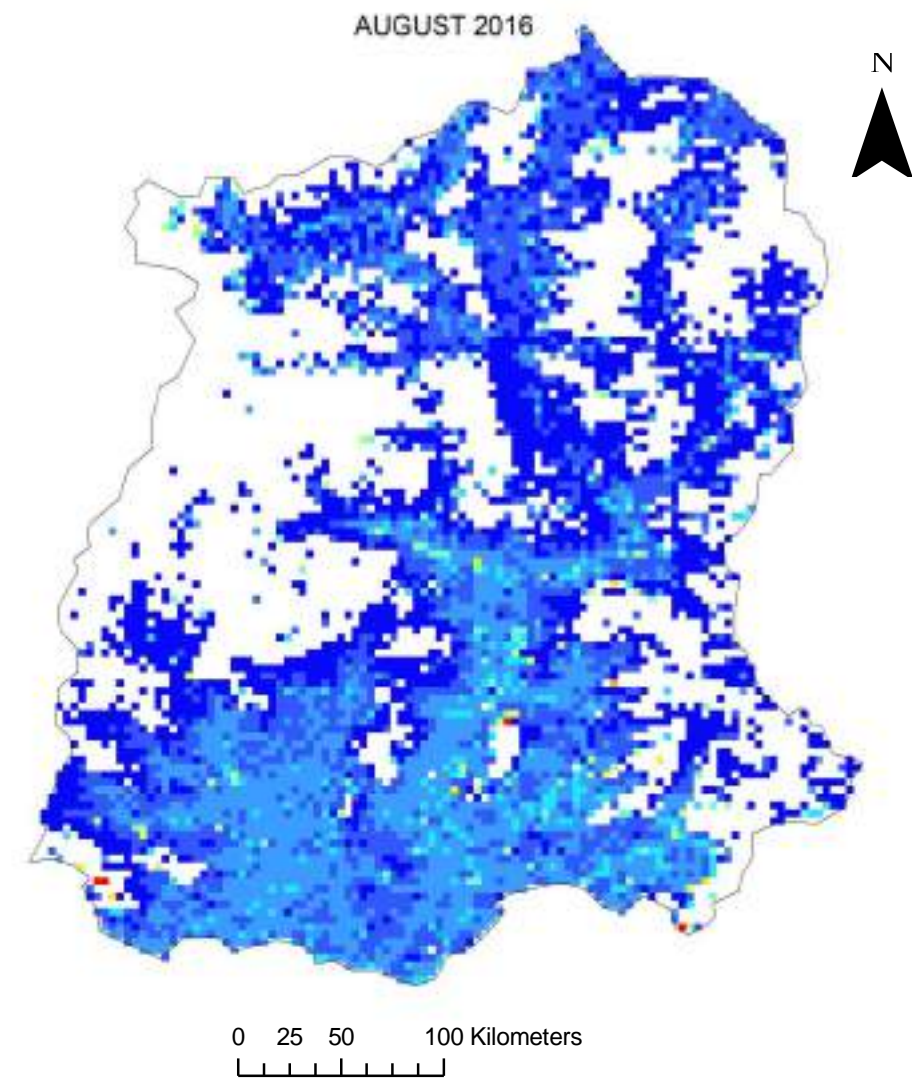
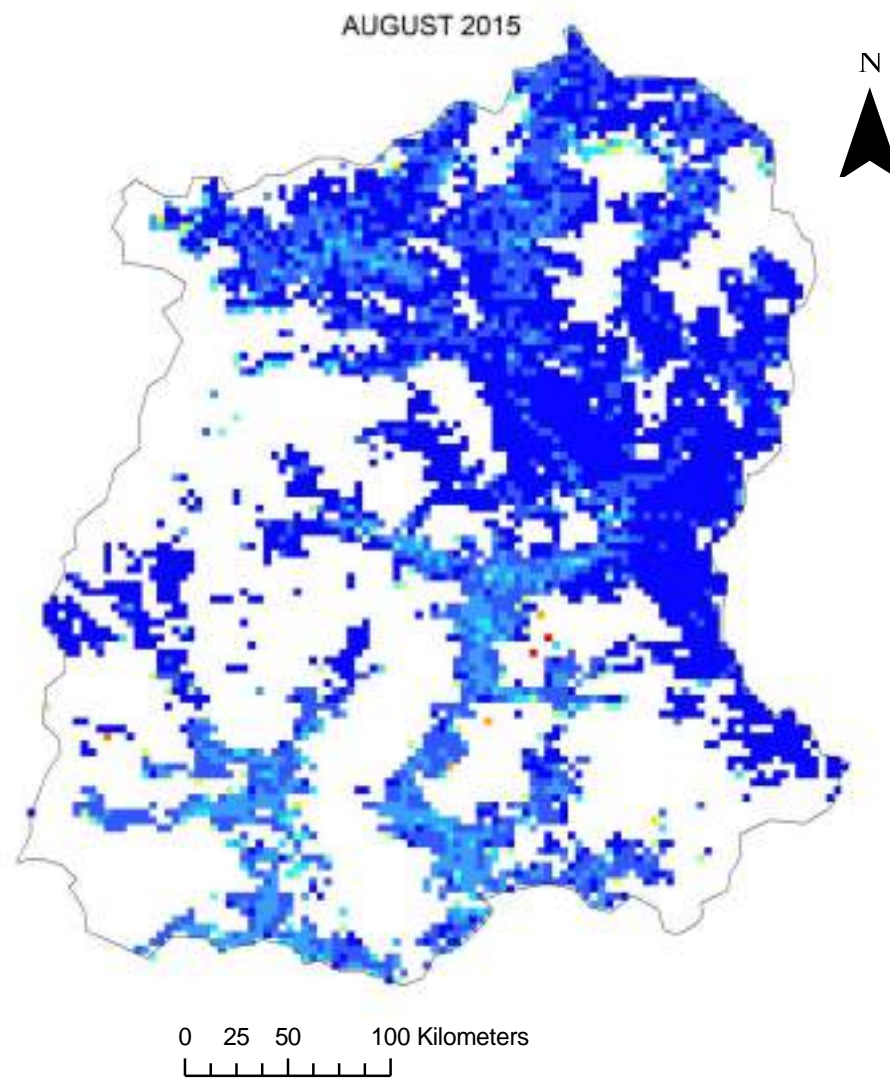




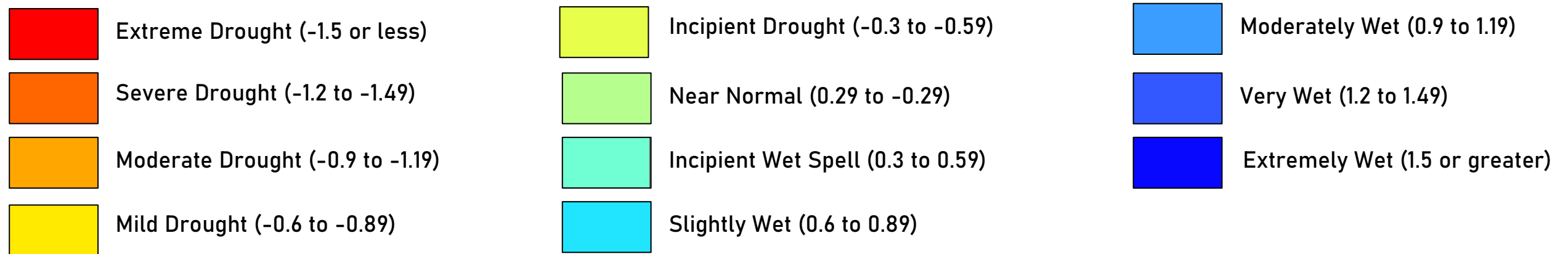


**Legend**

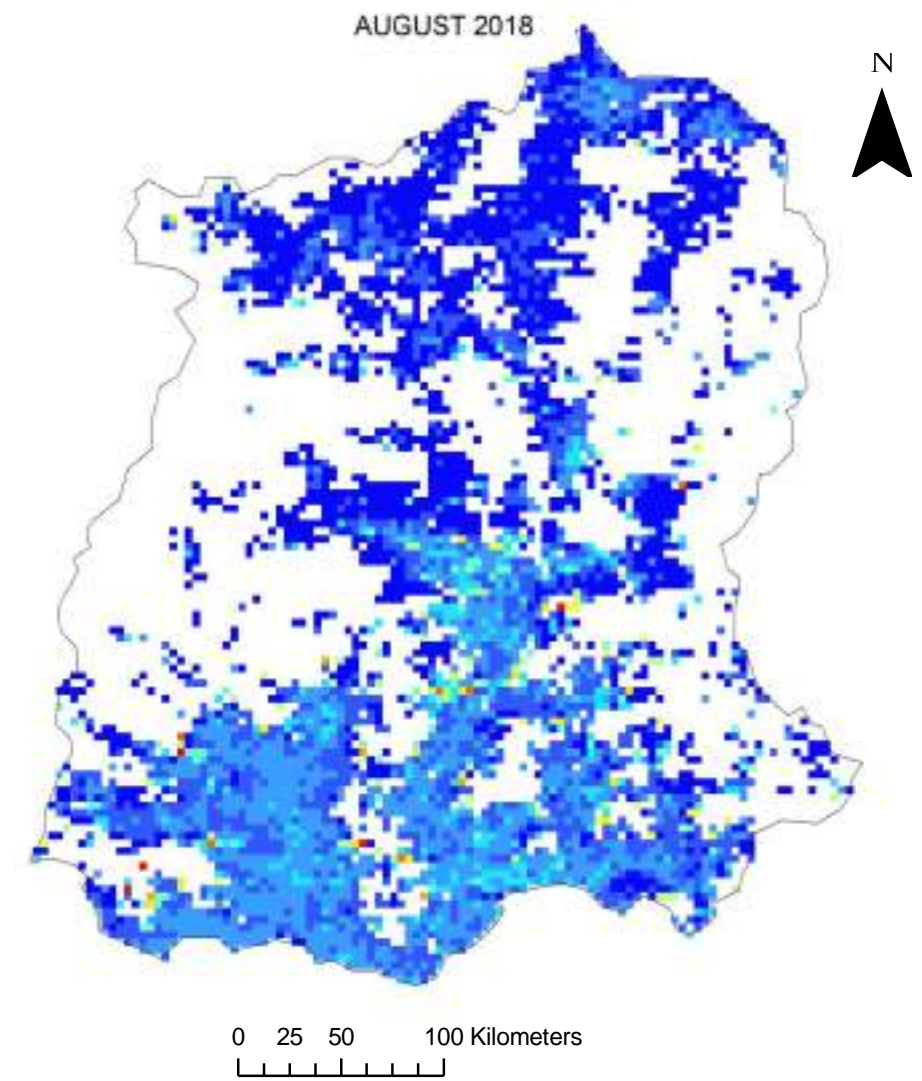
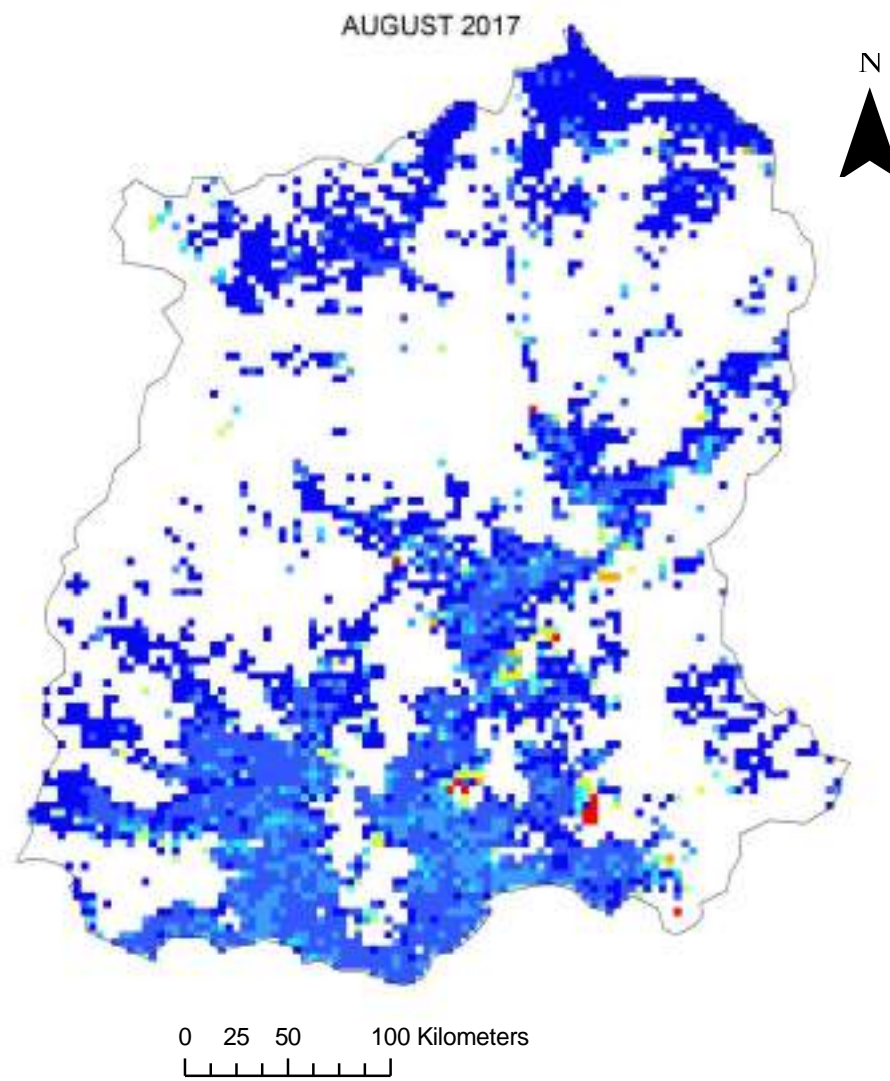
	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		



**Legend**





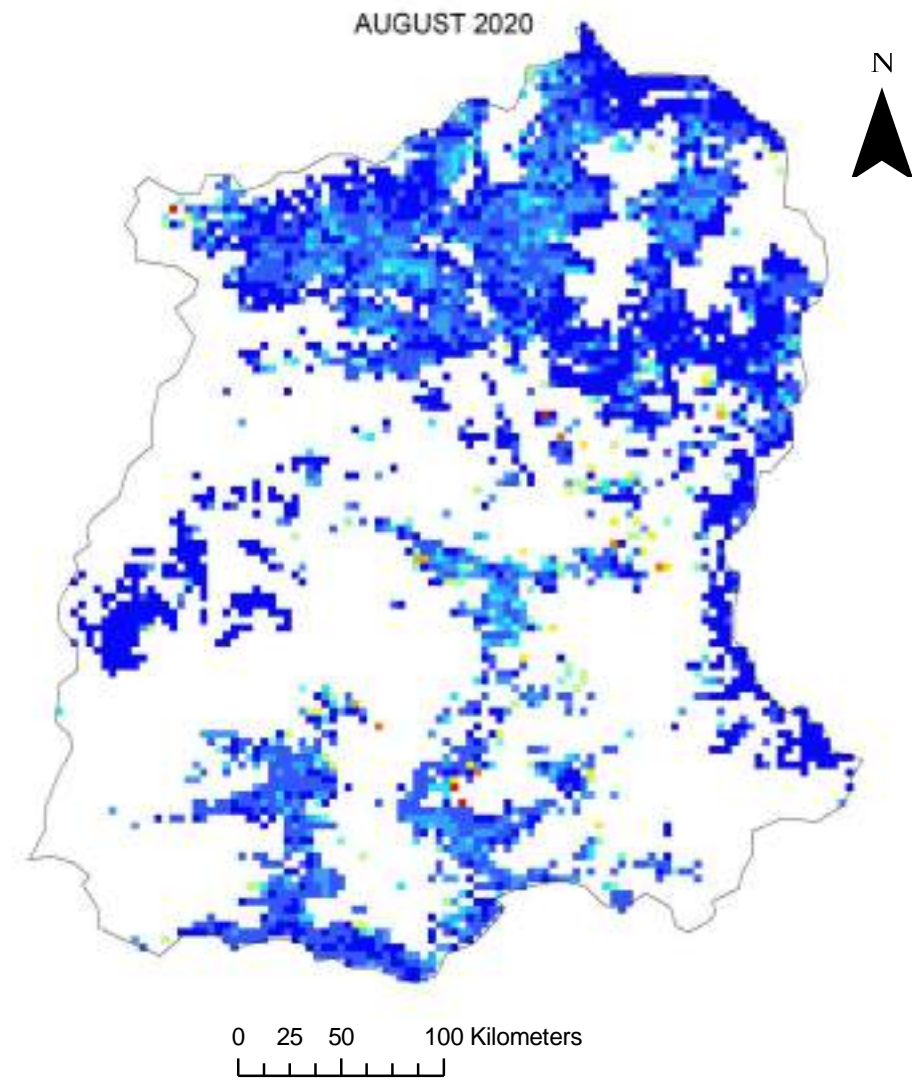
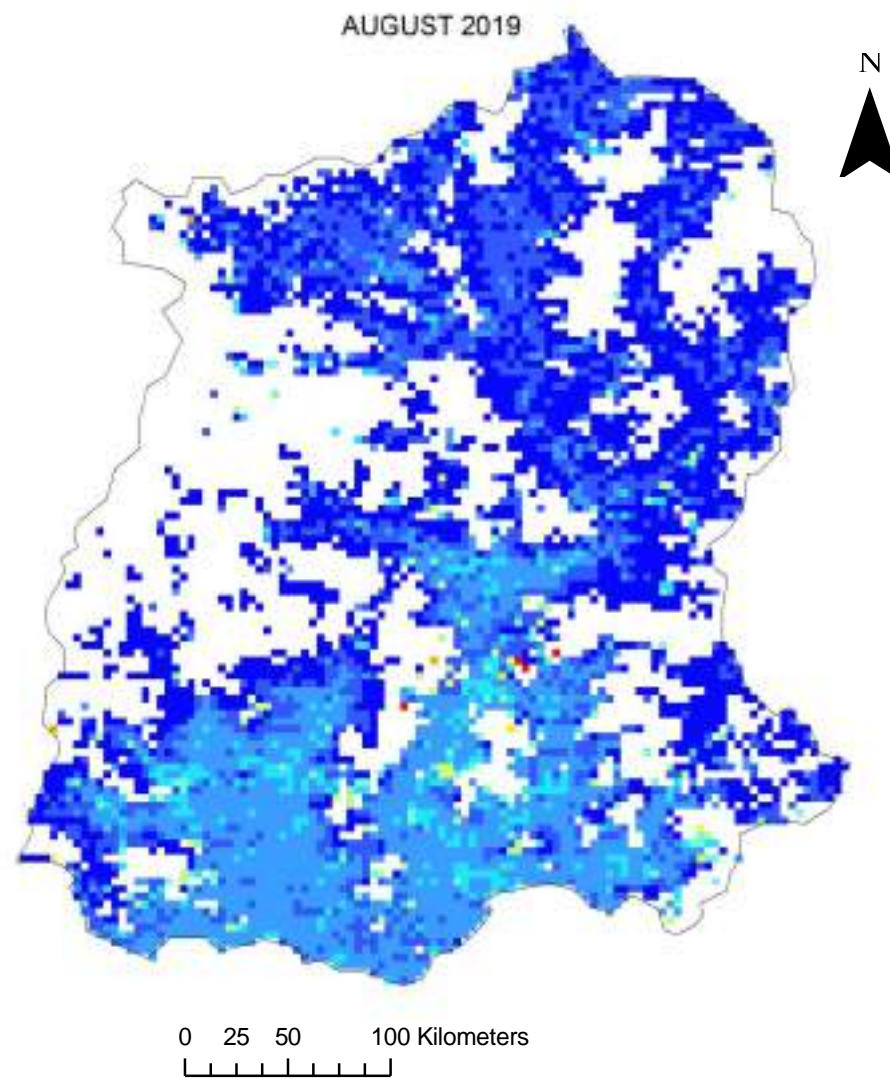


**Legend**

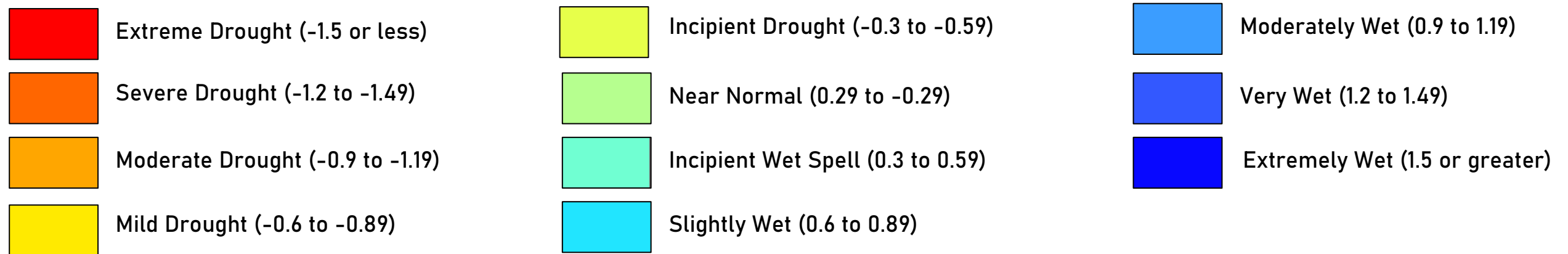
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



**Legend**

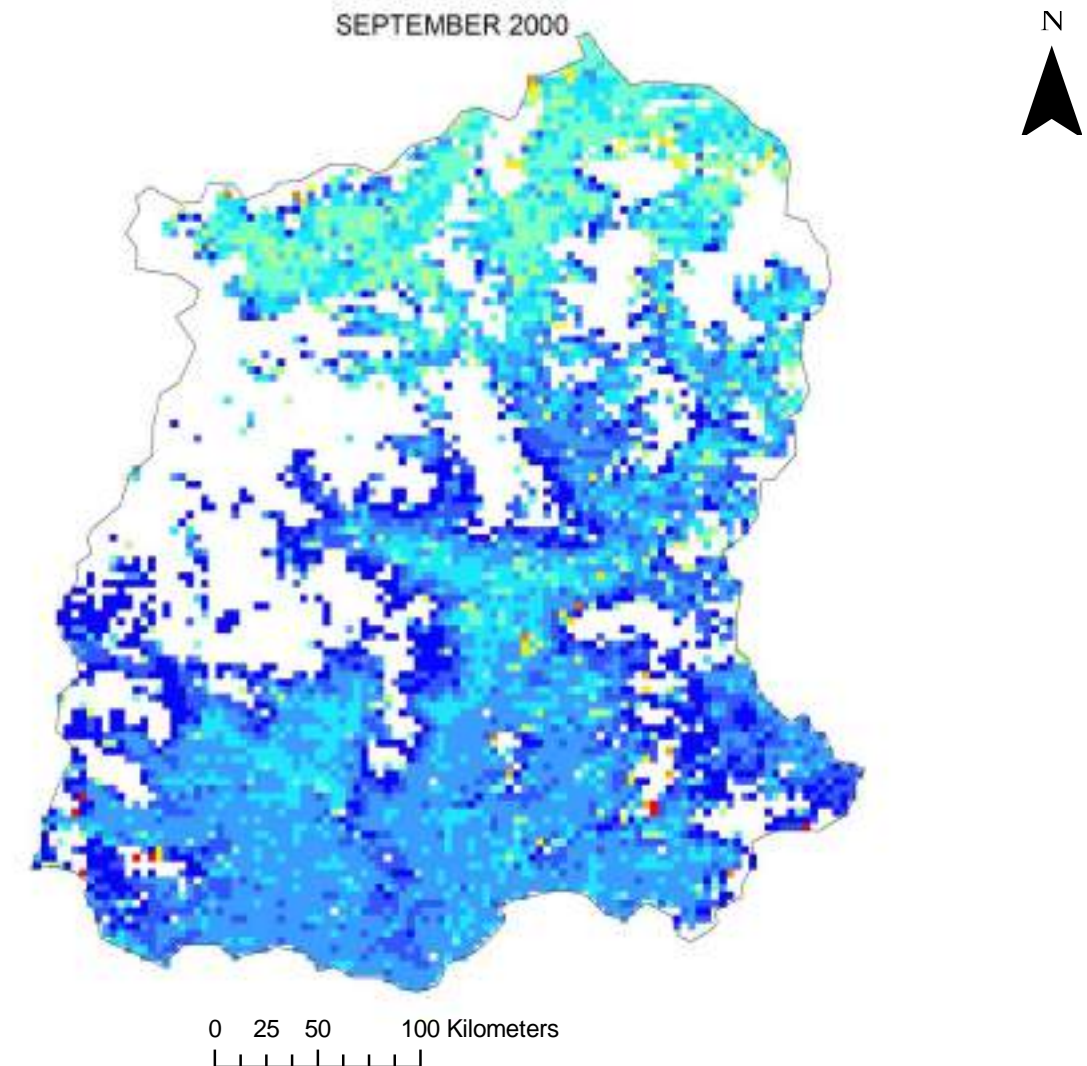




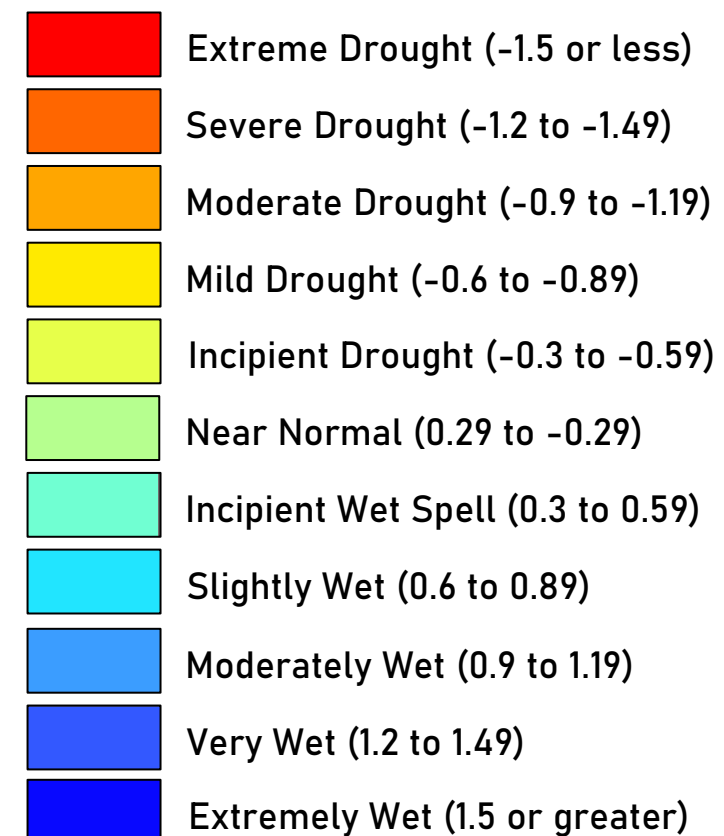
## September DSI Maps

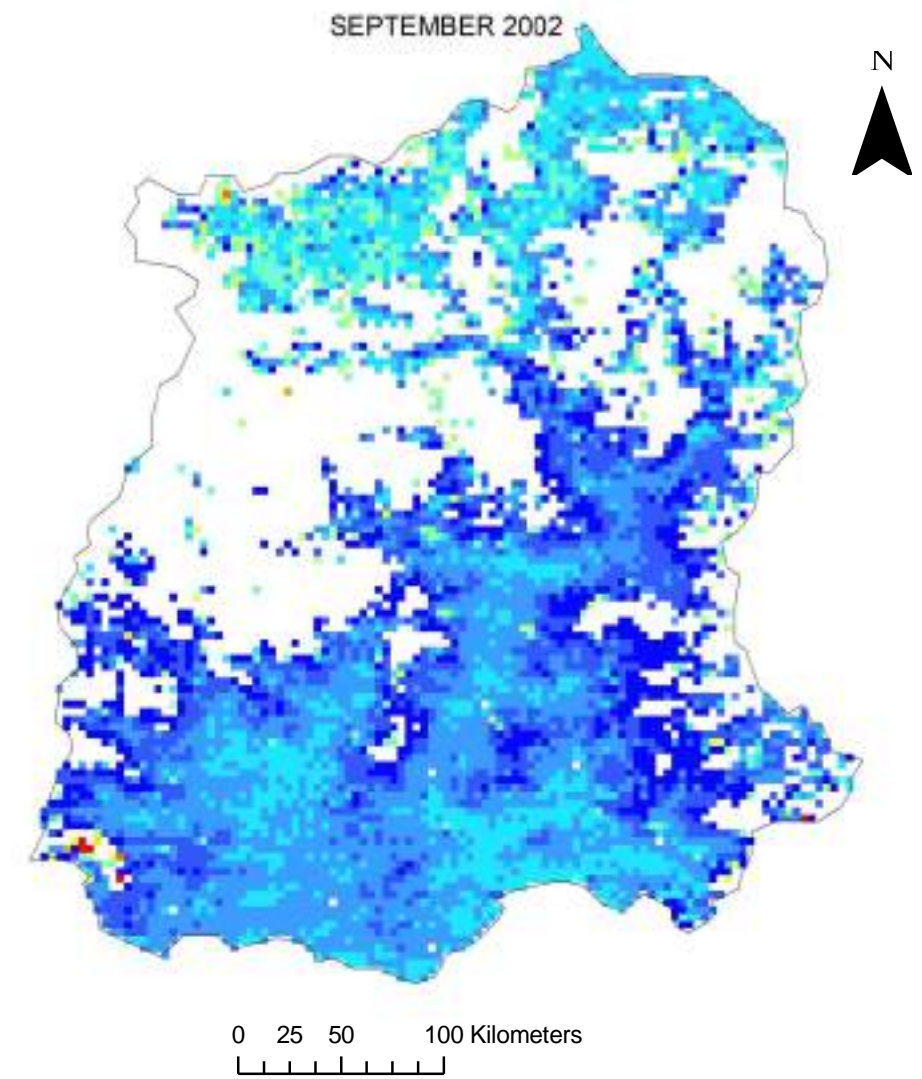
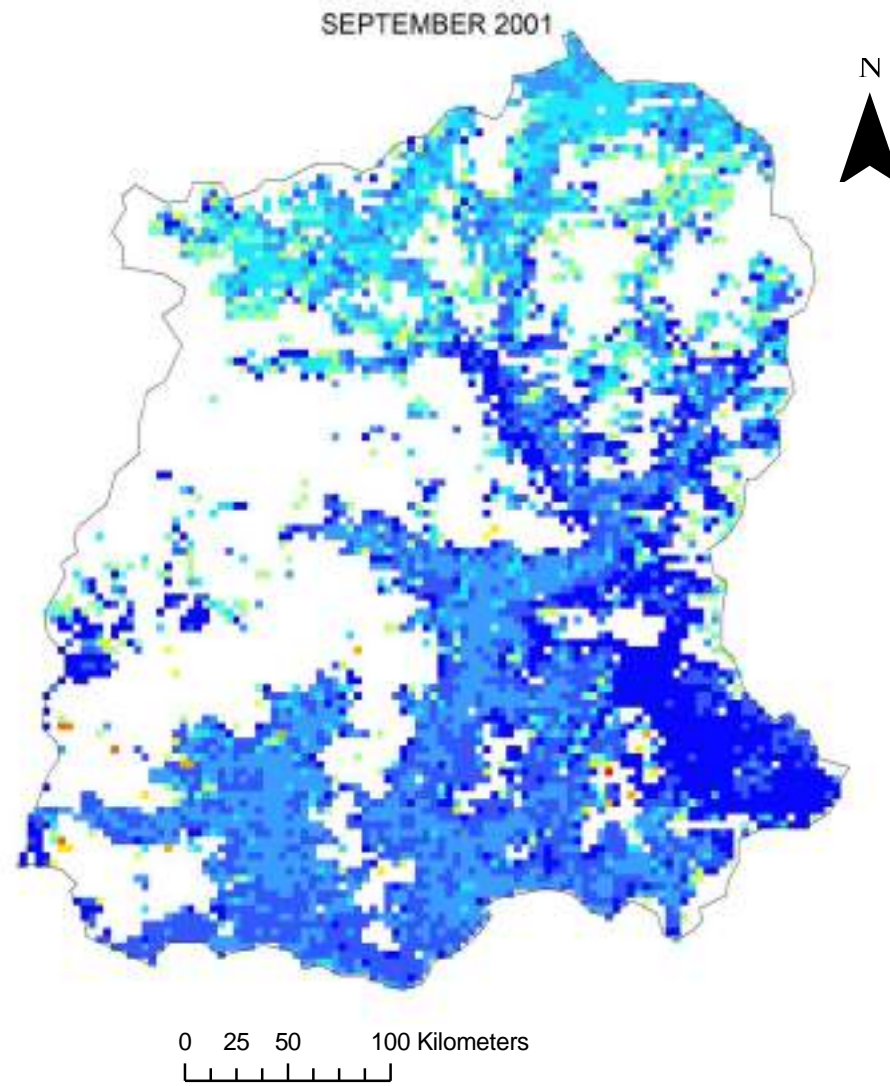
Drought conditions in September range from moderately wet to extremely wet condition. The characteristics of this monsoon month are marked by moderately wet conditions.

Mean September DSI Values		
Year	DSI Values	Drought Condition
2000	1.06	Moderately Wet
2001	1.11	Moderately Wet
2002	0.96	Moderately Wet
2003	0.92	Moderately Wet
2004	1.15	Moderately Wet
2005	0.93	Moderately Wet
2006	1.13	Moderately Wet
2007	1.18	Moderately Wet
2008	1.38	Very Wet
2009	1.18	Moderately Wet
2010	1.07	Moderately Wet
2011	1.06	Moderately Wet
2012	0.95	Moderately Wet
2013	1.09	Moderately Wet
2014	1.29	Very Wet
2015	0.90	Moderately Wet
2016	1.54	Extremely Wet
2017	1.30	Very Wet
2018	0.93	Moderately Wet
2019	1.03	Moderately Wet
2020	1.18	Moderately Wet














### Legend

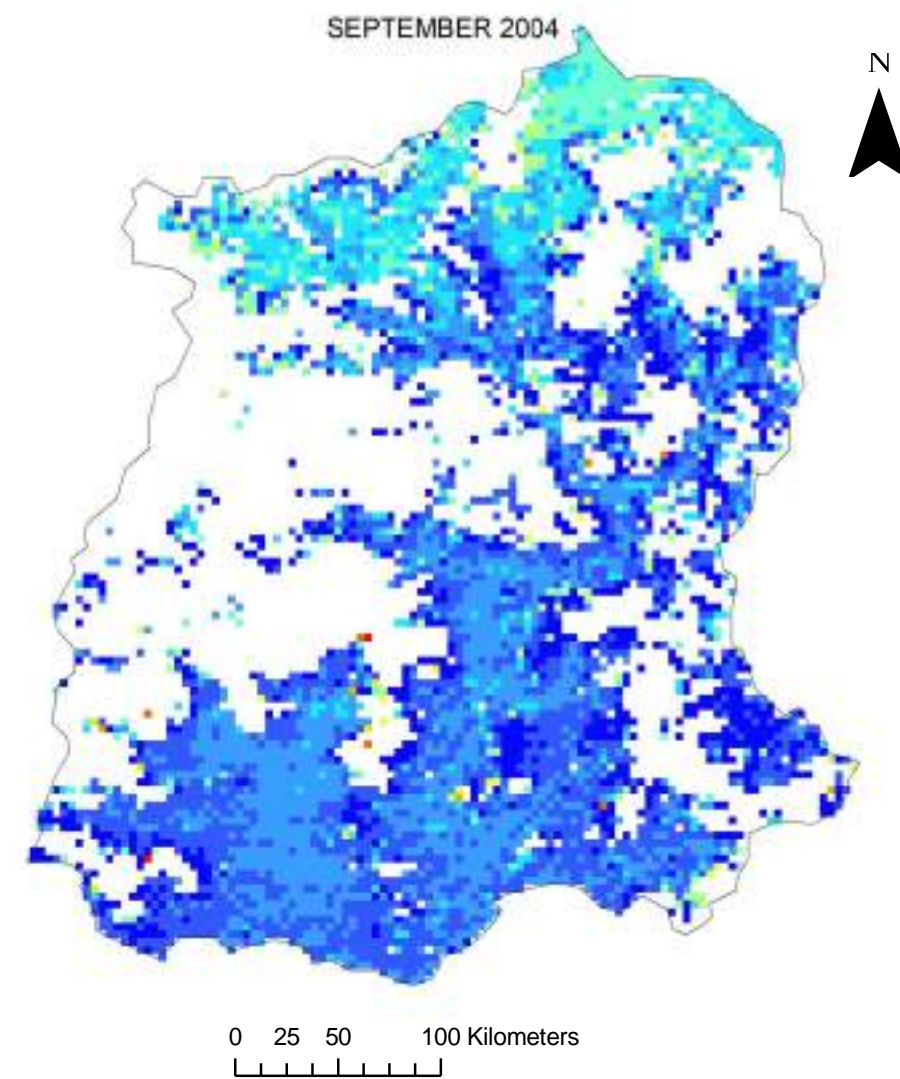
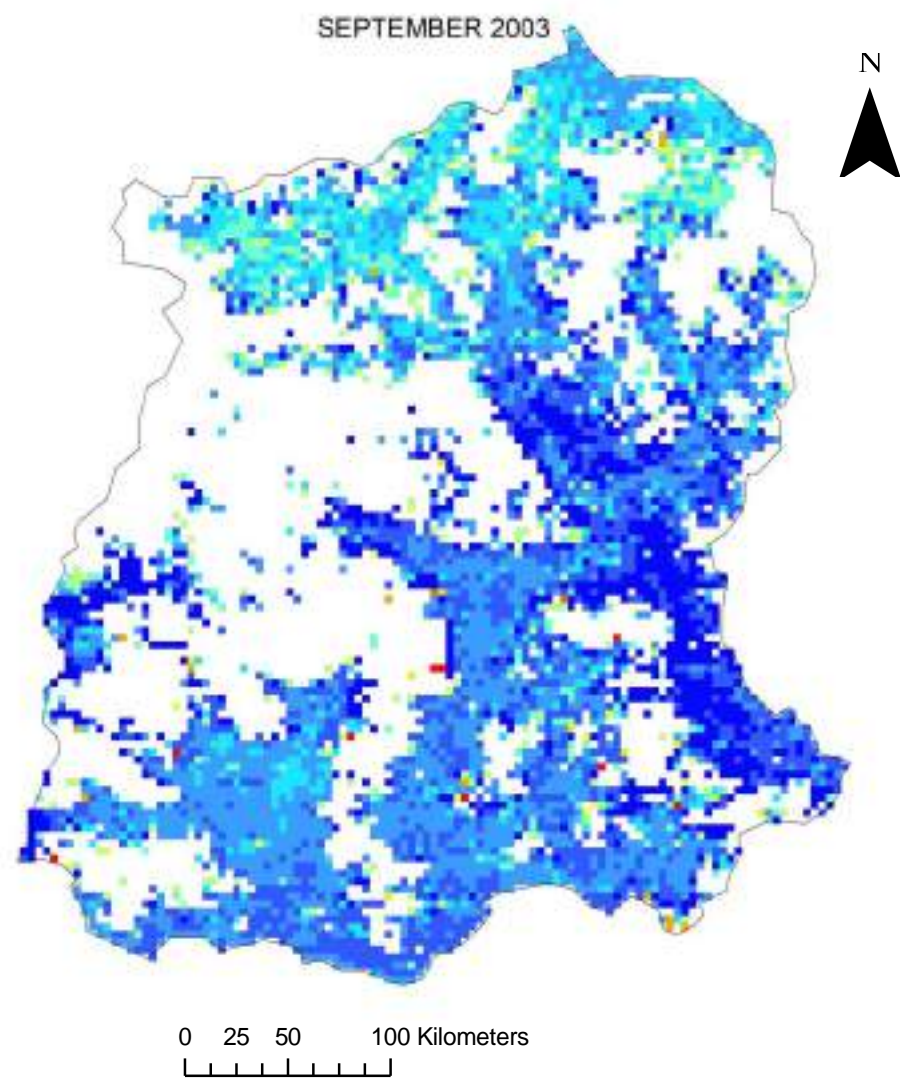




**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



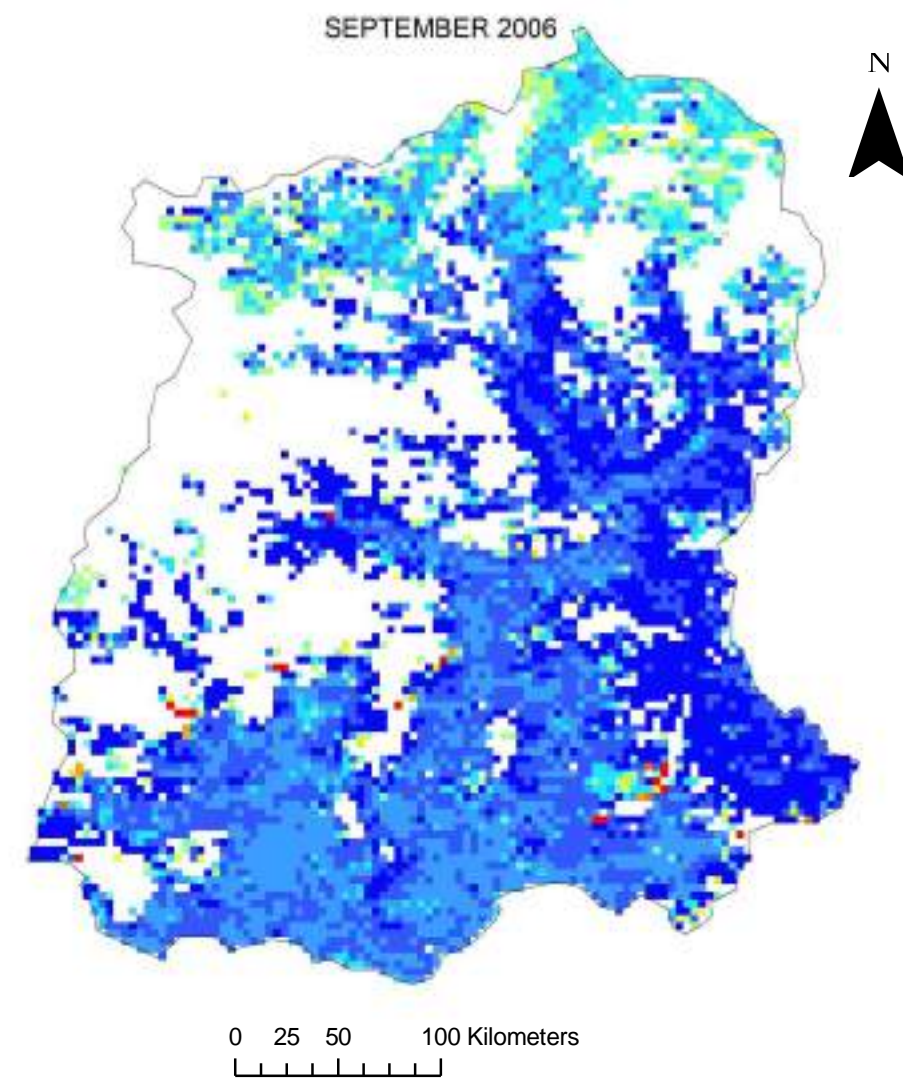
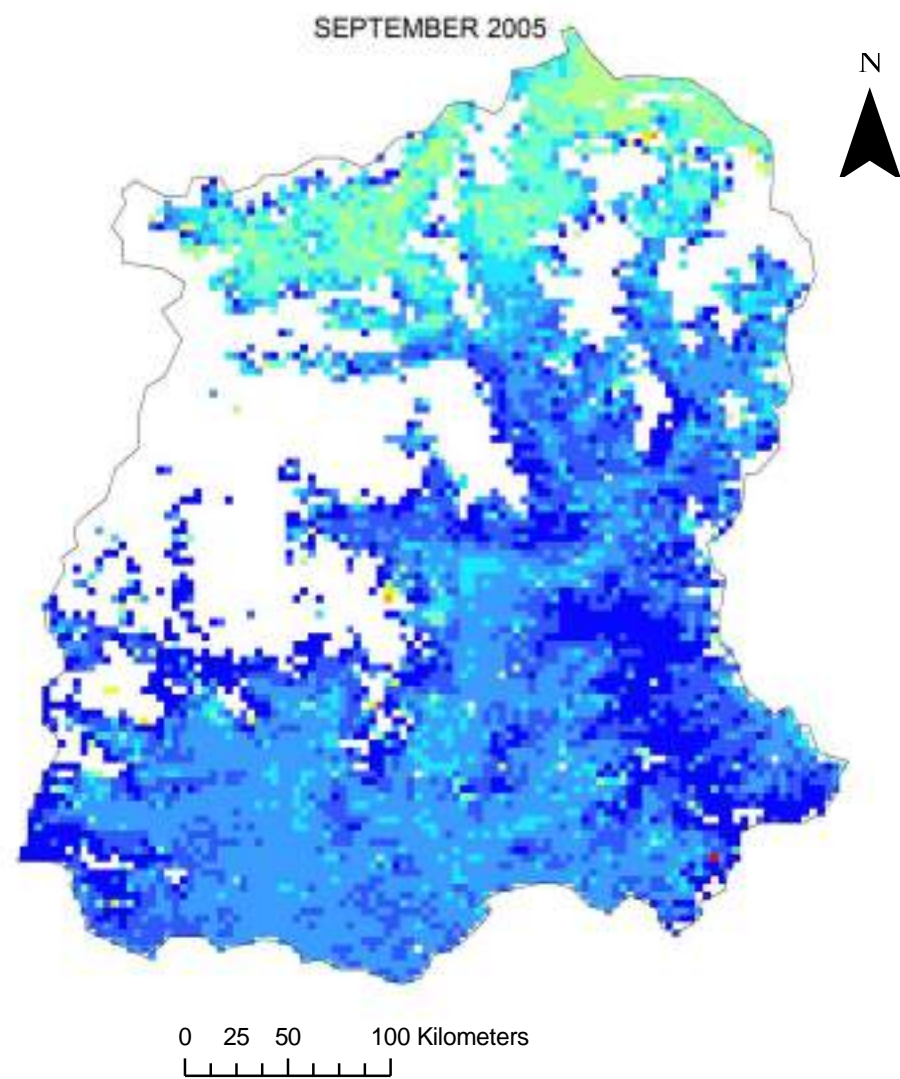


**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



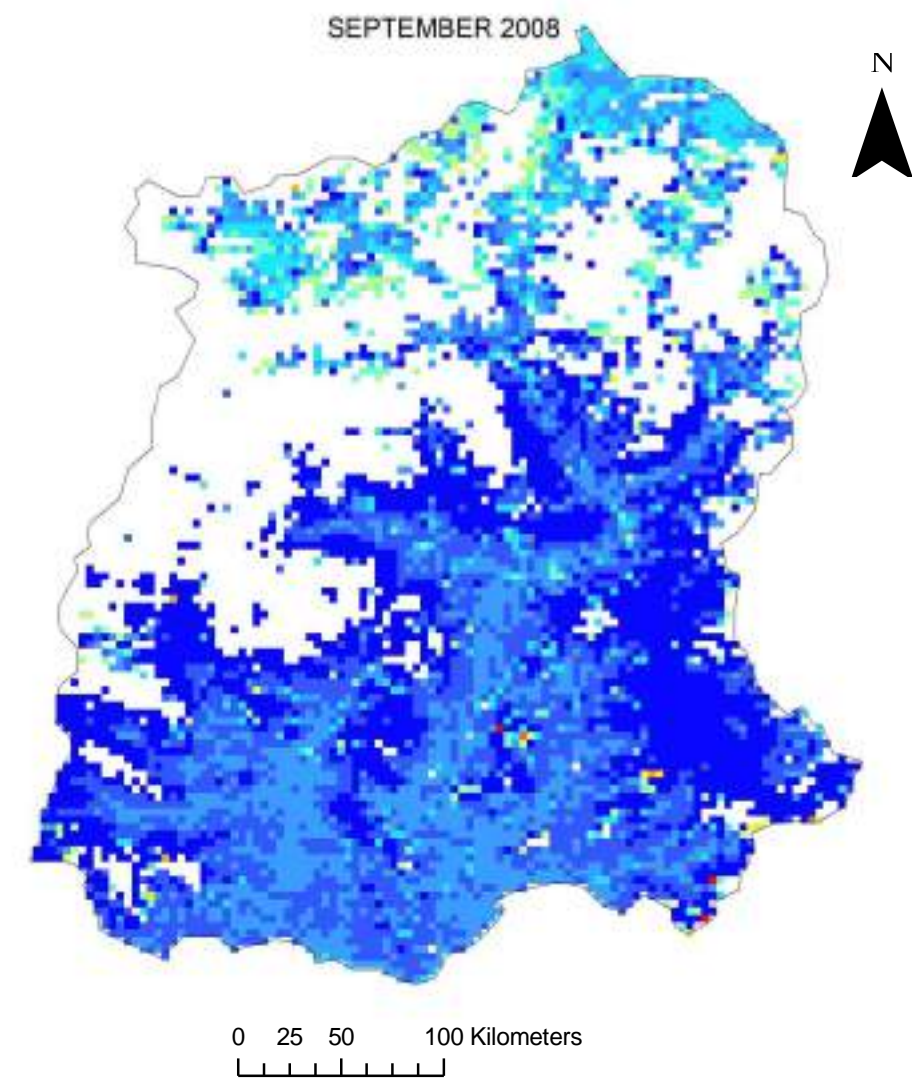
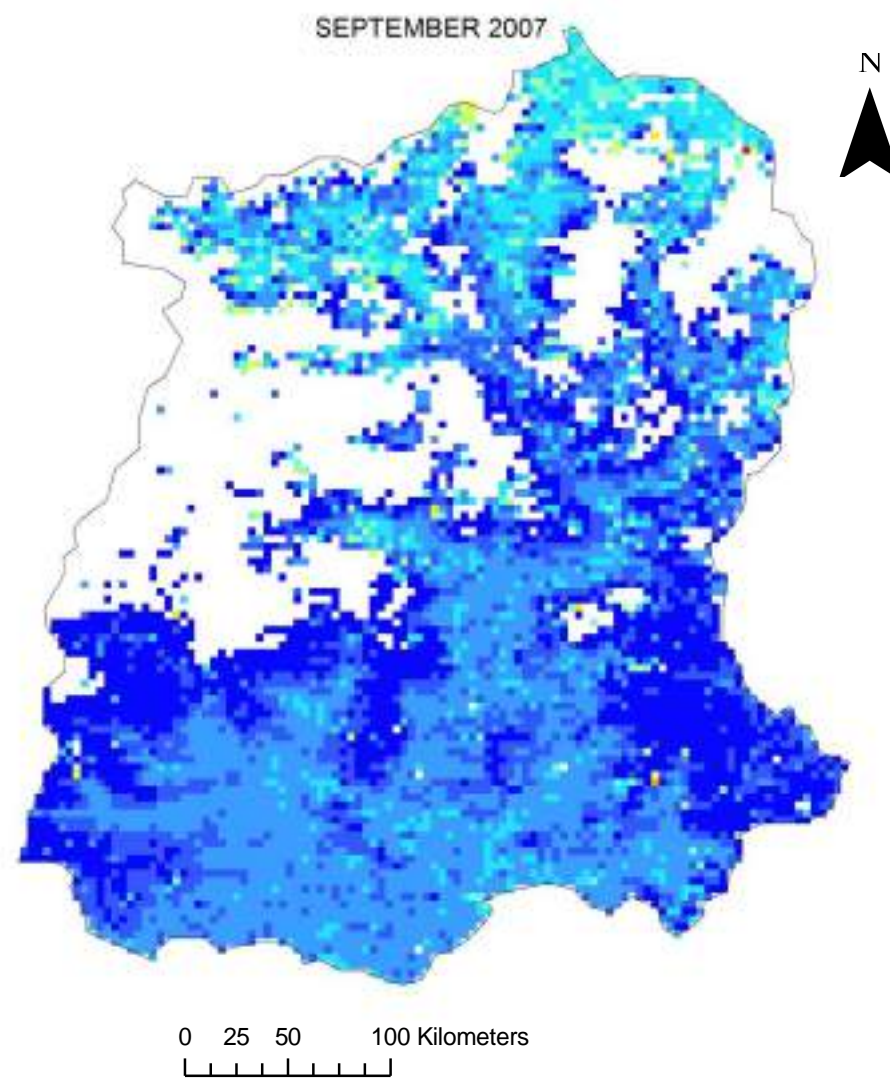
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

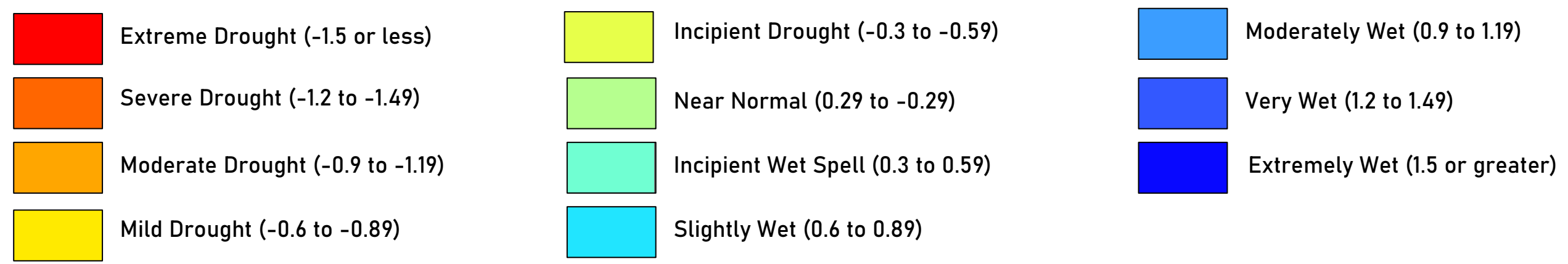
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

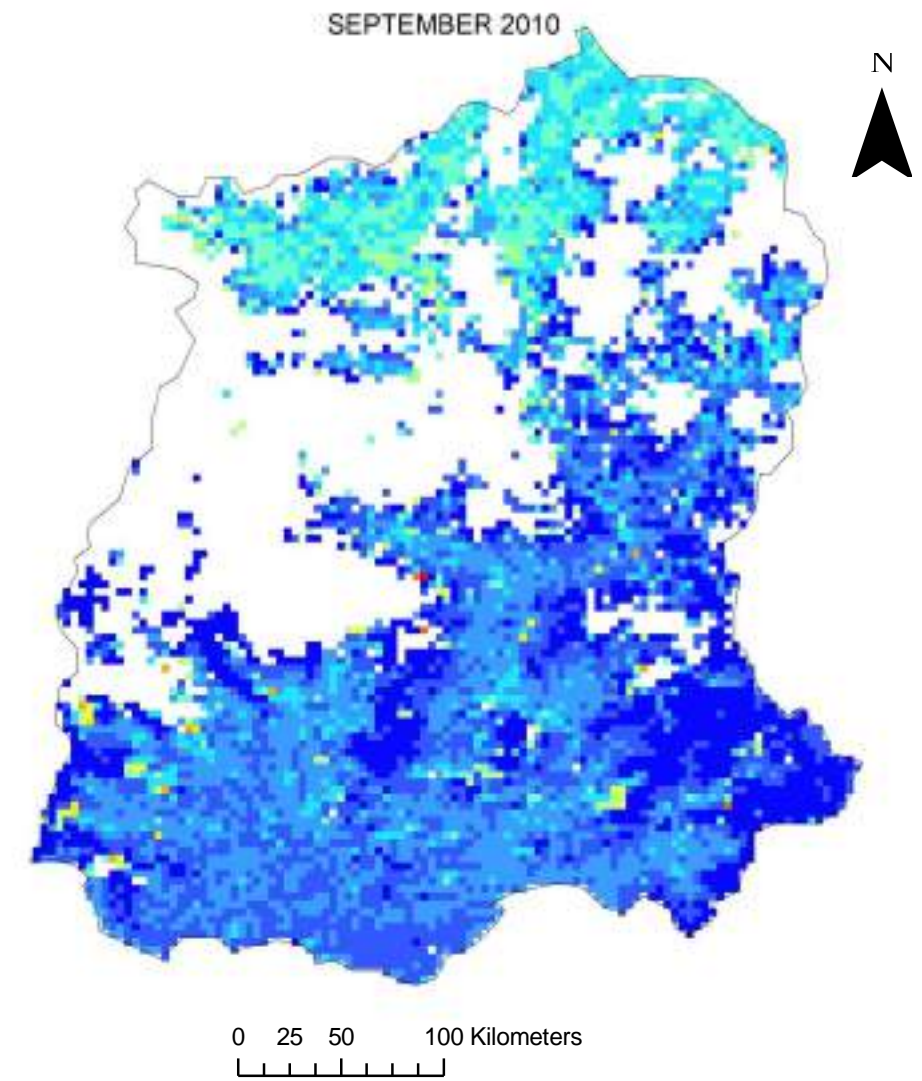
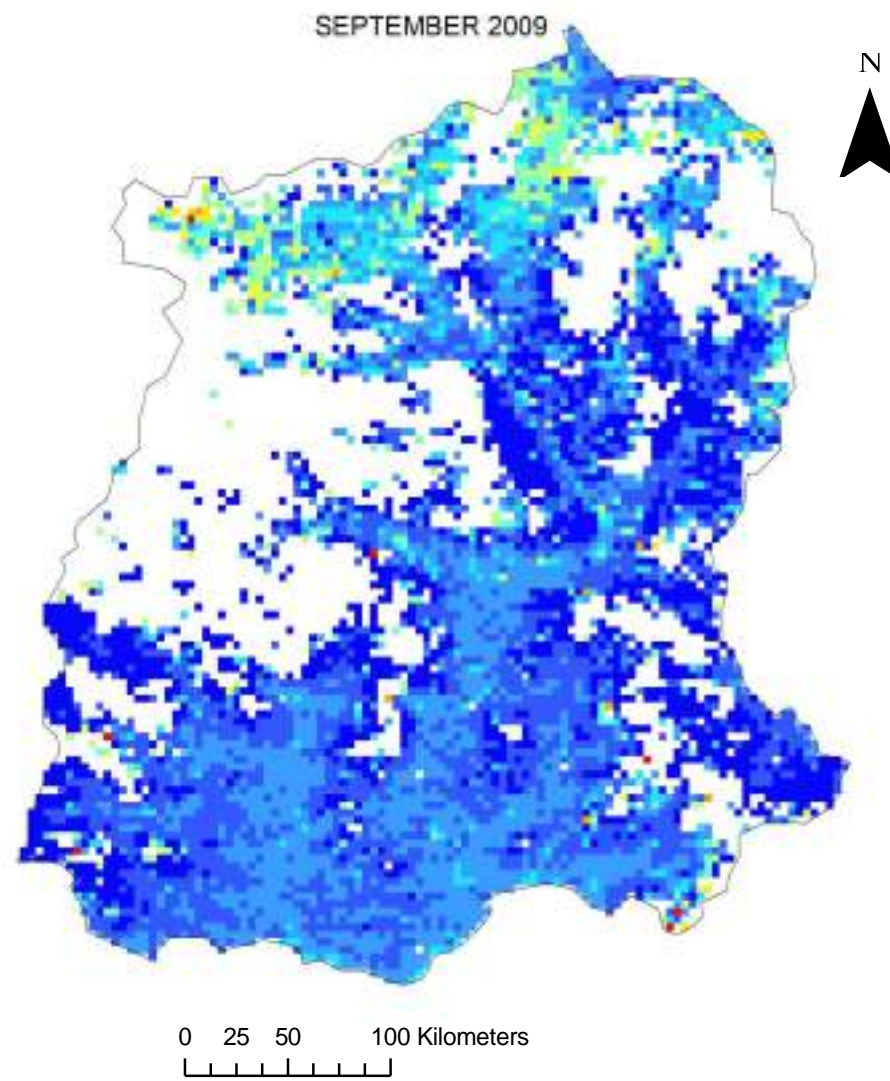
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



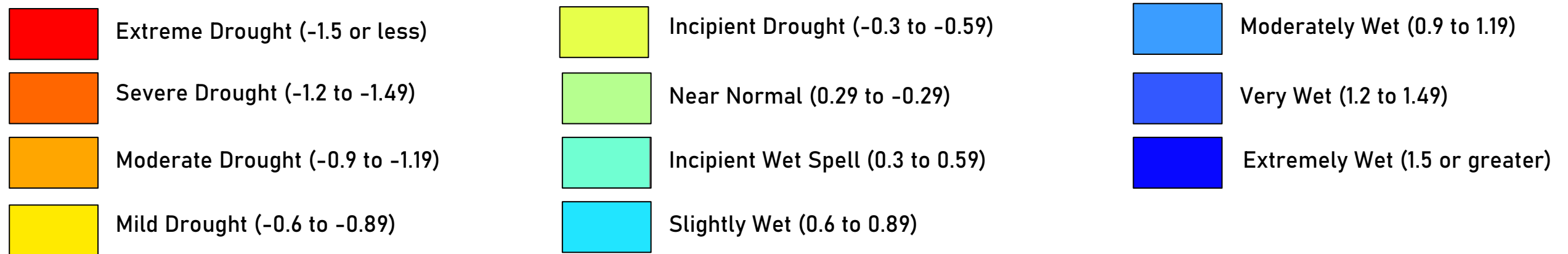


**Legend**

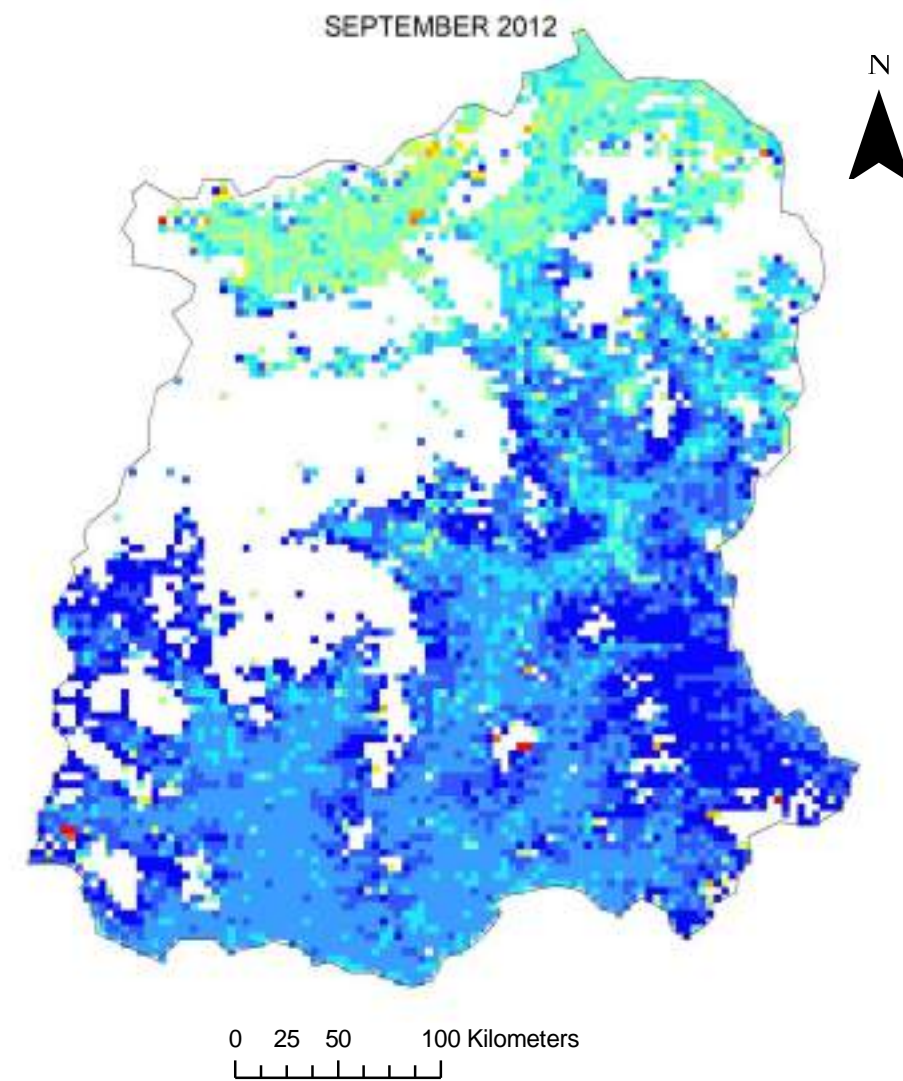
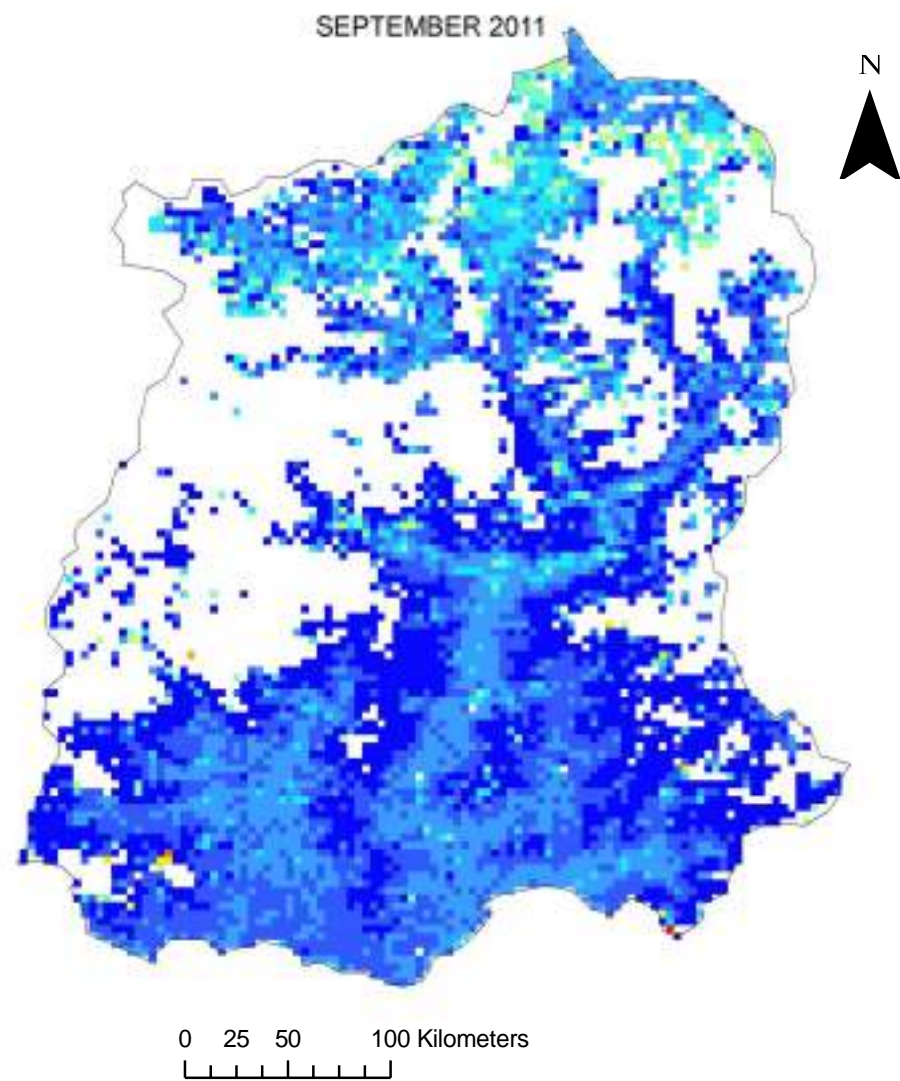




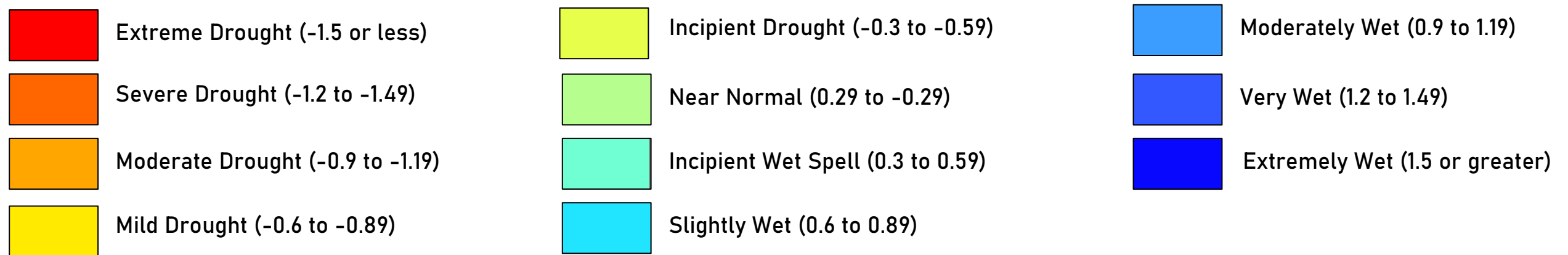
**Legend**

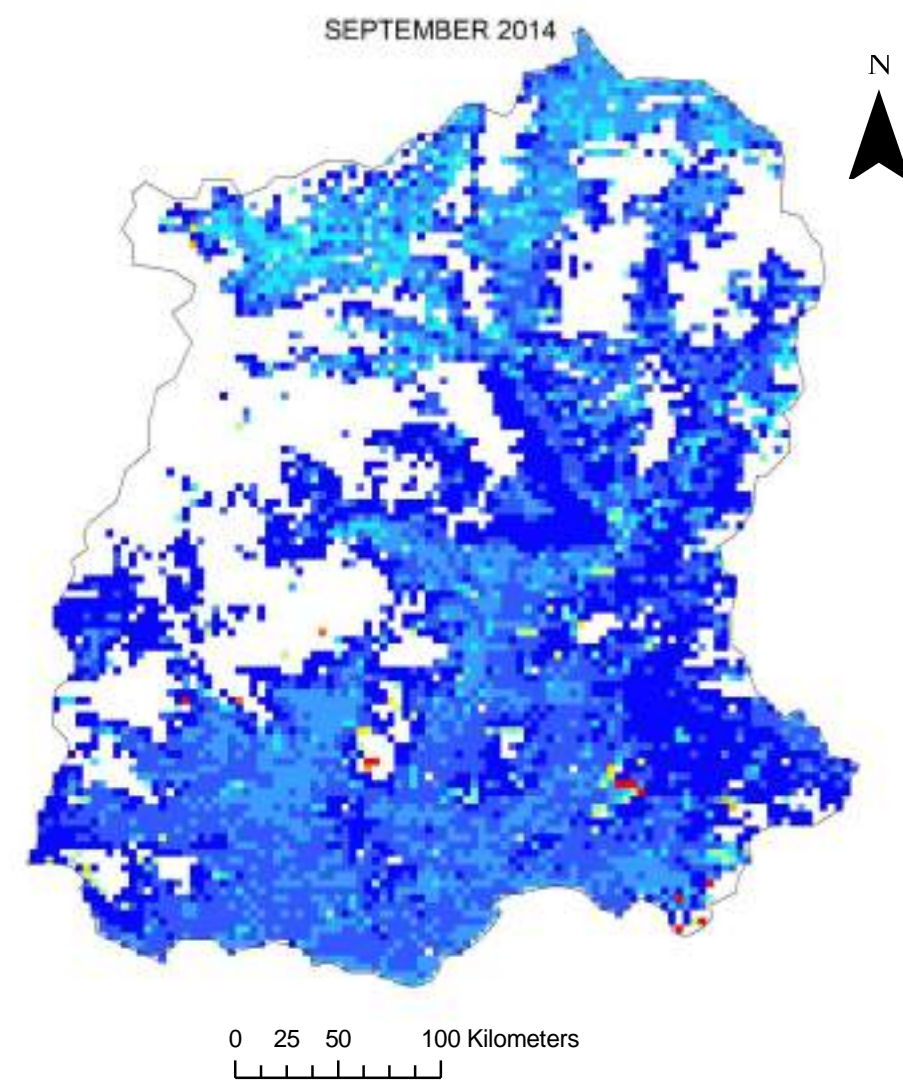
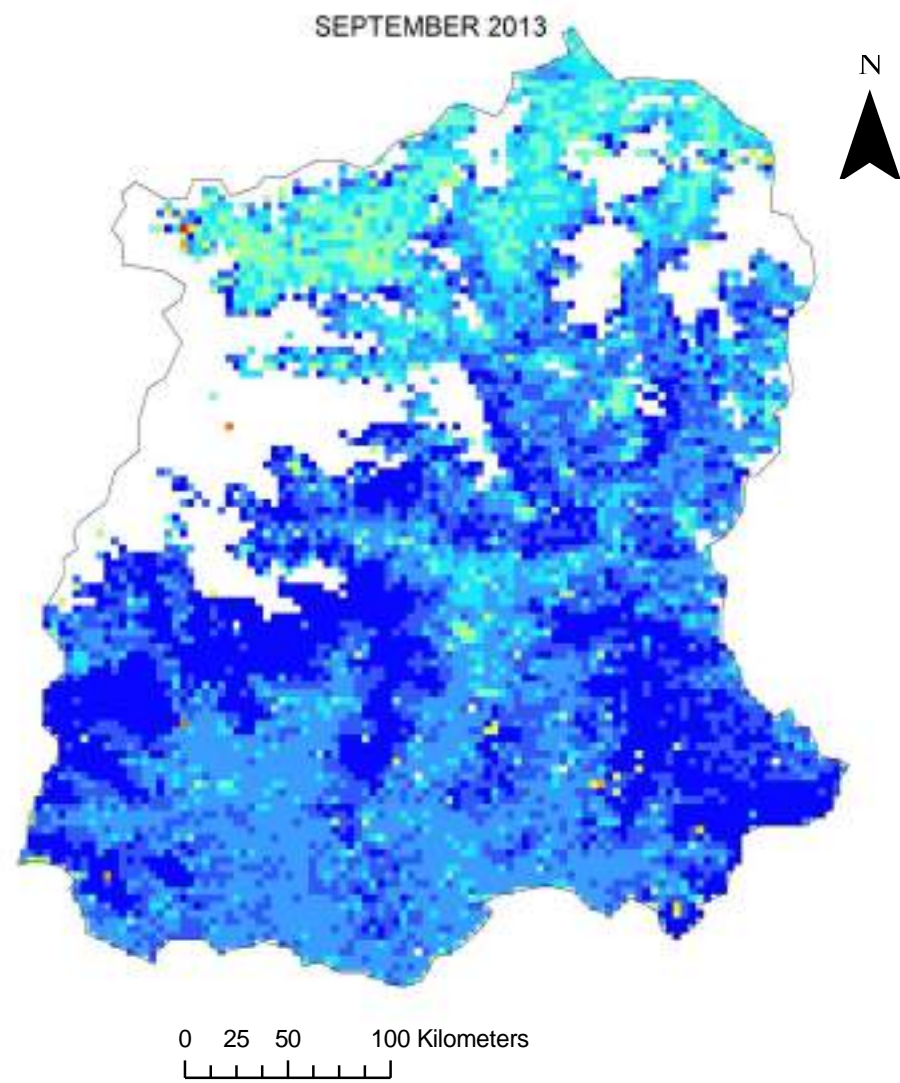




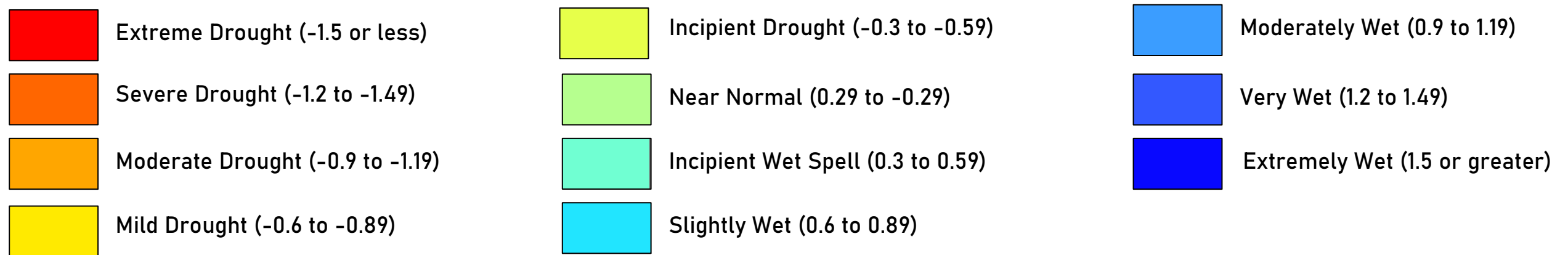


**Legend**

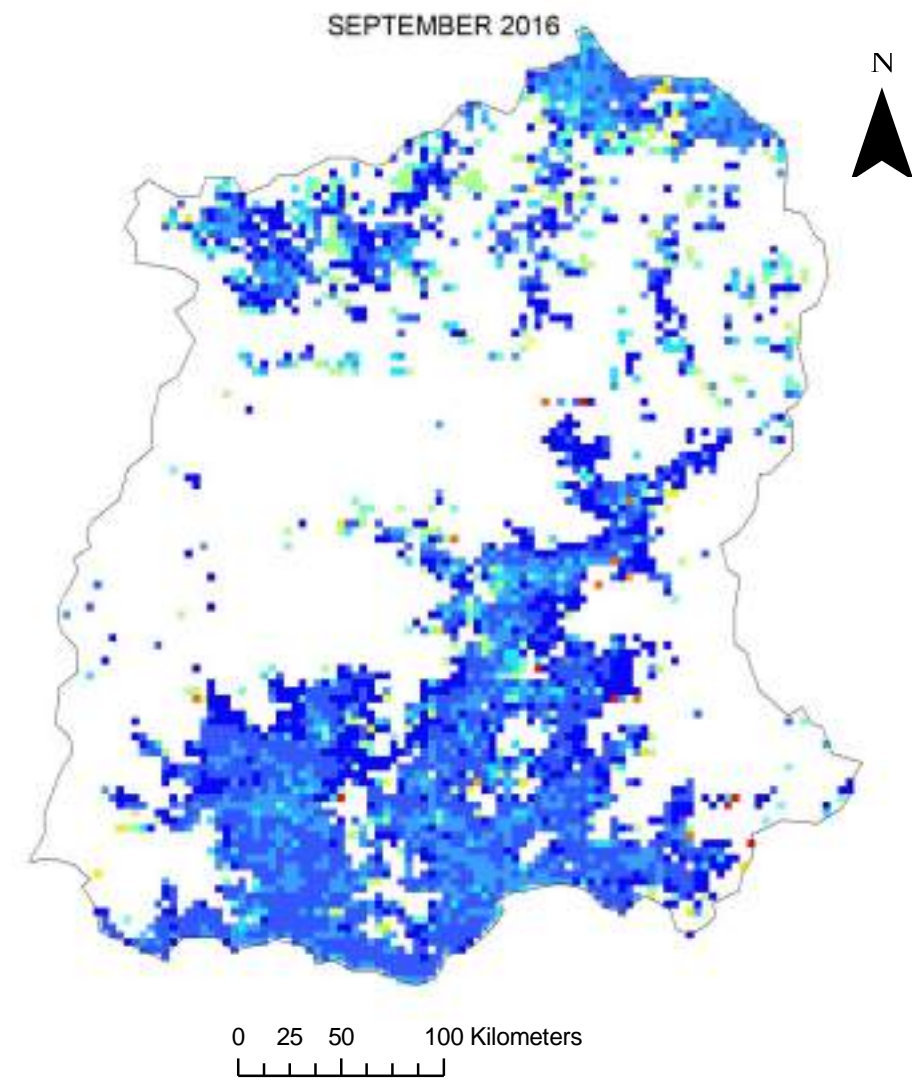
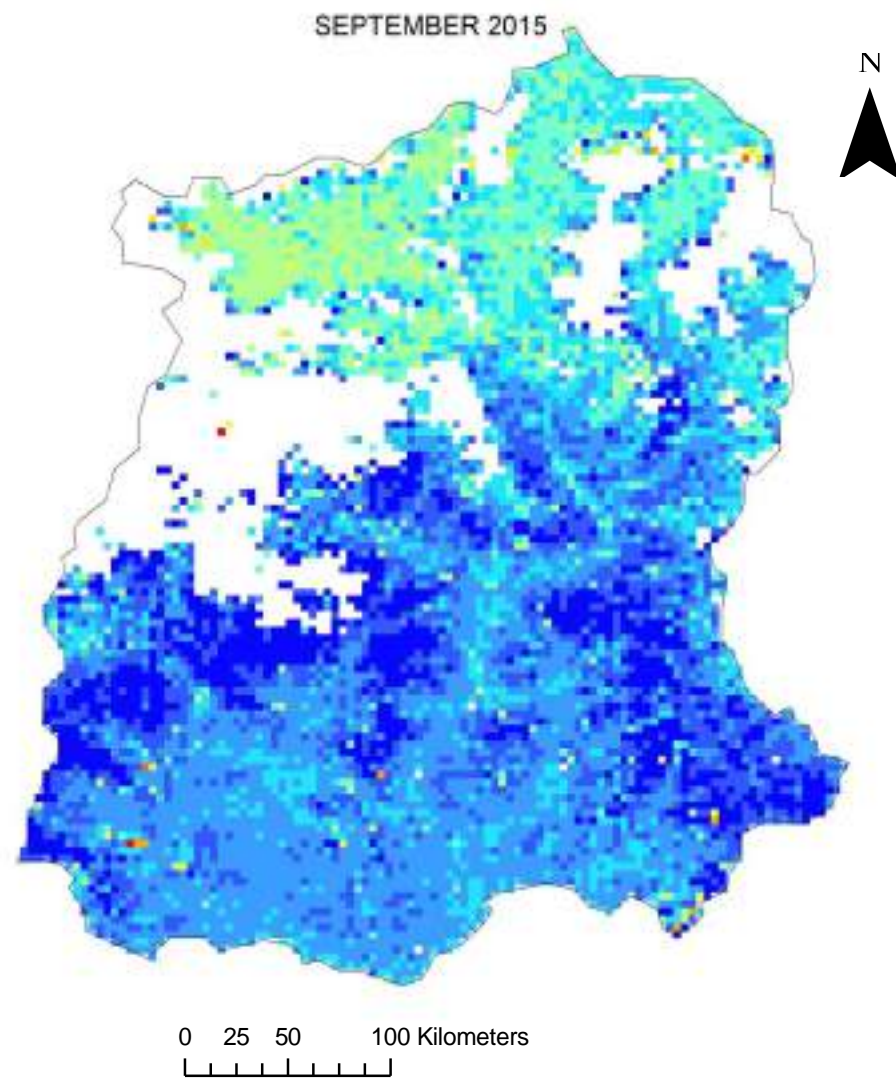




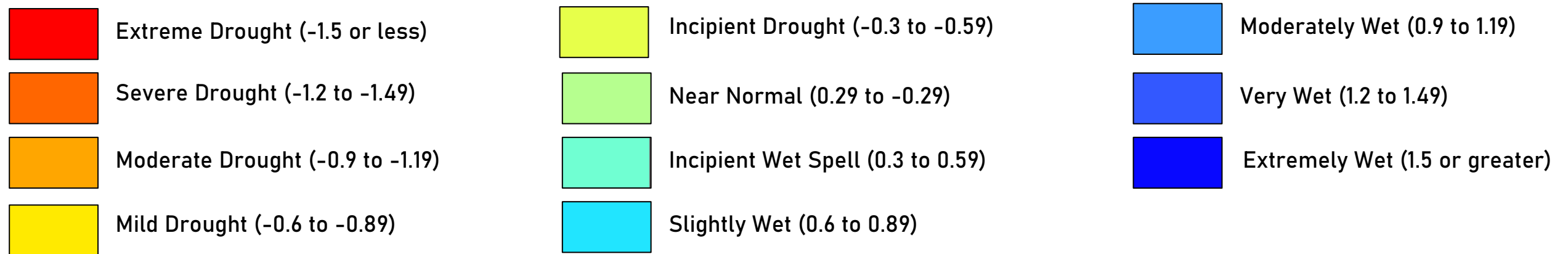
**Legend**

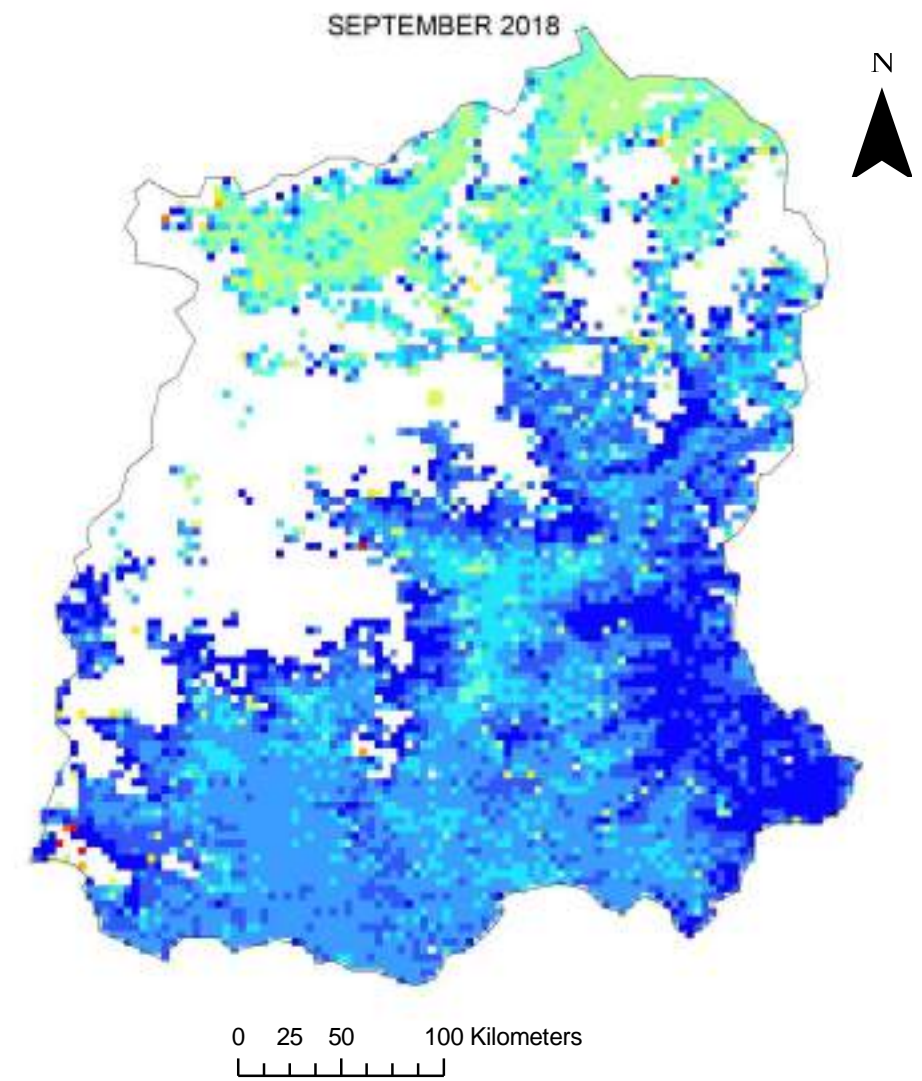
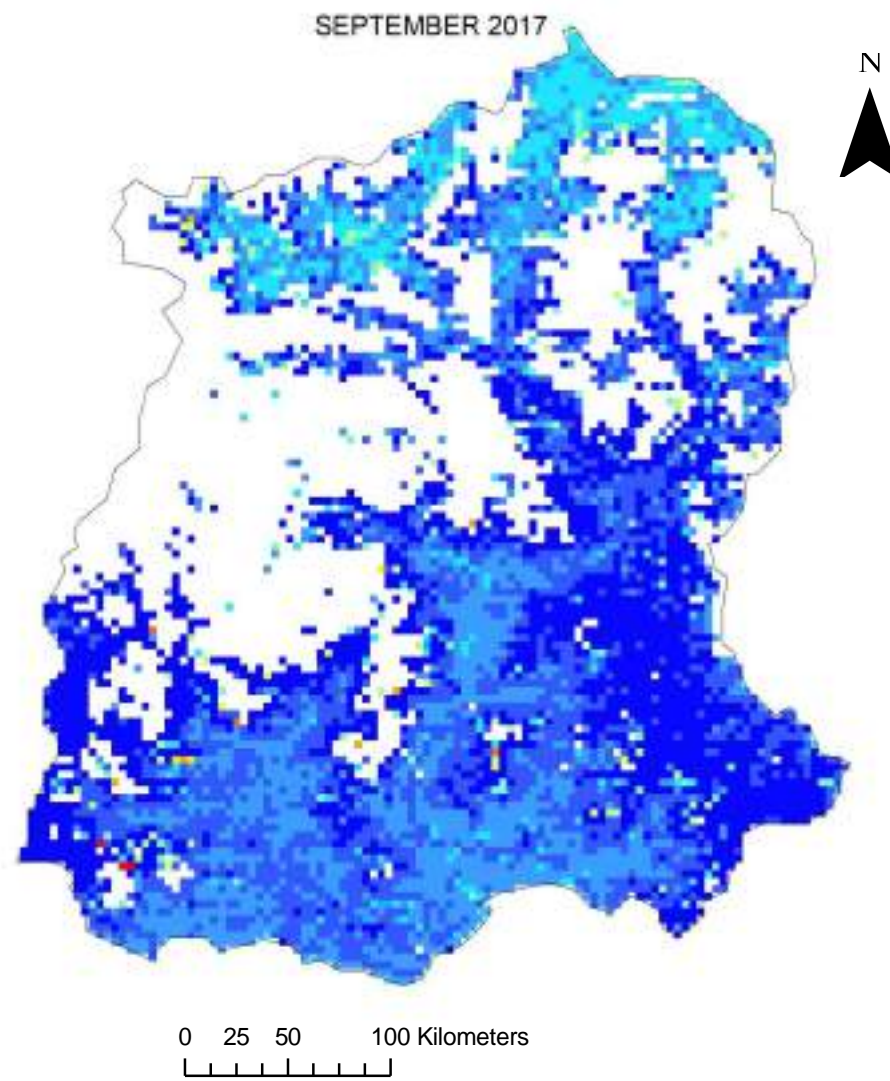




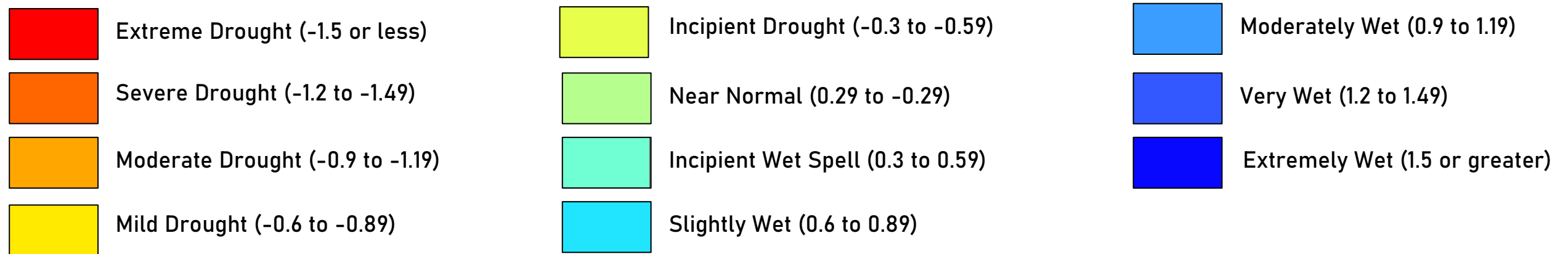


**Legend**

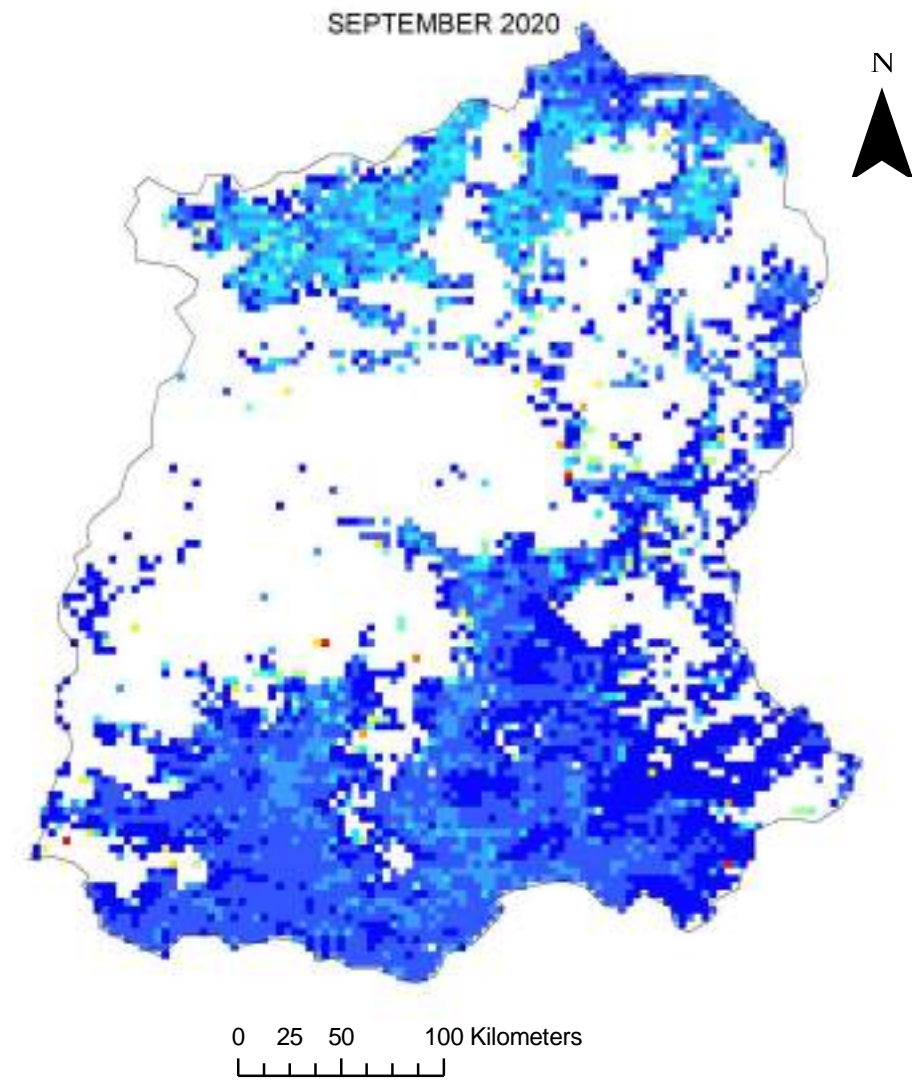
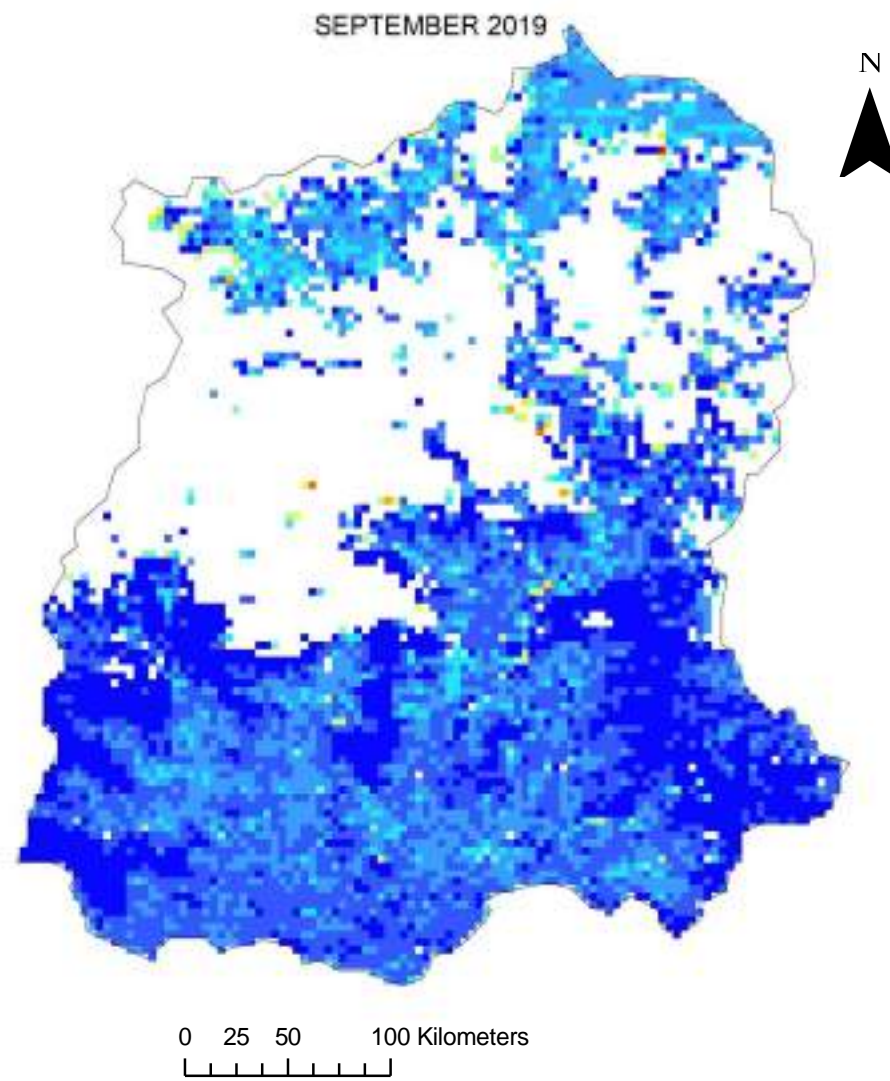




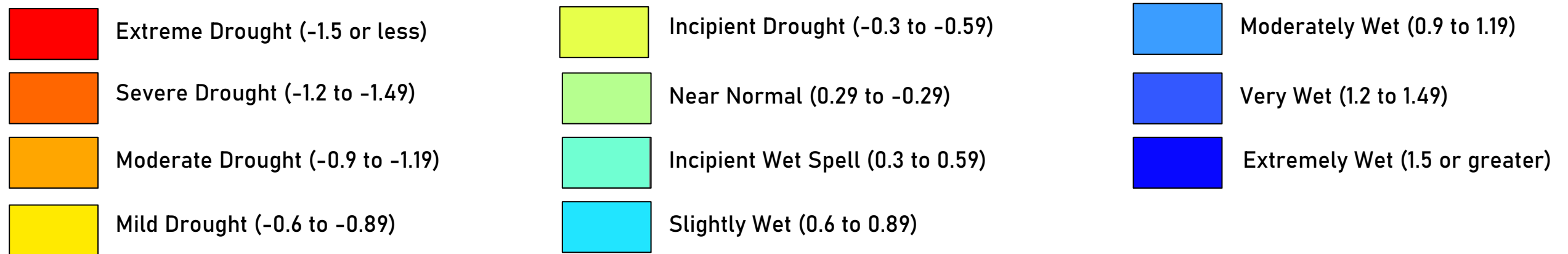
**Legend**







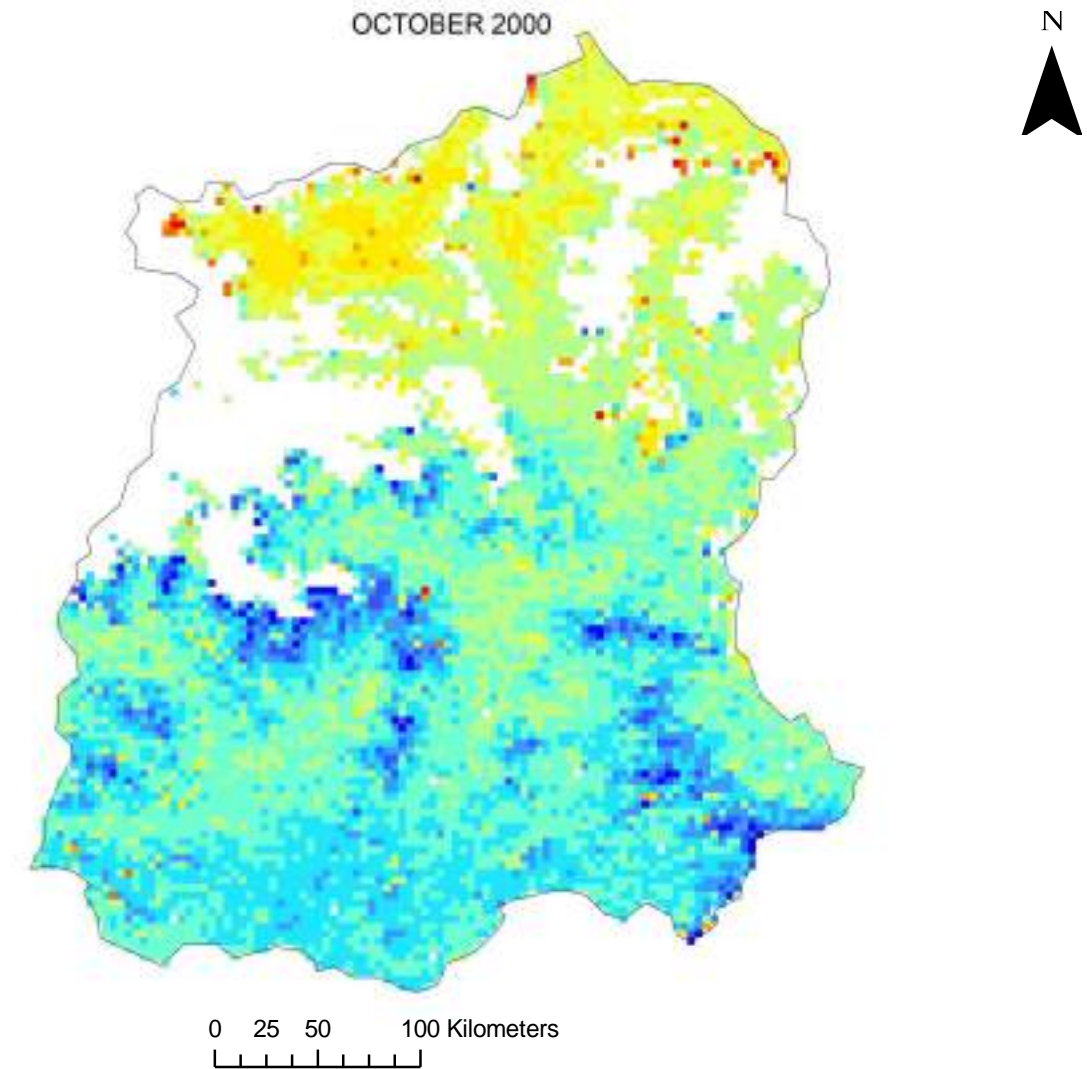
**Legend**



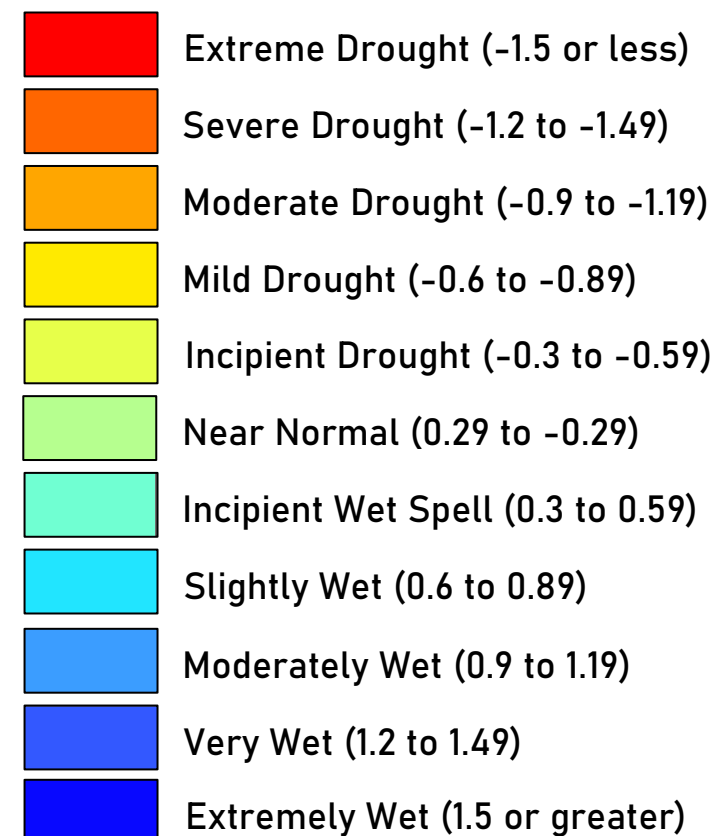
## October DSI Maps

Drought conditions in October vary from near normal to slightly wet condition. The characteristics of month are characterized by incipient wet spell.

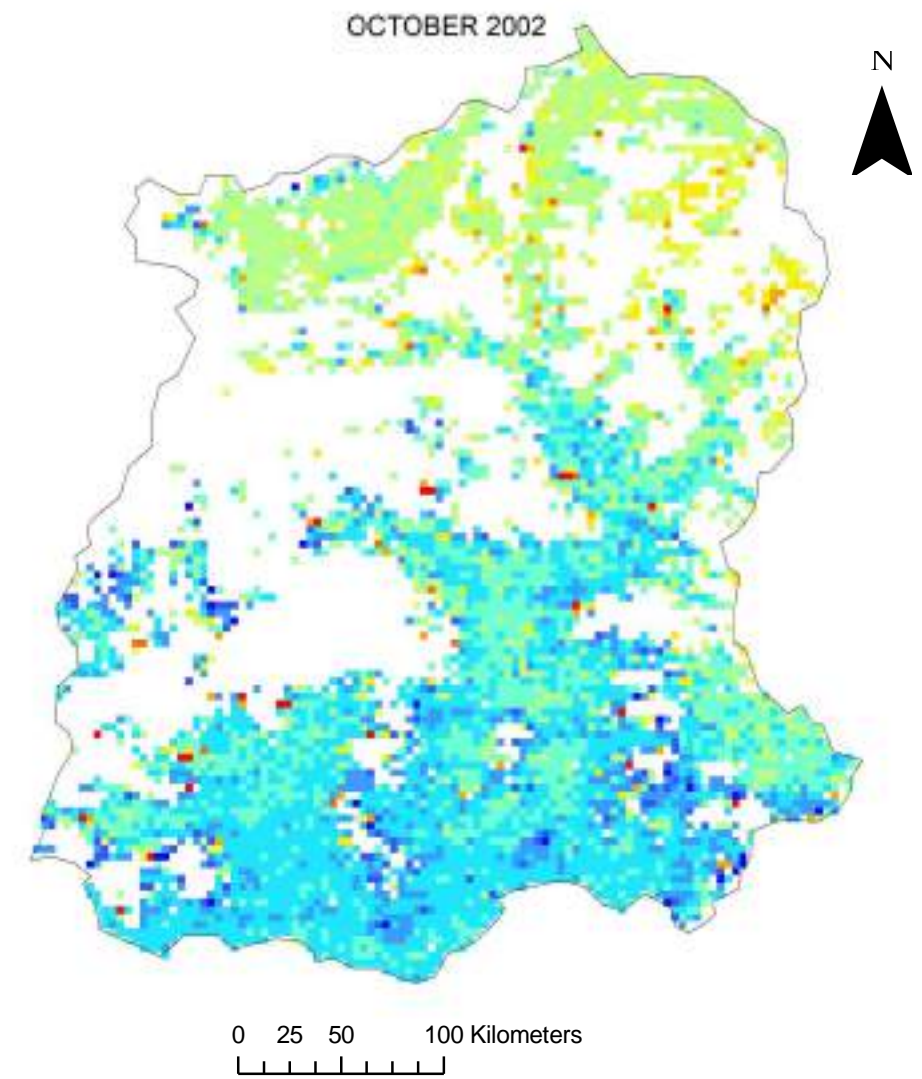
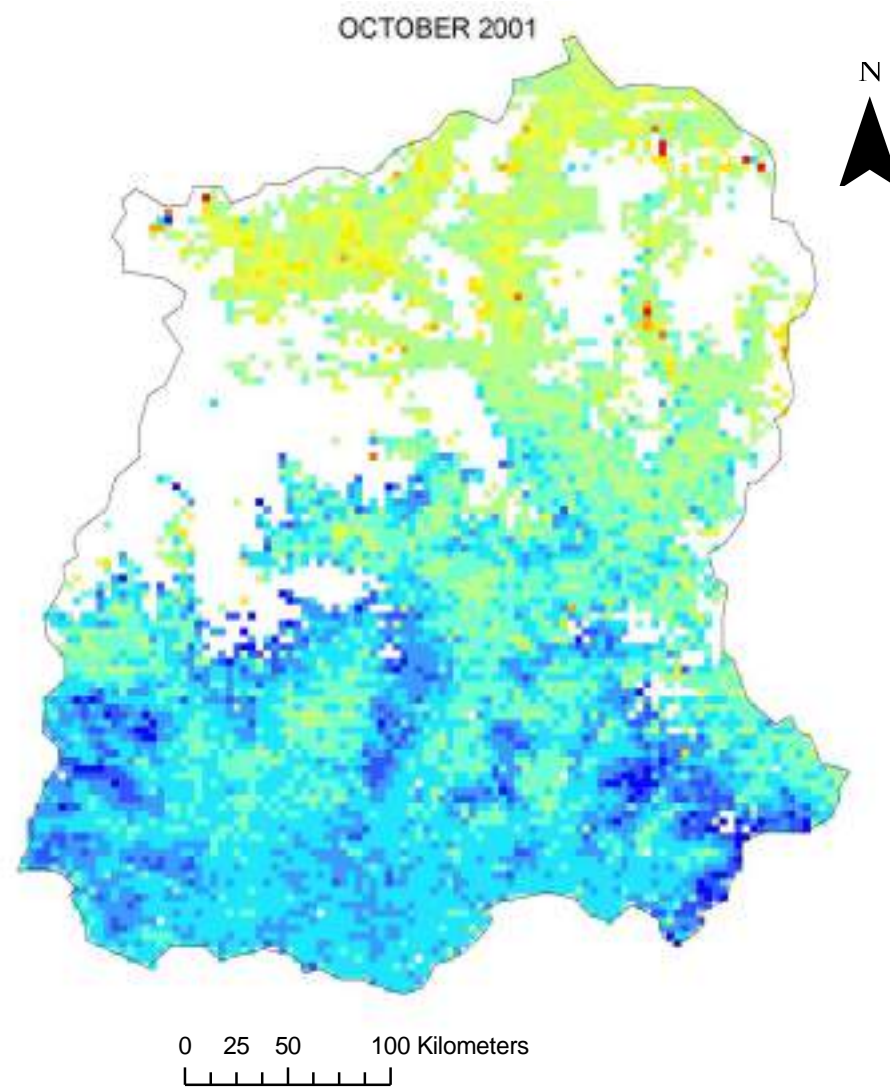
Mean October DSI Values		
Year	DSI Values	Drought Condition
2000	0.01	Near Normal
2001	0.26	Near Normal
2002	0.38	Incipient Wet Spell
2003	0.26	Near Normal
2004	0.54	Incipient Wet Spell
2005	0.08	Near Normal
2006	0.38	Incipient Wet Spell
2007	0.67	Slightly Wet
2008	0.40	Incipient Wet Spell
2009	0.12	Near Normal
2010	0.30	Incipient Wet Spell
2011	0.36	Incipient Wet Spell
2012	-0.15	Near Normal
2013	0.76	Slightly Wet
2014	0.48	Incipient Wet Spell
2015	0.30	Incipient Wet Spell
2016	0.07	Near Normal
2017	0.52	Incipient Wet Spell
2018	-0.03	Near Normal
2019	0.38	Incipient Wet Spell
2020	0.12	Near Normal














### Legend

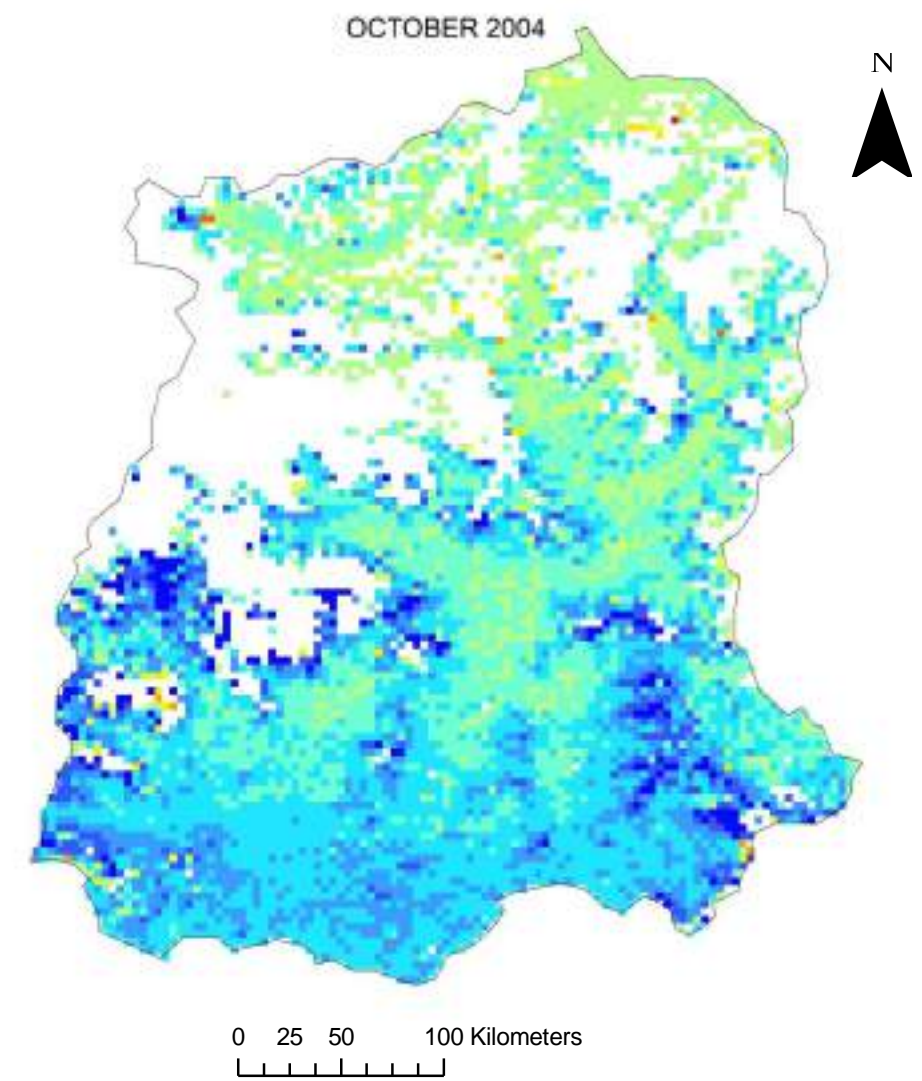
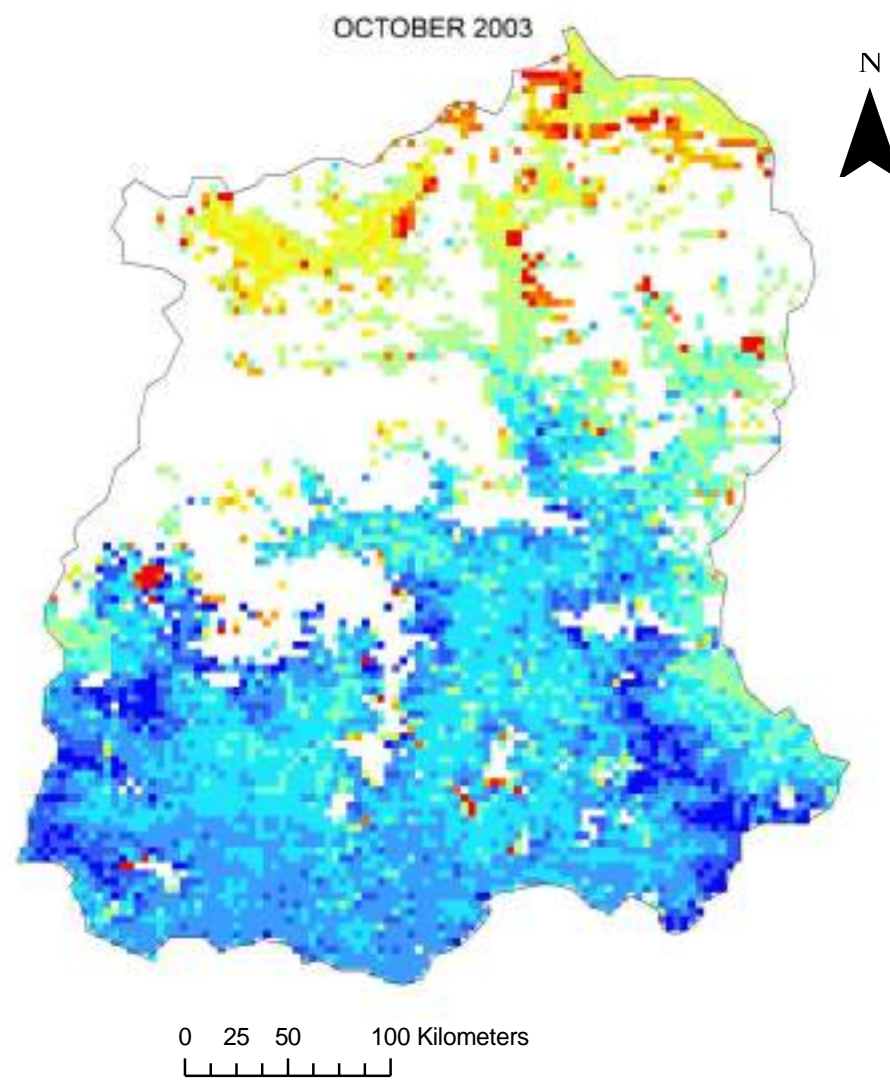











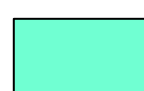





**Legend**

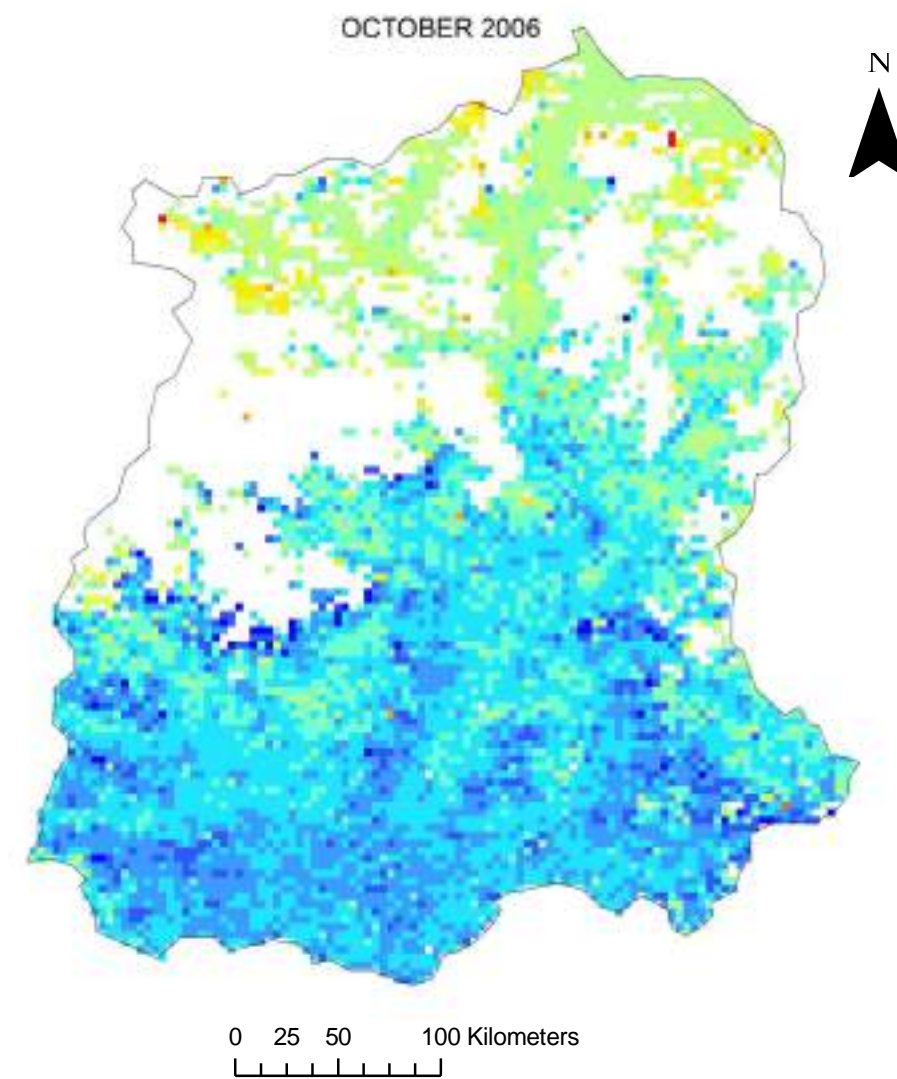
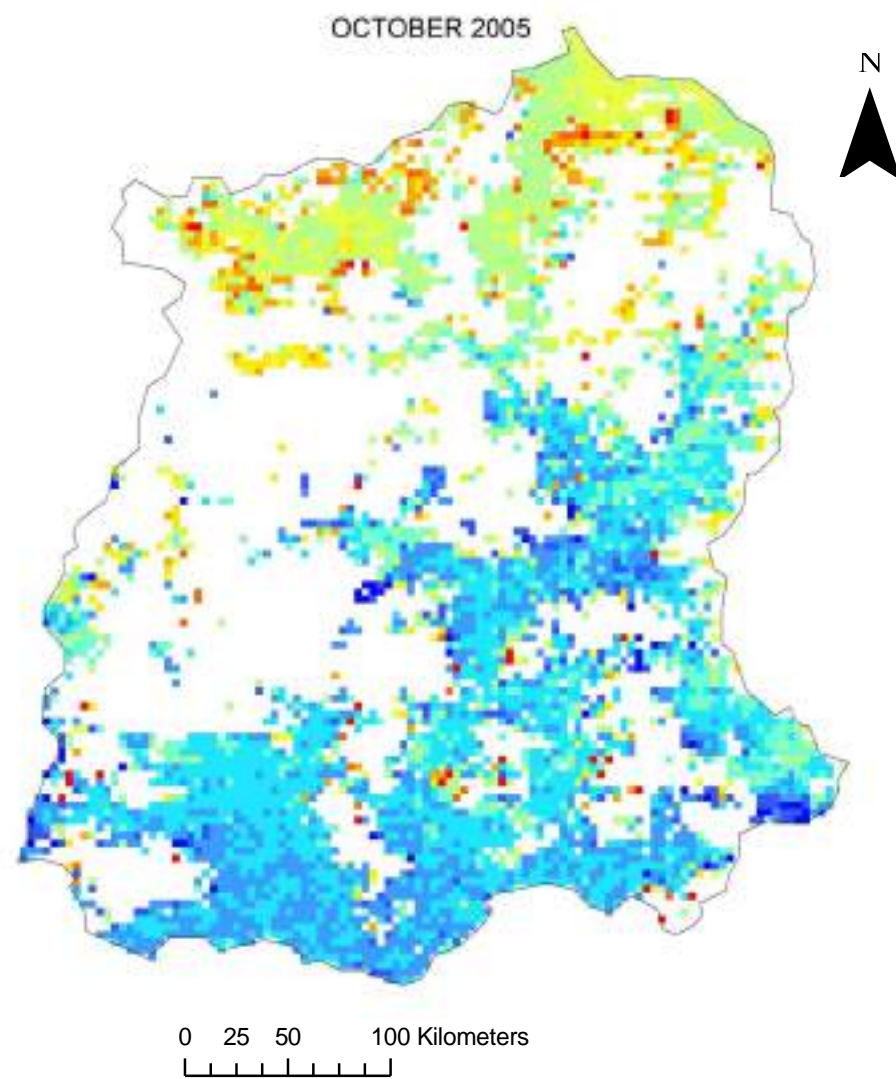
- |  |   |  |
|--|---|--|
|  Extreme Drought (-1.5 or less)   |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19)   |
|  Severe Drought (-1.2 to -1.49)   |  Near Normal (0.29 to -0.29)       |  Very Wet (1.2 to 1.49)         |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89)     |  Slightly Wet (0.6 to 0.89)        |  |



**Legend**

- |  |   |  |
|--|---|--|
|  Extreme Drought (-1.5 or less)   |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19)   |
|  Severe Drought (-1.2 to -1.49)   |  Near Normal (0.29 to -0.29)       |  Very Wet (1.2 to 1.49)         |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89)     |  Slightly Wet (0.6 to 0.89)        |  |



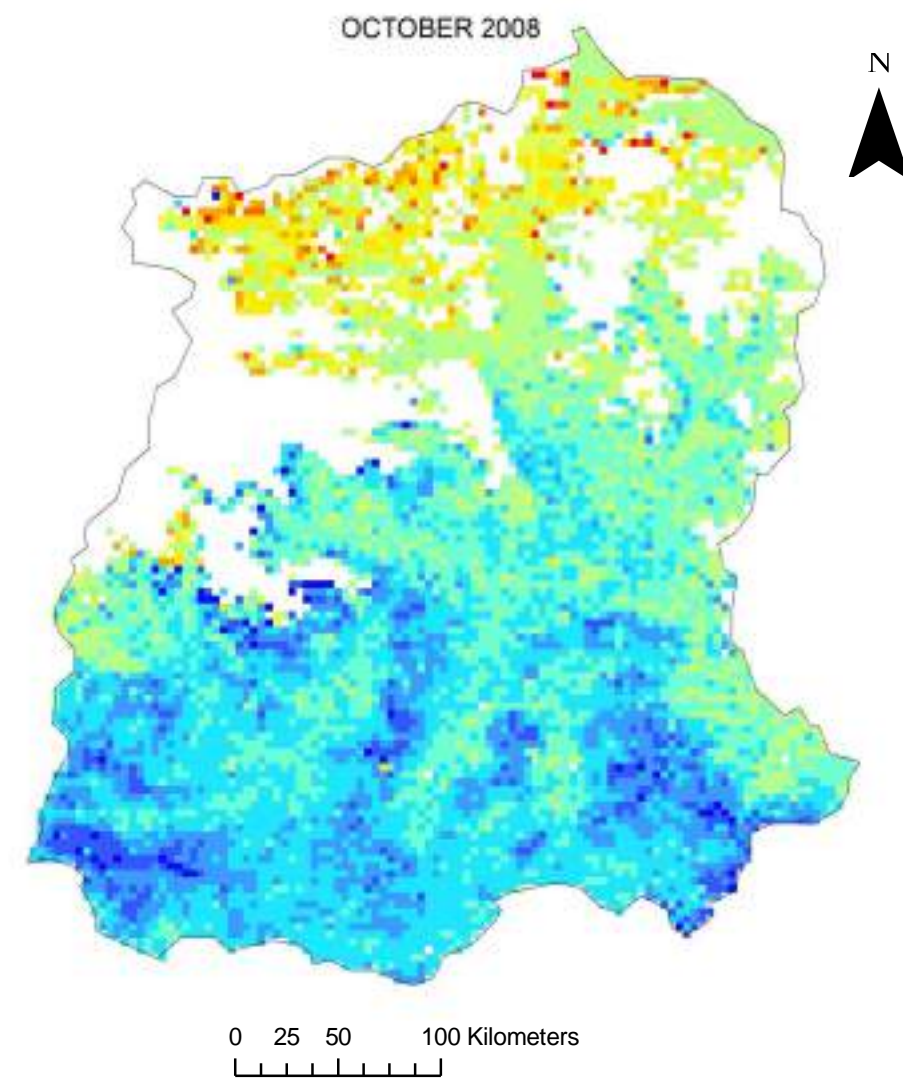
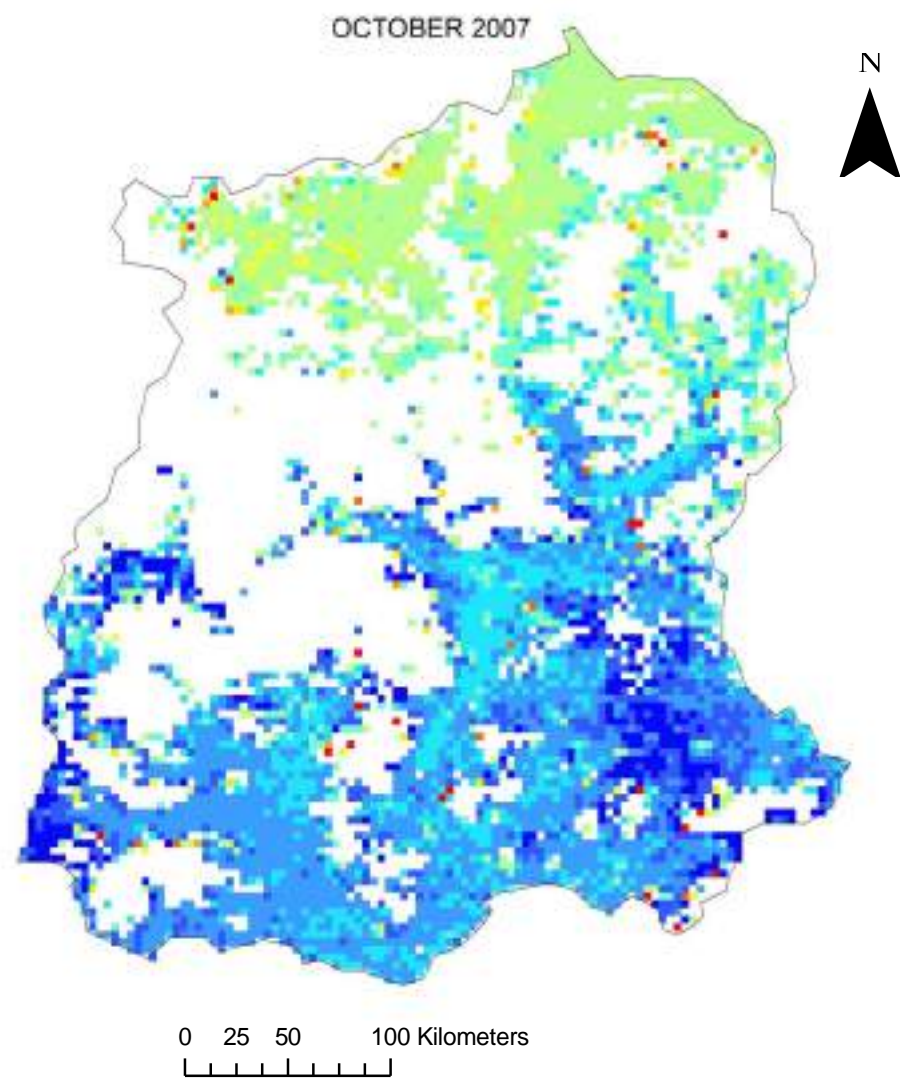


**Legend**

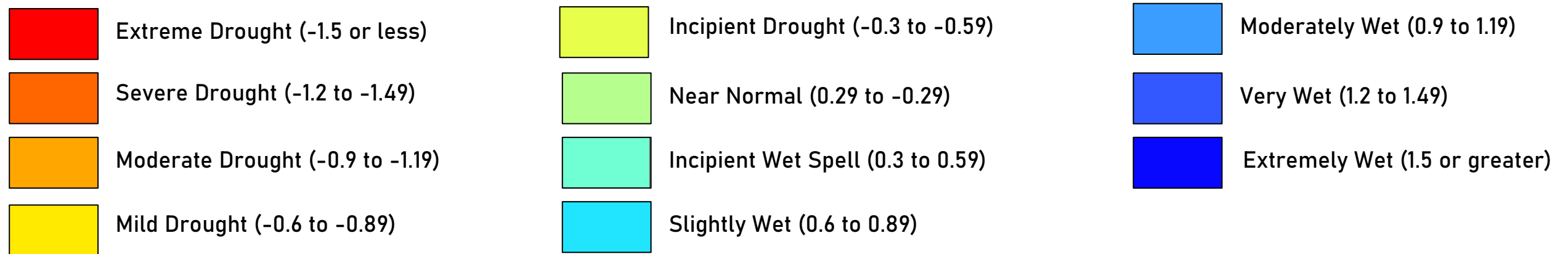
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

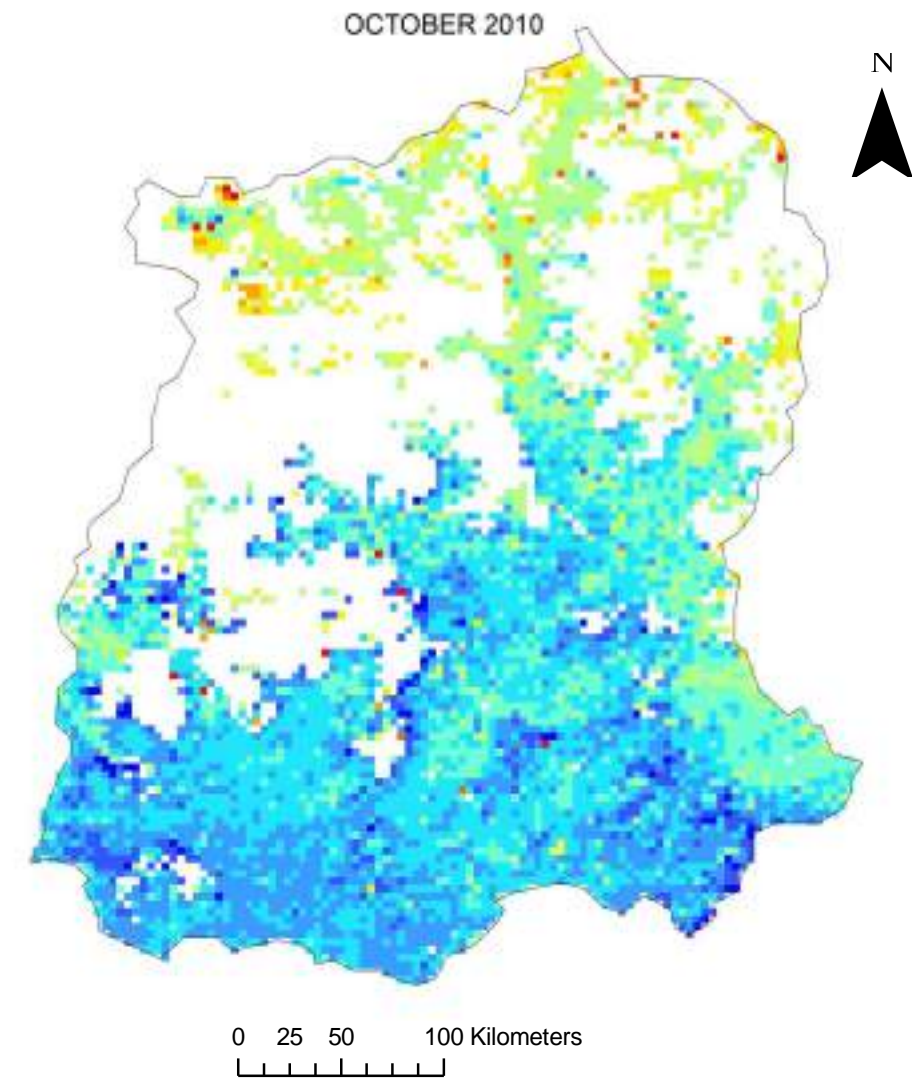
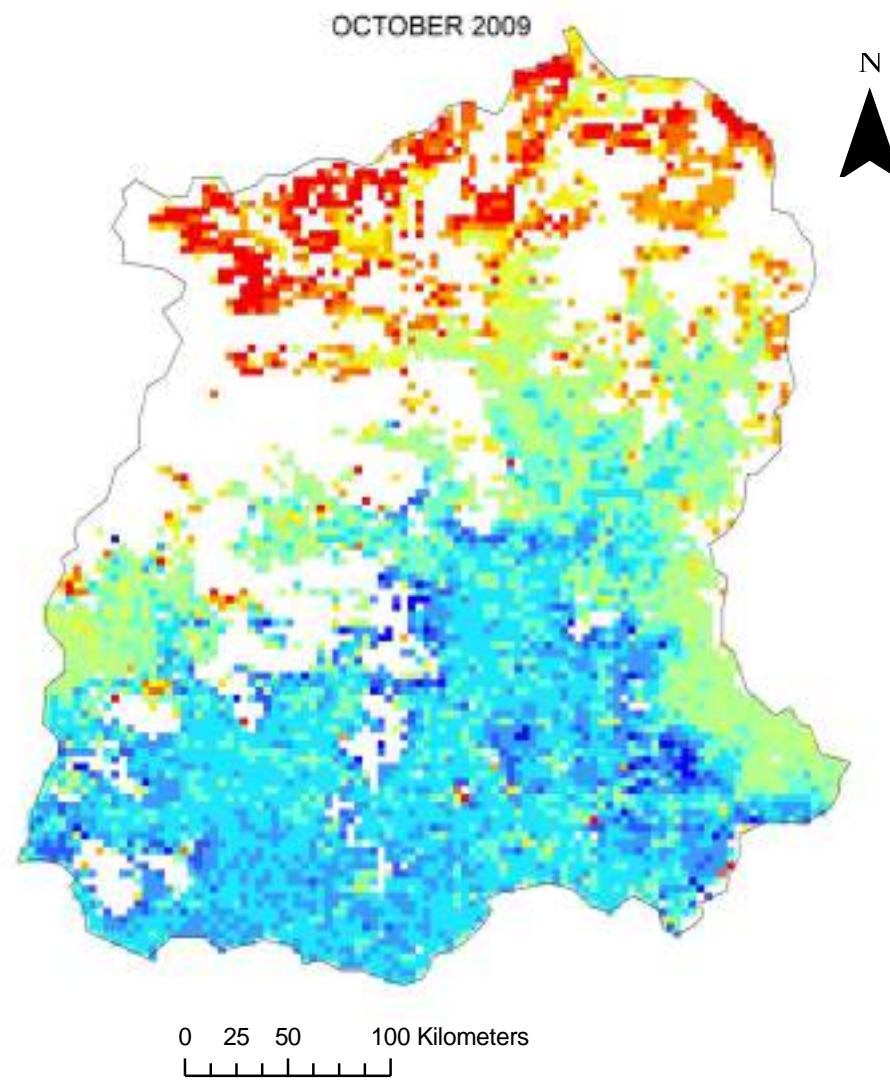
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



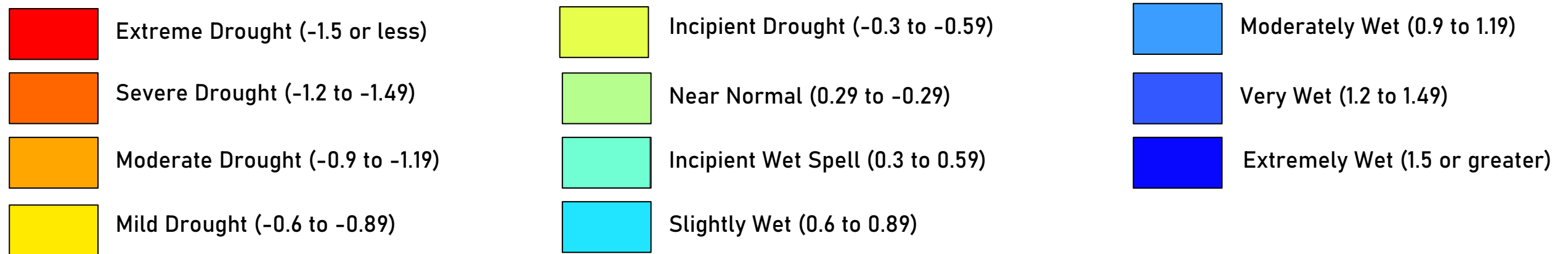
**Legend**

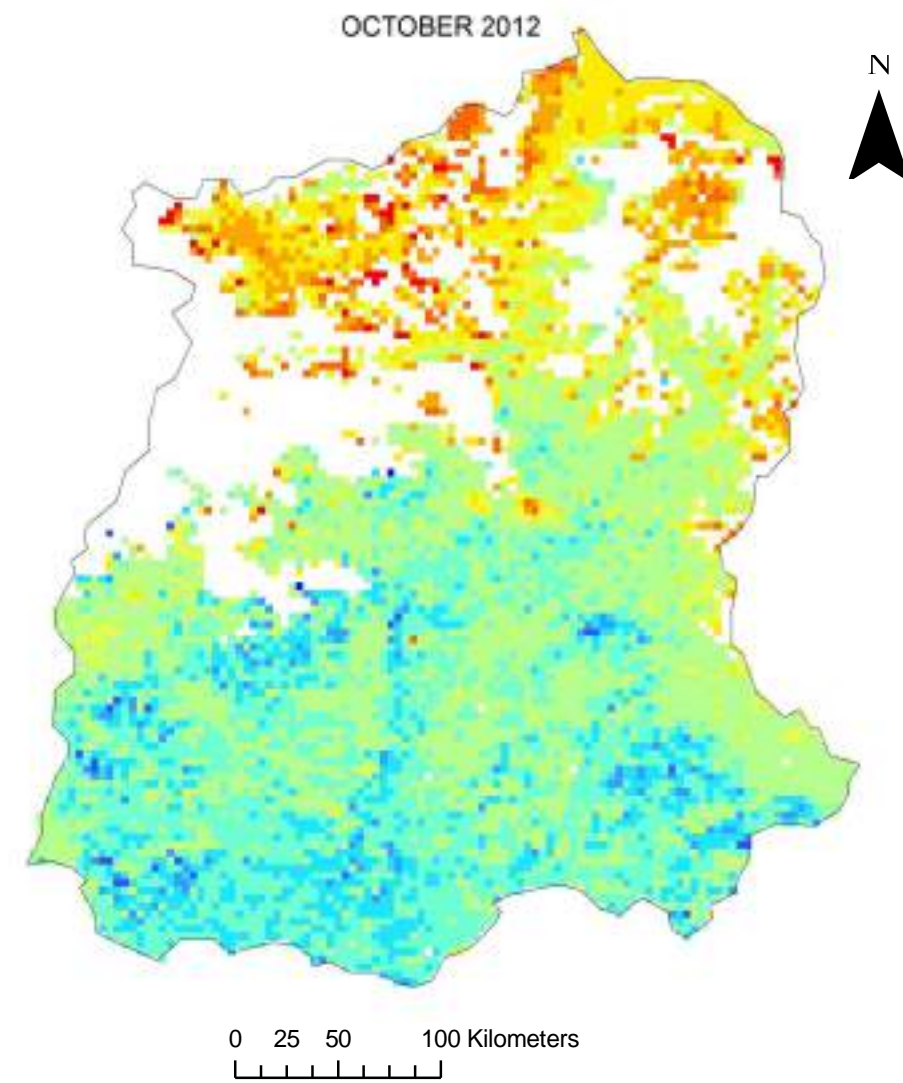
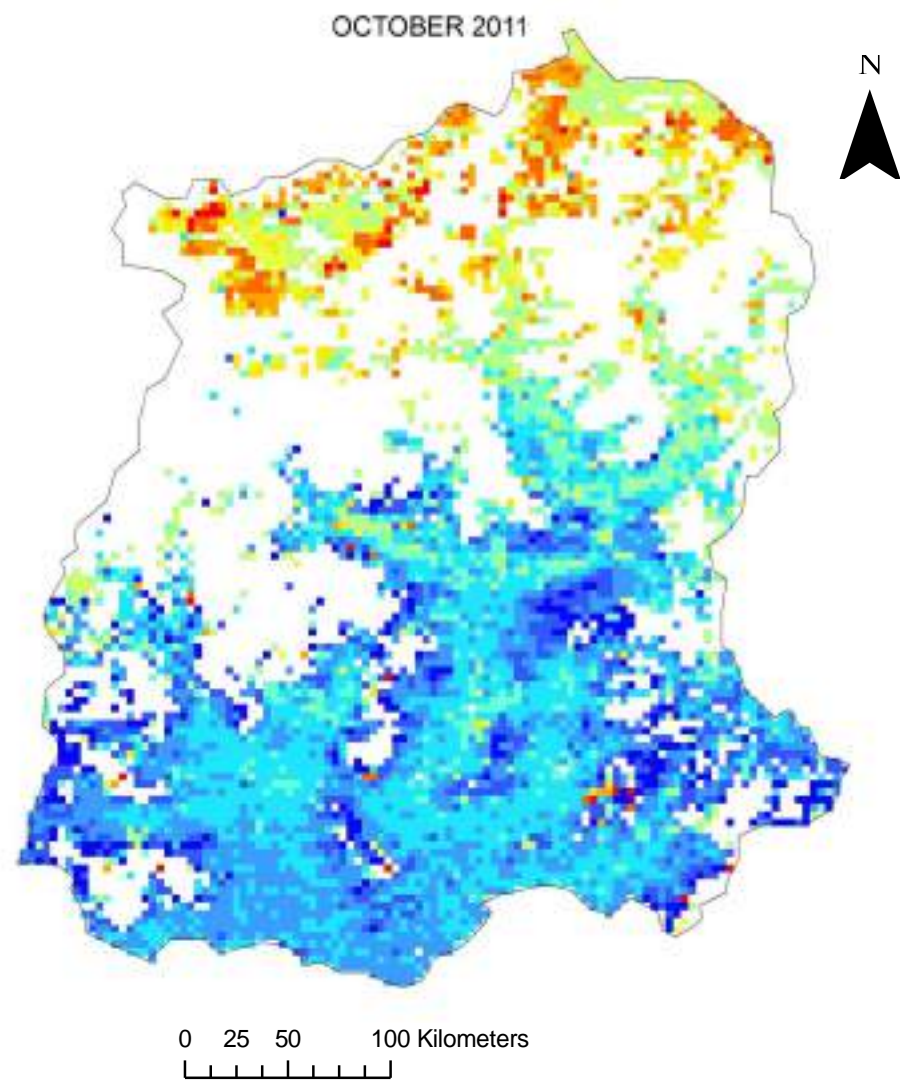




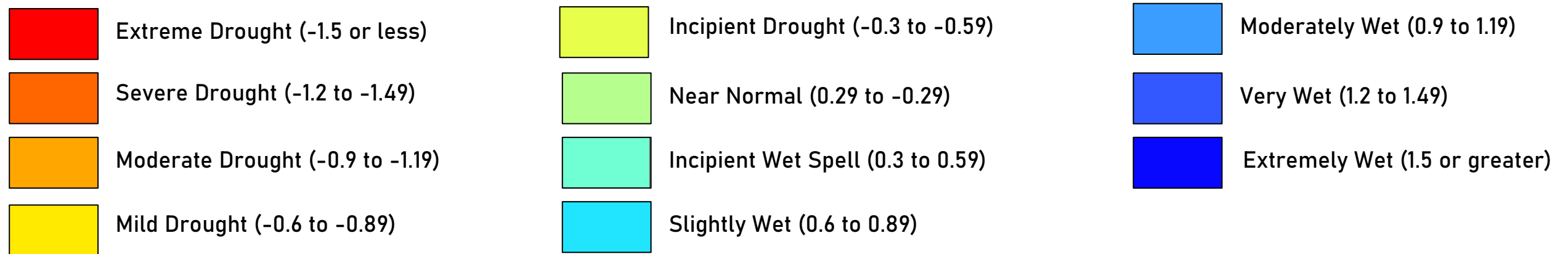


**Legend**

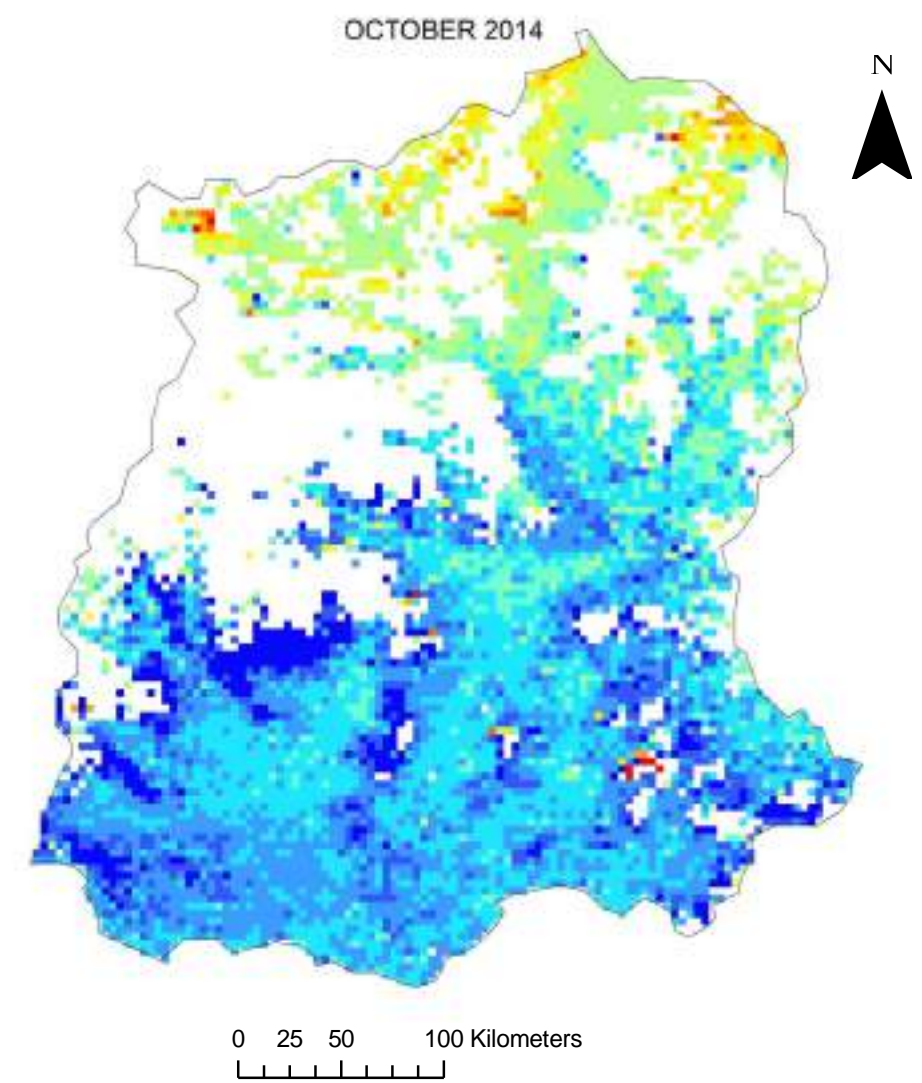
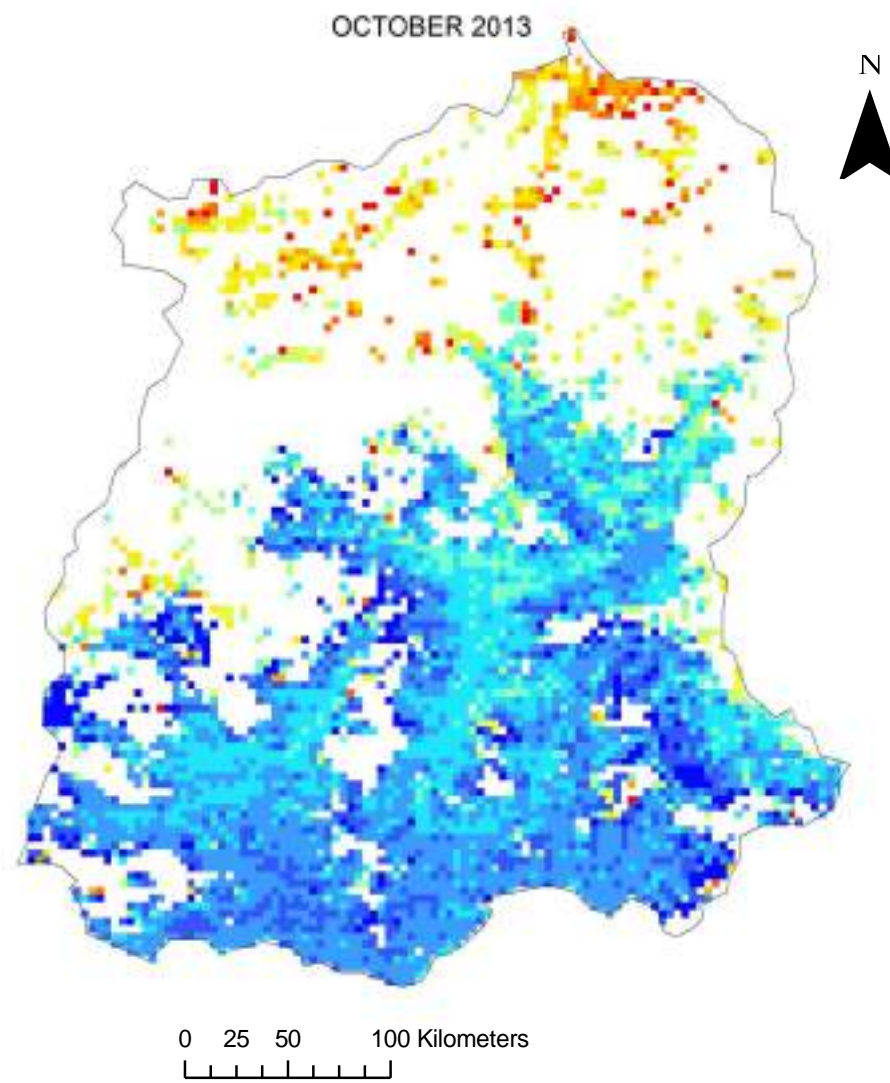















**Legend**

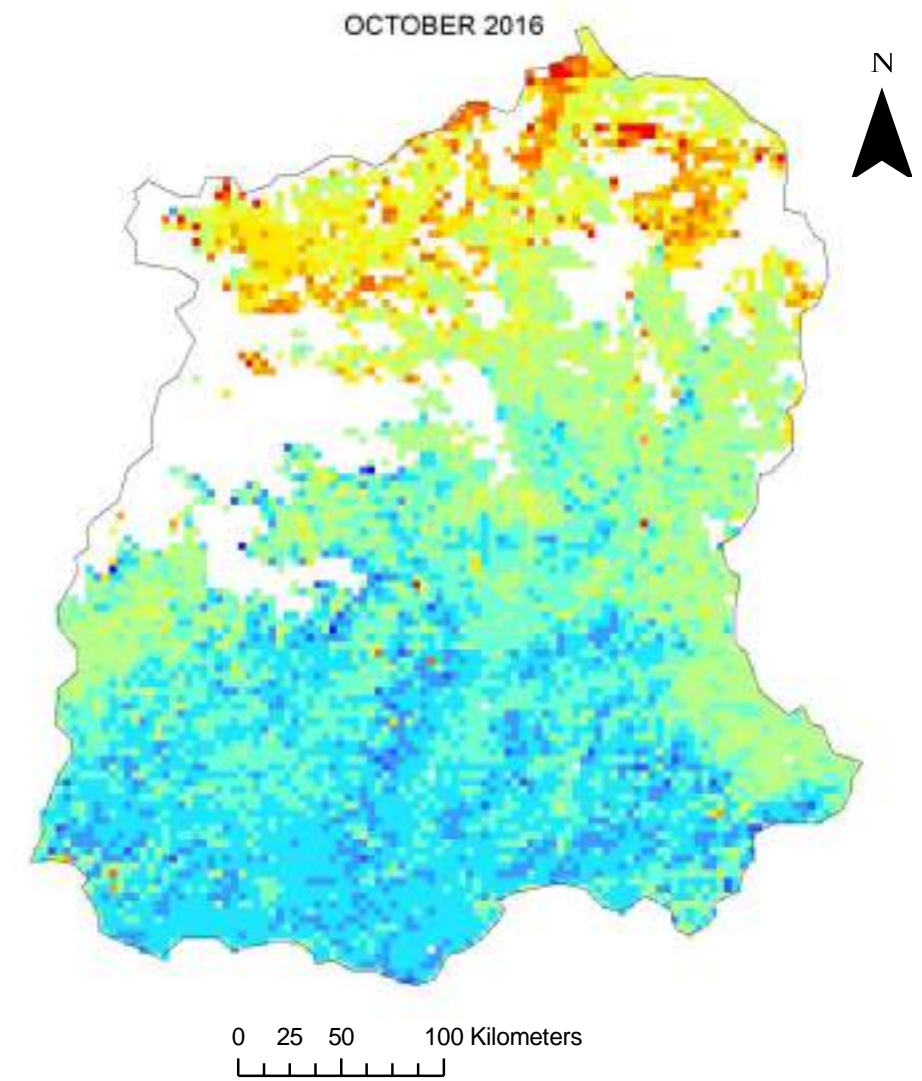
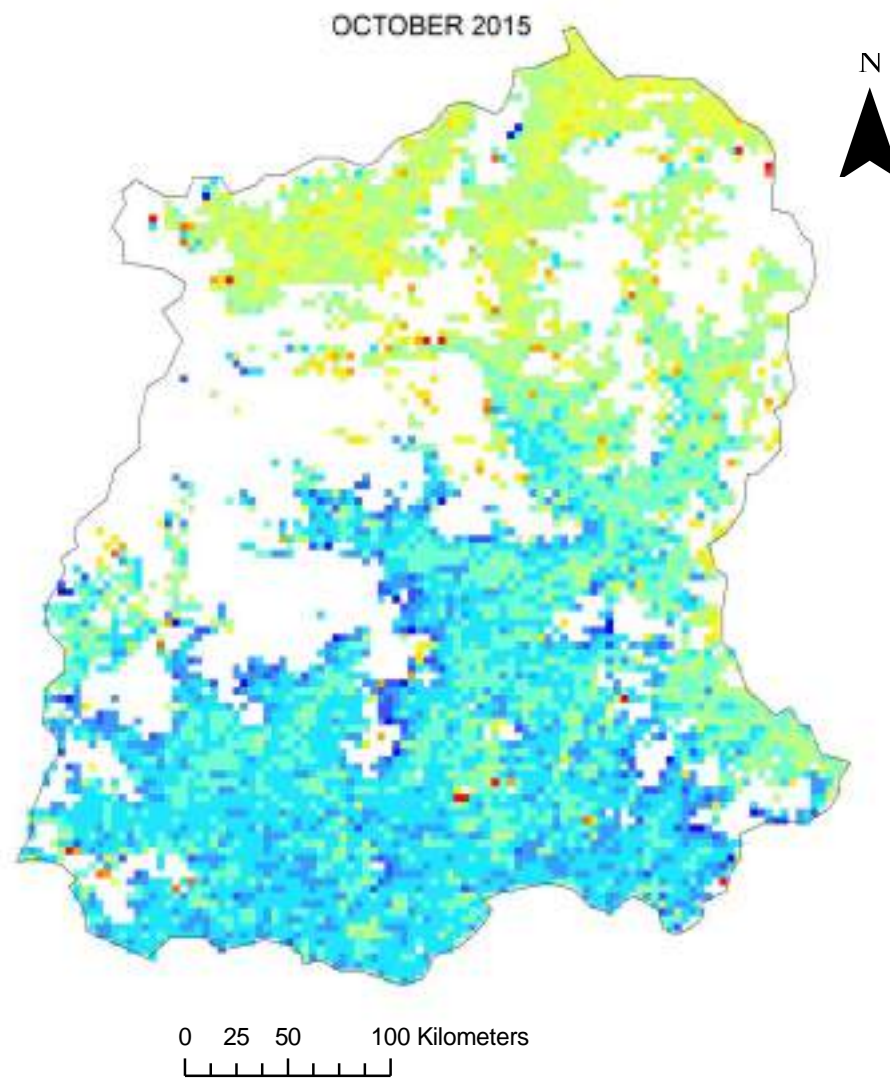




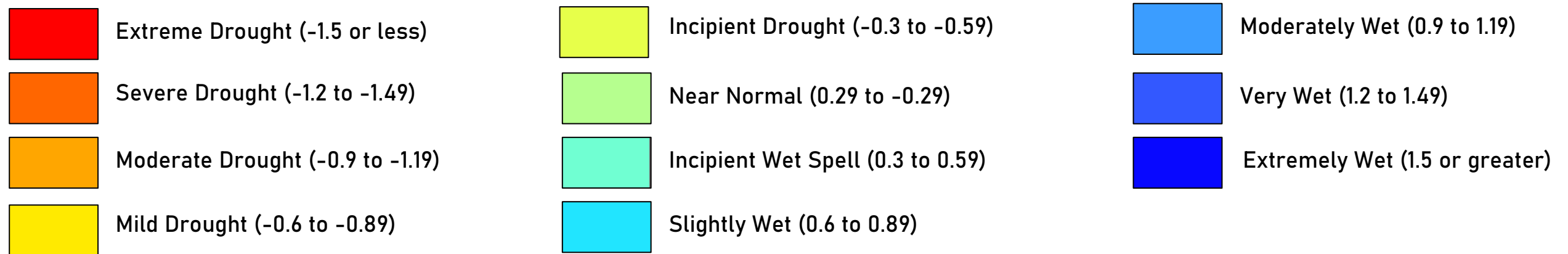


**Legend**

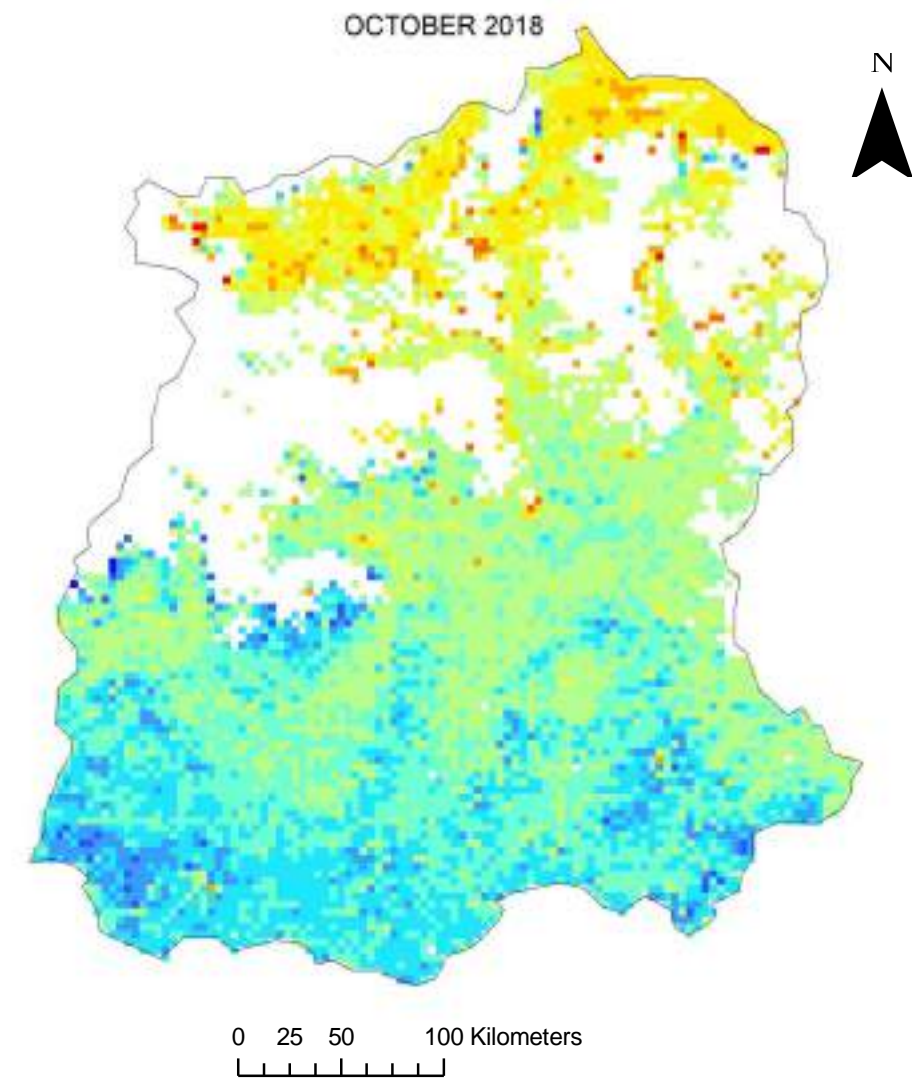
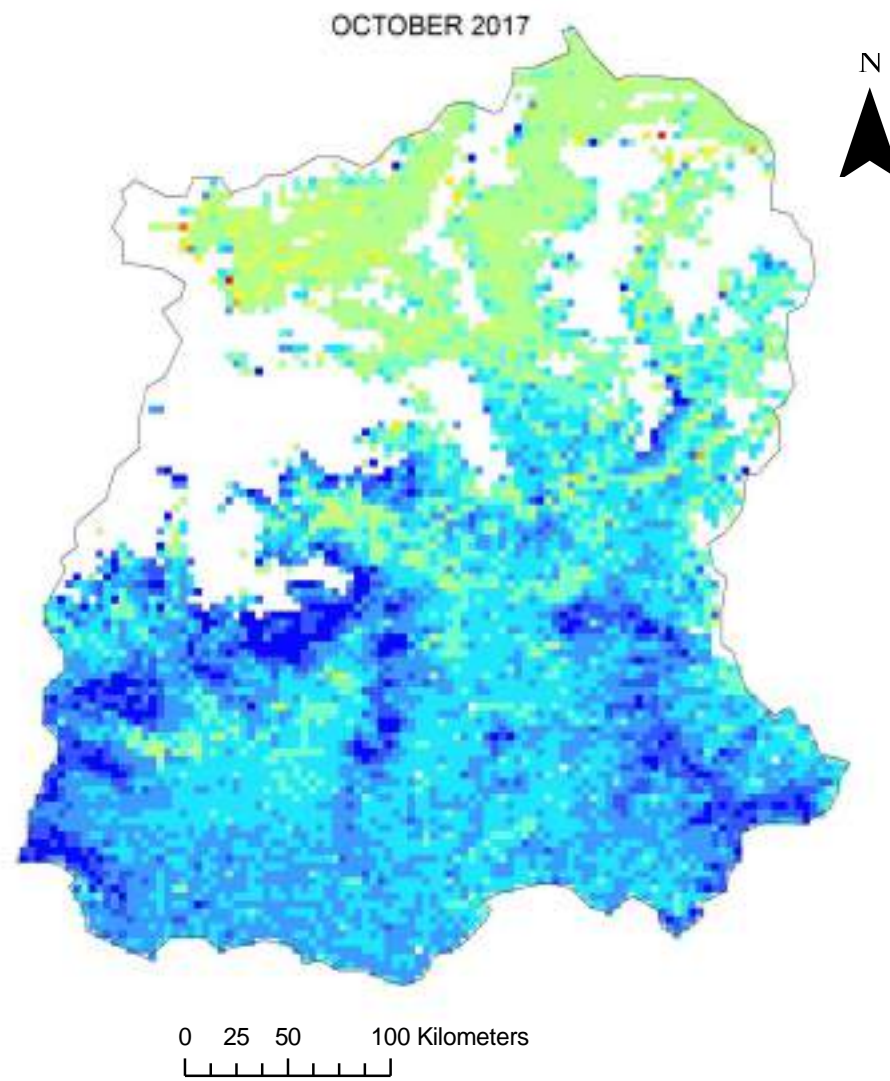
	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		



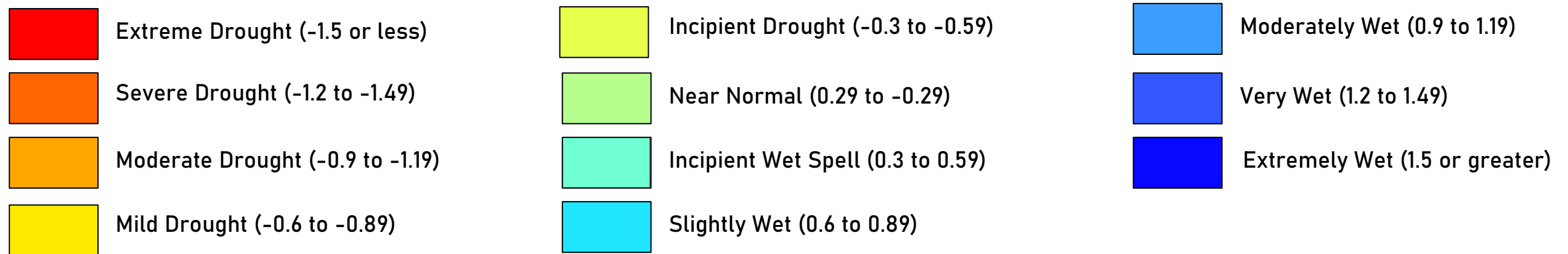
**Legend**

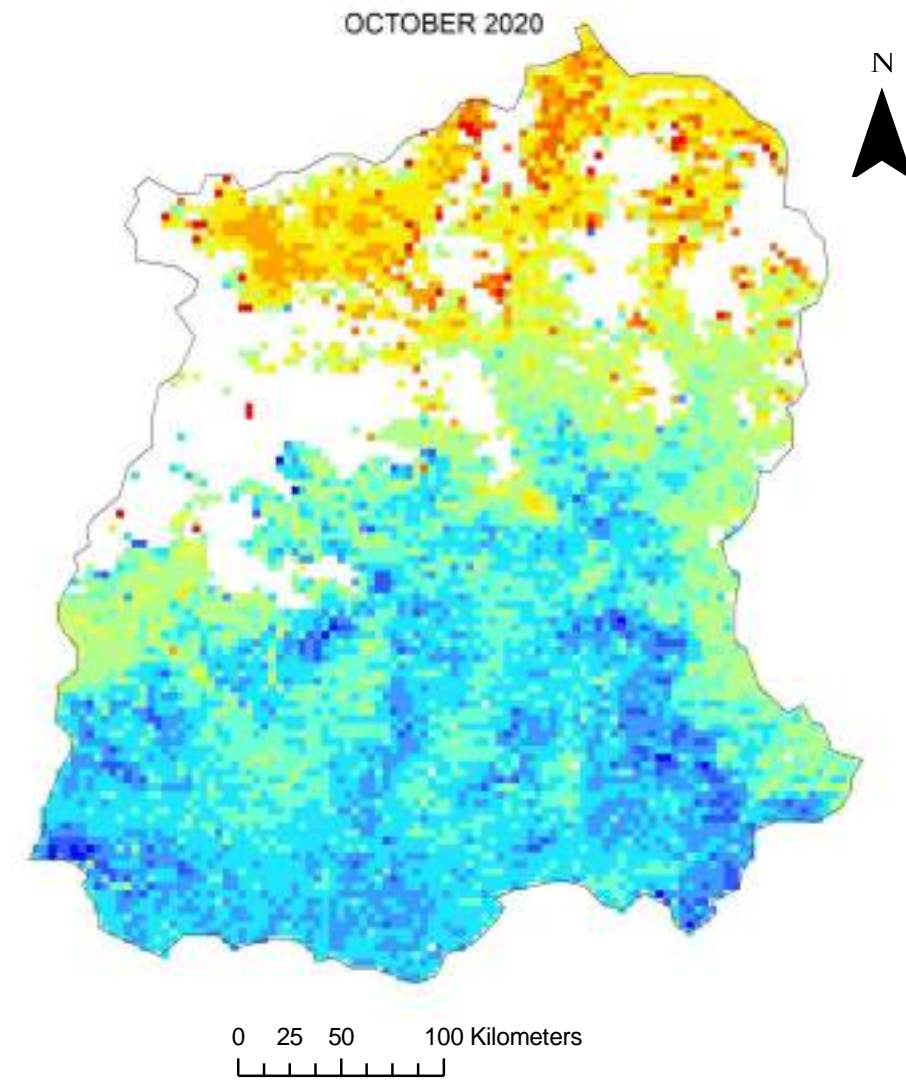
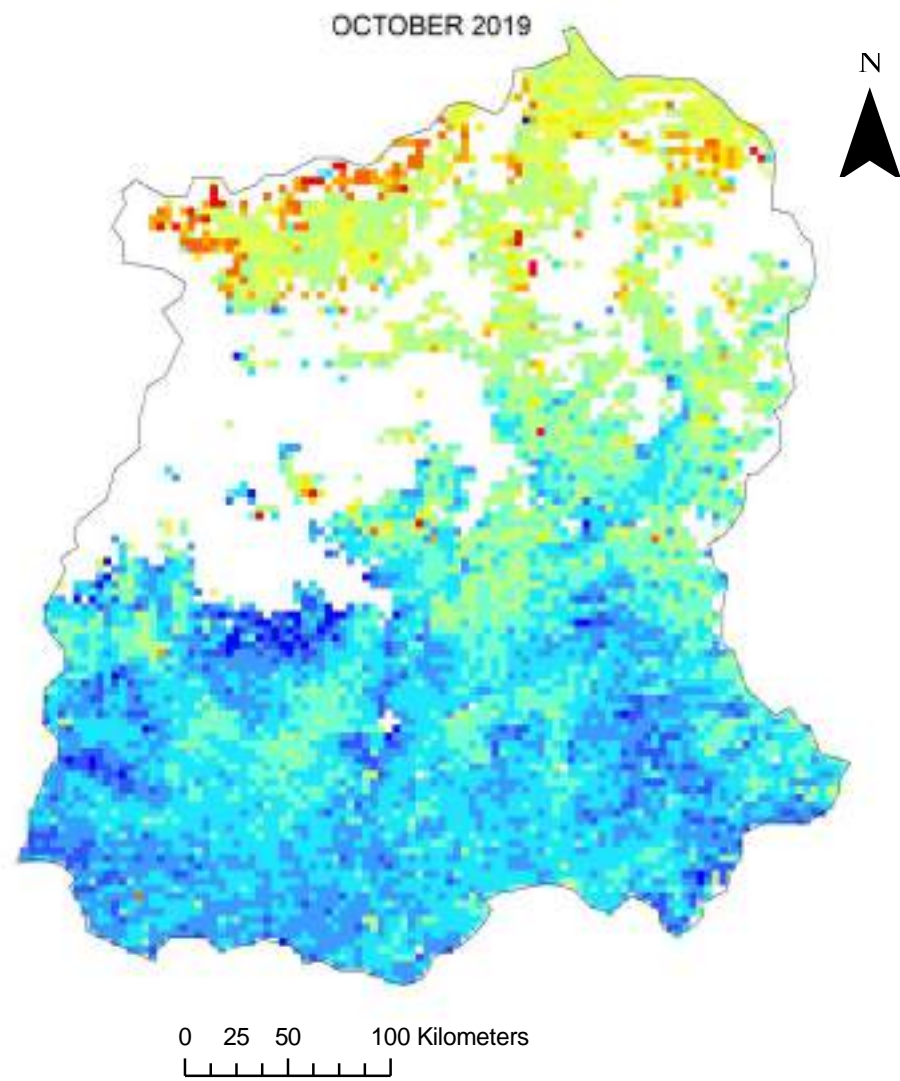




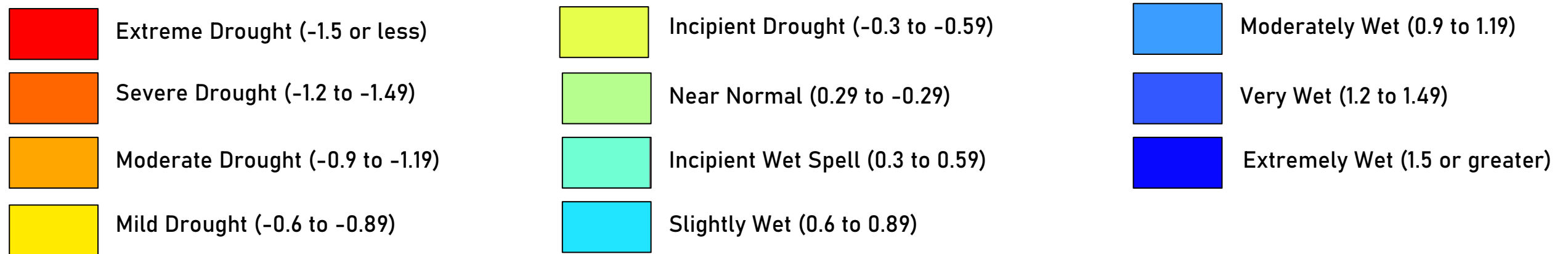


**Legend**





**Legend**

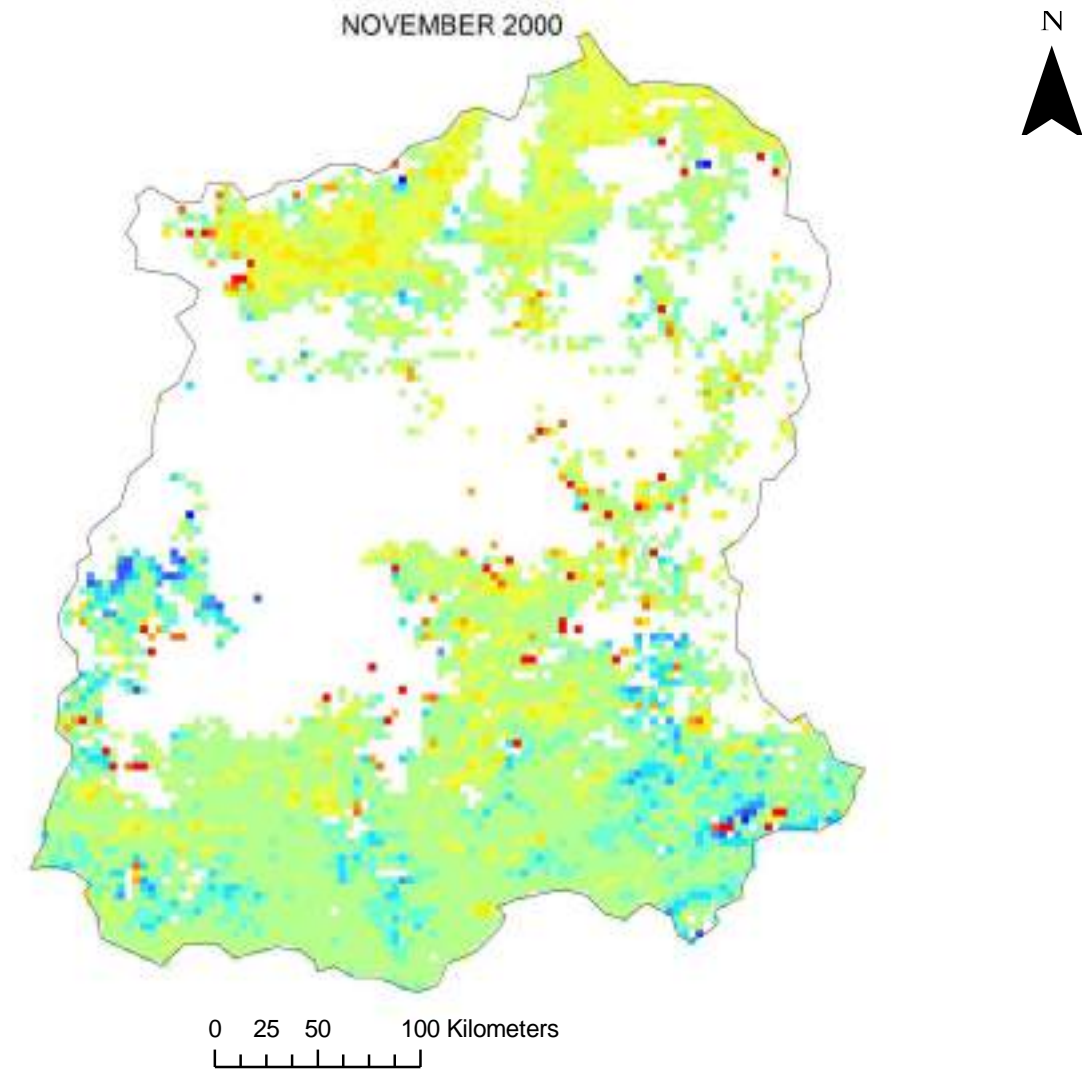




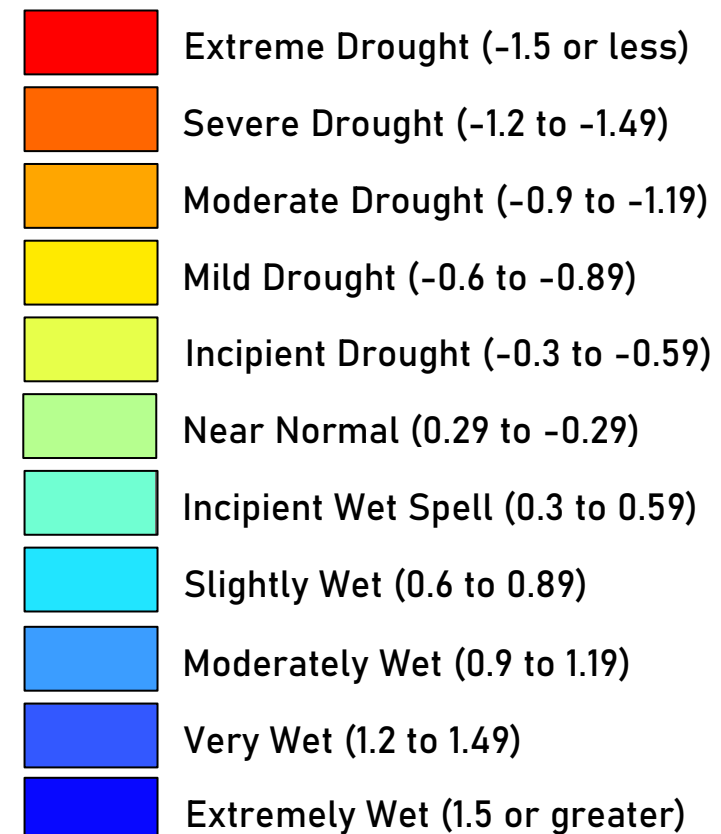
## November DSI Maps

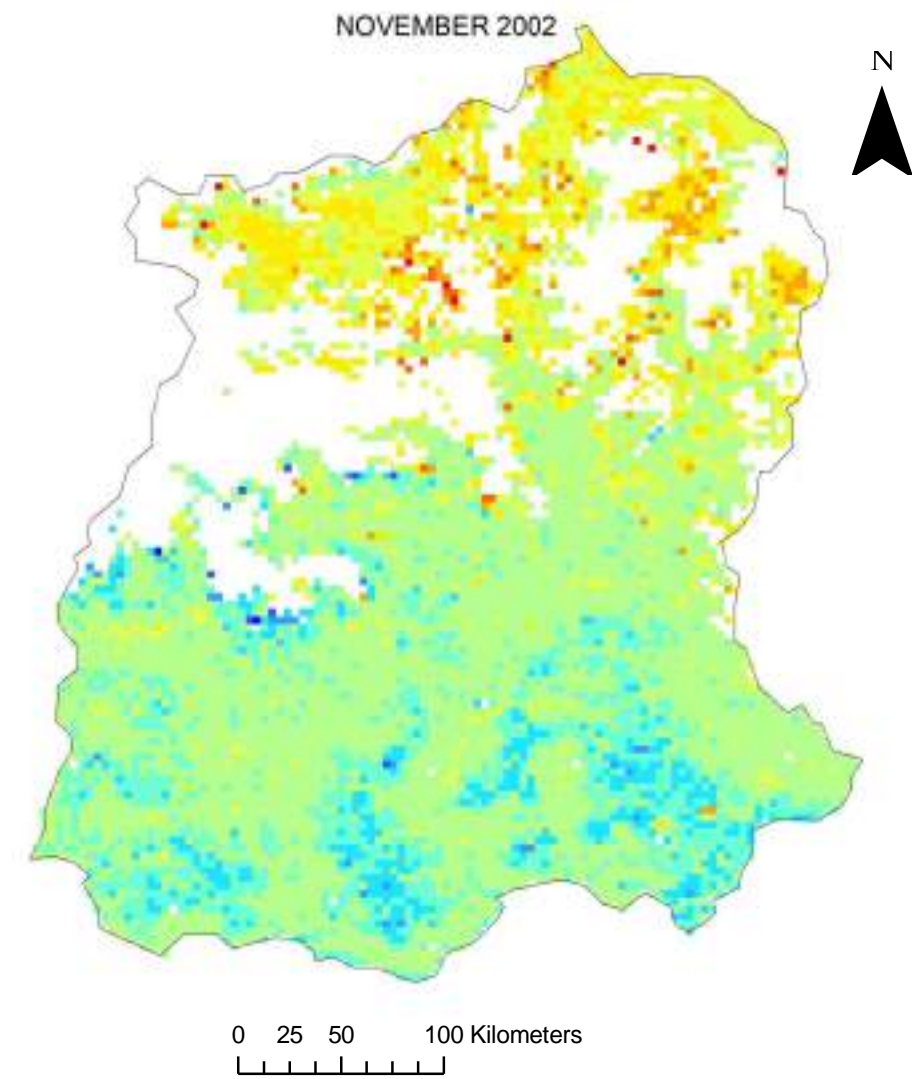
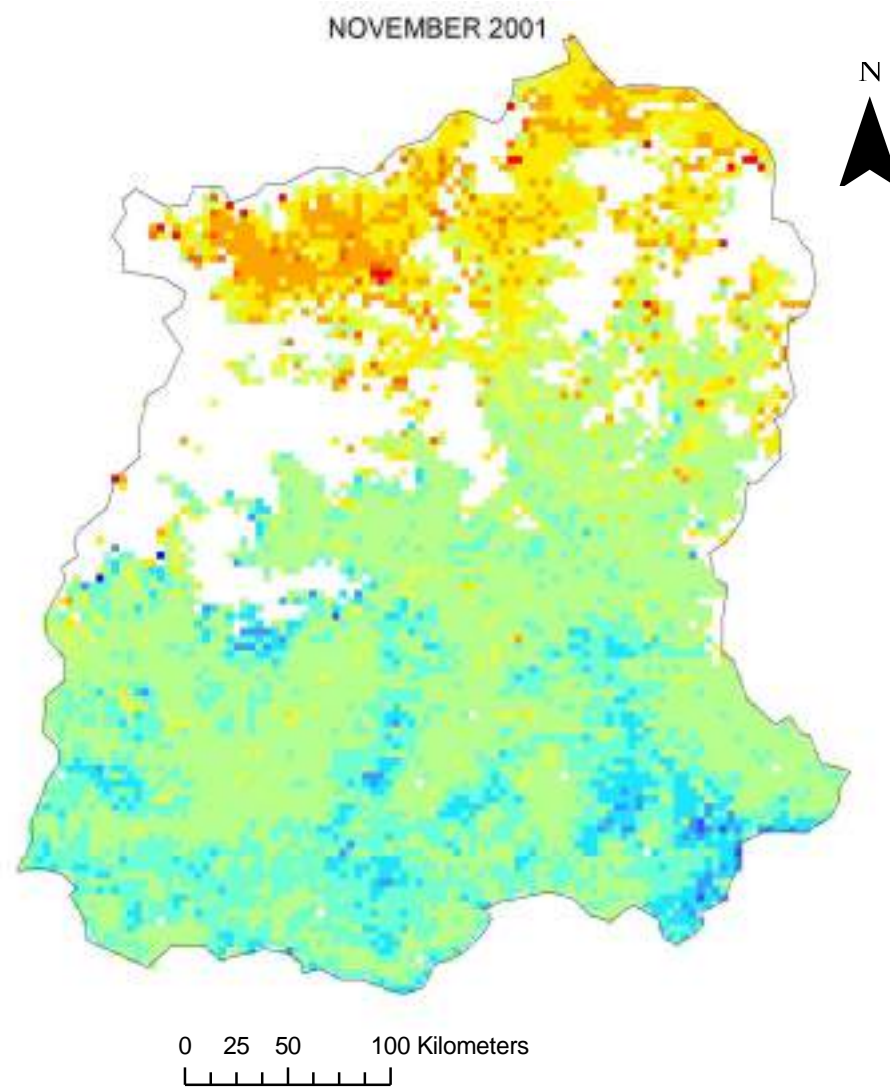
Drought conditions in November typically vary from moderate to incipient drought. Near normal condition dominate this month.

Mean November DSI Values		
Year	DSI Values	Drought Condition
2000	-0.11	Near Normal
2001	-0.13	Near Normal
2002	-0.12	Near Normal
2003	-0.10	Near Normal
2004	0.23	Near Normal
2005	-0.31	Incipient Drought
2006	-0.09	Near Normal
2007	0.14	Near Normal
2008	-0.23	Near Normal
2009	-0.12	Near Normal
2010	0.08	Near Normal
2011	-0.02	Near Normal
2012	-0.33	Incipient Drought
2013	-0.23	Near Normal
2014	-0.09	Near Normal
2015	-0.03	Near Normal
2016	-0.41	Incipient Drought
2017	0.02	Near Normal
2018	-0.34	Incipient Drought
2019	-0.20	Near Normal
2020	-0.48	Incipient Drought














### Legend

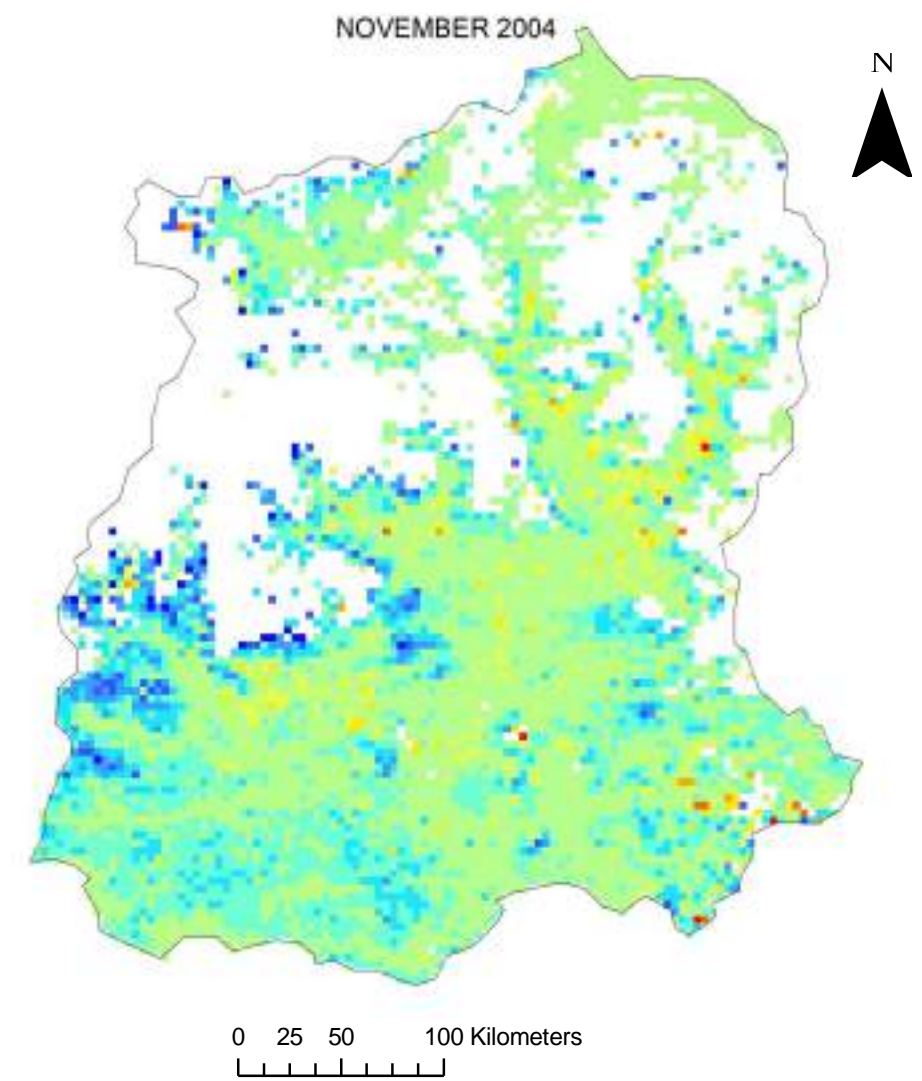
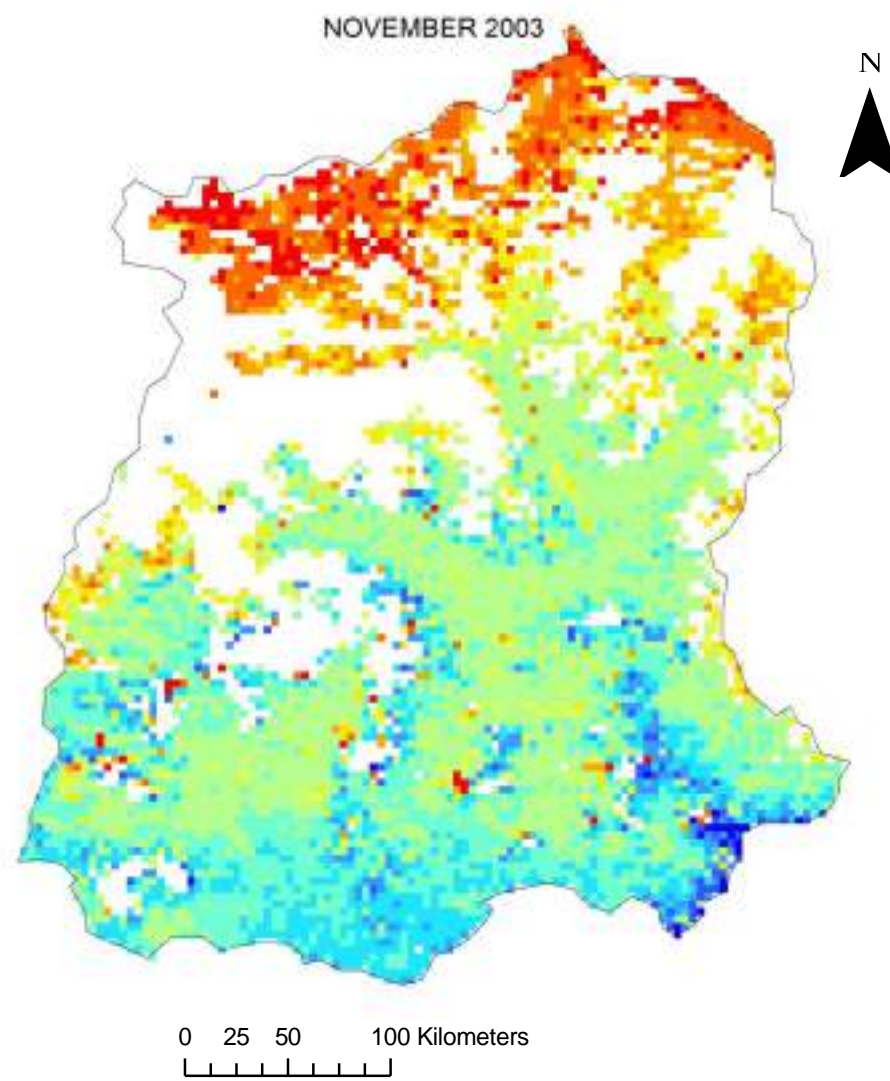














**Legend**

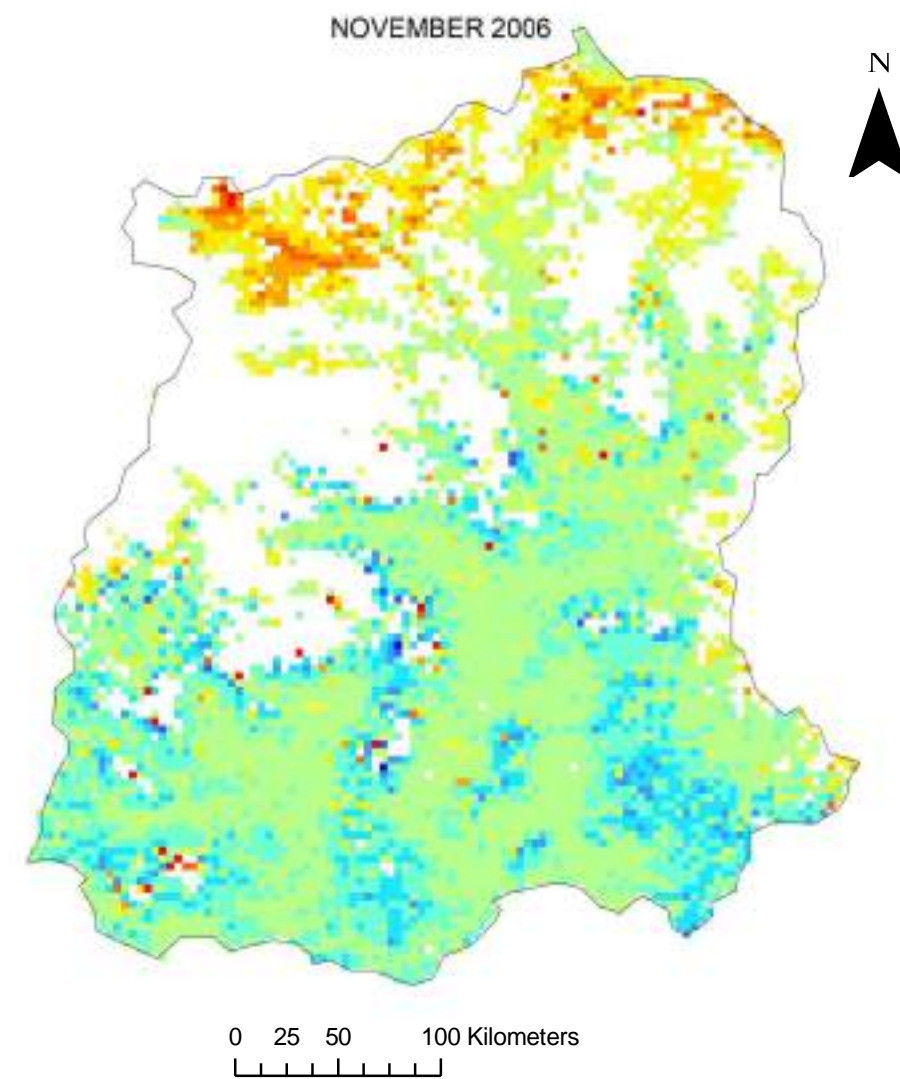
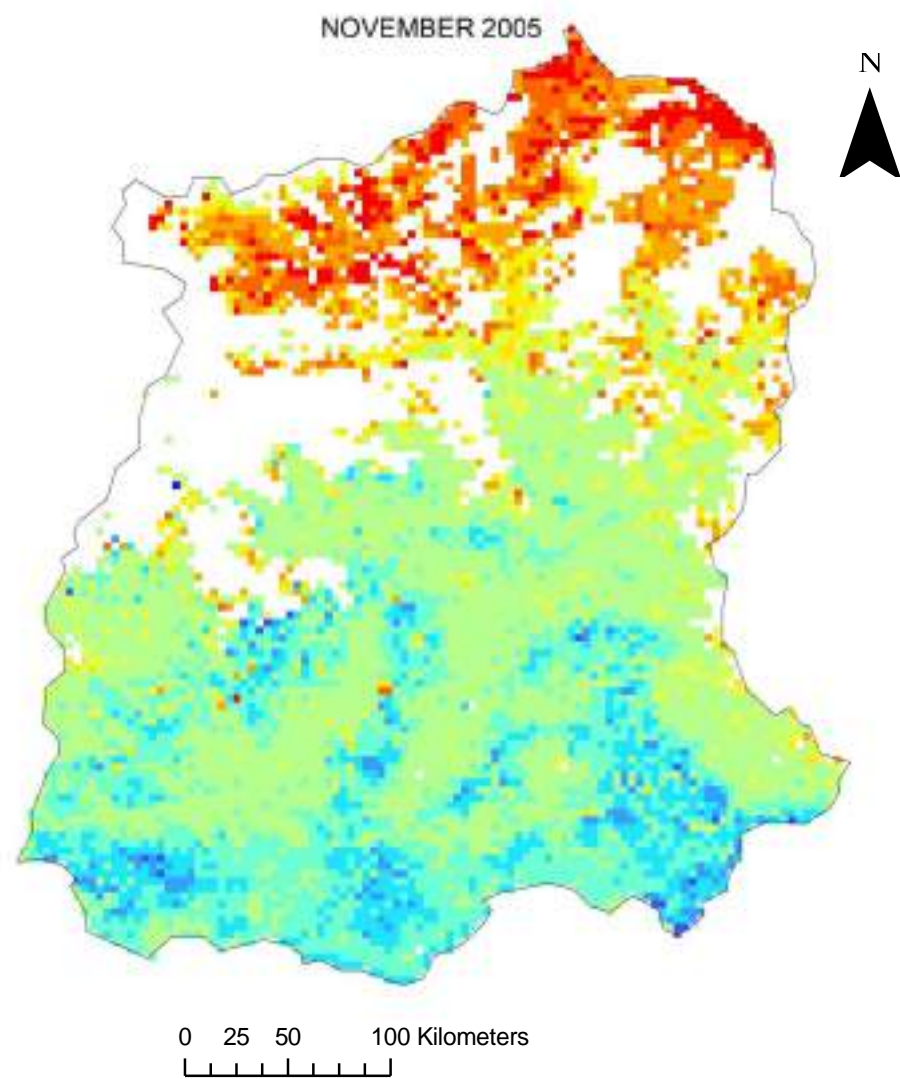
- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |





**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |   | Slightly Wet (0.6 to 0.89)        |   |                                |



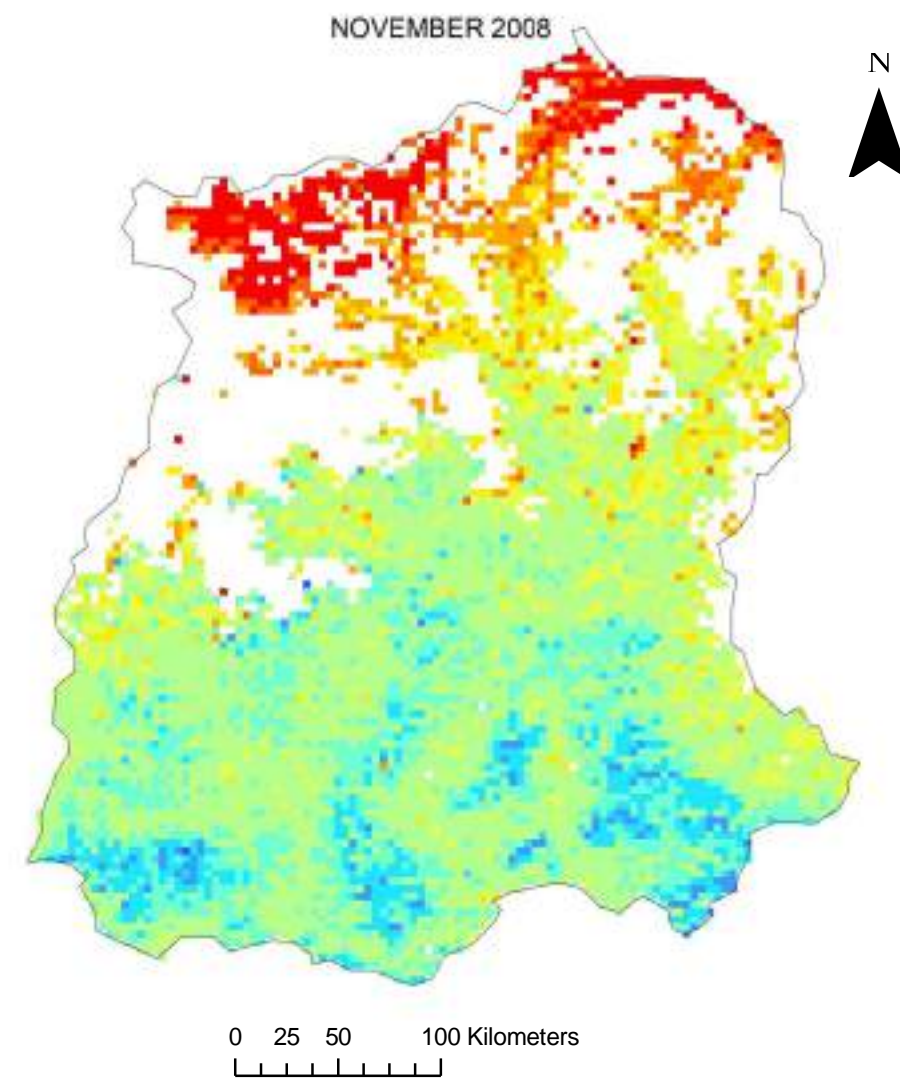
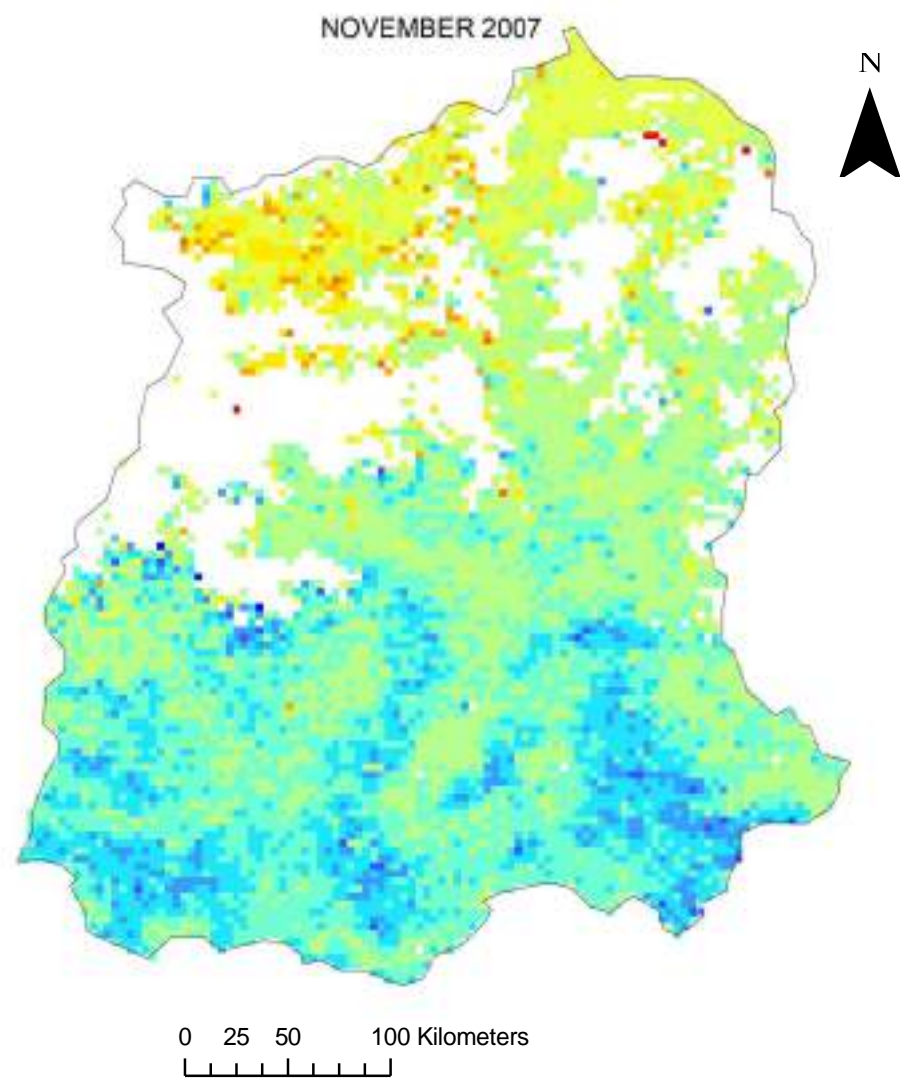
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



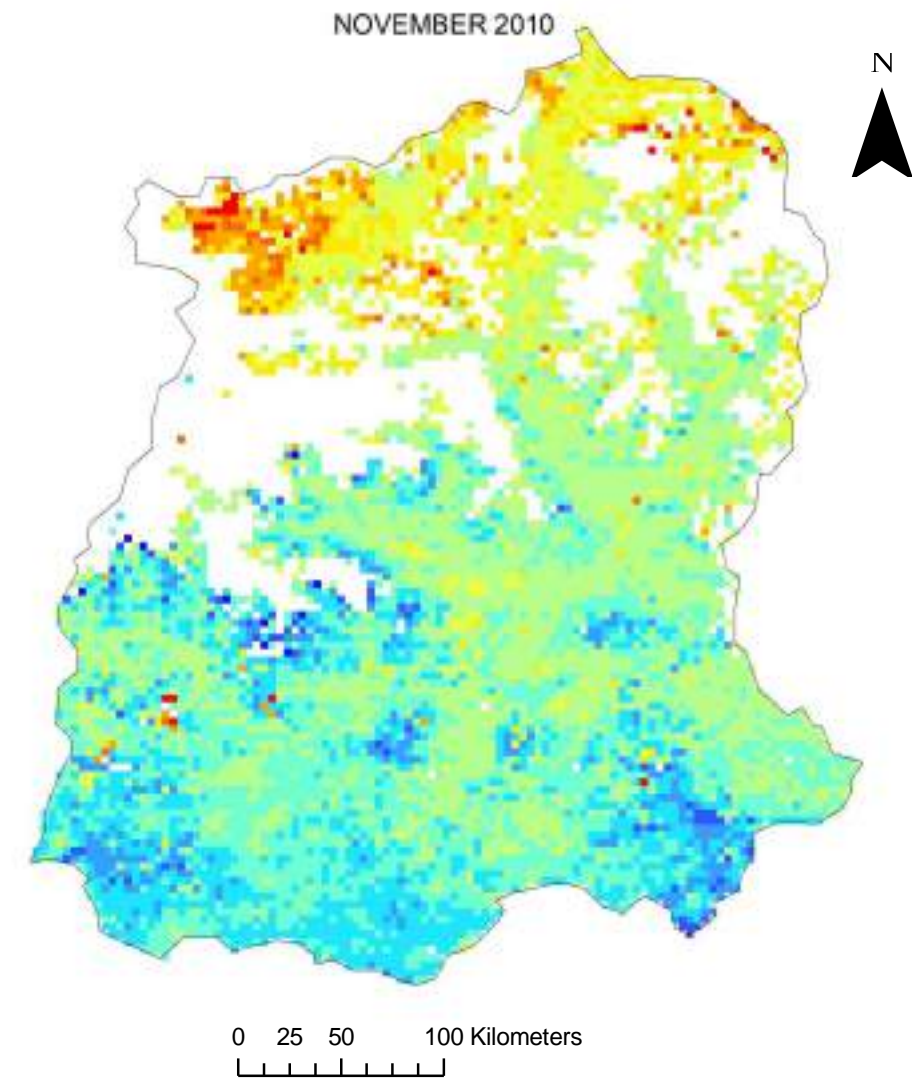
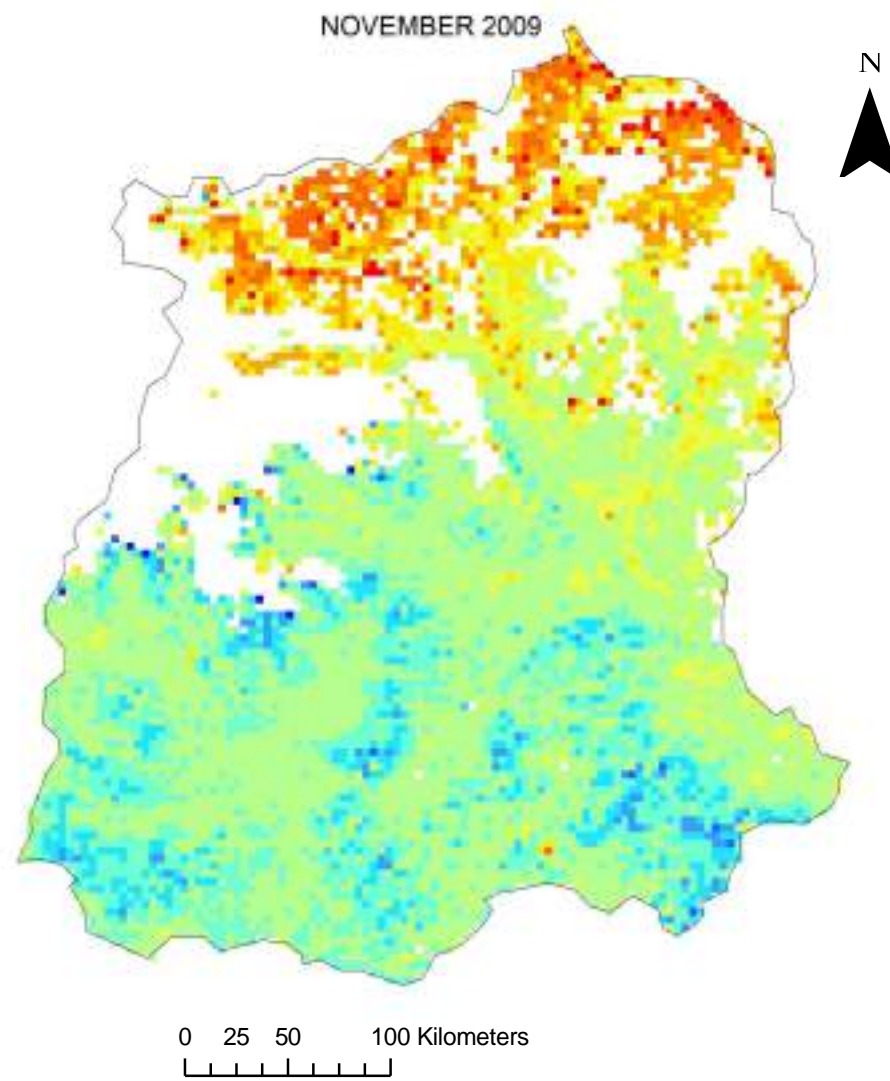


**Legend**

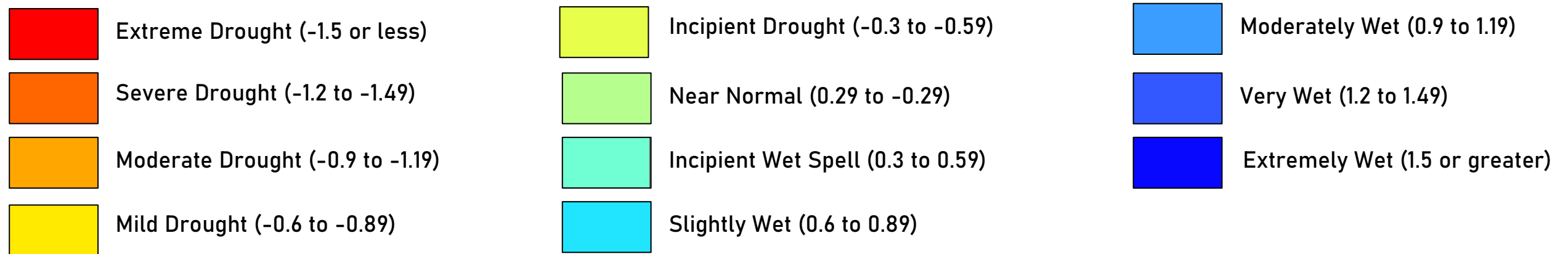
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

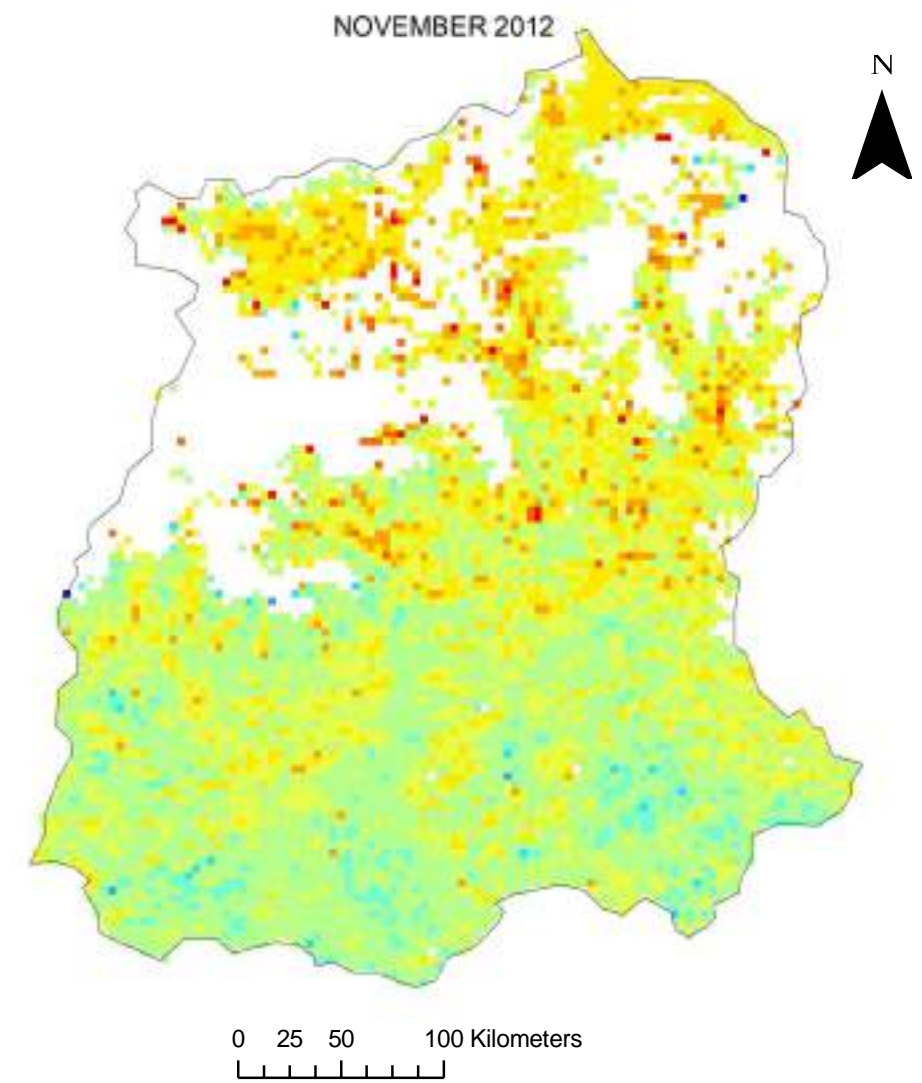
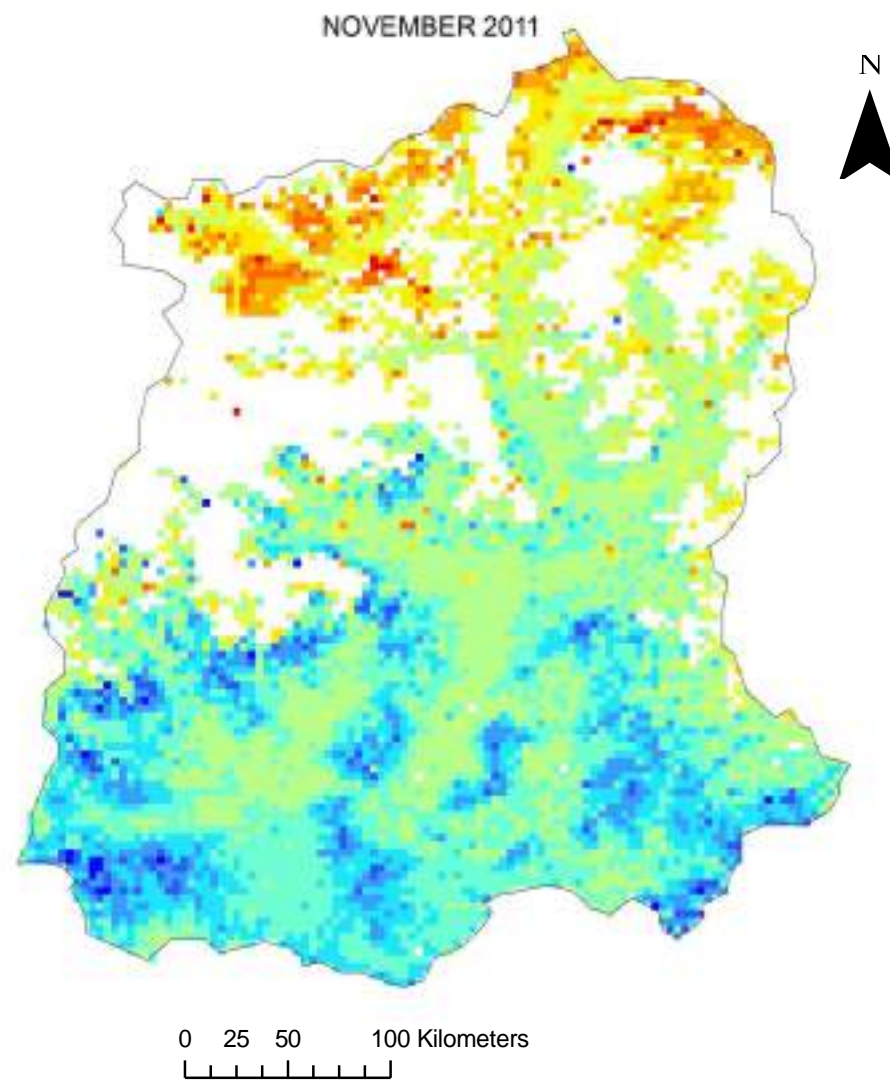
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)














**Legend**

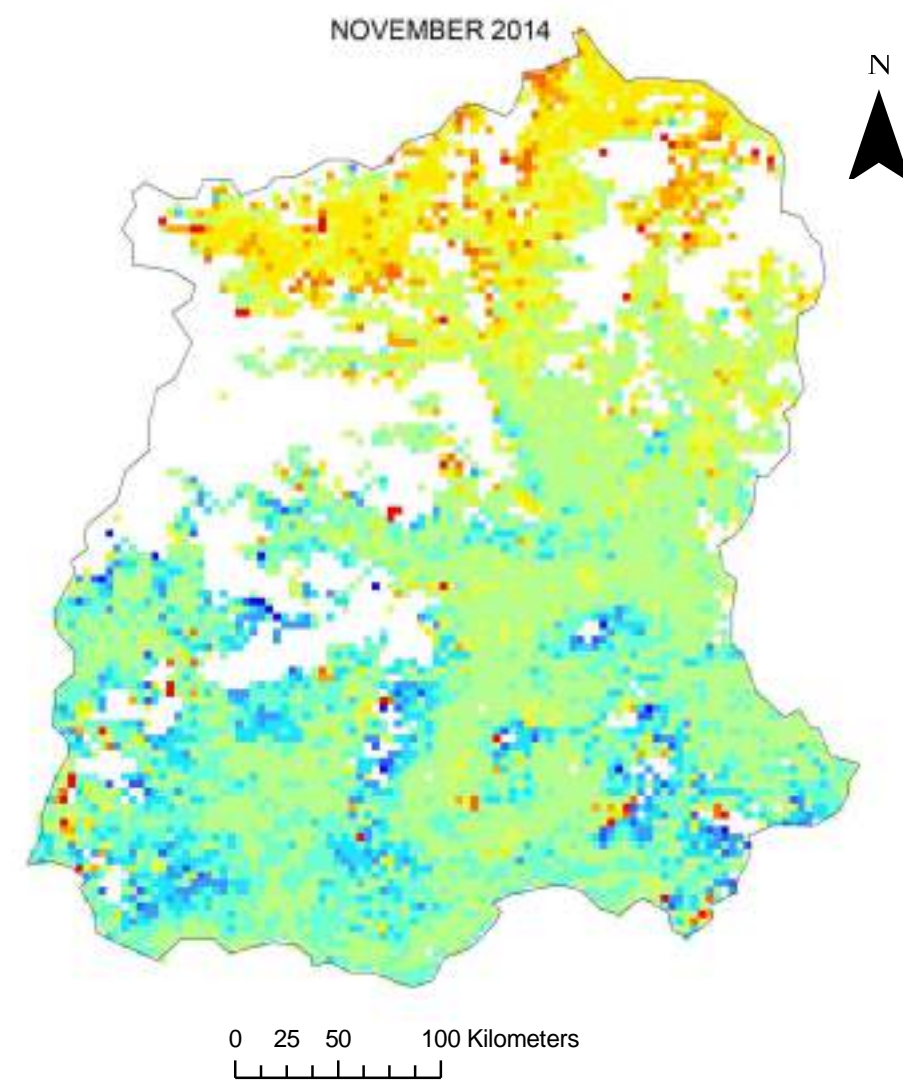
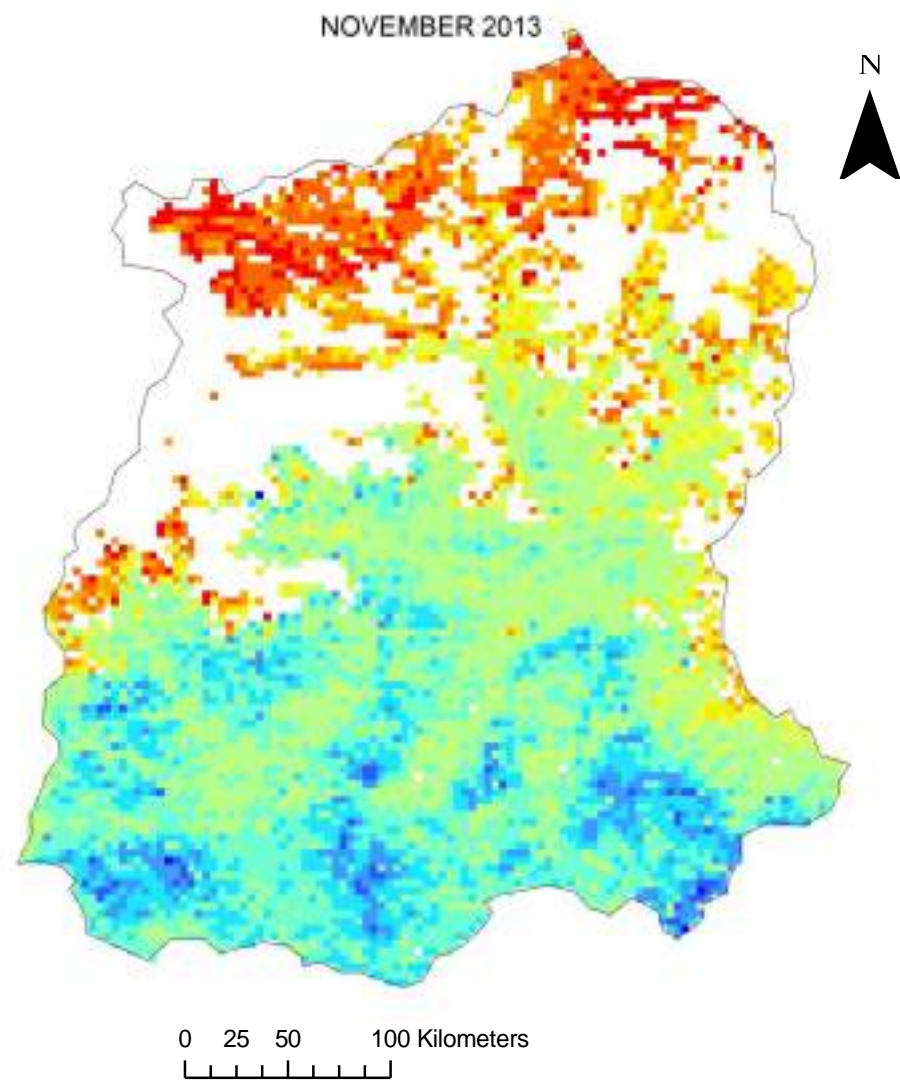






**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



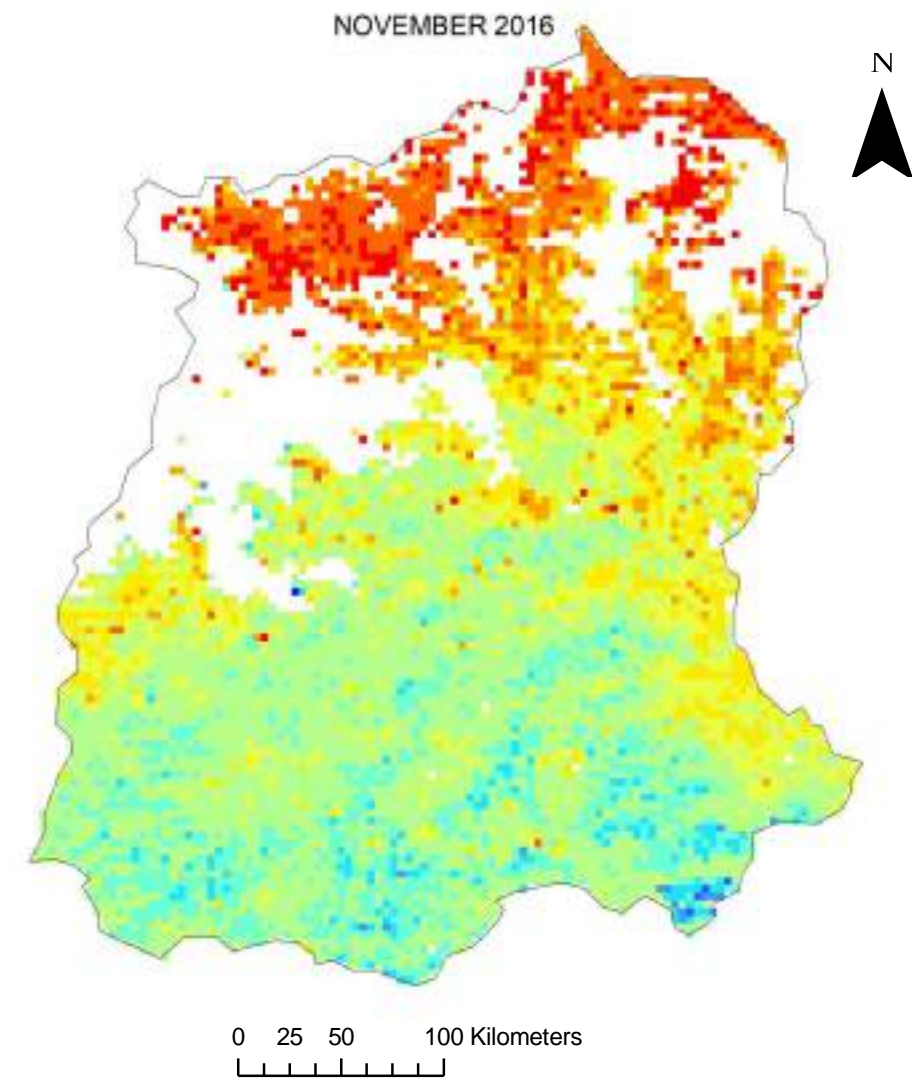
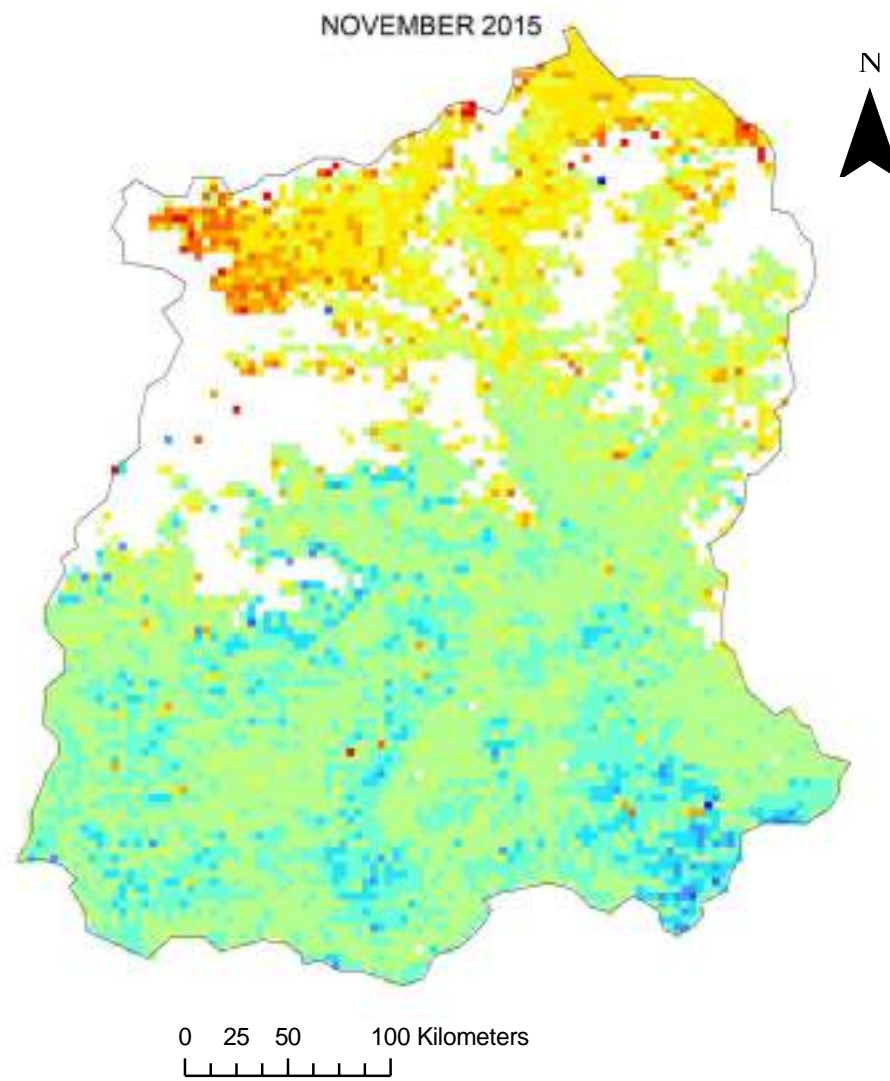
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

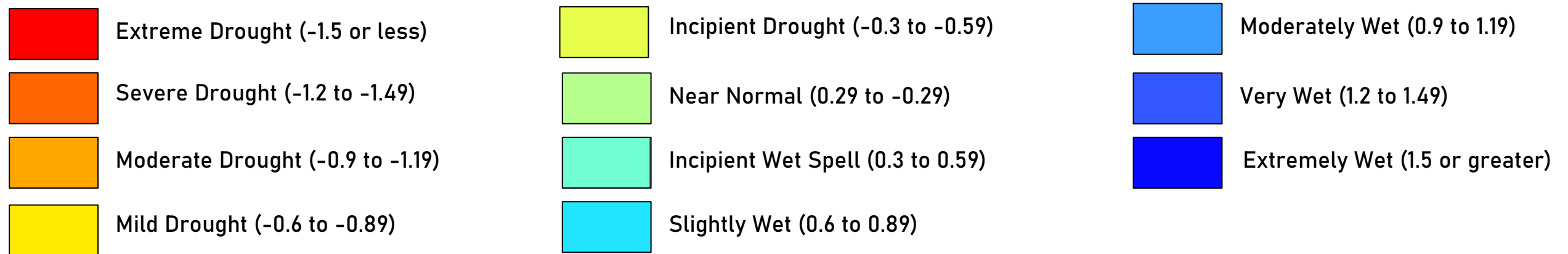
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

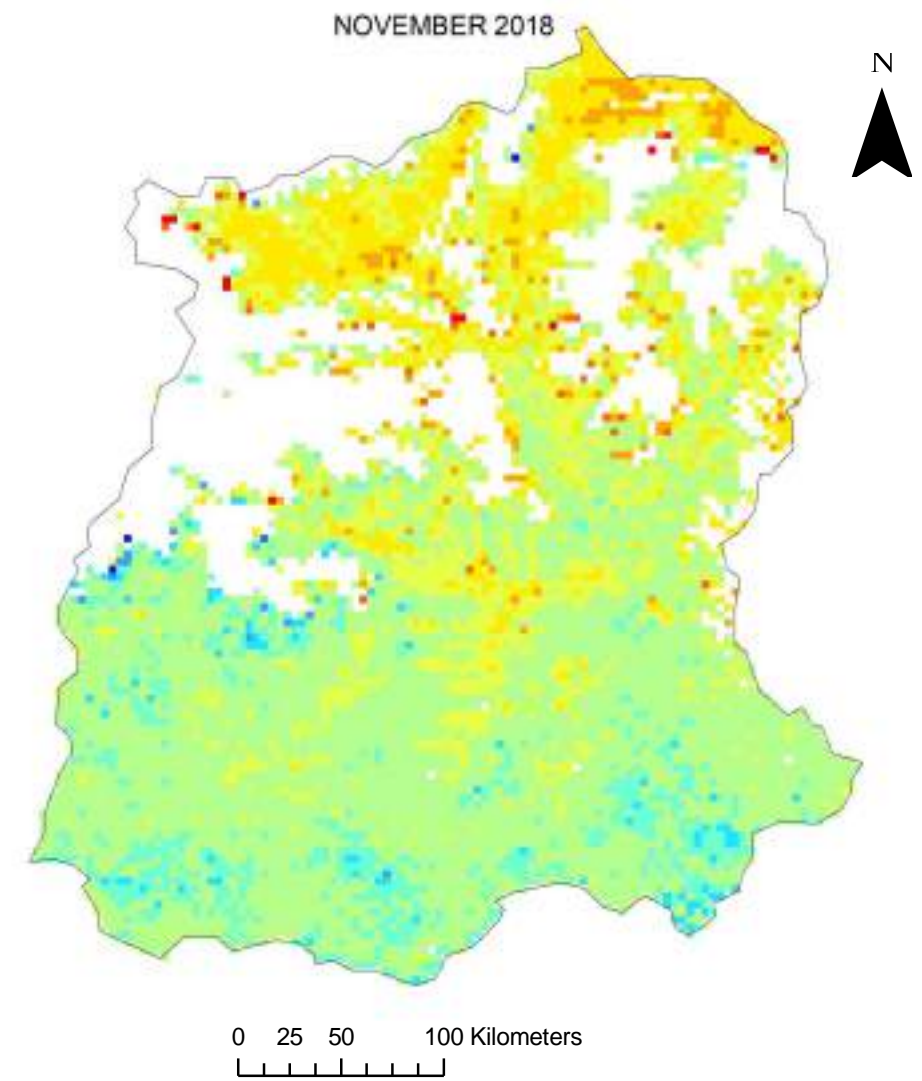
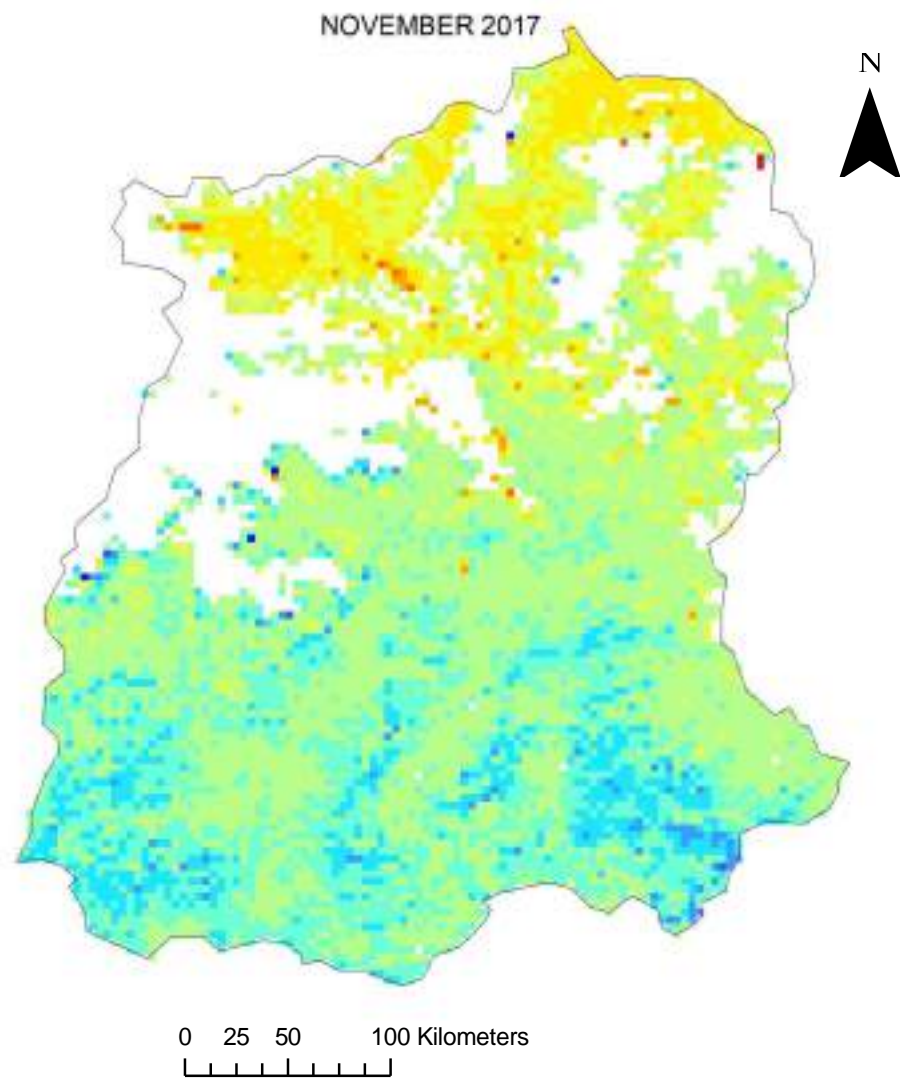
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



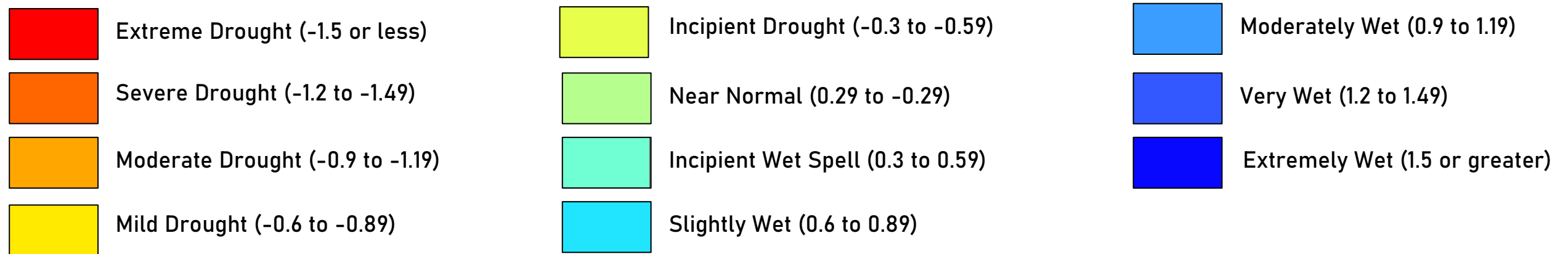


**Legend**

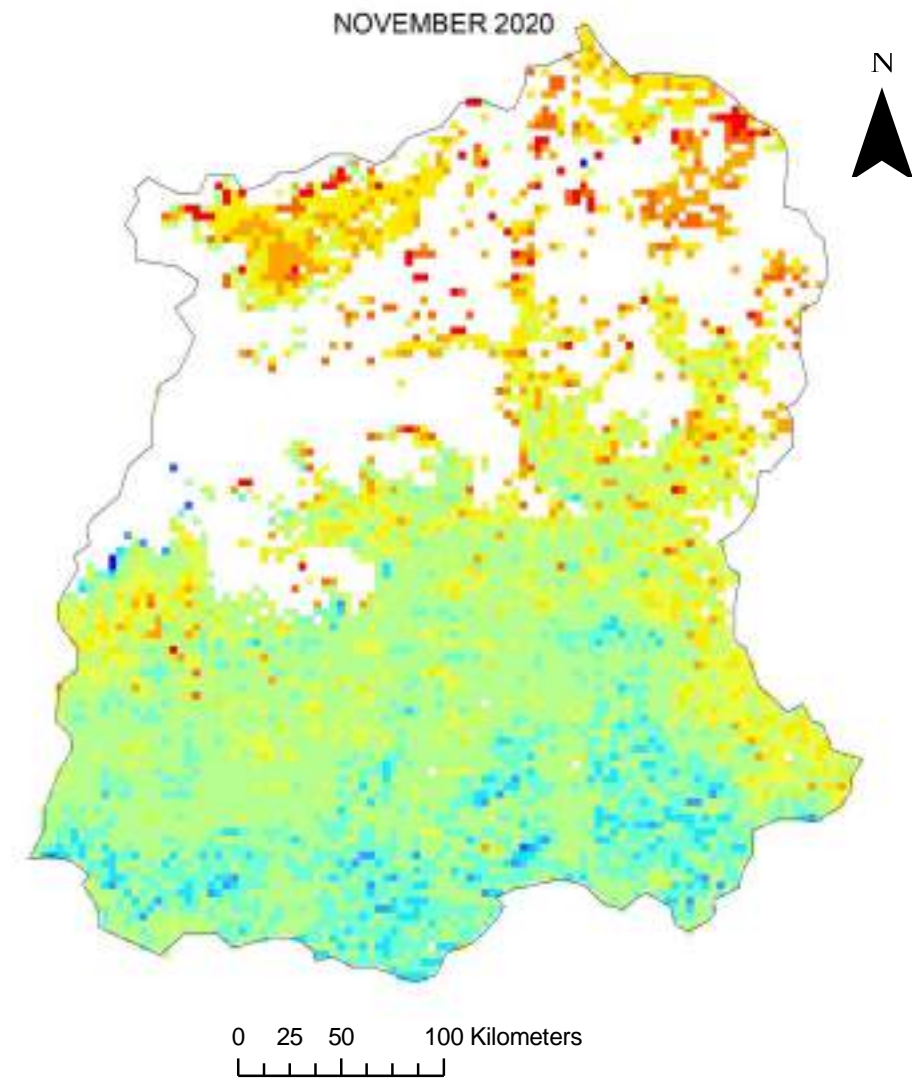
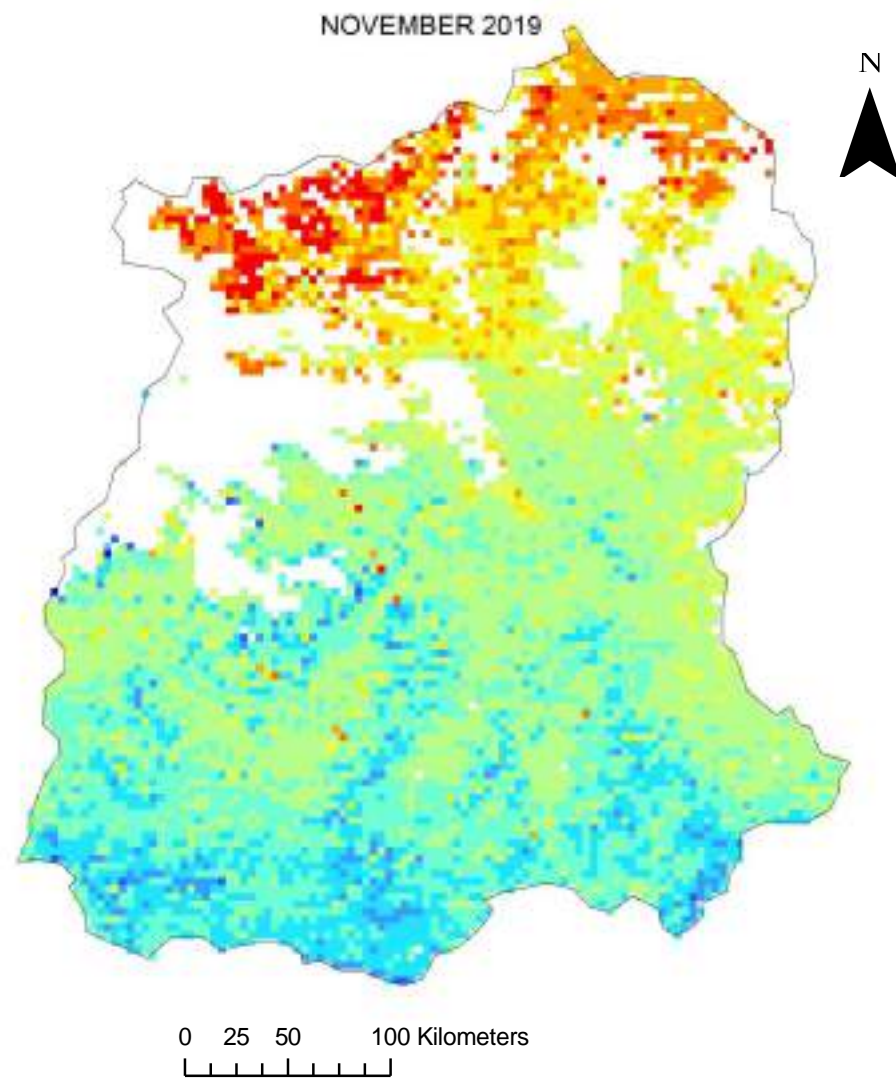




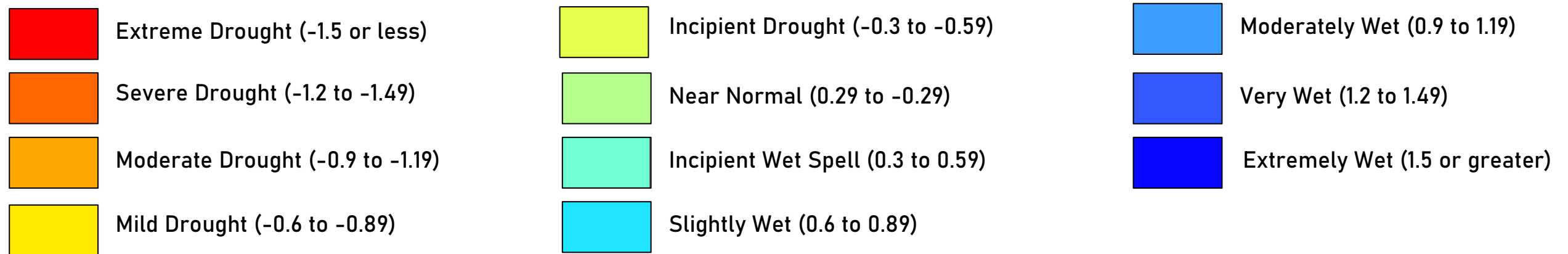
**Legend**







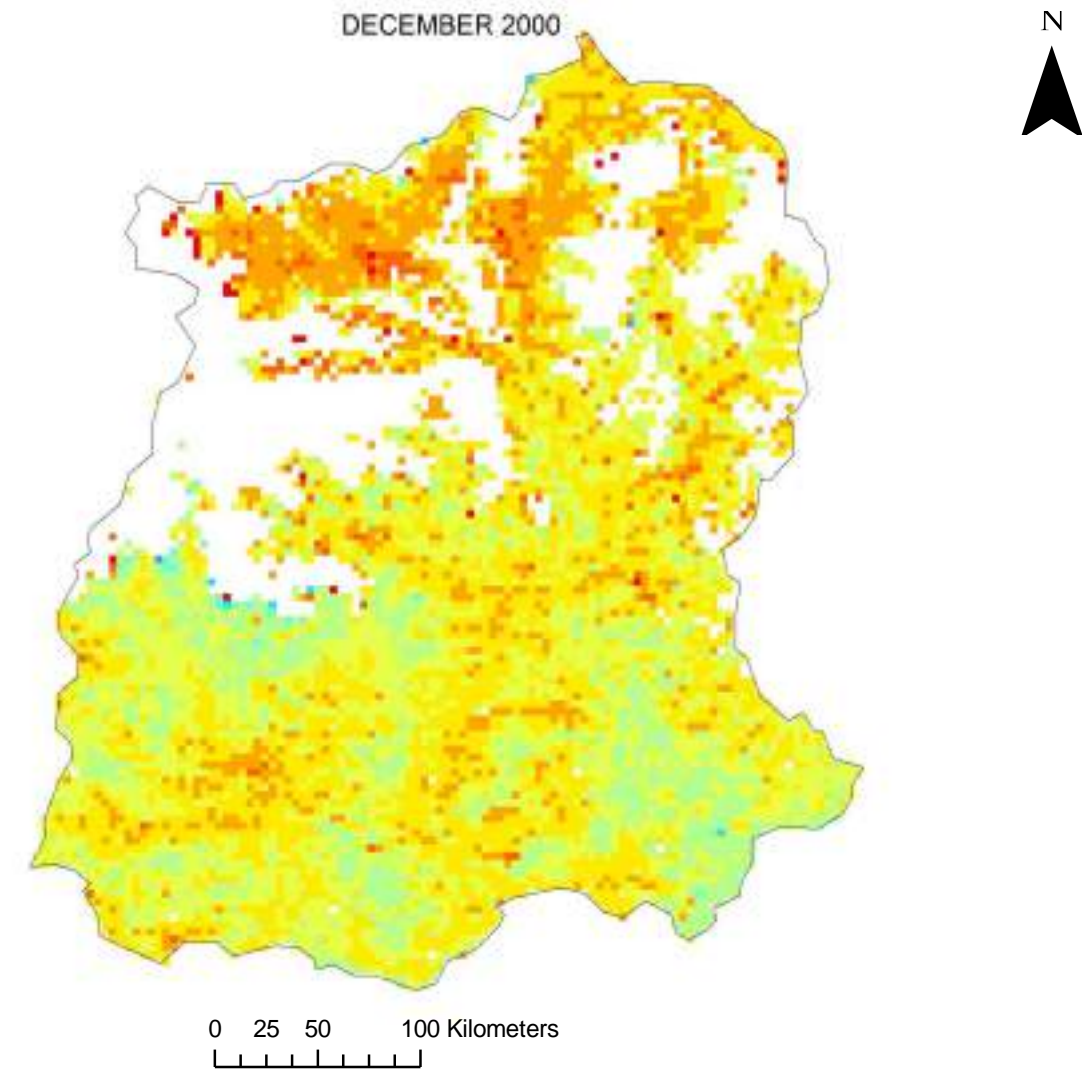
**Legend**



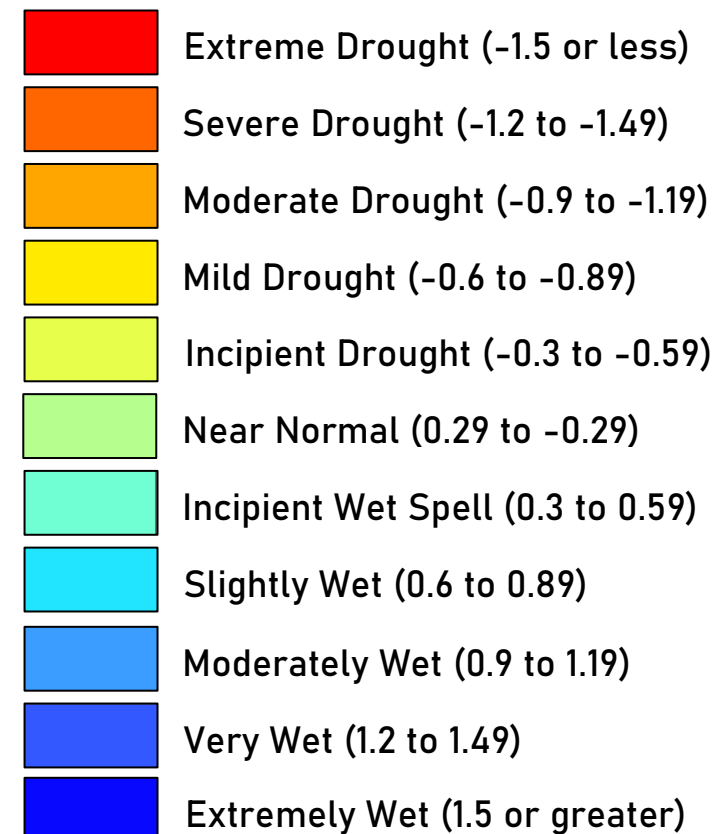
## December DSI Maps

Drought conditions in January typically vary from moderate to incipient drought. The characteristics of this winter month are frequently characterized by incipient drought.

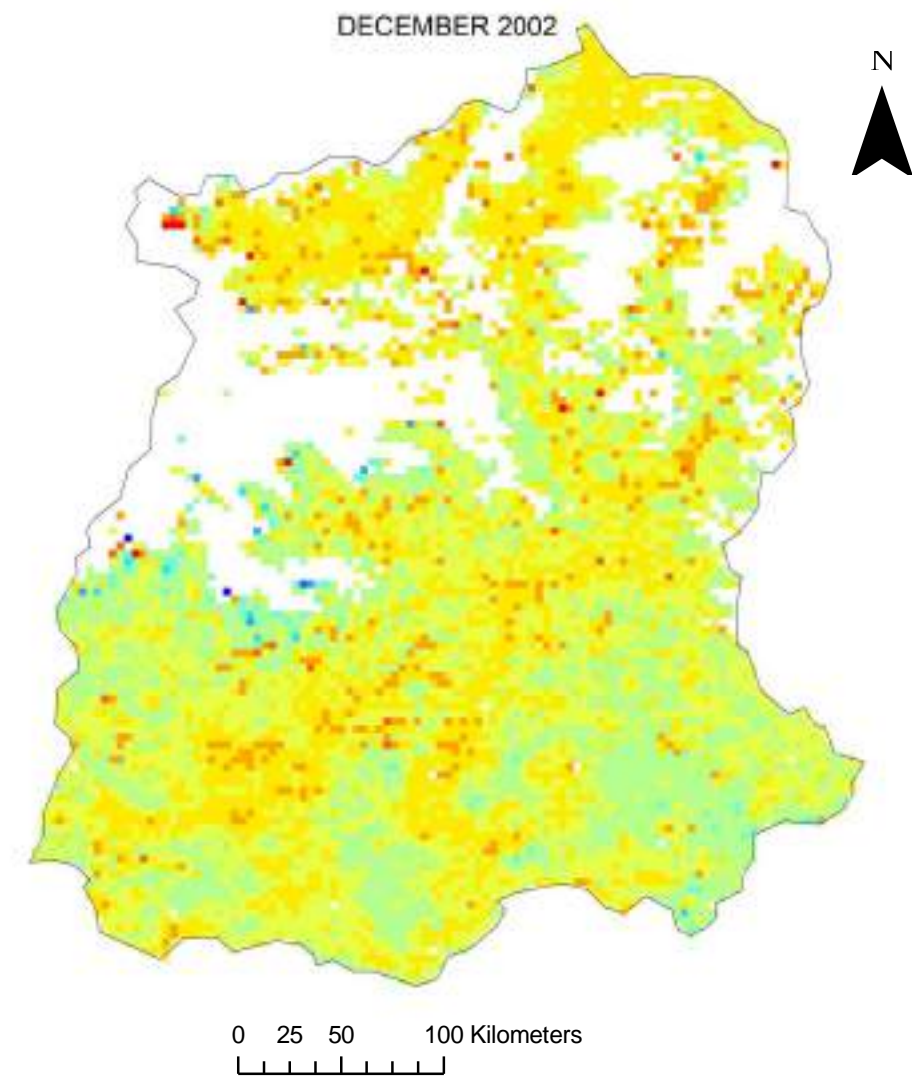
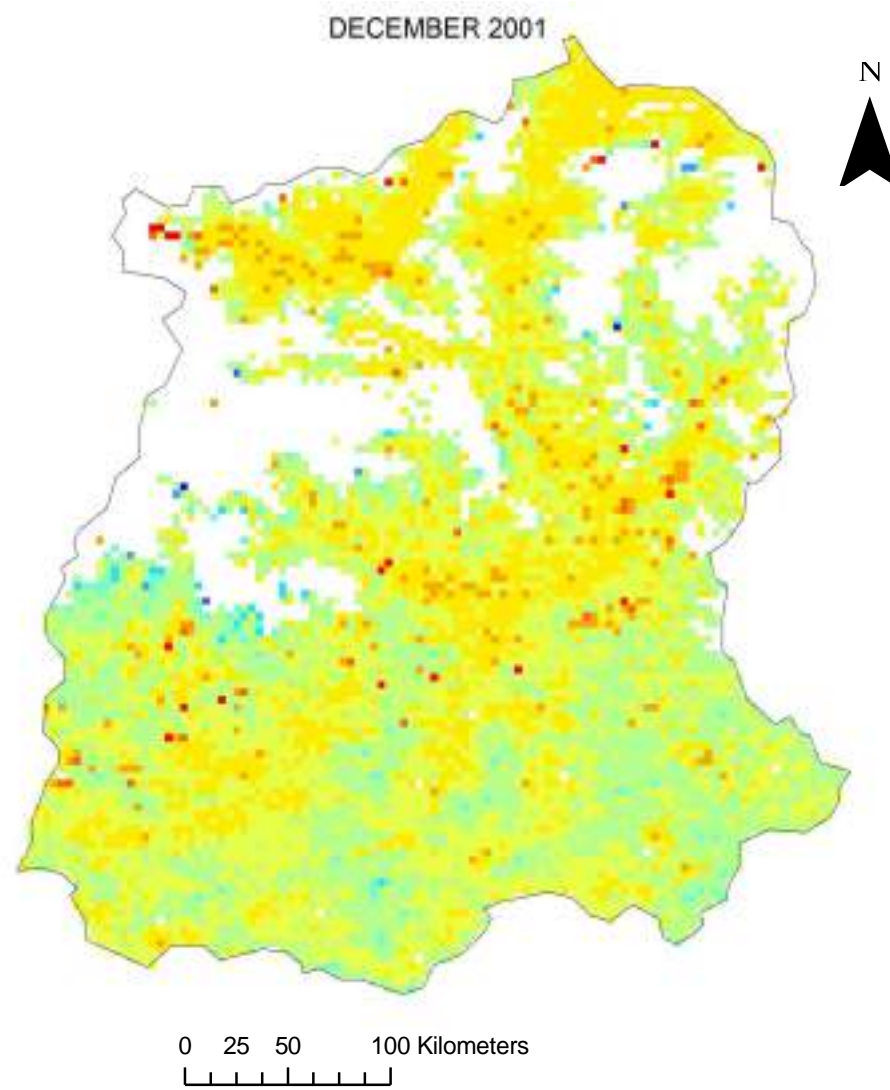
Mean December DSI Values		
Year	DSI Values	Drought Condition
2000	-0.66	Mild Drought
2001	-0.33	Incipient Drought
2002	-0.44	Incipient Drought
2003	-0.26	Near Normal
2004	-0.37	Incipient Drought
2005	-0.53	Incipient Drought
2006	-0.49	Incipient Drought
2007	-0.61	Mild Drought
2008	-0.51	Incipient Drought
2009	-0.65	Mild Drought
2010	-0.66	Mild Drought
2011	-0.48	Incipient Drought
2012	-0.78	Mild Drought
2013	-0.50	Incipient Drought
2014	-0.42	Incipient Drought
2015	-0.62	Mild Drought
2016	-0.74	Mild Drought
2017	-0.60	Mild Drought
2018	-0.63	Mild Drought
2019	-0.41	Incipient Drought
2020	-0.56	Incipient Drought














### Legend

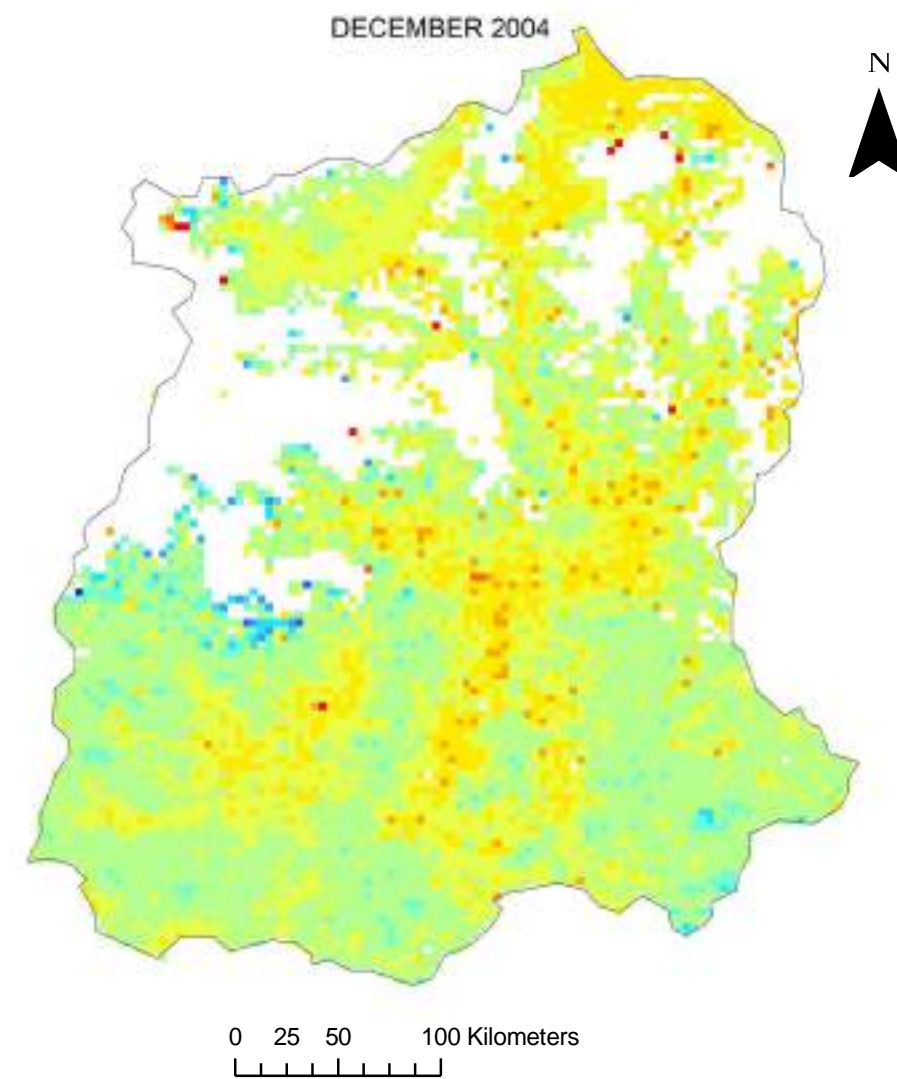
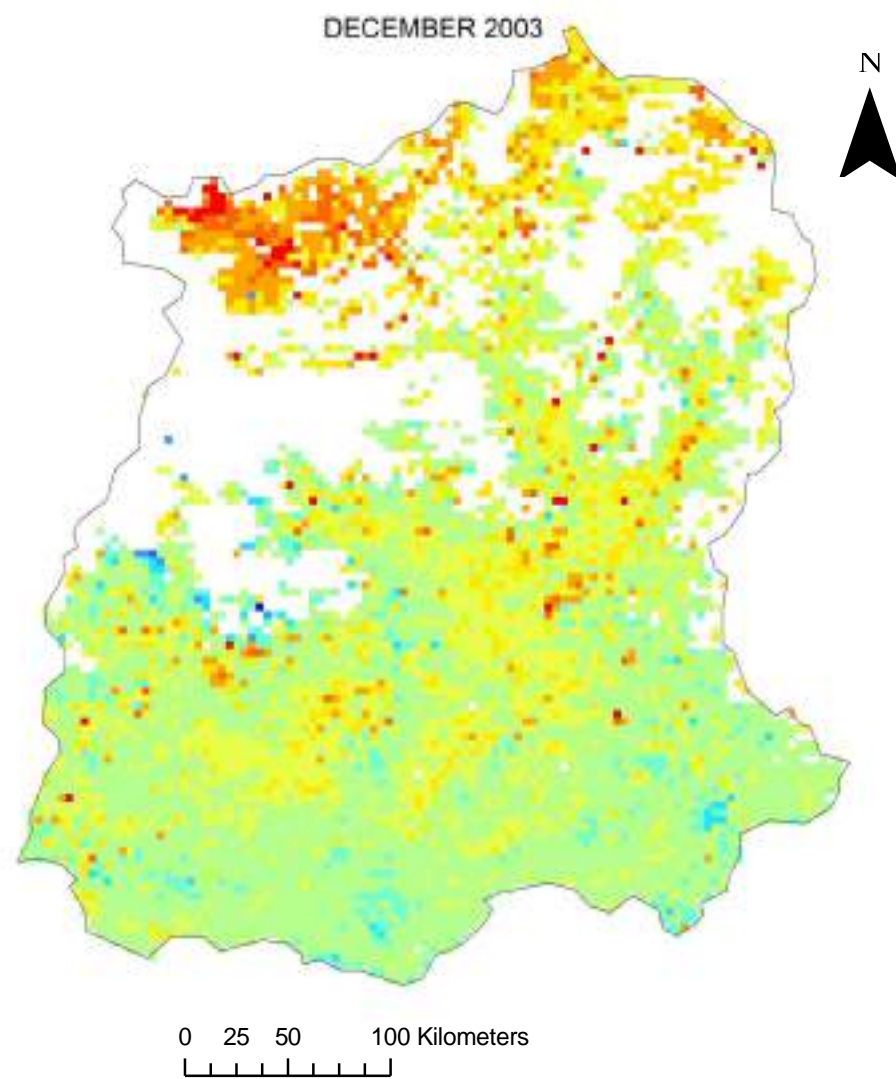






**Legend**

- |   |                                  |   |                                   |   |                                |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less)   |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19)   |
|  | Severe Drought (-1.2 to -1.49)   |  | Near Normal (0.29 to -0.29)       |  | Very Wet (1.2 to 1.49)         |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89)     |  | Slightly Wet (0.6 to 0.89)        |   |                                |



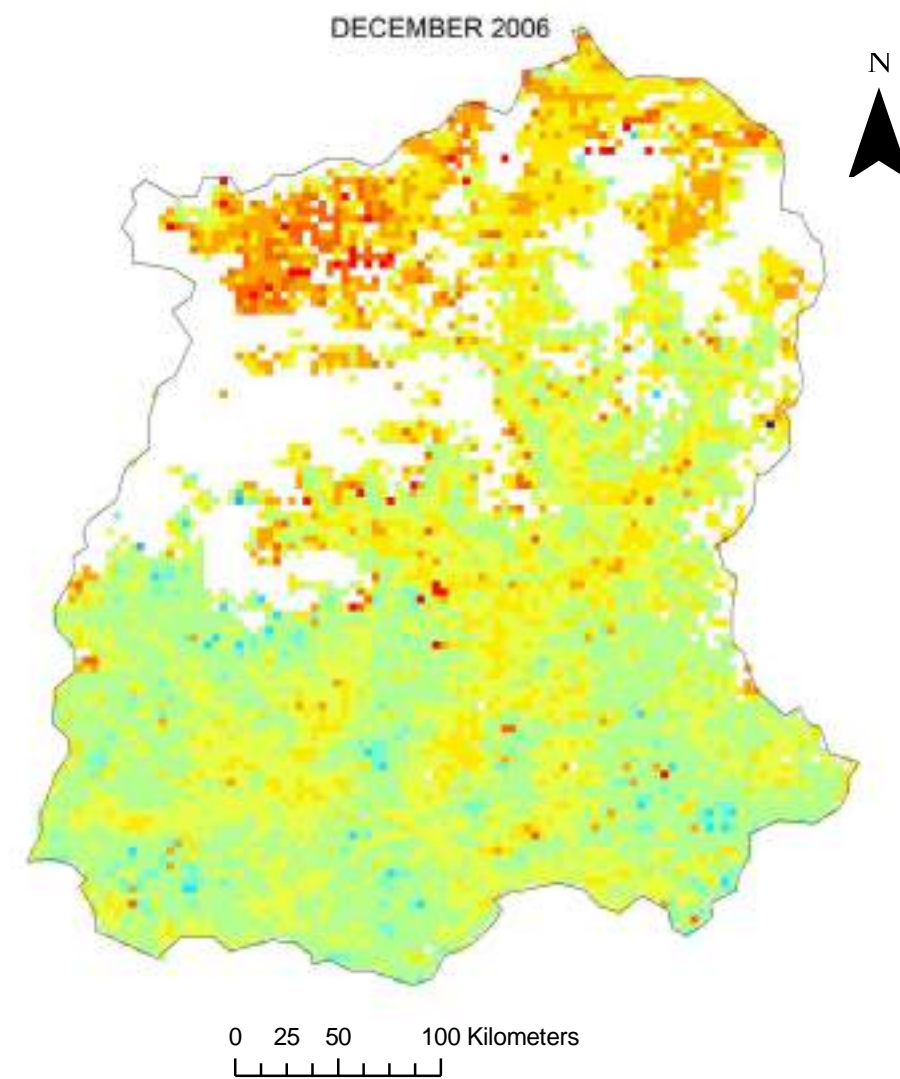
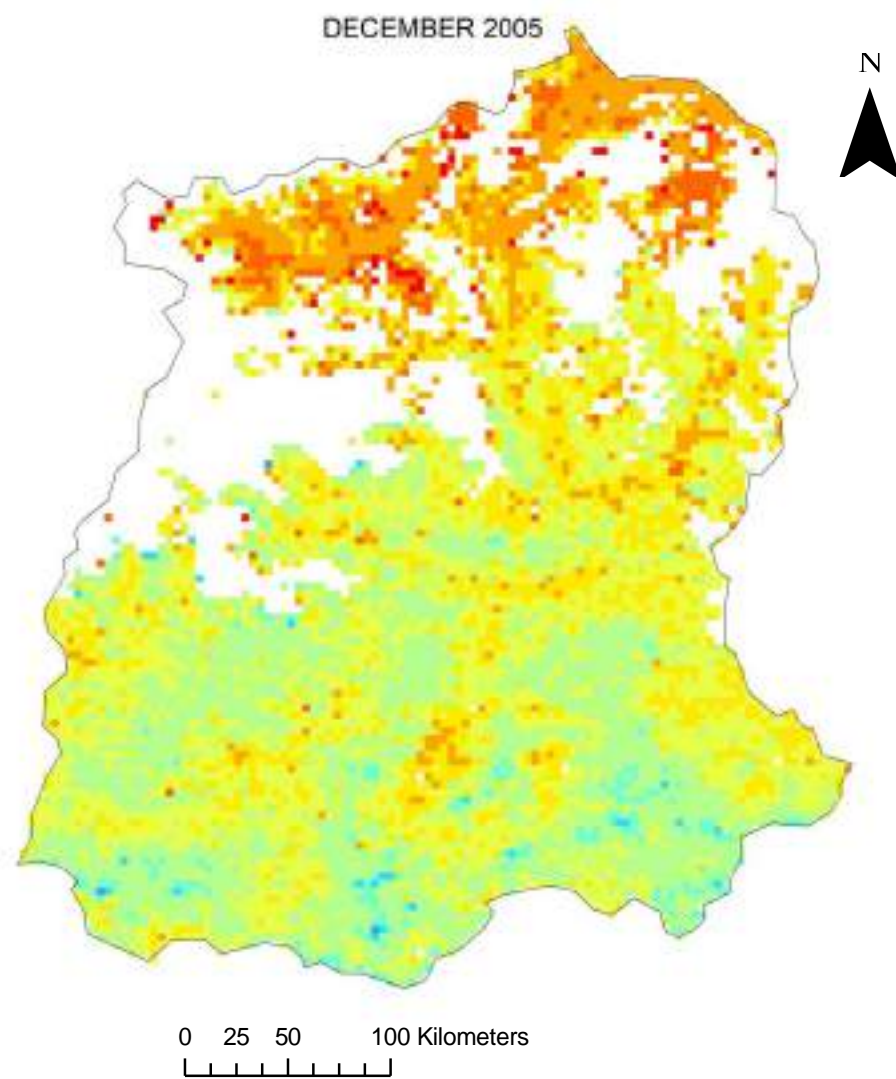
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



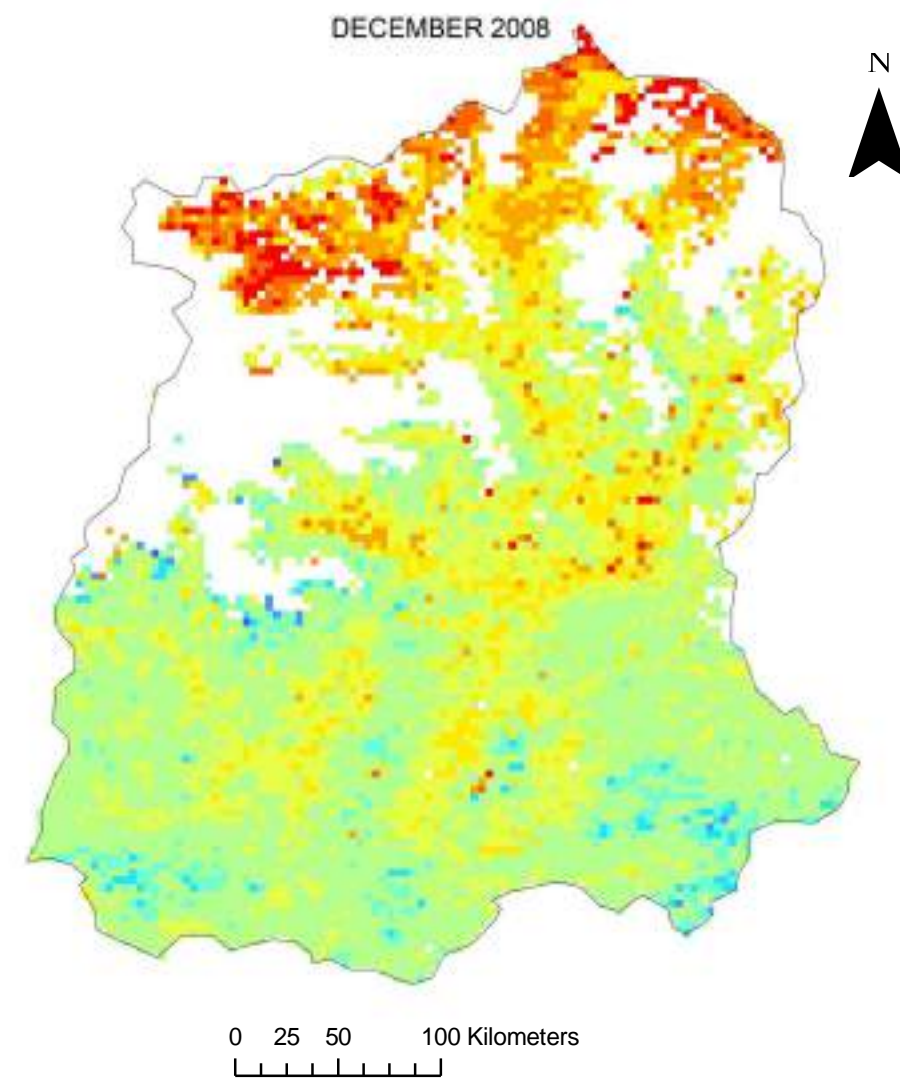
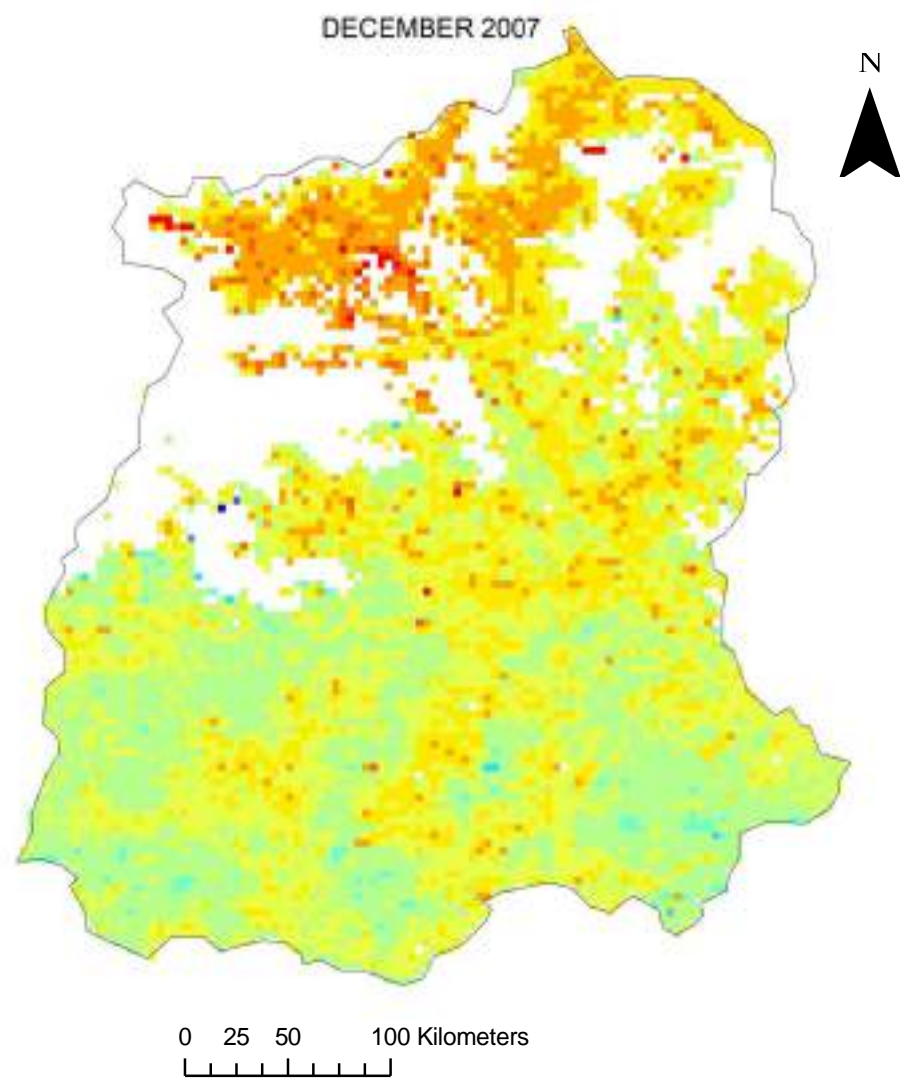


**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



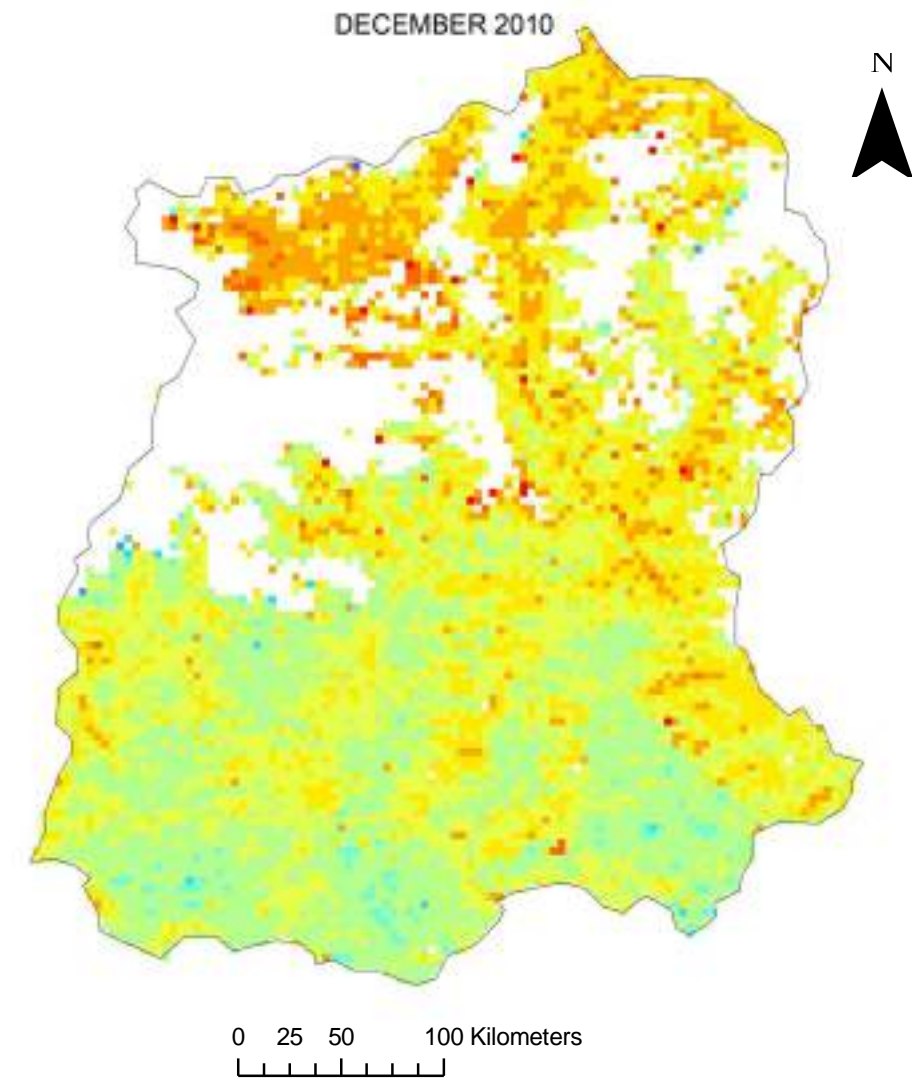
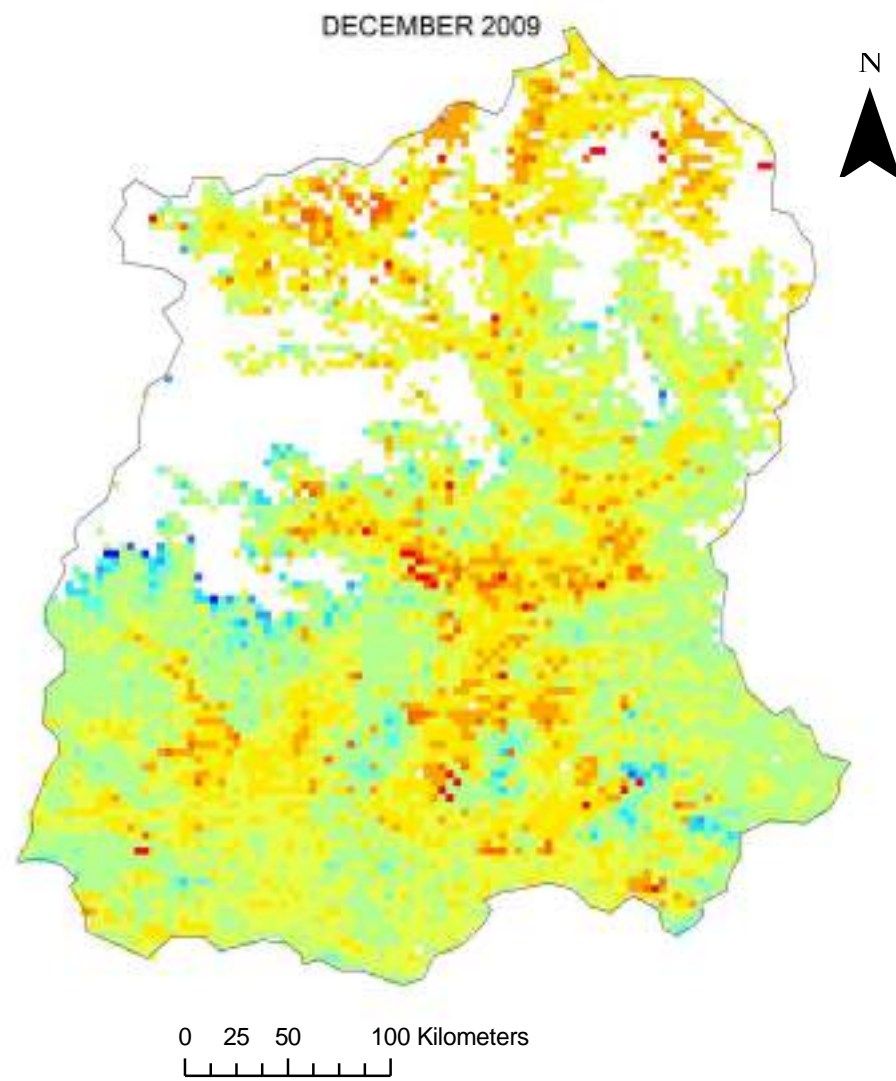
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

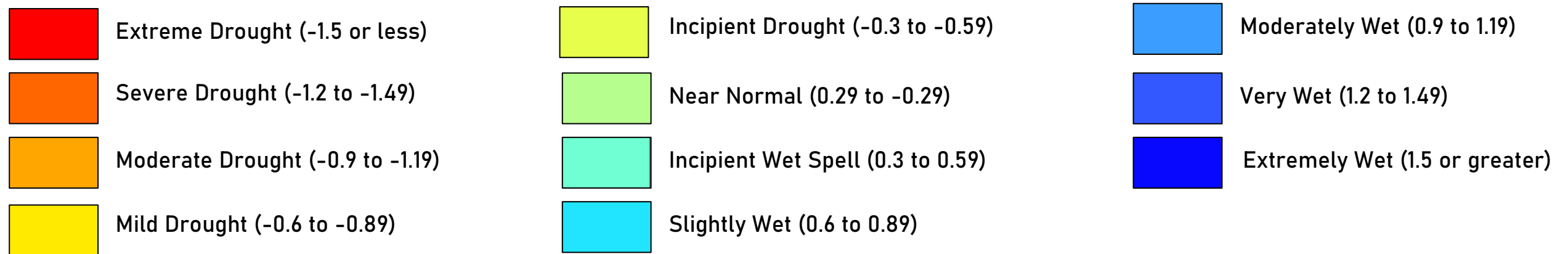
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

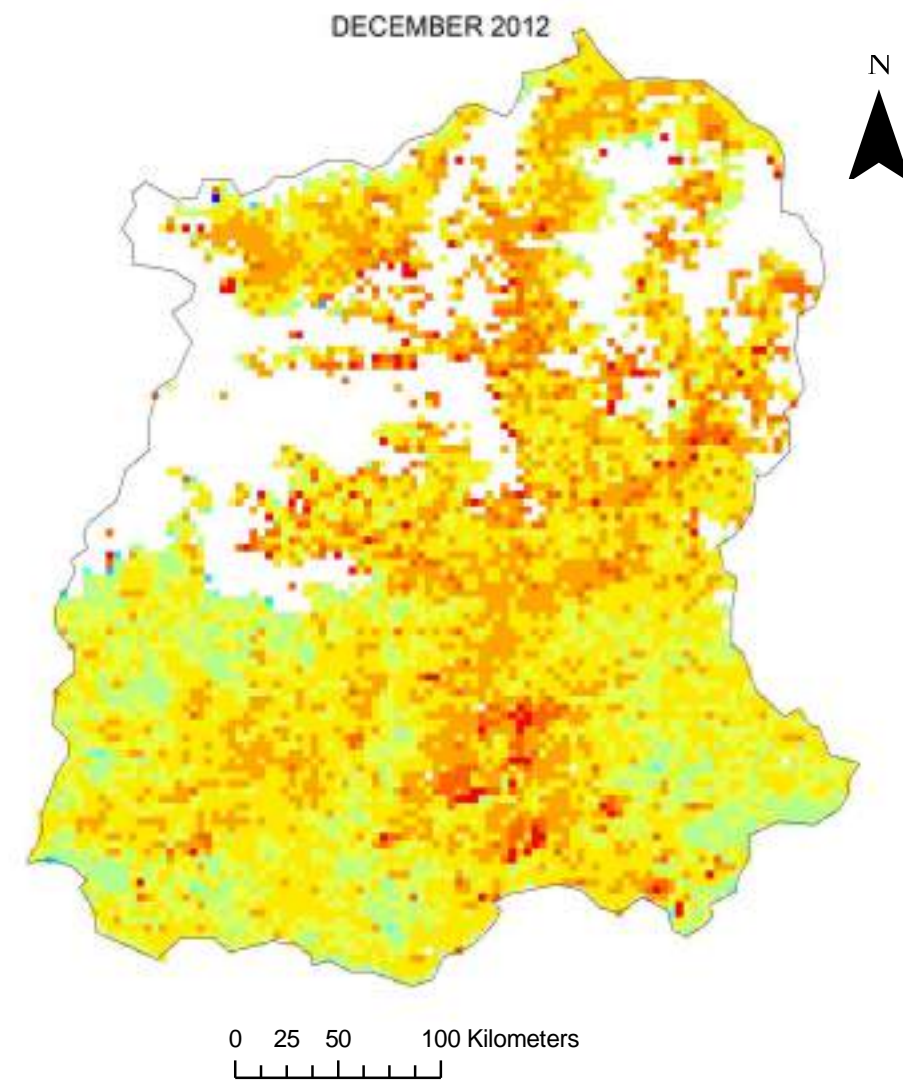
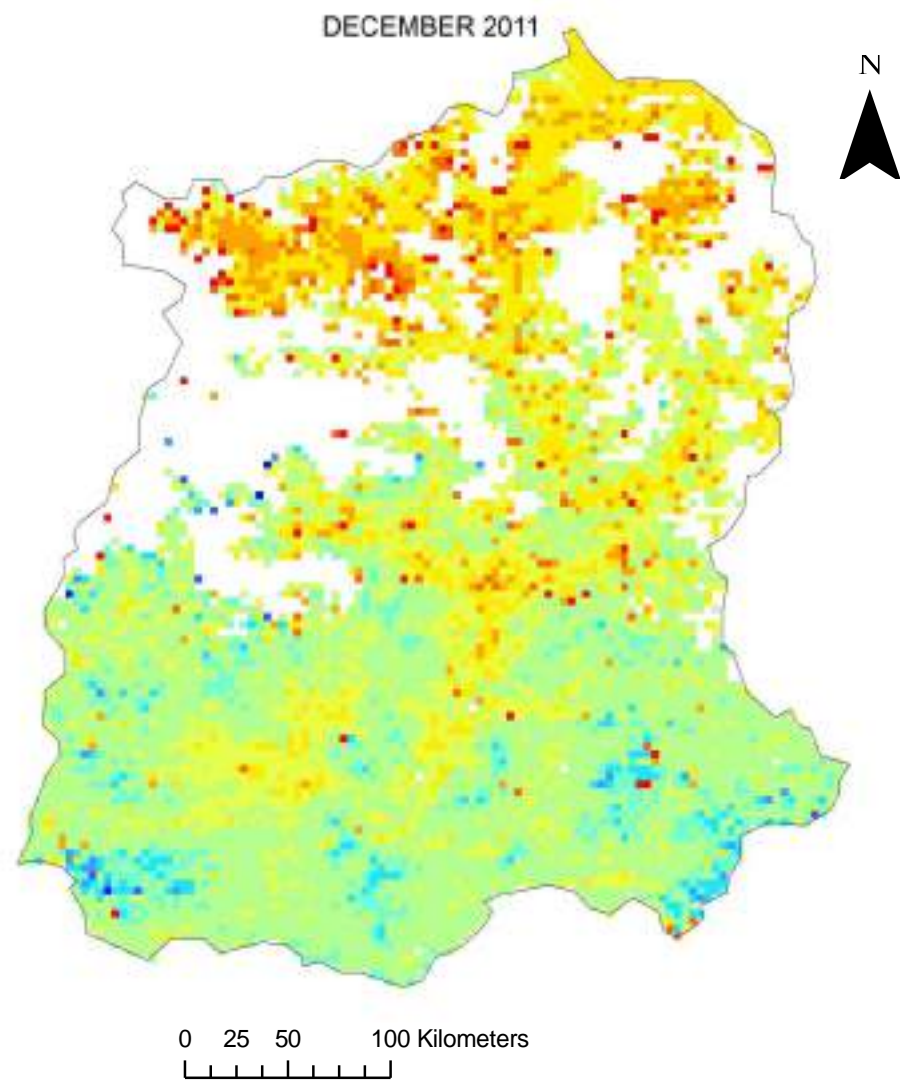
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)





**Legend**





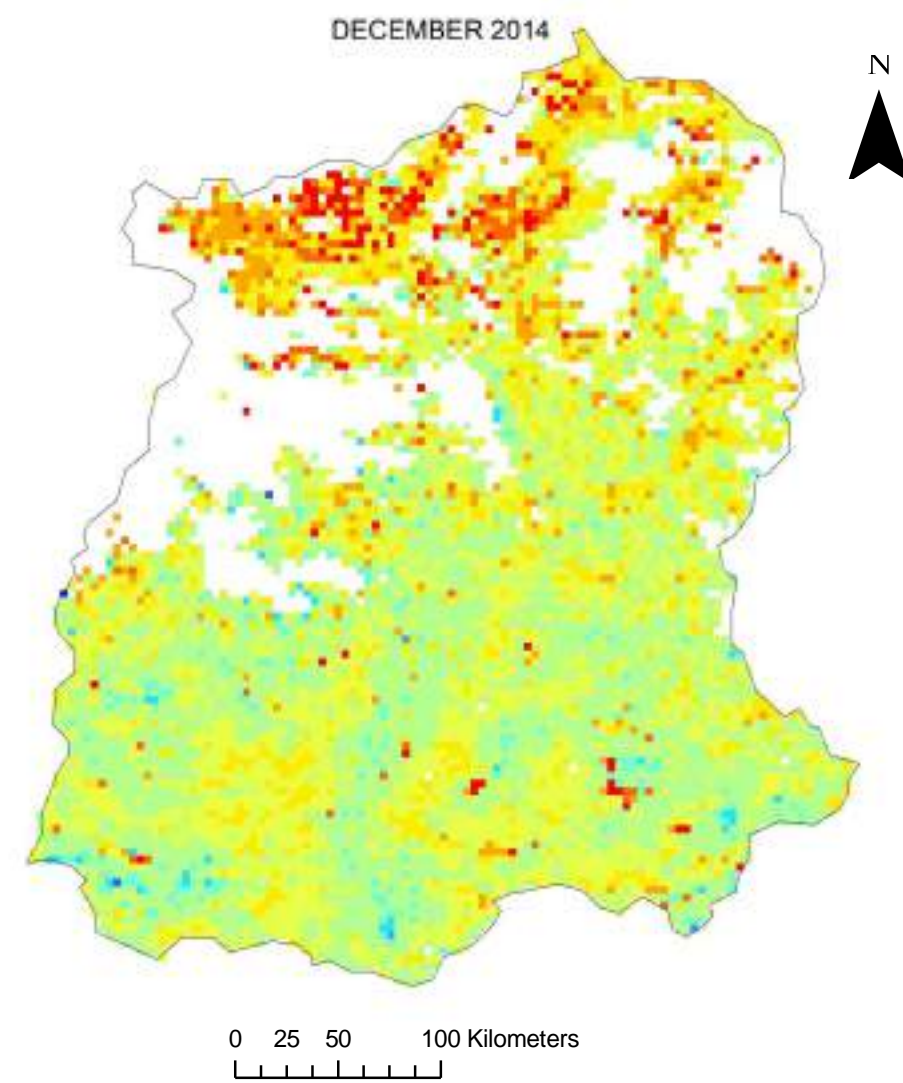
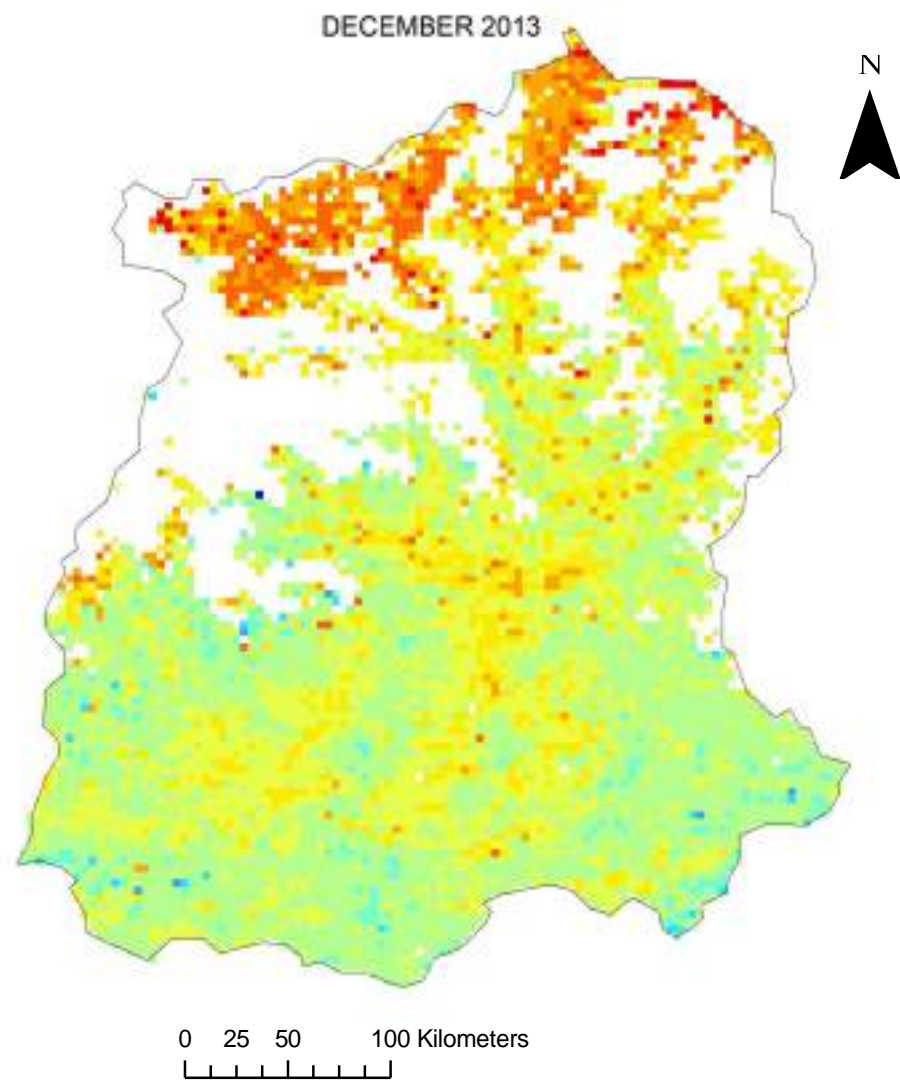
**Legend**

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



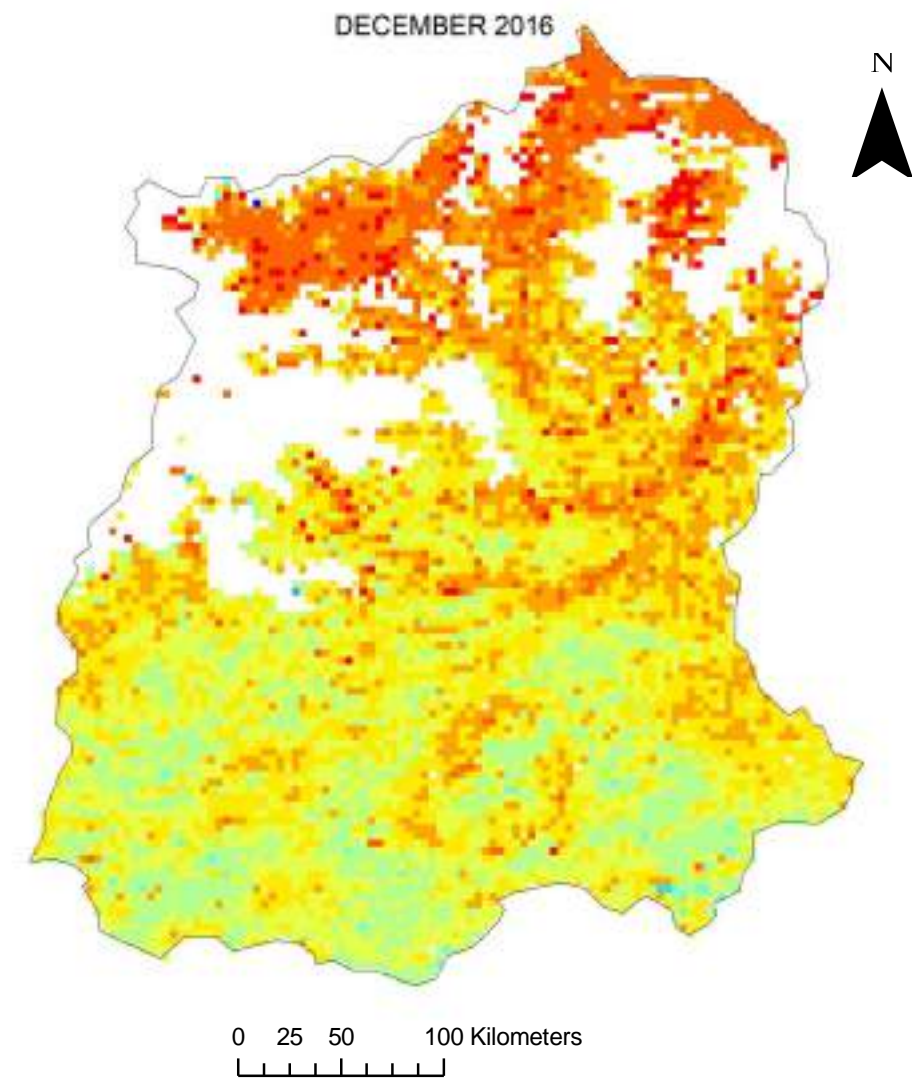
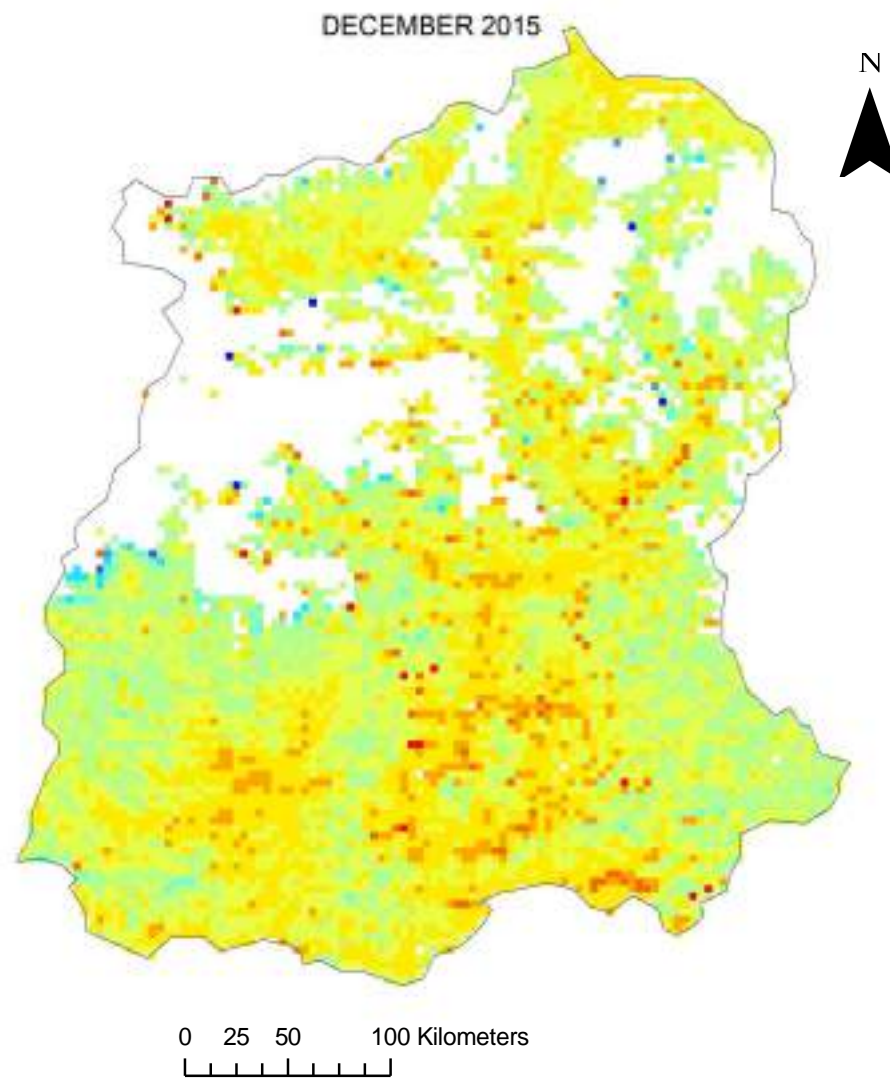


**Legend**

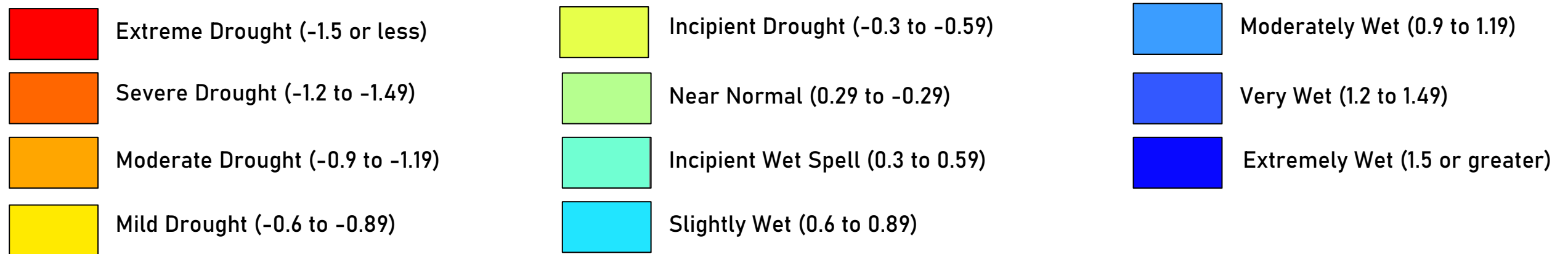
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

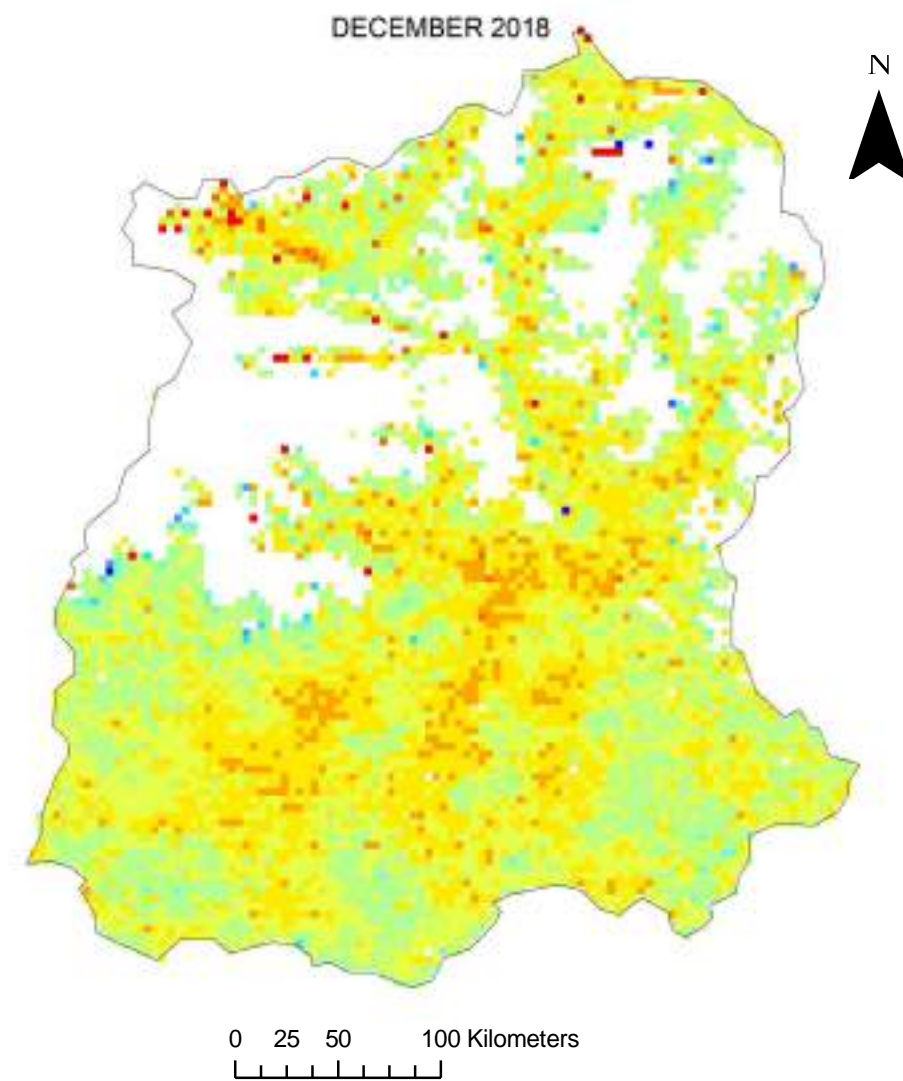
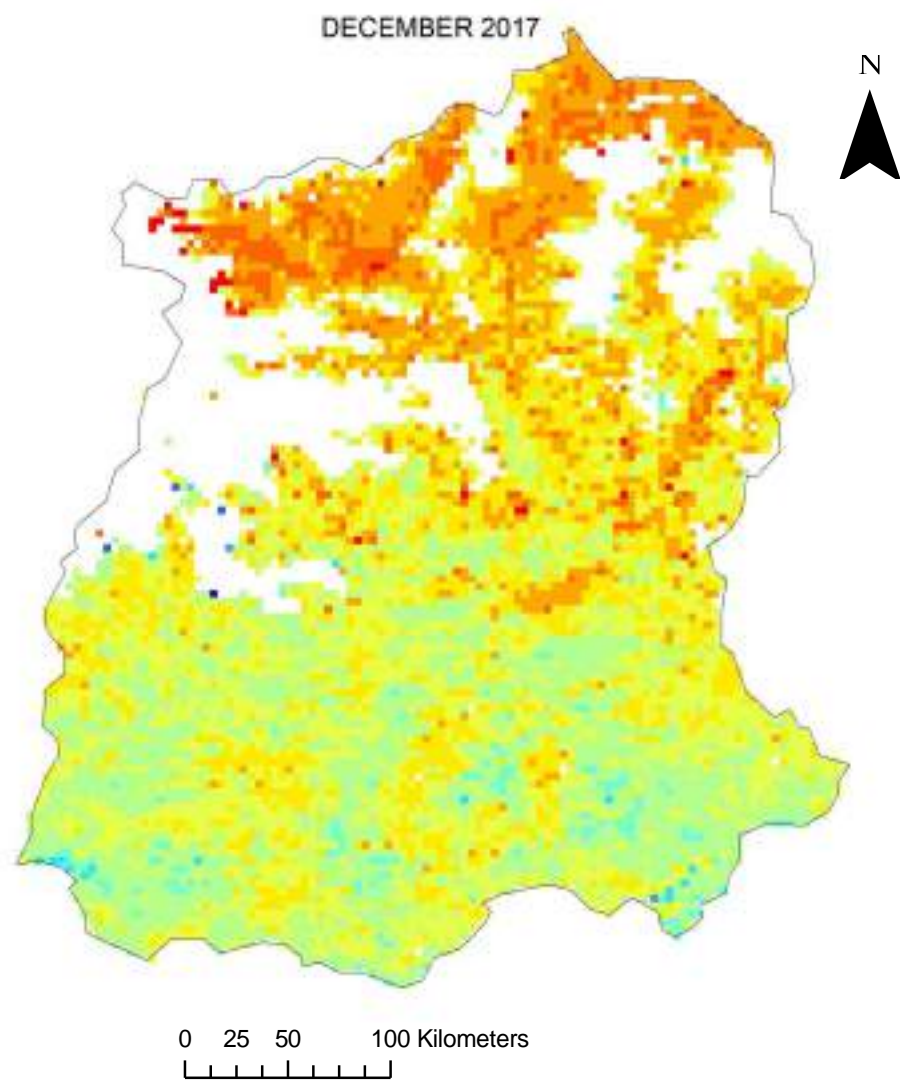
- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



**Legend**





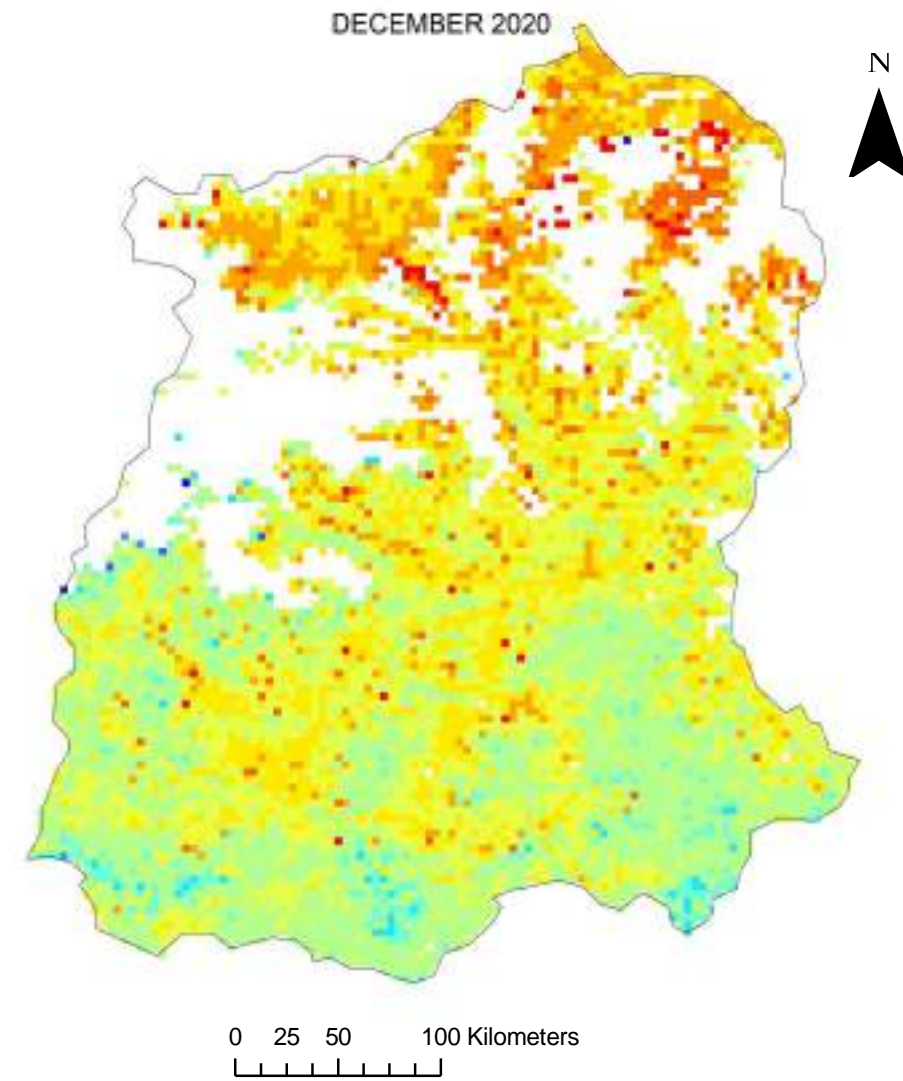
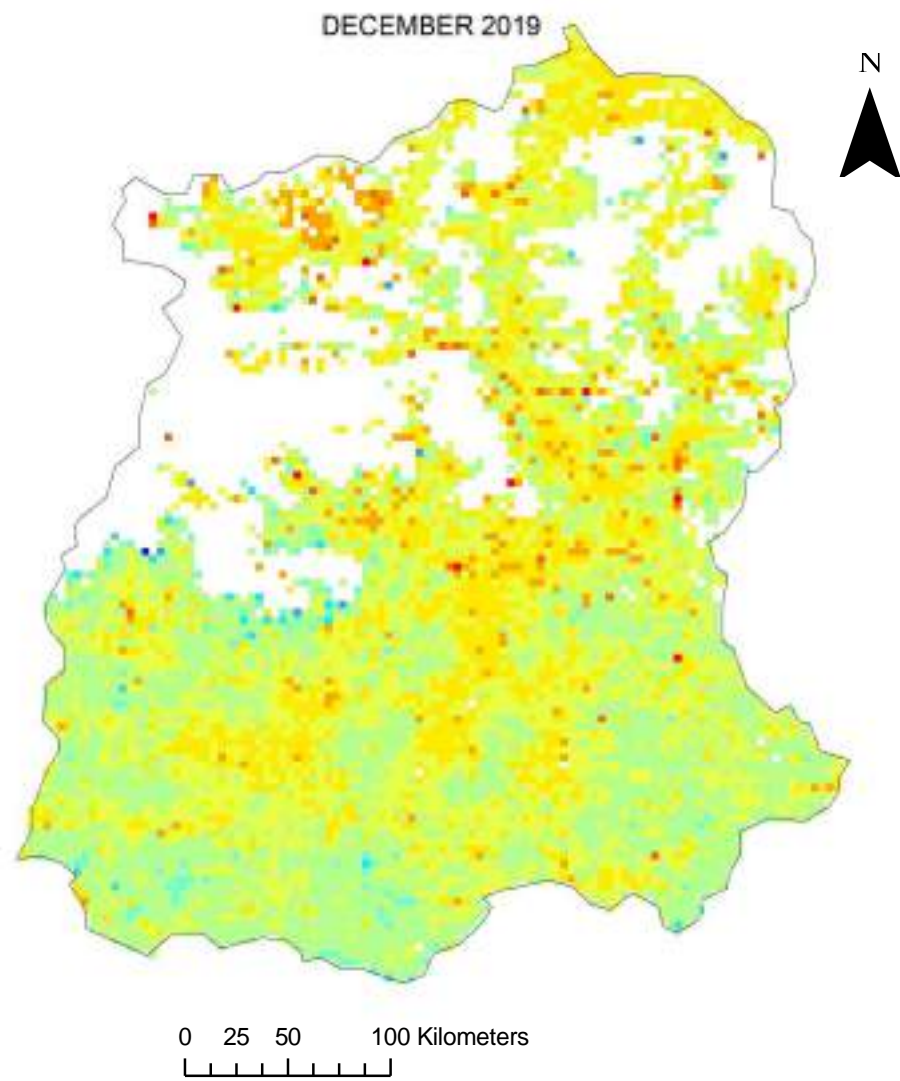


**Legend**

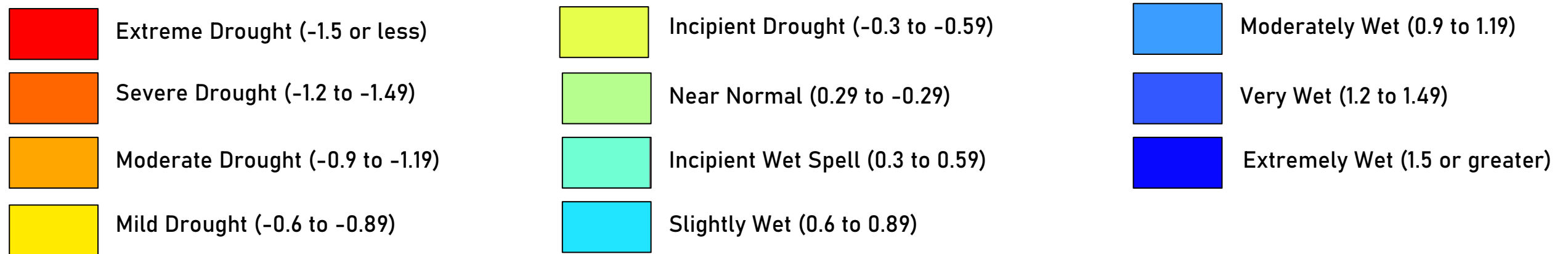
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



**Legend**

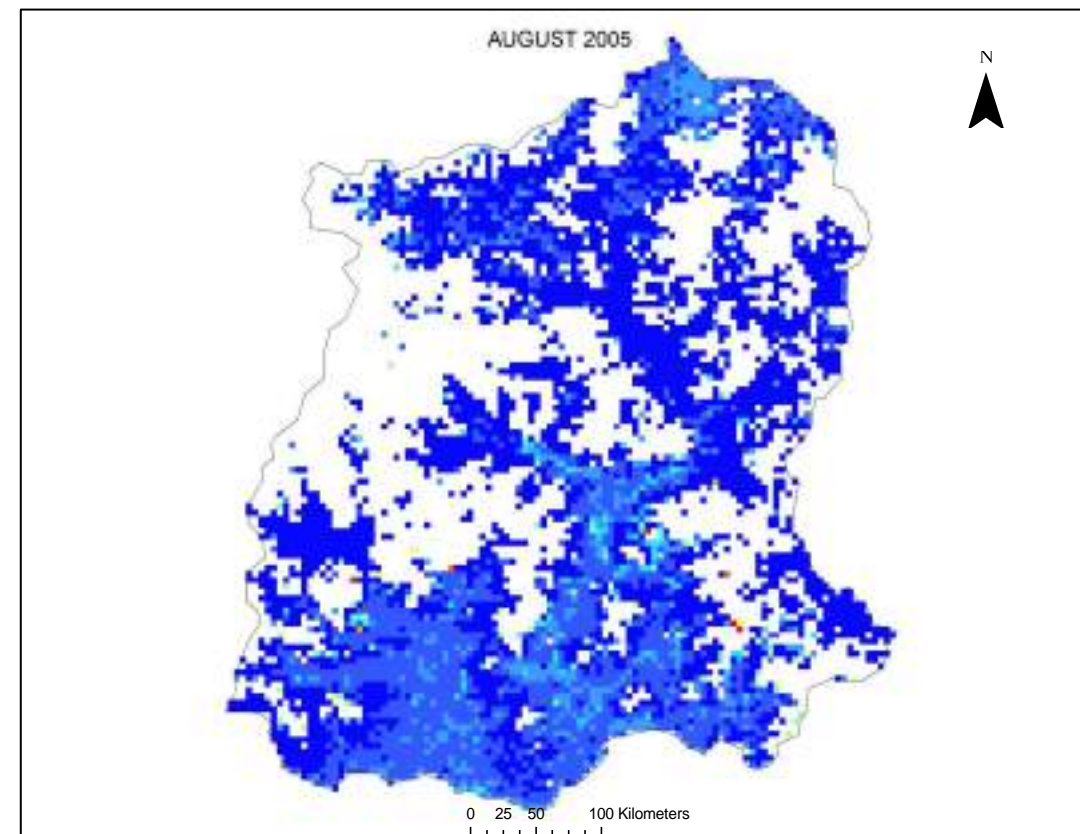
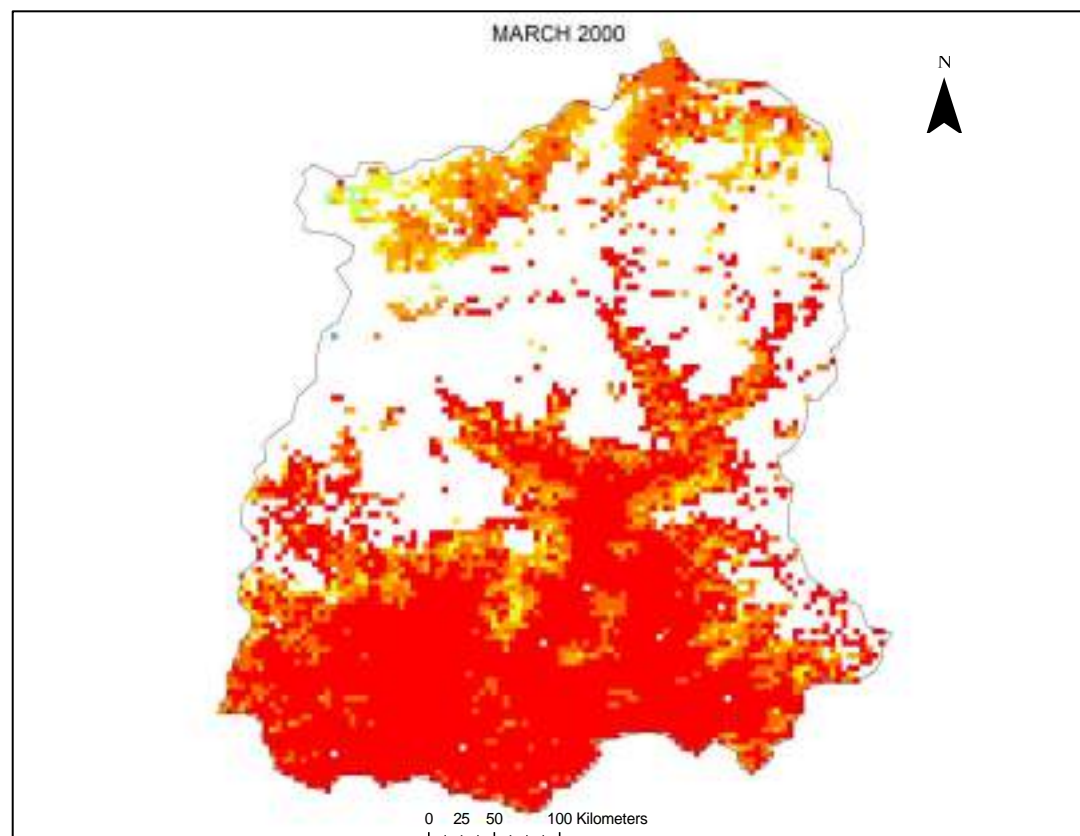
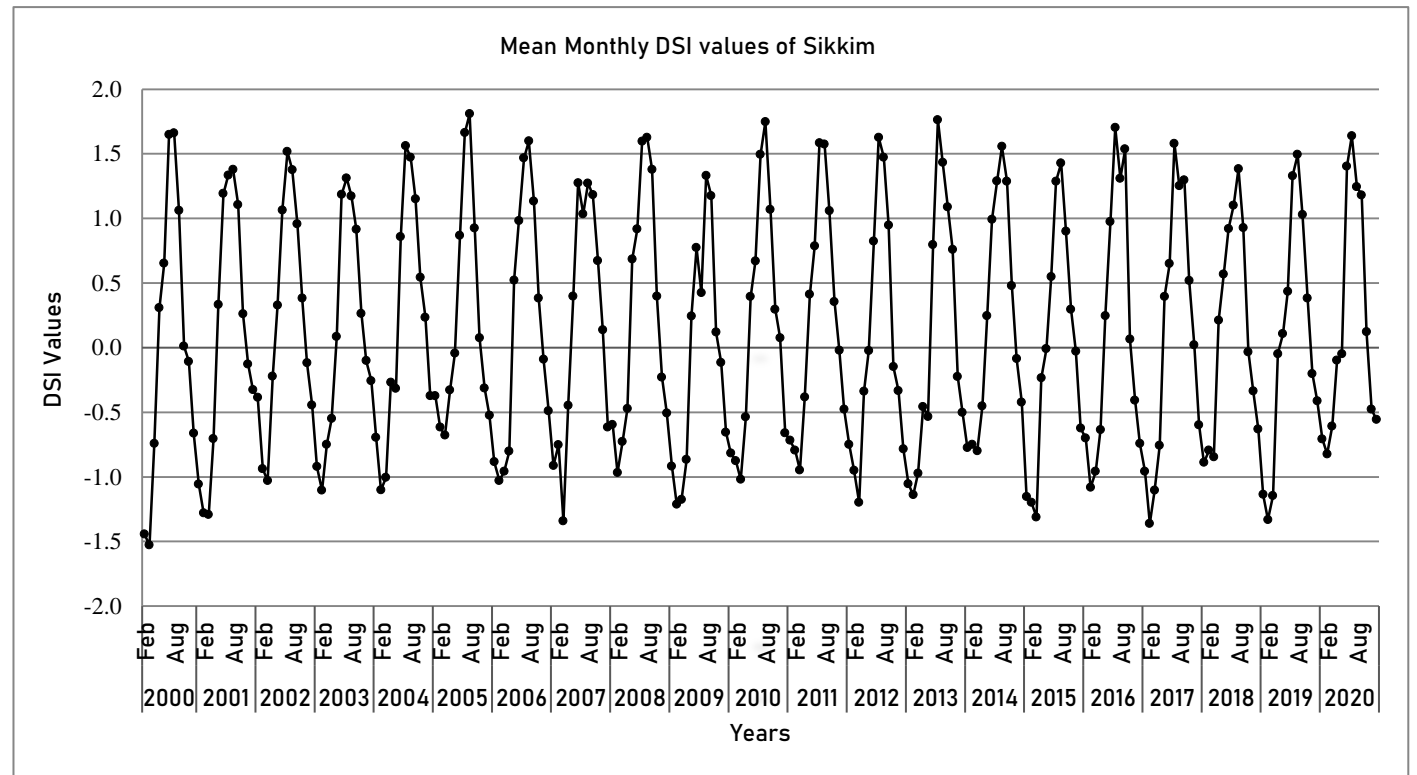




## Drought Severity Index of Sikkim

Droughts are one of the most serious risks to Sikkim's agricultural crop production, as the country's economy is primarily largely dependent on agriculture. Using satellite-based MODIS data, this study shows geographical and temporal drought characteristics.

According to spatial maps, the south region of Sikkim was the worst impacted in February and March. The temporal aspects of the DSI were investigated by plotting the mean monthly DSI for Sikkim from 2000 to 2020. The lowest DSI value (-1.53) was recorded in March 2000, indicating significant drought throughout the research period. August 2005 was the wettest month (1.81). The years 2000 and 2001 were also the driest. In most of the analyzed year, March was the most affected by extreme drought intensity. Droughts intensity was seen higher in January, February, March and April.



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As a result of changing climatic conditions, alter in precipitation events such as drought have emerged as a source of vulnerability in several South Asian nations, including Nepal, India, Pakistan, and Bangladesh. Recent declines in agricultural productivity have weakened rural economies, encouraging widespread famine and urban migration.

Drought monitoring and assessment techniques are used to forecast drought and identify drought-prone areas, allowing drought mitigation measures to be put in place to lessen the impact of drought on food production and water supplies. To estimate the severity of the drought in Sikkim, we applied the Drought Severity Index (DSI), which combines the Normalized Difference Vegetation Index (NDVI) and the ratio of Evapotranspiration to Potential Evapotranspiration (ET/PET).

This Atlas provides an overview of Sikkim's drought frequency during the last two decades. It portrays the spatiotemporal occurrences of drought in Sikkim. I hope this atlas will assist in the creation of policies and plans for timely drought mitigation and forecasting in the agricultural sector.

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ISBN: 978-9937-1-3062-2

