BLOCK-WISE DROUGHT ASSESSMENT OF ODISHA USING RAINFALL-BASED INDICES

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Abstract - *Drought may be experienced due to delay in the onset of monsoon, scanty rainfall during monsoon, early departure of the rainy season and erratic or inconsistent distribution of rainfall. The blocks of Odisha were studied a combination of they face meteorological drought for not. This study analyses the block wise drought (meteorological) and compares between the drought indices for better drought assessment. The goal of the study were to evaluate meteorological drought using Standardized Precipitation Index (SPI), Percent of Normal index (PNI) and Decile Index (DI) and to compare and critically interpret them for better drought assessment. At present the study was conducted for all the blocks of Odisha. SPI is a meteorological drought index which was designed to quantify the precipitation deficit for multiple timescales. But in this case, only monsoon season studied in the time scale of 1-month. This study also reveals that SPI is better than other indices used in. The weightage is given using the AHP technique. The results indicated that the western region of Odisha more vulnerable towards the meteorological comparing to coastal region blocks, and also facing drought in every alternate year. And there was water stress in the drought years with negative SPI values. But very often there were mismatches between SPI and OSDMA (ground truthing) information. Hence, SPI may not be taken as a good indicator for more effective drought risk assessment.*

Key Words: *SPI*,PNI, DI, Meteorological drought, OSDMA, AHP

1. INTRODUCTION

1.1 Drought

According to Hisdal and Tallaksen (2003), drought is a complicated process that is poorly understood. It is a natural danger brought on by an extreme occurrence as a consequence of a protracted shortage of water. This phenomenon may be caused by below-average rainfall, unequal rainfall distribution, a higher demand for water than supply, or a combination of all three. The demand for water resources rises as a consequence, which may cause customers to get their supply inconsistently. These may lead to disputes between the different rivals, which are more likely to occur during extreme droughts. Erroneous assessment of drought may also have detrimental effects on the environment and economy. Drought damage is not limited to any one area of the world. The severity of this specific disaster varies depending on the location since it happens slowly and gradually.

A protracted lack of water, whether from the atmosphere (below-average precipitation), surface water, or subsurface water, is referred to as a drought. A drought may be proclaimed in as little as 15 days, or it may last for months or years. It may negatively influence the local economy and have a significant effect on the afflicted region's agricultural and ecology. In tropical regions, there is a substantial increase in the likelihood of a drought and associated bush fires during annual dry seasons. Heat waves have the potential to dramatically exacerbate drought conditions by speeding up the evaporation of water vapor. Unlike other natural disasters like floods and cyclones, drought is a slow-moving, creeping phenomena (WMO 2006). It is difficult to pinpoint the start and end of a drought since the urban, rural, and industrial sectors all experience droughts in various ways. Although predicting persistence and monitoring droughts always provide special scientific problems, doing so is crucial as droughts grow more frequent and severe as a result of the effects of climate change (Mishra & Singh 2009 Alexander et al. 2009). The climate in much of the globe, including India, is characterized by recurrent droughts.

India's history of drought indicates that the country is very susceptible to drought because of its monsoonal climate and natural rainfall variability in both space and time. In varied degrees, 68% of the region is vulnerable to drought. 35% of the whole area is classified as drought-prone because it gets precipitation between 750 and 1,125 mm, while another 33% is classified as chronically drought-prone because it receives less than 750 mm. ecology and the economics of agriculture.

This problem is made worse by the difficulty in accurately predicting when it will occur and the uncertainties around its intensity and pace of spread. Consequently, a period of below-average precipitation in a particular area that causes sustained limitations in the water supply is studied as a drought. The environment of the impacted area is significantly impacted. For humanity as a whole and for government in particular, creating a contingency plan based on its features is crucial (Dash et al., 2013; Panigrahi and Panda, 2001). In order to effectively prepare for crops and water resources, drought indices are used to track and evaluate the severity of drought.

Numerous scholars have conducted research on the identification and measurement of drought indicators. The majority of these drought indexes rely on hydrological or meteorological factors. The definition of meteorological drought often takes into account the length of the dry spell as well as the degree of dryness relative to an average or typical quantity of rainfall. Meteorological drought definitions need to be seen as region-specific. According to Kumar et al. (2018), alternative definitions might associate monthly, seasonal, or yearly average rainfall quantities with actual rainfall deviations.

Every year, drought affects a sizable portion of India's cropland, resulting in significant economic losses for the nation. Only 35 percent of the 62 lakh hectares of cultivated land in the state of Odisha have irrigation infrastructure from different sources, meaning that the majority of agriculture there is rainfed (OSDMA, 2003). About 85% of the state's 45 million residents live in rural regions, and a sizable portion of them are marginal farmers, suggesting a high degree of reliance on agriculture. The state's monsoonal patterns are crucial for agricultural output and, by extension, food security. The southwest monsoon contributes around 86% of the state's yearly rainfall (CGWB, 1999).

Numerous plant species, including those in the Cactaceae family (often known as cacti), have evolved adaptations to withstand dryness, such as decreased leaf area and waxy cuticles. Some others, like buried seedlings, endure dry spells. A semi-permanent drought creates dry biomes like grasslands and deserts.Humanitarian crises and mass migration have been brought on by protracted droughts. The majority of dry habitats are by nature little productive. The Atacama Desert in Chile saw the longest drought in recorded history, lasting 400 years.

1.2 Some definitions of Drought

There is no exact description for the drought. Numerous hydro-meteorological variables, socioeconomic considerations, and regional variations in water needs have prevented scholars from creating or revising a single, comprehensive definition of drought. A definition of drought that works well in one area may not always translate well to another. Nonetheless, the following general definitions are listed:

- As defined by the World Meteorological Organization (WMO, 1986), "a sustained, extended deficiency in precipitation" constitutes a drought.
- "Drought means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydro-logical imbalances that adversely affect land resource production systems," according to the UN Convention to Combat Drought and Desertification (UN Secretariat General, 1994).
- A drought is characterized as a danger by the Food and Agriculture Organization (FAO, 1983) of the United Nations as "the percentage of years when crops fail from the lack of moisture."
- A drought is described as "an extended period - a season, a year, or several years - of deficient rainfall relative to the statistical multi-year mean for a region" in Schneider, 1996's Encyclopedia of Climate and Weather.
- "Drought as a sustained period of time without significant rainfall" was the definition given by Linsley et al. in 1959.
- "Drought as the smallest annual value of daily stream flow," according to Gumbel (1963).
- "Drought as a significant deviation from the normal hydrologic conditions of an area" was how Palmer (1965) defined it.

Its definition, however, differs depending on the fields it affects, the reasons it happens for, and the transaction phases for which it occurs. As a result, the many definitions of drought may be arranged into groups referred to as types of droughts.

1.3 Categorization of Dry spells

A hydrological drought occurs when there aren't enough surface and subsurface water resources available for the water uses that have been defined under a certain water resources management system. Numerous studies (Dracup et al., 1980; Sen, 1980; Zelenhasic and Salvai, 1987; Chang and Stenson, 1990; Frick et al., 1990; Mohan and Rangacharya, 1991; Clausen and Pearson, 1995) have used streamflow data for hydrologic drought research. Geology is one of the primary variables driving hydrological droughts, according to regression analyses linking droughts in streamflow to catchment features (Zecharias and Brutsaert, 1988; Vogel and Kroll, 1992).

A period of decreasing soil moisture and subsequent crop failure without regard to surface water supplies is often referred to as an agricultural drought. A decrease in soil moisture is dependent on a number of variables, including variations between actual and prospective evapotranspiration and climatic and hydrological droughts. The biological traits of the particular plant and its stage of development, the physical and biological qualities of the soil, and the current weather all affect how much water plants need. A number of drought indicators have been developed to analyze agricultural droughts. These indices are based on a mix of precipitation, temperature, and soil moisture.

Droughts are linked to the supply and demand for water, an economic good, since socio-economic droughts are caused by water resource systems' inability to fulfill demand (AMS, 2004). A socio-economic drought happens when there is a weather-related shortage in water supply, which causes demand for an economic product to outpace supply.

2. Effects of the Drought

When compared to other natural calamities, droughts are among the most expensive. It has detrimental effects on the economy, energy, recreation, agriculture, water resources, ecosystems, and human health, among other societal sectors (Dai et al., 2004; Watson et al., 1997). The following discusses a few of the most severe consequences of drought.

2.1. Effect on the Economy

The effects of the drought on industries including forestry, fishing, and agriculture may have a negative influence on the national economy. The supplies of surface and ground water are necessary for these sectors to function. A drought event's existence may serve as the foundation for production losses in terms of livestock and agricultural output. As a consequence, a nation's GDP eventually declines, which also affects the economy.

2.2. Effects on the Environment

Drought-related environmental effects include degrading landscape quality, reducing biodiversity, causing soil erosion, and harming a variety of plant and animal species, wildlife habitats, and forests. In the event of temporary impacts, normal circumstances are restored. However, long-term impacts like these might possibly cause irreversible harm. For instance, increasing soil erosion brought on by a decline in the quality of the landscape may cause a permanent loss of biological production.

2.3. Effects on the Community

The drought's long-term persistence and extremeness have an influence on society. In India, farmer suicides due to a lack of agricultural output are a frequent annoyance. Food shortages may sometimes result in fatalities, which can incite fear and violence in the community. Extreme drought often results in disputes between water users, most of which are of a political, social, or industrial character. Public unhappiness with government drought response efforts may be attributed to social instability. Drought, which either directly or indirectly contributes to poverty, is the most prevalent worry in developing nations like India.

3. Odisha Drought History

In the state of Odisha, agriculture is mostly rainfed; just 35 percent of the 62 lakh hectares of cultivated land have irrigation facilities, some of which are reliant on rainfall (OSDMA, 2002). The 37 million people who make up the state's population are mostly rural (85%), and a significant portion of them are marginal farmers (Census, 2001), demonstrating the state's heavy reliance on agriculture. According to a 2008 World Bank assessment, the state's agricultural land depends on rainfall to the tune of almost 75%. Therefore, the state's monsoonal patterns are crucial for agricultural output, which in turn determines food security. The southwest monsoon contributes around 86% of the state's yearly rainfall (CGWB, 1999). Poor crop output and drought conditions indicate a delayed or premature monsoon and/or less precipitation throughout the season, which may have detrimental effects and lower resilience.

4. Assessment of Drought

We refer to the process of measuring the severity of a drought as drought assessment. An appropriate drought indicator may be used to evaluate the drought. The application of drought assessment determines the selection of the drought index.

In India, 44% of all crop output comes from rainfed agriculture (Vittal et al., 2005). For sustainable agricultural output in rainfed countries, the unpredictability in the occurrence of active-break phases of South-West monsoon rainfall is a key problem (Chandrasekar et al., 2010). Delays in the monsoon season cause seeding activities in certain areas to be postponed. The quantity of rainfall and the likelihood of a wet or dry spell throughout a growing season determine whether there is enough soil moisture available for crops. For the purpose of assessing agricultural drought, rainfall and crop vigor must be recorded on a regular basis.

Forecasting droughts and taking precautions against them are critical to increasing agricultural output, particularly in regions that get rain. Several significant drought indices are the National Rainfall Index (RI; Gommes and Petrassi, 1994), the Rainfall Anomaly Index (RAI; Van Rooy, 1965), the Rainfall Deciles (Gibbs and Maher, 1967), and the Palmer Drought Severity Index (PDSI; Palmer, 1965). SPI is one of these indexes that is often used in many different places throughout the globe to measure meteorological drought. SPI has the benefit of being a useful drought indicator as it can be computed over various time periods and used to analyze various drought classifications (Capra & Scicolone, 2012). Furthermore, since SPI is based on a single piece of data—precipitation—it is simpler to compute than more complicated indices (Vicente-Serrano, 2006; Wu et al., 2005). After comparing the SPI and PDSI, Guttman (1998) came to the conclusion that the SPI has benefits in statistical consistency and can characterize the effects of drought over the long run at various time scales due to precipitation anomalies.

Several drought indices were developed in the past century by combining meteorological factors including temperature, evapotranspiration, and rainfall into a single figure. The standardized precipitation index (SPI) (McKee et al., 1993, 1995), the aridity index (Gore and Sinha Ray, 2002), the Palmer drought severity index (PDSI) and the moisture anomaly index (Z-index) (Palmer, 1965), and the percent normal deciles (Gibbs and Maher, 1967) are among the most widely used drought indices. In general, drought indices make it possible to identify when drought occurrences begin and to quantify their intensity. This makes it possible to investigate the temporal and geographical features of drought and to draw comparisons between various places (Alley, 1984).

It should be a natural process that occurs for a variety of reasons. It could be brought on by little rain during the monsoon, an early monsoon withdrawal, irregular or unequal rainfall distribution, or a delayed monsoon.

5. RESOURCES AND TECHNIQUES

5.1 Study Area

Odisha as a whole has been chosen as the research area. The state is situated between latitudes 17°49' and 22°34'N and longitudes 81°27' and 87°29'E. The Bay of Bengal forms its eastern boundary, while the states of Madhya Pradesh and Andhra Pradesh encircle it on the west and south, respectively. It has an area of 155,707 square feet. kilometers, or around 4.87% of India's total land area. Spread over 10 distinct agro-climatic zones (ACZs), it consists of 30 districts and 314 blocks (Fig. 5.1).

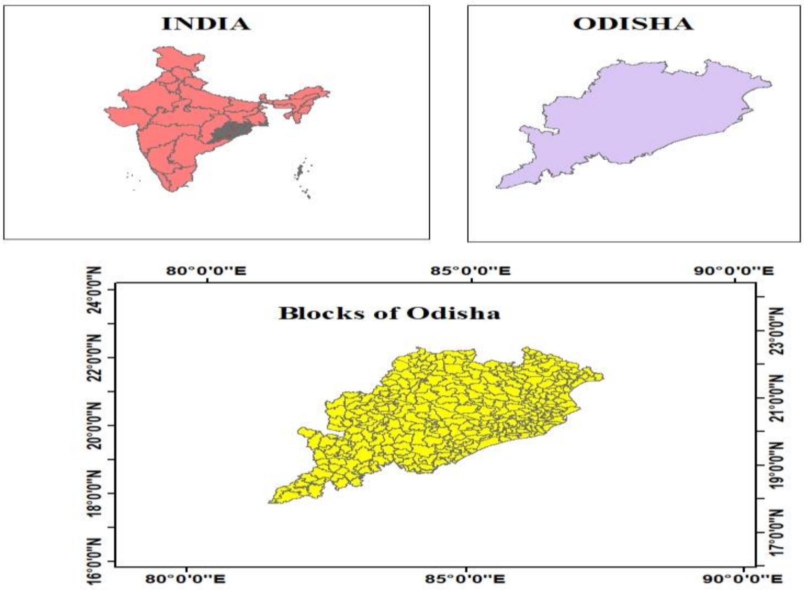

Figure. 5.1. Where the study area is located

5.2. Climate

Similar to most other regions of the nation, Orisha has tropical monsoon-style weather. Summertime temperatures may reach as high as 40°C on average. The lowest temperature during the typically mild winters is 16°C. About 1450 mm of rain fall on the state during the monsoon season.

Eight of the thirty districts are located in the coastal areas and are part of two CACZs. Figure. Based on the soil composition, humidity, elevation, terrain, vegetation, rainfall, and other agroclimatic characteristics of Odisha, including the two CACZs, Figure 3.2 displays ten distinct agroclimatic zones (ACZs) (OMEGA, 2014).

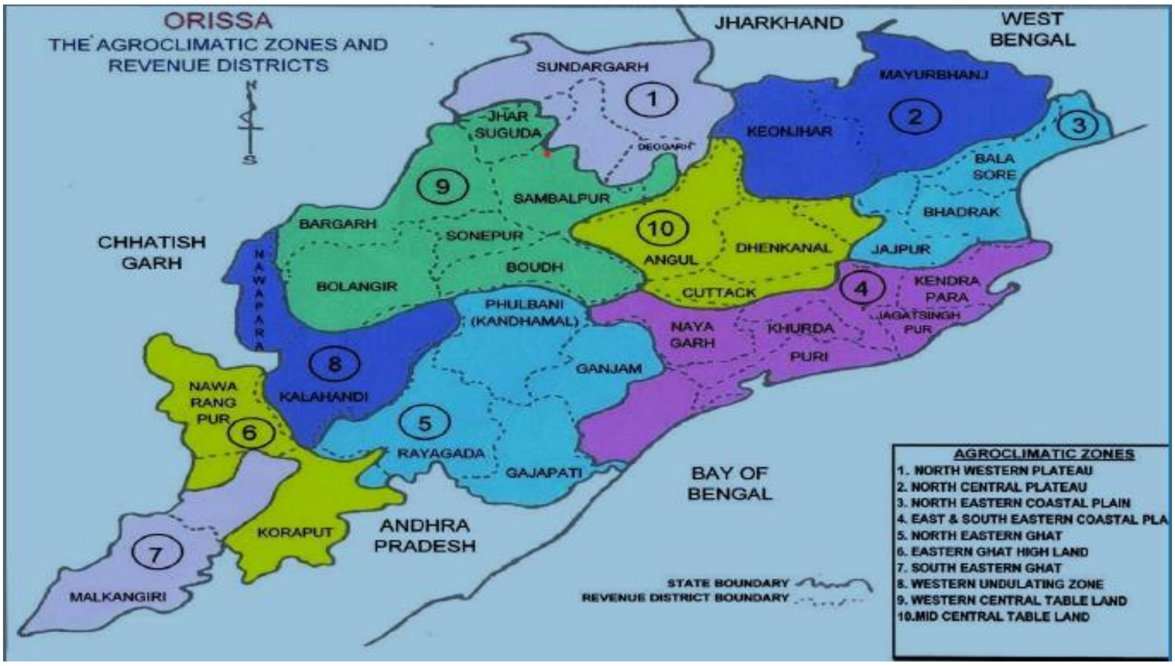

Figure. 5.2. Odisha's agroclimatic zones (OMEGA, 2014)

Early June marks the arrival of the southwest monsoon, which ends in mid-October. Rainfall occurs 80% of the year during the monsoon season, which lasts from June 1 to October 15. The remaining sum is paid out throughout the course of the year. The primary agricultural season, known as Kharif, is when rice (Oryza sativa) is grown. Rabi season cropping is mostly limited to irrigated and residually wet locations. Pulses, oil seeds, fibers (cotton, jute, and mesta), sugarcane, and vegetables are among the other significant crops grown in the state. The primary horticultural crops grown in the state are cashew nuts, bananas, coconuts, and mangoes.

5.3 Water-related resources

There are abundant water resources in Odisha. Every year, the state receives 231 BMC (billion m3) of water from precipitation. Odisha receives around 1500 mm of precipitation on average year, with June through September accounting for 80% of that total. The southwest monsoon is mostly responsible for Odisha's rainfall. During the monsoon, the state receives roughly 70 days of rain. The district of Keonjhar has the fewest rainy days, whereas Koraput experiences the most. According to estimates from government entities, Odisha has 21 BCM of yearly replenishable ground water. According to estimates from 2004, the total yearly ground water draft was 3.85 BCM. As a result, the groundwater stage was determined to be 14.8%.

5.3.1. Farming

Over 70% of the workers in Odisha make their living from agriculture and related industries. Nevertheless, agriculture and animal husbandry's portion of the GDP remains relatively modest, at 23.43 percent. The entire cultivable land in Odisha is around 65.59 lakh hectares. It has been estimated that 49.90 lakh hectares might be submerged in water. According to the state, by 2009–10, irrigation potential has been established on 29.31 lakh hectares, or around 47.5% of the total cultivable land. Of this potential, large and medium irrigation projects accounted for 45.1% of the developed potential; flow-based minor irrigation sources accounted for 18.8%, lift-based minor irrigation projects for 16.8%, and other sources for 19.3% of the sources created. As many as 198 out of 314 blocks in Odisha were found to have less than 35 percent of their cultivable area under irrigation in the 2005–06 fiscal year (source: Water Resources of Odisha Issues and Challenges, 2010).

6. Weather-Related Drought Indexes

The three indicators listed below are used to evaluate the block-by-block drought in Odisha. In this research, the Decile Index (DI), the Percent of Normal Index (PNI), and the Standardized Precipitation Index (SPI) were used. In addition, the state's meteorological droughts were evaluated using the famous Multiple Criteria Decision Making (MCDM) Analytic Hierarchy Process (AHP). The following are the indexes' specifics.

6.1. Standardized Precipitation Index (SPI)

Standardizing the likelihood of observed precipitation for any period yields the SPI. This index may be applied to agricultural interests over periods of weeks or months, and to interests in water supply and management over longer periods of years (Guttman, 1999). The 1-month SPI reflects short-term conditions, and its application can be closely related to soil moisture; the 3-month SPI offers a seasonal estimate of precipitation; the 6- and 9-month SPI indicates medium-term trends in precipitation patterns; and so on. The applicability of SPI varies with the time scale (Ji and Peters, 2003). The impacts of a precipitation shortfall on several water resource components (groundwater, reservoir storage, soil moisture, and stream flow) may be evaluated by using distinct timelines. More precipitation than the mean is indicated by positive SPI numbers, while less precipitation than the mean is indicated by negative values. "Drought magnitude" is the positive sum of the SPI for each month during a drought occurrence. It is possible to monitor both wet and dry conditions with the SPI. Table 3.1 divides the SPI range's "drought" portion into several circumstances. When the SPI value drops to -1.0, a drought event begins, and it ends when the SPI rises once again.

According to Karabulut (2015), the SPI is the most extensively used drought index and is a well-known indicator for describing meteorological droughts (Hayes et al., 1999; Deo, 2011). McKee et al. (1993, 1995) established SPI with output values ranging from -2.0 to 2.0, appropriate for various periods (1, 3, 6, 12, 24 and 48 months).

Table 6.1. SPI ranges and drought categories

Category of Drought	Range
Extremely Dry	<-2.0
Severely Dry	(-1.5) - (-2.0)
Moderately Dry	(-1.0) - (-1.5)
Near Normal	(-1.0) - (+1.0)
Moderately Wet	(+1.0) - (+1.5)
Very Wet	(+1.5) - (+2.0)
Extremely Wet	> 2.0

The SPI is determined by utilizing a probability density function of the gamma distribution, as precipitation data may be fitted by a gamma distribution:

$$g(x)=\frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{(\alpha-1)} \exp(-x/\beta) \qquad (x > 0) \qquad \ldots\ldots\ldots\ldots (1)$$

where x (mm) is the precipitation quantity (x>0), α is the shape parameter (α>0), β is the scale parameter (β>0), and Γ (α) is the gamma function. Further information is available in Dogan et al. (2012) and Edwards and McKee (1997).

6.2. Percent of Normal Index (PNI)

One of the easiest ways to gauge how much rainfall deviates from the long-term average is to use the PNI. "Normal" may refer to a long-term mean precipitation value at a place, and it typically does. A month, a season, or a year may be used to get the value of "normal," which is 100%. It is possible for the same precipitation shortfall to have varying particular affects at various sites, hence measuring it is a little bit of an oversimplified process. Willeke et al. (1994) expressed the PNI as a percentage of average precipitation. Different time scales (monthly, seasonal, and annual) may be used to compute it. According to Hayes (2006), PNI is quite useful for characterizing drought for a specific area or/and season. PNI is determined in this way:

$$\mathbf{PNI} = \frac{P_i}{P} \times 100 \qquad \ldots\ldots\ldots\ldots (2)$$

where P is the typical precipitation for the Station and Pi is the precipitation in time increment i (mm).

Table 6.2 Categories of drought according to PNI

Category of Drought	Range
Extreme drought	<40
Severe drought	40 - 55
Moderate drought	55 - 70
Weak drought	70 - 80
Normal	80 - 100
Wet	>100

6.3. Index of Deciles (DI)

In Australia (Coughlan, 1987), this method—which was proposed by Gibbs and Maher (1967)—is frequently used. Monthly precipitation totals from a long-term record are first ordered from highest to lowest in order to create a cumulative frequency distribution. Next, the distribution is divided into ten segments, sometimes known as deciles or tenths of distribution. The precipitation value that is not surpassed by the 10% lowest of all precipitation values in a record is the first decile. The lowest 10 and 20%, etc., are in the second decile. The severity of drought may be determined by comparing the quantity of precipitation that falls during a month (or over a period of many months) with the long-term cumulative distribution of precipitation quantities during that time. There are five classes for the deciles, with two deciles in each class. Precipitation is categorized as significantly below normal if it falls into the lowest 20% (deciles 1 and 2). Deciles 3 through 4 (20–40%) denote precipitation that is below normal, deciles 5 through 6 (40–60%) denote precipitation that is near normal, deciles 7 and 8 (60–80%) indicate precipitation that is above normal, and deciles 9 and 10 (80–100%) represent precipitation that is far above normal (Table 3.3).

Table 6.3. Types of drought and DI

Category of Drought	Range
Extreme	1
Severe	2
Moderate	3
Weak	4
No	>=5

6.4. Meteorological Drought Monitoring (MDM) Software

A software program called Meteorological Drought Monitoring (MDM), created by Nasrin et al. (2017), was used to estimate the drought indices employed in this investigation. The Windows-based software can be used to calculate eight rain-based meteorological drought indices in the form of yearly, seasonally, monthly, and moving average for 3, 6, 9, 12, 18, 24, and 48 months. These indices are called SPI (Standardized Precipitation Index), DI (deciles index), PN (Percent of Normal Index), RAI (Rainfall Anomaly Index), EDI (effective drought index), CZI (China-Z index), MCZI (modified CZI), and ZSI (Z-Score Index). This program is easy to use and may be used to effectively calculate and compare data from many sources, regions, and time periods.

6.5. Collection of data and doing pre- and post-processing

The SRC Odisha (https://srcodisha.nic.in/rain_fall.php) provided the daily precipitation data for 314 blocks in Odisha for 32 years, from 1988 to 2019. A spreadsheet was then used to combine the daily data into monthly data. The frequency study of various drought circumstances was conducted using the drought indicators that were acquired for each block throughout the rainy season (June-September), or 128 months, using MDM software.

7. Result and Discussion

Preparing the Data for Rainfall

Table 7.4. Based on SPI, a frequency study of the various types of drought in Niali Block

Category	Range	No. of Occurrences	Percent of Occurrences
Extremely Dry	<-2.0	0	0.00
Severely Dry	(-1.5) - (-2.0)	9	7.03
Moderately Dry	(-1.0) - (-1.5)	6	4.69
Near Normal	(-1.0) - (+1.0)	98	76.56
Moderately Wet	(+1.0) - (+1.5)	5	3.91
Very Wet	(+1.5) - (+2.0)	8	6.25
Extremely Wet	> 2.0	2	1.56
	Total	128	100.00

Table 7.5. Based on PNI, a frequency study of the various types of drought in Boudh Block

Category	Range	No. of occurrences	Percent of occurrences
Extreme Draught	<40	18	14.06
Severe Draught	40 - 55	16	12.50
Moderate Draught	55 - 70	12	9.38
Weak Draught	70 - 80	11	8.59
Normal	80 - 100	15	11.72
Wet	>100	56	43.75
	Total	128	100.00

Table 7.6. Based on DI, a frequency analysis of the various types of drought in Padampur Block

Category	Range	No. of occurrences	Percent of occurrences
Extreme Draught	1	12	9.38
Severe Draught	2	12	9.38
Moderate Draught	3	16	12.5
Weak Draught	4	13	10.16
No Draught	>=5	75	58.59
	Total	128	100.00

8. Calculation of AHP

The weights for the indices and draught conditions were determined using the methods given in the preceding chapter. The findings are provided in Tables 4.8 to 4.13. It can be noted from Tables 4.10 and 4.13 that the CI for both the situations is less than 0.1 which meets the criteria for application of the weights.

Table 8.7. Normalized matrix for drought indices

	A1		
	SPI	PNI	DI
SPI	1	4	9
PNI	1/4	1	5
DI	1/9	1/5	1

	A2	A3	A4
3.174802104	0.69861528	2.16	3.094015108
1.077217345	0.237041703	0.73	3.094015108
0.292401774	0.064343017	0.20	3.094015108
4.544421223			

Table 8.8. CI and CR for drought indices

	CI	RCI
	0.031338369	0.58
CR	0.054031671	

Table 8.9. Normalized matrix for drought severity

	A1			
	Extreme	Severe	Moderate	Low
Extreme	1	3	7	9
Severe	1/3	1	4	6
Moderate	1/7	1/4	1	4
Low	1/9	1/6	1/4	1

Table 8.10. Weightage of each factor of drought severity

A2		A3	A4
Geometric Mean	Normalized Weight		
3.707793	0.591805565	2.46	4.154578
1.681793	0.268433115	1.11	4.127715
0.614788	0.098127127	0.42	4.242617
0.260847	0.041634193	0.18	4.243171
6.265221	1		4.19202

Table 8.11. CI as well as the Intensity of the Drought

	CI	RCI
	0.064007	0.89
CR	0.071918	

9. Composite Meteorological Drought Analysis

Composite maps of severe and extreme drought were created on a GIS platform using AHP. The maps are shown in the figures. 9.3 and 9.6.

It is noted that there is a drought in the western region of the state of Odisha. This region's blocks experience drought on alternating occasions. From the figures 9.3 to 9.6, we clearly seen that Balangir, Baragarh, Phulbani, Baliguda, and other blocks that are affected by severe drought and have shorter recovery times. Certain blocks exhibit both a mild and high dought character. While certain coastal blocks are less sensitive to the drought, the map still highlights those that fall inside the very high meteorological drought prone zone, including Khalilote, Rangeilinda, Bramhagiri, Gop, Astaranga, and Erasama.

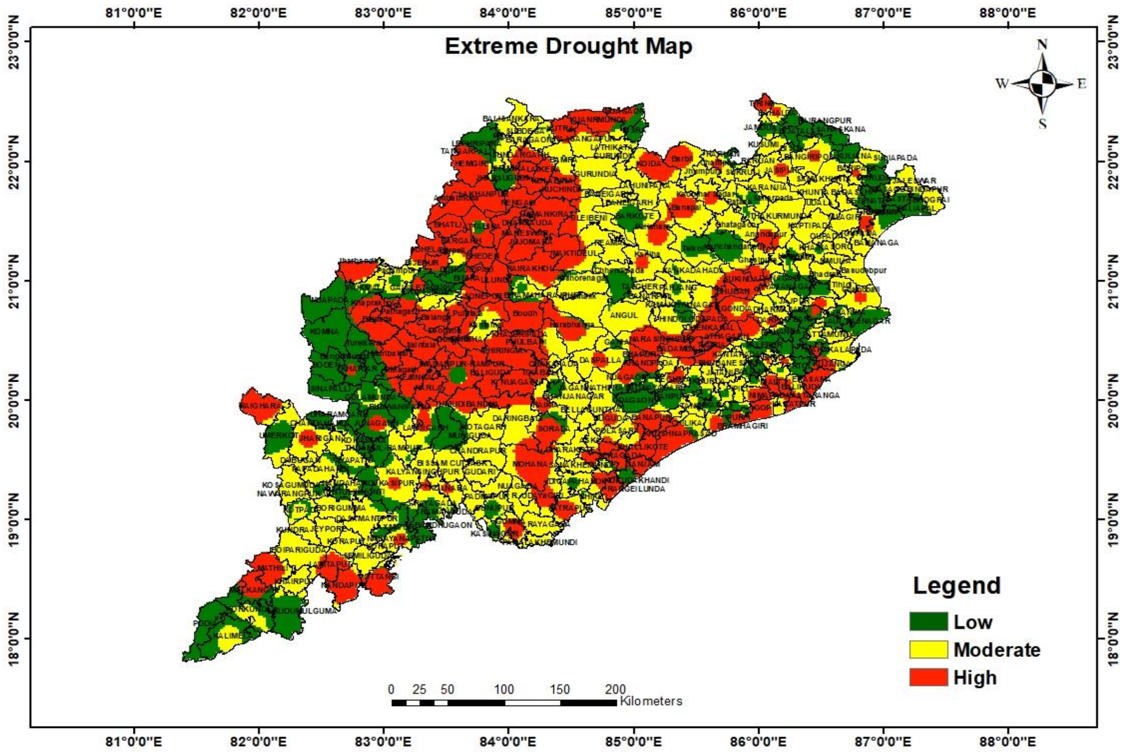

Figure. 9.3. Combined map showing Extreme flooding.

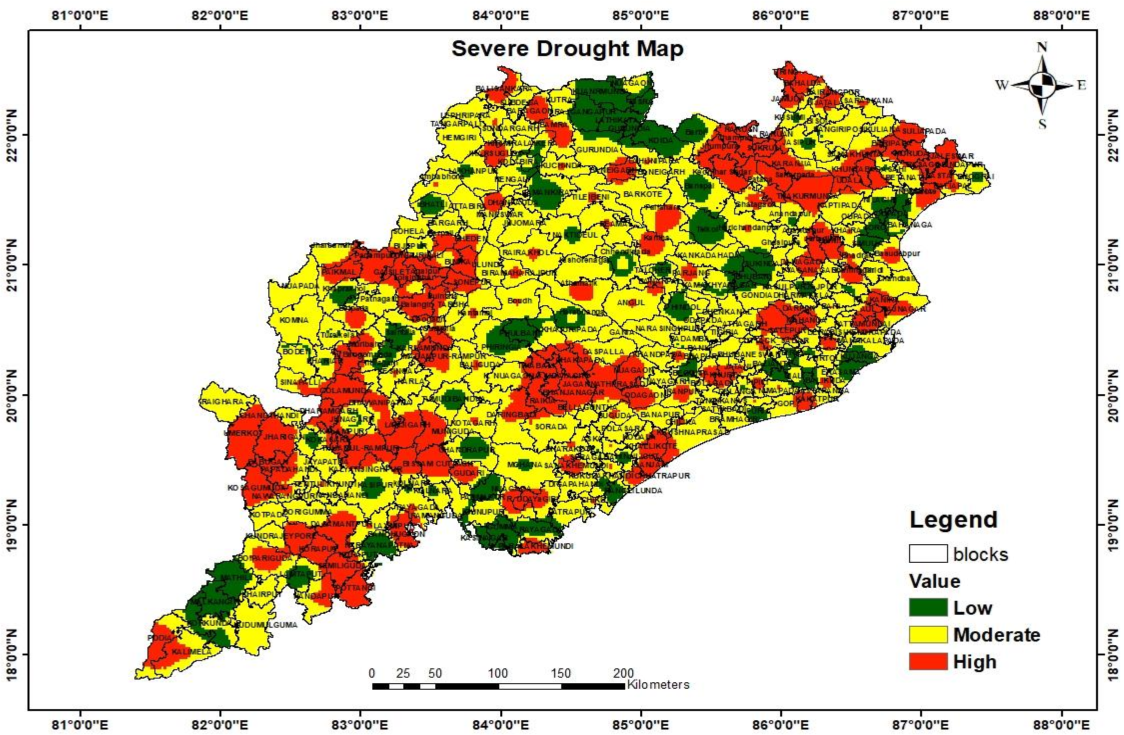

Figure. 9.4. A Composite Severe Draught Map

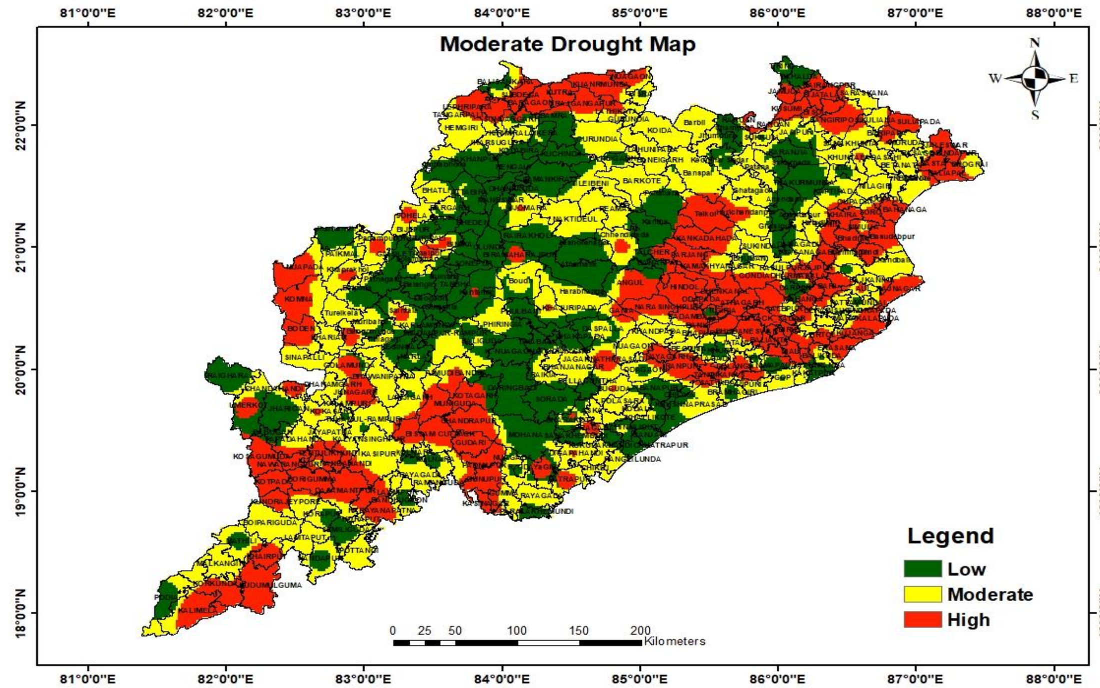

Figure. 9.5. Combination Map of Moderate Drought

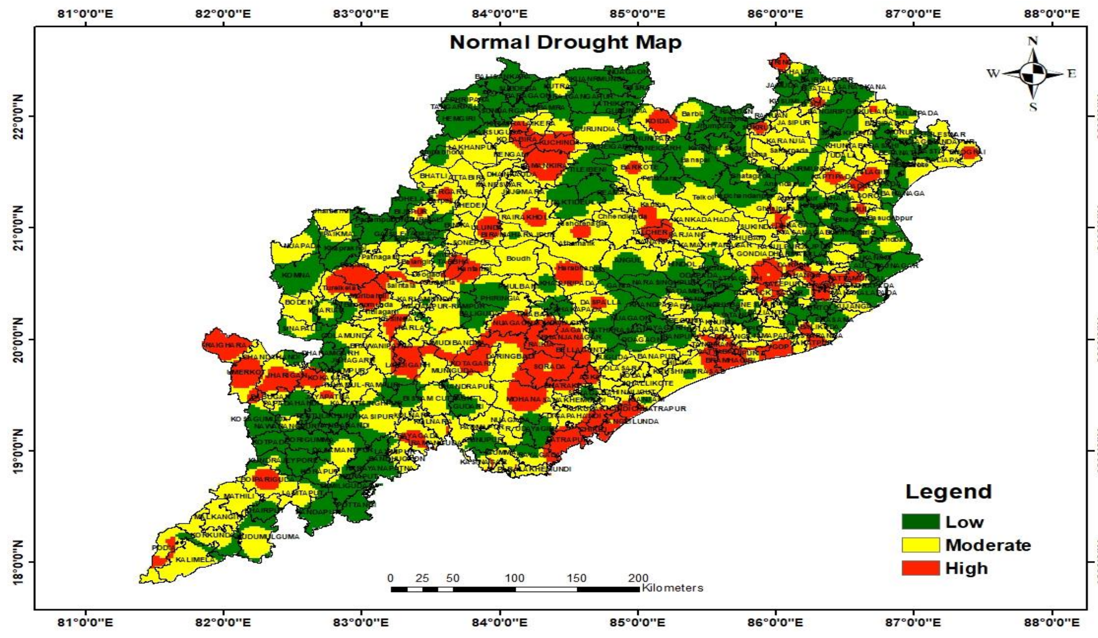

Figure. 4.16. Composite Normal Draught Map

OVERVIEW AND RESULTS

Using MDM software, rainfall data from 314 blocks in Odisha were evaluated, and for each block, the three meteorological drought indices—SP, PNI, and DI—were calculated. For every block, the frequency of drought at varying intensities was calculated using the ranges of these indicators. Based on the indices, the susceptible blocks that saw frequent draughts were plotted on a GIS platform. Blocks impacted by extreme and severe drought were identified, and composite maps of the drought were created using the Analytic Hierarchy Process.

In conclusion

- The investigation led to the following findings.
- It has been discovered that the Meteorological Drought Monitoring (MDM) program is useful for quickly assessing drought using several metrics.
- SPI was shown to be more beneficial than PNI and DI, two other indices.
- Compared to utilizing the SPI, PNI, and DI single meteorological indicators, the Analytic Hierarchy Process (AHP), a Multi Criteria Decision Making (MCDM) technique, proved useful in determining the amount of drought severity.
- The majority of the state of Odisha's western regions are said to be experiencing severe drought.
- Compared to the coastal area, the western portion of the state is more susceptible to severe drought.

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