

# **ASSESSMENT OF DROUGHT IN NASHIK DISTRICT USING STANDARDIZED PRECIPITATION INDEX (SPI)**

Submitted by

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(Reg. No.019/328)

A Thesis submitted to the  
**MAHATMA PHULE KRISHI  
VIDYAPEETH, RAHURI-413 722, DIST-  
AHMEDNAGAR, MAHARASHTRA STATE  
(INDIA)**

In partial fulfillment of the requirement for the degree  
of  
**MASTER OF SCIENCE (AGRICULTURE)**  
in  
**AGRICULTURAL METEOROLOGY**



**DEPARTMENT OF AGRICULTURAL METEOROLOGY  
CENTRE FOR ADVANCED FACULTY TRAINING (CAFT) IN  
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MAHARASHTRA, INDIA**

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**ABSTRACT**


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Indian agriculture is highly influenced by the south-west monsoon rainfall. According to Guhathakurta and Rajeevan (2008) although average annual rainfall in the country is 119.4 cm, about 60 % of the country's total cultivable land still remain as rainfed. Under a climate variability scenario, the rainfall distribution pattern has become erratic and unpredictable; subsequently increasing the probability of occurrence of a long dry spell or drought-like situation in the country. Drought analysis is useful to examine frequency of drought events over different subdivisions. Knowledge and sequence of dry spells can assist to acquire specific information for agricultural planning. Understanding the events of occurrence of dry spells is crucial to decrease the adverse effect of dry spells at sensitive crop development stage. Rainfall pattern and the quantity decide the cropping system in the rainfed agriculture. Rainfall amount, distribution and intensity of rainfall mainly determine the choice of any particular crop and agronomic practices. In the present study entitled, 'Assessment of drought in Nashik district using standardized precipitation index (SPI)', is undertaken, keeping all these facts in view.

The study area of this research was the Nashik district which lies in western side of Deccan plateau in state of Maharashtra. It comprises of Fifteen tehsils *i.e.* Baglan, Chandwad, Deola, Dindori, Igatpuri, Kalwan, Malegaon, Nandgaon, Nashik, Niphad, Peth, Sinnar, Surgana, Trimbakeshwar and Yevla. Nashik district of Maharashtra region is spread over 19°35' to 20°52' North Latitude and 73°16' to 75°16' East Longitude at North-West part of Maharashtra state.

Daily rainfall data of Baglan, Chandwad, Deola, Dindori, Igatpuri, Kalwan, Malegaon, Nandgaon, Nashik, Niphad, Peth, Sinnar, Surgana, Trimbakeshwar and Yevla tehsils were collected from Department of Agril. Meteorology, College of Agriculture, Pune, State Agriculture Department, Nashik and

Downloaded from [www.maharain.gov.in](http://www.maharain.gov.in) from January to December. Therefore, The rainfall data of 59 years (1961 to 2019) for some tehsils 22 Years(1998-2019) on daily basis was processed to study statistical characteristics and analysis of frequency of drought events using standardized precipitation index(SPI), Precipitation Deciles(PD), to determine probabilities of dry and wet weeks by using Markov-Chain model, to determine the onset and withdrawal of monsoon and to suggest crop management and planning based on rainfall analysis.

The Nashik district is having 1066.80 mm mean average annual rainfall. It was varied from 522.6 mm at Deola to 2991.58 mm at Igatpuri. The average annual rainfall of Nashik district was received in 50 mean rainy days with the highest (112) rainy days during 1963 at Igatpuri tehsil and the lowest (9) rainy days during 1972 at Nandgaon tehsil.

In Nashik district, mean annual rainfall of Nashik district was 1066.80 mm in which July month contributes highest amount of mean rainfall 328.9 mm with 48.86 per cent variation. Followed by August, June, September, October, November, May, December ,April, March, February and lowest amount of mean rainfall in the month of January 0.75 mm with 475.8 per cent.

The average mean annual rainy days of Nashik district was 50 days in which July month contributes the highest amount of mean rainy days (13.8 days) with 32.7 per cent variation followed by August, September, June, October, November, May, December, April, March, February and lowest amount of mean rainy days in the month of January 0.064 day with 420.9 per cent variation. Cropping pattern in all tehsils depends on south west monsoon season and north east monsoon having additional benefits. Hence, area is dominated by *Kharif* crops and short to medium duration *Rabi* crops.

Drought analysis using Standardized Precipitation Index (SPI) in selected stations of Nashik district at 12 month's timescale. It was observed that in Kalwan, Nandgaon and Peth tehsils during the last two decade period (2001-2010, 2011-2019) the frequency of drought increased severely.. In all other tehsils we observed more Years which shows negative value of SPI in recent decades. This indicates that, a SPI value becomes more negative with increase in time scales in recent times.This is due to the non-uniform, irregular and erratic pattern of rainfall which may have adverse impact on the cropping system.

Drought analysis using Precipitation deciles (PD) showed that, there were 24 drought events in the period of 1961-2019 were observed in Baglan, Dindori, Igatpuri, Kalwan, Malegaon, Nandgaon, Niphad, Peth ,Sinnar, Surgana and Trimbakeshwar. For Deola, Nashik & Yevla 9 drought events were observed during the period of 1998-2019. While in Chandwad 13 drought events were observed during the period of 1978-2019. In case of Deola, Kalwan, Igatpuri, Nandgaon, Malegaon, Peth, Yeola tehsils, it was observed that the frequency of the drought event was increased during the last decade (2011-2019) as compared to previous decades. Whereas in remaining tehsils the frequency of the drought event was increased in the last two decade (2001-2010, 2011-2019) as compared to previous decades.while in Dindori and Niphad Freuency of wet years increased in last two decades. As severity of drought is more in recent decades, more efforts are needed for in situ moisture conservation.

Monsoon starts effectively from 26<sup>th</sup> MW (25<sup>th</sup> June to 1<sup>st</sup> July) in Nashik district which shows sudden rise in the rainfall assuring sufficient moisture for crop germination and remain active up to 42 MW (15<sup>th</sup> October to 21<sup>st</sup> October) with a total length of 17 weeks (119days).Therefore, we expected good monsoon shower for 17 weeks (26<sup>th</sup> to 42<sup>nd</sup> MW) in the region.

The Markov-chain probability analysis showed that more probability of occurrence of dry weeks is observed that Baglan tehsil has more probability of at least 20 mm rainfall in 27, 30, 36, 40, 38 MWs. Similarly, chandwad tehsil has more probability of at least 20 mm rainfall in 27, 29, 30, 32, 38 MWs, Deola tehsil in 30, 38-40 MWs, Dindori in 25-33, 39 MWs, Igatpuri tehsil in 23-39 MWs, kalwan tehsil in 27-30, 32, 36 MWs, Malegaon tehsil in 30 MWs, Nandgaon tehsil in 36 MWs, Nashik tehsil 25-32, 38-39 MWs, Niphad tehsil in 27-32 MWs and Pe tehsil in 24-37, 39 MWs, Sinnar tehsil in 38-39 MWs, Surgana tehsil in 24-39 MWs, Trimbakeshwar tehsil in 24-40 MWs and Yevla tehsil has more probability of at least 20 mm rainfall in 27, 30, 34, 38 MWs. The dry and wet week initial, conditional and consecutive probabilities are helpful for crop management planning in different tehsils of Nashik district. Thus, chances of rainwater harvesting in wet weeks is more and judicious use of harvested water in dry spells as protective irrigation is beneficial for the sustainable yield. This indicates that all tehsils of Nashik district are *kharif* dominated.

By considering the overall situation of the onset and withdrawal of monsoon, Standardized Precipitation Index, and Precipitation Deciles, initial, conditional and consecutive dry and wet weeks probability at different critical growth stages of selected *kharif* crops (Rice, Pearl millet and Maize, Finger millet) and *rabi* crops (Rabi sorghum and gram, Wheat) tehsil wise contingency measures viz. MW for sowing, protective irrigation and hoeing operation, etc were suggested.

#### **Statistical Analysis**

The data collected for each tehsil of Nashik district were subjected to statistical analysis such as mean standard deviation, coefficient of variation, extreme rainfall events and drought analysis. All these parameters are calculated using software named “Weather Cock” developed by CRIDA, Hyderabad. Microsoft office sub-module MS-Excel was used for data analysis..

# 1. INTRODUCTION

It is said, "Agriculture is gamble of monsoon and its failure and success mars or makes their destiny". In predominantly agricultural country like India, national economy is largely dependent on the agricultural production. The major agricultural enterprise component is still under *rainfed* cropping and hence agricultural production is still dependent on vagaries of monsoon. This situation is likely to remain so in near future also. So, the economic prosperity of India is very intricately connected with monsoon. Indian monsoon is highly erratic in nature both in quantum as well as distribution. The monsoon its time of arrival, cessation and distribution controls agricultural production and hence, the lively hood of the people. Agricultural production in India is closely related with rainfall. In India about 70 per cent of the total cropped area is *rainfed* which accounts 45 per cent of food bowl. Crop production in this area is very uncertain due to erratic behavior of rainfall. The main reason for low and highly unstable yields in this area is the unavailability of adequate soil moisture during active growth period of crops (Anonymous, 2014 b).

Water is limited resource and its efficient use is important, especially in view of ever increasing population. The basic source of water is the precipitation in the form of rainfall or snowfall and is the most critical and key variable of hydrological cycle. The human activities such as rapid urbanization, ever increasing population and deforestation have interrupted the natural hydrological cycle. This ecological imbalance resulted in non-uniform distribution and erratic variation of rainfall pattern. The present world has to meet the challenges of increasing water demand, the depleting water resources along with non-uniform distribution of water. In the country like India, there are huge and abrupt variations in rainfall characteristics including rainfall amount and its distribution, onset and withdrawal of monsoon and occurrence of dry spells both temporally and spatially. Hence the crop planning and water resource management in the *rainfed* area is difficult and complex.

The Indian economy is inextricably linked with the monsoon and its prosperity is entirely dependent on the rainfall received during monsoon. However the rainfall in India is characterized by recurring cycles of floods and droughts. There is also great regional and temporal variation in the distribution of rainfall. Rainfall in the greater part of India is uncertain, erratic and subjected to vagaries of monsoon and also unevenly distributed Venkateswaralu, (2011). Similarly in the state of Maharashtra, the variability of rainfall is high and it affects the agricultural production and the economy of the state. Especially in Western Maharashtra more than 80 percent area falls under *rainfed* condition. Due to uneven and erratic temporal distribution of rainfall in these areas, there is a tendency to over exploit underground water resources for irrigations during dry spells, and hence the quality of natural resources in the rain fed ecosystem is gradually declining. *Rainfed* areas suffer from bio-physical and socio economic constraints affecting the productivity

of crops and livestock. Irrigated areas have reached plateau in the yield but *rainfed* areas are considered to offer future scope for increasing food production. Thus there is a need to understand rainfall pattern and drought characteristics in *rainfed* area to enable to plan crops and provide optimal protective irrigations during the dry spells for sustainable development of agriculture and increase crop production.

Irrigated agriculture has made a major contribution to food production and food security throughout the world. Without irrigation much of the impressive growth in agricultural productivity over the last 50 years could not have been achieved. Nevertheless it was widely accepted that the overall performance of irrigation investments has too often fallen short of the expectations of planners. With inadequate water resources for irrigation, India remains at least 60 percent under *rainfed* agriculture and as discussed before, in the state of Maharashtra more than 80 percent of cultivable area is still *rainfed*. As the vast portion of cultivable land is still unirrigated, in future the *rainfed* areas are also required to meet the challenge of rising demand of food, pulses, oilseeds, vegetables, fruits, etc. on sustained basis. But the crop production in *rainfed* areas remains unsustainable due to uncertainties in rainfall. Uncertainties in rainfall that influences the crop production are uneven spatial and temporal distribution of rainfall and unknown periods of dry spell in rainy season causing water stress to plant. Any extended period of water stress is especially injurious to plants and is termed as drought. Further delayed or advanced onset and withdrawal of monsoon are also results of uncertainties in rainfall. The crop production in rainy season in *rainfed* areas is thus dependent on vagaries of monsoon and is adversely influenced. The knowledge of different rainfall characteristics such as onset and withdrawal of monsoon, dry spell and drought would enable the optimal crop planning and implementation of protective irrigation strategies, thus mitigating the adverse impact of uncertainties of rainfall.

Even though the droughts are inevitable and unavoidable, but are manageable. Over decades, several technologies to mitigate drought affects at farm level have been evolved. The investigations related to characterization of droughts play very important role in planning of *rainfed* agriculture by providing guidelines for crop planning, and to implement the protective irrigation strategies.

However the perception of drought is different for different people. To the farmer, drought is a period during which his/her normal farm operations are hampered. To the hydrologist, with prolonged deficiency of rainfall, drought occurs with marked depletion of surface water and consequent drying up of reservoirs, lakes, streams and rivers, cessation of spring flows and fall in ground water levels. To the meteorologist, it is a situation, when there is a significant decrease of rainfall from the normal values over a given area. On the other hand, to the agricultural scientist, it occurs when the soil moisture and rainfall are inadequate during the

growing season to support healthy crop growth to maturity and cause extreme water stress. Precipitation deficiency causes meteorological drought which subsequently causes the moisture deficiency in the root zone, influencing crop production thus triggering as agriculture drought. But unlike meteorological drought, agriculture drought depends on climate, soil, crop and their interaction. Therefore agriculture drought needs to be evaluated separately by considering these interactions in contrast to the consideration of only precipitation in meteorological drought. There is no single widely accepted indicator to characterize the agricultural drought. The indicators developed in the literature are mainly related to moisture deficit causing evapotranspiration or moisture deficits itself yield reduction. These indices normally consider the relative reduction in these actual values. Considering relative reduction in actual evapotranspiration and actual yield would be appropriate as they represent the influence of the moisture stress over the entire crop season, which is ultimately due to the deficit in precipitation. However considering the relative reduction in moisture in the root zone would not be appropriate as it does not represent the ability of different crops to withstand different moisture stress in the root zone.

Agricultural operations in *rainfed* area start with the onset of southwest monsoon. It is essential to forecast the calendar of onset of effective monsoon since a slight delay in sowing of *rainfed* crops may lead to drastic reduction in grain yield and adversely affects the next crop too. The duration of the *kharif* crops depends on the withdrawal of monsoon rainfall. It has been experienced that quite often the crops suffer from terminal drought due to the early cessation of rainfall. The knowledge of withdrawal of monsoon is also required for the planning of *Rabi* season crops based on residual moisture in the root zone. Therefore it is necessary to know the onset and withdrawal of monsoon for appropriate crop planning and planning of water sources available for protective irrigation. There are enumerable criteria for deciding onset and withdrawal of monsoon Morris and Zandesta, (1979) ; and Babu and Laxminarayana, (1997). The information of onset and withdrawal of monsoon is mainly required for crop planning based on the moisture content in the root zone. Some criteria adopted in the literature consider only rainfall and some consider rainfall and evapotranspiration. However only rainfall and evapotranspiration do not reflect the optimum availability of moisture in the root zone for sowing/planting. For this purpose it is necessary to consider water holding capacity of soil which varies with soil type and perform the soil water balance in the root zone.

The climate of a region is determined by long-term average, frequency and extremes of several weather variables, notably precipitation and temperature. In a large semiarid country such as India, precipitation is precious and varies both in space and time. Thus, any departure in precipitation patterns seldom leads to widespread natural disasters such as drought and floods affecting natural habitats, ecosystems and, importantly, agricultural and economic sectors.

Drought, in particular, is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard (Hagman, 1984). Generally, large-scale spatiotemporal variability in timing and duration of drought impact hinders a universal definition of drought. However, Wilhite and Glantz (1985) have categorized drought into meteorological (lack of precipitation); hydrological (drying of surface water storage); agricultural (lack of root zone soil moisture) and socio-economic (lack of water supply for socio-economic purpose). In the last century, many drought indices were formulated by integrating weather variables such as rainfall, evapotranspiration and temperature into a single number.

Although rainfall deviation from the long-term mean continues to be a widely adopted indicator for drought intensity assessment because of its simplicity, the application of this indicator is strongly limited by its inherent nature of dependence on mean. Rainfall deviations can not be applied uniformly to different areas having different amounts of mean rainfall since a high rainfall area and a low rainfall area can have the same rainfall deviation for two different amounts of actual rainfall. Therefore, rainfall deviations across space and time need to be interpreted with at most care.

The most commonly used drought indices include the Palmer drought severity index (PDSI) and the moisture anomaly index (Z-index) (Palmer, 1965), the standardized precipitation index (SPI) (MacKee *et al.*, 1993, 1995), aridity index (Gore and Sinha Ray, 2002) and Percent Normal, Deciles (Gibbs and Maher, 1967). Drought indices, in general, enable the detection of the onset of drought events and enable their severity to be measured, thereby allowing an examination of the spatial and temporal characteristics of drought, and comparisons between different regions to be made (Alley, 1984). The majority of drought indices have a fixed time-scale. For example, the PDSI has a time-scale of about 9 months (Guttman, 1998), which does not allow identification of droughts at shorter time scales, as in the case of agricultural drought.

Standardized Precipitation Index (SPI) expresses the actual rainfall as standardized departure from rainfall probability distribution function and, hence, this index has gained importance in recent years as a potential drought indicator permitting comparisons across space and time. Computation of SPI requires long term data on precipitation to determine the probability distribution function which is then transformed to normal distribution with mean of zero and standard deviation of one. However, SPI is designed in such a way that it can detect drought over different periods at multiple time scales. This index is calculated by fitting a gamma distribution to observed values of precipitation totals at different time steps (e.g. 1, 2, 3, . . ., 48 months), and then transforming back to the normal distribution with mean zero and a variance of one. The SPI is equal to the Z-score applied to normally distributed precipitation totals at different time scales. For example, the 1-month SPI of September represents standard

deviation in precipitation of September only; 3-month SPI of September represents the standard deviation in precipitation totals of September and the previous 2 months. Positive values in SPI indicate greater than mean precipitation, and negative values indicate less than mean precipitation. The SPI is produced by standardizing the probability of observed precipitation for any duration. Durations of weeks or months can be used to apply this index to agricultural interests, and longer durations of years can be used to apply this index to water supply and water management interests (Guttman,1999). The applicability of SPI varies with the time scale because the 1-month SPI reflects short-term conditions and its application can be related closely to soil moisture; the 3-month SPI provides a seasonal estimation of precipitation;6- and 9-month SPI indicates medium term trends in precipitation patterns (Ji and Peters, 2003).

Maharashtra state of India has experienced recurring severe droughts in past few decades affecting thousands of villages, lakh of cattle and crores of people. The worst drought in Maharashtra has made water supply in the state a scary issue. The agriculture sector is badly affected; people had to migrate from their native places for water, livelihood and fodder for cattle. Not only loss of cattle and other livestock is a major issue but also increase in farmer suicides is a serious concern.

The appropriate knowledge of nature of occurrence of drought and its characteristic features is one of the important aspects in the *rainfed* farming, water resource planning and management, and allocation of water for protective irrigation. These studies provide basic information for evaluating climatic potential of an area for agricultural development, for evolving suitable cropping patterns, protective irrigation and for implementing cultural/conservation practices to rainfall distribution in the area. Various developmental agencies involved in tackling drought problems in the region lack the information about the drought characteristics. As a result, rainfall and water resources are utilized in an inefficient way leading to crop failure even in normal rainfall year. These facts call for the studies of the drought characterization to develop control measures and consequent management of drought with appropriate planning.

It is necessary to know the chances of occurrence of onset or withdrawal of monsoon in a particular week. This is particularly important to know the suitability of the crops for sowing/planting and the risks associated with these crops. It is also important to know the chances of occurrence of dry spells during the critical stages of the crops for deciding the sowing date, cropping pattern and planning for protective irrigation and intercultural operations. The Nashik district of Maharashtra being subjected to rainfall variabilities and large tract of this region being *rainfed*, has been chosen as the study area. It is recognised as the region of drought impacts which directed to study the analysis of drought band using Precipitation Deciles (PD) and Standardized Precipitation Index (SPI), onset and withdrawal for their occurrence,

probability and crop planning for different tehsils in Nashik district.

In Maharashtra, the net sown area is about 173.9 Lakh ha and gross cropped area is 234.73 Lakh ha. The Nashik district of Maharashtra ranks third in area in the state. The total geographical area reported is 15,36,430 ha, out of the total area net sown area is 7,42,400 ha, gross cropped area is 7,98,500 ha, the gross irrigated area is 4,07,400 ha and the net irrigated area is 1,93,000 ha and majority of area is under rainfed crops 5,49,400 ha. This indicated that only 48.31 % of net sown area is irrigated (Anonymous, 2016-2017a).

Nashik district of Maharashtra region is spread over 19°35' to 20°52' North Latitude and 73°16' to 75°16' East Longitude at North-West part of Maharashtra state. It is called as the 'Grape capital of India'. Nashik district is situated at 648 m height above mean sea level. The Nashik district is bounded by Dhule district to the North, Jalgaon district to the East, Aurangabad district to the South-East, Ahmednagar district to the South, Thane district to the South-West, Valsad and Navsari districts of Gujrat to the West and The Dangs district to the North-West. The geographical structure of Nashik district is classified into four agro-climatic zones as under, Western Ghat Zone, Scarcity Zone, Western Maharashtra Plain zone and Sub Mountain zone. There are 15 tahasils in Nashik district viz., Nashik, Sinnar, Igatpuri, Trimbakeshwar, Niphad, Yeola, Peth, Dindori, Chandwad, Nandgaon, Surgana, Kalwan, Deola, Baglan and Malegaon.

The climate of the district is on the whole is agreeable. The climate of Nashik district is characterized by general dryness throughout the year except during South-West monsoon season. In the hilly western part of the district, the climate is slightly cool. May month is the hottest and January is the coldest month and the temperature varied from 17.6°C to 31.56°C. In the scarcity zone, the maximum temperature is around 42.5°C (during April and May) and minimum temperature around 5°C (during December) (Anonymous, 2017).

The soils of the district are the weathering products of Basalt and have various shades from grey to black, red and deep black colour. The soils in the district are classified as namely lateritic black soil (*kali*), reddish brown soil (*mal*), coarse shallow reddish black soil (*koral*), medium light brownish black soil (*barad*). In general the soils are very fertile and suitable for growing cereal and pulses. Godavari which is popularly known as Ganga of South India originates at holy place Trimbakeshwar. The northern part of the district falls under Tapi basin and is drained by easterly flowing Girna river along with its tributeries, whereas the southern part of the district falls under Godavari basin and is drained by Godavari river and its tributeries. Other important rivers in the district are Damanganga, Vitarna, Darana, Kadva, Aram, Mosam, Panjan and Manegad.

The average annual rainfall of the district is 1066.80 mm, most of which is received during South-West monsoon. However, scarcity zone of the district having an average rainfall of 500-700 mm. Transition zone I have an average rainfall of 700-1240 mm, Transition zone II have an average rainfall 1250-3000 mm and Ghat zone have an average rainfall 3000-5000 mm.

Out of the total net irrigated area, 67 per cent area irrigated through well irrigation including lift irrigation and remaining as surface irrigation, *i.e.* canal irrigation 26.1 per cent area. Thus, the study was undertaken to analyze rainfall pattern and on the basis of rainfall to suggest crop and cropping systems in different soil types. The rainfall analysis comprises of annual, seasonal, monthly and weekly variation onset and withdrawal of monsoon, length of growing season, and probability occurrence of rainfall of specific amount in a given period of time (Anonymous, 2016-2017a).

The major *kharif* crops of Nashik district are sorghum, pearl millet, rice, groundnut, sugarcane, onion and soybean while, in *rabi*, sorghum, wheat, onion, and gram are cultivated. However, fruit crops *viz.*, grape, pomegranate and guava are cultivated. The important vegetables grown in the district are onion, tomato, brinjal, chili, cauliflower and cabbage (Anonymous, 2017).

Hence, the present investigation has been undertaken to study the “**Assessment of Drought in Nashik District using Standardized Precipitation Index (SPI)**” is planned with following objectives

1. To analyze rainfall data for drought using Precipitation Deciles (PD) and Standardized Precipitation Index (SPI) for different tehsils in Nashik district.
2. To determine the onset and withdrawal of monsoon for different tehsils in Nashik district.
3. To determine probabilities of dry and wet weeks by using Markov-chain model
4. To suggest crop management planning based on rainfall analysis.

## 2. Review of Literature

The study of annual, seasonal, monthly and weekly rainfall variability and also its onset withdrawal and effect on drought occurrence is essential to manage the agriculture and livestock production.

This chapter deals with the review of study carried out by various investigator on “**Assessment of Drought in Nashik District using Standardized Precipitation Index (SPI)**” is planned with following objective

Reviews on following selected points are studied to determine the present topic:

1. To analyse rainfall for drought using Precipitation Deciles (PD) and Standardized Precipitation Index (SPI) for different tehsils in Nashik district.
2. To determine probabilities of dry and wet weeks by using Markov-chain model.
3. To determine the onset and withdrawal of monsoon for different tehsils in Nashik district.
4. To suggest crop management planning based on rainfall analysis.

### 2.1. Rainfall Analysis

**Rai and Srivastava, (1996)** analysed variation of weekly rainfall pattern (35 years) at Raipur district of Chattisgarh during crop growing season (23–44<sup>th</sup>mw). The mean weekly rainfall pattern showed that, it has four peaks. The first peak appears during 27<sup>th</sup>week, the second during 33week, third during 35<sup>th</sup>week and fourth during 37<sup>th</sup>standard week for the *Kharif* growing season. There is a sudden increase inrainfall from 23 to 27<sup>th</sup> week and again decreases in 29<sup>th</sup> and it remains steady for the next 3 to 4 weeks. It steeply declines after 37<sup>th</sup> week. The rainfall suddenly decreases from 37<sup>th</sup> week onwards, which means that, the contribution by northeast monsoon rain is very low to the annual rainfall of Raipur.

**Ghadekar and Miskin, (1998)** analysed 28 years (1962-89) rainfall data of Nagpur and studied the rainfall suitability at various probability levels for sorghum crop. The total rainfall during *Kharif* season was 861.5 mm. The coefficient of variation ranged between 74.3 per cent (25<sup>th</sup>week) to 144.7 per cent (39<sup>th</sup>week). The rainfall at 50 per cent probability was well distributed during 12 weeks (25-36<sup>th</sup>) ranging between 44.5 to 36.3 mm. This was adequate and sufficient for sorghum crop considering its weekly demand (21-35 mm perweek).

**Pandey et al. (1999)** analysed daily rainfall data for ninety years (1901-1990) of all the districts of Gujarat state to work out the occurrence of drought and floods in the state. The study revealed that the arid region of the state received rainfall of 500 mm or less in most of the years while humid region of the state received more than 1000 mm. However, the drought and floods were observed in both theregions.

**Mishra, (2002)** analysed weekly rainfall data for a period of 39 years at Shore, Madhya Pradesh and 35 years weekly rainfall data of Jabalpur district of Madhya Pradesh. The

average weekly rainfall, standard deviation (SD) and the coefficient of variation (CV) were evaluated. The CV in general, decreased for the weeks having large amount of rainfall and increased for the weeks receiving scanty rainfall.

**Nath and Deka, (2002)** compared major climatic elements of Jorhat in Assam, for the period 1981-90 with those of the normal values. The results revealed that, the average annual rainfall at Jorhat during the decade (1981-90) was 13.12 per cent lower than the normal values. The total rainfall was lower than their normal values in all the other months except in January, April and October.

**Singh *et al.* (2002)** analysed fifty years (1946-95) rainfall at Jhansi, Uttar Pradesh to estimate occurrence of drought. Analysis showed that mean annual rainfall of Jhansi was 913.2 mm with 24.0 per cent variation. It was found that August was the wettest month followed by July.

**De and De, (2003)** carried out rainfall analysis of Sriniketan, West Bengal using 35 years (1966-2000) of data. The analysis revealed that the total annual rainfall ranged between 831.4 mm (1982) to 2087.9 mm (1978) with the average annual rainfall of 1484.0 mm and coefficient of variation (CV) of 20.1%. The annual average rainy days (inclusive of trace rainfall) ranged between 85 days in 1972 to 154 days in 1990 with an average of 112.6 days and CV of 12.0%.

**Kumar, (2003)** studied rainfall data of varying length (15 to 27) at different stations in Shimla district of Himachal Pradesh on monthly, seasonal and annual basis. The statistical parameters like mean, standard deviation, coefficient of variation and coefficient of skewness of the rainfall were determined. Mean annual rainfall was found to be maximum at Phancha (2086 mm) and minimum at Kumarsain (556 mm). The coefficient of variation of annual rainfall varied from 17 % to 50 %. The annual rainfall was found to be non-symmetrically distributed at all stations.

**Basu *et al.* (2004)** carried out statistical analysis of rainfall distribution and trend of rainfall anomalies district wise during monsoon period over West Bengal. The coefficients of skewness and kurtosis were significant (positively skewed and leptokurtic) for most of the districts in the months of August and September in Sub- Himalayan West Bengal. In Gangetic West Bengal, the coefficients were significant for most of the districts in June and for all the districts in September. High values of coefficient of skewness and kurtosis showed heavy rainfall cases. The trends of monsoon rainfall anomalies of Sub-Himalayan West Bengal showed both positive and negative slopes ranging from 6.639 at Coochbehar to -8.455 at Darjeeling. In case of districts of Gangetic West Bengal, the rainfall showed increasing trends for all the districts except in the district of Howrah.

**Singh and Singh, (2004)** studied climatological parameters and its variation at

Bikramganj, Bihar. At Bikramganj, the annual rainfall during the study period (1979- 1998) varied from 656.6 mm to 1584.5 mm with average of 1024.2 mm. About 90 per cent of total rainfall occurred during the period from June to October. July was the month of highest rainfall. The data showed that 241.9 mm month<sup>-1</sup>rainfalls are received from July to September. This period could be called as effective months for rainfall. Total amount of rainfall received during winter (i.e. November to February) was only about four per cent. The weekly distribution of rainfall showed that weekly rainfall was maximum in 28<sup>th</sup>, 29<sup>th</sup>, 30<sup>th</sup>, 36<sup>th</sup> and 37<sup>th</sup> standard meteorological week.

**Dixit *et al.* (2005)** analysed the variability of rainfall in Konkan region of Maharashtra. The historical rainfall data of 32 years (1972-2003) indicated that the region received normal annual rainfall of 3465.7 mm. The annual rainfall varied from 2403.4 mm (2001) to 5134.3 mm (1975) in approximately 110 rainy days during the study period.

**Jat *et al.* (2005)** analysed 81 years (1921-2001) of rainfall data for Udaipur region. The mean annual rainfall of the region was 623.7 mm with coefficient of variation of 33.3%. Of the total annual rainfall, 91.75% was contributed by monsoon season, whereas 5.24% and 3% were contributed by post- monsoon season and pre- monsoon season. The weekly average rainfall ranged from 0.07 mm (14<sup>th</sup> week) to 48.52 mm (30<sup>th</sup> week). The average weekly rainfall during the monsoon season of June to September (weeks 23 to 39<sup>th</sup>) was higher than other season varying from 9.1 mm to 48.5 mm.

**Saha and Mishra, (2005)** analysed the daily rainfall data of 15 years (1988-2002) for Union region, Central part of Meghalaya. The results indicated that the region received more than 84 per cent of annual rainfall during the months of May to October. July was the wettest month with an average of 437.18 mm rainfall. December was the driest month with a mean rainfall of 12.15 mm.

**Soni and Kumar, (2005)** analysed rainfall pattern of south-west monsoon in Malwa region of Madhya Pradesh. The mean value of seasonal contribution of monsoon season to annual rainfall was found to be 74.7% in the region with highest (85.5%) in 1991 and lowest (61.3%) in 1999.

**Ali *et al.* (2007)** analysed the trend of rainfall in different regions of Bangladesh. The study revealed no significant trend in annual rainfall. Significant decreasing trend of monthly rainfall during monsoon (wet season) was observed at two stations and increasing trend during dry season at several stations were observed.

**Jhajharia *et al.* (2007)** analysed rainfall pattern for Guwahati, Assam. Analysis of monthly rainfall revealed that the month of December was found to be the most drought prone.

**Bhakar *et al.* (2007)** studied the rainfall analysis for drought estimation of Kota region by recording the daily rainfall data for the period of thirty five years used for computation of

drought months and drought seasons. Analysis of the data showed that 17 per cent years were drought years, 20 per cent were abnormal years and remaining were normal years receiving rainfall between 470- 982 mm. There was a possibility of one drought year in a span of 6 years. It could be estimated that about 19 per cent of the total months during monsoon period were drought months.

**Ksndmc, (2008)** analysed weekly rainfall pattern of Karnataka state during 23– 52<sup>nd</sup> week (rainy season) for the period of 2005 to 2008. Based on weekly rainfall the talukas were classified as excess ( $\geq 20$  %), +ve normal (0 to +19 %), -venormal (-1to-19 %), deficit (-20 to -59 %), scanty (-60 to -99 %) and no rainfall (-100 %) areas based on the departure of weekly rainfall from normal rainfall values of respective weeks. Analysis revealed that the most of the talukas were under deficit (-20to-59%) rainfall pattern, during the period of 2005-2008.

**Nyatuameet al. (2014)** analysed rainfall trend for Volta region in Ghana for 30- year period of 1981 to 2011. Linear regression analysis revealed upward and downward trend in the data in some months and years in the mentioned zones but statistically insignificant.

**Pawee and Chotpantararat, (2015)** performed statistical analysis of rainfall variations in the Bangkok urban area, Thailand. The moving average and Mann–Kendall analyses revealed that the annual rainfall level significantly increased in the urban fringe in the western part and slightly decreased in the inner city in the eastern part of the study area, while the maximum 1-day rainfall decreased all over the study area except for in the commercial area in the eastern part where the trend was unclear.

**Patil (2017)** studied characterization of rainfall for Kolhapur district of Maharashtra. She observed that amongst the various tahasils, the annual rainfall ranged between 615.7 to 5662.3 mm. The year to year variations was the highest in Shirol tahasil while the lowest variation was noticed in Bhudargad tahasil. The commencement of rainy season in the district was average and noticed in 30 to 38 MW and persistence of monsoon activities in the following weeks suggested strongly to initiate sowing operation in 24 MW onwards. The start of rainy season at probability of about 50 per cent rainfall ranged between MW 24 to 25 while the end of rainy season ranged between 42 to 48 MW for all tahasils.

**Shaikh et al. (2017a)** reported that average annual rainfall of Satara district was 1345 mm. It was varied from 519.2 mm at Phaltan to 5635.2 mm at Mahabaleshwar. Further, average annual rainfall recorded in various tahasils in descending order was 5635.2 mm at Mahabaleshwar, 1772.2 mm at Phaltan, 1645.3 mm at Javli, 1085 mm at Satara, 903.4 mm at Wai, 768.9 mm at Koregaon, 755.8 mm at Karad, 589.7 mm at Man, 579.4 at Khatav 550.9mm at Khandala and 519.2mm at Phaltan.

## 2.2. Drought Characterization

### 2.2.1 Analysis of Drought by Standardized Precipitation Index.

**Paul, (1993)** proposed a methodology to characterize meteorological drought based on the normality of seasonal and deficit year's rainfall (mean and standard deviation). The years were classified as incipient, large, severe, disastrous and extreme droughts based on developed drought index.

**Edwards and McKee, (1997)** developed the standardized precipitation index (SPI) to evaluate meteorological drought. The observed rainfall was categorized as a standardized departure with respect to a rainfall probability distribution function. It indicates how precipitation for any given duration (1-72 months) at a particular observing site compares with the long-term precipitation record at the same site of the same duration.

**Wu *et al.*, (2001)** evaluated the SPI, China-Z Index (CZI) and the statistical Z-Score on 1-, 3-, 6-, 9- and 12-month time scales using monthly precipitation totals for four locations in China from January 1951 to December 1998 representing humid and arid climates, and cases of drought and flood. The CZI and Z-Score provided results similar to the SPI for all time scales, and that the calculations of the CZI and Z-Score was relatively easily compared with the SPI, possibly offering better tools to monitor moisture conditions.

**Lloyd-Hughes and Saunders (2002)** analysed the incidence of 20th century European drought, based on the monthly SPIs calculated on a 0.5° grid over the European region 35– 70° N and 35° E–10° W at time scales of 3, 6, 9, 12, 18, and 24 months for the period 1901–1999. Their approach provided, for a given location or region, the time series of drought strength, the number, the mean duration, and the maximum duration of droughts of a given intensity, and the trend in drought incidence.

**Bonaccorso *et al.*, (2003)** carried out an analysis of drought in Sicily from 1926 to 1996. Drought occurrence was estimated by means of the SPI. To study long-term drought variability, a Principal Component Analysis (PCA) was also applied to the SPI field. A combination of SPI and PCA was also used by Bordi *et al.* (2004) for studying the time– space covariability of dry and wet periods during the last 50 years in eastern China.

**Min *et al.*, (2003)** showed that the occurrence of droughts over central eastern China, Manchuria, and the north coast of Japan was highly correlated with those in Korea. However, the time scales of occurrence of droughts over the three regions were different: droughts in eastern China represented in-phase variations with those in Korea with a time interval of 5–8 years; those in Manchuria occurred with a time interval of 15 years; and those in Japan had no coincident variations.

**Quiring and Papakryiakou (2003)** carried out a comparative performance analysis to determine the most appropriate index for monitoring agricultural drought and predicting spring wheat yield on the Canadian prairies. A series of curvilinear regression-based crop yield models were generated for each of the 43 crop districts (20 in Saskatchewan, 12 in Manitoba, and 11 in Alberta) based on four commonly used measures of agricultural drought (SPI, PDSI, Palmer's Z-index, and NOAA Drought Index). The significant variations in model performance between the four agricultural drought indices underscored the necessity of carrying out a performance evaluation prior to selecting the most appropriate agricultural drought index for a particular application.

**Wu *et al.*, (2004)** developed an agricultural drought risk-assessment model for Nebraska, USA, for corn and soybeans on the basis of variables derived from the SPI and crop specific drought index using multivariate techniques. The model can be used to assess real time agricultural drought risk for specific crops at critical times before and during the growing season by retaining previous and adding current, weather information as the crops pass through the various growth stages

**Farda *et al.*, (2012)** investigated meteorological droughts in the Lankaran region of Azerbaijan. As chosen region was characterized by large precipitation, they preferred to use the SPI method to carry study. During the research, dry years were determined according to the seasonal and annual data from weather stations in the province.

**Rajkumar dharkar, santan pradhan et al (2013)** Study on inter-seasonal and intra-seasonal relationships of meteorological and agricultural drought indices in the Rajasthan State of India. Use of rainfall anomaly based Standardized Precipitation Index (SPI) and satellite-derived Vegetation Condition Index (VCI) are becoming common to assess the impacts of drought on crops. This study analyzed spatio-temporal intra-seasonal and inter-seasonal relationships for 24 years between rainfall and NDVI and between SPI and VCI to understand crop response to water availability in the Rajasthan State, India.

**Lin *et al.*, (2014)** investigated impact of meteorological drought on streamflow drought in Jinghe river basin of China. Streamflow drought was detected by using the Standardized Runoff. According to authors, results not only play an important theoretical role in understanding relationships between different drought categories, but also have practical implications for streamflow drought mitigation and regional water resources management.

**Abari et al., (2015)** showed fluctuations of the extremely drought and wet by SPI in different stations. All the stations had been affected by drought at different time scales. Calculation of standardized precipitation index in three different time scales (SPI3, SPI6 and SPI9) in different stations showed that station had been moderately wet from 1996 to 1998 and in 4 stations (Lordegan, MalKhalifeh, Naghan and Saman) observed the severe droughts

in the scale 3 and 6 months (SPI6 and SPI9) in 1999, in the same year Borujen Station faced with extremely drought in scale 3 months (SPI3). The slightly drought in 2009 and 2012 observed on scale of 3, 6 and 9 months of the Borujen and Lordegan stations.

**Shah et al., (2015)** observed and described drought based on forty (40) year precipitation data of Surat district. Finding drought index with twelve month time scale basis and compared with the actual drought of the station. Positive SPI values point to normal condition to wet condition and negative values indicate normal condition to dry condition. SPI method resulted in showing as 50% variation of normal to wet and normal to dry condition.

**Dimitris Tigkas et al (2015)** presenting the overall design and the implementation of the software along with the utilisation of various approaches for drought analysis. DrinC can be used for the calculation of two recently developed indices, the Reconnaissance Drought Index (RDI) and the Streamflow Drought Index (SDI), as well as two widely known indices, the Standardised Precipitation Index (SPI) and the Precipitation Deciles (PD). Moreover, the software includes a module for the estimation of potential evapotranspiration (PET) through temperature based methods, useful for the calculation of RDI. The software may be used in a variety of applications, such as drought monitoring, assessment of the spatial distribution of drought, investigation of climatic and drought scenarios, etc.

**Juliani, Bruno H.T. and Okawa, Cristhiane M.P. (2017)** observed that for a return period of 100 years, the estimated cumulative 12-month precipitation varies from 353 mm in a 1-month drought duration to 458 mm in a 12-month drought duration.

**Zaidoon et al., (2019)** showed that the northeast region has the higher rainfall indices and the southwest region has the lowest rainfall. An analysis of the drought and rain conditions showed that the quantity of extreme drought events was higher than that expected in the study area, especially in the south and southwest areas. Therefore, an alternate classification is proposed to describe the drought, which spatially classifies the drought type as mild, moderate, severe and extreme. In conclusion, the integration between TRMM data SPI data proved to be an effective tool to map the spatial distribution and drought assessment in the study area.

**Das et al., (2020)** revealed that Jalore station was the highest drought frequency station, while the lowest drought frequency was observed in Vijaynagar station. The annual SPI result showed that the following years witnessed major drought events: 1981, 1984, 1985, 1988, 1989, 1991, 1993, 1999, 2000, 2004, 2005, and 2008. Besides, the results of the Mann–Kendall test showed that a substantial portion of the eastern basin experienced an increase in the intensity of drought, while the western basin experienced a decrease in the severity of the drought. The comprehensive analysis is indicative of climate change, and

there is a possibility that such droughts would become more common in the future in the Luni River Basin.

### 2.2.2. Analysis of Drought by Precipitation Deciles

**Gibbs et al. (1967)** made a study of drought in Australia by using annual rainfall deciles as drought indicator. Using a network of 100 stations, maps were prepared showing the decile ranges in which rainfall for each year had occurred.

**Abed et al. (2005)** assessed drought using four different indices; SPI, Normal Precipitation Index (PI), Deciles and Techniques to Evaluate Drought using Rainfall Data (TEDR) in Zarqa river basin, Jordan. They reported that PI and SPI could be used for drought forecasting and monitoring. The PI index provides probability of occurrence of below normal conditions used for each month. Using SPI analysis several stages were identified such as normal, watch, warning and emergency conditions in study area. IS maps also showed the direction of drought movement according to time and geographical area.

**Shah et al. (2013)** assessed drought using SPI and Decile Index in Theobroma region of Gujarat for period from 1968 to 2010. As per deciles, the extreme drought decades were 1978, 1985, 1986, 1987, 1988, 1993, 1998, 2003 and 2005 in their study.

**Tadic et al. (2015)** studied five drought identification methods for continental Croatia for 15 weather stations in the period from 1981 to 2011 namely SPI, Deciles percent of normal, rainfall anomaly index, and threshold level method. Results revealed that each of these methods has its specific features but that all are applicable for the area under study. They concluded that there was a significant correlation between the SPI and deciles index as well as rainfall anomaly and percent of normal in study area.

**Alami et al. (2017)** examined meteorological drought in Kabul River Basin (KRB) Afghanistan, using monthly data of rainfall of 38-years, based on Standard Precipitation Index (SPI), Percent of Normal Precipitation Index (PNPI), Decile Index (DI) and China Z-Index (CZI). The results of analysis showed that the drought event occurs in year 2000 to 2004 in the study region. They also found that the SPI calculated using log and gamma distributions and decile captured the extreme and severe drought period successfully for the study location.

**Dikici, M. (2020)** in this study, drought risk analyses were performed using meteorological, hydrogeological and hydrological data of the Asi basin and as a result of the determination of different indices and indicators available in the literature. The DI (Deciles Index), SPI (Standardized Precipitation Index), SPEI (Standardized Precipitation Evapotranspiration Index) and SRI (Standardized Runoff Index) indices were described. Drought severity and magnitude were found according to these indices. Based on 1, 3, 6, 9, 12, 48-month recurrence intervals, analyses were made. Classification of droughts and their threshold values

were determined. The indices were compared, the correlation between them was examined and a common conclusion was reached. The drought severities, which has a precipitation area of 7800 m<sup>2</sup>, were evaluated for certain recurrence intervals. For this purpose, based on meteorological, hydrological and hydrogeological data for the years between 1970 and 2016, DI, SPI, SPEI, and SRI indices were analyzed and compared.

### 2.3. Studies on onset and withdrawal of monsoon.

**Morris and Zandestra, (1979)** developed the criteria of onset of wet season by forward accumulation of rainfall in relation to cropping patterns, in rainfed low land rice. The authors used 75 mm accumulated rainfall as the onset time for growing season for dry seeded crops. The results show that 80 % probability is expected to receive at least 75 mm rainfall in 21<sup>th</sup> to 26<sup>th</sup> MW of week.

**R.Ananthkrishnan et.al, (1980)** studied The onset of the southwest monsoon over Kerala, Utilising daily mean rainfall from dense rain gauge networks, the dates of onset of the southwest monsoon over south and north Kerala have been derived on the basis of objective criteria for the years 1901 to 1980. These dates have been compared with the onset dates as per records of the India Meteorological Department. Statistics of the onset dates are presented. The mean onset date for south Kerala is found to be 30 May and for north Kerala 1 June with a standard deviation of about 9 days in both cases.

**Dash and Senapati, (1992)** developed the criteria of onset and withdrawal by forward and backward accumulation of rainfall. The authors used 75 mm accumulated rainfall as the onset time for growing season for dry seeded crops and 300 mm as the termination of rain to sustain a second rice crop. The results show that 75 % probability is expected to receive at least 75 mm rainfall in 22<sup>nd</sup> week and 300 mm in 26<sup>th</sup> week.

**Samui et al., (1994)** worked on the mean weekly rainfall and its rate of change at Tadong and Gangtok in Assam. He has analysed to fix dates of onset and withdrawl of south west monsoon. The study attempts to analyse broad aspects of rainfall precipitation distribution during the four seasons. The study was based on data of 12 stations and of varying period of 4 to 25 years and concluded the rainfall over this mountainous slope was found monomodal with a maximum in July-August. Rainfall in the valley shows striking difference in patterns even at short distance (4 km) and situated at a higher altitude.

**Das and Mukhopadhyay, (1996)** studied onset of effective monsoon (OEM) in two north Bengal districts by using slightly modified Raman's definition of OEM. The results revealed that although the retreat of monsoon in the study area occurred about at the same time of withdrawal of monsoon rains from the rest of India, the onset of monsoon was much

advance (last part of April to early May) in comparison to that of Kerala where the southwest monsoon hits its first spell in the Indian Peninsula.

**Rath *et al.* (1996)** determined the safe growing period during *Kharif* season based on the onset and termination of the wet season. The authors used 75 mm forward accumulation of rainfall as the onset time for the growing season for dry seeded crops. The end of the wet season was determined by backward summing of 300 mm rainfall that would be expected to sustain a second rice crop or other short duration field crops.

**Babu and Lakshminarayana, (1997)** determined the crop growing season by estimating beginning and end of the rainy season by fixing the forward accumulation and backward accumulation of rainfall respectively at 75 mm and 30 mm. The analysis of 26 years weekly rainfall data at Polkepadin Andhra Pradesh revealed that the rainy season begins in the 27<sup>th</sup> standard week and ends in the 40<sup>th</sup> standard week.

**Panigrahi and Panda, (2002)** considered forward accumulation of 75 mm rainfall and backward accumulation of 20 mm rainfall to ascertain the start and end of monsoon, respectively, in rainfed belt of Kharagpur area, West Bengal. The probabilities of occurrence of these values in different weeks were estimated. The analysis revealed that the monsoon starts effectively from 24<sup>th</sup> week and remains active up to 39<sup>th</sup> week.

**Jat *et al.* (2003)** estimated onset and withdrawal of rainy season for Bhilwara in Rajasthan by fixing forward accumulation of 75 mm rainfall from 22<sup>nd</sup> week and backward accumulation of 10 mm rainfall from 52<sup>nd</sup> week, respectively. Results indicated that rainy season starts in 28<sup>th</sup> week with 72 per cent probability and terminates in 39<sup>th</sup> week with 48 per cent probability. The coefficients of variation of onset and withdrawal were observed to be 5.39 and 13.0 %, respectively.

**Singh *et al.* (2003)** studied characteristics of south-west monsoon at three locations (Hisar, Bhiwani and Sirsa) of Haryana. The mean onset date was observed 4 July at Hisar and Bhiwani with standard deviation of 7 to 9 days respectively, whereas 7 July at Sirsa with standard deviation of 9 days. The mean withdrawal dates of south-west monsoon were 15 September at Hisar and Bhiwani and 11 September for Sirsa with standard deviation of 9 days at all three locations.

**Dixit *et al.* (2005)** carried out analysis of weekly rainfall data of 32 years (1972-03) for Konkan region of Maharashtra. The results indicated that the mean week of start of rainy season were 24<sup>th</sup> MW (11-17<sup>th</sup> June). The earliest and delayed weeks of start of rainy season were 21<sup>st</sup> MW (21-27<sup>th</sup> May) and 29<sup>th</sup> MW (16-22<sup>nd</sup> July) respectively. Mean week of withdrawal of rainy season were 40<sup>th</sup> MW (1-7<sup>th</sup> October). The earliest and delayed week of cessation of rainy season were 36<sup>th</sup> MW (3-9<sup>th</sup> September) and 44<sup>th</sup> MW (29-4<sup>th</sup> November) respectively. Mean duration of rainy season was 17 weeks (119 days) and the highest and lowest length of rainy

season was 19 and 15 weeks respectively.

**Soni and Kumar, (2005)** studied rainfall pattern of south-west monsoon in Malwa region of Madhya Pradesh. The results showed that the mean date of onset of monsoon ranged from 19 June at Indore to 5 July at Neemuch and giving mean date of on-set of monsoon 28-29 June for Malwa region with standard deviation of 7.28 days.

**Reddy *et al.* (2008 )** analysed onset and withdrawal of rainy season at Bangalore by fixing the forward accumulation and backward accumulation of rainfall respectively at 75 mm and 30 mm. The results revealed that the earliest, delayed and mean week of onset of rainy season was found to be 21<sup>st</sup>, 32<sup>nd</sup> and 24<sup>th</sup> MW and earliest, delayed and mean week of withdrawal of rainy season was found to be 41<sup>st</sup>, 48<sup>th</sup> and 45<sup>th</sup> MW.

**Benjamin and Buckley, (2009)** determined monsoon season onset, withdrawal, and length, using daily precipitation data from a network of weather stations across mainland Thailand. They applied a two-phase linear regression model to objectively determine the onset, withdrawal, and length of the summer monsoon season for the years 1951-2005. Onset metric proposed by authors compared favorably with an independent determination of onset. Both onset and withdrawal were associated with expected wind and geopotential height anomalies in the lower atmosphere. Comparisons between stations showed no coherent spatial variability in either onset or withdrawal, and trends at each station.

**Andrea Alessandri *et.al* (May 2010)** studied Predictability of Indian summer monsoon onset and withdrawal using dynamical seasonal forecasts .In this study dynamical seasonal forecasts are used to investigate the predictability of Indian Summer Monsoon (ISM) onset and withdrawal. Nine member ensemble forecasts performed with the latest version of the CMCC-INGV Seasonal Prediction System (SPS) are used. They applied objective large scale methods (both hydrological and circulation indexes) to the forecasts in order to diagnose the onset and the withdrawal of the monsoon.

**Kingpaiboon and Khuanmar, (2015)** determined of the dates of the southwest monsoon in north-eastern Thailand from the data on precipitable water vapor obtained by GPS. The dates of onset and withdrawal of monsoons calculated from this method were compared with those obtained with other methods. The difference equaled 1-2 day except years 2010 and 2012 when the errors were more than two days.

**Rodrigo J. Bombardi *et.al* (August 2019)** studied Detection, variability, and predictability of monsoon onset and withdrawal dates: A review. his article presents a review of the scientific literature on detection, sources of variability, and predictability of the timing of monsoons. The timing of monsoons is characterized by the

beginning (commonly referred to as onset) and end (commonly referred to as demise, cessation, retreat, or withdrawal) dates of the summer monsoons. The main methods used to detect the timing of monsoons are divided into two categories: local-scale methods and regional-to-large-scale methods. The sources of variability of the timing of monsoons are also separated into two categories: local-scale and large-scale sources.

**Krishnan et al., (2020)** studied The Indian summer monsoon rainfall (ISMR) is weakening over several regions (e.g., Krishnan et al., 2020), with a simultaneous increase in the extreme events in the recent ~150 years (Boyaj et al., 2020, and the references therein). Observation-based studies in the last 50-100 years suggest that, on inter annual time scales, tropical oceanic phenomena such as the ENSO dominantly influence the ISM variability. However, Proxy studies indicate that ISMR also varied on the decadal, centennial, and millennial to multi-millennial time scales, in addition to intra-annual, and inter annual scales (e.g., Ramesh et al., 2010; Chakraborty et al., 2012).

**Shrivastava et al., (2020)** carried out study on Effect of monsoon onset and withdrawal on rice production in Chhattisgarh. The main effort of this study was to analyse the impacts of the onset and withdrawal variability of the southwest monsoon on the production of kharif rice in Chhattisgarh. The date of onset and withdrawal of the southwest monsoon in Chhattisgarh is important for farmers as it affects the timing of crop sowing and the length of the southwest monsoon season. Comparing average rice production data for different categories of monsoon onset and withdrawal, we found that late monsoon withdrawal conditions are favorable for rice production and productivity. Based on the correlation study, we found that there is a significant association between the date of withdrawal of monsoon and the production of rice.

#### **2.4. Probabilities of dry and wet weeks by using Markov-chain Model**

**Gaikwad et al., (1995)** suggested the suitable sowing date for sunflower on rainfall probabilities. They carried a field study to evaluate the performance of sunflower and sunflower + red gram (2:1) intercropping system sown according to rainfall probabilities for 5 successive years during *kharif* season on 30 cm soil depths and observed that the yield of sunflower and sunflower + redgram intercropping were increased when crop was either sown during 24MW or 25MW.

**Gaikwad et al., (1996)** studied rainfall variability at Solapur station for which they used data of 29 years (1963-1992). Potential Evapotranspiration values were estimated. Probability analysis was based on first order Markov Chain through which dry seeding was suggested in early June for *kharif* crops.

**Sahane and Jadhav (1998)** studied the rainfall probabilities at Vadgaon Maval by using 27 years data in which majority of weeks recorded more than 50 per cent probability receiving more than 25 mm rainfall and observed that out of 52 weeks, 12 weeks recorded more than 50 per cent initial probabilities for 25 mm rainfall followed by 8, 2 and 1 weeks for more than 50, 75 and 100 mm rainfall, respectively.

**Jadhav et al., (1999)** studied rainfall probability analysis for crop planning in scarcity zone of Maharashtra. They collected historical data of rainfall for 30 years (1966-1995) from 9 different stations of scarcity zone. Rainfall at various probability levels for weekly, monthly, seasonal and annual were estimated. Trends calculated separately for these stations. They concluded that MW 24 and MW 38 had the highest probability of rainfall. This helped in sowing of *kharif* and *rabi* crops for dry seeding.

**Gare et al., (2000)** studied rainfall variability analysis at Gadhinglaj (Maharashtra) on the basis of 28 years rainfall data(1969-1996) for weekly, monthly, seasonal and annual rainfall at different probability levels. They concluded that *kharif* season was more assured than the *rabi* season and MW 29 was suitable for dry seeding in that area.

**Reddy et al., (2008)** used Markov Chain Model to study spell distribution. They carried it to find the probabilities of occurrence of dry and wet weeks, onset and withdrawal of rainy season and weekly analysis of rainfall for Bangalore region. Higher values of coefficient of variation of weekly rainfall indicated the erratic distribution of rainfall. The average annual rainfall of GKVK campus, Bangalore was found to be 923.9 mm and coefficient of variation (CV) of 25.4 per cent. The data on onset and withdrawal of rainy season indicated that the monsoon starts effectively from 24<sup>th</sup>MW (11-17<sup>th</sup>June) and remains active up to 45<sup>th</sup>MW (5-11<sup>th</sup>November). During rainy season the probability of occurrence of wet week is more than 35 per cent except during 25<sup>th</sup>- 27<sup>th</sup>MW and 44<sup>th</sup>- 48<sup>th</sup>MW. The mean weekly rainfall is found to be more than 40 mm during 36<sup>th</sup>- 41<sup>th</sup> MW and found to be less than 20 mm during 20<sup>th</sup> MW, 25<sup>th</sup>- 27<sup>th</sup>MW and 44<sup>th</sup>- 48<sup>th</sup>MW. The results through analysis have been used for agricultural planning at Bangalore region.

**Pandharinath, (1991)** estimated probabilities of dry, wet weeks, conditional probabilities of dry week preceded by dry week, wet week preceded by a wet week and consecutive 2 or 3 dry/wet weeks at nine stations in Andhra Pradesh during monsoon season(June- September) using Markov-Chain model. The study revealed that leaving the first two weeks of June; the probability of occurrence of a dry week was moderate to high (30 to 60 %) in North Andhra Pradesh and was 20 to 50 % in south coastal Andhra Pradesh. The conditional probability of occurrence of a dry week given the preceding week dry was also high, but the occurrence of two or three consecutive dry weeks was small.

**Dash and Senapati, (1992)** used Markov-Chain model to study the probability of dry

and wet spells for Bhubaneswar, Orissa. The study concluded that from 22<sup>nd</sup> week to 36<sup>th</sup> week, rainfall was adequate to grow rice crop. The authors also found that sowing rice crop in 25<sup>th</sup> week has 7.5 % probability of two consecutive dry weeks. The study concluded that there are 40 % chances of recurring dry weeks till the 22<sup>nd</sup> week; hence a period is not suitable for crop planning.

**Das and Mukhopadhyay, (1996)** analysed daily rainfall data of Coach Behar (1971-90) and Jalpaiguri (1972- 90) districts of Teraizone of West Bengal to study the nature of critical dry spells during the monsoon season. The study revealed that, there was possibility of occurrence of dry spell of 10 days or more once in every 4 years. Expected length of dry spell (in days) for 2,5,10 and 20 year return periods was estimated with the help of suitably fitted curves for each location.

**Khichar *et al.* (2000)** used Markov-Chain model to analyse weekly rainfall data of Haryana and calculated probabilities of different lengths and expected frequencies of dry spells. The study concluded that superimposing crop calendar on dry and wet spells sequences would provide information about water deficiency or water surplus. It was also concluded that initial and conditional probabilities provided the basic information on rainfall distribution needed for agricultural operations.

**Sarkar *et al.* (2001)** investigated 10 days period wise simple probability and probability of consecutive dry and wet spells of different lengths, using Markov- Chain model over Vidarbha region of Maharashtra during south-west monsoon months considering 30 years daily data (1960-1990). The study revealed that probability of a day being a wet and probability of consecutive wet spell of different lengths are by and large high during the last and first 10 day periods of July and August, respectively when the monsoon is at its peak. During the first two 10 day periods in June and last two 10 day periods in September, the probability of a dry day and that of consecutive dry spell of different length are quite high.

**Jat *et al.* (2005)** determined dry and wet spells for agricultural planning in Udaipur region. The results revealed that, the probability of occurrence of a dry week was high (77 to 100 per cent) in the first 25 weeks of the year and then decreased subsequently. The probability of occurrence of dry week again increased from 36<sup>th</sup> to 52<sup>nd</sup> week of the year. Similarly the probability of wet week was very low (0 to 27 %) up to 26<sup>th</sup> week and then started increasing up to 34<sup>th</sup> week. Thus, till 44<sup>th</sup> week except 51<sup>st</sup> week after which it reduces even to the level to 0%.

**Reddy *et al.* (2008)** evaluated dry and wet spells for Bangalore region. Markov chain Model was extensively used to study spell distribution. The results revealed that, during rainy season there are more than 50 % chances that two consecutive dry weeks may occur during 24<sup>th</sup>-26<sup>th</sup> MW and 44<sup>th</sup>-48<sup>th</sup> MW. Similarly, the probabilities of occurrence of three consecutive dry weeks were also very high (more than 35 %) during 23<sup>rd</sup> - 26<sup>th</sup> MW and 44<sup>th</sup> - 48<sup>th</sup> MW.

**Mathugama and Peiris, (2011)** provided critical evaluation of dry spell research. Markov models of order 1-10, Negative Binomial, Truncated Negative Binomial, Eggemberg-Polya and Weibull distributions were used to find the probabilities of a dry spell event greater than or equal to a certain value. They concluded that some of the fitted models were not compared with the results obtained from empirical statistical models. Also, such models were not attempted to forecast length and starting dates of dry spells and thus the information derived from past studies cannot be used efficiently for planning purposes. Further, as forecasting of all the dry spells was impossible, it was also recommended to concentrate only on the most critical dry spells.

**Admasu et al., (2014)** presented the study after using Markov Chain probability model to explain long term frequency behaviour of wet and dry weather spells at Dhera, Ethiopia. Weekly rainfall data from 1984 to 2010 was used to study the probability of occurrences of dry and wet weeks. The probability of occurrences of initial and conditional probability is more than 50 per cent at 10 mm per week threshold limit in 26<sup>th</sup> MW and at 20 mm per week threshold limit in 28<sup>th</sup> MW, therefore land preparation and sowing could be undertaken in 26<sup>th</sup> and 28<sup>th</sup> MW respectively. Initial and conditional probabilities at 20 mm threshold limit per week showed that, supplementary irrigation moisture conservation practice need to be practiced between 38<sup>th</sup> and 40<sup>th</sup> MW. In addition, harvesting runoff water for supplementary irrigation and construction of soil erosion measures need to be practiced between 28<sup>th</sup> and 33<sup>rd</sup> MW for rainwater management.

**M.Ray et al (2018)** In the studied, Markov chain probability model to calculate the chances of occurrences of dry and wet spells was applied for Mayurbhanj using 20 years (1997 to 2016) weekly rainfall. The rainfall characteristics were analyzed on annual, seasonal, monthly and weekly basis. The average annual rainfall of Mayurbhanj was found to be 1790.8 mm and coefficient of variation (CV) was 11.8 % which is less than threshold limit that indicates that the rainfall is highly dependable. Monsoon starts on the 24<sup>th</sup> standard meteorological week (MW) (11 – 17<sup>th</sup> June) and remains active up to 43<sup>rd</sup> MW (22-28<sup>th</sup> October) with a total length of 20 weeks (140 days). Initial, conditional and consecutive dry and wet week probabilities showed that chances of occurrence of a week getting wet is high during from 24<sup>th</sup> week onwards upto 40<sup>th</sup> week. Chances of occurrence of wet week of more than 50% at the beginning of Kharif season indicates that summer ploughing and initial seed bed preparations shall be taken up in the 20<sup>th</sup> – 22<sup>nd</sup> MW (14<sup>th</sup> May - 3<sup>rd</sup> June) and sowing operations can be taken up since 23<sup>rd</sup> MW (4<sup>th</sup> – 10<sup>th</sup> June).

**Dugal et al., (2018)** collected and processed block wise historical rainfall data of 23 years (1995 to 2017) of Bhadrak District by using Weather cock software which revealed that the total mean annual rainfall of the district is 1431 mm. Bhadrak receives almost 70% of mean

annual rainfall during SW monsoon. Monsoon starts effectively from 24th MW (12th June to 15th June) in Bhadrak district and remain active up to 41st MW (9th October to 13th October). The initial rainfall probability,  $P(W)$  of getting 20 mm rainfall per week was  $>30$  per cent during 22nd MW at Bhadrak district, hence, field preparation should be done during this period. The initial as well as conditional probability of wet week followed by wet week  $P(W/W)$ , of getting 20 mm rainfall was more than 50 per cent in 23<sup>rd</sup> MW, this week is more suitable for sowing of crops. During 44<sup>th</sup> to 46<sup>th</sup> MW (29<sup>th</sup> Oct. to 18<sup>th</sup> Nov.) probability of getting 10 mm rainfall per week was more than 30 per cent. This period is suitable for land preparation and sowing of rabi crops. Proper crop planning with suitable water conservation measures are needed to be adopted to enhance the acreage, production and productivity rabi crops of the district.

**Dash *et al* (2020)** Understanding the probable period of onset and withdrawal of monsoon, amount of rainfall and its distribution over a cropping season is pre-requisite to timely agricultural operations, selection of crop varieties and cropping pattern in a region. Dhanora block is one of the eight blocks of Seoni district with undulating landform, erratic rainfall and mainly rainfed farming with less irrigated area (22.02%). Here, Markov chain model used for dry and wet spell analysis for weekly rainfall. If total amount of any week of rainfall is equal or more than 10 mm, 20 mm and 40 mm, it considered as wet weeks and less than this considered as dry weeks. Probability of two or three consecutive dry weeks at 20.00 mm rainfall is less than 40% during 25th MW to 39th MW and more than 50% from 1st to 23 MW and 40th MW to 52nd MW. Probability of two and three consecutive wet weeks at 20 mm rainfall is more than 50% from 25th MW to 36th MW and 27<sup>th</sup>MW to 36<sup>th</sup> MW, respectively. Based on probability analysis of rainfall and moisture availability, various water management and crop planning strategies have been discussed in this paper for Dhanora block, Seoni.

## 2.5. Studies on crop management planning based on rainfall analysis.

**Manorama *et al.*, (2007)** carried out study on rainfall analysis and crop planning for the Nilgiris (Tamil nadu). Weekly, monthly, seasonal and annual study was carried out at different probability levels. He suggested potato, cabbage, carrot etc can be taken up in the 3 week of April and the second crop can be planted at end of August rotating among these vegetables.

**Sheoran *et al.*, (2008)** made rainfall analysis and suggested crop planning in lower Shivalika foot hills of Punjab. They recorded the daily rainfall data of Punjab for 26 years for long term averages of annual, seasonal, monthly and weekly rainfall and its temporal variability. They observed that there was an ample scope for rain water harvesting from July to

September which can be utilized as crop saving irrigation as well as pre-sowing irrigation for succeeding rabi crops which are generally sown on residual soil moisture.

**Singh *et al.*, (2008)** studied the rainfall distribution pattern and crop planning at Pusa in Bihar by collecting the daily data of fifty two years for establishing the long term averages of weekly, monthly, seasonal and annual rainfall and its variability. They observed that the average duration of the rainy season was from 26<sup>th</sup> to 40<sup>th</sup> MW. Pre monsoon rains at 75 per cent probability level can be utilized for seedbed preparation and at 50 per cent probability level summer crops like cow pea and black gram could be grown successfully

**Gaikwad (2009)** studied the daily tahasilwise rainfall characterization for last 30 years (1979-2008) of Jalna district. The study revealed that the probability analysis of occurrence of dry and wet spells provided the relevant information for different intercultural operations and can be useful for farm planning. The data studied in the project revealed that the probability of occurrence of 2 weeks dry spell was the highest in 44 MW while the probability of occurrence of 3 weeks dry spell was the highest in 43 MW and the probability of occurrence of 4 weeks dry spell was the highest in 42MW. So crops like maize can be sown dry which will be germinated just after the rains and can save the time of land preparation. Further based on the rainfall characterization and depth of soil, the cropping pattern was suggested according to soil depths as less than 7.5 cm (Pastures and Rainfed fruits), 7.5 cm to 22.5 cm (Pasture, horse gram, kidney bean, castor, pearl millet +horse gram), 22.5 to 45 cm (Monocropping of sunflower, pearl millet, red gram, pearl millet + red gram), 45 to 60 cm (*rabi* sorghum and safflower) and more than 60 cm (*rabi* sorghum, safflower, sunflower, gram, cotton or double cropping).

**Jat *et al.*, (2010)** worked on crop planning in semi-arid tracts of Udaipur region based on analysis of weekly rainfall. Incomplete gamma distribution is used to predict the minimum assured rainfall at different probabilities of exceedance in all weeks of the whole year. The study reveals that chances of drought are more at critical stages of maize but there is a scope for *in-situ* moisture conservation and runoff collection in tanks for supplemental irrigation. *Rabi* crops are found to be grown under moisture stress.

**Chand *et al.*, (2011)** analyzed rainfall for crop planning in Jhansi district of Bundelkhand zone of Uttar Pradesh. The historical rainfall data for the period of 34 years (1975-2008) of Jhansi in Bundelkhand agro climatic zone of U.P. were analyzed to know weekly, monthly, seasonal and annual probabilities at different levels of rainfall for suitable crop planning. The analysis revealed that, occurrence of 70 % of initial probability of a dry week from 1 to 24<sup>th</sup> week and the conditional probability of wet week preceded by a wet week is also high from 26<sup>th</sup> to 37<sup>th</sup> week. The *Kharif* season crops and their varieties may be chosen with the growing period to avoid moisture stress. The sowing of rainfed crops in *Rabi* season may be completed between 40<sup>th</sup> to 41<sup>nd</sup> standard weeks because subsequent week has rare chance to get rains.

**Chinchorkar et al., (2012)** analyzed daily rainfall data of 30 years (1972-2002) of different 20 rain gauge stations from the scarcity zone of Maharashtra. Weekly actual rainfall was considered for calculating Moisture Availability Index (MAI). The wet and dry spells were calculated by Markov Chain model. The arrival and departure of monsoon were decided by weekly rainfall frequency distribution method. It was suggested to grow grasses and dry land horticulture *viz.*, custard apple, pomegranate etc. on shallow soil in addition to present cropping pattern. Similarly, in medium and deep soils during *kharif* season sunflower, pearl millet, pigeon pea, castor, groundnut etc. were suggested. During *rabi*, sunflower, safflower, *rabi* sorghum, gram etc. were suggested with the provision of supplemental irrigations. Fodder sorghum in *kharif* and safflower in *rabi*, pearl millet in *kharif* and gram in *rabi*, black gram in *kharif* and sorghum in *rabi*, green gram in *kharif* and sunflower in *rabi*, cowpea for fodder in *kharif* and sunflower in *rabi* were suggested.

**Admasu et al., (2014)** presented the study after using Markov Chain probability model to explain long term frequency behaviour of wet and dry weather spells at Dhera, Ethiopia. Weekly rainfall data from 1984 to 2010 was used to study the probability of occurrences of dry and wet weeks. The probability of occurrences of initial and conditional probability is more than 50 per cent at 10 mm per week threshold limit in 26thMW and at 20 mm per week threshold limit in 28thMW, therefore land preparation and sowing could be undertaken in 26th and 28thMW respectively. Initial and conditional probabilities at 20 mm threshold limit per week showed that, supplementary irrigation moisture conservation practice need to be practiced between 38th and 40thMW. In addition, harvesting runoff water for supplementary irrigation and construction of soil erosion measures need to be practiced between 28th and 33rdMW for rainwater management.

**Pali et al., (2015)** worked on daily rainfall data for 20 years (1994-2013) collected from Durg, Dhamdha and Patan blocks of Durg district of Chhattisgarh and other climatic data on minimum and maximum temperatures, relative humidity and evaporation for the same period (1994-2013) were collected from Durg block only. Using rainfall and evaporation data, weekly and seasonal mean rainfall, expected rainwater availability at given probability levels and ET demands of the rice crop at different growth stages were estimated and analyzed. This analysis showed that a severe drought situation may occur at all the blocks of Durg district. Thus, supplemental irrigation is essential at all the study blocks to obtain good rice yields.

**Shaikh et al., (2017 a)** reported the availability of water for crops in a season depends on the distribution and variability of rainfall. Hence, from crop management point of view, onset and withdrawal of monsoon is to be considered the ideal for crop planning, scheduling farm operations on land use operations and therefore the onset and withdrawal pattern of monsoon of each tahasil were worked out and presented in Table 1. Onset and withdrawal of

Satara district mean start of rainy season is 24 MW in most of the tahasils and early onset is at 23 MW in all the tahasils. While late onset observed from 25 MW to 26 MW. Mean termination of rainy season was noted in 42 MW to 48 MW. Early termination was observed during 41 MW to 43 MW in all the tahasils while late termination observed during 49 MW.

**Shaikh *et al.*, (2017 b)** reported the average number of drought years of district for no drought, moderate drought and severe drought were 45, 8 and 2 and their contribution 82, 15 and 3 per cent, respectively. The information regarding different aspect of rainfall, like severity of drought in each tahasil along with the different soil types of Satara district is very meager. Hence, it was necessary to undertake the characterization of rainfall for agricultural crop planning to the farmers of the district. With these considerations, a systematic study was planned on meteorological drought pattern in different tahasils of Satara district

**Punitha *et al.*, (2017)** used Markov chain probability model to enlighten the long term frequency behavior of wet or dry weather spells during the main rainy season. This study used 35 years (1981 to 2015) of rainfall data and aggregated weekly rainfall data (52 weeks) was considered as standard week to study the probability of occurrence of wet and dry weeks. The probability of occurrences of initial and conditional probability is more than 50 % on 35th week with threshold limit of 20 mm per week. Therefore the land preparation for sowing or planting could be undertaken in 35th week respectively for the main rainy season crop cultivation.

**Dugal *et al.*, (2018)** collected and processed block wise historical rainfall data of 23 years (1995 to 2017) of Bhadrak District by using Weather cock software which revealed that the total mean annual rainfall of the district is 1431 mm. Bhadrak receives almost 70% of mean annual rainfall during SW monsoon. Monsoon starts effectively from 24th MW (12th June to 15th June) in Bhadrak district and remain active up to 41st MW (9th October to 13th October). The initial rainfall probability,  $P(W)$  of getting 20 mm rainfall per week was >30 per cent during 22nd MW at Bhadrak district, hence, field preparation should be done during this period. The initial as well as conditional probability of wet week followed by wet week  $P(W/W)$ , of getting 20 mm rainfall was more than 50 per cent in 23 MW, this week is more suitable for sowing of crops. During 44th to 46th MW (29th Oct. to 18th Nov.) probability of getting 10 mm rainfall per week was more than 30 per cent. This period is suitable for land preparation and sowing of rabi crops. Proper crop planning with suitable water conservation measures are needed to be adopted to enhance the acreage, production and productivity rabi crops of the district.

**Joshi (2019)** studied trends in weekly, monthly, seasonal and annual rainfall of Solapur district using Mann-Kendall test Z and Sen's slope method, to determine probabilities of dry and wet weeks by using Markov-Chain model and to suggest crop management and planning. The study revealed that maximum seasonal, monthly and weekly rainfall was observed in South-

West monsoon season, September month and MW 38th and 39th respectively. Therefore, selected tahsils of Solapur district are *Rabi* dominated as there is sufficient availability of residual moisture from rainfall at the end of the South-West monsoon season. However, short duration *kharif* crops with in-situ moisture conservation practices and proper crop planning are possible to grow in the study area. The mean date of onset of effective monsoon lies between 25th June and 16th July in the study area, hence this period should be considered for the sowing of selected *kharif* crops.

**Dash *et al* (2020)** Understanding the probable period of onset and withdrawal of monsoon, amount of rainfall and its distribution over a cropping season is pre-requisite to timely agricultural operations, selection of crop varieties and cropping pattern in a region. Dhanora block is one of the eight blocks of Seoni district with undulating landform, erratic rainfall and mainly rainfed farming with less irrigated area (22.02%). Here, Markov chain model used for dry and wet spell analysis for weekly rainfall. If total amount of any week of rainfall is equal or more than 10 mm, 20 mm and 40 mm, it considered as wet weeks and less than this considered as dry weeks. Probability of two or three consecutive dry weeks at 20.00 mm rainfall is less than 40% during 25th MW to 39th MW and more than 50% from 1st to 23 MW and 40th MW to 52nd MW. Probability of two and three consecutive wet weeks at 20 mm rainfall is more than 50% from 25th MW to 36th MW and 27<sup>th</sup>MW to 36<sup>th</sup> MW, respectively. Based on probability analysis of rainfall and moisture availability, various water management and crop planning strategies have been discussed in this paper for Dhanora block, Seoni.

### 3. MATERIALS AND METHODS

This chapter gives detailed information about the study area, data and software used for rainfall analysis to study drought using Standardized Precipitation Index (SPI) and Precipitation Deciles (PD), start and end of rainfall, probabilities of dry and wet weeks by using Markov-chain Model for crop planning over Nashik district.

#### 3.1 Study Area

Nashik district of Maharashtra region is spread over 19°35' to 20°52' North Latitude and 73°16' to 75°16' East Longitude at North-West part of Maharashtra state. It is called as the 'Grape capital of India'. Nashik district is situated at 648 m height above mean sea level. The Nashik district is bounded by Dhule district to the North, Jalgaon district to the East, Aurangabad district to the South-East, Ahmednagar district to the South, Thane district to the South-West, Valsad and Navsari districts of Gujrat to the West and The Dangs district to the North-West. The geographical structure of Nashik district is classified into four agro-climatic zones as under, Western Ghat Zone, Scarcity Zone, Western Maharashtra Plain zone and Sub Mountain zone. There are 15 tahasils in Nashik district viz., Nashik, Sinnar, Igatpuri, Trimbakeshwar, Niphad, Yevla, Peth, Dindori, Chandwad, Nandgaon, Surgana, Kalwan, Deola, Baglan and Malegaon.

#### 3.2 Climate and Rainfall

The climate of the district is on the whole is agreeable. The climate of Nashik district is characterized by general dryness throughout the year except during South-West monsoon season. In the hilly western part of the district, the climate is slightly cool. May month is the hottest and January is the coldest month and the temperature varied from 17.6°C to 31.56°C. In the scarcity zone, the maximum temperature is around 42.5°C (during April and May) and minimum temperature around 5°C (during December) (Anonymous, 2017)

The average annual rainfall of the district is 1066.80 mm, most of which is received during South-West monsoon. However, scarcity zone of the district having an average rainfall of 500-700 mm. Transition zone I have an average rainfall of 700-1240 mm, Transition zone II have an average rainfall 1250-3000 mm and Ghat zone have an average rainfall 3000-5000 mm.

##### 3.2.1 Monsoon season

June to September is considered as Monsoon. The rains start with the south-west winds. Nearly 86.55 % of the total average rainfall occurs in this season. The number of average annual rainy days in Nashik district is 50 as compared to 67 in Maharashtra state.

### 3.2.2 Post Monsoon

The good weather season with less rainfall between October to December is called as Post Monsoon season. Nearly 11.49 % to total annual rainfall occurs in this season. Yield of *Rabi* crops depends upon the weather during this season.

### 3.2.3 Winter season

Winter season is described as a period of two months from January to February. Approximately, 0.25% of annual rainfall occurs in winter. Most of the *Rabi* crops depend upon the weather during these months.

### 3.2.3 Pre Monsoon

Also known as summer, this season lasts for three months; March-May. Climate is cool and dry and temperature is in between 26<sup>0</sup>C-31<sup>0</sup>C. Nashik district receives 1.17% pre monsoon rains during this period. The average rainfall of Nashik district is approximately 1066.80 mm which is only 73.29 % of the average rainfall of the state (1455.5 mm). Nashik district received rainfall from both south west and north east monsoon. The proportion of rainfall received from north east monsoon increases towards eastern tehsils while rainfall from south west monsoon increases towards western tehsils due to Sahyadri Mountain region.

## 3.3 Data Collection

### 3.3.1 Historical rainfall data

**For the present study, rainfall data of all 15 tehsils in Nashik district for the period of 1961-2019 in some tehsils and 1998-2019 in remaining tehsils is downloaded from following websites.**

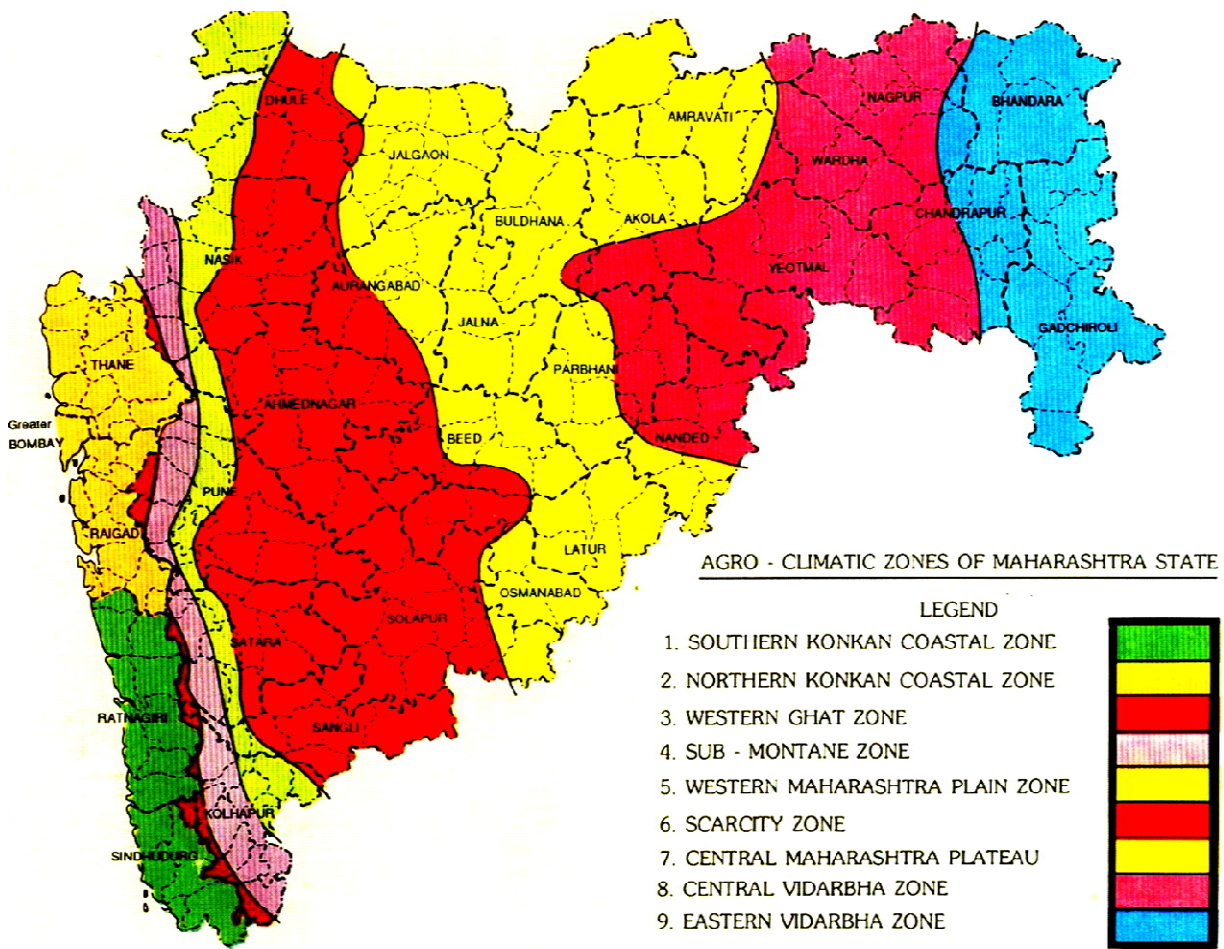
- (1) Department of Agricultural Meteorology, College of Agriculture, Pune
- (2) State Agriculture Department, Pune
- (3) India Meteorological Department, Pune
- (4) Downloaded from [www.maharain.gov.in](http://www.maharain.gov.in) ([www.krishi.maharashtra.gov.in](http://www.krishi.maharashtra.gov.in))



**MAHARASHTRA STATE**



**Fig.3.1: Tehsilwise Map of Nashik District**



**Fig.3.2: Agro-climatic zones of Maharashtra State**

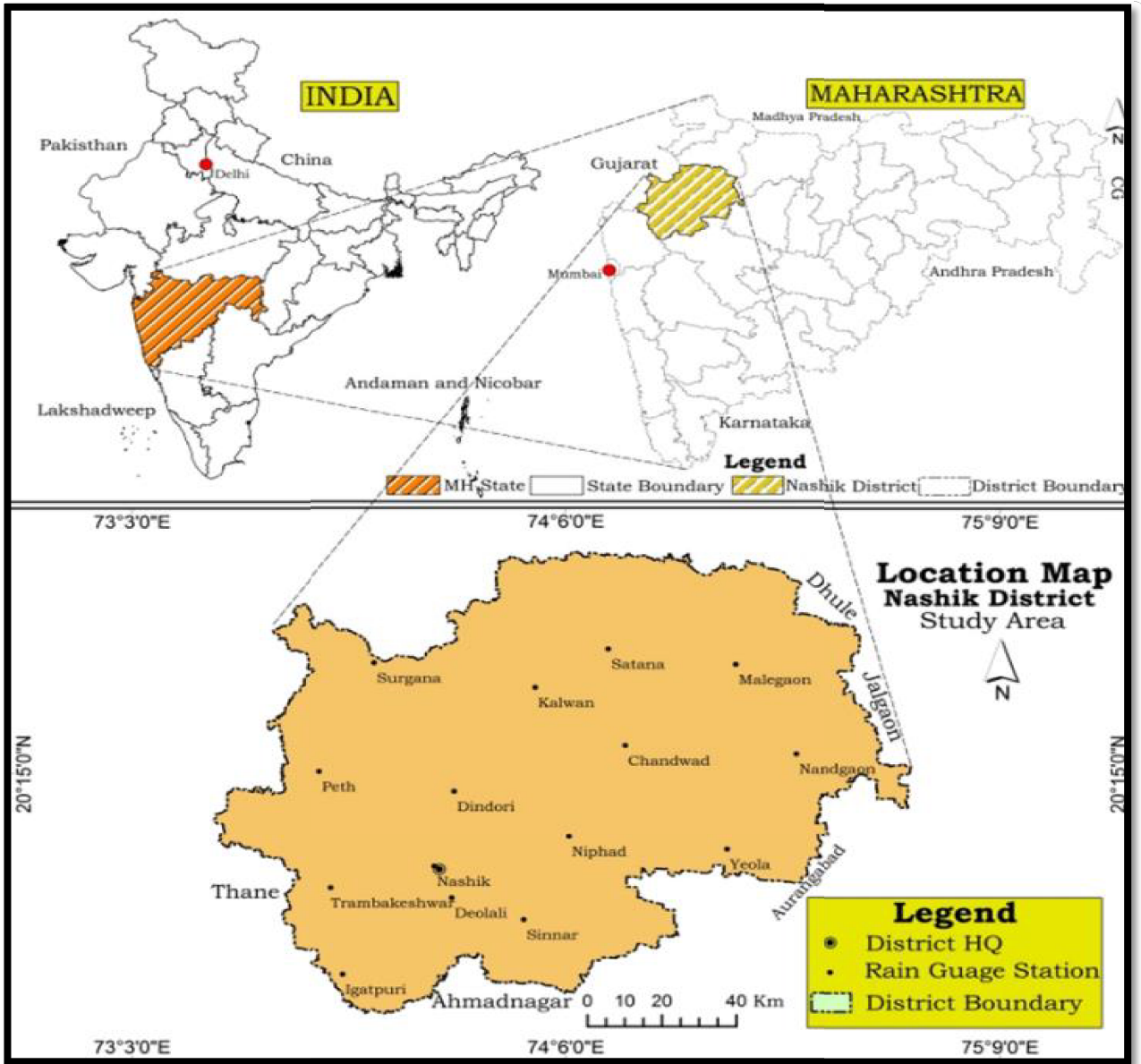


Figure.3.3 Location map of study area

Weather cock software is used to convert daily rainfall data into weekly, seasonal, monthly and annual data for further analysis. This weekly, monthly and annual rainfall data is presented in Appendix-1. Four different indices namely Precipitation Decile (PD), Standard Precipitation Index (SPI), Probability of dry and wet weeks and Start and End of rainfall are calculated using this rainfall data. The geographical area of rain gauge stations and duration of rainfall data collected is presented in Table 3.1.

**Table 3.1: Geographical location and availability of data for study Areas.**

| <b>Sr.no.</b> | <b>Name of tahsils</b> | <b>Geographic Area km<sup>2</sup></b> | <b>Latitude</b>        | <b>longitude</b>      | <b>Period of year</b> | <b>No. of years</b> |
|---------------|------------------------|---------------------------------------|------------------------|-----------------------|-----------------------|---------------------|
| 1             | Baglan                 | 1477.83                               | 20.59 <sup>0</sup> N   | 74.22 <sup>0</sup> E  | 1961-2019             | 59                  |
| 2             | Chandwad               | 953                                   | 20.32 <sup>0</sup> N   | 74.25 <sup>0</sup> E  | 1978-2019             | 42                  |
| 3             | Deola                  | 548                                   | 20.46 <sup>0</sup> N   | 74.18 <sup>0</sup> E  | 1998-2019             | 22                  |
| 4             | Dindori                | 1319                                  | 20.20 <sup>0</sup> N   | 73.83 <sup>0</sup> E  | 1961-2019             | 59                  |
| 5             | Igatpuri               | 867                                   | 19.69 <sup>0</sup> N   | 73.56 <sup>0</sup> E  | 1961-2019             | 59                  |
| 6             | Kalwan                 | 864                                   | 20.47 <sup>0</sup> N   | 74.023 <sup>0</sup> E | 1961-2019             | 59                  |
| 7             | Malegaon               | 1818                                  | 20.54 <sup>0</sup> N   | 74.32 <sup>0</sup> E  | 1961-2019             | 59                  |
| 8             | Nandgaon               | 1089                                  | 20.30 <sup>0</sup> N   | 74.65 <sup>0</sup> E  | 1961-2019             | 59                  |
| 9             | Nashik                 | 891                                   | 19.997 <sup>0</sup> N  | 73.79 <sup>0</sup> E  | 1998-2019             | 22                  |
| 10            | Niphad                 | 1049                                  | 20.0833 <sup>0</sup> N | 74.11 <sup>0</sup> E  | 1961-2019             | 59                  |
| 11            | Peth                   | 557                                   | 18.93 <sup>0</sup> N   | 73.92 <sup>0</sup> E  | 1961-2019             | 59                  |
| 12            | Sinnar                 | 1344                                  | 19.85 <sup>0</sup> N   | 74.00 <sup>0</sup> E  | 1961-2019             | 59                  |
| 13            | Surgana                | 821                                   | 20.34 <sup>0</sup> N   | 73.37 <sup>0</sup> E  | 1961-2019             | 59                  |
| 14            | Trimbakeshwar          | 900                                   | 19.56 <sup>0</sup> N   | 73.32 <sup>0</sup> E  | 1961-2019             | 59                  |
| 15            | Yeola                  | 1059                                  | 20.04 <sup>0</sup> N   | 74.48 <sup>0</sup> E  | 1998-2019             | 22                  |

### 3.4 Software Used for Study

Microsoft office sub-module Microsoft-Excel-2010 is used for data analysis. The formulation and conditional statements were also executed in MS-excel. The Weather Cock-15 software developed by CRIDA, Hyderabad was used for the analysis of annual, seasonal, monthly and weekly rainfall, mean, standard deviation, coefficient of variation of rainfall, Probability of Wet and Dry weeks. The SPI\_SL\_6.exe software developed by T.B. McKee, N.J. Doesken and J. Kleist, Colorado State University, 1993 is used for analysis of drought by calculating standardized precipitation index (SPI). The DrinC (drought indices calculator) software developed at National Technical University of Athens was used for analysis of drought using Precipitation Deciles Index. The STENDRF.EXE software was used for analyzing start and end of monsoon. ARC GIS software was used for the preparation of the tehsil wise GIS-based maps of rainfall analysis.

**Table 3.2. Software's used for rainfall data analysis**

| <b>Indices</b>   | <b>Software used</b>                          | <b>Developed by</b>                        |
|--|---|--|
| Conversion of data for<br>Daily, Weekly,<br>Monthly, Seasonal, | Weather cock-15                               | CRIDA, Hyderabad                           |
| Standardized<br>Precipitation Index<br>(SPI)                   | SPI_SL_6.exe<br>Svoboda <i>et al.</i> ,(2012) | Edwards and MacKee,<br>(1997)              |
| Precipitation Deciles  | DrinC   | National Technical<br>University of Athens |
| Onset and Withdrawal<br>of monsoon                             | STENDRF.EXE                                   | CRIDA, Hyderabad                           |
| Markov chain<br>probability model for<br>dry and wet spell     | Weather cock-15                               | CRIDA, Hyderabad                           |

### 3.5 Statistical Characteristics of Climatological Data

The statistical behavior or characteristics of series of any climatological variables can be described on the basis of several parameters. These parameters are mean,

standard deviation, coefficient of variation. All these parameters were used to describe the variability of climatological variables (rainfall) in this study.

The statistical characteristics of rainfall of 15 stations were determined on weekly, monthly, seasonal, annual basis.

### 3.5.1 Mean

Mean represents the measure of central tendency. It is the average of given values and given by

$$X = \frac{\sum_{i=1}^n X_i}{n} \dots \dots \dots (3.1)$$

Where,

$X$  = Mean

$X_i$  = Variables

$n$  = Total number of variables

### 3.5.2 Standard Deviation

Standard deviation is the best measure of dispersion. It gives more weight to extreme items and less to those which are near the mean. It is defined as the positive square root of the arithmetic mean of the squares of the deviations of the given values from the arithmetic mean.

$$\sigma = \sqrt{\frac{\sum (X_i - X)^2}{n-1}} \dots \dots \dots (3.2)$$

Where,

$\sigma$  = Standard deviation

$X_i$  = Variables

$X$  = Mean

$n$  = Total number of variables

### 3.5.3 Coefficient of Variation

The coefficient of variation is the percentage of variation in the mean, the standard deviation being treated as the total variation in the mean. The coefficient of variation (CV) is a statistical measure of how the individual data points vary about the mean value.

$$CV = \frac{\sigma}{X} 100 \dots \dots \dots (3.3)$$

Where,

CV = Coefficient of variation

X = Mean

$\sigma$  = Standard deviation

This measure is indicative of dependability of variable expressed in percentage. The threshold levels for CV for any interpretation are <25, <50, <100, <150 and <250 per cent for yearly, seasonal, monthly, weekly and daily rainfall respectively **Manorama *et al.*, (2007).**

### 3.6 Methodology -Assessment of meteorological drought by various Indices

Meteorological drought was analyzed by using Precipitation Deciles (PD) and Standardized Precipitation Index (SPI) for Nashik district

#### 3.6.1. Precipitation Deciles

The method of Deciles is one of the simplest meteorological drought indices which was introduced by Gibbs and Maher (1967). It is based on dividing the distribution of monthly record precipitation into 10% parts. This method requires an extended length of precipitation data record for accurate estimation. The precipitation totals for the preceding three months are ranked against climatological records and if the sum falls within the lowest decile of the historical distribution of 3-month totals, then the region is considered to be under drought conditions (Kininmonth *et al.*, 2000). The drought ends when:

- (i) The precipitation measured during the past month already places the 3-month total in or above the fourth decile, or
- (ii) The precipitation total for the past three months is in or above the eighth decile.

The advantage of the method of deciles is its computational ease but its simplicity can lead to conceptual difficulties. The deciles are grouped into five classes as presented in Table 3.3.

**Table 3.3 : Classification of drought conditions according to deciles**

| <b>Decile Class</b>           | <b>Description</b> |
|-------------------------------|--------------------|
| Deciles 1-2: lowest 20%       | Much below normal  |
| Deciles 3-4: next lowest 20%  | Below normal       |
| Deciles 5-6: middle 20%       | Near normal        |
| Deciles 7-8: next highest 20% | Above normal       |
| Deciles 9-10: highest 20%     | Much above normal  |

### 3.6.2. Standardized Precipitation Index (SPI)

The SPI index was designed by McKee *et al.*, to quantify the precipitation deficit in 1993 in University of Colorado. The calculation of the SPI index in any place is based on the precipitation history over a long period corresponding to the period of time studied. This effort was accomplished by quantifying the rainfall deficit at multiple time scales. More specifically, McKee *et al.*, (1993) estimated the SPI for the time scales of 1, 3, 6, 12, 24, and 48 months. Drought at time scales 1-, 3-, and 6-month is relevant for agriculture, 12-month for hydrology and 24-month for socioeconomic impact. Any drought including meteorological and agriculture is a result of deficient rainfall. The SPI has been used widely to quantify the deficit of precipitation. It could be computed at different time scales from less than 1 month to 48 months or more. The calculation time period depends on the user's application. Short-term SPI is used to detect agricultural drought, and long-term SPI can be used for water supply management. In addition, the 1-month SPI reflects a short-term condition; the 3-month SPI provides a seasonal estimation of precipitation; the 12-month SPI also reflects medium-term trends in precipitation patterns and may provide an annual estimation of water condition. Therefore, this study used the SPI values at 1-, 3- and 6-month scales to discover the drought discrepancy (Tan *et al.*, 2015). Therefore, this multi-temporal approach of SPI provides "a macroscopic insight of the impacts of drought on the availability of water resources" (Angelidis *et al.*, 2012; Καραμπατάκης, Θ.Μ., 2017). The advantage of SPI is, it needed only precipitation data and can be used for both dry and rainy seasons while some indices using specific data as per designed. It can describe drought conditions that are important for a range of meteorological, agricultural, and hydrological applications. Studies have shown that the SPI is suitable for quantifying most types of drought events (Guenang and Kamga, 2014). To calculate the SPI, a long-term precipitation record at the desired station is first fitted to a probability distribution (e.g. gamma distribution), which is then transformed into a normal distribution so that the mean SPI is zero (McKee *et al.*, 1993, McKee *et al.*, 1995, Edwards and McKee, 1997). The SPI value is derived from the inverse value of the cumulative probability function of the observed precipitation distribution. Standardized precipitation index was calculated according to the following formula Edwards and McKee, (1997).

$$\text{SPI} = \text{Z score} = \frac{x_i - \bar{x}}{\sigma} \dots (3.4)$$

The SPI is equivalent to Z-score which is often used in statistics *i.e.* SPI=Z-score

Where,

$X_i$ = Precipitation of the specified time scale for  $i^{\text{th}}$  year (*i.e.* for annual SPI is the precipitation of  $i^{\text{th}}$  year; for monthly SPI, it is the precipitation of particular month in  $i^{\text{th}}$  year; and for two month time scale, it is the sum of the precipitation of the particular month and the month preceding to this particular month)

$\bar{X}$ = Long-term average precipitation of the specified time scale

$\sigma$  = Standard deviation of the precipitation of the specified time scale

To adjust for this empirical fact, the precipitation data is transformed to a more normal or Gaussian symmetrical distribution by applying the gamma function. After the precipitation data have been transformed, the SPI is calculated in a manner that mirrors the Z-score formula Edwards and Mackee, (1997). Procedure and formulae adopted for computation of SPI is;

I. The transformation of the precipitation value in to standardized precipitation index (SPI) with the purpose of:

- a) Transforming the mean of the precipitation value adjusted to 0;
- b) Standard deviation of the precipitation is adjusted to 1.0; and
- c) Skewness of the existing data is readjusted to 0.

When these goals are achieved the standardized precipitation, index is interpreted as mean 0 and standard deviation of 1.0.

The precipitation needs to convert to lognormal values and the statistics, U shape and  $\beta$  scale parameters of gamma distribution are computed as:

$$\log \text{mean} = \bar{X}_{\ln} = \ln(\bar{X}) \quad \dots (3.5)$$

$$U = \bar{X}_{\ln} - \frac{\sum \ln(X)}{N}$$

$$\text{Shape parameter} = \beta = \frac{1 + \sqrt{1 + \frac{4U}{3}}}{4U} \quad \dots (3.6)$$

$$\text{Scale factor} = \alpha = \frac{\bar{X}}{\beta} \quad \dots (3.7)$$

The resulting parameters are then used to find the cumulative probability of an observed precipitation event. The cumulative probability is given by:

$$G(x) = \frac{\int_0^x x^{\alpha-1} e^{-\frac{x}{\beta}} dx}{\beta^{\alpha} \Gamma(\alpha)} \quad \dots (3.8)$$

Since the gamma function is undefined for  $x=0$  and a precipitation distribution may contain zeros, the cumulative probability is becomes:

$$H(x) = q + (1 - q)G(x) \quad \dots (3.9)$$

Where

$q$  = the probability of zero.

The cumulative probability  $H(x)$  is then transformed to the standard normal random variable  $Z$  with mean zero and variance of one, which is the value of the SPI

(Edwards and MacKee, 1997). Abramowitz and Stegun, (1965) provide the approximate conversion as an alternative:

$$Z = \text{SPI} = - \left( t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right) \quad 0 < H(x) \leq 0.5 \quad \dots (3.10)$$

$$Z = \text{SPI} = + \left( t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right) \quad 0.5 < H(x) \leq 1 \quad \dots (3.11)$$

Where,

$$t = \sqrt{\ln \left( \frac{1}{H(x)^2} \right)} \quad 0 < H(x) \leq 0.5 \quad \dots (3.12)$$

$$t = \sqrt{\ln \left( \frac{1}{(1.0 - H(x))^2} \right)} \quad 0.5 < H(x) \leq 1.0 \quad \dots (3.13)$$

$$C_0 = 2.515517$$

$$C_1 = 0.802593$$

$$C_2 = 0.010328$$

$$d_1 = 1.432788$$

$$d_2 = 0.189269$$

$$d_3 = 0.001308$$

The values of  $c_0$ ,  $c_1$ ,  $c_2$ ,  $d_1$ ,  $d_2$  and  $d_3$  given in equation are constants widely employed for SPI computation Edwards and MacKee, (1997).

Anomalous behaviour of rainfall can be identified from SPI values as extraordinary heavy rainfall indicates more positive SPI while scanty rainfall shows deviation towards more negative SPI. Drought event is considered commencing when SPI goes below -1 and is said offsetting when SPI becomes positive (i.e. rainfall just above the mean rainfall). The region is said to have continuous drought when several consecutive months show negative SPI values. According to the SPI method the severity of a drought is determined. The negative value from zero shows the severity of dryness. The SPI value normally ranges from (-2) to (+ 2). The SPI is grouped into five classes as presented in Table 3.4.

**Table3.4 : Classification of Drought condition according to SPI Class**

| Index Class       | Description    |
|-------------------|----------------|
| +2                | Extremely wet  |
| 1.5 to 1.99       | Very wet       |
| 1.0 to 1.49       | Moderately wet |
| (0.99) to (-0.99) | Near normal    |
| (-1.0) to (-1.49) | Moderately dry |
| (-1.5) to (-1.99) | Severely dry   |
| (-2.0) or Less    | Extremely dry  |

In this study SPI value will be computed for twelve different time scale *i.e.* 1 month, 2 month, 3month, 4 month, 5 month, 6 months, 7 month, 8 month, 9 month, 10 month,11 months, and 12 month for all the 14stations in Nashik districts of Maharashtra. The software SPI\_SL\_6.exe Svoboda *et al.*,(2012) is used.

### 3.6.3. Markov chain probability model for dry and wet spell analysis

The success or failure of crops particularly under *rainfed* conditions is closely linked with the rainfall patterns. Simple criterion related to sequential phenomenon like dry and wet spell was used for analyzing rainfall data to obtain specific information needed for crop planning and for carrying out agricultural operations including protective irrigations. It is always useful to ascertain the probability of sequential events like a wet week following another wet week or a dry week following a wet or dry week during the crop growing season. This is the basis for the analysis of rainfall for dry spell and wet spell using Markov-Chain process, which is described in this section.

Rainfall amount of 20 mm per week will be considered as adequate for all the growth stages of all the crops grown. Thus, if in a given week the rainfall received will be less than 20 mm, that week will be designated as a dry week and vice versa Pandharinath, (1991). On the basis of this criterion each week was categorized as a dry week and wet week and respective probabilities were calculated as follows:

#### 3.6.3.1 Initial Probability of Dry and Wet Weeks

Based on historical data of weekly rainfall and following the above mentioned criteria of dry and wet week, the initial probabilities can be calculated as:

$$P(D) = F(D)/N \dots\dots\dots(3.7)$$

$$P(W) = F(W)/N \dots\dots\dots(3.8)$$

Where,

P(D) is the probability of occurrence of dry week,

P(W) is the probability of occurrence of wet week,

F(D) is the frequency of occurrence of dry week,

F(W) is the frequency of occurrence of wet week,

N is the total number of years

#### 3.6.3.2 Conditional Probability of Dry and Wet Weeks

$$P(D/D) = F(DD)/F(D) \dots\dots\dots(3.9)$$

$$P(W/W) = F(WW)/F(W) \dots\dots\dots(3.10)$$

$$P(W/D) = 1 - P(D/D) \dots\dots\dots(3.11)$$

$$P(D/W) = 1 - P(W/W) \dots\dots\dots(3.12)$$

where,

$P(D/D)$  = probability of a week being dry preceded by another dry week,

$F(DD)$  = frequency of dry week preceded by another dry week,

$P(W/W)$  = probability of a week being wet preceded by another wet week,

$F(WW)$  = frequency of a wet week preceded by another wet week,

$P(W/D)$  = probability of a wet week preceded by a dry week, and

$P(D/W)$  = probability of a dry week preceded by a wet week.

**3.6.3. 3Consecutive Probability of Dry and Wet Weeks :**

$$P(2D) = P(DW1) \times P(DDW2) \dots\dots\dots(3.13)$$

$$P(3D) = P(DW1) \times P(DDW2) \times P(DDW3) \dots\dots\dots(3.14)$$

$$P(2W) = P(WW1) \times P(WWW2) \dots\dots\dots(3.15)$$

$$P(3W) = P(WW1) \times P(WWW2) \times P(WWW3) \dots\dots\dots(3.16)$$

where,

$P(2D)$  = probability of two consecutive dry weeks starting with the week,

$P(DW1)$  = probability of the first week being dry,

$P(DDW2)$  = probability of the second week being dry, given the preceding week being dry,

$P(3D)$  = probability of three consecutive dry weeks starting with the week,

$P(DDW3)$  = probability of the third week being dry, given the preceding week dry,

$P(2W)$  = probability of two consecutive dry weeks starting with the week,

$P(WW1)$  = probability of the first week being wet,

$P(WWW2)$  = probability of the second week being wet, given the preceding week being wet,

$P(3W)$  = probability of three consecutive wet weeks starting with the week and

$P(WWW3)$  = probability of the third week being wet, given the preceding week wet.

Dry spell of different duration will be estimated for different stations by using above procedure.

**Markov chain model**

The model assumes that the transition probability for a given week depends as the weather (dry or wet) of its previous week. Under such a model the following relations hold:

$$P(W_i) = 1 - P(D_i)$$

$$P(W_i/D_{i-1}) = 1 - P(D_i/D_{i-1})$$

$$P(W_i/D_{i-1}) = \frac{P(D_i) - P(D_{i-1})P(D_i/D_{i-1})}{P(W_{i-1})} \text{ and}$$

$$P(W_i/W_{i-1}) = 1 - P(D_i/W_{i-1})$$

Where,

$P(D_i/W_{i-1})$  is the transition probability that  $i^{\text{th}}$  week is dry given that  $(i-1)^{\text{th}}$  week is wet and the other definitions automatically follow. It is interesting to note that only the initial probability the  $i^{\text{th}}$  week of a year is dry,  $P(D_i)$  and the transition probability of  $i^{\text{th}}$  week that it is dry provided previous week is dry,  $P(D_i/D_{i-1})$ , need to be calculated from the original data and the other probabilities are easily obtained by substitution. On the basis of above methodology when applied on rainfall data the results are obtained and the tehsil wise crop management planning is suggested for Nashik District.

#### 3.6.4. Onset and withdrawal:

Forward and backward accumulation methods were used for computation of onset and withdrawal of rainy season from weekly rainfall data. In this method weekly rainfall was summed by forward accumulation (20+21+...+52 weeks) until a certain amount of rainfall was accumulated. 75 mm of rainfall accumulation has been considered as the onset time for the growing season of dry seeded crops and land preparation (Babu and Lakshminarayana, 1997; Panigrahi and Panda, 2002). The withdrawal of rainy season was determined by backward accumulation of rainfall (48+47+46+...+30 weeks) data. 20 mm of rainfall accumulation was chosen for the end of rainy season, which is sufficient for ploughing of fields after harvesting the crops (Babu and Lakshminarayana, 1997).

By considering prevailing rainfall condition of selected area, 50, 60, 70 mm of rainfall accumulation has been considered as the onset time and 10 mm rainfall accumulation has been considered as the withdrawal time

#### 3.7.1 Crop Planning and Management

Crop planning and management has its application to ensure the yield of the crop. Dry spell coincidence with sensitive phenological stages of crop is very likely to affect the crop development. Hence, it is very important to analyze the sequence of dry and wet weeks for crop planning purpose.

Crop calendar can be considered as a key or tool for crop management information when it is superimposed over dry and wet weeks sequence. Accordingly, from where the

initial probability of week being wet increases land preparation starts and where the conditional probability of week being wet i.e. occurrence of rainfall at 20 mm per week is above 50 per cent, is the right week of planting. Supplementary irrigation and moisture conservation practices need to be undertaken if at 20 mm threshold the probability of dry week and dry week followed by dry week exceeds 50 per cent (Admasu *et al.*, 2014). The irrigation can be withheld for some time if there is a probability of wet week or apply irrigation during the dry week in a very sensitive phenological or critical growth stage of crop (Singh *et al.*, 2014).

### 3.7.2 Crop Calendar

The following crop calendar has been used as a key tool for crop planning which is recommended by Mahatma Phule Krishi Vidyapeeth, Rahuri in its University publication *Krishidarshani* (2020)

**Table 3.5.: Crop calendar as suggested by M.P.K.V., Rahuri**

| Season              | Crop          | Sowing Window  |       | Critical Growth Stages | Period  |       | Total Water Requirement |
|---------------------|---------------|--|-------|------------------------|---------|-------|-------------------------|
|                     |               | Date   | MW    |                        | DAS     | MW    |                         |
| <i>Kharif</i>       | Finger millet | 15 <sup>th</sup> June-15 <sup>th</sup> July                              | 24-28 | Tillering stage        | 25-30   | 28    | 10                      |
|                     |               |  |       | Flowering              | 35-45   | 30-31 |                         |
|                     | Rice          | 15 <sup>th</sup> May-15 <sup>th</sup> June<br>(Transplanting: 21-25 DAS) | 20-24 | Early tillering        | Upto 45 | 29-30 | 2-3                     |
|                     |               |  |       | Active Tillering       | Upto 60 | 32-33 | 3-5                     |
|                     |               |  |       | Panicle initiation     | 60-65   | 33-34 | 5-10                    |
|                     |               |  |       | Flowering              | 90-105  | 36-38 | 10                      |
|                     |               |  |       | Grain Filling          | 105-115 | 39-40 |                         |
|                     |               |  |       | Grain maturity         | 115-135 | 41-43 |                         |
|                     | Pearl millet  | 15 <sup>th</sup> June-15 <sup>th</sup> July                              | 24-28 | Panicle                | 14-21   | 28-29 | 25-30                   |
|                     |               |  |       | Booting stage          | 28-35   | 31    |                         |
|                     |               |  |       | Grain filling stage    | 60-65   | 35    |                         |
|                     | Maize         | 15 <sup>th</sup> June-15 <sup>th</sup> July                              | 24-28 | Seedling stage         | 25-30   | 29-30 | 40-55                   |
|                     |               |  |       | Silking stage          | 45-50   | 32    |                         |
|                     |               |  |       | Flowering              | 60-65   | 35    |                         |
| Grain filling stage |               |  |       | 75-80                  | 37      |       |                         |
| <i>Rabi</i>         | Rabi Sorghum  | 15 sept-15 oct   | 37-42 | Growing point          | 30-40   | 45-50 |                         |
|                     |               |  |       | Booting stage          | 50-55   |       | 45-46                   |
|                     |               |  |       | Flowering stage        | 70-75   |       | 48-49                   |
|                     |               |  |       | Grain filling stage    | 90-95   |       | 51                      |
|                     | Gram          | 2 <sup>nd</sup> fortnight of September                                   | 39-40 | Pre flowering          | 40-50   | 45-47 | 25-40                   |
|                     |               |  |       | Pod filling            | 75-80   | 51    |                         |
|                     | Wheat         | 1 Nov-10 Nov   | 44-45 | Crown root             | 18-21   | 48-49 | 50-100                  |
|                     |               |  |       | Tillering and stem     | 40-65   | 52-54 |                         |
|                     |               |  |       | Flowering              | 80-100  | 6-7   |                         |
|                     |               |  |       | Grain filling stage    | 115-120 | 8-9   |                         |

## **4. RESULTS AND DISCUSSION**

The results obtained from the analysis of rainfall data are presented in this chapter under following subtitles with keeping objectives of the study in mind.

- 1) Variation of rainfall and rainy days in Nashik District
- 2) Drought analysis by using Standardized Precipitation Index
- 3) Drought analysis by using Decile Index
- 4) Onset and withdrawal of monsoon
- 5) Initial, conditional and consecutive probabilities of dry and wet weeks
- 6) Contingency crop management planning based on rainfall analysis.

### **4.1 Variation of Rainfall and Rainy Days in Nashik District.**

#### **4.1.1 Variation of Annual Rainfall and Rainy Days in Nashik District**

##### **4.1.1.1 Annual rainfall variation**

The statistical analysis of annual rainfall data is presented in Table 4.1. The annual rainfall for different years in fifteen tehsils of Nashik district is used for calculation of variation of rainfall.

From the Table 4.1, it is revealed that the average annual rainfall of Nashik district was 1066.80 mm. It was varied from 522.6 mm at Deola to 2991.58 mm at Igatpuri, Further average annual rainfall recorded in various tehsils in descending order was 2991.58 mm at Igatpuri, 2100.89 mm at Trimbakeshwar, 2018.87mm at Peth, 1899.67 mm at Surgana, 849 mm at Nashik, 804.66 mm at Dindori, 715.6mm at Kalwan, 644.57mm at Baglan, 629.82 mm at Chandwad, 626.56 mm at Sinnar, 566.87 mm at Yevla, 564.44 mm at Nandgaon, 562.08 mm at Niphad, 545.36mm at Malegaon, 522.6mm at Deola. The highest standard deviation was observed at Igatpuri (790.88 mm) with 26.79 per cent variation whereas, the lowest was observed at Deola (155.79 mm) with 29.91 per cent variation.

##### **4.1.1.2 Annual rainy days variation**

The number of rainy days was a good indicator for distribution of annual rainfall. It will be helpful for region specific crop planning. Rainfall received more than 2.5 mm is called rainy days. The analysis of the annual rainy days and its variability are presented in Table 4.2. The annual rainy days for different years in fifteen tehsils of Nashik district are used for calculation of variation of rainy days. From the Table 4.2, it is observed that the average annual rainfall of Nashik district was 1066.80 mm which was received in 50 mean rainy days with the highest (112) rainy days during 1963 at Igatpuri tehsil and the lowest (9) rainy days during 1972 at Nandgaon tehsil.

There was wide variation in the tehsils with respect to number of rainy days during the period under study. The average number of rainy days ranged from 32 rainy days in Malegaon to 91.29 rainy days in Igatpuri. The mean rainy days recorded in different tehsils of Nashik district were 91.29 rainy days in Igatpuri, 75.92 rainy days in Peth, 74.36 rainy days in Trimbakeshwar, 73.44 rainy days in Surgana, 51.5 rainy days in Nashik, 49.54 rainy days in Dindori, 42.31 rainy days in Kalwan, 41.6 rainy days in Chandwad, 41 rainy days in Sinnar, 38.18 rainy days in Yevla, 37.14 rainy days in Niphad, 34.64 rainy days in Deola, 34.37 rainy days in Baglan, 33.75 rainy days in Nandgaon, 32 rainy days in Malegaon. The highest standard deviation was 14.32 at Surgana tehsil with 19.57 per cent variation whereas; the lowest was 8.55 at Malegaon tehsil with 26.73 per cent variation. All the above observations showed that the total number of rainy days varied from agroclimatic zone from Western ghat zone to scarcity zone.

**Table 4.1. Tehsilwise annual rainfall(mm) variation in Nashik district**

| Tehsil                  | Maximum Rainfall |           | Minimum Rainfall |      | Mean Rainfall (mm) | S.D. (mm)      | C.V. (%)     |
|-------------------------|------------------|-----------|------------------|------|--------------------|----------------|--------------|
|                         | Rainfall (mm)    | Year      | Rainfall (mm)    | Year |                    |                |              |
| <b>Baglan</b>           | 1077             | 1990      | 375.3            | 1982 | 644.57             | 159.86         | 24.8         |
| <b>Chandwad</b>         | 1160.5           | 2006      | 313.5            | 2018 | 629.82             | 199.45         | 31.67        |
| <b>Deola</b>            | 864.3            | 2006      | 284.9            | 2015 | <b>522.6</b>       | 155.79         | 29.81        |
| <b>Dindori</b>          | 1819.9           | 2017      | 347.6            | 1986 | 804.66             | 293.83         | 36.52        |
| <b>Igatpuri</b>         | 4974.6           | 1970      | 1463             | 2015 | <b>2951.58</b>     | 790.88         | 26.79        |
| <b>Kalwan</b>           | 1414             | 1986,2006 | 318              | 1980 | 715.6              | 219.69         | 30.7         |
| <b>Malegaon</b>         | 886              | 1996      | 197.8            | 1972 | 545.36             | 180.34         | 33.16        |
| <b>Nandgaon</b>         | 1019.4           | 1964      | 116.9            | 1972 | 564.44             | 189.92         | 33.65        |
| <b>Nashik</b>           | 1323.1           | 2006      | 504              | 2012 | 849                | 253.99         | 29.92        |
| <b>Niphad</b>           | 1043.7           | 2004      | 256.4            | 1972 | 562.08             | 173.75         | 30.91        |
| <b>Peth</b>             | 3928.4           | 1990      | 832.3            | 1965 | 2018.87            | 603.05         | 29.87        |
| <b>Sinnar</b>           | 1196.5           | 1963      | 218.1            | 2018 | 626.56             | 195.1          | 31.14        |
| <b>Surgana</b>          | 3426             | 1981      | 652.2            | 2015 | 1899.67            | 628.82         | 33.1         |
| <b>Trimbakeshwar</b>    | 3794             | 1981,2006 | 935              | 1973 | 2100.89            | 661.23         | 31.47        |
| <b>Yevla</b>            | 931.5            | 2006      | 284.2            | 2018 | 566.87             | 186.12         | 32.83        |
| <b>District average</b> |                  |           |                  |      | <b>1066.80</b>     | <b>326.121</b> | <b>31.09</b> |

**Table 4.2. Tehsilwise Annual rainy days variation in Nashik District**

| Tehsil                  | Maximum Rainy days |      | Minimum Rainy days |           | Mean Rainy Days | S.D.         | C.V. (%)     |
|-------------------------|--------------------|------|--------------------|-----------|-----------------|--------------|--------------|
|                         | Rainy Days         | Year | Rainy days         | Year      |                 |              |              |
| Baglan                  | 60                 | 2019 | 16                 | 1966      | 34.37           | 9.43         | 27.43        |
| Chandwad                | 67                 | 2019 | 20                 | 2000      | 41.6            | 9.94         | 23.89        |
| Deola                   | 53                 | 2010 | 21                 | 2008      | 34.64           | 9.95         | 28.71        |
| Dindori                 | 74                 | 2017 | 30                 | 1972      | 49.54           | 10.65        | 21.49        |
| Igatpuri                | 112                | 1963 | 55                 | 1976      | 91.29           | 13.29        | 14.56        |
| Kalwan                  | 66                 | 2013 | 20                 | 1969      | 42.31           | 10.23        | 24.18        |
| Malegaon                | 61                 | 2019 | 13                 | 1972      | 32              | 8.55         | 26.73        |
| Nandgaon                | 61                 | 2019 | 9                  | 1972      | 33.75           | 9.22         | 27.32        |
| Nashik                  | 68                 | 2017 | 37                 | 2002,2009 | 51.5            | 9.73         | 18.89        |
| Niphad                  | 64                 | 2019 | 19                 | 1966      | 37.14           | 9.82         | 26.44        |
| Peth                    | 101                | 2013 | 36                 | 1965      | 75.92           | 14.86        | 19.57        |
| Sinnar                  | 64                 | 2019 | 14                 | 1972      | 41              | 10.23        | 24.94        |
| Surgana                 | 101                | 2013 | 36                 | 1966,1971 | 73.44           | 14.32        | 19.5         |
| Trimbakeshwar           | 99                 | 1978 | 45                 | 1967      | 74.36           | 12.95        | 17.41        |
| Yevla                   | 55                 | 2019 | 27                 | 2015,2018 | 38.18           | 9.13         | 23.92        |
| <b>District average</b> |                    |      |                    |           | <b>50</b>       | <b>10.82</b> | <b>22.99</b> |

#### 4.1.2 Variation of Monthly Rainfall and Rainy Days in Nashik District

##### 4.1.2.1 Monthly rainfall variation

Statistical analysis of rainfall data of Nashik districts shown in the Table 4.3 which showed that mean annual rainfall of Nashik district was 1066.80 mm in which July month contributes highest amount of mean rainfall 328.9 mm with 48.86 per cent variation. Followed by August, June, September, October, November, May, December, April, March, February and lowest amount of mean rainfall in the month of January 0.75 mm with 475.8 per cent.

The rainfall from June to October showed less variation as compared to rainfall received during rest of month. The average monthly rainfall variation was in the range of 48.86 per cent to 475.8 per cent in July and January month respectively. In all the tehsil of Nashik district, it was observed that tehsils received more rainfall in the month of July except Baglan, Deola, Malegaon, Nandgaon, Niphad, Sinnar, Yevla. The highest monthly rainfall was observed at Igatpuri 1056 mm in the month of July followed by Trimbakeshwar, Peth, Surgana, Nashik, Dindori, Kalwan, Chandwad, Baglan, Sinnar, Niphad, Yevla, Deola, Malegaon, Nandgaon

tehsils.

As far as tehsils wise monthly variability in rainfall was considered Igatpuri, Trimbakeshwar, Peth, Surgana, Nashik, Dindori, Kalwan, Chandwad, tehsils were received highest rainfall in the month of July. Igatpuri received 1056 mm rainfall with 30.31 per cent variation, Trimbakeshwar received 798.2 mm rainfall with 38.8 per cent variation, Peth received 725.8 mm rainfall with 35.36 per cent variation, Surgana received 708.5 mm rainfall with 37.53 per cent variation. Nashik received 242.1 mm rainfall with 44.83 per cent variation, Dindori received 233.3 mm rainfall with 57.78 per cent variation and Kalwan received 185.8 mm rainfall with 40.34 per cent variation, Chandwad received 147.8 mm rainfall with 48.25 per cent variation in the month of July respectively. Baglan, Deola, Malegaon, Nandgaon, Niphad, sinnar, Yevla tehsils were received highest rainfall in the month of September that are 177.6 mm, 131.5 mm, 119.8 mm, 135.4 mm, 139.0 mm, 147.4 mm, 147.8 mm rainfall with 50.91 per cent, 50.8 per cent, 70.74 per cent, 76.31 per cent, 74.28 per cent, 58.25 per cent, 74.1 per cent variation respectively.

The lowest rainfall was received in the month of January for all tehsils in study period. As compared, Sinnar tehsil was received the highest 1.68 mm rainfall with 468.2 per cent variation in the month of January followed by Malegaon, Deola, Kalwan, Yevla, Igatpuri, Nashik, Nandgaon, Niphad, Chandwad, Surgana, Peth, Dindori, Trimbakeshwar and Baglan tehsil was received lowest mm rainfall 0.07 mm with 613 per cent.

#### **4.1.2.2 Per cent contribution of monthly rainfall to the annual rainfall**

Average monthly rainfall contribution to the average annual rainfall for the Nashik district were calculated and presented in Table 4.4 which showed that the average annual rainfall of Nashik district was 1066.80 mm in which July month contributes the highest amount of rainfall 26.58 per cent followed by August, September, June, October, November, May, December, April, March, February and the lowest in the month of January 0.11 per cent. Igatpuri, Trimbakeshwar, Peth, Surgana, Nashik, Dindori, Kalwan, Chandwad, tehsils were received more rainfall in the month of July were 38.9 per cent, 37.6 per cent, 35.2 per cent, 27.4 per cent, 25.7 per cent, 24.9 per cent respectively. While Baglan, Deola, Malegaon, Nandgaon, Niphad, Sinnar, Yevla in month of September 27.56 per cent, 25.17 per cent and 21.98 per cent, 24 per cent, 24.74 per cent, 23.54 per cent, 26.7 per cent respectively.

**Table 4.3: Tehsilwise monthly rainfall (mm) variation in Nashik district**

| Tehsil Name |      | Jan          | Feb          | Mar          | Apr          | May          | June         | July         | Aug          | Sep          | Oct          | Nov          | Dec          |
|-------------|------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Baglan      | Mean | 0.07         | 2.26         | 1.69         | 1.72         | 11.06        | 109.5        | 147.0        | 106.8        | <b>177.6</b> | 68.87        | 13.95        | 3.76         |
|             | S.D. | 0.45         | 7.2          | 4.17         | 7.03         | 25.63        | 96.06        | 79.65        | 78.15        | 90.46        | 93.74        | 32.3         | 13.7         |
|             | C.V. | 613          | 317.8        | 246.8        | 408.7        | 231.7        | 87.7         | 54.16        | 73.12        | 50.91        | 136.1        | 231.5        | 364          |
| Chandwad    | Mean | 0.43         | 1.55         | 1.2          | 1.34         | 16.26        | 122.4        | 147.8        | 134.4        | 121.0        | 49.92        | 30.15        | 3.12         |
|             | S.D. | 1.81         | 7.15         | 2.79         | 5.17         | 27.67        | 91.75        | 71.35        | 85.52        | 93.12        | 58.53        | 53.16        | 9.29         |
|             | C.V. | 421.4        | 462.0        | 231.9        | 386.3        | 170.1        | 74.92        | 48.25        | 63.61        | 76.93        | 117.2        | 176.3        | 297.5        |
| Deola       | Mean | 1.23         | 1            | 0.06         | 1.95         | 4.73         | 88.83        | 97.58        | 95.7         | <b>131.5</b> | 78.53        | 19.79        | 1.68         |
|             | S.D. | 3.21         | 3.68         | 0.3          | 5.57         | 10.81        | 57.99        | 48.63        | 62.87        | 66.81        | 72.48        | 46.12        | 6.3          |
|             | C.V. | 261.2        | 367.7        | 469.0        | 284.8        | 228.4        | 65.28        | 49.84        | 65.69        | 50.8         | 92.3         | 233.0        | 375.7        |
| Dindori     | Mean | 0.32         | 0.28         | 0.89         | 4.68         | 7.87         | 119.8        | 233.3        | 197.4        | 147.4        | 71.97        | 16.95        | 3.67         |
|             | S.D. | 1.99         | 1.61         | 4.46         | 14.81        | 16.71        | 88.43        | 134.8        | 117.7        | 112.6        | 104.4        | 36.6         | 13.22        |
|             | C.V. | 623.1        | 584.0        | 499.6        | 316.0        | 212.3        | 73.8         | 57.78        | 59.65        | 76.39        | 145.1        | 215.9        | 360.2        |
| Igatpuri    | Mean | 0.93         | 0.11         | 1.03         | 2.58         | 16.67        | 456.1        | 1056         | 921.9        | 397.8        | 76.09        | 17.99        | 4.3          |
|             | S.D. | 3.4          | 0.66         | 4.93         | 10.88        | 50.21        | 244.0        | 320.0        | 371.4        | 227          | 62.04        | 33.53        | 15.58        |
|             | C.V. | 364.5        | 594.1        | 479.6        | 422.3        | 301.1        | 53.5         | 30.31        | 40.29        | 57.06        | 81.53        | 186.3        | 362.2        |
| Kalwan      | Mean | 1.02         | 2.56         | 1.34         | 2.44         | 19.88        | 119.2        | 185.8        | 149          | 147.9        | 62.81        | 21.13        | 2.29         |
|             | S.D. | 3.46         | 10.64        | 5.37         | 10.44        | 42.11        | 92.14        | 74.99        | 106.5        | 113.7        | 57.09        | 40.15        | 6.93         |
|             | C.V. | 337.7        | 415.4        | 400.8        | 428.5        | 211.8        | 77.26        | 40.34        | 71.51        | 76.85        | 90.9         | 190.0        | 302.4        |
| Malegaon    | Mean | 1.48         | 2.59         | 1.48         | 1.13         | 14.58        | 98.21        | 119.0        | 107.1        | <b>119.8</b> | 56.01        | 18.65        | 5.21         |
|             | S.D. | 4.67         | 9.95         | 3.27         | 2.82         | 25.87        | 69.74        | 76.86        | 66.51        | 84.79        | 64.75        | 33.75        | 15.69        |
|             | C.V. | 316.6        | 383.4        | 220.1        | 248.6        | 177.4        | 71.01        | 64.56        | 62.1         | 70.74        | 115.6        | 181          | 301.0        |
| Nandgaon    | Mean | 0.75         | 0.19         | 1.23         | 2.05         | 7.11         | 107.1        | 114.0        | 115.9        | <b>135.4</b> | 52.35        | 23.76        | 4.41         |
|             | S.D. | 3.15         | 0.84         | 3.62         | 8.18         | 16.19        | 75.76        | 79.46        | 77.52        | 103.3        | 61.18        | 45.07        | 10.48        |
|             | C.V. | 423          | 440.2        | 294.4        | 398.4        | 227.7        | 70.7         | 69.69        | 66.85        | 76.31        | 116.8        | 189.6        | 237.5        |
| Nashik      | Mean | 0.84         | 0.14         | 1.29         | 2.06         | 5.95         | 156.7        | 242.1        | 192.8        | 155.9        | 70.54        | 20.19        | 0.32         |
|             | S.D. | 3.83         | 0.47         | 4            | 7.91         | 12.12        | 110.6        | 108.5        | 127.2        | 135.2        | 48.45        | 33.23        | 0.93         |
|             | C.V. | 455.9        | 342.8        | 310.6        | 383.0        | 203.6        | 70.57        | 44.83        | 65.99        | 86.69        | 68.69        | 164.5        | 292.0        |
| Niphad      | Mean | 0.55         | 0.95         | 1.86         | 1.94         | 7.39         | 97.07        | 114.7        | 115.3        | <b>139.0</b> | 60.67        | 18.81        | 3.67         |
|             | S.D. | 2.72         | 4.24         | 7.9          | 5.97         | 15.25        | 76.71        | 56.53        | 65.14        | 103.2        | 54.39        | 37.34        | 13.08        |
|             | C.V. | 497.7        | 447.1        | 425.4        | 308.2        | 206.3        | 79.03        | 49.24        | 56.47        | 74.28        | 89.64        | 198.5        | 356.4        |
| Peth        | Mean | 0.39         | 0            | 0.23         | 0.31         | 3.54         | 262.2        | 725.8        | 644.4        | 303.6        | 64           | 12.13        | 2.06         |
|             | S.D. | 2.86         | 0            | 1.64         | 1.48         | 8.66         | 167.8        | 256.6        | 315.7        | 187.4        | 60.43        | 24.3         | 8.43         |
|             | C.V. | 734.9        | 0            | 728.1        | 478.6        | 244.8        | 64.02        | 35.36        | 48.99        | 61.74        | 94.43        | 200.3        | 408.1        |
| Sinnar      | Mean | 1.68         | 0.8          | 1.9          | 2.66         | 10.45        | 112.8        | 135.5        | 111.7        | <b>147.4</b> | 62.72        | 30.84        | 7.9          |
|             | S.D. | 7.89         | 3.63         | 5.93         | 9.11         | 27.81        | 81.22        | 81.72        | 61.38        | 85.9         | 61.47        | 53.47        | 21.48        |
|             | C.V. | 468.2        | 452.4        | 311.4        | 342.3        | 266.1        | 71.97        | 60.31        | 54.93        | 58.25        | 98.01        | 173.3        | 271.7        |
| Surgana     | Mean | 0.39         | 0.41         | 0.16         | 0.15         | 2.94         | 241.0        | 708.5        | 571.4        | 282.8        | 72.05        | 15.84        | 3.84         |
|             | S.D. | 2.03         | 2.22         | 0.75         | 1.17         | 7.59         | 200.9        | 265.9        | 303.1        | 171.7        | 67.74        | 31.76        | 11.71        |
|             | C.V. | 521.8        | 546.1        | 475.8        | 768.1        | 258.2        | 83.34        | 37.53        | 53.06        | 60.71        | 94.02        | 200.4        | 304.7        |
| Trambak     | Mean | 0.12         | 0.68         | 0.34         | 0.83         | 2.47         | 304.7        | 798.2        | 608.5        | 290.2        | 79.76        | 13.8         | 1.1          |
|             | S.D. | 0.91         | 3.65         | 2.12         | 3.18         | 8.22         | 216.8        | 309.7        | 361.5        | 194.4        | 68.52        | 35.96        | 4.52         |
|             | C.V. | 768.1        | 538.4        | 621.9        | 381.9        | 332.8        | 71.17        | 38.8         | 59.42        | 66.99        | 85.9         | 260.6        | 410.0        |
| Yevla       | Mean | 1            | 0.15         | 2.13         | 1.38         | 10.22        | 98.4         | 108.7        | 107.4        | <b>147.8</b> | 61.85        | 25.85        | 1.85         |
|             | S.D. | 3.3          | 0.53         | 5.69         | 4.67         | 24.58        | 68.15        | 56.41        | 53.09        | 109.5        | 55.74        | 53.01        | 4.02         |
|             | C.V. | 329.5        | 350.2        | 266.6        | 338.2        | 240.5        | 69.26        | 51.87        | 49.39        | 74.1         | 90.12        | 205.1        | 217.4        |
| District    | Mean | <b>0.75</b>  | <b>0.91</b>  | <b>1.12</b>  | <b>1.81</b>  | <b>9.41</b>  | <b>166.3</b> | <b>328.9</b> | <b>278.6</b> | <b>189.7</b> | <b>65.88</b> | <b>19.99</b> | <b>3.28</b>  |
|             | S.D. | <b>3.05</b>  | <b>3.76</b>  | <b>3.80</b>  | <b>6.56</b>  | <b>21.30</b> | <b>115.8</b> | <b>134.7</b> | <b>150.2</b> | <b>125.3</b> | <b>66.07</b> | <b>39.32</b> | <b>10.36</b> |
|             | C.V. | <b>475.8</b> | <b>416.1</b> | <b>398.8</b> | <b>392.9</b> | <b>234.2</b> | <b>72.24</b> | <b>48.86</b> | <b>59.40</b> | <b>67.92</b> | <b>101.1</b> | <b>200.4</b> | <b>324.1</b> |

**Table 4.4: Monthly rainfall contribution to the total annual rainfall**

| Tehsil Name     | Annual R.F. (mm) | Jan (%) | Feb (%) | Mar (%) | Apr (%) | May (%) | June (%) | July (%) | Aug (%)      | Sep (%)      | Oct (%) | Nov (%) | Dec (%) |
|-----------------|------------------|---------|---------|---------|---------|---------|----------|----------|--------------|--------------|---------|---------|---------|
| <b>Baglan</b>   | 644.57           | 0.01    | 0.35    | 0.26    | 0.27    | 1.72    | 16.99    | 22.81    | 16.58        | <b>27.56</b> | 10.68   | 2.16    | 0.58    |
| <b>Chandwad</b> | 629.82           | 0.07    | 0.25    | 0.19    | 0.21    | 2.58    | 19.45    | 23.48    | 21.35        | 19.22        | 7.93    | 4.79    | 0.50    |
| <b>Deola</b>    | 522.6            | 0.24    | 0.19    | 0.01    | 0.37    | 0.91    | 17.00    | 18.67    | 18.31        | <b>25.17</b> | 15.03   | 3.79    | 0.32    |
| <b>Dindori</b>  | 804.66           | 0.04    | 0.03    | 0.11    | 0.58    | 0.98    | 14.89    | 28.99    | 24.54        | 18.32        | 8.94    | 2.11    | 0.46    |
| <b>Igatpuri</b> | 2951.58          | 0.03    | 0.00    | 0.03    | 0.09    | 0.56    | 15.45    | 35.78    | 31.24        | 13.48        | 2.58    | 0.61    | 0.15    |
| <b>Kalwan</b>   | 715.6            | 0.14    | 0.36    | 0.19    | 0.34    | 2.78    | 16.67    | 25.98    | 20.82        | 20.68        | 8.78    | 2.95    | 0.32    |
| <b>Malegaon</b> | 545.36           | 0.27    | 0.47    | 0.27    | 0.21    | 2.67    | 18.01    | 21.83    | 19.64        | <b>21.98</b> | 10.27   | 3.42    | 0.96    |
| <b>Nandgaon</b> | 564.44           | 0.13    | 0.03    | 0.22    | 0.36    | 1.26    | 18.99    | 20.20    | <b>20.54</b> | <b>24.00</b> | 9.27    | 4.21    | 0.78    |
| <b>Nashik</b>   | 849              | 0.10    | 0.02    | 0.15    | 0.24    | 0.70    | 18.46    | 28.52    | 22.71        | 18.37        | 8.31    | 2.38    | 0.04    |
| <b>Niphad</b>   | 562.08           | 0.10    | 0.17    | 0.33    | 0.35    | 1.31    | 17.27    | 20.42    | <b>20.52</b> | <b>24.74</b> | 10.79   | 3.35    | 0.65    |
| <b>Peth</b>     | 2018.87          | 0.02    | 0.00    | 0.01    | 0.02    | 0.18    | 12.99    | 35.95    | 31.92        | 15.04        | 3.17    | 0.60    | 0.10    |
| <b>Sinnar</b>   | 626.56           | 0.27    | 0.13    | 0.30    | 0.42    | 1.67    | 18.01    | 21.63    | 17.83        | <b>23.54</b> | 10.01   | 4.92    | 1.26    |
| <b>Surgana</b>  | 1899.67          | 0.02    | 0.02    | 0.01    | 0.01    | 0.15    | 12.69    | 37.30    | 30.08        | 14.89        | 3.79    | 0.83    | 0.20    |
| <b>Trambak</b>  | 2100.89          | 0.01    | 0.03    | 0.02    | 0.04    | 0.12    | 14.50    | 38.00    | 28.96        | 13.82        | 3.80    | 0.66    | 0.05    |
| <b>Yevla</b>    | 566.87           | 0.18    | 0.03    | 0.38    | 0.24    | 1.80    | 17.36    | 19.19    | 18.96        | <b>26.07</b> | 10.91   | 4.56    | 0.33    |
| Average         | <b>1066.80</b>   | 0.11    | 0.14    | 0.17    | 0.25    | 1.29    | 16.58    | 26.58    | 22.93        | 20.46        | 8.28    | 2.76    | 0.45    |

#### 4.1.2.3 Monthly rainy days variation

The statistical analysis of monthly rainy days data of Nashik district is shown in the Table 4.5 which showed that the mean annual rainy days of Nashik district was 50 days in which July month contributes the highest amount of mean rainy days (13.8 days) with 32.7 per cent variation followed by August, September, June, October, November, May, December, April, March, February and lowest amount of mean rainy days in the month of January 0.064 day with 420.9 per cent variation. The average monthly rainy days variation was in the range of 32.7 per cent to 420.9 per cent in July and January month respectively. In all the tehsils of Nashik district, it was observed that tehsils received more rainy days in the month of July except Deola, Peth. The highest monthly rainy days was observed at Igatpuri (26.6 days) in the month of July followed by Peth, Trimbakeshwar, Surgana, Nashik, Dindotri, Kalwan,

Chandwad, Sinnar, Niphad, Yevla, Baglan, Deola, Nandgaon, Malegaon.

Tehsilswise monthly variability in rainy days was considered. Igatpuri, Trimbakeshwar, Surgana, Nashik, Dindori, Kalwan, Chandwad, Sinnar, Niphad, Yevla, Baglan, Nandgaon, Malegaon tehsils were received highest rainy days in the month of July and Deola tehsil received highest rainy days in the month of September while Peth in month of August. Igatpuri tehsil was received 26.6 rainy days with 14.5 per cent variation, Trimbakeshwar received 23.2 rainy days with 23.1 per cent variation, Surgana received 22.9 rainy days with 23.1 per cent variation, Nashik received 14.5 rainy days with 29.7 per cent variation, Dindori received 14.3 rainy days with 32.1 per cent variation, Kalwan received 12 rainy days with 31 per cent variation. Chandwad received 10.9 rainy days with 35.1 per cent variation, Sinnar received 10.7 rainy days with 38.4 per cent variation, Niphad received 9.51 rainy days with 34.7 per cent variation, Yevla received 8.77 rainy days with 38.5 per cent variation, Baglan received 8.17 rainy days with 40.4 per cent variation, Nandgaon received 7.39 rainy days with 41.7 per cent variation, Malegaon received 7.24 rainy days with 44.3 per cent variation. Also, Deola received 7.73 rainy days with 40.9 per cent variation for the month of September and Peth received 23.8 rainy days with 20.9 per cent variation for month of August. The lowest rainfall was received in the month January for all tehsils in study period.

#### **4.1.2.4 Per cent contribution of monthly rainy days to the annual rainy days**

The average monthly rainy days contribution to the average annual rainy days for the Nashik district were calculated and presented in Table 4.6 which showed that the average annual rainy days of Nashik district was 50 days in which July month contributes highest amount of rainy days (26.66 per cent) followed by August, September, June, October, November, May, April, March, December, February, and the lowest in the month of January 0.16 per cent. Igatpuri, Trimbakeshwar, Surgana, Nashik, Dindori, Kalwan, Chandwad, Sinnar, Niphad, Baglan, Yevla, Malegaon, Nandgaon were received more rainy days in the month of July where 29.23 per cent, 31.25 per cent, 31.21 per cent, 28.16 per cent, 28.95 per cent, 28.53 per cent, 26.39 per cent, 26.22 per cent, 25.61 per cent, 23.77 per cent, 22.97 per cent, 22.63 per cent and 21.90 per cent, respectively. Deola received highest rainy days 24.39 per cent in month of September while Peth received highest rainy days 31.41 per cent in month of August.

**Table 4.5: Tehsilwise monthly rainy days variation in Nashik district**

| Tehsil Name |      | Jan          | Feb          | Mar          | Apr          | May          | Jun         | July        | Aug         | Sep         | Oct         | Nov          | Dec          |
|-------------|------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|
| Baglan      | Mean | 0            | 0.14         | 0.22         | 0.15         | 0.75         | 5.85        | 8.17        | 6.59        | 8.12        | 3.37        | 0.83         | 0.19         |
|             | S.D. | 0            | 0.43         | 0.53         | 0.61         | 1.8          | 3.42        | 3.31        | 4           | 3.63        | 2.79        | 1.48         | 0.51         |
|             | C.V. | 0            | 319.9        | 239.3        | 400.3        | 240.8        | 58.4        | 40.4        | 60.6        | 44.6        | 82.7        | 177.6        | 272.3        |
| Chandwad    | Mean | 0.07         | 0.07         | 0.17         | 0.07         | 1.05         | 6.57        | 10.9        | 10.0        | 7.69        | 3.31        | 1.33         | 0.24         |
|             | S.D. | 0.34         | 0.34         | 0.38         | 0.26         | 1.67         | 3.6         | 3.85        | 3.72        | 3.64        | 3.03        | 1.66         | 0.66         |
|             | C.V. | 478.3        | 478.3        | 226.3        | 364.9        | 159.1        | 54.8        | 35.1        | 37.0        | 47.3        | 91.6        | 124.6        | 275.3        |
| Deola       | Mean | 0.14         | 0.09         | 0            | 0.14         | 0.27         | 6.23        | 7.73        | 7.05        | <b>8.45</b> | 3.68        | 0.73         | 0.14         |
|             | S.D. | 0.35         | 0.29         | 0            | 0.35         | 0.63         | 3.41        | 3.17        | 3.24        | 3.32        | 3.06        | 1.39         | 0.47         |
|             | C.V. | 257.5        | 323.6        | 0            | 257.5        | 231.4        | 54.7        | 40.9        | 46.0        | 39.2        | 83.1        | 190.6        | 342.8        |
| Dindori     | Mean | 0.03         | 0.03         | 0.08         | 0.27         | 0.51         | 6.44        | 14.3        | 14.2        | 8.49        | 3.93        | 0.92         | 0.2          |
|             | S.D. | 0.18         | 0.18         | 0.43         | 0.61         | 0.9          | 3.38        | 4.61        | 4.81        | 3.54        | 2.86        | 1.56         | 0.61         |
|             | C.V. | 538.4        | 538.4        | 503.8        | 225.3        | 176.5        | 52.5        | 32.1        | 33.6        | 41.7        | 72.6        | 170.1        | 299.7        |
| Igatpuri    | Mean | 0.05         | 0.02         | 0.03         | 0.12         | 0.64         | 15.1        | 26.6        | 26.5        | 16.0        | 4.75        | 1.03         | 0.2          |
|             | S.D. | 0.22         | 0.13         | 0.18         | 0.49         | 1.35         | 4.74        | 3.88        | 3.8         | 4.48        | 3.01        | 1.56         | 0.58         |
|             | C.V. | 435.7        | 768.1        | 538.4        | 416.6        | 209.4        | 31.3        | 14.5        | 14.3        | 27.8        | 63.5        | 151.3        | 285.5        |
| Kalwan      | Mean | 0.12         | 0.1          | 0.15         | 0.15         | 0.85         | 5.95        | 12.0        | 10.1        | 8.03        | 3.46        | 1.08         | 0.2          |
|             | S.D. | 0.38         | 0.44         | 0.48         | 0.48         | 1.47         | 3.32        | 3.75        | 4.55        | 3.8         | 2.76        | 1.76         | 0.52         |
|             | C.V. | 316.3        | 435.7        | 317.7        | 317.7        | 173.6        | 55.7        | 31.0        | 44.9        | 47.3        | 79.9        | 162.6        | 254.6        |
| Malegaon    | Mean | 0.12         | 0.14         | 0.19         | 0.15         | 1            | 5.61        | 7.24        | 6.85        | 6.39        | 2.97        | 1.05         | 0.31         |
|             | S.D. | 0.33         | 0.47         | 0.43         | 0.41         | 1.43         | 2.86        | 3.21        | 2.83        | 3.66        | 2.74        | 1.48         | 0.79         |
|             | C.V. | 274.8        | 348.0        | 233.0        | 267.0        | 142.6        | 50.9        | 44.3        | 41.3        | 57.3        | 92.2        | 140.7        | 260.0        |
| Nandgaon    | Mean | 0.08         | 0.05         | 0.19         | 0.12         | 0.53         | 5.9         | 7.39        | 7.37        | 7.29        | 3.2         | 1.2          | 0.42         |
|             | S.D. | 0.34         | 0.22         | 0.51         | 0.38         | 0.99         | 2.59        | 3.09        | 3.3         | 3.85        | 2.54        | 1.84         | 0.93         |
|             | C.V. | 397.3        | 435.7        | 272.3        | 316.3        | 188.2        | 43.9        | 41.7        | 44.6        | 52.8        | 79.2        | 152.5        | 220.0        |
| Nashik      | Mean | 0.05         | 0            | 0.14         | 0.09         | 0.59         | 7.64        | 14.5        | 12.9        | 9.41        | 4.95        | 1.18         | 0.05         |
|             | S.D. | 0.21         | 0            | 0.47         | 0.29         | 1.05         | 3.79        | 4.31        | 4.69        | 3.5         | 2.61        | 1.4          | 0.21         |
|             | C.V. | 469.0        | 0            | 342.8        | 323.6        | 178.3        | 49.5        | 29.7        | 36.3        | 37.2        | 52.6        | 118.6        | 469.0        |
| Niphad      | Mean | 0.07         | 0.07         | 0.15         | 0.2          | 0.58         | 5.66        | 9.51        | 8.69        | 7.27        | 3.64        | 1.08         | 0.2          |
|             | S.D. | 0.25         | 0.31         | 0.52         | 0.61         | 1.07         | 3.14        | 3.3         | 3.64        | 3.45        | 2.89        | 1.63         | 0.61         |
|             | C.V. | 373.9        | 463.5        | 340.2        | 299.7        | 185.6        | 55.4        | 34.7        | 41.8        | 47.4        | 79.4        | 150.5        | 299.7        |
| Peth        | Mean | 0.02         | 0            | 0.03         | 0.03         | 0.27         | 10.3        | 23.3        | <b>23.8</b> | 13.5        | 3.59        | 0.76         | 0.14         |
|             | S.D. | 0.13         | 0            | 0.26         | 0.18         | 0.64         | 3.85        | 5.3         | 5.01        | 4.97        | 2.55        | 1.39         | 0.39         |
|             | C.V. | 768.1        | 0            | 768.1        | 538.4        | 235.5        | 37.1        | 22.7        | 20.9        | 36.8        | 70.8        | 182.7        | 289.1        |
| Sinnar      | Mean | 0.07         | 0.08         | 0.2          | 0.24         | 0.71         | 6.14        | 10.7        | 9.63        | 7.58        | 3.66        | 1.56         | 0.39         |
|             | S.D. | 0.25         | 0.43         | 0.55         | 0.57         | 1.47         | 3.14        | 4.13        | 3.75        | 3.46        | 2.97        | 2.31         | 0.87         |
|             | C.V. | 373.9        | 503.8        | 270.5        | 239.1        | 207.1        | 51.1        | 38.4        | 39          | 45.6        | 81.2        | 148.3        | 223.5        |
| Surgana     | Mean | 0.03         | 0.03         | 0.02         | 0.02         | 0.25         | 9.32        | 22.9        | 22.8        | 13          | 3.85        | 0.9          | 0.24         |
|             | S.D. | 0.18         | 0.18         | 0.13         | 0.13         | 0.6          | 4.02        | 5.3         | 5.49        | 5.1         | 3.28        | 1.4          | 0.63         |
|             | C.V. | 538.4        | 538.4        | 768.1        | 768.1        | 237.7        | 43.1        | 23.1        | 24          | 39.2        | 85.3        | 155.6        | 263.5        |
| Trambak     | Mean | 0.02         | 0.03         | 0.03         | 0.12         | 0.15         | 10.8        | 23.2        | 22.3        | 13          | 4.05        | 0.47         | 0.07         |
|             | S.D. | 0.13         | 0.18         | 0.26         | 0.49         | 0.48         | 4.45        | 5.37        | 5.56        | 4.38        | 2.82        | 0.9          | 0.25         |
|             | C.V. | 768.1        | 538.4        | 768.1        | 416.6        | 317.7        | 41.0        | 23.1        | 24.8        | 33.6        | 69.5        | 189.1        | 373.9        |
| Yevla       | Mean | 0.09         | 0            | 0.27         | 0.14         | 0.64         | 6.91        | 8.77        | 8.05        | 8.41        | 3.59        | 1.05         | 0.27         |
|             | S.D. | 0.29         | 0            | 0.7          | 0.47         | 1.26         | 3.53        | 3.38        | 2.59        | 3.67        | 2.74        | 1.53         | 0.55         |
|             | C.V. | 323.6        | 0            | 257.5        | 342.8        | 197.2        | 51.1        | 38.5        | 32.2        | 43.6        | 76.2        | 146.0        | 201.8        |
| Average     | Mean | <b>0.064</b> | <b>0.057</b> | <b>0.125</b> | <b>0.134</b> | <b>0.59</b>  | <b>7.64</b> | <b>13.8</b> | <b>13.1</b> | <b>9.51</b> | <b>3.73</b> | <b>1.01</b>  | <b>0.22</b>  |
|             | S.D. | <b>0.24</b>  | <b>0.24</b>  | <b>0.39</b>  | <b>0.42</b>  | <b>1.12</b>  | <b>3.55</b> | <b>3.99</b> | <b>4.07</b> | <b>3.90</b> | <b>2.84</b> | <b>1.55</b>  | <b>0.57</b>  |
|             | C.V. | <b>420.9</b> | <b>379.4</b> | <b>389.7</b> | <b>366.3</b> | <b>205.4</b> | <b>48.7</b> | <b>32.7</b> | <b>36.1</b> | <b>42.8</b> | <b>77.3</b> | <b>157.4</b> | <b>288.7</b> |

**Table 4.6: Monthly rainy days contribution to the total annual rainy days**

| Tehsil Name     | Annual Rainy Day | Jan (%) | Feb (%) | Mar (%) | Apr (%) | May (%) | June (%) | July (%) | Aug (%)      | Sep (%)      | Oct (%) | Nov (%) | Dec (%) |
|-----------------|------------------|---------|---------|---------|---------|---------|----------|----------|--------------|--------------|---------|---------|---------|
| <b>Baglan</b>   | 34.37            | 0.00    | 0.41    | 0.64    | 0.44    | 2.18    | 17.02    | 23.77    | 19.17        | 23.63        | 9.81    | 2.41    | 0.55    |
| <b>Chandwad</b> | 41.6             | 0.17    | 0.17    | 0.41    | 0.17    | 2.52    | 15.79    | 26.39    | 24.16        | 18.49        | 7.96    | 3.20    | 0.58    |
| <b>Deola</b>    | 34.64            | 0.40    | 0.26    | 0.00    | 0.40    | 0.78    | 17.98    | 22.32    | 20.35        | <b>24.39</b> | 10.62   | 2.11    | 0.40    |
| <b>Dindori</b>  | 49.54            | 0.06    | 0.06    | 0.16    | 0.55    | 1.03    | 13.00    | 28.95    | 28.85        | 17.14        | 7.93    | 1.86    | 0.40    |
| <b>Igatpuri</b> | 91.29            | 0.05    | 0.02    | 0.03    | 0.13    | 0.70    | 16.60    | 29.23    | 29.06        | 17.61        | 5.20    | 1.13    | 0.22    |
| <b>Kalwan</b>   | 42.31            | 0.28    | 0.24    | 0.35    | 0.35    | 2.01    | 14.06    | 28.53    | 23.97        | 18.98        | 8.18    | 2.55    | 0.47    |
| <b>Malegaon</b> | 32               | 0.38    | 0.44    | 0.59    | 0.47    | 3.13    | 17.53    | 22.63    | 21.41        | 19.97        | 9.28    | 3.28    | 0.97    |
| <b>Nandgaon</b> | 33.75            | 0.24    | 0.15    | 0.56    | 0.36    | 1.57    | 17.48    | 21.90    | 21.84        | 21.60        | 9.48    | 3.56    | 1.24    |
| <b>Nashik</b>   | 51.5             | 0.10    | 0.00    | 0.27    | 0.17    | 1.15    | 14.83    | 28.16    | 25.07        | 18.27        | 9.61    | 2.29    | 0.10    |
| <b>Niphad</b>   | 37.14            | 0.19    | 0.19    | 0.40    | 0.54    | 1.56    | 15.24    | 25.61    | 23.40        | 19.57        | 9.80    | 2.91    | 0.54    |
| <b>Peth</b>     | 75.92            | 0.03    | 0.00    | 0.04    | 0.04    | 0.36    | 13.65    | 30.77    | <b>31.41</b> | 17.80        | 4.73    | 1.00    | 0.18    |
| <b>Sinnar</b>   | 41               | 0.17    | 0.20    | 0.49    | 0.59    | 1.73    | 14.98    | 26.22    | 23.49        | 18.49        | 8.93    | 3.80    | 0.95    |
| <b>Surgana</b>  | 73.44            | 0.04    | 0.04    | 0.03    | 0.03    | 0.34    | 12.69    | 31.21    | 31.13        | 17.70        | 5.24    | 1.23    | 0.33    |
| <b>Trambak</b>  | 74.36            | 0.03    | 0.04    | 0.04    | 0.16    | 0.20    | 14.56    | 31.25    | 30.04        | 17.48        | 5.45    | 0.63    | 0.09    |
| <b>Yevla</b>    | 38.18            | 0.24    | 0.00    | 0.71    | 0.37    | 1.68    | 18.10    | 22.97    | 21.08        | 22.03        | 9.40    | 2.75    | 0.71    |
| <b>Average</b>  | <b>50</b>        | 0.16    | 0.15    | 0.31    | 0.32    | 1.40    | 15.57    | 26.66    | 24.96        | 19.54        | 8.11    | 2.31    | 0.16    |

## 4.2. Standardized Precipitation Index (SPI)

Drought is creeping environmental phenomenon which occurs notably in the arid and semi-arid regions and causes many damages and losses. Drought is normal recurrent feature of climate, although it is random event. In this study meteorological drought was analysed by using Standardized Precipitation Index (SPI). Any drought including meteorological and agriculture is a result of deficient rainfall. The SPI has been used widely to quantify the deficit of precipitation. It could be computed at different time scales from less than 1 month to 48 months or more. The calculation time period depends on the user's application. Short-term SPI is used to detect agricultural drought, and long-term SPI can be used for water supply management. According to the SPI method the severity of a drought is determined. The negative value from zero shows the severity of dryness. The positive value of SPI shows the degree of wetness. The SPI value normally ranges from (-2) to (+ 2). An index of (+2) indicates extremely wet; (1.5) - (1.99) very wet; (1.0) - (1.49) moderately wet; (0.99) - (- 0.99) near normal; (-1.0) - (1.49) moderately dry; (-1.5) - (-1.99) severely dry; (-2.0) or (less) extremely dry.

### 4.2.1 Standardized Precipitation Index of Baglan Tehsil

Meteorological drought for Baglan station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 4 years out of 59 years. Moderately wet (1.0-1.49) condition was observed for 5 years. Near normal (0.99to-0.99) condition was seen for 39 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 8 years. Severely dry (-1.50 to -1.99) condition was observed for 2 years extreme dry (-2.0 or less) condition was observed for single year. In the history of last 59 years. Baglan station have 9 wet years, 39 near normal years and remaining 11 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 27% means once in every 4 year, probability of recurrence of moderate drought is 14% means once in every 7 years, probability of recurrence of severe drought is 3% means once in every 33year and probability of recurrence of extreme drought condition is 2% means once in every 50 years over Baglan station. But observing the 59 years data frequency of drought is constant over the decades but in recent decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.1.

#### 4.2.2 Standardized Precipitation Index of Chandwad Tehsil

Meteorological drought for Chandwad station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 1 years out of 22 years. Moderately wet (1.0-1.49) condition was observed for 2 years. Near normal (0.99 to -0.99) condition was seen for 16 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 3 years. Severely dry (-1.50 to -1.99) condition was observed for 0 year. extreme dry (-2.0 or less) condition was observed for 0 year. In the history of last 22 years, Chandwad station have 3 wet years, 16 near normal years and remaining 3 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 27% means once in every 4 year, probability of recurrence of moderate drought is 14 %means once in every 7 years, probability of recurrence of severe drought is 0% means no in 22 years and probability of recurrence of extreme drought condition is 0% means no in 22 years over Chandwad station. But after 2011 i.e. in last decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1998-2019 is shown in the Figure 4.2

#### 4.2.3 Standardized Precipitation Index of Deola Tehsil

Meteorological drought for Deola station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 1 year, very wet (1.5-1.99) condition was observed for 2 years out of 22 years. Moderately wet (1.0-1.49) condition was observed for 1 year. Near normal (0.99 to -0.99) condition was seen for 14 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 2 years. Severely dry (-1.50 to -1.99) condition was observed for 2 years .extreme dry (-2.0 or less) condition was observed for 0 year. In the history of last 22 years, Deola station have 4 wet years, 14 near normal years and remaining 4 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 36% means once in every 3 years, probability of recurrence of moderate drought is 9% means once in every 11 years, probability of recurrence of severe drought is 9% means once in every 11 years and probability of recurrence of extreme drought condition is 0% means 0 in every 22 years over Deola station. But after 2011 i.e. in last decade frequency of drought years and also comparative

severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1998-2019 is shown in the Figure 4.3.

#### **4.2.4 Standardized Precipitation Index of Dindori Tehsil**

Meteorological drought for Dindori station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 2 years, very wet (1.5-1.99) condition was observed for 3 years out of 59 years. Moderately wet (1.0-1.49) condition was observed for 7 years. Near normal (0.99 to -0.99) condition was seen for 40 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 2 years. Severely dry (-1.50 to -1.99) condition was observed for 3 years. extreme dry (-2.0 or less) condition was observed for 2 year. In the history of last 59 years, Dindori station have 12 wet years, 40 near normal years and remaining 7 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 40% means once in every 3 years, probability of recurrence of moderate drought is 3% means once in every 33 years, probability of recurrence of severe drought is 5% means once in every 20 year and probability of recurrence of extreme drought condition is 3% means once in every 33 years over Dindori station. Tehsil have so many drought years between 1981-2000 but after 2000 decade frequency of drought years and also comparative severity of droughts are decrease rapidly which may be very adverse impactful for the cropping system as wet years increase in recent decade.. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.4

#### **4.2.5 Standardized Precipitation Index of Igatpuri Tehsil**

Meteorological drought for Igatpuri station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 1 year, very wet (1.5-1.99) condition was observed for 3 years out of 59 years. Moderately wet (1.0-1.49) condition was observed for 6 years. Near normal (0.99 to -0.99) condition was seen for 39 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 6 years. Severely dry (-1.50 to -1.99) condition was observed for 2 years

extreme dry (-2.0 or less) condition was observed for 2 years. In the history of last 59 years, Igatpuri station have 10 wet years, 39 near normal years and remaining 10 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 30% means once in every 3 year, probability of recurrence of moderate drought is 10% means once in every 10 years, probability of recurrence of severe drought is 3 % means once in every 33 year and probability of recurrence of extreme drought condition is 3 % means once in every 33 years over Igatpuri station. But in recent decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.5.

#### **4.2.6 Standardized Precipitation Index of Kalwan Tehsil**

Meteorological drought for Kalwan station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 5 years, very wet (1.5-1.99) condition was observed for 1 years out of 59 years. Moderately wet (1.0-1.49) condition was observed for 2 years. Near normal (0.99to-0.99) condition was seen for 46 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 3 years. Severely dry (-1.50 to -1.99) condition was observed for 2 years extreme dry (-2.0 or less) condition was observed for 0 year. In the history of last 59 years, Kalwan station have 8 wet years, 46 near normal years and remaining 5 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 51% means once in every 2 year, probability of recurrence of moderate drought is 5% means once in every 20 years, probability of recurrence of severe drought is 3% means once in every 33 year and probability of recurrence of extreme drought condition is 0% means 0 in 59 years over Kalwan station. Table 4.7. But in recent one decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 1 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.6

#### **4.2.7 Standardized Precipitation Index of Malegaon Tehsil**

Meteorological drought for Malegaon station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet

condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 1 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 10 years. Near normal (0.99to-0.99) condition was seen for 40 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 3 years. Severely dry (-1.50 to -1.99) condition was observed for 3 years extreme dry (-2.0 or less) condition was observed for 2 years. In the history of last 59 years, Malegaon station have 11 wet years, 40 near normal years and remaining 8 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 32% means once in every 3 year, probability of recurrence of moderate drought is 5 % means once in every 20 years, probability of recurrence of severe drought is 5 % means once in every 20 year and probability of recurrence of extreme drought condition is 3 % means once in every 33 years over Malegaon station. For tehsil frequency of drought is seen constant over years and also comparative severity of droughts are increasing rapidly in last one decade which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.7.

#### **4.2.8 Standardized Precipitation Index of Nandgaon Tehsil**

Meteorological drought for Nandgaon station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 1 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 8 years. Near normal (0.99to-0.99) condition was seen for 40 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 5 years. Severely dry (-1.50 to -1.99) condition was observed for 3 years extreme dry (-2.0 or less) condition was observed for 2 years. In the history of last 59 years, Nandgaon station have 9 wet years, 40 near normal years and remaining 10 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 25% means once in every 4 year, probability of recurrence of moderate drought is 8% means once in every 12 years, probability of recurrence of severe drought is 5% means once in every 20 year and probability of recurrence of extreme drought condition is 3% means once in every 33 years over Nandgaon station. But after 1990-2000 decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time

scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.8.

#### **4.2.9 Standardized Precipitation Index of Nashik Tehsil**

Meteorological drought for Nashik station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 1 year out of 22 years. Moderately wet (1.0-1.49) condition was observed for 4 years. Near normal (0.99to-0.99) condition was seen for 12 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 3 years. Severely dry (-1.50 to -1.99) condition was observed for 2 years extreme dry (-2.0 or less) condition was observed for 0 year. In the history of last 22 years, Nashik station have 5 wet years, 12 near normal years and remaining 5 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 32% means once in every 3 year, probability of recurrence of moderate drought is 14% means once in every 7 years, probability of recurrence of severe drought is 9% means once in every 11 year and probability of recurrence of extreme drought condition is 0 % means 0 in every 22 years over Nashik station. But after 2011 decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.9.

#### **4.2.10 Standardized Precipitation Index of Niphad Tehsil**

Meteorological drought for Niphad station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 1 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 8 years. Near normal (0.99to-0.99) condition was seen for 45 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 1 year. Severely dry (-1.50 to -1.99) condition was observed for 3 years extreme dry (-2.0 or less) condition was observed for 1 year. In the history of last 59 years, Niphad station have 9 wet years, 45 near normal years and remaining 5 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 36% means once in every 3 year, probability of recurrence of moderate drought is 2% means once in every 50 years,

probability of recurrence of severe drought is 5 % means once in every 20 year and probability of recurrence of extreme drought condition is 2% means once in every 50 years over Niphad station. But in last few decade wet year increase decade frequency of drought years and also comparative severity of droughts are decreasing rapidly which may be very adverse impactful for the cropping system as wet years increase. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.10.

#### **4.2.11 Standardized Precipitation Index of Peth Tehsil**

Meteorological drought for Peth station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 1 year, very wet (1.5-1.99) condition was observed for 2 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 5 years. Near normal (0.99to-0.99) condition was seen for 42 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 5 year. Severely dry (-1.50 to -1.99) condition was observed for 1 year extreme dry (-2.0 or less) condition was observed for 3 years. In the history of last 59 years, Peth station have 8 wet years, 42 near normal years and remaining 9 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 32% means once in every 3 year, probability of recurrence of moderate drought is 8% means once in every 12 years, probability of recurrence of severe drought is 2% means once in every 50 year and probability of recurrence of extreme drought condition is 5% means once in every 20 years over Peth station. But in recent decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.11

#### **4.2.12 Standardized Precipitation Index of Sinnar Tehsil**

Meteorological drought for Sinnar station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 1 year, very wet (1.5-1.99) condition was observed for 0 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 7 years. Near normal (0.99to-0.99)

condition was seen for 42 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 5 year. Severely dry (-1.50 to -1.99) condition was observed for 2 years extreme dry (-2.0 or less) condition was observed for 2 years. In the history of last 59 years, Sinnar station have 8 wet years, 42 near normal years and remaining 9 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 32% means once in every 3 year, probability of recurrence of moderate drought is 8% means once in every 12 years, probability of recurrence of severe drought is 3% means once in every 33 year and probability of recurrence of extreme drought condition is 3% means once in every 33 years over Sinnar station. But in recent decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.12.

#### **4.2.13 Standardized Precipitation Index of Surgana Tehsil**

Meteorological drought for Surgana station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 7 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 2 years. Near normal (0.99to-0.99) condition was seen for 41 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 5 year. Severely dry (-1.50 to -1.99) condition was observed for 3 years extreme dry (-2.0 or less) condition was observed for 1 years. In the history of last 59 years, Surgana station have 9 wet years, 41 near normal years and remaining 9 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 34% means once in every 3 year, probability of recurrence of moderate drought is 8% means once in every 12 years, probability of recurrence of severe drought is 5 % means once in every 20 year and probability of recurrence of extreme drought condition is 2% means once in every 50 years over Surgana station.. But in recent decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.13.

#### **4.2.14 Standardized Precipitation Index of Trimbakeshwar Tehsil**

Meteorological drought for Trimbakeshwar station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 4 year, very wet (1.5-1.99) condition was observed for 2 year out of 59 years. Moderately wet (1.0-1.49) condition was observed for 2 years. Near normal (0.99to-0.99) condition was seen for 44 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 4 year. Severely dry (-1.50 to -1.99) condition was observed for 1 years extreme dry (-2.0 or less) condition was observed for 2 years. In the history of last 59 years, Trimbakeshwar station have 8 wet years, 44 near normal years and remaining 7 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 42% means once in every 2 year, probability of recurrence of moderate drought is 7% means once in every 14 years, probability of recurrence of severe drought is 2% means once in every 50 year and probability of recurrence of extreme drought condition is 3% means once in every 33 years over Trimbakeshwar station. But after 2011 decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1961-2019 is shown in the Figure 4.14.

#### **4.2.15 Standardized Precipitation Index of Yevla Tehsil**

Meteorological drought for Yevla station is assessed for 12 month's timescales. The negative value of SPI indicates drought (dry) condition and positive value indicates wet condition. From the Table 4.7 it is observed that that extremely wet condition (Above +2) was observed for 0 year, very wet (1.5-1.99) condition was observed for 2 year out of 22 years. Moderately wet (1.0-1.49) condition was observed for 2 years. Near normal (0.99to-0.99) condition was seen for 14 years which is high in number. Moderately dry (-1 to -1.49) condition was observed for 2 years. Severely dry (-1.50 to -1.99) condition was observed for 2 years extreme dry (-2.0 or less) condition was observed for 0 year. In the history of last 22 years, Yevla station have 4 wet years, 14 near normal years and remaining 4 years shows dry or extreme drought condition. . Probability of recurrence of mild drought is 41 % means once in every 2 year, probability of recurrence of moderate drought is 9 % means once in every 11 years, probability of recurrence of severe drought is 9 % means once in every 11 year and probability of recurrence of extreme drought condition is 0% means 0 in 22 years over Yevla station. But after 2011 decade frequency of drought years and also comparative severity of droughts are increasing rapidly which may be very adverse impactful for the cropping system. It

is also observed from Table 4.7 that a SPI value becomes more negative with increase in time scales. This is due to the non-uniform, irregular and erratic pattern of rainfall. The graphical representation of annual SPI for the period of 1998-2019 is shown in the Figure 4.15.

**Table 4.7 . Annual SPI Values (12 month basis) of different Tehsils of Nashik District**

| Annual SPI for tehsils |        |          |       |         |          |        |          |
|------------------------|--------|----------|-------|---------|----------|--------|----------|
| Year                   | Baglan | Chandwad | Deola | Dindori | Igatpuri | Kalwan | Malegaon |
| 1961                   | -0.36  | NA       | NA    | -0.06   | 1.62     | 0.17   | -0.33    |
| 1962                   | 0.02   | NA       | NA    | -0.42   | 0.43     | -0.18  | 0.31     |
| 1963                   | 1.10   | NA       | NA    | -0.48   | 0.80     | 0.41   | 0.61     |
| 1964                   | 0.08   | NA       | NA    | -0.39   | 0.82     | -0.46  | 0.06     |
| 1965                   | 0.59   | NA       | NA    | 0.03    | -1.29    | 0.15   | 0.50     |
| 1966                   | -0.58  | NA       | NA    | 0.55    | -0.61    | -0.37  | 0.88     |
| 1967                   | -0.49  | NA       | NA    | -0.71   | 0.72     | -0.83  | -1.60    |
| 1968                   | -0.19  | NA       | NA    | 0.48    | 0.48     | -0.48  | -0.59    |
| 1969                   | 0.29   | NA       | NA    | 1.00    | 0.75     | -1.16  | -0.20    |
| 1970                   | -1.90  | NA       | NA    | -0.10   | 2.08     | -0.49  | -0.98    |
| 1971                   | -1.30  | NA       | NA    | 0.18    | 1.06     | -1.04  | -0.62    |
| 1972                   | 0.01   | NA       | NA    | -1.70   | -0.89    | -0.57  | -2.52    |
| 1973                   | -0.02  | NA       | NA    | -0.28   | 1.15     | -0.50  | 0.82     |
| 1974                   | 0.79   | NA       | NA    | -0.45   | -0.69    | 0.55   | -0.48    |
| 1975                   | 0.12   | NA       | NA    | -0.49   | -2.02    | -1.16  | 1.09     |
| 1976                   | 1.61   | NA       | NA    | 1.66    | -1.16    | -0.51  | 0.60     |
| 1977                   | 1.06   | NA       | NA    | 1.19    | 0.19     | 0.31   | -0.39    |
| 1978                   | -0.21  | NA       | NA    | 1.21    | -0.08    | -0.13  | -0.32    |
| 1979                   | 0.82   | NA       | NA    | 1.54    | -0.24    | -0.39  | 0.63     |
| 1980                   | -0.36  | NA       | NA    | 0.81    | 0.33     | -1.76  | 0.15     |
| 1981                   | -0.17  | NA       | NA    | 2.13    | 0.46     | -0.94  | -1.58    |
| 1982                   | -1.40  | NA       | NA    | -1.83   | -0.56    | 0.15   | 0.39     |
| 1983                   | 0.97   | NA       | NA    | 0.20    | 0.36     | -0.07  | 0.26     |
| 1984                   | -0.55  | NA       | NA    | -0.82   | 0.15     | 0.48   | -0.53    |
| 1985                   | -1.39  | NA       | NA    | -0.97   | -0.46    | 0.17   | -1.36    |
| 1986                   | -0.12  | NA       | NA    | -2.23   | -0.92    | 1.08   | -0.04    |
| 1987                   | -1.23  | NA       | NA    | 0.13    | -1.14    | 0.06   | 0.71     |
| 1988                   | 0.97   | NA       | NA    | 0.20    | 0.36     | 0.01   | 0.26     |
| 1989                   | 0.66   | NA       | NA    | -1.86   | -0.38    | -0.04  | 1.36     |
| 1990                   | 1.97   | NA       | NA    | -0.45   | 0.90     | -0.59  | 0.93     |
| 1991                   | 1.70   | NA       | NA    | -0.50   | 0.03     | -0.98  | -0.32    |
| 1992                   | 0.02   | NA       | NA    | -0.71   | -0.76    | 2.03   | -0.65    |
| 1993                   | 0.84   | NA       | NA    | 0.35    | 0.60     | 2.73   | -0.97    |
| 1994                   | -1.09  | NA       | NA    | 0.35    | 1.45     | 3.17   | 0.61     |
| 1995                   | 0.70   | NA       | NA    | -2.05   | -1.09    | 1.87   | 1.40     |
| 1996                   | 0.77   | NA       | NA    | -1.39   | 0.07     | 2.46   | 1.50     |
| 1997                   | 1.25   | NA       | NA    | -0.17   | -0.36    | 2.24   | 1.34     |
| 1998                   | -3.11  | 0.64     | 1.36  | 0.35    | 1.05     | -0.25  | 0.03     |
| 1999                   | 0.29   | 0.44     | 0.44  | -0.25   | -0.15    | -0.39  | 1.22     |
| 2000                   | -1.90  | -0.43    | -0.47 | -0.99   | -1.18    | -1.81  | -0.58    |
| 2001                   | -1.35  | -0.07    | -0.19 | -1.27   | 0.18     | -0.94  | -0.75    |
| 2002                   | 0.01   | 0.53     | -0.76 | 0.39    | 0.00     | 0.15   | 0.23     |
| 2003                   | 0.04   | -0.65    | -1.15 | -0.03   | 0.83     | 0.00   | -0.52    |
| 2004                   | 0.79   | 0.89     | -0.06 | 1.05    | 1.17     | 0.48   | 0.76     |
| 2005                   | 0.12   | 0.26     | 0.12  | 0.15    | 1.67     | 0.17   | -0.49    |
| 2006                   | 1.61   | 1.71     | 2.00  | 1.03    | 1.93     | 1.08   | 1.39     |
| 2007                   | 1.20   | 0.88     | 1.54  | 0.21    | 0.99     | 0.34   | 1.27     |
| 2008                   | -0.21  | 0.51     | -0.13 | 1.05    | 1.14     | 0.01   | 0.26     |
| 2009                   | 0.82   | 0.86     | 0.77  | -0.66   | -0.97    | -0.04  | 1.10     |
| 2010                   | -0.36  | 1.03     | -0.22 | -0.06   | 0.30     | -0.59  | 1.45     |
| 2011                   | -0.17  | -0.10    | -1.68 | -0.82   | 0.23     | -0.98  | -0.66    |
| 2012                   | -0.73  | 0.29     | -0.70 | -0.46   | -0.08    | -0.78  | 0.01     |
| 2013                   | 0.22   | -0.65    | 0.38  | 0.69    | -0.94    | -0.09  | 0.72     |
| 2014                   | -0.69  | -1.09    | -0.64 | -0.17   | -1.71    | -0.52  | -0.64    |
| 2015                   | -1.26  | -1.24    | -1.69 | -0.05   | -2.48    | -0.49  | -1.59    |
| 2016                   | 0.08   | -0.69    | 0.20  | 1.10    | -1.26    | -0.20  | -1.39    |
| 2017                   | -0.07  | 0.03     | 0.36  | 2.52    | -0.62    | -0.29  | -1.21    |
| 2018                   | -1.45  | -1.48    | -1.10 | 0.58    | -1.62    | -0.71  | -2.86    |
| 2019                   | 1.13   | 1.07     | 1.64  | 1.71    | -0.63    | 0.44   | 1.31     |

| Table4.7 continue..... |        | Annual SPI for tehsils |        |       |        |         |               |       |
|------------------------|--------|------------------------|--------|-------|--------|---------|---------------|-------|
| years                  | Nashik | Nandgaon               | Niphad | Peth  | Sinnar | Surgana | Trimbakeshwar | Yevla |
| 1961                   | NA     | 0.44                   | -0.81  | -1.13 | 1.17   | 0.05    | -0.31         | NA    |
| 1962                   | NA     | 1.07                   | -0.56  | -0.54 | 0.20   | -0.70   | -0.95         | NA    |
| 1963                   | NA     | 0.54                   | -0.20  | 0.48  | 2.10   | -0.29   | 0.31          | NA    |
| 1964                   | NA     | 1.65                   | -0.64  | 0.05  | 0.33   | -0.13   | 0.59          | NA    |
| 1965                   | NA     | -0.10                  | 0.03   | -2.73 | 0.98   | -0.14   | 0.60          | NA    |
| 1966                   | NA     | 0.76                   | -1.63  | 1.13  | -0.21  | -1.62   | 0.36          | NA    |
| 1967                   | NA     | -1.41                  | -0.21  | -0.79 | 0.82   | -0.53   | -0.54         | NA    |
| 1968                   | NA     | -1.20                  | -0.04  | -1.44 | 0.68   | -0.98   | -0.11         | NA    |
| 1969                   | NA     | 0.85                   | 0.55   | 0.78  | 1.42   | 1.06    | 0.78          | NA    |
| 1970                   | NA     | 0.50                   | -0.29  | 0.69  | 0.26   | -0.09   | 0.95          | NA    |
| 1971                   | NA     | -0.01                  | -0.63  | 0.28  | -0.53  | -1.74   | -0.45         | NA    |
| 1972                   | NA     | -3.75                  | -1.90  | -0.01 | -2.49  | -1.20   | 0.44          | NA    |
| 1973                   | NA     | -0.43                  | -0.96  | 1.18  | 0.97   | 0.86    | -2.52         | NA    |
| 1974                   | NA     | 0.31                   | -1.42  | -2.03 | 1.34   | -1.21   | -0.22         | NA    |
| 1975                   | NA     | 0.44                   | -0.29  | 0.36  | -0.26  | -0.18   | -1.01         | NA    |
| 1976                   | NA     | 0.03                   | 0.92   | 1.66  | 1.10   | 1.64    | -0.36         | NA    |
| 1977                   | NA     | 0.13                   | -0.40  | 0.59  | 0.45   | 0.74    | 0.18          | NA    |
| 1978                   | NA     | -0.23                  | 0.11   | -0.02 | -0.19  | 0.84    | 0.47          | NA    |
| 1979                   | NA     | 1.05                   | 0.47   | -1.93 | 0.73   | 0.94    | 0.67          | NA    |
| 1980                   | NA     | -0.10                  | 0.47   | 0.43  | 0.32   | 0.72    | 2.06          | NA    |
| 1981                   | NA     | -0.32                  | -0.51  | 0.99  | 0.71   | 1.94    | 2.10          | NA    |
| 1982                   | NA     | -1.17                  | 0.04   | -0.45 | -1.13  | 1.06    | 0.75          | NA    |
| 1983                   | NA     | 0.33                   | 0.05   | 0.59  | -0.51  | 1.75    | 0.45          | NA    |
| 1984                   | NA     | -0.71                  | -1.00  | -0.15 | -1.39  | -0.12   | -1.15         | NA    |
| 1985                   | NA     | -1.56                  | -0.89  | -0.61 | -1.85  | -0.57   | -0.68         | NA    |
| 1986                   | NA     | -0.29                  | -0.98  | -0.98 | -0.95  | -1.08   | -0.66         | NA    |
| 1987                   | NA     | 0.26                   | 0.43   | -1.09 | -0.39  | -0.56   | -0.97         | NA    |
| 1988                   | NA     | 0.33                   | 0.05   | 0.59  | -0.51  | 1.75    | 1.56          | NA    |
| 1989                   | NA     | 0.53                   | -0.33  | -0.32 | -0.20  | -0.54   | -0.95         | NA    |
| 1990                   | NA     | 0.61                   | -0.24  | 2.31  | -0.06  | 0.26    | -0.07         | NA    |
| 1991                   | NA     | 0.02                   | -4.30  | 0.93  | 0.53   | -0.23   | -0.61         | NA    |
| 1992                   | NA     | 0.81                   | 0.14   | 0.93  | -0.59  | 0.05    | -0.30         | NA    |
| 1993                   | NA     | 1.00                   | 0.54   | 0.44  | -1.74  | 0.26    | -0.07         | NA    |
| 1994                   | NA     | -0.04                  | 0.36   | 1.30  | -0.32  | 1.71    | 1.51          | NA    |
| 1995                   | NA     | 0.41                   | 0.38   | -0.80 | 1.18   | -0.69   | -1.12         | NA    |
| 1996                   | NA     | 0.62                   | 1.10   | -0.30 | -0.95  | 0.29    | -0.04         | NA    |
| 1997                   | NA     | -0.40                  | 1.37   | 0.17  | 0.24   | 0.21    | -0.13         | NA    |
| 1998                   | 0.33   | 1.28                   | 1.20   | 0.35  | 0.72   | -0.05   | -2.48         | 0.71  |
| 1999                   | -0.04  | 0.83                   | 1.11   | -0.05 | 0.66   | 0.53    | -0.22         | 0.76  |
| 2000                   | -0.18  | 0.72                   | 0.08   | -1.45 | -0.14  | -1.44   | -0.99         | -0.19 |
| 2001                   | -0.77  | -0.80                  | -0.12  | -0.44 | -1.04  | -0.50   | -0.36         | -0.32 |
| 2002                   | 0.00   | 0.26                   | 0.76   | -0.28 | -0.74  | 0.39    | 0.18          | -0.58 |
| 2003                   | 0.34   | -0.75                  | 0.27   | 0.26  | 0.64   | 0.16    | 0.40          | -1.14 |
| 2004                   | 0.88   | -0.04                  | 1.86   | 0.97  | 0.50   | 0.96    | 0.67          | 1.44  |
| 2005                   | 1.31   | -0.61                  | 1.41   | 1.26  | 0.38   | 1.60    | 2.06          | -0.18 |
| 2006                   | 1.63   | 1.27                   | 1.40   | 1.79  | 1.41   | 1.53    | 2.10          | 1.67  |
| 2007                   | 0.34   | 0.69                   | 1.39   | 0.20  | 0.50   | 0.35    | 0.90          | 1.05  |
| 2008                   | 1.40   | 0.98                   | 0.91   | 0.46  | 0.42   | 0.33    | 0.45          | 0.90  |
| 2009                   | -1.46  | 1.02                   | 0.23   | -0.80 | 0.78   | -0.89   | -1.15         | -0.16 |
| 2010                   | -0.18  | 1.01                   | 0.88   | -0.15 | 0.90   | -0.66   | -0.68         | 1.50  |
| 2011                   | -1.20  | 0.20                   | -0.83  | -0.17 | -0.98  | 0.02    | -0.66         | 0.50  |
| 2012                   | -1.60  | -1.34                  | -0.08  | -0.42 | -0.86  | -0.52   | -0.91         | -0.33 |
| 2013                   | -0.36  | 0.49                   | 0.18   | 0.05  | -0.65  | 0.09    | 0.04          | -0.44 |
| 2014                   | -0.90  | -1.92                  | -0.19  | -1.28 | -1.20  | -1.51   | -0.79         | -1.38 |
| 2015                   | -1.05  | -1.76                  | -0.20  | -2.33 | -1.09  | -3.05   | -1.70         | -1.81 |
| 2016                   | 1.04   | -1.06                  | 0.50   | 0.11  | 0.00   | -1.45   | 0.47          | -0.36 |
| 2017                   | 0.86   | -0.27                  | 0.56   | 0.35  | 0.22   | 0.23    | 1.02          | -0.30 |
| 2018                   | -1.58  | -2.28                  | -1.60  | -0.04 | -3.01  | -0.22   | -0.01         | -1.94 |
| 2019                   | 1.17   | 1.12                   | 1.48   | 1.07  | 1.28   | 0.59    | 1.09          | 0.59  |

Table 4.8.a) Annual Frequency and b) Annual Probability of different Tehsils in Nashik district

| Annual frequency |               |          |                |             |                |              |               |       |
|------------------|---------------|----------|----------------|-------------|----------------|--------------|---------------|-------|
| Tehsils          | Extermely wet | Very wet | Moderately wet | Near normal | Moderately dry | Severely dry | Extermely dry | Total |
| Baglan           | 0             | 4        | 5              | 39          | 8              | 2            | 1             | 59    |
| Chandwad         | 0             | 1        | 2              | 16          | 3              | 0            | 0             | 22    |
| Devla            | 1             | 2        | 1              | 14          | 2              | 2            | 0             | 22    |
| Dindori          | 2             | 3        | 7              | 40          | 2              | 3            | 2             | 59    |
| Igatpuri         | 1             | 3        | 6              | 39          | 6              | 2            | 2             | 59    |
| Kalwan           | 5             | 1        | 2              | 46          | 3              | 2            | 0             | 59    |
| Malegaon         | 0             | 1        | 10             | 40          | 3              | 3            | 2             | 59    |
| Nashik           | 0             | 1        | 4              | 12          | 3              | 2            | 0             | 22    |
| Nandgaon         | 0             | 1        | 8              | 40          | 5              | 3            | 2             | 59    |
| Niphad           | 0             | 1        | 8              | 45          | 1              | 3            | 1             | 59    |
| Peth             | 1             | 2        | 5              | 42          | 5              | 1            | 3             | 59    |
| Sinnar           | 1             | 0        | 7              | 42          | 5              | 2            | 2             | 59    |
| Surgana          | 0             | 7        | 2              | 41          | 5              | 3            | 1             | 59    |
| Trimbakesh       | 4             | 2        | 2              | 44          | 4              | 1            | 2             | 59    |
| Yevla            | 0             | 2        | 2              | 14          | 2              | 2            | 0             | 22    |

b)

| Annual Probability |               |          |                |             |                |              |               |       |
|--------------------|---------------|----------|----------------|-------------|----------------|--------------|---------------|-------|
| Tehsils            | Extermely wet | Very wet | Moderately wet | Near normal | Moderately dry | Severely dry | Extermely dry | Total |
| Baglan             | 0             | 7        | 8              | 66          | 14             | 3            | 2             | 10    |
| Chandwad           | 0             | 5        | 9              | 73          | 14             | 0            | 0             | 10    |
| Devla              | 5             | 9        | 5              | 64          | 9              | 9            | 0             | 10    |
| Dindori            | 3             | 5        | 12             | 68          | 3              | 5            | 3             | 10    |
| Igatpuri           | 2             | 5        | 10             | 66          | 10             | 3            | 3             | 10    |
| Kalwan             | 8             | 2        | 3              | 78          | 5              | 3            | 0             | 10    |
| Malegaon           | 0             | 2        | 17             | 68          | 5              | 5            | 3             | 10    |
| Nashik             | 0             | 5        | 18             | 55          | 14             | 9            | 0             | 10    |
| Nandgaon           | 0             | 2        | 14             | 68          | 8              | 5            | 3             | 10    |
| Niphad             | 0             | 2        | 14             | 76          | 2              | 5            | 2             | 10    |
| Peth               | 2             | 3        | 8              | 71          | 8              | 2            | 5             | 10    |
| Sinnar             | 2             | 0        | 12             | 71          | 8              | 3            | 3             | 10    |
| Surgana            | 0             | 12       | 3              | 69          | 8              | 5            | 2             | 10    |
| Trimbakesh         | 7             | 3        | 3              | 75          | 7              | 2            | 3             | 10    |
| Yevla              | 0             | 9        | 9              | 64          | 9              | 9            | 0             | 10    |

**Table 4.9. Standardized Precipitation Index (SPI) with Drought categories of Nashik**

| Tehsils              | SPI            | Category         | Number of times in<br>100 years | Severity of event |
|----------------------|----------------|------------------|---------------------------------|-------------------|
| <b>Baglan</b>        | 0 to -0.99     | Mild dryness     | 27                              | 1 in 4 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 14                              | 1 in 7 yrs        |
|                      | -1.5 to -1.99  | Severe dryness   | 3                               | 1 in 33 yrs       |
|                      | < -2.0         | Extreme dryness  | 2                               | 1 in 50 yrs       |
| <b>Chandwad</b>      | 0 to -0.99     | Mild dryness     | 27                              | 1 in 4 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 14                              | 1 in 7 yrs        |
|                      | -1.5 to -1.99  | Severe dryness   | 0                               | -                 |
|                      | < -2.0         | Extreme dryness  | 0                               | -                 |
| <b>Deola</b>         | 0 to -0.99     | Mild dryness     | 36                              | 1 in 3yrs         |
|                      | -1.00 to -1.49 | Moderate dryness | 9                               | 1 in 11 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 9                               | 1 in 11 yrs       |
|                      | < -2.0         | Extreme dryness  | 0                               | -                 |
| <b>Dindori</b>       | 0 to -0.99     | Mild dryness     | 40                              | 1 in 3yrs         |
|                      | -1.00 to -1.49 | Moderate dryness | 3                               | 1 in 33 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 5                               | 1 in 20 yrs       |
|                      | < -2.0         | Extreme dryness  | 3                               | 1 in 33 yrs       |
| <b>Igatpuri</b>      | 0 to -0.99     | Mild dryness     | 30                              | 1 in 3 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 10                              | 1 in 10 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 3                               | 1 in 33yrs        |
|                      | < -2.0         | Extreme dryness  | 3                               | 1 in 33yrs        |
| <b>Kalwan</b>        | 0 to -0.99     | Mild dryness     | 51                              | 1 in 2 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 5                               | 1 in 20 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 3                               | 1 in 33 yrs       |
|                      | < -2.0         | Extreme dryness  | 0                               | -                 |
| <b>Malegaon</b>      | 0 to -0.99     | Mild dryness     | 32                              | 1 in 3 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 5                               | 1 in 20 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 5                               | 1 in 20 yrs       |
|                      | < -2.0         | Extreme dryness  | 3                               | 1 in 33 yrs       |
| <b>Nandgaon</b>      | 0 to -0.99     | Mild dryness     | 25                              | 1 in 4 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 8                               | 1 in 12 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 5                               | 1 in 20 yrs       |
|                      | < -2.0         | Extreme dryness  | 3                               | 1 in 33 yrs       |
| <b>Nashik</b>        | 0 to -0.99     | Mild dryness     | 32                              | 1 in 3 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 14                              | 1 in 7 yrs        |
|                      | -1.5 to -1.99  | Severe dryness   | 9                               | 1 in 11 yrs       |
|                      | < -2.0         | Extreme dryness  | 0                               | -                 |
| <b>Niphad</b>        | 0 to -0.99     | Mild dryness     | 36                              | 1 in 3yrs         |
|                      | -1.00 to -1.49 | Moderate dryness | 2                               | 1 in 50yrs        |
|                      | -1.5 to -1.99  | Severe dryness   | 5                               | 1 in 20 yrs       |
|                      | < -2.0         | Extreme dryness  | 2                               | 1 in 50 yrs       |
| <b>Peth</b>          | 0 to -0.99     | Mild dryness     | 32                              | 1 in 3 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 8                               | 1 in 12 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 2                               | 1 in 50 yrs       |
|                      | < -2.0         | Extreme dryness  | 5                               | 1 in 20 yrs       |
| <b>Sinnar</b>        | 0 to -0.99     | Mild dryness     | 32                              | 1 in 3 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 8                               | 1 in 12 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 3                               | 1 in 33yrs        |
|                      | < -2.0         | Extreme dryness  | 3                               | 1 in 33 yrs       |
| <b>Surgana</b>       | 0 to -0.99     | Mild dryness     | 34                              | 1 in 3 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 8                               | 1 in 12yrs        |
|                      | -1.5 to -1.99  | Severe dryness   | 5                               | 1 in 20 yrs       |
|                      | < -2.0         | Extreme dryness  | 2                               | 1 in 50yrs        |
| <b>Trimbakeshwar</b> | 0 to -0.99     | Mild dryness     | 42                              | 1 in 2 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 7                               | 1 in 14 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 2                               | 1 in 50 yrs       |
|                      | < -2.0         | Extreme dryness  | 3                               | 1 in 33 yrs       |
| <b>Yevla</b>         | 0 to -0.99     | Mild dryness     | 41                              | 1 in 2 yrs        |
|                      | -1.00 to -1.49 | Moderate dryness | 9                               | 1 in 11 yrs       |
|                      | -1.5 to -1.99  | Severe dryness   | 9                               | 1 in 11 yrs       |
|                      | < -2.0         | Extreme dryness  | 0                               | -                 |

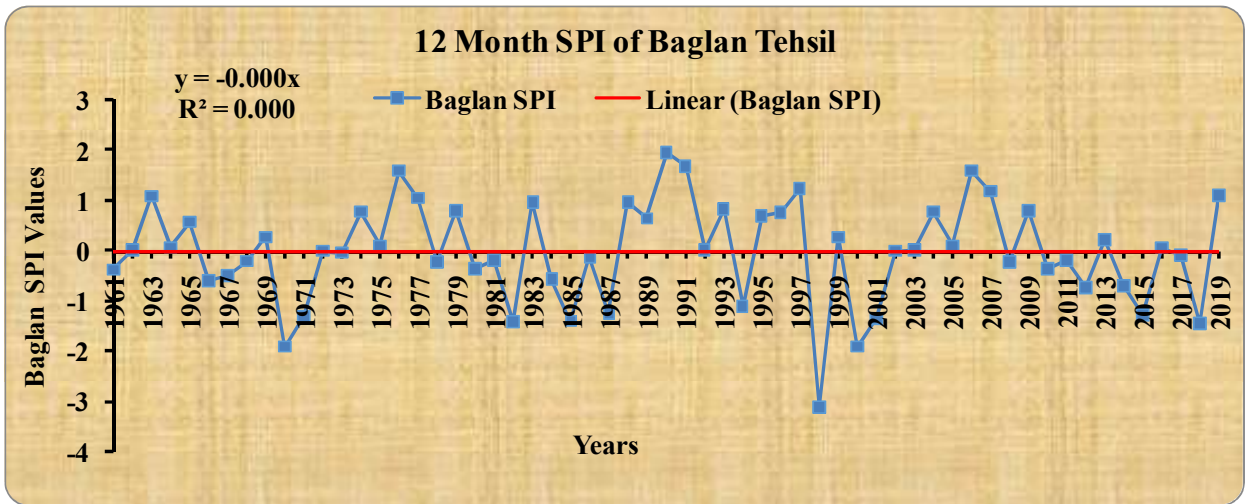


Fig.4.1 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Baglan tehsil.

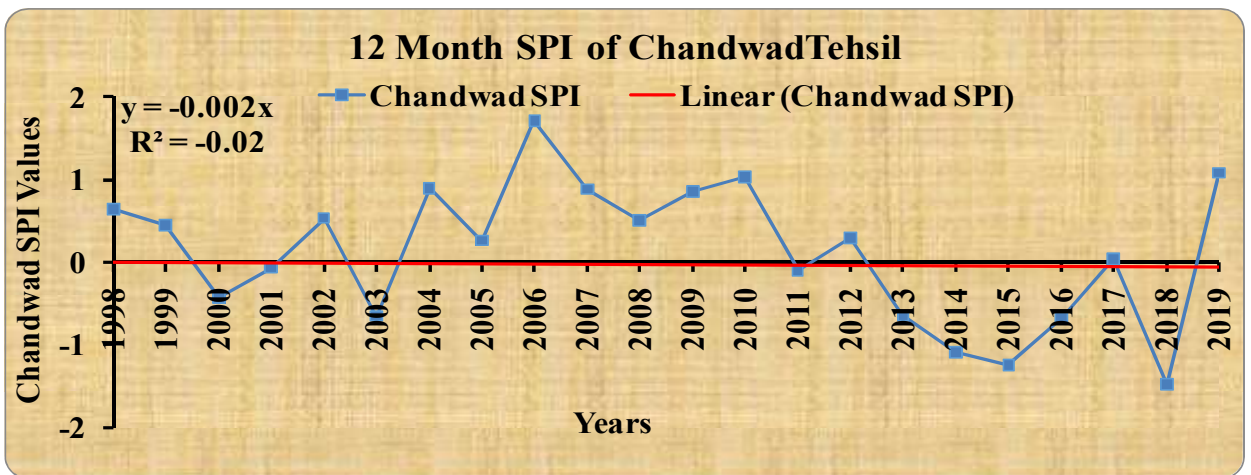


Fig4.2 Standardized Precipitation Index (SPI)for the period of 1998-2019 of Chandwad tehsil

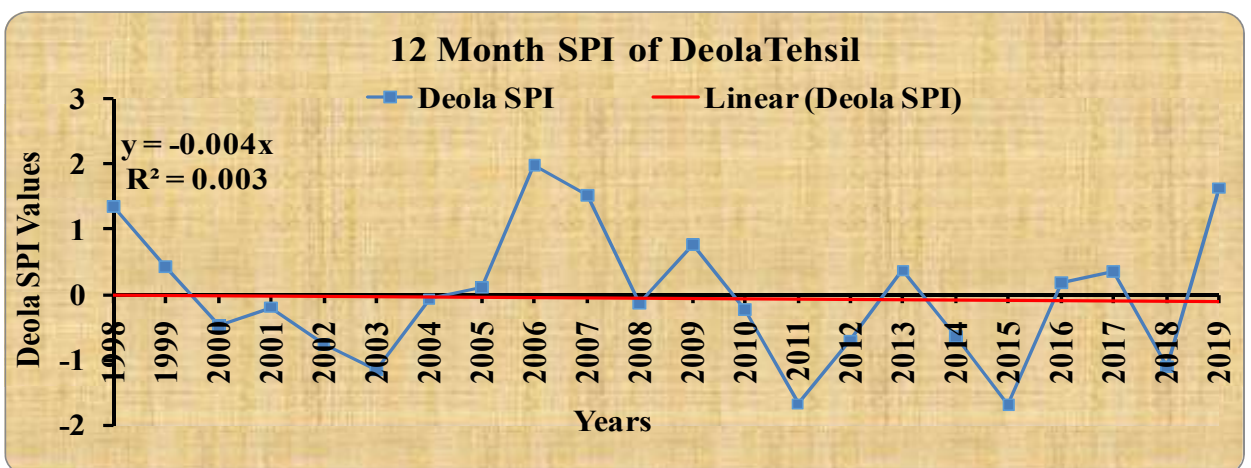


Fig.4.3 Standardized Precipitation Index (SPI)for the period of 1998-2019 of Deola tehsil.

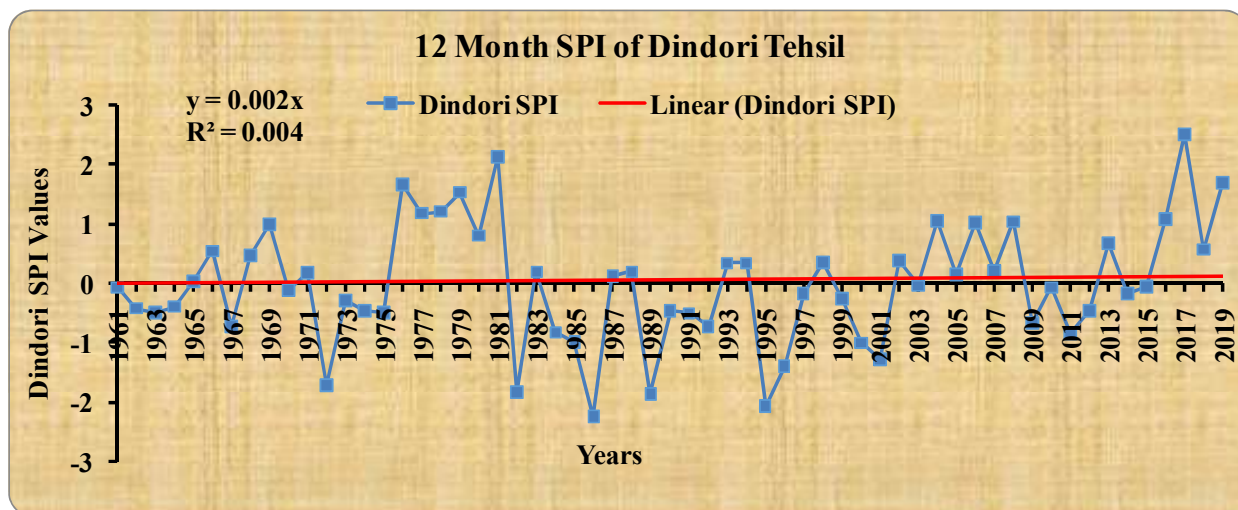


Fig.4.4 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Dindori tehsil.

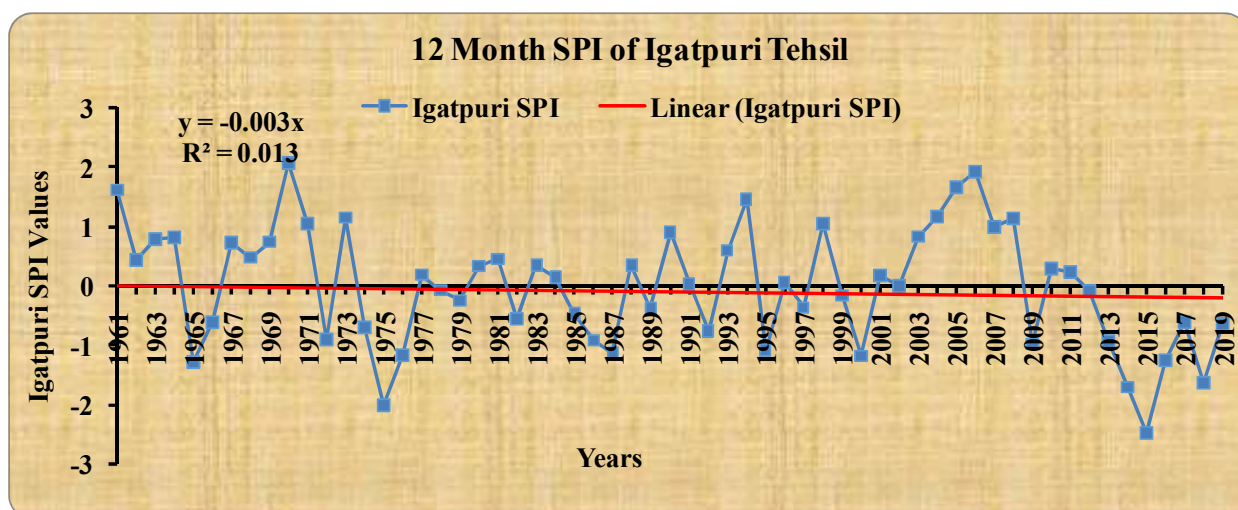


Fig.4.5 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Igatpuri tehsil.

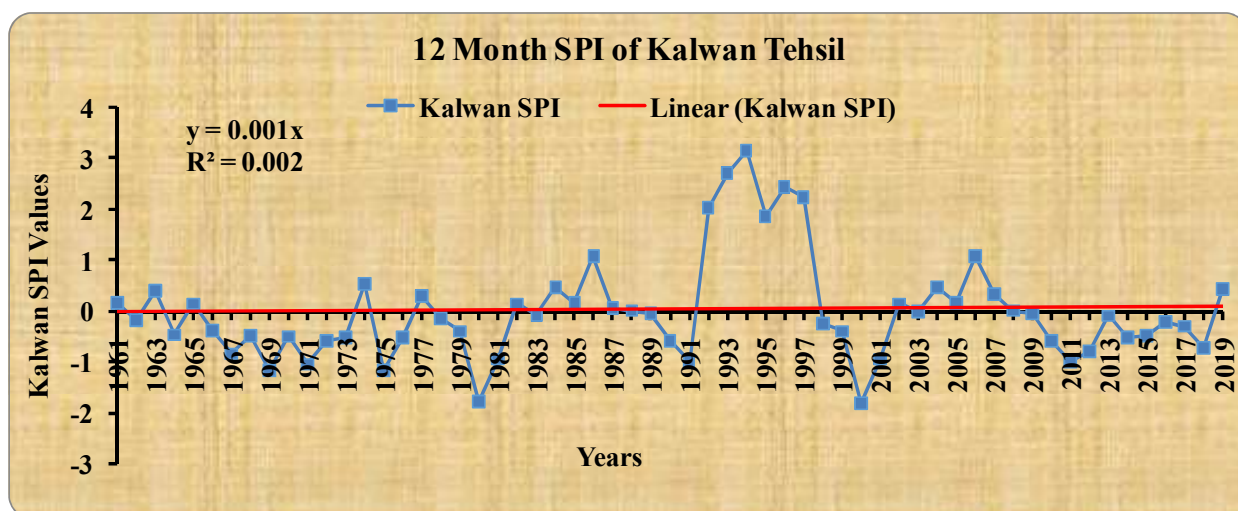


Fig.4.6 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Kalwan tehsil.

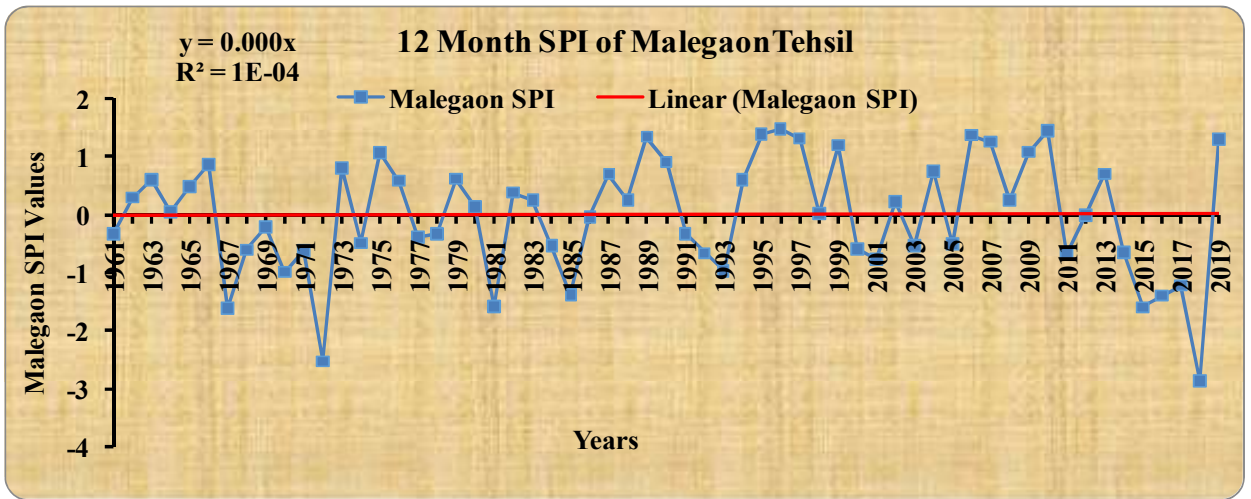


Fig.4.7 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Malegaon tehsil.

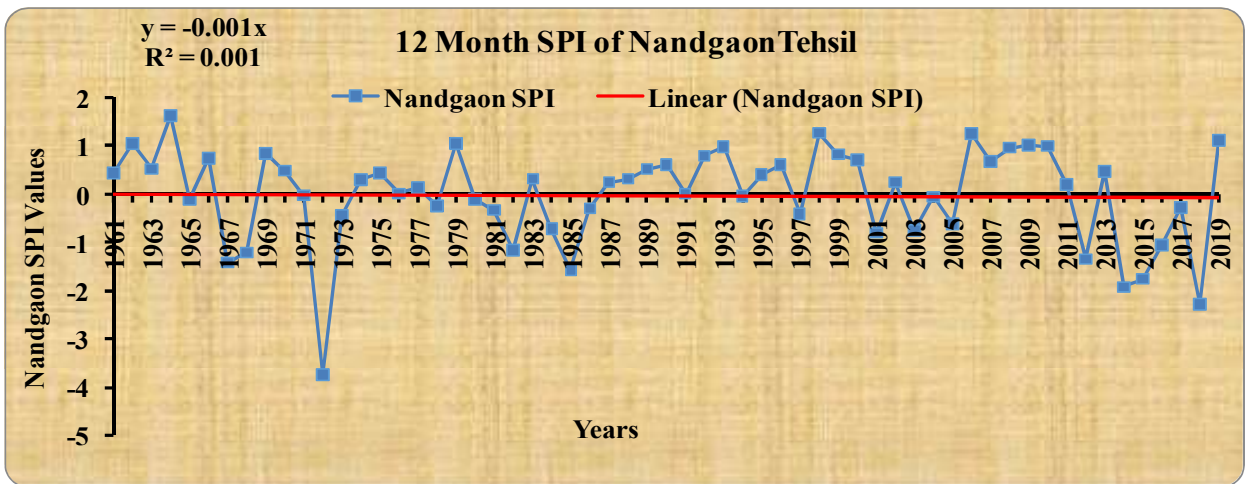


Fig.4.8 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Nandgaon tehsil.

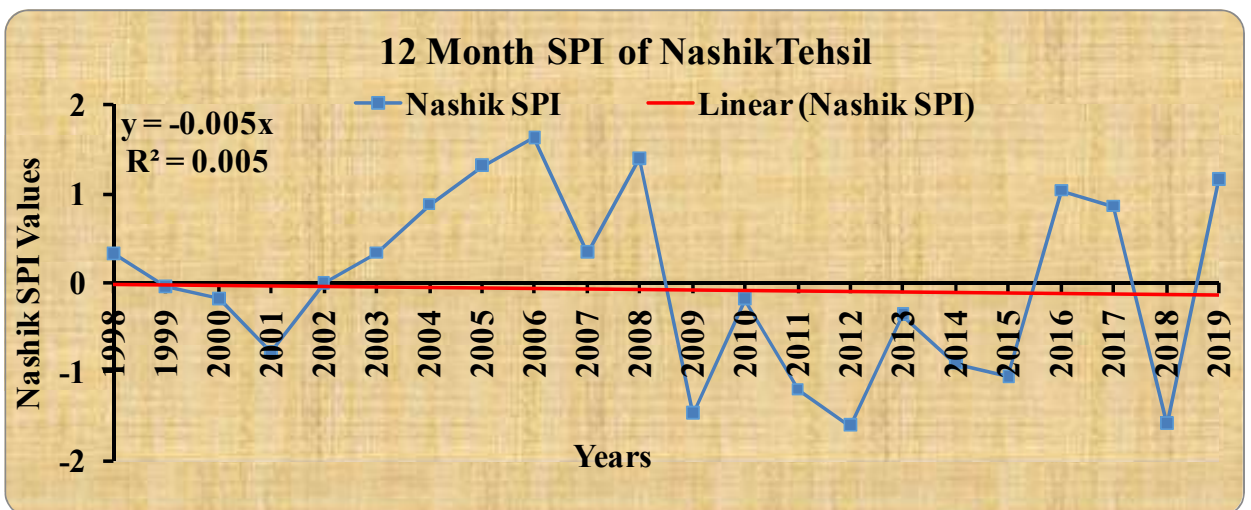


Fig.4.9 Standardized Precipitation Index (SPI)for the period of 1998-2019 of Nashik tehsil.

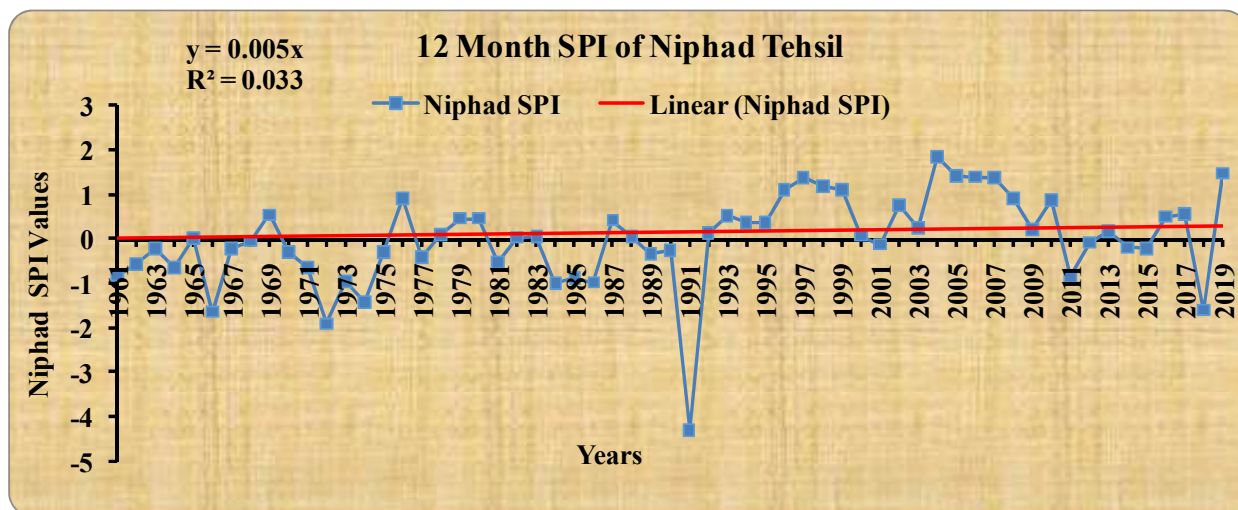


Fig.4.10 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Niphad tehsil.

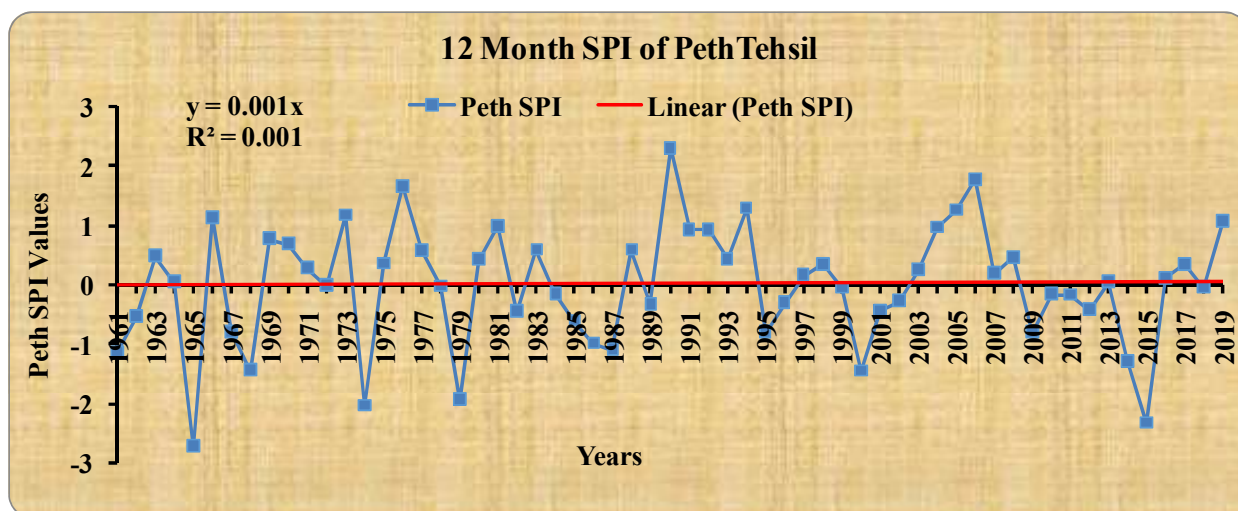


Fig.4.11 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Peth tehsil.

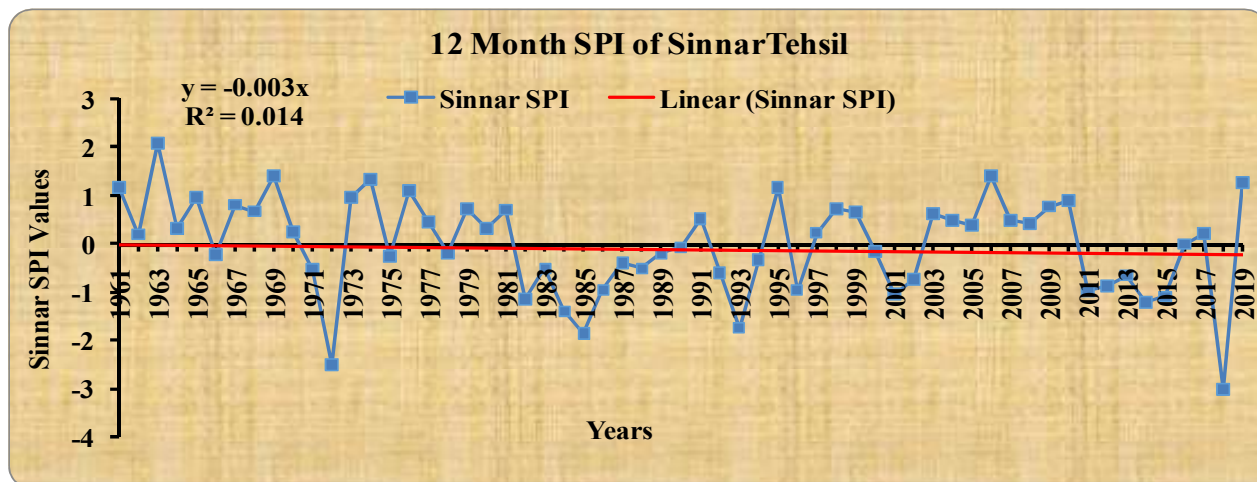


Fig.4.12 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Sinnar tehsil.

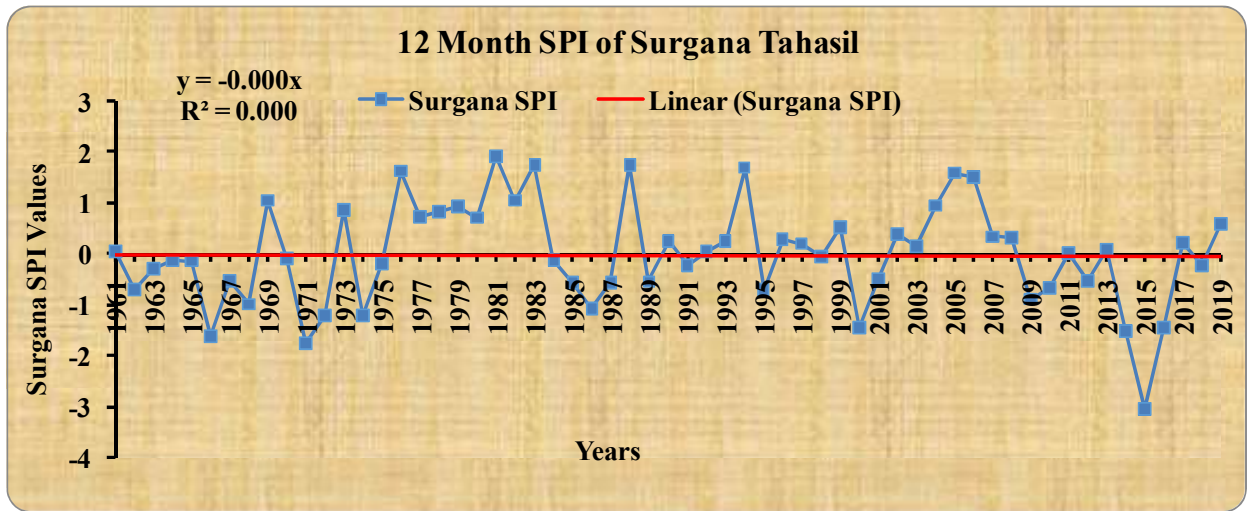


Fig.4.13 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Surgana tehsil.

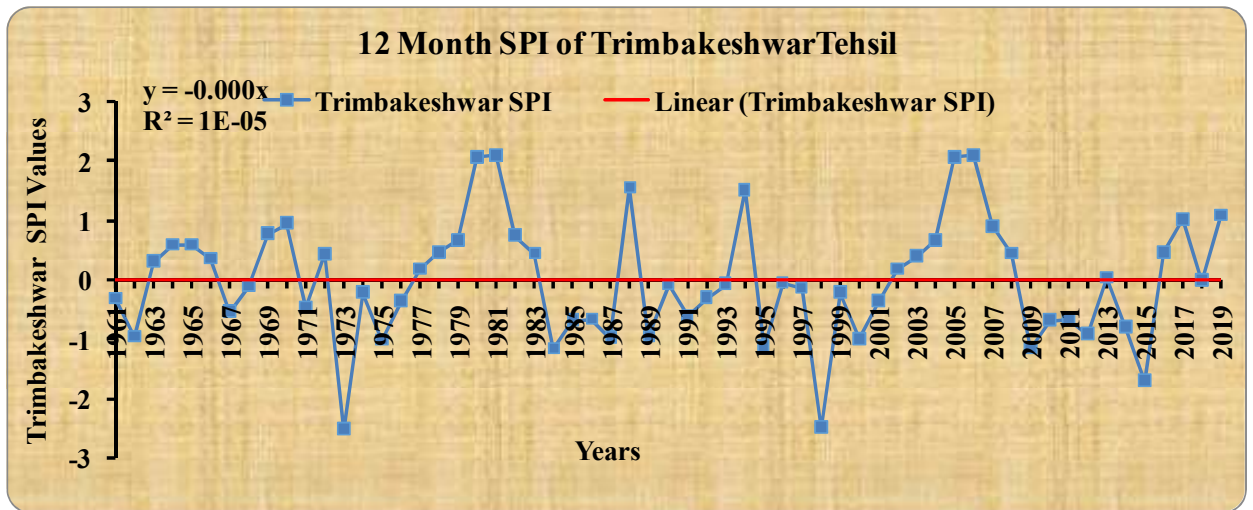


Fig.4.14 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Trimbakeshwar tehsil.

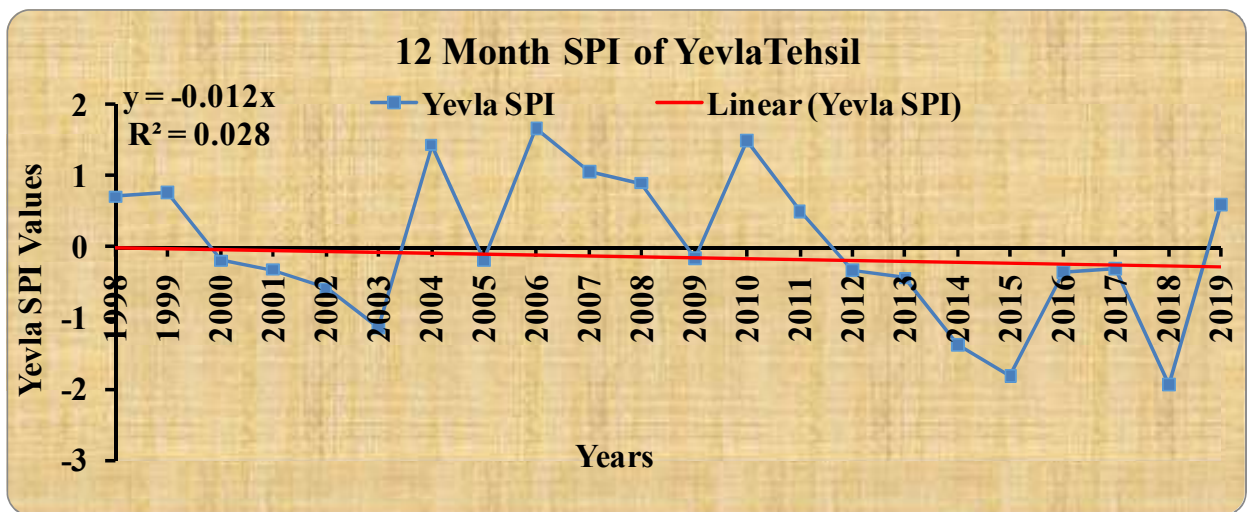


Fig.4.15 Standardized Precipitation Index (SPI)for the period of 1961-2019 of Yevla tehsil.

### 4.3. Precipitation deciles (PD)

Drought is a complex phenomenon which can be characterised mainly by its severity, duration and areal extent. Among these three dimensions, drought severity is the key factor which can be used for drought analysis. DrinC (Drought Indices Calculator) is a software package which was developed for providing a simple, though adaptable interface for the calculation of drought indices like precipitation deciles. The drought is usually estimated by comparing the current situation to the historical average, often based on minimum 30 year period of record. Precipitation decile (PD) is one of the simplest meteorological drought indices. The precipitation totals for the preceding three months are ranked against climatologic records and if the sum falls within the lowest decile of the historical distribution of 3-month totals, then the region is considered to be under drought conditions. The drought ends when the precipitation measured during the past month already places the 3-month total in or above the fourth decile, or the precipitation total for the past three months is in or above the eighth decile. Decile is a meteorological drought measurement tool which uses rainfall. The threshold ranges of deciles used to define drought condition are presented in the table 4.10 (Gibbs and Maher).

**Table 4.10: The Threshold ranges of deciles**

| Decile Class                  | Description       |
|-------------------------------|-------------------|
| Deciles 1-2: lowest 20%       | Much below normal |
| Deciles 3-4: next lowest 20%  | Below normal      |
| Deciles 5-6: middle 20%       | Near normal       |
| Deciles 7-8: next highest 20% | Above normal      |
| Deciles 9-10: highest 20%     | Much above normal |

In this study deciles 1-2 and deciles 3-4 were considered as drought event. The advantage of the method of deciles is its computational ease, but its simplicity can lead to conceptual difficulties. The precipitation deciles for different tehsils of Nashik district is calculated and results are discussed below :

#### 4.3.1 Precipitation Deciles of Baglan Tehsil

For Baglan tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.11(a) it is observed that there were 24 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1970,1971,1982,1985,1987,1994,1998,2000,2001,2012,2015,2018). Much above normal (Deciles 9-10) condition was observed for 12 years (1963,1976,1977,1983,1988,1990,1991,1993,1997,2006,2007,2019). From Table 4.11(b) It is also observed that the frequency of the drought event is increasing in the last one decade as

compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.16.

**Table 4.11(a). Classification of drought conditions according to Deciles in Baglan Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 3            | Below Normal      | 1991 - 1992 | 10           | Much above normal |
| 1962 - 1963 | 6            | Near normal       | 1992 - 1993 | 6            | Near normal       |
| 1963 - 1964 | 9            | Much above normal | 1993 - 1994 | 9            | Much above normal |
| 1964 - 1965 | 6            | Near normal       | 1994 - 1995 | 2            | Much below normal |
| 1965 - 1966 | 7            | Above normal      | 1995 - 1996 | 8            | Above normal      |
| 1966 - 1967 | 3            | Below normal      | 1996 - 1997 | 8            | Above normal      |
| 1967 - 1968 | 3            | Below normal      | 1997 - 1998 | 10           | Much above normal |
| 1968 - 1969 | 4            | Below normal      | 1998 - 1999 | 1            | Much below normal |
| 1969 - 1970 | 7            | Above normal      | 1999 - 2000 | 7            | Above normal      |
| 1970 - 1971 | 1            | Much below normal | 2000 - 2001 | 1            | Much below normal |
| 1971 - 1972 | 2            | Much below normal | 2001 - 2002 | 2            | Much below normal |
| 1972 - 1973 | 5            | Near normal       | 2002 - 2003 | 5            | Near normal       |
| 1973 - 1974 | 5            | Near normal       | 2003 - 2004 | 6            | Near normal       |
| 1974 - 1975 | 8            | Above normal      | 2004 - 2005 | 8            | Above normal      |
| 1975 - 1976 | 7            | Above normal      | 2005 - 2006 | 7            | Above normal      |
| 1976 - 1977 | 10           | Much above normal | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 9            | Much above normal | 2007 - 2008 | 10           | Much above normal |
| 1978 - 1979 | 4            | Below normal      | 2008 - 2009 | 4            | Below normal      |
| 1979 - 1980 | 8            | Above normal      | 2009 - 2010 | 8            | Above normal      |
| 1980 - 1981 | 4            | Below normal      | 2010 - 2011 | 4            | Below normal      |
| 1981 - 1982 | 4            | Below normal      | 2011 - 2012 | 4            | Below normal      |
| 1982 - 1983 | 1            | Much below normal | 2012 - 2013 | 2            | Much below normal |
| 1983 - 1984 | 9            | Much above normal | 2013 - 2014 | 7            | Above normal      |
| 1984 - 1985 | 3            | Below normal      | 2014 - 2015 | 3            | Below normal      |
| 1985 - 1986 | 1            | Much below normal | 2015 - 2016 | 2            | Much below normal |
| 1986 - 1987 | 5            | Near normal       | 2016 - 2017 | 6            | Near normal       |
| 1987 - 1988 | 2            | Much below normal | 2017 - 2018 | 5            | Near normal       |
| 1988 - 1989 | 9            | Much above normal | 2018 - 2019 | 1            | Much below normal |
| 1989 - 1990 | 7            | Above normal      | 2019 - 2020 | 9            | Much above normal |
| 1990 - 1991 | 10           | Much above normal |             |              |                   |

**Table 4.11(b) :Decadal Statistics of drought and wet years of Baglan tehsil according to Decile method**

| Period     | Much Below | Below Normal | Near Normal | Above Normal | Much Above |
|------------|------------|--------------|-------------|--------------|------------|
| 1961-1969  | 0          | 4            | 2           | 2            | 1          |
| 1970-1979  | 2          | 1            | 2           | 3            | 2          |
| 1980- 1989 | 3          | 3            | 1           | 1            | 2          |
| 1990 -1999 | 2          | 0            | 1           | 3            | 4          |
| 2000- 2009 | 2          | 1            | 2           | 3            | 2          |
| 2010- 2019 | 3          | 3            | 2           | 1            | 1          |

### 4.3.2 Precipitation Deciles of chandwad Tehsil

For Chandwad tehsil, Deciles were computed from the long term historical rainfall data of 42 years (1978-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.12(a) it is observed that there were 13 drought events in the period of 1978-2019. Much below normal (Deciles 1-2) condition was observed for 9 years (1989,1991,1995,2003,2013,2014,2015,2016,2018). Much above normal (Deciles 9-10) condition was observed for 9 years (1986,1993,1996,2004,2006,2007,2009,2010,2019). From table 4.12(b)It is also observed that the frequency of the drought event is is increasing in the last decade as compared to previous decades which may become very severe in the upcoming decade. also there is decrease in wet event in recent decade . This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts and extreme weather. The graphical representation of precipitation deciles for the period of 1978-2019 is shown in the Figure 4.17.

**Table 4.12.(a) Classification of drought conditions according to Deciles in Chandwad Tehsil during the period 1978-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1978 - 1979 | 5            | Near normal       | 1999 – 2000 | 7            | Above normal      |
| 1979 - 1980 | 6            | Near normal       | 2000 – 2001 | 4            | Below normal      |
| 1980 - 1981 | 8            | Above normal      | 2001 – 2002 | 5            | Near normal       |
| 1981 - 1982 | 3            | Below normal      | 2002 – 2003 | 8            | Above normal      |
| 1982 - 1983 | 3            | Below normal      | 2003 – 2004 | 2            | Much below normal |
| 1983 - 1984 | 3            | Below normal      | 2004 – 2005 | 9            | Much above normal |
| 1984 - 1985 | 7            | Above normal      | 2005 – 2006 | 6            | Near normal       |
| 1985 - 1986 | 3            | Below normal      | 2006 – 2007 | 10           | Much above normal |
| 1986 - 1987 | 10           | Much above normal | 2007 – 2008 | 9            | Much above normal |
| 1987 - 1988 | 4            | Below normal      | 2008 – 2009 | 8            | Above normal      |
| 1988 - 1989 | 4            | Below normal      | 2009 – 2010 | 9            | Much above normal |
| 1989 - 1990 | 1            | Much below normal | 2010 – 2011 | 9            | Much above normal |
| 1990 - 1991 | 4            | Below normal      | 2011 – 2012 | 5            | Near normal       |
| 1991 - 1992 | 1            | Much below normal | 2012 – 2013 | 6            | Near normal       |
| 1992 - 1993 | 6            | Near normal       | 2013 – 2014 | 2            | Much below normal |
| 1993 - 1994 | 10           | Much above normal | 2014 – 2015 | 1            | Much below normal |
| 1994 - 1995 | 7            | Above normal      | 2015 – 2016 | 1            | Much below normal |
| 1995 - 1996 | 2            | Much below normal | 2016 – 2017 | 2            | Much below normal |
| 1996 - 1997 | 10           | Much above normal | 2017 – 2018 | 5            | Near normal       |
| 1997 - 1998 | 7            | Above normal      | 2018 – 2019 | 1            | Much below normal |
| 1998 - 1999 | 8            | Above normal      | 2019 – 2020 | 10           | Much above normal |

**Table 4.12(b) :Decadal Statistics of drought and wet years of Chandwad tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1980- 1989 | 1                 | 6            | 0           | 2            | 1                 |
| 1990 -1999 | 2                 | 1            | 1           | 4            | 2                 |
| 2000- 2009 | 1                 | 1            | 2           | 2            | 4                 |
| 2010- 2019 | 5                 | 0            | 3           | 0            | 2                 |

#### 4.3.3 Precipitation Deciles of Deola Tehsil

For Deola tehsil, Deciles were computed from the long term historical rainfall data of 22 years (1998-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.13(a) it is observed that there were 9 drought events in the period of 1980-2019. Much below normal (Deciles 1-2) condition was observed for 5 years (2002,2003,2011,2015,2018). Much above normal (Deciles 9-10) condition was observed for 5 years (1998,2006,2007,2009,2019). From Table 4.13(b) It is also observed that the frequency of the drought event is increasing in the last decade as compared to previous decade(almost double) which may become very severe in the upcoming decade.as there is no normal rainfall year in deola in last one decade, This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1998-2019 is shown in the Figure 4.18.

**Table 4.13.(a) Classification of drought conditions according to Deciles in Deola Tehsil during the period 1980-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1998 - 1999 | 9            | Much above normal | 2009 - 2010 | 9            | Much above normal |
| 1999 - 2000 | 8            | Above normal      | 2010 - 2011 | 4            | Below normal      |
| 2000 - 2001 | 4            | Below normal      | 2011 - 2012 | 1            | Much below normal |
| 2001 - 2002 | 5            | Near normal       | 2012 - 2013 | 3            | Below normal      |
| 2002 - 2003 | 2            | Much below normal | 2013 - 2014 | 8            | Above normal      |
| 2003 - 2004 | 1            | Much below normal | 2014 - 2015 | 3            | Below normal      |
| 2004 - 2005 | 6            | Near normal       | 2015 - 2016 | 1            | Much below normal |
| 2005 - 2006 | 6            | Near normal       | 2016 - 2017 | 7            | Above normal      |
| 2006 - 2007 | 10           | Much above normal | 2017 - 2018 | 7            | Above normal      |
| 2007 - 2008 | 10           | Much above normal | 2018 - 2019 | 2            | Much below normal |
| 2008 - 2009 | 5            | Near normal       | 2019 - 2020 | 10           | Much above normal |

**Table 4.13(b) :Decadal Statistics of drought and wet years of Devla tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 2000- 2009 | 2                 | 1            | 4           | 0            | 3                 |
| 2010- 2019 | 3                 | 3            | 0           | 3            | 1                 |

#### 4.3.4 Precipitation Deciles of Dindori Tehsil

For Dindori tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.14(a) it is observed that there were 24 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1967,1972,1982,1984,1985,1986,1989,1995,1996,2000,2001,2011). Much above normal (Deciles 9-10) condition was observed for 12 years (1969,1976,1977,1978,1979,1981,2004,2006,2008,2016,2017,2019).From Table 4.14(b) It is also observed that the frequency of the Wet event is increasing in the last two decade as compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the impacts of extreme events. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.19

**Table4.14(a). Classification of drought conditions according to Deciles in Dindori Tehsil during the period 1961-2019.**

| Year   | Decile | Drought      | Year   | Decile | Drought Condition  |
|--------|--------|--------------|--------|--------|--------------------|
| 1961 – | 5      | Near normal  | 1991 – | 3      | Below normal       |
| 1962 – | 4      | Below normal | 1992 – | 3      | Below normal       |
| 1963 – | 3      | Below normal | 1993 – | 7      | Above normal       |
| 1964 – | 4      | Below normal | 1994 – | 7      | Above normal       |
| 1965 – | 6      | Near normal  | 1995 – | 1      | Much below normal  |
| 1966 – | 8      | Above normal | 1996 – | 1      | Much below normal  |
| 1967 – | 2      | Much below   | 1997 – | 5      | Near normal        |
| 1968 – | 8      | Above normal | 1998 – | 7      | Above normal       |
| 1969 – | 9      | Much above   | 1999 – | 4      | Below normal       |
| 1970 – | 5      | Near normal  | 2000 – | 2      | Much below normal  |
| 1971 – | 6      | Near normal  | 2001 – | 2      | Much below normal  |
| 1972 – | 1      | Much below   | 2002 – | 8      | Above normal Above |
| 1973 – | 4      | Below normal | 2003 – | 6      | Near normal        |
| 1974 – | 4      | Below normal | 2004 – | 9      | Much above normal  |
| 1975 – | 3      | Below normal | 2005 – | 6      | Near normal        |
| 1976 – | 10     | Much above   | 2006 – | 9      | Much above normal  |
| 1977 – | 9      | Much above   | 2007 – | 7      | above normal       |
| 1978 – | 10     | Much above   | 2008 – | 9      | Much above normal  |

| Year   | Decile | Drought      | Year   | Decile | Drought Condition |
|--------|--------|--------------|--------|--------|-------------------|
| 1979 – | 10     | Much above   | 2009 – | 3      | Below normal      |
| 1980 – | 8      | above normal | 2010 – | 5      | Near normal       |
| 1981 – | 10     | Much above   | 2011 – | 2      | Much below normal |
| 1982 – | 1      | Much below   | 2012 – | 3      | Below normal      |
| 1983 – | 7      | above normal | 2013 – | 8      | above normal      |
| 1984 – | 2      | Much below   | 2014 – | 5      | Near normal       |
| 1985 – | 2      | Much below   | 2015 – | 6      | Near normal       |
| 1986 – | 1      | Much below   | 2016 – | 9      | Much above normal |
| 1987 – | 6      | Near normal  | 2017 – | 10     | Much above normal |
| 1988 – | 7      | above normal | 2018 – | 8      | above normal      |
| 1989 – | 1      | Much below   | 2019 – | 10     | Much above normal |
| 1990 – | 4      | Below normal |        |        |                   |

**Table4.14(b) :Decadal Statistics of drought and wet years of Dindori tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 1                 | 3            | 2           | 2            | 1                 |
| 1970-1979  | 1                 | 3            | 2           | 0            | 4                 |
| 1980- 1989 | 5                 | 0            | 1           | 3            | 1                 |
| 1990 -1999 | 2                 | 4            | 1           | 3            | 0                 |
| 2000- 2009 | 2                 | 1            | 2           | 2            | 3                 |
| 2010- 2019 | 1                 | 1            | 3           | 2            | 3                 |

#### 4.3.5 Precipitation Deciles of Igatpuri Tehsil

For Igatpuri tehsil, Deciles were computed from the long term historical rainfall data of 40 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.15(a) it is observed that there were 24 drought events in the period of 1980-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1965,1975,1976,1987,1995,2000,2009,2013,2014,2015,2016,2018). Much above normal (Deciles 9-10) condition was observed for 12 years (1961,1970,1971,1973,1998,1994,1998,2004,2005,2006,2007,2008).From Table 4.15(b)It is also observed that the frequency of the drought event is increasing in the last **one** decade as compared to previous decades( 6 drought events in last one decade) which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.20.

**Table 4.15(a). Classification of drought conditions according to Deciles in Igatpuri Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 10           | Much above normal | 1991 - 1992 | 5            | Near normal       |
| 1962 - 1963 | 7            | Above normal      | 1992 - 1993 | 3            | Below normal      |
| 1963 - 1964 | 8            | Above normal      | 1993 - 1994 | 8            | Above normal      |
| 1964 - 1965 | 8            | Above normal      | 1994 - 1995 | 10           | Much above normal |
| 1965 - 1966 | 1            | Much below normal | 1995 - 1996 | 2            | Much below normal |
| 1966 - 1967 | 4            | Below normal      | 1996 - 1997 | 6            | Near normal       |
| 1967 - 1968 | 8            | Above normal      | 1997 - 1998 | 4            | Below normal      |
| 1968 - 1969 | 7            | Above normal      | 1998 - 1999 | 9            | Much above normal |
| 1969 - 1970 | 8            | Above normal      | 1999 - 2000 | 5            | Near normal       |
| 1970 - 1971 | 10           | Much above normal | 2000 - 2001 | 2            | Much below normal |
| 1971 - 1972 | 9            | Much above normal | 2001 - 2002 | 6            | Near normal       |
| 1972 - 1973 | 3            | below normal      | 2002 - 2003 | 5            | Near normal       |
| 1973 - 1974 | 9            | Much above normal | 2003 - 2004 | 8            | Above normal      |
| 1974 - 1975 | 3            | below normal      | 2004 - 2005 | 10           | Much above normal |
| 1975 - 1976 | 1            | Much below normal | 2005 - 2006 | 10           | Much above normal |
| 1976 - 1977 | 2            | Much below normal | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 6            | Near normal       | 2007 - 2008 | 9            | Much above normal |
| 1978 - 1979 | 5            | Near normal       | 2008 - 2009 | 9            | Much above normal |
| 1979 - 1980 | 4            | below normal      | 2009 - 2010 | 2            | Much below normal |
| 1980 - 1981 | 7            | Above normal      | 2010 - 2011 | 6            | Near normal       |
| 1981 - 1982 | 7            | Above normal      | 2011 - 2012 | 6            | Near normal       |
| 1982 - 1983 | 4            | Below normal      | 2012 - 2013 | 5            | Near normal       |
| 1983 - 1984 | 7            | Above normal      | 2013 - 2014 | 2            | Much below normal |
| 1984 - 1985 | 6            | Near normal       | 2014 - 2015 | 1            | Much below normal |
| 1985 - 1986 | 4            | Below normal      | 2015 - 2016 | 1            | Much below normal |
| 1986 - 1987 | 3            | Below normal      | 2016 - 2017 | 1            | Much below normal |
| 1987 - 1988 | 2            | Much below normal | 2017 - 2018 | 3            | Below normal      |
| 1988 - 1989 | 7            | Above normal      | 2018 - 2019 | 1            | Much below normal |
| 1989 - 1990 | 4            | Below normal      | 2019 - 2020 | 3            | below normal      |
| 1990 - 1991 | 9            | Much above normal |             |              |                   |

**Table 4.15(b) :Decadal Statistics of drought and wet years of Igatpuri tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 1                 | 1            | 0           | 6            | 1                 |
| 1970-1979  | 2                 | 3            | 2           | 0            | 3                 |
| 1980- 1989 | 1                 | 4            | 1           | 4            | 0                 |
| 1990 -1999 | 1                 | 2            | 3           | 1            | 3                 |
| 2000- 2009 | 2                 | 0            | 2           | 1            | 5                 |
| 2010- 2019 | 5                 | 2            | 3           | 0            | 0                 |

### 4.3.6 Precipitation Deciles of Kalwan Tehsil

For Kalwan tehsil, Deciles were computed from the long term historical rainfall data of 40 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.16A(a) it is observed that there were 24 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1967,1969,1971,1975,1980,1981,1991,2000,2001,2011,2012,2018). Much above normal (Deciles 9-10) condition was observed for 12 years (1974,1984,1986,1992,1993,1994,1995,1996,1997,2004,2006,2019). From Table 4.16(b) It is also observed that the frequency of the drought event is increasing in the last two decade as compared to previous decades which may become very severe in the upcoming decade. As last decades have 6 drought events(from Table 4.16b), This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.21.

**Table 4.16(a). Classification of drought conditions according to Deciles in Kalwan Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 8            | Above normal      | 1991 - 1992 | 2            | Much below normal |
| 1962 - 1963 | 5            | Near normal       | 1992 - 1993 | 10           | Much above normal |
| 1963 - 1964 | 8            | Above normal      | 1993 - 1994 | 10           | Much above normal |
| 1964 - 1965 | 4            | Below normal      | 1994 - 1995 | 10           | Much above normal |
| 1965 - 1966 | 7            | Above normal      | 1995 - 1996 | 10           | Much above normal |
| 1966 - 1967 | 5            | Near normal       | 1996 - 1997 | 10           | Much above normal |
| 1967 - 1968 | 2            | Much below normal | 1997 - 1998 | 10           | Much above normal |
| 1968 - 1969 | 4            | Below normal      | 1998 - 1999 | 5            | Near normal       |
| 1969 - 1970 | 1            | Much below normal | 1999 - 2000 | 4            | Below normal      |
| 1970 - 1971 | 4            | Below normal      | 2000 - 2001 | 1            | Much below normal |
| 1971 - 1972 | 1            | Much below normal | 2001 - 2002 | 2            | Much below normal |
| 1972 - 1973 | 3            | Below normal      | 2002 - 2003 | 7            | Above normal      |
| 1973 - 1974 | 3            | Below normal      | 2003 - 2004 | 6            | Near normal       |
| 1974 - 1975 | 9            | Much above normal | 2004 - 2005 | 9            | Much above normal |
| 1975 - 1976 | 1            | Much below normal | 2005 - 2006 | 8            | Above normal      |
| 1976 - 1977 | 3            | Below normal      | 2006 - 2007 | 9            | Much above normal |
| 1977 - 1978 | 8            | Above normal      | 2007 - 2008 | 8            | Above normal      |
| 1978 - 1979 | 6            | Near normal       | 2008 - 2009 | 7            | Above normal      |
| 1979 - 1980 | 4            | Below normal      | 2009 - 2010 | 6            | Near normal       |
| 1980 - 1981 | 1            | Much below normal | 2010 - 2011 | 3            | Below normal      |
| 1981 - 1982 | 2            | Much below normal | 2011 - 2012 | 2            | Much below normal |
| 1982 - 1983 | 7            | Above normal      | 2012 - 2013 | 2            | Much below normal |
| 1983 - 1984 | 6            | Near normal       | 2013 - 2014 | 6            | Near normal       |
| 1984 - 1985 | 9            | Much above normal | 2014 - 2015 | 3            | Below normal      |
| 1985 - 1986 | 8            | Above normal      | 2015 - 2016 | 4            | Below normal      |

|             |   |                   |             |   |                   |
|-------------|---|-------------------|-------------|---|-------------------|
| 1986 - 1987 | 9 | Much above normal | 2016 – 2017 | 5 | Near normal       |
| 1987 - 1988 | 7 | Above normal      | 2017 – 2018 | 5 | Near normal       |
| 1988 - 1989 | 7 | Above normal      | 2018 - 2019 | 2 | Much below normal |
| 1989 - 1990 | 6 | Near normal       | 2019 - 2020 | 9 | Much above normal |
| 1990 - 1991 | 3 | Below normal      |             |   |                   |

**Table 4.16(b) : Decadal Statistics of drought and wet years of Kalwan tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 2                 | 2            | 2           | 3            | 0                 |
| 1970-1979  | 2                 | 5            | 1           | 1            | 1                 |
| 1980- 1989 | 2                 | 0            | 2           | 4            | 2                 |
| 1990 -1999 | 1                 | 2            | 1           | 0            | 6                 |
| 2000- 2009 | 2                 | 0            | 2           | 4            | 2                 |
| 2010- 2019 | 3                 | 3            | 3           | 0            | 1                 |

#### 4.3.7 Precipitation Deciles of Malegaon Tehsil

For Malegaon tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.17(a) it is observed that there were 23 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1967,1970,1972,1981,1985,1993,2001,2011,2015,2016,2017,2018). Much above normal (Deciles 9-10) condition was observed for 12 years (1975,1989,1990,1995,1996,1997,1999,2006,2007,2009,2010,2019). From Table 4.17(b) It is also observed that the frequency of the drought event is increasing in the last decade(10 drought events) as compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.22.

**Table 4.17(a). Classification of drought conditions according to Deciles in Malegaon Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 4            | Below normal      | 1991 - 1992 | 5            | Near normal       |
| 1962 - 1963 | 7            | Above normal      | 1992 - 1993 | 3            | Below normal      |
| 1963 - 1964 | 7            | Above normal      | 1993 - 1994 | 2            | Much below normal |
| 1964 - 1965 | 6            | Near normal       | 1994 - 1995 | 7            | Above normal      |
| 1965 - 1966 | 7            | Above normal      | 1995 - 1996 | 10           | Much above normal |
| 1966 - 1967 | 8            | Above normal      | 1996 - 1997 | 10           | Much above normal |
| 1967 - 1968 | 1            | Much below normal | 1997 - 1998 | 10           | Much above normal |
| 1968 - 1969 | 3            | Below normal      | 1998 - 1999 | 5            | Near normal       |
| 1969 - 1970 | 5            | Near normal       | 1999 - 2000 | 9            | Much above normal |
| 1970 - 1971 | 2            | Much below normal | 2000 - 2001 | 3            | Below normal      |
| 1971 - 1972 | 3            | Below normal      | 2001 - 2002 | 2            | Much below normal |
| 1972 - 1973 | 1            | Much below normal | 2002 - 2003 | 6            | Near normal       |
| 1973 - 1974 | 8            | Above normal      | 2003 - 2004 | 4            | Below normal      |
| 1974 - 1975 | 4            | Below normal      | 2004 - 2005 | 8            | Above normal      |
| 1975 - 1976 | 9            | Much above normal | 2005 - 2006 | 4            | Below normal      |
| 1976 - 1977 | 7            | Above normal      | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 4            | Below normal      | 2007 - 2008 | 9            | Much above normal |
| 1978 - 1979 | 5            | Near normal       | 2008 - 2009 | 6            | Near normal       |
| 1979 - 1980 | 8            | Above normal      | 2009 - 2010 | 9            | Much above normal |
| 1980 - 1981 | 6            | Near normal       | 2010 - 2011 | 10           | Much above normal |
| 1981 - 1982 | 1            | Much below normal | 2011 - 2012 | 2            | Much below normal |
| 1982 - 1983 | 7            | Above normal      | 2012 - 2013 | 5            | Near normal       |
| 1983 - 1984 | 6            | Near normal       | 2013 - 2014 | 8            | Above normal      |
| 1984 - 1985 | 3            | Below normal      | 2014 - 2015 | 3            | Below normal      |
| 1985 - 1986 | 2            | Much below normal | 2015 - 2016 | 1            | Much below normal |
| 1986 - 1987 | 5            | Near normal       | 2016 - 2017 | 1            | Much below normal |
| 1987 - 1988 | 8            | Above normal      | 2017 - 2018 | 2            | Much below normal |
| 1988 - 1989 | 6            | Near normal       | 2018 - 2019 | 1            | Much below normal |
| 1989 - 1990 | 10           | Much above normal | 2019 - 2020 | 9            | Much above normal |
| 1990 - 1991 | 9            | Much above normal |             |              |                   |

**Table 4.17(b) : Decadal Statistics of drought and wet years of Malegaon tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 1                 | 2            | 2           | 4            | 0                 |
| 1970-1979  | 2                 | 3            | 1           | 3            | 1                 |
| 1980- 1989 | 2                 | 1            | 4           | 2            | 1                 |
| 1990 -1999 | 1                 | 1            | 2           | 1            | 5                 |
| 2000- 2009 | 1                 | 3            | 2           | 1            | 3                 |
| 2010- 2019 | 5                 | 1            | 1           | 1            | 2                 |

#### 4.3.8 Precipitation Deciles of Nandgaon Tehsil

For Nandgaon tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2

and 3-4. From the Table 4.18(a) it is observed that there were 24 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1967,1968,1972,1982,1985,2001,2003,2012,2014,2015,2016,2018) . Much above normal (Deciles 9-10) condition was observed for 12 years (1962,1964,1969,1979,1993,1998,1999,2005,2008,2009,2010 and 2019). From Table 4.18(b)It is also observed that the frequency of the drought event is increasing in the last decade (140 drought events in last two decades)as compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.23.

**Table 4.18(a). Classification of drought conditions according to Deciles in Nandgaon Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 7            | Above normal      | 1991 - 1992 | 5            | Near normal       |
| 1962 - 1963 | 10           | Much above normal | 1992 - 1993 | 8            | Above normal      |
| 1963 - 1964 | 7            | Above normal      | 1993 - 1994 | 9            | Much above normal |
| 1964 - 1965 | 10           | Much above normal | 1994 - 1995 | 4            | Below normal      |
| 1965 - 1966 | 4            | Below normal      | 1995 - 1996 | 6            | Near normal       |
| 1966 - 1967 | 8            | Above normal      | 1996 - 1997 | 8            | Above normal      |
| 1967 - 1968 | 1            | Much below normal | 1997 - 1998 | 3            | Below normal      |
| 1968 - 1969 | 2            | Much below normal | 1998 - 1999 | 10           | Much above normal |
| 1969 - 1970 | 9            | Much above normal | 1999 - 2000 | 9            | Much above normal |
| 1970 - 1971 | 7            | Above normal      | 2000 - 2001 | 8            | Above normal      |
| 1971 - 1972 | 5            | Near normal       | 2001 - 2002 | 2            | Much below normal |
| 1972 - 1973 | 1            | Much below normal | 2002 - 2003 | 6            | Near normal       |
| 1973 - 1974 | 3            | Below normal      | 2003 - 2004 | 2            | Much below normal |
| 1974 - 1975 | 6            | Near normal       | 2004 - 2005 | 4            | Below normal      |
| 1975 - 1976 | 7            | Above normal      | 2005 - 2006 | 3            | Below normal      |
| 1976 - 1977 | 5            | Near normal       | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 5            | Near normal       | 2007 - 2008 | 8            | Above normal      |
| 1978 - 1979 | 4            | Below normal      | 2008 - 2009 | 9            | Much above normal |
| 1979 - 1980 | 10           | Much above normal | 2009 - 2010 | 9            | Much above normal |
| 1980 - 1981 | 4            | Below normal      | 2010 - 2011 | 9            | Much above normal |
| 1981 - 1982 | 3            | Below normal      | 2011 - 2012 | 5            | Near normal       |
| 1982 - 1983 | 2            | Much below normal | 2012 - 2013 | 2            | Much below normal |
| 1983 - 1984 | 6            | Near normal       | 2013 - 2014 | 7            | Above normal      |
| 1984 - 1985 | 3            | Below normal      | 2014 - 2015 | 1            | Much below normal |
| 1985 - 1986 | 1            | Much below normal | 2015 - 2016 | 1            | Much below normal |
| 1986 - 1987 | 3            | Below normal      | 2016 - 2017 | 2            | Much below normal |
| 1987 - 1988 | 6            | Near normal       | 2017 - 2018 | 4            | Below normal      |
| 1988 - 1989 | 6            | Near normal       | 2018 - 2019 | 1            | Much below normal |
| 1989 - 1990 | 7            | Above normal      | 2019 - 2020 | 10           | Much above normal |
| 1990 - 1991 | 8            | Above normal      |             |              |                   |

**Table 4.18(b) :Decadal Statistics of drought and wet years of Nandgaon tehsil according to Decile method.**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 2                 | 1            | 0           | 3            | 3                 |
| 1970-1979  | 1                 | 2            | 4           | 2            | 1                 |
| 1980- 1989 | 2                 | 4            | 3           | 1            | 0                 |
| 1990 -1999 | 0                 | 2            | 2           | 3            | 3                 |
| 2000- 2009 | 2                 | 2            | 1           | 2            | 3                 |
| 2010- 2019 | 5                 | 1            | 1           | 1            | 2                 |

#### 4.3.9 Precipitation Deciles of Nashik Tehsil

For Nashik tehsil, Deciles were computed from the long term historical rainfall data of 22 years (1998-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.19(a) it is observed that there were 9 drought events in the period of 1998-2019. Much below normal (Deciles 1-2) condition was observed for 5 years (2009,2011,2012,2015,2018). Much above normal (Deciles 9-10) condition was observed for 5 years (2005,2006,2008,2016, and 2019). It is also observed From Table 4.19(b) that the frequency of the drought event is increasing in the last decade as compared to previous decade (7 drought events in last decade as compared to 2 in previous decade) .which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1998-2019 is shown in the Figure 4.24.

**Table4.19(a). Classification of drought conditions according to Deciles in Nashik Tehsil during the period 1998-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1998 - 1999 | 6            | Near normal       | 2009 - 2010 | 1            | Much below normal |
| 1999 - 2000 | 5            | Near normal       | 2010 - 2011 | 4            | Below normal      |
| 2000 - 2001 | 5            | Near normal       | 2011 - 2012 | 2            | Much below normal |
| 2001 - 2002 | 3            | Below normal      | 2012 - 2013 | 1            | Much below normal |
| 2002 - 2003 | 6            | Near normal       | 2013 - 2014 | 4            | Below normal      |
| 2003 - 2004 | 7            | Above normal      | 2014 - 2015 | 3            | Below normal      |
| 2004 - 2005 | 8            | Above normal      | 2015 - 2016 | 2            | Much below normal |
| 2005 - 2006 | 10           | Much above normal | 2016 - 2017 | 9            | Much above normal |
| 2006 - 2007 | 10           | Much above normal | 2017 - 2018 | 8            | Above normal      |
| 2007 - 2008 | 7            | Above normal      | 2018 - 2019 | 1            | Much below normal |
| 2008 - 2009 | 10           | Much above normal | 2019 - 2020 | 9            | Much above normal |

**Table4.19(b) :Decadal Statistics of drought and wet years of Nashik tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 2000- 2009 | 1                 | 1            | 2           | 3            | 3                 |
| 2010- 2019 | 4                 | 3            | 0           | 1            | 2                 |

#### 4.3.10 Precipitation Deciles of Niphad Tehsil

For Niphad tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.20(a) it is observed that there were 24 drought events in the period of 1980-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1961,1964,1966,1972,1973,1974,1984,1985,1986,1991,2011,2018). Much above normal (Deciles 9-10) condition was observed for 12 years (1976,1996,1997,1998,1999,2004,2005,2006,2007,2008,2010, and 2019). It is also observed from Table 4.20(b) that the frequency of the wet event is increasing in the last two decade as compared to previous decades(12 wet events in last two decades) which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the impacts of extreme events. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.25.

**Table 4.20(a). Classification of drought conditions according to Deciles in Niphad Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 2            | Much below normal | 1991 - 1992 | 1            | Much below normal |
| 1962 - 1963 | 3            | Below normal      | 1992 - 1993 | 6            | Near normal       |
| 1963 - 1964 | 4            | Below normal      | 1993 - 1994 | 8            | Above normal      |
| 1964 - 1965 | 2            | Much below normal | 1994 - 1995 | 7            | Above normal      |
| 1965 - 1966 | 5            | Near normal       | 1995 - 1996 | 7            | Above normal      |
| 1966 - 1967 | 1            | Much below normal | 1996 - 1997 | 9            | Much above normal |
| 1967 - 1968 | 4            | Below normal      | 1997 - 1998 | 10           | Much above normal |
| 1968 - 1969 | 5            | Near normal       | 1998 - 1999 | 9            | Much above normal |
| 1969 - 1970 | 8            | Above normal      | 1999 - 2000 | 9            | Much above normal |
| 1970 - 1971 | 3            | Below normal      | 2000 - 2001 | 6            | Near normal       |
| 1971 - 1972 | 3            | Below normal      | 2001 - 2002 | 5            | Near normal       |
| 1972 - 1973 | 1            | Much below normal | 2002 - 2003 | 8            | Above normal      |
| 1973 - 1974 | 2            | Much below normal | 2003 - 2004 | 7            | Above normal      |
| 1974 - 1975 | 1            | Much below normal | 2004 - 2005 | 10           | Much above normal |
| 1975 - 1976 | 4            | Below normal      | 2005 - 2006 | 10           | Much above normal |
| 1976 - 1977 | 9            | Much above normal | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 3            | Below normal      | 2007 - 2008 | 10           | Much above normal |
| 1978 - 1979 | 6            | Near normal       | 2008 - 2009 | 9            | Much above normal |

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1979 - 1980 | 8            | Above normal      | 2009 - 2010 | 7            | Above normal      |
| 1980 - 1981 | 8            | Above normal      | 2010 - 2011 | 9            | Much above normal |
| 1981 - 1982 | 3            | Below normal      | 2011 - 2012 | 2            | Much below normal |
| 1982 - 1983 | 5            | Near normal       | 2012 - 2013 | 5            | Near normal       |
| 1983 - 1984 | 6            | Near normal       | 2013 - 2014 | 6            | Near normal       |
| 1984 - 1985 | 1            | Much below normal | 2014 - 2015 | 4            | Below normal      |
| 1985 - 1986 | 2            | Much below normal | 2015 - 2016 | 4            | Below normal      |
| 1986 - 1987 | 2            | Much below normal | 2016 - 2017 | 8            | Above normal      |
| 1987 - 1988 | 7            | Above normal      | 2017 - 2018 | 8            | Above normal      |
| 1988 - 1989 | 6            | Near normal       | 2018 - 2019 | 1            | Much below normal |
| 1989 - 1990 | 3            | Below normal      | 2019 - 2020 | 10           | Much above normal |
| 1990 - 1991 | 4            | Below normal      |             |              |                   |

**Table 4.20(b) :Decadaal Statistics of drought and wet years of Niphad tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 3                 | 3            | 2           | 1            | 0                 |
| 1970-1979  | 3                 | 4            | 1           | 1            | 1                 |
| 1980- 1989 | 3                 | 2            | 3           | 2            | 0                 |
| 1990 -1999 | 1                 | 1            | 1           | 3            | 4                 |
| 2000- 2009 | 0                 | 0            | 2           | 3            | 5                 |
| 2010- 2019 | 2                 | 2            | 2           | 2            | 2                 |

#### 4.3.11 Precipitation Deciles of Peth Tehsil

For Peth tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.21(a) it is observed that there were 24 drought events in the period of 1980-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1961, 1965, 1968, 1974, 1979, 1986, 1987, 1995, 2000, 2009, 2014, 2015). Much above normal (Deciles 9-10) condition was observed for 12 years (1966, 1973, 1976, 1981, 1990, 1991, 1992, 1994, 2004, 2005, 2006, and 2019). From Table 4.21(b) It is also observed that the frequency of the drought event is increasing in the last two decades as compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to change the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.26.

**Table 4.21(a). Classification of drought conditions according to Deciles in Peth Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 2            | Much below normal | 1991 - 1992 | 9            | Much above normal |
| 1962 - 1963 | 3            | Below normal      | 1992 - 1993 | 9            | Much above normal |
| 1963 - 1964 | 8            | Above normal      | 1993 - 1994 | 7            | Above normal      |
| 1964 - 1965 | 6            | Near normal       | 1994 - 1995 | 10           | Much above normal |
| 1965 - 1966 | 1            | Much below normal | 1995 - 1996 | 2            | Much below normal |
| 1966 - 1967 | 9            | Much above normal | 1996 - 1997 | 4            | Below normal      |
| 1967 - 1968 | 3            | Below normal      | 1997 - 1998 | 6            | Near normal       |
| 1968 - 1969 | 1            | Much below normal | 1998 - 1999 | 7            | Above normal      |
| 1969 - 1970 | 8            | Above normal      | 1999 - 2000 | 5            | Near normal       |
| 1970 - 1971 | 8            | Above normal      | 2000 - 2001 | 1            | Much below normal |
| 1971 - 1972 | 6            | Near normal       | 2001 - 2002 | 3            | Below normal      |
| 1972 - 1973 | 5            | Near normal       | 2002 - 2003 | 4            | Below normal      |
| 1973 - 1974 | 10           | Much above normal | 2003 - 2004 | 6            | Near normal       |
| 1974 - 1975 | 1            | Much below normal | 2004 - 2005 | 9            | Much above normal |
| 1975 - 1976 | 7            | Above normal      | 2005 - 2006 | 10           | Much above normal |
| 1976 - 1977 | 10           | Much above normal | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 8            | Above normal      | 2007 - 2008 | 6            | Near normal       |
| 1978 - 1979 | 5            | Near normal       | 2008 - 2009 | 7            | Above normal      |
| 1979 - 1980 | 1            | Much below normal | 2009 - 2010 | 2            | Much below normal |
| 1980 - 1981 | 7            | Above normal      | 2010 - 2011 | 4            | Below normal      |
| 1981 - 1982 | 9            | Much above normal | 2011 - 2012 | 4            | Below normal      |
| 1982 - 1983 | 3            | Below normal      | 2012 - 2013 | 3            | Below normal      |
| 1983 - 1984 | 8            | Above normal      | 2013 - 2014 | 5            | Near normal       |
| 1984 - 1985 | 4            | Below normal      | 2014 - 2015 | 2            | Much below normal |
| 1985 - 1986 | 3            | Below normal      | 2015 - 2016 | 1            | Much below normal |
| 1986 - 1987 | 2            | Much below normal | 2016 - 2017 | 6            | Near normal       |
| 1987 - 1988 | 2            | Much below normal | 2017 - 2018 | 7            | Above normal      |
| 1988 - 1989 | 8            | Above normal      | 2018 - 2019 | 5            | Near normal       |
| 1989 - 1990 | 4            | Below normal      | 2019 - 2020 | 9            | Much above normal |
| 1990 - 1991 | 10           | Much above normal |             |              |                   |

**Table 4.21(b) :Decadal Statistics of drought and wet years of Peth tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 3                 | 2            | 1           | 2            | 1                 |
| 1970-1979  | 2                 | 0            | 3           | 3            | 2                 |
| 1980- 1989 | 2                 | 4            | 0           | 3            | 1                 |
| 1990 -1999 | 1                 | 1            | 2           | 2            | 4                 |
| 2000- 2009 | 2                 | 2            | 2           | 1            | 3                 |
| 2010- 2019 | 2                 | 3            | 3           | 1            | 1                 |

#### 4.3.12 Precipitation Deciles of Sinnar Tehsil

For Sinnar tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1980-2019) and historical drought events were identified which fall under deciles 1-2 and 3-

4. From the Table 4.22(a) it is observed that there were 24 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1972,1982,1984,1985,1986,1993,1996,2001,2011,2014,2015,2018). Much above normal (Deciles 9-10) condition was observed for 12 years (1961,1963,1965,1967,1969,1973,1974,1976,1995,2006,2010, and 2019). It is also observed from Table 4.22(b) that the frequency of the drought event is increasing in the last decade as compared to previous decade . drought events are increase after 1980. which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.27.

**Table 4.22(a). Classification of drought conditions according to Deciles in Sinnar Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 9            | Much above normal | 1991 - 1992 | 7            | Above normal      |
| 1962 - 1963 | 5            | Near normal       | 1992 - 1993 | 3            | Below normal      |
| 1963 - 1964 | 10           | Much above normal | 1993 - 1994 | 1            | Much below normal |
| 1964 - 1965 | 6            | Near normal       | 1994 - 1995 | 4            | Below normal      |
| 1965 - 1966 | 9            | Much above normal | 1995 - 1996 | 10           | Much above normal |
| 1966 - 1967 | 4            | Below normal      | 1996 - 1997 | 2            | Much below normal |
| 1967 - 1968 | 9            | Much above normal | 1997 - 1998 | 6            | Near normal       |
| 1968 - 1969 | 8            | Above normal      | 1998 - 1999 | 8            | Above normal      |
| 1969 - 1970 | 10           | Much above normal | 1999 - 2000 | 8            | Above normal      |
| 1970 - 1971 | 6            | Near normal       | 2000 - 2001 | 5            | Near normal       |
| 1971 - 1972 | 3            | Below normal      | 2001 - 2002 | 2            | Much below normal |
| 1972 - 1973 | 1            | Much below normal | 2002 - 2003 | 3            | Below normal      |
| 1973 - 1974 | 9            | Much above normal | 2003 - 2004 | 7            | Above normal      |
| 1974 - 1975 | 10           | Much above normal | 2004 - 2005 | 7            | Above normal      |
| 1975 - 1976 | 4            | Below normal      | 2005 - 2006 | 6            | Near normal       |
| 1976 - 1977 | 9            | Much above normal | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 7            | Above normal      | 2007 - 2008 | 7            | Above normal      |
| 1978 - 1979 | 5            | Near normal       | 2008 - 2009 | 7            | Above normal      |
| 1979 - 1980 | 8            | Above normal      | 2009 - 2010 | 8            | Above normal      |
| 1980 - 1981 | 6            | Near normal       | 2010 - 2011 | 9            | Much above normal |
| 1981 - 1982 | 8            | Above normal      | 2011 - 2012 | 2            | Much below normal |
| 1982 - 1983 | 2            | Much below normal | 2012 - 2013 | 3            | Below normal      |
| 1983 - 1984 | 4            | Below normal      | 2013 - 2014 | 3            | Below normal      |
| 1984 - 1985 | 1            | Much below normal | 2014 - 2015 | 1            | Much below normal |
| 1985 - 1986 | 1            | Much below normal | 2015 - 2016 | 2            | Much below normal |
| 1986 - 1987 | 2            | Much below normal | 2016 - 2017 | 5            | Near normal       |
| 1987 - 1988 | 4            | Below normal      | 2017 - 2018 | 6            | Near normal       |
| 1988 - 1989 | 4            | Below normal      | 2018 - 2019 | 1            | Much below normal |
| 1989 - 1990 | 4            | Below normal      | 2019 - 2020 | 10           | Much above normal |
| 1990 - 1991 | 5            | Near normal       |             |              |                   |

**Table 4.22(b) :Decadal Statistics of drought and wet years of Sinnar tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 0                 | 1            | 2           | 1            | 5                 |
| 1970-1979  | 1                 | 2            | 2           | 2            | 8                 |
| 1980- 1989 | 4                 | 4            | 1           | 1            | 0                 |
| 1990 -1999 | 2                 | 2            | 2           | 3            | 1                 |
| 2000- 2009 | 1                 | 1            | 2           | 5            | 1                 |
| 2010- 2019 | 4                 | 2            | 2           | 0            | 2                 |

#### 4.3.13 Precipitation Deciles of Surgana Tehsil

For Surgana tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1980-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.23(a) it is observed that there were 24 drought events in the period of 1961-2019. Much below normal (Deciles 1-2) condition was observed for 12 years (1962,1966,1968,1971,1972,1974,1986,2000,2009,2014,2015,2016). Much above normal (Deciles 9-10) condition was observed for 12 years (1969,1973,1976,1979,1981,1982,1983,1988,1994,2004,2005,2006). From Table 4.23(b)It is also observed that the frequency of the drought event is increasing in the last decade as compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.28

**Table 4.23(a). Classification of drought conditions according to Deciles in Surgana Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 6            | Near normal       | 1991 - 1992 | 4            | Below normal      |
| 1962 - 1963 | 2            | Much below normal | 1992 - 1993 | 6            | Near normal       |
| 1963 - 1964 | 4            | Below normal      | 1993 - 1994 | 7            | Above normal      |
| 1964 - 1965 | 5            | Near normal       | 1994 - 1995 | 10           | Much above normal |
| 1965 - 1966 | 5            | Near normal       | 1995 - 1996 | 3            | Below normal      |
| 1966 - 1967 | 1            | Much below normal | 1996 - 1997 | 7            | Above normal      |
| 1967 - 1968 | 3            | Below normal      | 1997 - 1998 | 6            | Near normal       |
| 1968 - 1969 | 2            | Much below normal | 1998 - 1999 | 5            | Near normal       |
| 1969 - 1970 | 9            | Much above normal | 1999 - 2000 | 8            | Above normal      |
| 1970 - 1971 | 5            | Near normal       | 2000 - 2001 | 1            | Much below normal |
| 1971 - 1972 | 1            | Much below normal | 2001 - 2002 | 4            | Below normal      |
| 1972 - 1973 | 2            | Much below normal | 2002 - 2003 | 8            | Above normal      |
| 1973 - 1974 | 9            | Much above normal | 2003 - 2004 | 6            | Near normal       |
| 1974 - 1975 | 2            | Much below normal | 2004 - 2005 | 9            | Much above normal |
| 1975 - 1976 | 4            | Below normal      | 2005 - 2006 | 10           | Much above normal |
| 1976 - 1977 | 10           | Much above normal | 2006 - 2007 | 9            | Much above normal |
| 1977 - 1978 | 8            | Above normal      | 2007 - 2008 | 7            | Above normal      |

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1978 - 1979 | 8            | Above normal      | 2008 - 2009 | 7            | Above normal      |
| 1979 - 1980 | 9            | Much above normal | 2009 - 2010 | 2            | Much below normal |
| 1980 - 1981 | 8            | Above normal      | 2010 - 2011 | 3            | Below normal      |
| 1981 - 1982 | 10           | Much above normal | 2011 - 2012 | 6            | Near normal       |
| 1982 - 1983 | 9            | Much above normal | 2012 - 2013 | 4            | Below normal      |
| 1983 - 1984 | 10           | Much above normal | 2013 - 2014 | 6            | Near normal       |
| 1984 - 1985 | 5            | Near normal       | 2014 - 2015 | 1            | Much below normal |
| 1985 - 1986 | 3            | Below normal      | 2015 - 2016 | 1            | Much below normal |
| 1986 - 1987 | 2            | Much below normal | 2016 - 2017 | 1            | Much below normal |
| 1987 - 1988 | 3            | Below normal      | 2017 - 2018 | 7            | Above normal      |
| 1988 - 1989 | 10           | Much above normal | 2018 - 2019 | 4            | Below normal      |
| 1989 - 1990 | 3            | Below normal      | 2019 - 2020 | 8            | Above normal      |
| 1990 - 1991 | 7            | Above normal      |             |              |                   |

**Table 4.23(b) :Decadal Statistics of drought and wet years of Surgana tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 3                 | 2            | 3           | 0            | 1                 |
| 1970-1979  | 3                 | 1            | 1           | 2            | 3                 |
| 1980- 1989 | 1                 | 3            | 1           | 1            | 4                 |
| 1990 -1999 | 0                 | 2            | 3           | 4            | 1                 |
| 2000- 2009 | 2                 | 1            | 1           | 3            | 3                 |
| 2010- 2019 | 3                 | 3            | 2           | 2            | 0                 |

#### 4.3.14 Precipitation Deciles of Trimbakeshwar tehsil

For Trimbakeshwar tehsil, Deciles were computed from the long term historical rainfall data of 59 years (1961-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.24(a) it is observed that there were 24 drought events in the period of 1980-2019. Much below normal (Deciles 1-2) condition was observed for 12 year(1962,1973,1975,1984,1987,1989,1995,1998,2000,2009,2012,2015). Much above normal (Deciles 9-10) condition was observed for 12 years (1969,1970,1980,1981,1982,1988,1994,2005,2006,2007,2017, and 2019).From 4.24(b) It is also observed that the frequency of the drought event is increasing in the last decade as compared to previous decades which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1961-2019 is shown in the Figure 4.29.

**Table 4.24(a). Classification of drought conditions according to Deciles in Trimbakeshwar Tehsil during the period 1961-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1961 - 1962 | 4            | below normal      | 1991 - 1992 | 3            | below normal      |
| 1962 - 1963 | 2            | Much below normal | 1992 - 1993 | 4            | below normal      |
| 1963 - 1964 | 7            | Above normal      | 1993 - 1994 | 6            | Near normal       |
| 1964 - 1965 | 8            | Above normal      | 1994 - 1995 | 10           | Much above normal |
| 1965 - 1966 | 8            | Above normal      | 1995 - 1996 | 1            | Much below normal |
| 1966 - 1967 | 7            | Above normal      | 1996 - 1997 | 6            | Near normal       |
| 1967 - 1968 | 4            | below normal      | 1997 - 1998 | 5            | Near normal       |
| 1968 - 1969 | 5            | Near normal       | 1998 - 1999 | 1            | Much below normal |
| 1969 - 1970 | 9            | Much above normal | 1999 - 2000 | 5            | Near normal       |
| 1970 - 1971 | 9            | Much above normal | 2000 - 2001 | 2            | Much below normal |
| 1971 - 1972 | 4            | below normal      | 2001 - 2002 | 4            | below normal      |
| 1972 - 1973 | 7            | Above normal      | 2002 - 2003 | 6            | Near normal       |
| 1973 - 1974 | 1            | Much below normal | 2003 - 2004 | 7            | Above normal      |
| 1974 - 1975 | 5            | Near normal       | 2004 - 2005 | 8            | Above normal      |
| 1975 - 1976 | 2            | Much below normal | 2005 - 2006 | 10           | Much above normal |
| 1976 - 1977 | 4            | below normal      | 2006 - 2007 | 10           | Much above normal |
| 1977 - 1978 | 6            | Near normal       | 2007 - 2008 | 9            | Much above normal |
| 1978 - 1979 | 8            | Above normal      | 2008 - 2009 | 7            | Above normal      |
| 1979 - 1980 | 8            | Above normal      | 2009 - 2010 | 1            | Much below normal |
| 1980 - 1981 | 10           | Much above normal | 2010 - 2011 | 3            | below normal      |
| 1981 - 1982 | 10           | Much above normal | 2011 - 2012 | 3            | below normal      |
| 1982 - 1983 | 9            | Much above normal | 2012 - 2013 | 2            | Much below normal |
| 1983 - 1984 | 7            | Above normal      | 2013 - 2014 | 6            | Near normal       |
| 1984 - 1985 | 1            | Much below normal | 2014 - 2015 | 3            | below normal      |
| 1985 - 1986 | 3            | below normal      | 2015 - 2016 | 1            | Much below normal |
| 1986 - 1987 | 3            | below normal      | 2016 - 2017 | 8            | Above normal      |
| 1987 - 1988 | 2            | Much below normal | 2017 - 2018 | 9            | Much above normal |
| 1988 - 1989 | 10           | Much above normal | 2018 - 2019 | 6            | Near normal       |
| 1989 - 1990 | 2            | Much below normal | 2019 - 2020 | 9            | Much above normal |
| 1990 - 1991 | 5            | Near normal       |             |              |                   |

**Table 4.24(b) : Statistics of drought and wet years of Trimbakeshwar tehsil according to Decile method.**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 1961-1969  | 1                 | 2            | 1           | 4            | 1                 |
| 1970-1979  | 2                 | 2            | 2           | 3            | 1                 |
| 1980- 1989 | 3                 | 2            | 0           | 1            | 4                 |
| 1990 -1999 | 2                 | 2            | 5           | 0            | 1                 |
| 2000- 2009 | 2                 | 1            | 1           | 3            | 3                 |
| 2010- 2019 | 2                 | 3            | 2           | 1            | 2                 |

### 4.3.15 Precipitation Deciles of Yevla Tehsil

For Yevla tehsil, Deciles were computed from the long term historical rainfall data of 22 years (1998-2019) and historical drought events were identified which fall under deciles 1-2 and 3-4. From the Table 4.25(a) it is observed that there were 9 drought events in the period of 1998-2019. Much below normal (Deciles 1-2) condition was observed for 5 years (2002,2003,2014,2015,2018). Much above normal (Deciles 9-10) condition was observed for 5 years (2004,2006,2007,2008,2010).From Table4.25(b) It is also observed that the frequency of the drought event is increasing (almost double) in the last decade as compared to previous decade which may become very severe in the upcoming decade. This is an alert to the agriculture system to changes the cropping pattern and water management at field level for the sustainable crop production and mitigate the drought impacts. The graphical representation of precipitation deciles for the period of 1998-2019 is shown in the Figure 4.30.

**Table 4.25(a). Classification of drought conditions according to Deciles in Yevla Tehsil during the period 1998-2019.**

| Year        | Decile Index | Drought Condition | Year        | Decile Index | Drought Condition |
|-------------|--------------|-------------------|-------------|--------------|-------------------|
| 1998 - 1999 | 8            | Above Normal      | 2009 - 2010 | 6            | Near Normal       |
| 1999 - 2000 | 8            | Above Normal      | 2010 - 2011 | 10           | Much Above Normal |
| 2000 - 2001 | 5            | Near Normal       | 2011 - 2012 | 7            | Above Normal      |
| 2001 - 2002 | 4            | Below normal      | 2012 - 2013 | 4            | Below normal      |
| 2002 - 2003 | 2            | Much below normal | 2013 - 2014 | 3            | Below normal      |
| 2003 - 2004 | 2            | Much below normal | 2014 - 2015 | 1            | Much below normal |
| 2004 - 2005 | 10           | Much Above Normal | 2015 - 2016 | 1            | Much below normal |
| 2005 - 2006 | 6            | Near Normal       | 2016 - 2017 | 3            | Below normal      |
| 2006 - 2007 | 10           | Much Above Normal | 2017 - 2018 | 5            | Near Normal       |
| 2007 - 2008 | 9            | Much Above Normal | 2018 - 2019 | 1            | Much below normal |
| 2008 - 2009 | 9            | Much Above Normal | 2019 - 2020 | 7            | Above Normal      |

**Table4.25(b) :Decadal Statistics of drought and wet years of Yevla tehsil according to Decile method**

| Period     | Much Below Normal | Below Normal | Near Normal | Above Normal | Much Above Normal |
|------------|-------------------|--------------|-------------|--------------|-------------------|
| 2000- 2009 | 2                 | 1            | 3           | 0            | 4                 |
| 2010- 2019 | 3                 | 3            | 1           | 2            | 1                 |

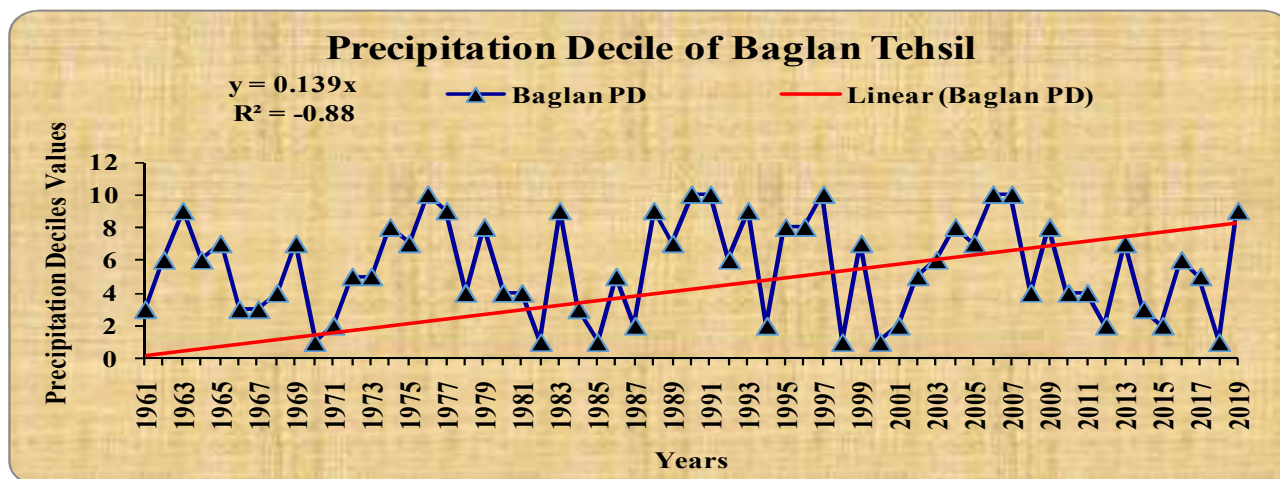


Fig 4.16. Drought conditions according to Deciles in Baglan Tehsil during the period 1961-2019.

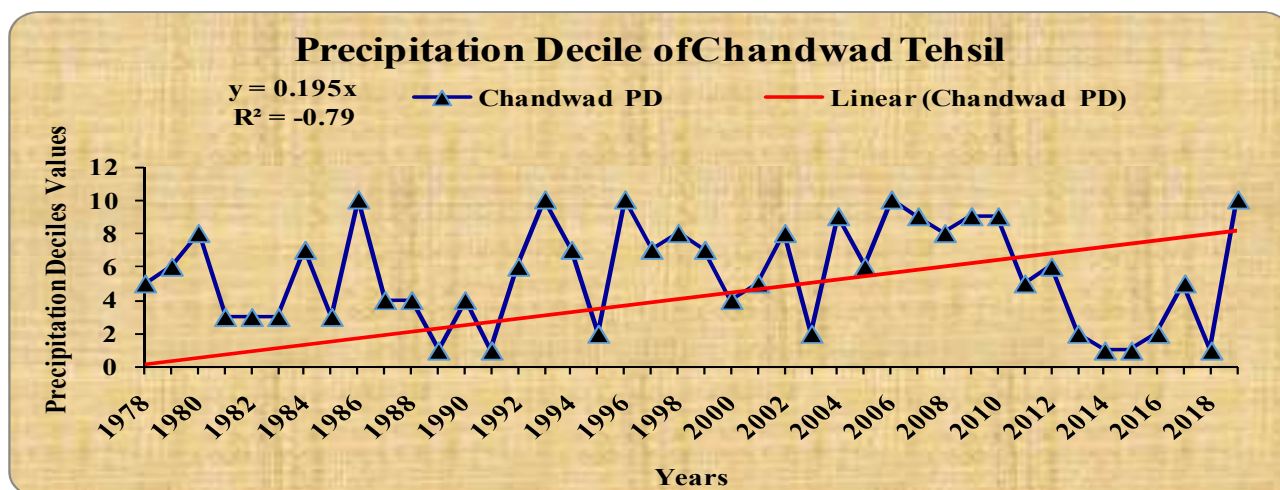


Fig 4.17. Drought conditions according to Deciles in Chandwad Tehsil during the period 1978-2019.

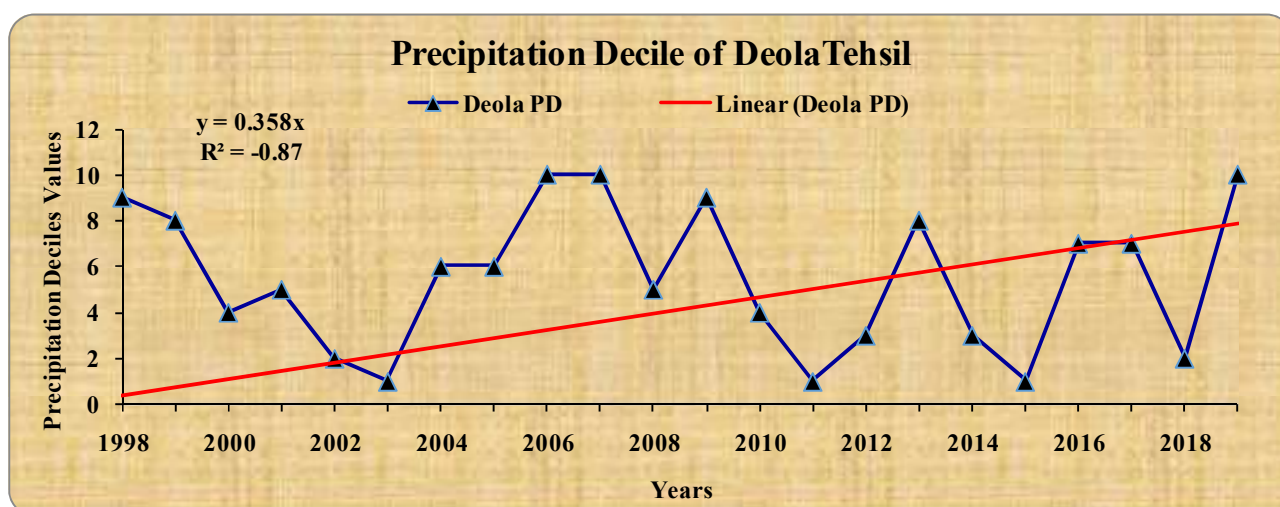


Fig4.18. Drought conditions according to Deciles in Deola Tehsil during the period 1980-2019.

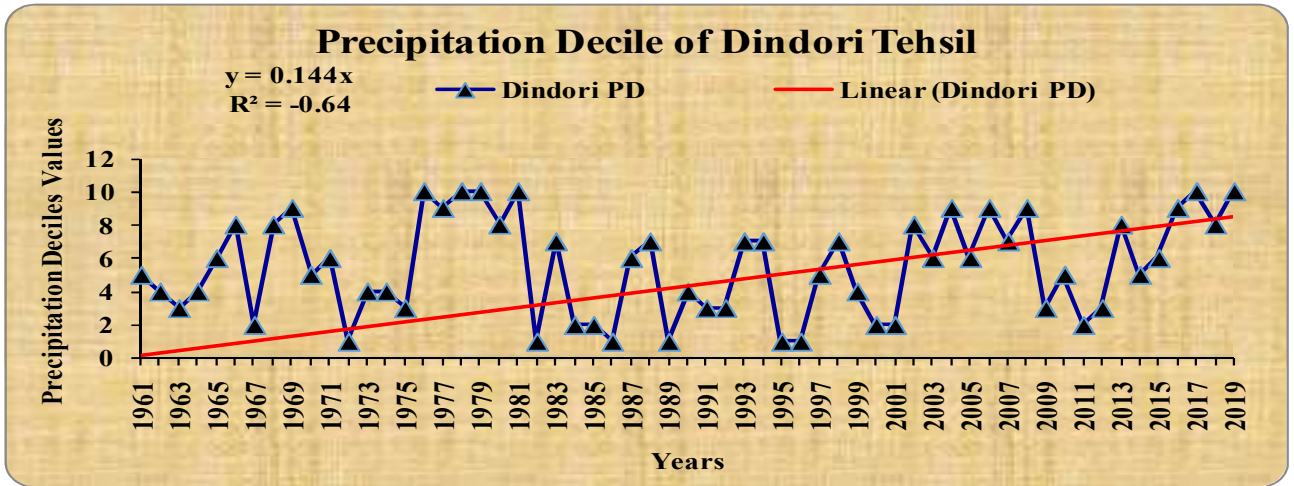


Fig 4.19 Drought conditions according to Deciles in Dindori Tehsil during the period 1961-2019.

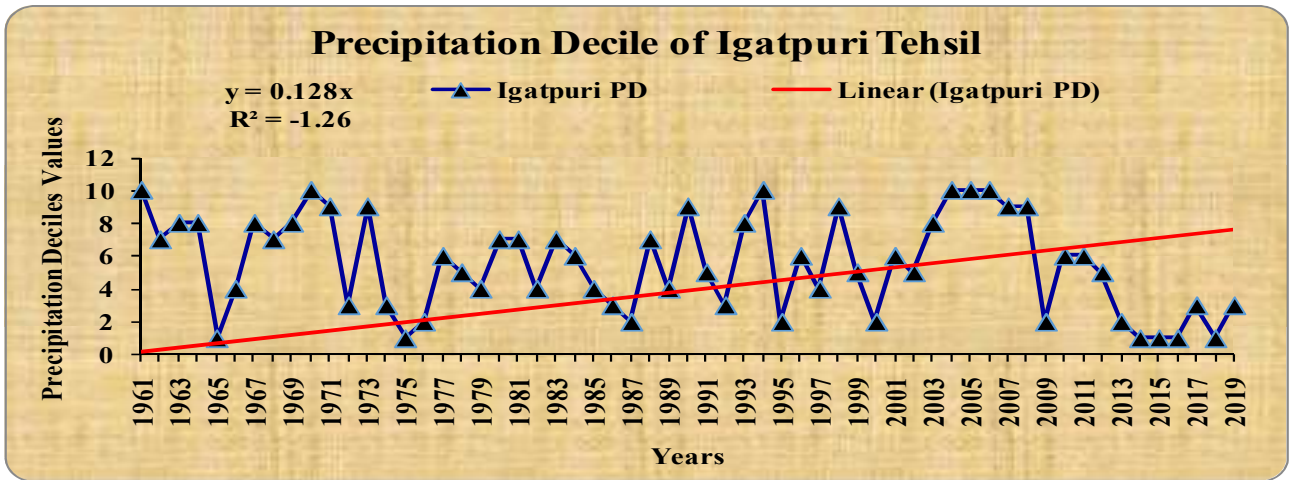


Fig 4.20 Drought conditions according to Deciles in Igatpuri Tehsil during the period 1961-2019.

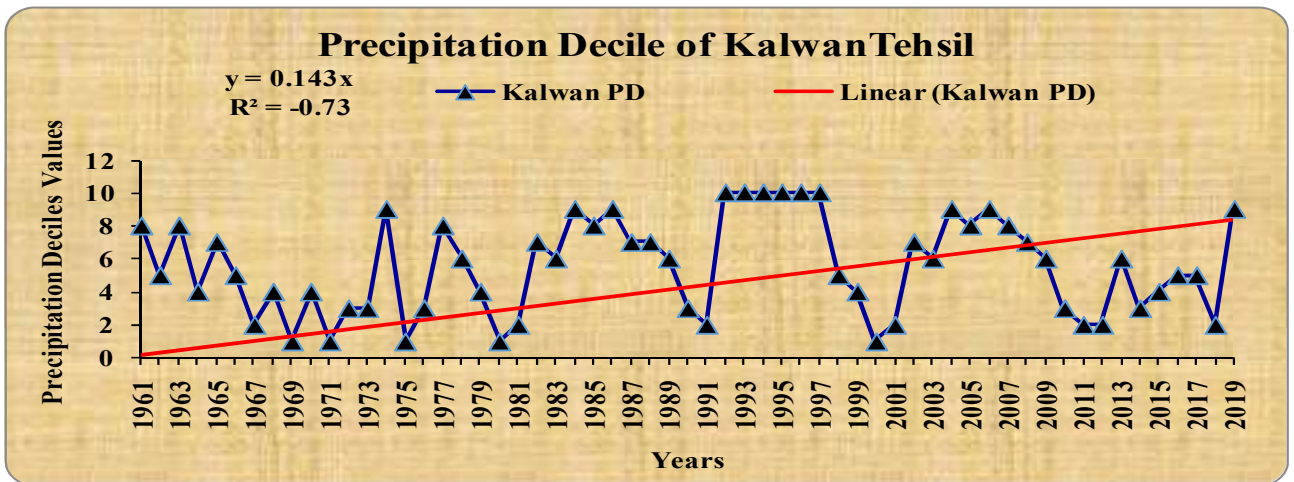


Fig4.21. Drought conditions according to Deciles in Kalwan Tehsil during the period 1961-2019

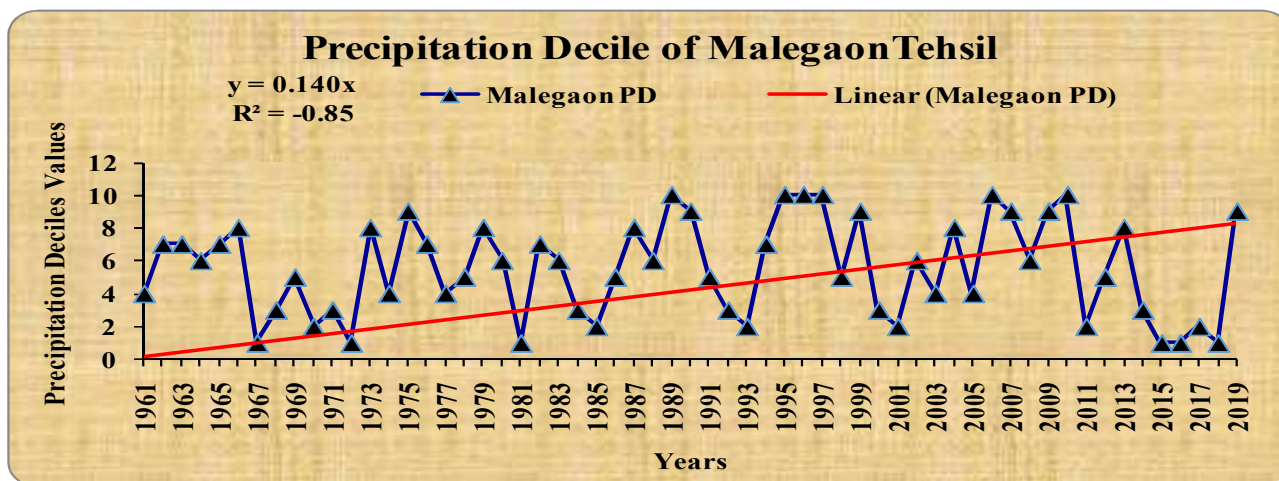


Fig.4.22 Drought conditions according to Deciles in Malegaon Tehsil during the period 1961-2019.

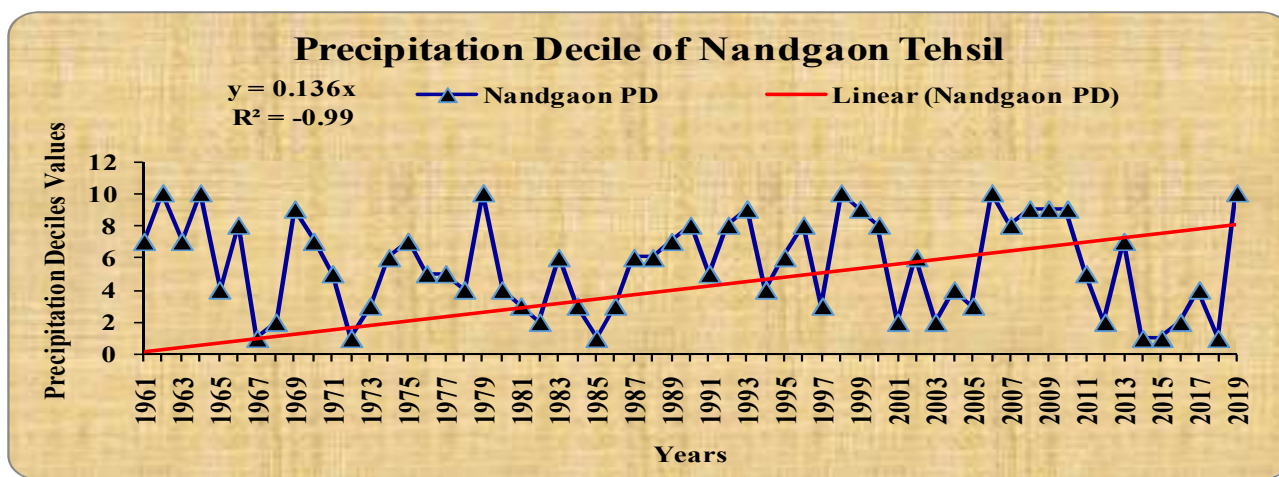


Fig. 4.23 Drought conditions according to Deciles in Nandgaon Tehsil during the period 1961-2019.

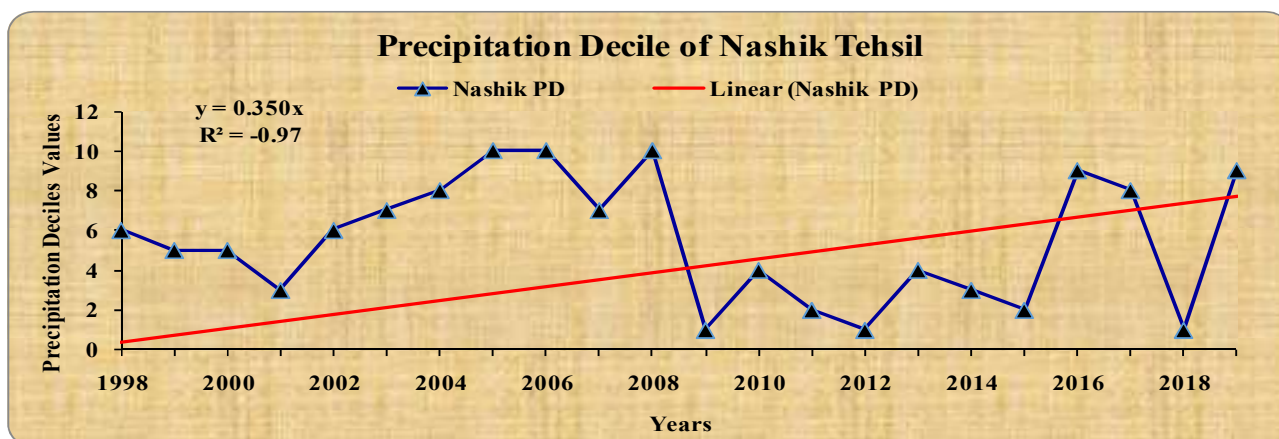


Fig.4.24 Drought conditions according to Deciles in Nashik Tehsil during the period 1998-2019.

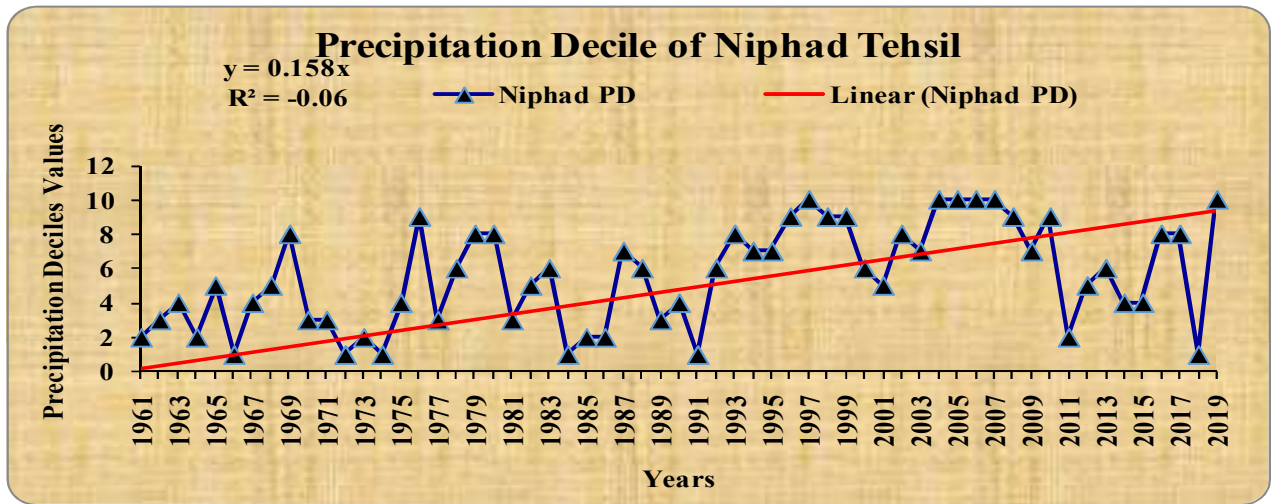


Fig 4.25 Drought conditions according to Deciles in Niphad Tehsil during the period 1961-2019.

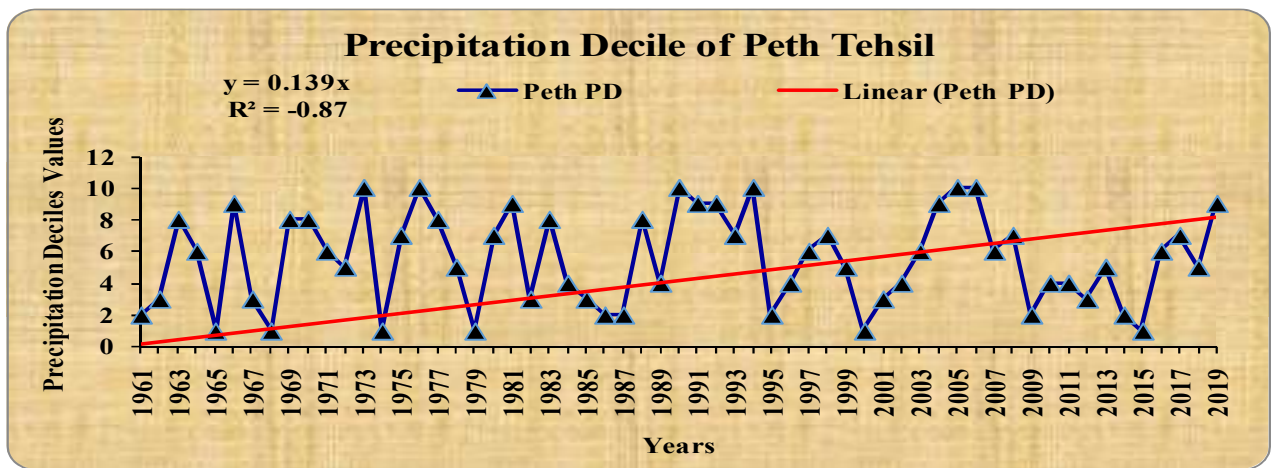


Fig. 4.26. Drought conditions according to Deciles in Peth Tehsil during the period 1961-2019.

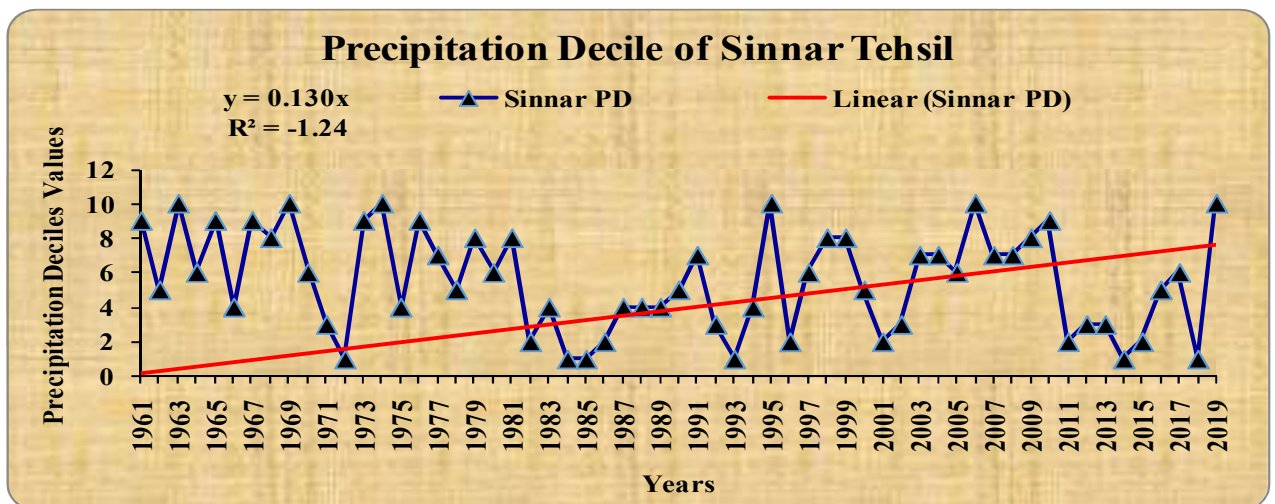


Fig. 4.27. Drought conditions according to Deciles in Sinnar Tehsil during the period 1961-2019.

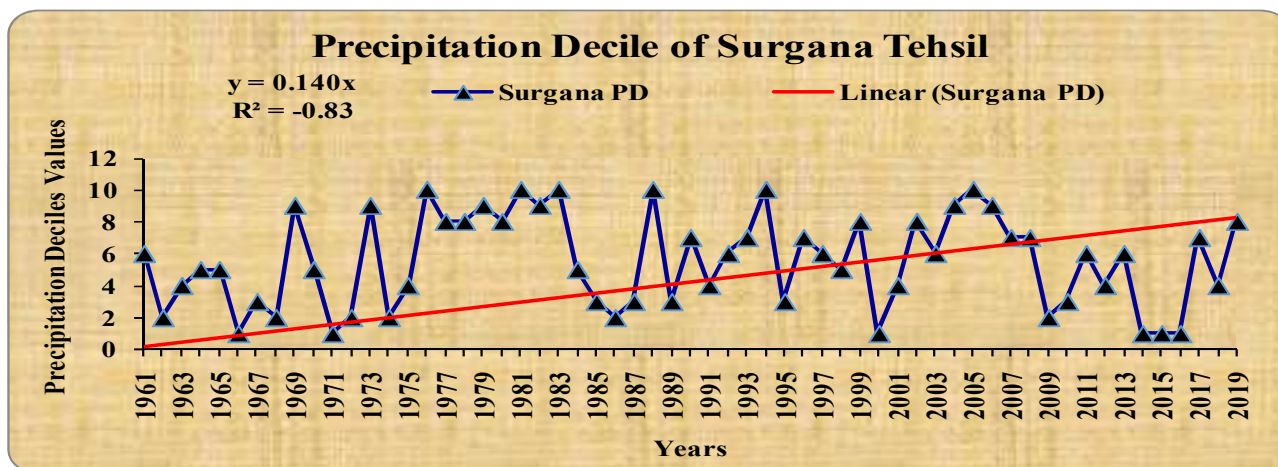


Fig. 4.28. Drought conditions according to Deciles in Surgana Tehsil during the period 1961-2019.

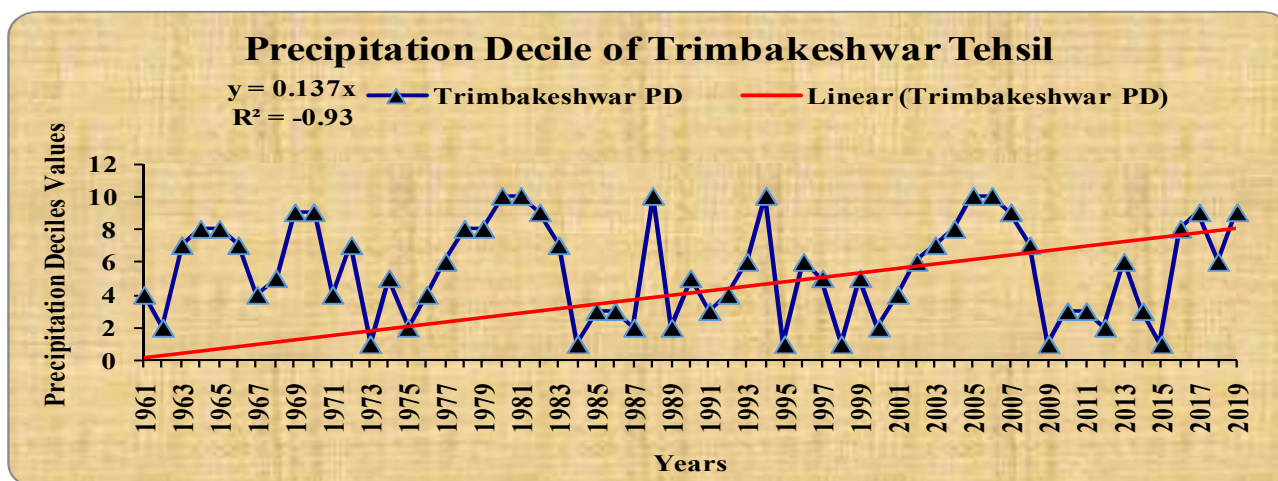


Fig. 4.29. Drought conditions according to Deciles in Trimbakeshwar Tehsil during the period 1961-2019.

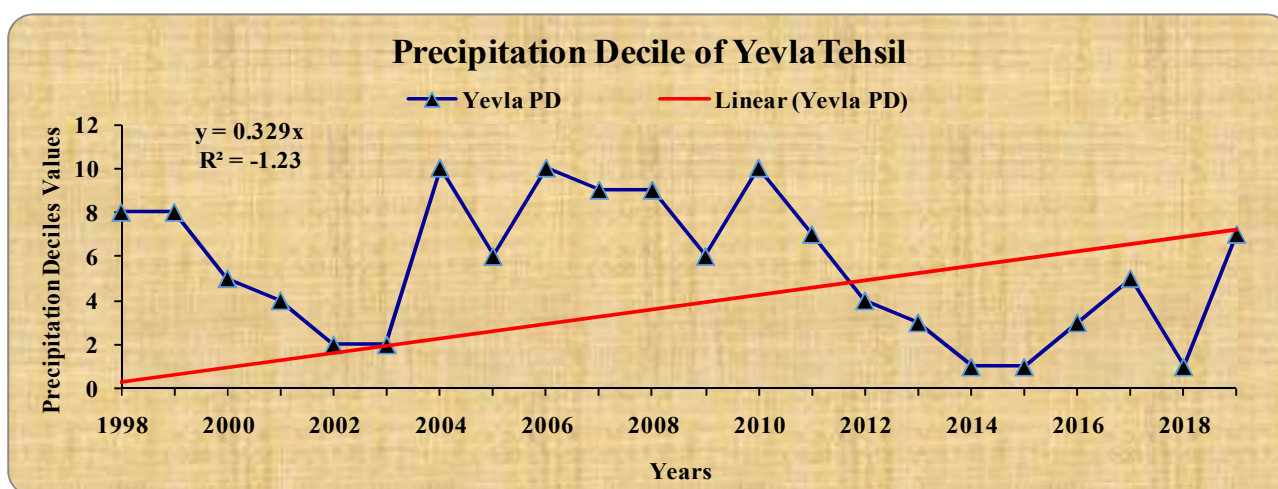


Fig.4.30. Drought conditions according to Deciles in Yevla Tehsil during the period 1998-2019.

#### 4.4 Onset and withdrawal of monsoon

The onset and withdrawal of rainy season was computed from mean weekly rainfall data by forward and backward accumulation methods as per the procedure suggested by ( Babu and Lakshminarayanan1997).

In this method weekly rainfall was summed by forward accumulation (20+21+...+52 weeks) until a certain amount of rainfall was accumulated. Seventy five millimeters of rainfall accumulation has been considered as the onset time for the growing season of dry seeded crops and land preparation (Babu and Lakshminarayana, 1997; Panigrahi and Panda, 2002). The withdrawal of rainy season was determined by backward accumulation of rainfall (48+47+46+...+30 weeks) data. Twenty millimeters of rainfall accumulation was chosen for the end of rainy season, which is sufficient for ploughing of fields after harvesting the crops (Babu and Lakshminarayana, 1997).

By considering prevailing rainfall condition of selected area, 70 millimeter of rainfall accumulation has been considered as the onset time and 20 millimeter rainfall accumulation has been considered as the withdrawal time. For all Tehsils of Nashik district 70 mm rainfall accumulation has been considered for deciding the onset of monsoon. Whereas 20 mm of rainfall accumulation was chosen for the end of rainy season, which is sufficient for ploughing of fields after harvesting the crops.

The results regarding the onset and withdrawal of monsoon for different Tehsils in Nashik district is discussed below.

##### 4.4.1: Onset and withdrawal of monsoon for Baglan Tehsil.

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Baglan is given in Table 4.26. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26 MW (25<sup>th</sup> June – 1<sup>st</sup>July) and mean week of withdrawal is 42<sup>th</sup> MW (15<sup>th</sup>October– 21<sup>th</sup> October). Therefore, mean length of rainy season was found to be 16 weeks (112 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 32 MW (6<sup>th</sup> – 12<sup>th</sup>August), respectively. Similarly , the earliest and delayed week of withdrawal of rainy season was 38 MW (17<sup>th</sup> – 23<sup>rd</sup>September) and 50 MW (10<sup>th</sup> – 16<sup>st</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 24 and 09 weeks, respectively. Probability occurrence of onset of monsoon in 26 MW is 17% which is observed for 10 years when 59 years of data is considered. But when we considered 25MW (18<sup>th</sup> - 24<sup>th</sup> June)and 26 MW (25<sup>th</sup> June –1<sup>st</sup>July) probability occurrence of onset of monsoon is 63% which is observed for 37 years out of total 59 years. Hence from 18<sup>th</sup>

June – 1<sup>st</sup> July there are maximum chances of onset of monsoon during this period in Baglan Tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Maize in the 25 (18<sup>th</sup> - 24<sup>th</sup> June) and 26<sup>th</sup> MW (25<sup>th</sup> June – 1<sup>st</sup> July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.2: Onset and withdrawal of monsoon for Chandwad Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Chandwad is given in Table 4.27. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26 MW (i.e., 25<sup>th</sup> June – 1<sup>st</sup> July) and mean week of withdrawal is 43 MW (i.e., 22<sup>nd</sup> October – 28<sup>th</sup> October). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 31 MW (30<sup>th</sup> July – 5 August), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 36 MW (3<sup>rd</sup> – 9<sup>th</sup> September) and 51 MW (16<sup>th</sup> – 23<sup>rd</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 27 and 08 weeks, respectively. Probability occurrence of onset of monsoon in 26<sup>th</sup> MW is 21.42% which is observed for 9 years when 42 years of data is considered. But when we considered 25 (18<sup>th</sup> - 24<sup>th</sup> June) and 26 MW (25<sup>th</sup> June – 1<sup>st</sup> July), 27<sup>th</sup> MW (2 July - 8 July), probability occurrence of onset of monsoon is 50% which is observed for 21 years out of total 42 years. Hence from 18<sup>th</sup> June – 8<sup>th</sup> July there are maximum chances of onset of monsoon during this period in Chandwad Tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Finger millet, maize in the 25 (8<sup>th</sup> - 24<sup>th</sup> June) and 26 MW (25<sup>th</sup> June – 1<sup>st</sup> July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.3: Onset and withdrawal of monsoon for Deola Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Deola is given in Table 4.28. From the analysis of 59

years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26<sup>th</sup> MW (i.e., 25<sup>th</sup> June – 1<sup>st</sup> July) and mean week of withdrawal is 42<sup>th</sup> MW (i.e., 15<sup>th</sup> October – 21<sup>th</sup> October). Therefore, mean length of rainy season was found to be 16 weeks (112 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 32 MW (6<sup>th</sup> – 12<sup>th</sup> Aug), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 36<sup>th</sup> MW (3<sup>rd</sup> – 9<sup>th</sup> September) and 50 MW (10<sup>th</sup> – 16<sup>th</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 22 and 08 weeks, respectively. Probability occurrence of onset of monsoon in 26 MW is 18.18% which is observed for 4 years when 22 years of data is considered. But when we considered 25<sup>th</sup> (18<sup>th</sup> - 24<sup>th</sup> June) and 26 MW (25<sup>th</sup> June – 1<sup>st</sup> July), 27 MW (2 July - 8 July) probability occurrence of onset of monsoon is 63.63% which is observed for 14 years out of total 22 years. Hence from 18 June – 8 July there are maximum chances of onset of monsoon during this period in Deola tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Finger millet Maize in the 25 (8<sup>th</sup> - 24<sup>th</sup> June) to 27 MW (2 July - 8 July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.4: Onset and withdrawal of monsoon for Dindori Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Dindori is given in Table 4.29. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 25 MW (i.e., 18<sup>th</sup> June – 24<sup>th</sup> June) and mean week of withdrawal is 42 MW (i.e., 15<sup>th</sup> October – 21<sup>th</sup> October). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 22 MW (28<sup>th</sup> May - 3<sup>rd</sup> June) and 30 MW (23<sup>rd</sup> – 29<sup>th</sup> July), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 36 MW (3<sup>rd</sup> – 9<sup>th</sup> September) and 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 28 and 10 weeks, respectively. Probability occurrence of onset of monsoon in 25 MW is 23.72% which is observed for 14 years when 59 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June), 26 MW (25 Jun - 1<sup>st</sup> July) probability occurrence of onset of monsoon is 52.54% which is observed

for 31 years out of total 59 years. Hence from 11<sup>th</sup> June – 1<sup>th</sup> July there are maximum chances of onset of monsoon during this period in Dindori tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Finger millet in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) to 26 MW (25Jun-1<sup>st</sup> July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.5: Onset and withdrawal of monsoon for Igatpuri Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Igatpuri is given in Table 4.30. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 24 MW (i.e., 11<sup>th</sup> June – 17<sup>th</sup> June) and mean week of withdrawal is 43 MW (i.e., 22<sup>nd</sup> October – 28<sup>th</sup> October). Therefore, mean length of rainy season was found to be 19 weeks (133 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 28 MW (9<sup>th</sup> July – 15<sup>th</sup> July), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 37<sup>th</sup> MW (10<sup>th</sup> – 16<sup>th</sup> September) and 51 MW (16<sup>th</sup> – 23<sup>rd</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 28 and 12 weeks, respectively. Probability occurrence of onset of monsoon in 24<sup>th</sup> MW is 45.76% which is observed for 27 years when 59 years of data is considered. But when we considered 23 (4<sup>th</sup> - 10<sup>th</sup> June) and 24 MW (11<sup>th</sup> June – 17<sup>th</sup> June) probability occurrence of onset of monsoon is 67.79% which is observed for 40 years out of total 59 years. Hence from 4<sup>th</sup> June – 17<sup>th</sup> June there are maximum chances of onset of monsoon during this period in Igatpuri tehsil. Hence we can suggest sowing of *kharif* crops like Rice, Finger millet in the 23 (4<sup>th</sup> - 10<sup>th</sup> June) and 24 MW (11<sup>th</sup> June – 17<sup>th</sup> June). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.6: Onset and withdrawal of monsoon for Kalwan Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Kalwan is given in Table 4.31. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26<sup>th</sup> MW (25 June – 1 July) and mean week of withdrawal is 42 MW (15<sup>th</sup> October – 21<sup>th</sup> October). Therefore, mean length of rainy season was found to be 16 weeks (112 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 31 MW (30<sup>th</sup> – 5<sup>th</sup> August), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 35 MW (27<sup>th</sup> Aug – 2<sup>nd</sup> September) and 50 MW (10<sup>th</sup> – 16<sup>th</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 27 and 08 weeks, respectively. Probability occurrence of onset of monsoon in 26 MW is 16.94% which is observed for 10 years when 59 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June), 26 MW, 27 MW (2<sup>th</sup> July - 8 July) probability occurrence of onset of monsoon is 72.88% which is observed for 43 years out of total 59 years. Hence from 11<sup>th</sup> June – 8<sup>th</sup> July there are maximum chances of onset of monsoon during this period in Kalwan tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Maize in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) to 27 MW (2<sup>th</sup> July - 8<sup>th</sup> July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.7: Onset and withdrawal of monsoon for Malegaon Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Malegaon is given in Table 4.32. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26 MW (i.e., 25<sup>th</sup> June – 1<sup>st</sup> July) and mean week of withdrawal is 42 MW (i.e., 15<sup>th</sup> October – 21<sup>st</sup> October). Therefore, mean length of rainy season was found to be 16 weeks (112 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 34 MW (20<sup>th</sup> – 26<sup>th</sup> August), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 35 MW (27<sup>th</sup> Aug – 2<sup>nd</sup> September) and 50 MW (10<sup>th</sup> – 16<sup>th</sup> December) respectively. The longest (subtraction of

earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 24 and 6 weeks, respectively. Probability occurrence of onset of monsoon in 26<sup>th</sup> MW is 11.86% which is observed for 7 years when 59 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25<sup>th</sup> MW (18<sup>th</sup> June – 24<sup>th</sup> June), 26 MW, 27 MW (2 July-8 July) probability occurrence of onset of monsoon is 61% which is observed for 36 years out of total 59 years. Hence from 11<sup>th</sup> June – 8<sup>th</sup> July there are maximum chances of onset of monsoon during this period in Malegaon Tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Maize in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) to 27 MW (2 July-8 July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilized during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.8: Onset and withdrawal of monsoon for Nandgaon Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Nandgaon is given in Table 4.33. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26 MW (25<sup>th</sup> June – 1<sup>st</sup> July) and mean week of withdrawal is 43 MW (22<sup>nd</sup> October – 28<sup>th</sup> October). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 34 MW (20<sup>th</sup> – 26<sup>th</sup> August), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 35 MW (27<sup>th</sup> August-2<sup>nd</sup> September) and 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 27 and 07 weeks, respectively. Probability occurrence of onset of monsoon in 26 MW is 15.25% which is observed for 9 years when 59 years of data is considered. But when we considered 24<sup>th</sup> (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June), 26 MW, 27 MW (2 July-8 July) probability occurrence of onset of monsoon is 66.10% which is observed for 39 years out of total 59 years. Hence from 11<sup>th</sup> June – 8<sup>th</sup> July there are maximum chances of onset of monsoon during this period in Nandgaon tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Finger millet in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) to 27 MW (2 July-8 July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilized during critical growth stages of

field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.9: Onset and withdrawal of monsoon for Nashik Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Nashik is given in Table 4.34. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June) and mean week of withdrawal is 42 MW (15<sup>th</sup> October – 21<sup>th</sup> October). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 30 MW (23<sup>rd</sup> – 29<sup>th</sup> July), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 36 MW (3<sup>th</sup> – 9 September) and 47 MW (19<sup>th</sup> – 25<sup>th</sup> November) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 23 and 12 weeks, respectively. Probability occurrence of onset of monsoon in 25 MW is 22.72% which is observed for 5 years when 22 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June) probability occurrence of onset of monsoon is 50% which is observed for 11 years out of total 22 years. Hence from 11<sup>th</sup> June – 24<sup>th</sup> June there are maximum chances of onset of monsoon during this period in Nashik tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Maize in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.10: Onset and withdrawal of monsoon for Niphad Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Niphad is given in Table 4.35. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26 MW (i.e., 25<sup>th</sup> June 1<sup>st</sup> July) and mean week of withdrawal is 42 MW (i.e., 15<sup>th</sup> October – 21<sup>st</sup> October). Therefore, mean length of rainy season was found to be 16 weeks (112 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 38 MW (17<sup>th</sup> Sept-29<sup>th</sup> Sept), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 37<sup>th</sup> MW (10<sup>th</sup> – 16<sup>th</sup> September) and 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) respectively. The longest

(subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 27 and 04 weeks, respectively. Probability occurrence of onset of monsoon in 26<sup>th</sup> MW is 15.25 % which is observed for 9 years when 59 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25<sup>th</sup> MW (18<sup>th</sup> June – 24<sup>th</sup> June), 26 MW, 27 MW (2<sup>nd</sup> July-8<sup>th</sup> July), probability occurrence of onset of monsoon is 66.10% which is observed for 39 years out of total 59 years. Hence from 11<sup>th</sup> June 8<sup>th</sup> July there are maximum chances of onset of monsoon during this period in Niphad tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Maize in the 24<sup>th</sup> (11<sup>th</sup> - 17<sup>th</sup> June) to 27<sup>th</sup> MW (2<sup>nd</sup> July-8<sup>th</sup> July). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.11: Onset and withdrawal of monsoon for Peth Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Peth is given in Table 4.36 From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 25 MW ( 18<sup>th</sup> June – 24<sup>th</sup> June) and mean week of withdrawal is 42 MW (i.e., 15<sup>th</sup> October– 21<sup>st</sup> October). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 29 MW (16<sup>th</sup> – 22<sup>nd</sup> July), respectively. Similarly , the earliest and delayed week of withdrawal of rainy season was 33 MW (13<sup>th</sup> – 19<sup>th</sup> August) and 51 MW (16<sup>th</sup> – 23<sup>rd</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 28 and 07 weeks, respectively. Probability occurrence of onset of monsoon in 25<sup>th</sup> MW is 33.89% which is observed for 20 years when 59 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June) probability occurrence of onset of monsoon is 62.71% which is observed for 37 years out of total 59 years. Hence from 11<sup>th</sup> June – 24<sup>th</sup> June there are maximum chances of onset of monsoon during this period in Peth tehsil. Hence we can suggest sowing of *kharif* crops like Finger millet, Rice in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season

which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.12: Onset and withdrawal of monsoon for Sinnar Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Sinnar is given in Table 4.37. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26 MW (i.e., 25<sup>th</sup> June – 1<sup>th</sup>July) and mean week of withdrawal is 43 MW (22<sup>nd</sup> october– 28<sup>th</sup>october). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 33 MW (13<sup>th</sup> – 19<sup>th</sup>August), respectively. Similarly , the earliest and delayed week of withdrawal of rainy season was 36 MW (3<sup>rd</sup> – 9<sup>th</sup>September) and 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 28 and 04weeks, respectively. Probability occurrence of onset of monsoon in 26<sup>th</sup> MW is 20.33% which is observed for 12 years when 59 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June)and 25 MW (18<sup>th</sup> June – 24<sup>th</sup>June), 26 MW, 27 MW(2<sup>nd</sup> july-8<sup>th</sup> july) probability occurrence of onset of monsoon is 66.10% which is observed for 39years out of total 59 years. Hence from 11<sup>th</sup> June – 24<sup>th</sup> June there are maximum chances of onset of monsoon during this period in Sinnar tehsil. Hence we can suggest sowing of *kharif* crops like finger millet, Maize in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) to 27 MW (2<sup>nd</sup> july-8<sup>th</sup> july). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### 4.4.13: Onset and withdrawal of monsoon for Surgana Tehsil

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Surgana is given in Table 4.38. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 25 MW (i.e., 18<sup>th</sup> June – 24<sup>th</sup>June) and mean week of withdrawal is 42 MW (i.e., 16<sup>th</sup> july– 22<sup>nd</sup> july). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 29 MW (16<sup>th</sup> – 22<sup>nd</sup> July), respectively. Similarly , the earliest and delayed week of withdrawal of rainy season was 36 MW (3<sup>rd</sup> –

9<sup>th</sup>September) and 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 28 and 11 weeks, respectively. Probability occurrence of onset of monsoon in 25 MW is 30.50% which is observed for 18 years when 59 years of data is considered. But when we considered 24(11<sup>th</sup> - 17<sup>th</sup> June) and 25MW (18<sup>th</sup> June – 24<sup>th</sup> June) probability occurrence of onset of monsoon is 57.62% which is observed for 34 years out of total 59 years. Hence from 11<sup>th</sup> June – 24<sup>th</sup> June there are maximum chances of onset of monsoon during this period in Surgana tehsil. Hence we can suggest sowing of *kharif* crops like Finger millet, Rice in the 24<sup>th</sup> (11<sup>th</sup> - 17<sup>th</sup> June) and 25MW (18<sup>th</sup> June – 24<sup>th</sup> June). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### **4.4.14: Onset and withdrawal of monsoon for Trimbakeshwar Tehsil.**

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Trimbakeshwar is given in Table 4.39. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 25 MW (i.e., 18<sup>th</sup> June – 24<sup>th</sup> June) and mean week of withdrawal is 41 MW (i.e., 8<sup>th</sup> October– 14<sup>th</sup> October). Therefore, mean length of rainy season was found to be 17 weeks (119 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 29 MW (16<sup>th</sup> – 22<sup>th</sup> July), respectively. Similarly, the earliest and delayed week of withdrawal of rainy season was 36<sup>th</sup> MW (3<sup>rd</sup> – 9<sup>th</sup> September) and 50 MW (10<sup>th</sup> – 16<sup>th</sup> December) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 26 and 11 weeks, respectively. Probability occurrence of onset of monsoon in 25 MW is 22.03% which is observed for 13 years when 59 years of data is considered. But when we considered 24(11<sup>th</sup> - 17<sup>th</sup> June) and 25MW (18<sup>th</sup> June – 24<sup>th</sup> June) probability occurrence of onset of monsoon is 64.40% which is observed for 38 years out of total 59 years. Hence from 11<sup>th</sup> June – 24<sup>th</sup> June there are maximum chances of onset of monsoon during this period in Trimbakeshwar tehsil. Hence we can suggest sowing of *kharif* crops like finger millet, Maize, Rice in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25MW (18<sup>th</sup> June – 24<sup>th</sup> June). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower

rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

#### **4.4.15: Onset and withdrawal of monsoon for Yevla Tehsil**

The onset, withdrawal and duration of the rainy season (difference between onset and withdrawal time) and its variability in Yevla is given in Table 4.40. From the analysis of 59 years (1961 – 2019) weekly rainfall data, it is observed that the mean week of onset of monsoon was 26<sup>th</sup> MW (i.e., 25<sup>th</sup> June – 1<sup>st</sup> July) and mean week of withdrawal is 42 MW (i.e., 15<sup>th</sup> october– 21<sup>st</sup> october). Therefore, mean length of rainy season was found to be 16 weeks (112 days) which include rainfall of both south west and north east monsoon. The earliest and delayed week of onset of rainy season was 23 MW (4<sup>th</sup> – 10<sup>th</sup> June) and 32<sup>rd</sup> MW (6Aug – 12Aug), respectively. Similarly , the earliest and delayed week of withdrawal of rainy season was 37<sup>th</sup> MW (10<sup>th</sup> – 16<sup>th</sup>September) and 47 MW (19<sup>th</sup> – 25<sup>th</sup> November) respectively. The longest (subtraction of earliest rainy season and delayed withdrawal of rainy week) and shortest length of rainy season was found as 23 and 06 weeks, respectively. Probability occurrence of onset of monsoon in 26<sup>th</sup> MW is 22.72% which is observed for 5 years when 22 years of data is considered. But when we considered 24 (11<sup>th</sup> - 17<sup>th</sup> June) and 25 MW (18<sup>th</sup> June – 24<sup>th</sup> June), 26 MW, 27 MW (2july-8july) probability occurrence of onset of monsoon is 72.72% which is observed for 16 years out of total 59 years. Hence from 11<sup>th</sup> June –8 July there are maximum chances of onset of monsoon during this period in Yevla tehsil. Hence we can suggest sowing of *kharif* crops like pearl millet, Maize in the 24 (11<sup>th</sup> - 17<sup>th</sup> June) to 27 MW (2july-8july). To take the advantage of *rabi* season sowing of short duration crop like green gram, black gram and cowpea should be sown in this period to utilize maximum moisture for good germination. The land preparation operation should be performed in summer by utilizing pre-monsoon shower rain. Conserve excess moisture during the monsoon season which can be utilize during critical growth stages of field crops and for production of *rabi* crops with the help of different in-situ soil moisture conservation techniques.

Table 4.26: Mean week of onset and withdrawal of rainfall in Baglan Tehsil

| 1.Baglan                              |                |                |                |              |                                     |                 |                   |                 |              |
|---------------------------------------|----------------|----------------|----------------|--------------|-------------------------------------|-----------------|-------------------|-----------------|--------------|
| Year                                  | Start          | End            | Durati<br>on   | Rainf<br>all | Year                                | Start           | End               | Duratio<br>n    | Rainf<br>all |
| 1961                                  | 23             | 39             | 16             | 482          | 1991                                | 23              | 39                | 16              | 950          |
| 1962                                  | 25             | 42             | 17             | 585          | 1992                                | 25              | 41                | 16              | 519          |
| 1963                                  | 24             | 43             | 19             | 812          | 1993                                | 25              | 49                | 24              | 690          |
| 1964                                  | 26             | 39             | 13             | 528.6        | 1994                                | 27              | 50                | 23              | 340.7        |
| 1965                                  | 23             | 40             | 17             | 698.2        | 1995                                | 25              | 41                | 16              | 531.1        |
| 1966                                  | 23             | 38             | 15             | 482.4        | 1996                                | 26              | 39                | 13              | 632          |
| 1967                                  | 30             | 40             | 10             | 436          | 1997                                | 25              | 41                | 16              | 817.5        |
| 1968                                  | 27             | 39             | 12             | 462.1        | 1998                                | 25              | 46                | 21              | 717          |
| 1969                                  | 27             | 41             | 14             | 506          | 1999                                | 27              | 41                | 14              | 501          |
| 1970                                  | 25             | 42             | 17             | 585          | 2000                                | 25              | 46                | 21              | 727          |
| 1971                                  | 25             | 42             | 17             | 595          | 2001                                | 25              | 41                | 16              | 817.5        |
| 1972                                  | 24             | 38             | 14             | 565.5        | 2002                                | 24              | 38                | 14              | 565.5        |
| 1973                                  | 25             | 39             | 14             | 481          | 2003                                | 25              | 39                | 14              | 481          |
| 1974                                  | 24             | 41             | 17             | 651          | 2004                                | 24              | 40                | 16              | 624          |
| 1975                                  | 26             | 40             | 14             | 582.2        | 2005                                | 26              | 40                | 14              | 582.2        |
| 1976                                  | 26             | 40             | 14             | 875          | 2006                                | 26              | 40                | 14              | 875          |
| 1977                                  | 24             | 38             | 14             | 759          | 2007                                | 24              | 40                | 16              | 805          |
| 1978                                  | 32             | 41             | 9              | 497          | 2008                                | 32              | 41                | 9               | 496          |
| 1979                                  | 25             | 46             | 21             | 717          | 2009                                | 25              | 46                | 21              | 717          |
| 1980                                  | 27             | 47             | 20             | 456          | 2010                                | 27              | 47                | 20              | 456          |
| 1981                                  | 28             | 40             | 12             | 483          | 2011                                | 28              | 40                | 12              | 483          |
| 1982                                  | 25             | 43             | 18             | 331.6        | 2012                                | 26              | 40                | 14              | 419          |
| 1983                                  | 26             | 41             | 15             | 764          | 2013                                | 25              | 41                | 16              | 519.8        |
| 1984                                  | 28             | 41             | 13             | 427.2        | 2014                                | 30              | 50                | 20              | 408.1        |
| 1985                                  | 29             | 40             | 11             | 311.4        | 2015                                | 25              | 40                | 15              | 309.3        |
| 1986                                  | 23             | 42             | 19             | 434.3        | 2016                                | 27              | 40                | 13              | 520.9        |
| 1987                                  | 27             | 50             | 23             | 327.2        | 2017                                | 27              | 41                | 14              | 494.9        |
| 1988                                  | 26             | 41             | 15             | 764          | 2018                                | 28              | 40                | 12              | 483          |
| 1989                                  | 26             | 39             | 13             | 621.3        | 2019                                | 29              | 44                | 15              | 753.2        |
| 1990                                  | 23             | 43             | 20             | 1077         |                                     |                 |                   |                 |              |
| <b>Mean week of start of rainfall</b> |                |                |                |              | <b>Mean week of end of rainfall</b> |                 |                   |                 |              |
|                                       | <b>Start</b>   | <b>Early</b>   | <b>Late</b>    | <b>SD</b>    |                                     | <b>End</b>      | <b>Early</b>      | <b>Late</b>     | <b>SD</b>    |
| <b>MW</b>                             | 25.9           | 23             | 32             | 2.1          | <b>MW</b>                           | 41.6            | 38                | 50              | 3.1          |
| <b>Period</b>                         | 25jun-<br>1jul | 4jun-<br>10jun | 6aug-<br>12aug |              | <b>Period</b>                       | 15oct-<br>21oct | 17sept-<br>23sept | 10dec-<br>16dec |              |
| <b>Mean duration</b>                  |                |                |                |              | <b>Mean rainfall</b>                |                 |                   |                 |              |
|                                       | <b>Dur</b>     | <b>Min</b>     | <b>Max</b>     | <b>SD</b>    |                                     | <b>Avg</b>      | <b>Min</b>        | <b>Max</b>      | <b>SD</b>    |
| <b>Total weeks</b>                    | 15.7           | 9              | 24             | 3.4          | <b>Rainfall</b>                     | 585.3           | 309.3             | 1077            | 167.6        |
| <b>Days</b>                           | 112            | 63             | 168            |              |                                     |                 |                   |                 |              |

**Table 4.27: Mean week of onset and withdrawal of rainfall in Chandwad Tehsil**

| 2.Chandwad         |                                       |                  |                |           |                 |                                     |                 |                 |           |
|--------------------|---------------------------------------|------------------|----------------|-----------|-----------------|-------------------------------------|-----------------|-----------------|-----------|
| Year               | Start                                 | End              | Duration       | Rainfall  | Year            | Start                               | End             | Duration        | Rainfall  |
| 1978               | 25                                    | 45               | 20             | 553.2     | 1999            | 25                                  | 41              | 16              | 565       |
| 1979               | 29                                    | 49               | 20             | 495.2     | 2000            | 26                                  | 41              | 15              | 341       |
| 1980               | 26                                    | 47               | 21             | 544.3     | 2001            | 25                                  | 46              | 21              | 469       |
| 1981               | 23                                    | 41               | 18             | 460.6     | 2002            | 24                                  | 36              | 12              | 667.7     |
| 1982               | 29                                    | 37               | 8              | 367.1     | 2003            | 26                                  | 39              | 13              | 307       |
| 1983               | 28                                    | 36               | 8              | 420.6     | 2004            | 25                                  | 45              | 20              | 690       |
| 1984               | 24                                    | 49               | 25             | 636.7     | 2005            | 26                                  | 39              | 13              | 606.6     |
| 1985               | 27                                    | 45               | 18             | 383.4     | 2006            | 25                                  | 45              | 20              | 1136.5    |
| 1986               | 26                                    | 38               | 12             | 920.9     | 2007            | 24                                  | 40              | 16              | 781.4     |
| 1987               | 24                                    | 40               | 16             | 435       | 2008            | 23                                  | 38              | 15              | 699       |
| 1988               | 29                                    | 40               | 11             | 398       | 2009            | 27                                  | 46              | 19              | 737.8     |
| 1989               | 25                                    | 45               | 20             | 553.2     | 2010            | 24                                  | 47              | 23              | 866       |
| 1990               | 23                                    | 42               | 19             | 522.5     | 2011            | 27                                  | 40              | 13              | 488       |
| 1991               | 31                                    | 42               | 11             | 284.5     | 2012            | 24                                  | 40              | 16              | 619       |
| 1992               | 24                                    | 42               | 18             | 531       | 2013            | 25                                  | 41              | 16              | 357       |
| 1993               | 23                                    | 47               | 24             | 1074      | 2014            | 30                                  | 46              | 16              | 320.2     |
| 1994               | 24                                    | 48               | 24             | 642.3     | 2015            | 25                                  | 41              | 16              | 293       |
| 1995               | 25                                    | 48               | 23             | 343.5     | 2016            | 28                                  | 40              | 12              | 396.8     |
| 1996               | 26                                    | 46               | 20             | 827       | 2017            | 24                                  | 41              | 17              | 516.2     |
| 1997               | 24                                    | 51               | 27             | 579       | 2018            | 26                                  | 38              | 12              | 222.9     |
| 1998               | 26                                    | 45               | 19             | 677       | 2019            | 26                                  | 44              | 18              | 855.3     |
|                    |                                       |                  |                |           |                 |                                     |                 |                 |           |
|                    | <b>Mean week of start of rainfall</b> |                  |                |           |                 | <b>Mean week of end of rainfall</b> |                 |                 |           |
|                    | <b>Start</b>                          | <b>Early</b>     | <b>Late</b>    | <b>SD</b> |                 | <b>End</b>                          | <b>Early</b>    | <b>Late</b>     | <b>SD</b> |
| <b>MW</b>          | 25.6                                  | 23               | 31             | 2         | <b>MW</b>       | 42.8                                | 36              | 51              | 3.9       |
| <b>Period</b>      | 25june-1st<br>july                    | 4june-<br>10june | 30jul-<br>5Aug |           | <b>Period</b>   | 22oct-<br>28oct                     | 3sept-<br>9sept | 16dec-<br>23dec |           |
|                    | <b>Mean duration</b>                  |                  |                |           |                 | <b>Mean rainfall</b>                |                 |                 |           |
|                    | <b>Dur</b>                            | <b>Min</b>       | <b>Max</b>     | <b>SD</b> |                 | <b>Avg</b>                          | <b>Min</b>      | <b>Max</b>      | <b>SD</b> |
| <b>Total weeks</b> | 17.2                                  | 8                | 27             | 4.5       | <b>Rainfall</b> | 561.5                               | 222.9.          | 1136.5          | 212.2     |
| <b>Days</b>        | 119                                   | 56               | 189            |           |                 |                                     |                 |                 |           |

Table 4.28: Mean week of onset and withdrawal of rainfall in Deola Tehsil

| 3.Deola     |                                |            |            |          |          |                              |             |          |          |
|-------------|--------------------------------|------------|------------|----------|----------|------------------------------|-------------|----------|----------|
| Year        | Start                          | End        | Duration   | Rainfall | Year     | Start                        | End         | Duration | Rainfall |
| 1998        | 27                             | 42         | 15         | 620      | 2009     | 27                           | 46          | 19       | 517      |
| 1999        | 27                             | 41         | 14         | 473      | 2010     | 26                           | 47          | 21       | 371.4    |
| 2000        | 23                             | 41         | 18         | 366.7    | 2011     | 27                           | 42          | 15       | 620      |
| 2001        | 24                             | 41         | 17         | 365.5    | 2012     | 27                           | 41          | 14       | 476      |
| 2002        | 24                             | 36         | 12         | 324      | 2013     | 23                           | 41          | 18       | 517.6    |
| 2003        | 26                             | 39         | 13         | 236      | 2014     | 30                           | 50          | 20       | 343.7    |
| 2004        | 27                             | 40         | 13         | 365.8    | 2015     | 25                           | 47          | 22       | 235.4    |
| 2005        | 26                             | 40         | 14         | 444.2    | 2016     | 29                           | 40          | 11       | 418.4    |
| 2006        | 25                             | 40         | 15         | 806.3    | 2017     | 26                           | 41          | 15       | 473.9    |
| 2007        | 25                             | 40         | 15         | 689      | 2018     | 25                           | 45          | 20       | 326.8    |
| 2008        | 32                             | 40         | 8          | 396      | 2019     | 29                           | 44          | 15       | 711.5    |
|             |                                |            |            |          |          |                              |             |          |          |
|             | Mean week of start of rainfall |            |            |          |          | Mean week of end of rainfall |             |          |          |
|             | Start                          | Early      | Late       | SD       |          | End                          | Early       | Late     | SD       |
| MW          | 26.4                           | 23         | 32         | 2.2      | MW       | 42                           | 36          | 50       | 3.2      |
| Period      | 25jun-1jul                     | 4jun-10jun | 6Aug-12Aug |          | Period   | 15oct-21oct                  | 3sept-9sept | 10-16Dec |          |
|             | Mean duration                  |            |            |          |          | Mean rainfall                |             |          |          |
|             | Dur                            | Min        | Max        | SD       |          | Avg                          | Min         | Max      | SD       |
| Total weeks | 15.6                           | 8          | 22         | 3.4      | Rainfall | 459                          | 235.4       | 806.3    | 151.9    |
| Days        | 112                            | 56         | 154        |          |          |                              |             |          |          |

Table 4.29: Mean week of onset and withdrawal of rainfall in Dindori Tehsil

| 4. Dindori         |                                       |                |              |              |                      |                                     |              |              |              |
|--------------------|---------------------------------------|----------------|--------------|--------------|----------------------|-------------------------------------|--------------|--------------|--------------|
| Year               | Start                                 | End            | Durati<br>on | Rainfa<br>ll | Year                 | Start                               | End          | Durati<br>on | Rainfa<br>ll |
| 1961               | 25                                    | 41             | 16           | 717.5        | 1991                 | 23                                  | 39           | 16           | 618.9        |
| 1962               | 27                                    | 39             | 12           | 539.6        | 1992                 | 25                                  | 42           | 17           | 575.5        |
| 1963               | 26                                    | 48             | 22           | 585.7        | 1993                 | 25                                  | 43           | 18           | 824          |
| 1964               | 26                                    | 42             | 16           | 595.1        | 1994                 | 25                                  | 43           | 18           | 824          |
| 1965               | 23                                    | 40             | 17           | 752          | 1995                 | 29                                  | 41           | 12           | 310          |
| 1966               | 25                                    | 37             | 12           | 833.9        | 1996                 | 24                                  | 43           | 19           | 420          |
| 1967               | 29                                    | 39             | 10           | 519.1        | 1997                 | 30                                  | 49           | 19           | 578          |
| 1968               | 25                                    | 41             | 16           | 831.6        | 1998                 | 27                                  | 45           | 18           | 781.6        |
| 1969               | 23                                    | 45             | 22           | 1027.1       | 1999                 | 25                                  | 41           | 16           | 671          |
| 1970               | 22                                    | 40             | 18           | 702.9        | 2000                 | 23                                  | 41           | 18           | 523          |
| 1971               | 26                                    | 40             | 14           | 738.8        | 2001                 | 24                                  | 41           | 17           | 429          |
| 1972               | 27                                    | 37             | 10           | 336.1        | 2002                 | 25                                  | 36           | 11           | 805.7        |
| 1973               | 24                                    | 40             | 16           | 606.3        | 2003                 | 24                                  | 39           | 15           | 735          |
| 1974               | 26                                    | 42             | 16           | 593.5        | 2004                 | 23                                  | 41           | 18           | 1074         |
| 1975               | 24                                    | 44             | 20           | 597.7        | 2005                 | 26                                  | 40           | 14           | 782.4        |
| 1976               | 23                                    | 47             | 24           | 1344.3       | 2006                 | 25                                  | 40           | 15           | 1024.2       |
| 1977               | 25                                    | 48             | 23           | 1084.4       | 2007                 | 24                                  | 40           | 16           | 760          |
| 1978               | 23                                    | 48             | 25           | 1064.2       | 2008                 | 27                                  | 40           | 13           | 1025         |
| 1979               | 28                                    | 46             | 18           | 1210.5       | 2009                 | 27                                  | 46           | 19           | 577.5        |
| 1980               | 23                                    | 51             | 28           | 963.3        | 2010                 | 24                                  | 47           | 23           | 707          |
| 1981               | 27                                    | 40             | 13           | 1514.4       | 2011                 | 28                                  | 42           | 14           | 501          |
| 1982               | 27                                    | 39             | 12           | 347.9        | 2012                 | 26                                  | 40           | 14           | 584          |
| 1983               | 25                                    | 40             | 15           | 739.2        | 2013                 | 24                                  | 40           | 16           | 796.3        |
| 1984               | 27                                    | 41             | 14           | 512.5        | 2014                 | 29                                  | 46           | 17           | 660.7        |
| 1985               | 28                                    | 41             | 13           | 478.4        | 2015                 | 25                                  | 47           | 22           | 661.1        |
| 1986               | 25                                    | 52             | 27           | 279.5        | 2016                 | 27                                  | 40           | 13           | 1107         |
| 1987               | 24                                    | 47             | 23           | 745.6        | 2017                 | 24                                  | 42           | 18           | 1781.7       |
| 1988               | 25                                    | 40             | 15           | 739.2        | 2018                 | 23                                  | 40           | 17           | 847          |
| 1989               | 27                                    | 38             | 11           | 340.3        | 2019                 | 27                                  | 44           | 17           | 1332.7       |
| 1990               | 24                                    | 41             | 17           | 628.5        |                      |                                     |              |              |              |
|                    | <b>Mean week of start of rainfall</b> |                |              |              |                      | <b>Mean week of end of rainfall</b> |              |              |              |
|                    | <b>Start</b>                          | <b>Early</b>   | <b>Late</b>  | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>          | 25.4                                  | 22             | 30           | 1.8          | <b>MW</b>            | 42.2                                | 36           | 52           | 3.5          |
| <b>Period</b>      | 18jun-<br>24jun                       | 28may-<br>3jun | 23-<br>29jul |              | <b>Period</b>        | 15-<br>21oct                        | 3-9<br>sept  | 24-<br>31Dec |              |
|                    | <b>Mean duration</b>                  |                |              |              |                      | <b>Mean rainfall</b>                |              |              |              |
|                    | <b>Dur</b>                            | <b>Min</b>     | <b>Max</b>   | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |
| <b>Total weeks</b> | 16.9                                  | 10             | 28           | 4            | <b>Rainfa<br/>ll</b> | 750.6                               | 279.5        | 1781.7       | 295.8        |
| <b>Days</b>        | 119                                   | 70             | 196          |              |                      |                                     |              |              |              |

Table 4.30: Mean week of onset and withdrawal of rainfall in Igatpuri Tehsil

| 5.Igatpuri         |                                       |              |              |              |                      |                                     |              |              |              |
|--------------------|---------------------------------------|--------------|--------------|--------------|----------------------|-------------------------------------|--------------|--------------|--------------|
| Year               | Start                                 | End          | Durati<br>on | Rainf<br>all | Year                 | Start                               | End          | Durati<br>on | Rainf<br>all |
| 1961               | 25                                    | 41           | 16           | 4300.4       | 1991                 | 23                                  | 39           | 16           | 2849.3       |
| 1962               | 26                                    | 49           | 23           | 2998.6       | 1992                 | 25                                  | 41           | 16           | 2317         |
| 1963               | 24                                    | 42           | 18           | 3444.7       | 1993                 | 24                                  | 47           | 23           | 3281.9       |
| 1964               | 23                                    | 46           | 23           | 3548         | 1994                 | 24                                  | 43           | 19           | 4139.6       |
| 1965               | 24                                    | 41           | 17           | 1940.8       | 1995                 | 25                                  | 42           | 17           | 2050.2       |
| 1966               | 25                                    | 41           | 16           | 2355         | 1996                 | 24                                  | 43           | 19           | 2872         |
| 1967               | 24                                    | 50           | 26           | 3377         | 1997                 | 25                                  | 46           | 21           | 2498         |
| 1968               | 24                                    | 45           | 21           | 3239.8       | 1998                 | 24                                  | 45           | 21           | 3711.6       |
| 1969               | 23                                    | 48           | 25           | 3468.9       | 1999                 | 24                                  | 41           | 17           | 2616.7       |
| 1970               | 23                                    | 40           | 17           | 4827.6       | 2000                 | 23                                  | 41           | 18           | 2006.6       |
| 1971               | 23                                    | 40           | 17           | 3695         | 2001                 | 24                                  | 41           | 17           | 2922.8       |
| 1972               | 25                                    | 37           | 12           | 2199.1       | 2002                 | 24                                  | 38           | 14           | 2789.3       |
| 1973               | 23                                    | 39           | 16           | 3879.1       | 2003                 | 24                                  | 39           | 15           | 3505         |
| 1974               | 26                                    | 43           | 17           | 1944.9       | 2004                 | 24                                  | 41           | 17           | 3791         |
| 1975               | 24                                    | 47           | 23           | 1655.5       | 2005                 | 24                                  | 42           | 18           | 4448         |
| 1976               | 23                                    | 51           | 28           | 2080.5       | 2006                 | 25                                  | 45           | 20           | 4597         |
| 1977               | 25                                    | 48           | 23           | 2970.5       | 2007                 | 24                                  | 40           | 16           | 3462.9       |
| 1978               | 24                                    | 48           | 24           | 2727.5       | 2008                 | 23                                  | 41           | 18           | 3869         |
| 1979               | 25                                    | 47           | 22           | 2666.1       | 2009                 | 26                                  | 46           | 20           | 2127         |
| 1980               | 23                                    | 51           | 28           | 3109         | 2010                 | 24                                  | 47           | 23           | 2999         |
| 1981               | 26                                    | 41           | 15           | 3152.9       | 2011                 | 23                                  | 42           | 19           | 3026         |
| 1982               | 24                                    | 41           | 17           | 2436         | 2012                 | 24                                  | 40           | 16           | 2746         |
| 1983               | 25                                    | 41           | 16           | 3131.5       | 2013                 | 23                                  | 41           | 18           | 2200.9       |
| 1984               | 24                                    | 40           | 16           | 2942.4       | 2014                 | 28                                  | 42           | 14           | 1708.6       |
| 1985               | 23                                    | 41           | 18           | 2514.4       | 2015                 | 24                                  | 43           | 19           | 1401.2       |
| 1986               | 24                                    | 45           | 21           | 2114.6       | 2016                 | 27                                  | 40           | 13           | 1965.4       |
| 1987               | 24                                    | 47           | 23           | 2045.4       | 2017                 | 24                                  | 41           | 17           | 2382.1       |
| 1988               | 25                                    | 41           | 16           | 3131.5       | 2018                 | 25                                  | 40           | 15           | 1790.8       |
| 1989               | 24                                    | 40           | 16           | 2508.7       | 2019                 | 26                                  | 43           | 17           | 2339.4       |
| 1990               | 24                                    | 41           | 17           | 3517.6       |                      |                                     |              |              |              |
|                    | <b>Mean week of start of rainfall</b> |              |              |              |                      | <b>Mean week of end of rainfall</b> |              |              |              |
|                    | <b>Start</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>          | 24.3                                  | 23           | 28           | 1.1          | <b>MW</b>            | 42.9                                | 37           | 51           | 3.4          |
| <b>Period</b>      | 11-<br>17jun                          | 4-<br>10jun  | 9-15jul      |              | <b>Period</b>        | 22-<br>28oct                        | 10-<br>16sep | 16-<br>23Dec |              |
|                    | <b>Mean duration</b>                  |              |              |              |                      | <b>Mean rainfall</b>                |              |              |              |
|                    | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |
| <b>Total weeks</b> | 18.6                                  | 12           | 28           | 3.6          | <b>Rainf<br/>all</b> | 2887.1                              | 1401.2       | 4827.6       | 784.4        |
| <b>Days</b>        | 133                                   | 84           | 196          |              |                      |                                     |              |              |              |

Table 4.31: Mean week of onset and withdrawal of rainfall in Kalwan Tehsil

| 6.Kalwan           |                                       |              |             |           |                 |                                     |              |             |           |
|--------------------|---------------------------------------|--------------|-------------|-----------|-----------------|-------------------------------------|--------------|-------------|-----------|
| Year               | Start                                 | End          | Duration    | Rainfall  | Year            | Start                               | End          | Duration    | Rainfall  |
| 1961               | 27                                    | 44           | 17          | 798       | 1991            | 29                                  | 37           | 8           | 393       |
| 1962               | 25                                    | 45           | 20          | 665       | 1992            | 25                                  | 45           | 20          | 553.2     |
| 1963               | 25                                    | 40           | 15          | 951       | 1993            | 28                                  | 49           | 21          | 518.7     |
| 1964               | 23                                    | 41           | 18          | 630.3     | 1994            | 26                                  | 47           | 21          | 544.3     |
| 1965               | 24                                    | 41           | 17          | 822.2     | 1995            | 23                                  | 41           | 18          | 460.6     |
| 1966               | 23                                    | 41           | 18          | 658.4     | 1996            | 28                                  | 37           | 9           | 424.2     |
| 1967               | 26                                    | 47           | 21          | 481.1     | 1997            | 28                                  | 36           | 8           | 378.8     |
| 1968               | 24                                    | 40           | 16          | 592.5     | 1998            | 27                                  | 42           | 15          | 602       |
| 1969               | 23                                    | 50           | 27          | 436.8     | 1999            | 25                                  | 42           | 17          | 618       |
| 1970               | 27                                    | 43           | 16          | 432       | 2000            | 24                                  | 47           | 23          | 572       |
| 1971               | 23                                    | 39           | 16          | 451       | 2001            | 24                                  | 41           | 17          | 441       |
| 1972               | 25                                    | 41           | 16          | 576       | 2002            | 24                                  | 36           | 12          | 804       |
| 1973               | 26                                    | 43           | 17          | 565.5     | 2003            | 25                                  | 44           | 19          | 609       |
| 1974               | 24                                    | 45           | 21          | 937       | 2004            | 24                                  | 41           | 17          | 816       |
| 1975               | 29                                    | 42           | 13          | 407       | 2005            | 26                                  | 38           | 12          | 835       |
| 1976               | 24                                    | 43           | 19          | 592       | 2006            | 26                                  | 40           | 14          | 1323      |
| 1977               | 26                                    | 48           | 22          | 783       | 2007            | 24                                  | 40           | 16          | 849       |
| 1978               | 27                                    | 42           | 15          | 654       | 2008            | 31                                  | 41           | 10          | 749       |
| 1979               | 25                                    | 42           | 17          | 618       | 2009            | 25                                  | 46           | 21          | 717       |
| 1980               | 27                                    | 39           | 12          | 222       | 2010            | 24                                  | 47           | 23          | 570       |
| 1981               | 24                                    | 41           | 17          | 441       | 2011            | 29                                  | 37           | 8           | 393       |
| 1982               | 24                                    | 36           | 12          | 804       | 2012            | 27                                  | 40           | 13          | 474       |
| 1983               | 25                                    | 44           | 19          | 609       | 2013            | 23                                  | 41           | 18          | 712.6     |
| 1984               | 24                                    | 41           | 17          | 816       | 2014            | 30                                  | 46           | 16          | 519       |
| 1985               | 26                                    | 38           | 12          | 835       | 2015            | 25                                  | 47           | 22          | 509       |
| 1986               | 26                                    | 40           | 14          | 1323      | 2016            | 28                                  | 40           | 12          | 678.7     |
| 1987               | 24                                    | 38           | 14          | 716       | 2017            | 27                                  | 41           | 14          | 631.2     |
| 1988               | 31                                    | 41           | 10          | 749       | 2018            | 26                                  | 35           | 9           | 479.3     |
| 1989               | 25                                    | 46           | 21          | 717       | 2019            | 28                                  | 44           | 16          | 938.8     |
| 1990               | 24                                    | 47           | 23          | 570       |                 |                                     |              |             |           |
|                    | <b>Mean week of start of rainfall</b> |              |             |           |                 | <b>Mean week of end of rainfall</b> |              |             |           |
|                    | <b>Start</b>                          | <b>Early</b> | <b>Late</b> | <b>SD</b> |                 | <b>End</b>                          | <b>Early</b> | <b>Late</b> | <b>SD</b> |
| <b>MW</b>          | 25.7                                  | 23           | 31          | 2         | <b>MW</b>       | 42                                  | 35           | 50          | 3.6       |
| <b>Period</b>      | 25Jun-1Jul                            | 4-10Jul      | 30Jul-5Aug  |           | <b>Period</b>   | 15-21Oct                            | 27Aug-2Sept  | 10-16Dec    |           |
|                    | <b>Mean duration</b>                  |              |             |           |                 | <b>Mean rainfall</b>                |              |             |           |
|                    | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>  | <b>SD</b> |                 | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>  | <b>SD</b> |
| <b>Total weeks</b> | 16.3                                  | 8            | 27          | 4.3       | <b>Rainfall</b> | 643.5                               | 222          | 1323        | 205.2     |
| <b>Days</b>        | 112                                   | 56           | 189         |           |                 |                                     |              |             |           |

Table 4.32: Mean week of onset and withdrawal of rainfall in Malegaon Tehsil

| 7.Malegaon         |                                       |              |              |              |                      |                                     |                 |              |              |
|--------------------|---------------------------------------|--------------|--------------|--------------|----------------------|-------------------------------------|-----------------|--------------|--------------|
| Year               | Start                                 | End          | Duratio<br>n | Rainfa<br>ll | Year                 | Start                               | End             | Duratio<br>n | Rainfa<br>ll |
| 1961               | 25                                    | 41           | 16           | 424.9        | 1991                 | 28                                  | 47              | 19           | 351          |
| 1962               | 27                                    | 49           | 22           | 469.5        | 1992                 | 28                                  | 40              | 12           | 343.5        |
| 1963               | 26                                    | 48           | 22           | 597.7        | 1993                 | 30                                  | 41              | 11           | 283.4        |
| 1964               | 29                                    | 40           | 11           | 425.2        | 1994                 | 27                                  | 41              | 14           | 506          |
| 1965               | 24                                    | 38           | 14           | 526          | 1995                 | 25                                  | 46              | 21           | 778.9        |
| 1966               | 28                                    | 48           | 20           | 488.5        | 1996                 | 27                                  | 42              | 15           | 830.4        |
| 1967               | 29                                    | 50           | 21           | 212.5        | 1997                 | 24                                  | 43              | 19           | 805          |
| 1968               | 25                                    | 35           | 10           | 347          | 1998                 | 24                                  | 39              | 15           | 479.6        |
| 1969               | 31                                    | 37           | 6            | 415.7        | 1999                 | 24                                  | 41              | 17           | 745          |
| 1970               | 24                                    | 35           | 11           | 302.3        | 2000                 | 26                                  | 41              | 15           | 313.3        |
| 1971               | 34                                    | 42           | 8            | 314.3        | 2001                 | 29                                  | 41              | 12           | 307.1        |
| 1972               | 26                                    | 44           | 18           | 134.6        | 2002                 | 26                                  | 38              | 12           | 492.8        |
| 1973               | 26                                    | 42           | 16           | 605.3        | 2003                 | 29                                  | 39              | 10           | 292.6        |
| 1974               | 27                                    | 41           | 14           | 260.8        | 2004                 | 24                                  | 45              | 21           | 624.2        |
| 1975               | 24                                    | 41           | 17           | 672.2        | 2005                 | 27                                  | 38              | 11           | 340.2        |
| 1976               | 23                                    | 47           | 24           | 631.2        | 2006                 | 25                                  | 40              | 15           | 797          |
| 1977               | 25                                    | 48           | 23           | 384          | 2007                 | 25                                  | 40              | 15           | 733          |
| 1978               | 24                                    | 48           | 24           | 375.2        | 2008                 | 30                                  | 40              | 10           | 463          |
| 1979               | 28                                    | 47           | 19           | 550.8        | 2009                 | 25                                  | 46              | 21           | 707          |
| 1980               | 23                                    | 39           | 16           | 498.7        | 2010                 | 24                                  | 47              | 23           | 776          |
| 1981               | 32                                    | 44           | 12           | 213.6        | 2011                 | 29                                  | 39              | 10           | 335          |
| 1982               | 25                                    | 45           | 20           | 554.8        | 2012                 | 24                                  | 40              | 16           | 464          |
| 1983               | 28                                    | 41           | 13           | 509.9        | 2013                 | 23                                  | 41              | 18           | 624          |
| 1984               | 26                                    | 40           | 14           | 346.5        | 2014                 | 30                                  | 46              | 16           | 315.5        |
| 1985               | 31                                    | 39           | 8            | 210.3        | 2015                 | 25                                  | 43              | 18           | 210.9        |
| 1986               | 24                                    | 40           | 16           | 468.1        | 2016                 | 29                                  | 40              | 11           | 226.2        |
| 1987               | 26                                    | 50           | 24           | 571.5        | 2017                 | 24                                  | 41              | 17           | 259          |
| 1988               | 28                                    | 41           | 13           | 509.9        | 2018                 | 25                                  | 41              | 16           | 424.9        |
| 1989               | 23                                    | 47           | 24           | 842.2        | 2019                 | 27                                  | 44              | 17           | 765          |
| 1990               | 25                                    | 40           | 15           | 688.7        |                      |                                     |                 |              |              |
|                    | <b>Mean week of start of rainfall</b> |              |              |              |                      | <b>Mean week of end of rainfall</b> |                 |              |              |
|                    | <b>Start</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b>    | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>          | 26.4                                  | 23           | 34           | 2.5          | <b>MW</b>            | 42.3                                | 35              | 50           | 3.7          |
| <b>Period</b>      | 25jun-<br>1jul                        | 4-<br>10jul  | 20-<br>26Aug |              | <b>Period</b>        | 15-<br>21Oct                        | 27Aug-<br>2Sept | 10-<br>16Dec |              |
|                    | <b>Mean duration</b>                  |              |              |              |                      | <b>Mean rainfall</b>                |                 |              |              |
|                    | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>      | <b>Max</b>   | <b>SD</b>    |
| <b>Total weeks</b> | 15.9                                  | 6            | 24           | 4.6          | <b>Rainfa<br/>ll</b> | 477                                 | 134.6           | 842.2        | 187.2        |
| <b>Days</b>        | 112                                   | 42           | 168          |              |                      |                                     |                 |              |              |

Table 4.33: Mean week of onset and withdrawal of rainfall for Nandgaon Tehsil

| 8.Nandgaon             |                                       |              |              |              |                      |                                     |                 |              |              |
|------------------------|---------------------------------------|--------------|--------------|--------------|----------------------|-------------------------------------|-----------------|--------------|--------------|
| Year                   | Start                                 | End          | Durati<br>on | Rainf<br>all | Year                 | Start                               | End             | Durati<br>on | Rainf<br>all |
| 1961                   | 25                                    | 41           | 16           | 517.8        | 1991                 | 23                                  | 40              | 17           | 514          |
| 1962                   | 23                                    | 49           | 26           | 791.6        | 1992                 | 25                                  | 41              | 16           | 672          |
| 1963                   | 26                                    | 48           | 22           | 536.7        | 1993                 | 25                                  | 49              | 24           | 706          |
| 1964                   | 23                                    | 45           | 22           | 998.4        | 1994                 | 26                                  | 45              | 19           | 435          |
| 1965                   | 28                                    | 35           | 7            | 371.1        | 1995                 | 27                                  | 42              | 15           | 579          |
| 1966                   | 28                                    | 48           | 20           | 637.3        | 1996                 | 24                                  | 43              | 19           | 675          |
| 1967                   | 27                                    | 50           | 23           | 242.2        | 1997                 | 27                                  | 49              | 22           | 368          |
| 1968                   | 29                                    | 41           | 12           | 267.7        | 1998                 | 24                                  | 42              | 18           | 846          |
| 1969                   | 26                                    | 48           | 22           | 669.7        | 1999                 | 24                                  | 41              | 17           | 736          |
| 1970                   | 24                                    | 39           | 15           | 516          | 2000                 | 23                                  | 39              | 16           | 654          |
| 1971                   | 34                                    | 42           | 8            | 415          | 2001                 | 25                                  | 46              | 21           | 293          |
| 1972                   | 26                                    | 44           | 18           | 69.9         | 2002                 | 26                                  | 46              | 20           | 532          |
| 1973                   | 26                                    | 44           | 18           | 364.6        | 2003                 | 25                                  | 39              | 14           | 258          |
| 1974                   | 28                                    | 42           | 14           | 532          | 2004                 | 24                                  | 40              | 16           | 428.9        |
| 1975                   | 24                                    | 41           | 17           | 553          | 2005                 | 29                                  | 38              | 9            | 336.6        |
| 1976                   | 23                                    | 47           | 24           | 532.3        | 2006                 | 25                                  | 40              | 15           | 852.3        |
| 1977                   | 25                                    | 48           | 23           | 528.7        | 2007                 | 25                                  | 40              | 15           | 651          |
| 1978                   | 24                                    | 48           | 24           | 417          | 2008                 | 30                                  | 41              | 11           | 730          |
| 1979                   | 28                                    | 48           | 20           | 743          | 2009                 | 27                                  | 46              | 19           | 753          |
| 1980                   | 25                                    | 51           | 26           | 434          | 2010                 | 24                                  | 47              | 23           | 773          |
| 1981                   | 27                                    | 44           | 17           | 409          | 2011                 | 27                                  | 38              | 11           | 509          |
| 1982                   | 25                                    | 39           | 14           | 295.1        | 2012                 | 26                                  | 40              | 14           | 244          |
| 1983                   | 28                                    | 39           | 11           | 564          | 2013                 | 24                                  | 41              | 17           | 561.2        |
| 1984                   | 26                                    | 41           | 15           | 336          | 2014                 | 31                                  | 41              | 10           | 165.1        |
| 1985                   | 29                                    | 40           | 11           | 225          | 2015                 | 29                                  | 47              | 18           | 203.7        |
| 1986                   | 25                                    | 52           | 27           | 414          | 2016                 | 28                                  | 40              | 12           | 314.9        |
| 1987                   | 24                                    | 50           | 26           | 559          | 2017                 | 24                                  | 41              | 17           | 398          |
| 1988                   | 28                                    | 39           | 11           | 564          | 2018                 | 28                                  | 38              | 10           | 116.1        |
| 1989                   | 25                                    | 39           | 14           | 568          | 2019                 | 26                                  | 44              | 18           | 797          |
| 1990                   | 24                                    | 43           | 19           | 571          |                      |                                     |                 |              |              |
|                        | <b>Mean week of start of rainfall</b> |              |              |              |                      | <b>Mean week of end of rainfall</b> |                 |              |              |
|                        | <b>Start</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b>    | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>              | 26                                    | 23           | 34           | 2.2          | <b>MW</b>            | 43.2                                | 35              | 52           | 4            |
| <b>Period</b>          | 25jun-<br>1jul                        | 4-<br>10jun  | 20-<br>26Aug |              | <b>Perio<br/>d</b>   | 22-<br>28Oct                        | 27Aug-<br>2Sept | 24-<br>31Dec |              |
|                        | <b>Mean duration</b>                  |              |              |              |                      | <b>Mean rainfall</b>                |                 |              |              |
|                        | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>      | <b>Max</b>   | <b>SD</b>    |
| <b>Total<br/>weeks</b> | 17.2                                  | 7            | 27           | 4.9          | <b>Rainf<br/>all</b> | 504.2                               | 69.9            | 998.4        | 187.2        |
| <b>Days</b>            | 119                                   | 49           | 199          |              |                      |                                     |                 |              |              |

Table 4.34: Mean week of onset and withdrawal of rainfall in Nashik Tehsil

| 9.Nashik           |                                       |              |              |              |                      |                                     |              |              |              |
|--------------------|---------------------------------------|--------------|--------------|--------------|----------------------|-------------------------------------|--------------|--------------|--------------|
| Year               | Start                                 | End          | Durati<br>on | Rainf<br>all | Year                 | Start                               | End          | Duratio<br>n | Rainf<br>all |
| 1998               | 24                                    | 43           | 19           | 826.8        | 2009                 | 28                                  | 46           | 18           | 464          |
| 1999               | 25                                    | 41           | 16           | 763.2        | 2010                 | 24                                  | 47           | 23           | 728          |
| 2000               | 23                                    | 41           | 18           | 673.5        | 2011                 | 27                                  | 42           | 15           | 519          |
| 2001               | 23                                    | 41           | 18           | 619.6        | 2012                 | 27                                  | 40           | 13           | 446          |
| 2002               | 24                                    | 36           | 12           | 755.2        | 2013                 | 24                                  | 41           | 17           | 648.8        |
| 2003               | 25                                    | 44           | 19           | 815.2        | 2014                 | 30                                  | 46           | 16           | 557.2        |
| 2004               | 24                                    | 45           | 21           | 1001         | 2015                 | 25                                  | 47           | 22           | 561.4        |
| 2005               | 26                                    | 42           | 16           | 1168.1       | 2016                 | 27                                  | 40           | 13           | 1070.9       |
| 2006               | 25                                    | 45           | 20           | 1284.9       | 2017                 | 24                                  | 41           | 17           | 1016.3       |
| 2007               | 25                                    | 40           | 15           | 784.1        | 2018                 | 26                                  | 40           | 14           | 436.2        |
| 2008               | 26                                    | 40           | 14           | 1218         | 2019                 | 26                                  | 44           | 18           | 1124.3       |
|                    |                                       |              |              |              |                      |                                     |              |              |              |
|                    | <b>Mean week of start of rainfall</b> |              |              |              |                      | <b>Mean week of end of rainfall</b> |              |              |              |
|                    | <b>Start</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>          | 25.4                                  | 23           | 30           | 1.7          | <b>MW</b>            | 42.4                                | 36           | 47           | 2.8          |
| <b>Period</b>      | 18-<br>24jun                          | 4-<br>10jun  | 23-<br>29jul |              | <b>Period</b>        | 15-<br>21Oct                        | 3-<br>9sept  | 19-<br>25Nov |              |
|                    | <b>Mean duration</b>                  |              |              |              |                      | <b>Mean rainfall</b>                |              |              |              |
|                    | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |
| <b>Total weeks</b> | 17                                    | 12           | 23           | 3            | <b>Rainf<br/>all</b> | 794.6                               | 436.2        | 1284.9       | 263.4        |
| <b>Days</b>        | 119                                   | 84           | 161          |              |                      |                                     |              |              |              |

Table 4.35: Mean week of onset and withdrawal of rainfall in Niphad Tehsil

| 10.Niphad              |                                       |              |               |              |                      |                                     |               |              |              |
|------------------------|---------------------------------------|--------------|---------------|--------------|----------------------|-------------------------------------|---------------|--------------|--------------|
| Year                   | Start                                 | End          | Durati<br>on  | Rainf<br>all | Year                 | Start                               | End           | Durati<br>on | Rainf<br>all |
| 1961                   | 25                                    | 41           | 16            | 341.5        | 1991                 | 23                                  | 41            | 18           | 448          |
| 1962                   | 27                                    | 49           | 22            | 337.6        | 1992                 | 25                                  | 40            | 15           | 524          |
| 1963                   | 26                                    | 47           | 21            | 405.5        | 1993                 | 27                                  | 47            | 20           | 565.5        |
| 1964                   | 25                                    | 45           | 20            | 370.1        | 1994                 | 23                                  | 45            | 22           | 570          |
| 1965                   | 24                                    | 41           | 17            | 485.2        | 1995                 | 30                                  | 42            | 12           | 518.2        |
| 1966                   | 24                                    | 41           | 17            | 241.6        | 1996                 | 24                                  | 43            | 19           | 764.8        |
| 1967                   | 24                                    | 39           | 15            | 456.6        | 1997                 | 24                                  | 49            | 25           | 847.1        |
| 1968                   | 29                                    | 40           | 11            | 377.4        | 1998                 | 27                                  | 42            | 15           | 738.4        |
| 1969                   | 26                                    | 37           | 11            | 604.8        | 1999                 | 27                                  | 42            | 15           | 724          |
| 1970                   | 24                                    | 40           | 16            | 399.8        | 2000                 | 23                                  | 41            | 18           | 428          |
| 1971                   | 31                                    | 39           | 8             | 263.8        | 2001                 | 23                                  | 41            | 18           | 453.6        |
| 1972                   | 27                                    | 37           | 10            | 246.3        | 2002                 | 26                                  | 45            | 19           | 640.6        |
| 1973                   | 26                                    | 39           | 13            | 267.4        | 2003                 | 26                                  | 39            | 13           | 427          |
| 1974                   | 38                                    | 42           | 4             | 219          | 2004                 | 24                                  | 41            | 17           | 940.7        |
| 1975                   | 25                                    | 44           | 19            | 419          | 2005                 | 26                                  | 38            | 12           | 826.3        |
| 1976                   | 23                                    | 47           | 24            | 734.3        | 2006                 | 25                                  | 40            | 15           | 868          |
| 1977                   | 25                                    | 48           | 23            | 363          | 2007                 | 24                                  | 40            | 16           | 839.9        |
| 1978                   | 24                                    | 48           | 24            | 442.2        | 2008                 | 28                                  | 40            | 12           | 670          |
| 1979                   | 30                                    | 46           | 16            | 525.8        | 2009                 | 27                                  | 46            | 19           | 518          |
| 1980                   | 30                                    | 46           | 16            | 538.8        | 2010                 | 24                                  | 47            | 23           | 712          |
| 1981                   | 27                                    | 37           | 10            | 402.2        | 2011                 | 27                                  | 40            | 13           | 326          |
| 1982                   | 25                                    | 39           | 14            | 464.4        | 2012                 | 27                                  | 40            | 13           | 480          |
| 1983                   | 30                                    | 40           | 10            | 453.9        | 2013                 | 26                                  | 41            | 15           | 437.7        |
| 1984                   | 29                                    | 41           | 12            | 290.1        | 2014                 | 30                                  | 46            | 16           | 411.1        |
| 1985                   | 29                                    | 40           | 11            | 311.3        | 2015                 | 25                                  | 41            | 16           | 402.6        |
| 1986                   | 25                                    | 52           | 27            | 262.9        | 2016                 | 28                                  | 40            | 12           | 540.5        |
| 1987                   | 26                                    | 50           | 24            | 551.3        | 2017                 | 24                                  | 41            | 17           | 581.6        |
| 1988                   | 30                                    | 40           | 10            | 453.9        | 2018                 | 26                                  | 38            | 12           | 224.2        |
| 1989                   | 29                                    | 40           | 11            | 418.6        | 2019                 | 27                                  | 44            | 17           | 858.4        |
| 1990                   | 29                                    | 43           | 14            | 385          |                      |                                     |               |              |              |
|                        | <b>Mean week of start of rainfall</b> |              |               |              |                      | <b>Mean week of end of rainfall</b> |               |              |              |
|                        | <b>Start</b>                          | <b>Early</b> | <b>Late</b>   | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b>  | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>              | 26.4                                  | 23           | 38            | 2.7          | <b>MW</b>            | 42.3                                | 37            | 52           | 3.6          |
| <b>Period</b>          | 25Jun-<br>1July                       | 4-<br>10jun  | 17-<br>23Sept |              | <b>Perio<br/>d</b>   | 15-<br>21Oct                        | 10-<br>16Sept | 24-<br>31Dec |              |
|                        | <b>Mean duration</b>                  |              |               |              |                      | <b>Mean rainfall</b>                |               |              |              |
|                        | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>    | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>    | <b>Max</b>   | <b>SD</b>    |
| <b>Total<br/>weeks</b> | 15.9                                  | 4            | 27            | 4.7          | <b>Rainf<br/>all</b> | 496.9                               | 219           | 940.7        | 182.3        |
| <b>Days</b>            | 112                                   | 28           | 199           |              |                      |                                     |               |              |              |

Table 4.36: Mean week of onset and withdrawal of rainfall in Peth Tehsil

| 11.Peth                               |                      |              |               |              |                                     |                      |              |              |              |
|---------------------------------------|----------------------|--------------|---------------|--------------|-------------------------------------|----------------------|--------------|--------------|--------------|
| Year                                  | Start                | End          | Durati<br>on  | Rainf<br>all | Year                                | Start                | End          | Durati<br>on | Rainf<br>all |
| 1961                                  | 25                   | 43           | 18            | 1333.8       | 1991                                | 25                   | 40           | 15           | 2557.8       |
| 1962                                  | 26                   | 48           | 22            | 1565.1       | 1992                                | 25                   | 40           | 15           | 2559.8       |
| 1963                                  | 24                   | 48           | 24            | 2176.8       | 1993                                | 24                   | 43           | 19           | 2203.7       |
| 1964                                  | 26                   | 46           | 20            | 1866         | 1994                                | 24                   | 38           | 14           | 2815         |
| 1965                                  | 25                   | 39           | 14            | 764.1        | 1995                                | 26                   | 42           | 16           | 1466.4       |
| 1966                                  | 25                   | 36           | 11            | 2699         | 1996                                | 24                   | 43           | 19           | 1755.7       |
| 1967                                  | 23                   | 45           | 22            | 1513.5       | 1997                                | 25                   | 49           | 24           | 1995.6       |
| 1968                                  | 23                   | 36           | 13            | 1218.6       | 1998                                | 24                   | 47           | 23           | 2111.4       |
| 1969                                  | 26                   | 45           | 19            | 2354.2       | 1999                                | 25                   | 41           | 16           | 1816.6       |
| 1970                                  | 24                   | 38           | 14            | 2305.6       | 2000                                | 26                   | 40           | 14           | 1146         |
| 1971                                  | 23                   | 40           | 17            | 1975.8       | 2001                                | 24                   | 41           | 17           | 1635.5       |
| 1972                                  | 26                   | 37           | 11            | 1872         | 2002                                | 25                   | 38           | 13           | 1719.1       |
| 1973                                  | 23                   | 39           | 16            | 2760.8       | 2003                                | 25                   | 40           | 15           | 2048.2       |
| 1974                                  | 26                   | 33           | 7             | 965.7        | 2004                                | 24                   | 40           | 16           | 2545.7       |
| 1975                                  | 25                   | 41           | 16            | 2107.8       | 2005                                | 26                   | 40           | 14           | 2799.1       |
| 1976                                  | 23                   | 47           | 24            | 3187.4       | 2006                                | 25                   | 45           | 20           | 3170.3       |
| 1977                                  | 24                   | 48           | 24            | 2217.6       | 2007                                | 24                   | 40           | 16           | 1991         |
| 1978                                  | 25                   | 48           | 23            | 1845.7       | 2008                                | 24                   | 38           | 14           | 2202         |
| 1979                                  | 25                   | 46           | 21            | 1006.5       | 2009                                | 27                   | 46           | 19           | 1469         |
| 1980                                  | 23                   | 51           | 28            | 2200         | 2010                                | 24                   | 47           | 23           | 1799         |
| 1981                                  | 26                   | 40           | 14            | 2604.5       | 2011                                | 25                   | 41           | 16           | 1771         |
| 1982                                  | 25                   | 42           | 17            | 1657.2       | 2012                                | 25                   | 40           | 15           | 1662         |
| 1983                                  | 25                   | 41           | 16            | 2312.5       | 2013                                | 24                   | 42           | 18           | 1900.2       |
| 1984                                  | 24                   | 41           | 17            | 1831.9       | 2014                                | 29                   | 42           | 13           | 1216.7       |
| 1985                                  | 23                   | 40           | 17            | 1585.8       | 2015                                | 25                   | 47           | 22           | 905.5        |
| 1986                                  | 25                   | 37           | 12            | 1352.8       | 2016                                | 27                   | 40           | 13           | 1997.1       |
| 1987                                  | 26                   | 40           | 14            | 1316.4       | 2017                                | 24                   | 41           | 17           | 2092.5       |
| 1988                                  | 25                   | 41           | 16            | 2312.5       | 2018                                | 26                   | 40           | 14           | 1831.2       |
| 1989                                  | 24                   | 40           | 16            | 1730.7       | 2019                                | 26                   | 43           | 17           | 2608.6       |
| 1990                                  | 24                   | 41           | 17            | 3835.2       |                                     |                      |              |              |              |
| <b>Mean week of start of rainfall</b> |                      |              |               |              | <b>Mean week of end of rainfall</b> |                      |              |              |              |
|                                       | <b>Start</b>         | <b>Early</b> | <b>Late</b>   | <b>SD</b>    |                                     | <b>End</b>           | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>                             | 24.8                 | 23           | 29            | 1.2          | <b>MW</b>                           | 41.9                 | 33           | 51           | 3.7          |
| <b>Period</b>                         | 18-<br>24Jun         | 4-<br>10Jun  | 16-<br>22July |              | <b>Perio<br/>d</b>                  | 15-<br>21Oct         | 13-<br>19Aug | 16-<br>23Dec |              |
|                                       | <b>Mean duration</b> |              |               |              |                                     | <b>Mean rainfall</b> |              |              |              |
|                                       | <b>Dur</b>           | <b>Min</b>   | <b>Max</b>    | <b>SD</b>    |                                     | <b>Avg</b>           | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |
| <b>Total<br/>weeks</b>                | 17.1                 | 7            | 28            | 4            | <b>Rainf<br/>all</b>                | 1970.6               | 764.1        | 3835.2       | 599.3        |
| <b>Days</b>                           | 119                  | 49           | 196           |              |                                     |                      |              |              |              |

| 12.SINNAR     |                                       |              |             |           |                 |                                     |              |             |           |
|---------------|---------------------------------------|--------------|-------------|-----------|-----------------|-------------------------------------|--------------|-------------|-----------|
| Year          | Start                                 | End          | Duration    | Rainfall  | Year            | Start                               | End          | Duration    | Rainfall  |
| 1961          | 25                                    | 43           | 18          | 802.6     | 1991            | 27                                  | 47           | 20          | 651.6     |
| 1962          | 29                                    | 49           | 20          | 555.2     | 1992            | 27                                  | 44           | 17          | 437.1     |
| 1963          | 23                                    | 47           | 24          | 1127.2    | 1993            | 25                                  | 36           | 11          | 318.6     |
| 1964          | 25                                    | 42           | 17          | 612.3     | 1994            | 26                                  | 48           | 22          | 477.4     |
| 1965          | 24                                    | 49           | 25          | 820.6     | 1995            | 24                                  | 45           | 21          | 832.8     |
| 1966          | 28                                    | 49           | 21          | 542.3     | 1996            | 29                                  | 41           | 12          | 355.3     |
| 1967          | 24                                    | 50           | 26          | 723.1     | 1997            | 24                                  | 44           | 20          | 626.1     |
| 1968          | 24                                    | 41           | 17          | 738.9     | 1998            | 26                                  | 44           | 18          | 678.1     |
| 1969          | 26                                    | 37           | 11          | 882       | 1999            | 25                                  | 42           | 17          | 701.9     |
| 1970          | 24                                    | 41           | 17          | 594.9     | 2000            | 23                                  | 41           | 18          | 440.7     |
| 1971          | 28                                    | 43           | 15          | 412.4     | 2001            | 24                                  | 42           | 18          | 348.8     |
| 1972          | 33                                    | 37           | 4           | 197.6     | 2002            | 26                                  | 39           | 13          | 363       |
| 1973          | 23                                    | 43           | 20          | 763.9     | 2003            | 24                                  | 44           | 20          | 660       |
| 1974          | 27                                    | 43           | 16          | 655.7     | 2004            | 24                                  | 45           | 21          | 630.6     |
| 1975          | 25                                    | 41           | 16          | 486.2     | 2005            | 26                                  | 42           | 16          | 615.7     |
| 1976          | 23                                    | 47           | 24          | 843.8     | 2006            | 26                                  | 45           | 19          | 853.8     |
| 1977          | 24                                    | 48           | 24          | 665.5     | 2007            | 24                                  | 38           | 14          | 599.7     |
| 1978          | 24                                    | 48           | 24          | 484.2     | 2008            | 28                                  | 40           | 12          | 624.6     |
| 1979          | 28                                    | 47           | 19          | 676.2     | 2009            | 29                                  | 46           | 17          | 696       |
| 1980          | 24                                    | 46           | 22          | 611.2     | 2010            | 24                                  | 47           | 23          | 767.8     |
| 1981          | 26                                    | 41           | 15          | 679       | 2011            | 27                                  | 40           | 13          | 353       |
| 1982          | 30                                    | 39           | 9           | 324.8     | 2012            | 29                                  | 43           | 14          | 393       |
| 1983          | 26                                    | 39           | 13          | 447.8     | 2013            | 26                                  | 41           | 15          | 332.2     |
| 1984          | 27                                    | 43           | 16          | 322.2     | 2014            | 30                                  | 46           | 16          | 333.2     |
| 1985          | 30                                    | 40           | 10          | 271.2     | 2015            | 25                                  | 47           | 22          | 392.2     |
| 1986          | 24                                    | 52           | 28          | 401.7     | 2016            | 28                                  | 40           | 12          | 531.5     |
| 1987          | 26                                    | 50           | 24          | 429.8     | 2017            | 24                                  | 41           | 17          | 611.4     |
| 1988          | 26                                    | 39           | 13          | 447.8     | 2018            | 28                                  | 36           | 8           | 121.8     |
| 1989          | 29                                    | 39           | 10          | 483.8     | 2019            | 26                                  | 49           | 23          | 867.3     |
| 1990          | 23                                    | 40           | 17          | 568.4     |                 |                                     |              |             |           |
|               | <b>Mean week of start of rainfall</b> |              |             |           |                 | <b>Mean week of end of rainfall</b> |              |             |           |
|               | <b>Start</b>                          | <b>Early</b> | <b>Late</b> | <b>SD</b> |                 | <b>End</b>                          | <b>Early</b> | <b>Late</b> | <b>SD</b> |
| <b>MW</b>     | 26                                    | 23           | 33          | 2.2       | <b>MW</b>       | 43.3                                | 36           | 52          | 3.9       |
| <b>Period</b> | 25Jun-1Jul                            | 4-10Jun      | 13-19Aug    |           | <b>Period</b>   | 22-28oct                            | 3-9Sept      | 24-31Dec    |           |
|               | <b>Mean duration</b>                  |              |             |           |                 | <b>Mean rainfall</b>                |              |             |           |
|               | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>  | <b>SD</b> |                 | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>  | <b>SD</b> |
| <b>Total</b>  | 17.4                                  | 4            | 28          | 4.9       | <b>Rainfall</b> | 562.5                               | 121.8        | 1127.2      | 195.9     |
| <b>Days</b>   | 119                                   | 28           | 196         |           |                 |                                     |              |             |           |

Table 4.38: Mean week of onset and withdrawal of rainfall in Surgana Tehsil

| 13.Surgana         |                                       |              |              |              |                      |                                     |              |              |              |
|--------------------|---------------------------------------|--------------|--------------|--------------|----------------------|-------------------------------------|--------------|--------------|--------------|
| Year               | Start                                 | End          | Durati<br>on | Rainf<br>all | Year                 | Start                               | End          | Durati<br>on | Rainf<br>all |
| 1961               | 25                                    | 41           | 16           | 1771.7       | 1991                 | 23                                  | 36           | 13           | 1651         |
| 1962               | 27                                    | 49           | 22           | 1365         | 1992                 | 25                                  | 40           | 15           | 1774         |
| 1963               | 26                                    | 47           | 21           | 1595         | 1993                 | 24                                  | 43           | 19           | 1950         |
| 1964               | 26                                    | 42           | 16           | 1694.7       | 1994                 | 24                                  | 42           | 18           | 3140         |
| 1965               | 25                                    | 38           | 13           | 1719.7       | 1995                 | 28                                  | 42           | 14           | 1407         |
| 1966               | 24                                    | 36           | 12           | 1042.6       | 1996                 | 24                                  | 43           | 19           | 1933         |
| 1967               | 25                                    | 50           | 25           | 1452.8       | 1997                 | 26                                  | 49           | 23           | 1803         |
| 1968               | 25                                    | 46           | 21           | 1269.4       | 1998                 | 24                                  | 44           | 20           | 1696.2       |
| 1969               | 23                                    | 48           | 25           | 2541.3       | 1999                 | 25                                  | 41           | 16           | 2097         |
| 1970               | 24                                    | 41           | 17           | 1716.8       | 2000                 | 24                                  | 41           | 17           | 1011.5       |
| 1971               | 26                                    | 44           | 18           | 952.6        | 2001                 | 24                                  | 41           | 17           | 1484.7       |
| 1972               | 26                                    | 37           | 11           | 1144.1       | 2002                 | 25                                  | 38           | 13           | 1966.6       |
| 1973               | 24                                    | 40           | 16           | 2324         | 2003                 | 25                                  | 39           | 14           | 1817         |
| 1974               | 26                                    | 43           | 17           | 1165.5       | 2004                 | 24                                  | 41           | 17           | 2432         |
| 1975               | 25                                    | 44           | 19           | 1695.9       | 2005                 | 26                                  | 39           | 13           | 3038.8       |
| 1976               | 23                                    | 47           | 24           | 3030         | 2006                 | 26                                  | 40           | 14           | 2882.2       |
| 1977               | 24                                    | 38           | 14           | 2274         | 2007                 | 25                                  | 40           | 15           | 1958         |
| 1978               | 25                                    | 48           | 23           | 2290.7       | 2008                 | 26                                  | 41           | 15           | 1953         |
| 1979               | 26                                    | 47           | 21           | 2419.9       | 2009                 | 27                                  | 46           | 19           | 1295         |
| 1980               | 23                                    | 51           | 28           | 2223         | 2010                 | 24                                  | 47           | 23           | 1393         |
| 1981               | 26                                    | 43           | 17           | 3395         | 2011                 | 24                                  | 42           | 18           | 1776         |
| 1982               | 25                                    | 43           | 18           | 2486         | 2012                 | 26                                  | 40           | 14           | 1436         |
| 1983               | 25                                    | 41           | 16           | 3217         | 2013                 | 23                                  | 41           | 18           | 1844.6       |
| 1984               | 24                                    | 41           | 17           | 1664.8       | 2014                 | 29                                  | 40           | 11           | 1071.5       |
| 1985               | 27                                    | 41           | 14           | 1434         | 2015                 | 25                                  | 40           | 15           | 591          |
| 1986               | 25                                    | 52           | 27           | 1231.3       | 2016                 | 27                                  | 40           | 13           | 1108.7       |
| 1987               | 24                                    | 50           | 26           | 1429         | 2017                 | 25                                  | 42           | 17           | 1890.3       |
| 1988               | 25                                    | 41           | 16           | 3217         | 2018                 | 26                                  | 38           | 12           | 1624.8       |
| 1989               | 24                                    | 40           | 16           | 1463         | 2019                 | 26                                  | 44           | 18           | 2160.7       |
| 1990               | 25                                    | 41           | 16           | 1800         |                      |                                     |              |              |              |
|                    | <b>Mean week of start of rainfall</b> |              |              |              |                      | <b>Mean week of end of rainfall</b> |              |              |              |
|                    | <b>Start</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>          | 25.1                                  | 23           | 29           | 1.3          | <b>MW</b>            | 42.5                                | 36           | 52           | 3.8          |
| <b>Period</b>      | 18-<br>24jun                          | 4-<br>10jun  | 16-<br>22jul |              | <b>Period</b>        | 15-<br>21oct                        | 3-<br>9Sept  | 24-<br>31Dec |              |
|                    | <b>Mean duration</b>                  |              |              |              |                      | <b>Mean rainfall</b>                |              |              |              |
|                    | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |
| <b>Total weeks</b> | 17.5                                  | 11           | 28           | 4.1          | <b>Rainf<br/>all</b> | 1851.1                              | 591          | 3395         | 629.4        |
| <b>Days</b>        | 126                                   | 77           | 196          |              |                      |                                     |              |              |              |

## 4.39 Mean week of onset and withdrawal of rainfall in Trimbakeshwar Tehsil

| 14.Trimbakeshwar   |                                       |              |                 |              |                      |                                     |              |              |              |
|--------------------|---------------------------------------|--------------|-----------------|--------------|----------------------|-------------------------------------|--------------|--------------|--------------|
| Year               | Start                                 | End          | Duratio<br>n    | Rainf<br>all | Year                 | Start                               | End          | Durati<br>on | Rainf<br>all |
| 1961               | 24                                    | 38           | 14              | 1755.8       | 1991                 | 23                                  | 36           | 13           | 1651         |
| 1962               | 26                                    | 40           | 14              | 1434.4       | 1992                 | 25                                  | 40           | 15           | 1774         |
| 1963               | 24                                    | 40           | 16              | 2190.5       | 1993                 | 24                                  | 43           | 19           | 1950         |
| 1964               | 23                                    | 38           | 15              | 2399.6       | 1994                 | 24                                  | 42           | 18           | 3140         |
| 1965               | 25                                    | 39           | 14              | 2331.9       | 1995                 | 28                                  | 42           | 14           | 1407         |
| 1966               | 23                                    | 42           | 19              | 2213.7       | 1996                 | 24                                  | 43           | 19           | 1933         |
| 1967               | 24                                    | 41           | 17              | 1705.2       | 1997                 | 26                                  | 49           | 23           | 1803         |
| 1968               | 23                                    | 42           | 19              | 1943.3       | 1998                 | 24                                  | 42           | 18           | 881.8        |
| 1969               | 26                                    | 40           | 14              | 2475.8       | 1999                 | 25                                  | 41           | 16           | 1870         |
| 1970               | 26                                    | 38           | 12              | 2617.8       | 2000                 | 23                                  | 41           | 18           | 1477         |
| 1971               | 25                                    | 40           | 15              | 1741.2       | 2001                 | 24                                  | 41           | 17           | 1791.3       |
| 1972               | 24                                    | 41           | 17              | 2247         | 2002                 | 25                                  | 36           | 11           | 2040.7       |
| 1973               | 24                                    | 42           | 18              | 861.8        | 2003                 | 25                                  | 40           | 15           | 2234         |
| 1974               | 25                                    | 41           | 16              | 1870         | 2004                 | 24                                  | 39           | 15           | 2441         |
| 1975               | 23                                    | 41           | 18              | 1477         | 2005                 | 26                                  | 40           | 14           | 3688         |
| 1976               | 24                                    | 41           | 17              | 1791.3       | 2006                 | 25                                  | 40           | 15           | 3675         |
| 1977               | 25                                    | 36           | 11              | 2040.7       | 2007                 | 24                                  | 40           | 16           | 2494         |
| 1978               | 25                                    | 40           | 15              | 2234         | 2008                 | 24                                  | 41           | 17           | 2281         |
| 1979               | 24                                    | 39           | 15              | 2440         | 2009                 | 26                                  | 46           | 20           | 1327         |
| 1980               | 26                                    | 40           | 14              | 3688         | 2010                 | 24                                  | 47           | 23           | 1630         |
| 1981               | 25                                    | 40           | 15              | 3675         | 2011                 | 24                                  | 42           | 18           | 1579         |
| 1982               | 24                                    | 39           | 15              | 2376         | 2012                 | 24                                  | 40           | 16           | 1472         |
| 1983               | 24                                    | 41           | 17              | 2291         | 2013                 | 23                                  | 39           | 16           | 2000.3       |
| 1984               | 26                                    | 46           | 20              | 1327         | 2014                 | 29                                  | 46           | 17           | 1517.8       |
| 1985               | 24                                    | 47           | 23              | 1630         | 2015                 | 24                                  | 47           | 23           | 1133.9       |
| 1986               | 24                                    | 42           | 18              | 1579         | 2016                 | 27                                  | 40           | 13           | 2297.7       |
| 1987               | 24                                    | 50           | 26              | 1429         | 2017                 | 24                                  | 41           | 17           | 2697.7       |
| 1988               | 25                                    | 41           | 16              | 3217         | 2018                 | 26                                  | 40           | 14           | 1959.6       |
| 1989               | 24                                    | 40           | 16              | 1463         | 2019                 | 26                                  | 44           | 18           | 2749.4       |
| 1990               | 25                                    | 41           | 16              | 1800         |                      |                                     |              |              |              |
|                    | <b>Mean week of start of rainfall</b> |              |                 |              |                      | <b>Mean week of end of rainfall</b> |              |              |              |
|                    | <b>Start</b>                          | <b>Early</b> | <b>Late</b>     | <b>SD</b>    |                      | <b>End</b>                          | <b>Early</b> | <b>Late</b>  | <b>SD</b>    |
| <b>MW</b>          | 24.6                                  | 23           | 29              | 1.2          | <b>MW</b>            | 41.3                                | 36           | 50           | 2.9          |
| <b>Period</b>      | 18-<br>24jun                          | 4-<br>10jun  | 16jul-<br>22jul |              | <b>Period</b>        | 8-<br>14oct                         | 3-9<br>sept  | 10-<br>16Dec |              |
|                    | <b>Mean duration</b>                  |              |                 |              |                      | <b>Mean rainfall</b>                |              |              |              |
|                    | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>      | <b>SD</b>    |                      | <b>Avg</b>                          | <b>Min</b>   | <b>Max</b>   | <b>SD</b>    |
| <b>Total weeks</b> | 16.6                                  | 11           | 26              | 3.6          | <b>Rainf<br/>all</b> | 2053.<br>3                          | 851.8        | 3688         | 1655.3       |
| <b>Days</b>        | 119                                   | 77           | 182             |              |                      |                                     |              |              |              |

**Table 4.40: Mean week of onset and withdrawal of rainfall in Yevla Tehsil**

| <b>15.Yevla</b>        |                                       |              |                      |                      |                      |                                     |               |                      |                      |
|------------------------|---------------------------------------|--------------|----------------------|----------------------|----------------------|-------------------------------------|---------------|----------------------|----------------------|
| <b>Year</b>            | <b>Start</b>                          | <b>End</b>   | <b>Durati<br/>on</b> | <b>Rainf<br/>all</b> | <b>Year</b>          | <b>Start</b>                        | <b>End</b>    | <b>Durati<br/>on</b> | <b>Rainf<br/>all</b> |
| 1998                   | 24                                    | 45           | 21                   | 622.1                | 2009                 | 29                                  | 46            | 17                   | 456                  |
| 1999                   | 24                                    | 41           | 17                   | 671                  | 2010                 | 24                                  | 47            | 23                   | 851.6                |
| 2000                   | 23                                    | 39           | 16                   | 467.5                | 2011                 | 24                                  | 40            | 16                   | 590                  |
| 2001                   | 24                                    | 41           | 17                   | 438                  | 2012                 | 27                                  | 40            | 13                   | 455                  |
| 2002                   | 26                                    | 42           | 16                   | 403.4                | 2013                 | 26                                  | 41            | 15                   | 364.5                |
| 2003                   | 27                                    | 39           | 12                   | 227                  | 2014                 | 31                                  | 46            | 15                   | 270.7                |
| 2004                   | 24                                    | 45           | 21                   | 755                  | 2015                 | 26                                  | 38            | 12                   | 174.7                |
| 2005                   | 27                                    | 42           | 15                   | 425.6                | 2016                 | 28                                  | 41            | 13                   | 434.6                |
| 2006                   | 25                                    | 44           | 19                   | 909                  | 2017                 | 26                                  | 41            | 15                   | 399.8                |
| 2007                   | 23                                    | 40           | 17                   | 738.6                | 2018                 | 25                                  | 37            | 12                   | 240.8                |
| 2008                   | 32                                    | 38           | 6                    | 648.8                | 2019                 | 26                                  | 44            | 18                   | 593.9                |
|                        |                                       |              |                      |                      |                      |                                     |               |                      |                      |
|                        | <b>Mean week of start of rainfall</b> |              |                      |                      |                      | <b>Mean week of end of rainfall</b> |               |                      |                      |
|                        | <b>Start</b>                          | <b>Early</b> | <b>Late</b>          | <b>SD</b>            |                      | <b>End</b>                          | <b>Early</b>  | <b>Late</b>          | <b>SD</b>            |
| <b>MW</b>              | 26                                    | 23           | 32                   | 2.4                  | <b>MW</b>            | 41.7                                | 37            | 47                   | 2.9                  |
| <b>Period</b>          | 25jun-<br>1Jul                        | 4-<br>10jun  | 6=12A<br>ug          |                      | <b>Perio<br/>d</b>   | 15-<br>21Oct                        | 10-<br>16sept | 19-<br>25Nov         |                      |
|                        | <b>Mean duration</b>                  |              |                      |                      |                      | <b>Mean rainfall</b>                |               |                      |                      |
|                        | <b>Dur</b>                            | <b>Min</b>   | <b>Max</b>           | <b>SD</b>            |                      | <b>Avg</b>                          | <b>Min</b>    | <b>Max</b>           | <b>SD</b>            |
| <b>Total<br/>weeks</b> | 15.7                                  | 6            | 23                   | 3.7                  | <b>Rainf<br/>all</b> | 506.3                               | 174.7         | 909                  | 201.4                |
| <b>Days</b>            | 112                                   | 42           | 161                  |                      |                      |                                     |               |                      |                      |

#### 4.5 Markov-chain initial, conditional and consecutive probabilities dry and wet weeks .

The initial, conditional and consecutive probability of a week being dry or wet is useful in crop management planning as well as deciding contingent measures to be carried out to overcome the adverse effect of dry spells on crop productivity. The initial, conditional and consecutive probability of dry and wet week at threshold limit 20 mm of rainfall during the crop growth period (MW 22 to 42) is calculated for different tehsils of Nashik district using 'Weather Cock' software developed by CRIDA, Hyderabad and the results are presented in Table 4.41 to 4.55 obtained are discussed below. Considering the period of rainy season i.e., onset in the first week of June and withdrawal during the third week of October (22 MW – 42 MW) and the crop growth period of major *kharif* and *rabi* crops in different tehsils of Nashik district, the results obtained are discussed for this period in following sections.

##### 4.5.1 Probability distribution of Baglan Tehsil.

The initial, conditional and consecutive dry and wet week probability observed in Baglan tehsil during crop growth period (MW 22<sup>nd</sup> to 42<sup>nd</sup>) is given in Table 4.41. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 8 to 61 and dry week i.e., P(D) ranges from 39 to 92. The probability of wet week i.e., P(W) more than 50 per cent is observed in, 27, 30, 36, 40, 38 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 33 to 91 per cent, 0 to 92 per cent, 9 to 57 per cent and 8 to 100 per cent respectively. Dry week preceded by another dry week that is the weeks having higher values of PDD more than 50 % are in 22<sup>nd</sup> -26, 29, 31-39, 41-42 MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 17 to 86 and 7 to 86 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 25, 28, 31 -35, 37, 40-42 MW and P(3D) greater than 20 per cent is observed in 22-24, 28, 31-34, 40-42 MW. The greater probability of being dry weeks was observed in 22, 41, 42 MWs. So, there will be more moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 2 to 39 and 1 to 19 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in, 37-38 MW and  $P(3W)$  greater than 20 per cent is not observed. The greater probability of being wet weeks was observed in 37, 38 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Baglan tehsil so that it can be utilized during dry spell.

#### 4.5.2 Probability distribution of Chandwad Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Chandwad tehsil during crop growth period (MW 22 to 42) is given in Table 4.42. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 14 to 67 and dry week i.e.,  $P(D)$  ranges from 33 to 80. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 27, 29 - 30, 32, 38 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 38 to 89 per cent, 0 to 75 per cent, 11 to 63 per cent and 25 to 100 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in 22 - 26, 29, 31-37, 39-42 MWs.

The probability of two and three consecutive dry weeks i.e.,  $P(2D)$ ,  $P(3D)$  ranges from 21 to 83 and 12 to 81 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks  $P(2D)$  greater than 30 per cent is observed in 22 - 25, 28, 31-35, 38 - 42 MW and  $P(3D)$  greater than 20 per cent is observed in 22 - 23, 31 - 35, 37-42 MW. The greater probability of being dry weeks was observed in 22, 41, 42<sup>nd</sup> MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 0 to 38 and 0 to 27 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 26, 28, 31<sup>st</sup>, 35 MW and  $P(3W)$  greater than 20 per cent is observed in 28 - 29 MW. As the probability of consecutive wet weeks ranges from 0 to 38 percent and probability of dry week preceded by wet week ranges from 25

to 100 percent, appropriate measures are to be taken for maximum conservation of soil moisture, rainwater harvesting and its storage for future use. The greater probability of being wet weeks was observed in 29-31, 35, 38 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Chandwad tehsil so that it can be utilized during dry spell.

#### 4.5.3 Probability distribution of Deola Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Deola tehsil during crop growth period (MW 22 to 42) is given in Table 4.43. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 9 to 59 and dry week i.e., P(D) ranges from 41 to 91. The probability of wet week i.e., P(W) more than 50 per cent is observed in 30, 38 -40 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 39 to 92 per cent, 0 to 89 per cent, 8 to 61 per cent and 11 to 100 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22 -24, 26-29, 31 -38, 40 -42. MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 18 to 86 and 11 to 86 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 37, 41 - 42 MW and P(3D) greater than 20 per cent is observed in 22-37, 39 -42 MW. The greater probability of being dry weeks was observed in 22, 28, 33, 41, 42. MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 0 to 41 and 0 to 20 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 30, 37 -39 MW and P(3W) greater than 20 per cent is observed in 36-38 MW. As the probability of consecutive wet weeks ranges from 0 to 41 percent and probability of dry week preceded by wet week ranges from 11 to 100 percent, appropriate measures are to be taken for maximum conservation of soil moisture, rainwater harvesting and its storage for future use. The greater probability of being wet weeks was observed in 30, 37, 39 MWs. So, there will be less moisture stress to crops in

*kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Deola tehsil so that it can be utilized during dry spell.

#### 4.5.4 Probability distribution of Dindori Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Dindori tehsil during crop growth period (MW 22 to 42) is given in Table 4.44. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 17 to 78 and dry week i.e.,  $P(D)$  ranges from 22 to 83. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 25–33, 39 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 31 to 84 per cent, 20 to 86 per cent, 16 to 69 per cent and 14 to 80 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22 -25, 34-42 MWs.

The probability of two and three consecutive dry weeks i.e.,  $P(2D)$ ,  $P(3D)$  ranges from 8 to 78 and 3 to 76 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks  $P(2D)$  greater than 30 per cent is observed in 22 - 24, 34 - 37, 40 - 42 MW and  $P(3D)$  greater than 20 per cent is observed in 22-23, 33-37, 39-42 MW. The greater probability of being dry weeks was observed in 22, 41, 42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 5 to 63 and 1 to 39 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in, 26-33 MW and  $P(3W)$  greater than 20 per cent is observed in 27-32 MW. The greater probability of being wet weeks was observed in 29 -31 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Dindori tehsil so that it can be utilized during dry spell.

#### 4.5.5 Probability distribution of Igatpuri Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Igatpuri tehsilduring crop growth period (MW 22 to 42) is given in Table 4.45. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 17 to 100 and dry week i.e.,  $P(D)$  ranges from 0 to 93. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 23–39 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 0 to 89 per cent, 26 to 100 per cent, 11 to 100 per cent and 0 to 74 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22<sup>nd</sup>, 40 - 42 MWs.

The probability of two and three consecutive dry weeks i.e.,  $P(2D)$ ,  $P(3D)$  ranges from 0 to 78 and 0 to 75 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks  $P(2D)$  greater than 30 per cent is observed in 22 - 40 - 42 MW and  $P(3D)$  greater than 20 per cent is observed in 40<sup>th</sup>-42<sup>nd</sup> MW. The greater probability of being dry weeks was observed in 41, 42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 5 to 100 and 0 to 98 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 23-39 MW and  $P(3W)$  greater than 20 per cent is observed in 23-38 MW. The greater probability of being wet weeks was observed in 25 - 35 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Igatpuri tehsil so that it can be utilized during dry spell.

#### **4.5.6 Probability distribution of Kalwan Tehsil**

The initial, conditional and consecutive dry and wet week probability observed in Kalwan tehsilduring crop growth period (MW 22 to 42) is given in Table 4.46. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 8 to 68 and dry week i.e.,  $P(D)$  ranges from 32 to 92. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is

observed in 27 –30, 32 ,36 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 32 to 91 per cent, 0 to 89 per cent, 9 to 68 per cent and 11 to 100 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22 -26 ,31 ,33 -42 MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 19 to 83 and 5 to 74 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 25, 33 – 42 MW and P(3D) greater than 20 per cent is observed in 22-24, 33-42 MW. The greater probability of being dry weeks was observed in 22 ,41 ,42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 3 to 46 and 1 to 20 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 28<sup>th</sup>- 31<sup>th</sup> MW and P(3W) greater than 20 per cent is observed in 27-30 MW. The greater probability of being wet weeks was observed in 28,29 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Kalwan tehsil so that it can be utilized during dry spell.

#### 4.5.7 Probability distribution of Malegaon Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Malegaon tehsil during crop growth period (MW 22 to 42) is given in Table 4.47. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 8 to 51 and dry week i.e., P(D) ranges from 49 to 92. The probability of wet week i.e., P(W) more than 50 per cent is observed in 30<sup>th</sup> MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 50 to 89 per

cent, 0 to 74 per cent, 11 to 50 per cent and 26 to 100 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22-42 MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 32 to 86 and 19 to 83 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22<sup>nd</sup> -28<sup>th</sup> ,30<sup>th</sup> - 42<sup>nd</sup> MW and P(3D) greater than 20 per cent is observed in 25, 28-36, 39-42 MW. The greater probability of being dry weeks was observed in 22 ,41 ,42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 0 to 27 and 0 to 13 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is not observed in any week and P(3W) greater than 20 per cent is not observed. As the probability of consecutive wet weeks ranges from 0 to 27 percent and probability of dry week preceded by wet week ranges from 26 to 100 percent, appropriate measures are to be taken for maximum conservation of soil moisture, rainwater harvesting and its storage for future use. The greater probability of being wet weeks was observed in 30 ,34 ,MWs but it is less than 25%. So, there will be less moisture stress to crops in *kharif* season during these weeks. There Some possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Malegaon tehsil so that it can be utilized during dry spell.

#### **4.5.8 Probability distribution of Nandgaon Tehsil**

The initial, conditional and consecutive dry and wet week probability observed in Nandgaon tehsil during crop growth period (MW 22 to 42) is given in Table 4.48. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 8 to 53 and dry week i.e., P(D) ranges from 47 to 92. The probability of wet week i.e., P(W) more than 50 per cent is observed in 36 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 54 to 93 per cent, 23 to 80 per cent, 7 to 46 per cent and 22 to 77 per cent respectively. Dry week preceded by

another dry week that is weeks having higher values of PDD more than 50 % are in 22nd - 42nd.MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 32 to 76 and 21 to 69 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 42MW and P(3D) greater than 20 per cent is observed in 22 -42 MW. The greater probability of being dry weeks was observed in 22,40-42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 2 to 29 and 0 to 19 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 35 MW and P(3W) greater than 20 per cent is not observed. The greater probability of being wet weeks was observed in 35 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Nandgaon tehsil so that it can be utilized during dry spell.

#### 4.5.9 Probability distribution of Nashik Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Nashik tehsil during crop growth period (MW 22 to 42) is given in Table 4.49. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 14 to 77 and dry week i.e., P(D) ranges from 23 to 86 The probability of wet week i.e., P(W) more than 50 per cent is observed in 25-32, 38-39 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 30 to 85 per cent, 0 to 86 per cent, 15 to 70 per cent and 0 to 89 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in 22nd - 42nd.MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 9 to 55 and 5 to 74 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 24, 33 - 37, 41 - 42

MW and P(3D) greater than 20 per cent is observed in 22-23,33 -35, 41-42MW. The greater probability of being dry weeks was observed in 22 ,23 ,35 ,42 ,41 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 0 to 55 and 0 to 43 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 26-32 MW and P(3W) greater than 20 per cent is observed in 25-31MW. The greater probability of being wet weeks was observed in 26-27, 30-31 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Nashik tehsil so that it can be utilized during dry spell.

#### 4.5.10 Probability distribution of Niphad Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Niphad tehsil during crop growth period (MW 22to 42) is given in Table 4.50. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 12 to 51 and dry week i.e., P(D) ranges from 49 to 88 The probability of wet week i.e., P(W) more than 50 per cent is observed in 27-32 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 50 to 97 per cent, 0 to 88 per cent, 3 to 50 per cent and 13 to 100 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22-42.MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 32 to 83 and 19 to 82 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 28, 31 – 42 MW and P(3D) greater than 20 per cent is observed in, 22-26,31 -38, 40-42 MW. The greater probability of being dry weeks was observed in 22 ,41 -42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 3 to 34 and 1 to 19 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 31 MW and  $P(3W)$  greater than 20 per cent is not observed. The greater probability of being wet weeks was observed in 30, 31 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Niphad tehsil so that it can be utilized during dry spell.

#### 4.5.11 Probability distribution of Peth Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Peth tehsilduring crop growth period (MW 22 to 42) is given in Table 4.51. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 15 to 97 and dry week i.e.,  $P(D)$  ranges from 3 to 85 The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 24-37 , 39 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 0 to 85 per cent, 0 to 96 per cent, 15 to 100 per cent and 4 to 100 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22-24 ,33 ,35 ,38-42 MWs.

The probability of two and three consecutive dry weeks i.e.,  $P(2D)$ ,  $P(3D)$  ranges from 0 to 81 and 0 to 80 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks  $P(2D)$  greater than 30 per cent is observed in 22 - 23, 38, 40 – 42 MW and  $P(3D)$  greater than 20 per cent is observed in 22, 40-42 MW. The greater probability of being dry weeks was observed in 41,42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 2 to 93 and 0 to 88 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 24-39 MW and  $P(3W)$  greater than 20 per cent is observed in 24-37 MW. The greater probability of being wet weeks was observed in 26 -35 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus

appropriate measures of water harvesting should be carried out in this period in Peth tehsil so that it can be utilized during dry spell.

#### 4.5.12 Probability distribution of Sinnar Tehsil

The initial, conditional and consecutive dry and wet week probability observed in Sinnar tehsilduring crop growth period (MW 22 to 42) is given in Table 4.52. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 17 to 53 and dry week i.e.,  $P(D)$  ranges from 47 to 83. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 38 -39 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 50 to 86 per cent, 27 to 63 per cent, 14 to 50 per cent and 41 to 73 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22 - 29, 31-42 MWs.

The probability of two and three consecutive dry weeks i.e.,  $P(2D)$ ,  $P(3D)$  ranges from 20 to 68 and 12 to 62 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks  $P(2D)$  greater than 30 per cent is observed in 22- 26, 30- 37, 39- 42 MW and  $P(3D)$  greater than 20 per cent is observed in, 22-26, 31--35, 39-42 MW. The greater probability of being dry weeks was observed in 22, 41 ,42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 5 to 29 and 1 to 16 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is not observed and  $P(3W)$  greater than 20 per cent is not observed. The greater probability of being wet weeks was observed in 31<sup>th</sup>, 38<sup>th</sup> MWs but it is less than 30%.. So, there will be less moisture stress to crops in *kharif* season during these weeks. There Some possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Sinnar tehsil so that it can be utilized during dry spell.

#### 4.5.13 Probability distribution of Surgana Tehsil

The initial, conditional and consecutive dry and wet week probability observed in surgana tehsil during crop growth period (MW 22 to 42) is given in Table 4.53. From Table it is

observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 14 to 95 and dry week i.e.,  $P(D)$  ranges from 5 to 86. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 24-39 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 0 to 88 per cent, 0 to 98 per cent, 12 to 100 per cent and 2 to 82 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22 -26, 28,36,38-42 MWs.

The probability of two and three consecutive dry weeks i.e.,  $P(2D)$ ,  $P(3D)$  ranges from 0 to 80 and 0 to 75 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks  $P(2D)$  greater than 30 per cent is observed in 22<sup>nd</sup> - 23, 39 - 42 MW and  $P(3D)$  greater than 20 per cent is observed in 22<sup>nd</sup>, 39-42 MW. The greater probability of being dry weeks was observed in 42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e.,  $P(2W)$  and  $P(3W)$  ranges from 3 to 92 and 1 to 87 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in, 24- 39 MW and  $P(3W)$  greater than 20 per cent is observed in 24<sup>th</sup>-38 MW. The greater probability of being wet weeks was observed in 26-34 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in surgana tehsil so that it can be utilized during dry spell.

#### **4.5.14 Probability distribution of Trimbakeshwar Tehsil**

The initial, conditional and consecutive dry and wet week probability observed in Trimbakeshwar tehsil during crop growth period (MW 22 to 42) is given in Table 4.54. From Table it is observed that, the initial probability of getting wet week i.e.,  $P(W)$  ranges from 10 to 95 and dry week i.e.,  $P(D)$  ranges from 5 to 90. The probability of wet week i.e.,  $P(W)$  more than 50 per cent is observed in 24-40 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e.,  $P(D)$  is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 0 to 90 per cent, 0 to 100 per cent, 10 to 100 per cent and 0 to 75 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22nd - 23, 41 - 42 MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 0 to 81 and 0 to 80 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22nd - 23, 40 - 42 MW and P(3D) greater than 20 per cent is observed in 40-42 MW. The greater probability of being dry weeks was observed in 41, 42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 2 to 88 and 0 to 83 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 23-39 MW and P(3W) greater than 20 per cent is observed in 23 - 38 MW. The greater probability of being wet weeks was observed in 27-34 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Trimbakeshwar tehsil so that it can be utilized during dry spell.

#### **4.5.15 Probability distribution of Yevla Tehsil**

The initial, conditional and consecutive dry and wet week probability observed in Yevla tehsil during crop growth period (MW 22 to 42) is given in Table 4.55. From Table it is observed that, the initial probability of getting wet week i.e., P(W) ranges from 18 to 68 and dry week i.e., P(D) ranges from 32 to 82. The probability of wet week i.e., P(W) more than 50 per cent is observed in 27, 30, 34, 38 MWs whereas in the remaining weeks during crop growth period probability of dry week i.e., P(D) is greater than 50 per cent.

The conditional probability of wet and dry weeks i.e., dry week preceded by another dry week (PDD), wet week preceded by another wet week (PWW), wet week preceded by another dry week (PWD) and dry week preceded by another wet week (PDW) ranges from 40 to 92 per cent, 0 to 90 per cent, 8 to 60 per cent and 0 to 83 per cent respectively. Dry week preceded by another dry week that is weeks having higher values of PDD more than 50 % are in - 22-29, 31 - 42 MWs.

The probability of two and three consecutive dry weeks i.e., P(2D), P(3D) ranges from 18 to 77 and 14 to 74 per cent respectively during crop growth period. The probability of getting two consecutive dry weeks P(2D) greater than 30 per cent is observed in 22 - 25, 27 - 28, 32 - 35, 39 - 42 MW and P(3D) greater than 20 per cent is observed in 22-24, 26-28, 31-33, 35, 39-42 MW. The greater probability of being dry weeks was observed in 22, 42 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. Hence contingency measures like hoeing, mulching, foliar spray, protective irrigation, etc. to be taken to reduce the impact of dry spell.

The probability of two and three consecutive wet weeks i.e., P(2W) and P(3W) ranges from 5 to 41 and 1 to 19 per cent respectively during crop growth period. The probability of getting two consecutive wet weeks greater than 30 per cent is observed in 30, 37-38 MW and P(3W) greater than 20 per cent is not observed. The greater probability of being wet weeks was observed in 37, 38 MWs. So, there will be less moisture stress to crops in *kharif* season during these weeks. There more possibility of water available for harvesting in these MWs, thus appropriate measures of water harvesting should be carried out in this period in Yevla tehsil so that it can be utilized during dry spell.

Table 4.41: Dry and wet week probability during crop growth period in Baglan Tehsil

| Baglan |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|--------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M      | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|        | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 4      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 5      | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 93    | 0                 | 0    | 0    |
| 6      | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 93    | 93    | 0                 | 0    | 0    |
| 7      | 0       | 100  | 0                       | 100  | 100  | 0    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 8      | 5       | 95   | 0                       | 0    | 95   | 5    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 9      | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 97    | 0                 | 0    | 0    |
| 12     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 97    | 97    | 0                 | 0    | 0    |
| 13     | 0       | 100  | 0                       | 0    | 100  | 0    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 14     | 3       | 97   | 0                       | 0    | 97   | 3    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 15     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 16     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 93    | 0                 | 0    | 0    |
| 17     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 93    | 88    | 0                 | 0    | 0    |
| 18     | 0       | 100  | 0                       | 0    | 100  | 0    | 93                | 88    | 87    | 0                 | 0    | 0    |
| 19     | 7       | 93   | 0                       | 0    | 93   | 7    | 88                | 87    | 79    | 0                 | 0    | 0    |
| 20     | 5       | 95   | 0                       | 100  | 95   | 5    | 93                | 85    | 60    | 0                 | 0    | 0    |
| 21     | 2       | 98   | 0                       | 100  | 98   | 2    | 90                | 63    | 41    | 0                 | 0    | 0    |
| 22     | 8       | 92   | 0                       | 100  | 91   | 9    | 64                | 42    | 24    | 5                 | 1    | 1    |
| 23     | 32      | 68   | 60                      | 40   | 70   | 30   | 44                | 25    | 13    | 8                 | 4    | 1    |
| 24     | 32      | 68   | 26                      | 74   | 65   | 35   | 39                | 21    | 8     | 14                | 5    | 3    |
| 25     | 42      | 58   | 42                      | 58   | 58   | 43   | 31                | 12    | 6     | 17                | 8    | 3    |
| 26     | 44      | 56   | 40                      | 60   | 53   | 47   | 22                | 10    | 8     | 22                | 7    | 4    |
| 27     | 56      | 44   | 50                      | 50   | 39   | 61   | 20                | 16    | 7     | 17                | 11   | 7    |
| 28     | 41      | 59   | 30                      | 70   | 46   | 54   | 46                | 20    | 13    | 27                | 16   | 6    |
| 29     | 41      | 59   | 67                      | 33   | 77   | 23   | 25                | 16    | 10    | 24                | 8    | 5    |
| 30     | 58      | 42   | 58                      | 42   | 43   | 57   | 27                | 16    | 14    | 20                | 12   | 4    |
| 31     | 36      | 64   | 35                      | 65   | 64   | 36   | 39                | 34    | 21    | 20                | 7    | 2    |
| 32     | 46      | 54   | 57                      | 43   | 61   | 39   | 47                | 29    | 23    | 15                | 5    | 3    |
| 33     | 22      | 78   | 33                      | 67   | 88   | 13   | 47                | 37    | 20    | 7                 | 4    | 3    |
| 34     | 37      | 63   | 31                      | 69   | 61   | 39   | 49                | 26    | 13    | 20                | 16   | 6    |
| 35     | 34      | 66   | 55                      | 45   | 78   | 22   | 36                | 17    | 11    | 27                | 10   | 9    |
| 36     | 58      | 42   | 80                      | 20   | 54   | 46   | 20                | 13    | 7     | 20                | 19   | 9    |
| 37     | 42      | 58   | 35                      | 65   | 48   | 52   | 36                | 19    | 6     | 39                | 19   | 7    |
| 38     | 61      | 39   | 92                      | 8    | 62   | 38   | 20                | 7     | 5     | 31                | 12   | 4    |
| 39     | 49      | 51   | 50                      | 50   | 52   | 48   | 17                | 13    | 12    | 19                | 6    | 0    |
| 40     | 53      | 47   | 38                      | 62   | 33   | 67   | 37                | 34    | 32    | 17                | 1    | 0    |
| 41     | 27      | 73   | 32                      | 68   | 79   | 21   | 66                | 62    | 62    | 2                 | 0    | 0    |
| 42     | 8       | 92   | 6                       | 94   | 91   | 9    | 86                | 86    | 83    | 2                 | 0    | 0    |
| 43     | 7       | 93   | 20                      | 80   | 94   | 6    | 93                | 90    | 82    | 2                 | 0    | 0    |
| 44     | 2       | 98   | 25                      | 75   | 100  | 0    | 95                | 87    | 83    | 0                 | 0    | 0    |
| 45     | 3       | 97   | 0                       | 100  | 97   | 3    | 88                | 85    | 85    | 3                 | 1    | 0    |
| 46     | 12      | 88   | 100                     | 0    | 91   | 9    | 85                | 85    | 83    | 3                 | 0    | 0    |
| 47     | 7       | 93   | 29                      | 71   | 96   | 4    | 93                | 92    | 87    | 0                 | 0    | 0    |
| 48     | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 93    | 93    | 0                 | 0    | 0    |
| 49     | 2       | 98   | 0                       | 0    | 98   | 2    | 93                | 93    | 93    | 0                 | 0    | 0    |
| 50     | 5       | 95   | 0                       | 100  | 95   | 5    | 95                | 95    | 0     | 0                 | 0    | 0    |
| 51     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52     | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

Table 4.42: Dry and wet week probability during crop growth period in Chandwad Tehsil

| Chandwad |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|----------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
|          | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|          | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 4        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 5        | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 6        | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 7        | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 12       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 13       | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 14       | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 95    | 0                 | 0    | 0    |
| 15       | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 98    | 93    | 0                 | 0    | 0    |
| 16       | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 93    | 84    | 0                 | 0    | 0    |
| 17       | 2       | 98   | 0                       | 0    | 98   | 2    | 93                | 84    | 81    | 0                 | 0    | 0    |
| 18       | 5       | 95   | 0                       | 100  | 95   | 5    | 86                | 83    | 81    | 0                 | 0    | 0    |
| 19       | 10      | 90   | 0                       | 100  | 90   | 10   | 88                | 86    | 73    | 5                 | 2    | 0    |
| 20       | 7       | 93   | 50                      | 50   | 97   | 3    | 90                | 77    | 49    | 2                 | 0    | 0    |
| 21       | 5       | 95   | 33                      | 67   | 97   | 3    | 81                | 52    | 34    | 0                 | 0    | 0    |
| 22       | 14      | 86   | 0                       | 100  | 85   | 15   | 55                | 36    | 19    | 7                 | 4    | 1    |
| 23       | 38      | 62   | 50                      | 50   | 64   | 36   | 40                | 21    | 13    | 19                | 6    | 3    |
| 24       | 40      | 60   | 50                      | 50   | 65   | 35   | 31                | 19    | 9     | 12                | 6    | 4    |
| 25       | 40      | 60   | 29                      | 71   | 52   | 48   | 36                | 16    | 6     | 19                | 14   | 5    |
| 26       | 43      | 57   | 47                      | 53   | 60   | 40   | 26                | 10    | 6     | 31                | 11   | 7    |
| 27       | 62      | 38   | 72                      | 28   | 46   | 54   | 14                | 9     | 3     | 21                | 15   | 11   |
| 28       | 45      | 55   | 35                      | 65   | 38   | 63   | 33                | 13    | 9     | 31                | 23   | 12   |
| 29       | 52      | 48   | 68                      | 32   | 61   | 39   | 19                | 12    | 8     | 38                | 20   | 15   |
| 30       | 67      | 33   | 73                      | 27   | 40   | 60   | 21                | 14    | 11    | 36                | 27   | 5    |
| 31       | 48      | 52   | 54                      | 46   | 64   | 36   | 33                | 26    | 15    | 36                | 6    | 2    |
| 32       | 55      | 45   | 75                      | 25   | 64   | 36   | 36                | 20    | 12    | 10                | 4    | 2    |
| 33       | 19      | 81   | 17                      | 83   | 79   | 21   | 45                | 28    | 20    | 7                 | 4    | 3    |
| 34       | 43      | 57   | 38                      | 63   | 56   | 44   | 36                | 25    | 14    | 24                | 16   | 8    |
| 35       | 45      | 55   | 56                      | 44   | 63   | 38   | 38                | 21    | 9     | 31                | 15   | 9    |
| 36       | 48      | 52   | 68                      | 32   | 70   | 30   | 29                | 13    | 12    | 24                | 14   | 7    |
| 37       | 48      | 52   | 50                      | 50   | 55   | 45   | 24                | 21    | 15    | 29                | 14   | 8    |
| 38       | 57      | 43   | 60                      | 40   | 45   | 55   | 38                | 27    | 23    | 29                | 16   | 3    |
| 39       | 33      | 67   | 50                      | 50   | 89   | 11   | 48                | 40    | 33    | 19                | 4    | 0    |
| 40       | 38      | 62   | 57                      | 43   | 71   | 29   | 52                | 43    | 42    | 7                 | 0    | 0    |
| 41       | 17      | 83   | 19                      | 81   | 85   | 15   | 69                | 67    | 65    | 0                 | 0    | 0    |
| 42       | 14      | 86   | 0                       | 100  | 83   | 17   | 83                | 81    | 63    | 2                 | 1    | 0    |
| 43       | 5       | 95   | 17                      | 83   | 97   | 3    | 93                | 72    | 65    | 2                 | 0    | 0    |
| 44       | 5       | 95   | 50                      | 50   | 98   | 3    | 74                | 67    | 63    | 0                 | 0    | 0    |
| 45       | 21      | 79   | 0                       | 100  | 78   | 23   | 71                | 68    | 64    | 5                 | 1    | 0    |
| 46       | 12      | 88   | 22                      | 78   | 91   | 9    | 83                | 79    | 77    | 2                 | 0    | 0    |
| 47       | 7       | 93   | 20                      | 80   | 95   | 5    | 88                | 86    | 86    | 0                 | 0    | 0    |
| 48       | 5       | 95   | 0                       | 100  | 95   | 5    | 93                | 93    | 91    | 0                 | 0    | 0    |
| 49       | 2       | 98   | 0                       | 100  | 98   | 3    | 98                | 95    | 95    | 0                 | 0    | 0    |
| 50       | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 0     | 0                 | 0    | 0    |
| 51       | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 0     | 0     | 0                 | 0    | 0    |
| 52       | 0       | 100  | 0                       | 100  | 100  | 0    |                   |       |       |                   |      |      |

Table 4.42: Dry and wet week probability during crop growth period in Deola Tehsil

| Deola |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|-------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
|       | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
| M     | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 15    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 16    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 91    | 0                 | 0    | 0    |
| 17    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 91    | 91    | 0                 | 0    | 0    |
| 18    | 0       | 100  | 0                       | 0    | 100  | 0    | 91                | 91    | 91    | 0                 | 0    | 0    |
| 19    | 9       | 91   | 0                       | 0    | 91   | 9    | 91                | 91    | 79    | 0                 | 0    | 0    |
| 20    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 86    | 68    | 0                 | 0    | 0    |
| 21    | 0       | 100  | 0                       | 0    | 100  | 0    | 86                | 68    | 47    | 0                 | 0    | 0    |
| 22    | 14      | 86   | 0                       | 0    | 86   | 14   | 68                | 47    | 22    | 9                 | 3    | 0    |
| 23    | 27      | 73   | 67                      | 33   | 79   | 21   | 50                | 23    | 15    | 9                 | 0    | 0    |
| 24    | 32      | 68   | 33                      | 67   | 69   | 31   | 32                | 20    | 14    | 0                 | 0    | 0    |
| 25    | 36      | 64   | 0                       | 100  | 47   | 53   | 41                | 27    | 17    | 9                 | 5    | 1    |
| 26    | 32      | 68   | 25                      | 75   | 64   | 36   | 45                | 28    | 22    | 18                | 4    | 1    |
| 27    | 41      | 59   | 57                      | 43   | 67   | 33   | 36                | 29    | 11    | 9                 | 1    | 1    |
| 28    | 32      | 68   | 22                      | 78   | 62   | 38   | 55                | 21    | 17    | 5                 | 2    | 1    |
| 29    | 18      | 82   | 14                      | 86   | 80   | 20   | 32                | 25    | 17    | 9                 | 6    | 3    |
| 30    | 59      | 41   | 50                      | 50   | 39   | 61   | 32                | 21    | 20    | 36                | 18   | 2    |
| 31    | 45      | 55   | 62                      | 38   | 78   | 22   | 36                | 34    | 18    | 23                | 3    | 0    |
| 32    | 41      | 59   | 50                      | 50   | 67   | 33   | 55                | 30    | 21    | 5                 | 0    | 0    |
| 33    | 9       | 91   | 11                      | 89   | 92   | 8    | 50                | 35    | 22    | 0                 | 0    | 0    |
| 34    | 41      | 59   | 0                       | 100  | 55   | 45   | 41                | 26    | 18    | 18                | 11   | 6    |
| 35    | 36      | 64   | 44                      | 56   | 69   | 31   | 41                | 27    | 19    | 23                | 11   | 10   |
| 36    | 45      | 55   | 63                      | 38   | 64   | 36   | 36                | 25    | 10    | 23                | 20   | 10   |
| 37    | 41      | 59   | 50                      | 50   | 67   | 33   | 41                | 16    | 10    | 36                | 18   | 14   |
| 38    | 55      | 45   | 89                      | 11   | 69   | 31   | 18                | 11    | 6     | 27                | 20   | 8    |
| 39    | 55      | 45   | 50                      | 50   | 40   | 60   | 27                | 15    | 14    | 41                | 16   | 4    |
| 40    | 59      | 41   | 75                      | 25   | 60   | 40   | 23                | 21    | 21    | 23                | 5    | 2    |
| 41    | 41      | 59   | 38                      | 62   | 56   | 44   | 55                | 55    | 55    | 9                 | 3    | 3    |
| 42    | 14      | 86   | 22                      | 78   | 92   | 8    | 86                | 86    | 78    | 5                 | 5    | 0    |
| 43    | 5       | 95   | 33                      | 67   | 100  | 0    | 95                | 86    | 82    | 5                 | 0    | 0    |
| 44    | 5       | 95   | 100                     | 0    | 100  | 0    | 86                | 82    | 74    | 0                 | 0    | 0    |
| 45    | 9       | 91   | 0                       | 100  | 90   | 10   | 86                | 78    | 78    | 5                 | 0    | 0    |
| 46    | 9       | 91   | 50                      | 50   | 95   | 5    | 82                | 82    | 82    | 0                 | 0    | 0    |
| 47    | 9       | 91   | 0                       | 100  | 90   | 10   | 91                | 91    | 87    | 0                 | 0    | 0    |
| 48    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 95    | 95    | 0                 | 0    | 0    |
| 49    | 0       | 100  | 0                       | 0    | 100  | 0    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 50    | 5       | 95   | 0                       | 0    | 95   | 5    | 95                | 95    | 0     | 0                 | 0    | 0    |
| 51    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52    | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

Table 4.44: Dry and wet week probability during crop growth period in Dindori Tehsil

| Dindori |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|---------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M       | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|         | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1       | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 97    | 0                 | 0    | 0    |
| 15      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 97    | 95    | 0                 | 0    | 0    |
| 16      | 0       | 100  | 0                       | 0    | 100  | 0    | 97                | 95    | 95    | 0                 | 0    | 0    |
| 17      | 3       | 97   | 0                       | 0    | 97   | 3    | 95                | 95    | 92    | 0                 | 0    | 0    |
| 18      | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 95    | 90    | 0                 | 0    | 0    |
| 19      | 0       | 100  | 0                       | 100  | 100  | 0    | 97                | 92    | 77    | 0                 | 0    | 0    |
| 20      | 3       | 97   | 0                       | 0    | 97   | 3    | 92                | 77    | 48    | 0                 | 0    | 0    |
| 21      | 5       | 95   | 0                       | 100  | 95   | 5    | 80                | 50    | 31    | 3                 | 1    | 1    |
| 22      | 19      | 81   | 67                      | 33   | 84   | 16   | 51                | 32    | 20    | 7                 | 3    | 2    |
| 23      | 37      | 63   | 36                      | 64   | 63   | 38   | 39                | 24    | 10    | 19                | 12   | 5    |
| 24      | 42      | 58   | 50                      | 50   | 62   | 38   | 36                | 15    | 6     | 27                | 11   | 7    |
| 25      | 49      | 51   | 64                      | 36   | 62   | 38   | 22                | 9     | 4     | 20                | 13   | 8    |
| 26      | 49      | 51   | 41                      | 59   | 43   | 57   | 20                | 8     | 3     | 32                | 19   | 15   |
| 27      | 63      | 37   | 66                      | 34   | 40   | 60   | 15                | 6     | 2     | 37                | 29   | 22   |
| 28      | 59      | 41   | 59                      | 41   | 41   | 59   | 17                | 6     | 2     | 46                | 35   | 26   |
| 29      | 69      | 31   | 77                      | 23   | 42   | 58   | 10                | 3     | 1     | 53                | 39   | 34   |
| 30      | 73      | 27   | 76                      | 24   | 33   | 67   | 8                 | 4     | 2     | 54                | 47   | 28   |
| 31      | 73      | 27   | 74                      | 26   | 31   | 69   | 12                | 5     | 4     | 63                | 38   | 22   |
| 32      | 78      | 22   | 86                      | 14   | 44   | 56   | 10                | 7     | 5     | 47                | 27   | 14   |
| 33      | 59      | 41   | 61                      | 39   | 46   | 54   | 29                | 20    | 15    | 34                | 18   | 11   |
| 34      | 46      | 54   | 57                      | 43   | 71   | 29   | 37                | 29    | 18    | 24                | 15   | 6    |
| 35      | 41      | 59   | 52                      | 48   | 69   | 31   | 46                | 29    | 19    | 25                | 10   | 5    |
| 36      | 39      | 61   | 63                      | 38   | 77   | 23   | 39                | 25    | 13    | 15                | 8    | 5    |
| 37      | 37      | 63   | 39                      | 61   | 64   | 36   | 41                | 20    | 12    | 20                | 11   | 6    |
| 38      | 42      | 58   | 55                      | 45   | 65   | 35   | 29                | 16    | 13    | 24                | 11   | 3    |
| 39      | 53      | 47   | 56                      | 44   | 50   | 50   | 27                | 21    | 18    | 25                | 8    | 2    |
| 40      | 46      | 54   | 48                      | 52   | 57   | 43   | 42                | 36    | 33    | 14                | 3    | 1    |
| 41      | 25      | 75   | 30                      | 70   | 78   | 22   | 63                | 59    | 58    | 5                 | 2    | 0    |
| 42      | 17      | 83   | 20                      | 80   | 84   | 16   | 78                | 76    | 71    | 7                 | 1    | 0    |
| 43      | 12      | 88   | 40                      | 60   | 94   | 6    | 86                | 80    | 75    | 2                 | 0    | 0    |
| 44      | 3       | 97   | 14                      | 86   | 98   | 2    | 90                | 83    | 79    | 0                 | 0    | 0    |
| 45      | 7       | 93   | 0                       | 100  | 93   | 7    | 86                | 82    | 76    | 2                 | 0    | 0    |
| 46      | 8       | 92   | 25                      | 75   | 93   | 7    | 86                | 80    | 80    | 2                 | 0    | 0    |
| 47      | 7       | 93   | 20                      | 80   | 94   | 6    | 86                | 86    | 86    | 0                 | 0    | 0    |
| 48      | 7       | 93   | 0                       | 100  | 93   | 7    | 93                | 93    | 92    | 2                 | 0    | 0    |
| 49      | 2       | 98   | 25                      | 75   | 100  | 0    | 98                | 97    | 95    | 0                 | 0    | 0    |
| 50      | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 97    | 0     | 0                 | 0    | 0    |
| 51      | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 0     | 0     | 0                 | 0    | 0    |
| 52      | 2       | 98   | 0                       | 100  | 98   | 2    |                   |       |       |                   |      |      |

Table 4.44: Dry and wet week probability during crop growth period in Igatpuri Tehsil

| Igatpuri |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|----------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M        | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|          | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1        | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 2        | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 11       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 12       | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 97    | 0                 | 0    | 0    |
| 13       | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 14       | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 95    | 0                 | 0    | 0    |
| 15       | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 95    | 90    | 2                 | 0    | 0    |
| 16       | 2       | 98   | 100                     | 0    | 100  | 0    | 95                | 90    | 87    | 0                 | 0    | 0    |
| 17       | 3       | 97   | 0                       | 100  | 97   | 3    | 92                | 88    | 84    | 0                 | 0    | 0    |
| 18       | 5       | 95   | 0                       | 100  | 95   | 5    | 92                | 87    | 85    | 0                 | 0    | 0    |
| 19       | 3       | 97   | 0                       | 100  | 96   | 4    | 92                | 90    | 71    | 0                 | 0    | 0    |
| 20       | 5       | 95   | 0                       | 100  | 95   | 5    | 93                | 73    | 33    | 3                 | 2    | 1    |
| 21       | 5       | 95   | 67                      | 33   | 98   | 2    | 75                | 33    | 13    | 3                 | 2    | 2    |
| 22       | 24      | 76   | 67                      | 33   | 79   | 21   | 34                | 14    | 3     | 15                | 13   | 12   |
| 23       | 58      | 42   | 64                      | 36   | 44   | 56   | 17                | 4     | 1     | 51                | 45   | 43   |
| 24       | 76      | 24   | 88                      | 12   | 40   | 60   | 5                 | 2     | 0     | 68                | 65   | 63   |
| 25       | 86      | 14   | 89                      | 11   | 21   | 79   | 5                 | 1     | 0     | 83                | 80   | 79   |
| 26       | 92      | 8    | 96                      | 4    | 38   | 63   | 2                 | 1     | 0     | 88                | 87   | 87   |
| 27       | 95      | 5    | 96                      | 4    | 20   | 80   | 2                 | 0     | 0     | 93                | 93   | 93   |
| 28       | 97      | 3    | 98                      | 2    | 33   | 67   | 0                 | 0     | 0     | 97                | 97   | 95   |
| 29       | 100     | 0    | 100                     | 0    | 0    | 100  | 0                 | 0     | 0     | 100               | 98   | 98   |
| 30       | 100     | 0    | 100                     | 0    | 0    | 0    | 0                 | 0     | 0     | 98                | 98   | 97   |
| 31       | 98      | 2    | 98                      | 2    | 0    | 0    | 0                 | 0     | 0     | 98                | 97   | 92   |
| 32       | 100     | 0    | 100                     | 0    | 0    | 100  | 0                 | 0     | 0     | 98                | 93   | 85   |
| 33       | 98      | 2    | 98                      | 2    | 0    | 0    | 0                 | 0     | 0     | 93                | 85   | 75   |
| 34       | 95      | 5    | 95                      | 5    | 0    | 100  | 0                 | 0     | 0     | 86                | 77   | 56   |
| 35       | 92      | 8    | 91                      | 9    | 0    | 100  | 3                 | 0     | 0     | 81                | 59   | 42   |
| 36       | 86      | 14   | 89                      | 11   | 40   | 60   | 0                 | 0     | 0     | 63                | 45   | 33   |
| 37       | 76      | 24   | 73                      | 27   | 0    | 100  | 8                 | 4     | 2     | 54                | 40   | 19   |
| 38       | 69      | 31   | 71                      | 29   | 36   | 64   | 14                | 7     | 4     | 51                | 24   | 9    |
| 39       | 68      | 32   | 73                      | 27   | 44   | 56   | 17                | 10    | 9     | 32                | 12   | 3    |
| 40       | 47      | 53   | 48                      | 53   | 53   | 47   | 31                | 27    | 25    | 17                | 4    | 1    |
| 41       | 39      | 61   | 36                      | 64   | 58   | 42   | 54                | 51    | 49    | 10                | 3    | 0    |
| 42       | 17      | 83   | 26                      | 74   | 89   | 11   | 78                | 75    | 66    | 5                 | 0    | 0    |
| 43       | 10      | 90   | 30                      | 70   | 94   | 6    | 86                | 76    | 70    | 0                 | 0    | 0    |
| 44       | 3       | 97   | 0                       | 100  | 96   | 4    | 85                | 78    | 77    | 2                 | 0    | 0    |
| 45       | 14      | 86   | 50                      | 50   | 88   | 12   | 80                | 78    | 74    | 3                 | 1    | 0    |
| 46       | 10      | 90   | 25                      | 75   | 92   | 8    | 88                | 83    | 82    | 3                 | 0    | 0    |
| 47       | 5       | 95   | 33                      | 67   | 98   | 2    | 90                | 88    | 87    | 0                 | 0    | 0    |
| 48       | 5       | 95   | 0                       | 100  | 95   | 5    | 93                | 92    | 88    | 0                 | 0    | 0    |
| 49       | 2       | 98   | 0                       | 100  | 98   | 2    | 97                | 93    | 93    | 0                 | 0    | 0    |
| 50       | 2       | 98   | 0                       | 100  | 98   | 2    | 95                | 95    | 0     | 0                 | 0    | 0    |
| 51       | 3       | 97   | 0                       | 100  | 97   | 3    | 97                | 0     | 0     | 0                 | 0    | 0    |
| 52       | 0       | 100  | 0                       | 100  | 100  | 0    |                   |       |       |                   |      |      |

Table 4.46: Dry and wet week probability during crop growth period in Kalwan Tehsil

| Kalwan |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|--------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M      | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|        | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 3      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 97    | 0                 | 0    | 0    |
| 4      | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 5      | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 97    | 95    | 0                 | 0    | 0    |
| 6      | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 7      | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 8      | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 9      | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 10     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 11     | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 12     | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 13     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 15     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 92    | 0                 | 0    | 0    |
| 16     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 92    | 83    | 0                 | 0    | 0    |
| 17     | 0       | 100  | 0                       | 0    | 100  | 0    | 92                | 83    | 82    | 0                 | 0    | 0    |
| 18     | 8       | 92   | 0                       | 0    | 92   | 8    | 83                | 82    | 80    | 0                 | 0    | 0    |
| 19     | 8       | 92   | 0                       | 100  | 91   | 9    | 90                | 88    | 81    | 2                 | 0    | 0    |
| 20     | 3       | 97   | 20                      | 80   | 98   | 2    | 95                | 87    | 58    | 0                 | 0    | 0    |
| 21     | 2       | 98   | 0                       | 100  | 98   | 2    | 90                | 60    | 37    | 0                 | 0    | 0    |
| 22     | 8       | 92   | 0                       | 100  | 91   | 9    | 61                | 38    | 27    | 3                 | 2    | 1    |
| 23     | 34      | 66   | 40                      | 60   | 67   | 33   | 41                | 29    | 16    | 22                | 10   | 4    |
| 24     | 47      | 53   | 65                      | 35   | 62   | 38   | 37                | 21    | 7     | 22                | 8    | 6    |
| 25     | 37      | 63   | 46                      | 54   | 71   | 29   | 36                | 12    | 4     | 14                | 10   | 4    |
| 26     | 41      | 59   | 36                      | 64   | 57   | 43   | 20                | 6     | 3     | 29                | 12   | 9    |
| 27     | 68      | 32   | 71                      | 29   | 34   | 66   | 10                | 5     | 2     | 29                | 20   | 15   |
| 28     | 51      | 49   | 43                      | 58   | 32   | 68   | 22                | 10    | 6     | 36                | 26   | 12   |
| 29     | 63      | 37   | 70                      | 30   | 45   | 55   | 17                | 9     | 4     | 46                | 21   | 14   |
| 30     | 66      | 34   | 73                      | 27   | 45   | 55   | 19                | 8     | 6     | 31                | 20   | 10   |
| 31     | 46      | 54   | 46                      | 54   | 55   | 45   | 24                | 17    | 11    | 31                | 14   | 9    |
| 32     | 61      | 39   | 67                      | 33   | 44   | 56   | 27                | 18    | 12    | 29                | 18   | 6    |
| 33     | 41      | 59   | 47                      | 53   | 70   | 30   | 39                | 27    | 16    | 25                | 8    | 8    |
| 34     | 46      | 54   | 63                      | 38   | 66   | 34   | 37                | 22    | 15    | 15                | 14   | 6    |
| 35     | 32      | 68   | 33                      | 67   | 69   | 31   | 41                | 28    | 19    | 29                | 12   | 8    |
| 36     | 56      | 44   | 89                      | 11   | 60   | 40   | 31                | 21    | 14    | 24                | 16   | 8    |
| 37     | 37      | 63   | 42                      | 58   | 69   | 31   | 42                | 29    | 19    | 25                | 12   | 7    |
| 38     | 46      | 54   | 68                      | 32   | 68   | 32   | 37                | 24    | 17    | 22                | 12   | 4    |
| 39     | 39      | 61   | 48                      | 52   | 69   | 31   | 39                | 27    | 25    | 22                | 7    | 2    |
| 40     | 44      | 56   | 57                      | 43   | 64   | 36   | 39                | 35    | 34    | 14                | 3    | 0    |
| 41     | 31      | 69   | 31                      | 69   | 70   | 30   | 63                | 60    | 54    | 7                 | 1    | 0    |
| 42     | 14      | 86   | 22                      | 78   | 90   | 10   | 83                | 74    | 70    | 2                 | 1    | 0    |
| 43     | 5       | 95   | 13                      | 88   | 96   | 4    | 85                | 80    | 74    | 2                 | 0    | 0    |
| 44     | 12      | 88   | 33                      | 67   | 89   | 11   | 83                | 77    | 73    | 2                 | 1    | 0    |
| 45     | 7       | 93   | 14                      | 86   | 94   | 6    | 86                | 82    | 80    | 3                 | 2    | 0    |
| 46     | 10      | 90   | 50                      | 50   | 93   | 7    | 85                | 83    | 82    | 5                 | 0    | 0    |
| 47     | 10      | 90   | 50                      | 50   | 94   | 6    | 88                | 87    | 85    | 0                 | 0    | 0    |
| 48     | 2       | 98   | 0                       | 100  | 98   | 2    | 97                | 95    | 95    | 0                 | 0    | 0    |
| 49     | 2       | 98   | 0                       | 100  | 98   | 2    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 50     | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 98    | 0     | 0                 | 0    | 0    |
| 51     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52     | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

**Table 4.47: Dry and wet week probability during crop growth period in Malegaon Tehsil**

| Malegaon |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|----------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M        | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|          | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1        | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 2        | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 95    | 0                 | 0    | 0    |
| 3        | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 97    | 95    | 0                 | 0    | 0    |
| 4        | 0       | 100  | 0                       | 0    | 100  | 0    | 97                | 95    | 95    | 0                 | 0    | 0    |
| 5        | 3       | 97   | 0                       | 0    | 97   | 3    | 95                | 95    | 93    | 0                 | 0    | 0    |
| 6        | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 7        | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 8        | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 9        | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 15       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 97    | 0                 | 0    | 0    |
| 16       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 97    | 93    | 0                 | 0    | 0    |
| 17       | 0       | 100  | 0                       | 0    | 100  | 0    | 97                | 93    | 90    | 0                 | 0    | 0    |
| 18       | 3       | 97   | 0                       | 0    | 97   | 3    | 93                | 90    | 85    | 0                 | 0    | 0    |
| 19       | 3       | 97   | 0                       | 100  | 96   | 4    | 93                | 88    | 77    | 0                 | 0    | 0    |
| 20       | 3       | 97   | 0                       | 100  | 96   | 4    | 92                | 80    | 55    | 0                 | 0    | 0    |
| 21       | 5       | 95   | 0                       | 100  | 95   | 5    | 83                | 57    | 37    | 2                 | 1    | 0    |
| 22       | 14      | 86   | 33                      | 67   | 88   | 13   | 59                | 39    | 25    | 5                 | 3    | 1    |
| 23       | 32      | 68   | 38                      | 63   | 69   | 31   | 44                | 29    | 16    | 19                | 4    | 2    |
| 24       | 42      | 58   | 58                      | 42   | 65   | 35   | 37                | 21    | 13    | 10                | 4    | 2    |
| 25       | 31      | 69   | 24                      | 76   | 65   | 35   | 39                | 24    | 15    | 12                | 6    | 2    |
| 26       | 42      | 58   | 39                      | 61   | 56   | 44   | 36                | 22    | 14    | 20                | 7    | 3    |
| 27       | 42      | 58   | 48                      | 52   | 62   | 38   | 36                | 22    | 11    | 14                | 7    | 4    |
| 28       | 36      | 64   | 32                      | 68   | 62   | 38   | 41                | 20    | 14    | 19                | 10   | 5    |
| 29       | 42      | 58   | 52                      | 48   | 63   | 37   | 29                | 20    | 11    | 22                | 12   | 5    |
| 30       | 51      | 49   | 52                      | 48   | 50   | 50   | 34                | 19    | 15    | 27                | 11   | 2    |
| 31       | 42      | 58   | 53                      | 47   | 69   | 31   | 32                | 26    | 17    | 17                | 3    | 1    |
| 32       | 42      | 58   | 40                      | 60   | 56   | 44   | 46                | 30    | 19    | 7                 | 4    | 2    |
| 33       | 19      | 81   | 16                      | 84   | 79   | 21   | 53                | 34    | 24    | 10                | 7    | 3    |
| 34       | 39      | 61   | 55                      | 45   | 65   | 35   | 39                | 28    | 19    | 25                | 13   | 4    |
| 35       | 47      | 53   | 65                      | 35   | 64   | 36   | 37                | 26    | 19    | 24                | 8    | 6    |
| 36       | 39      | 61   | 50                      | 50   | 71   | 29   | 42                | 32    | 19    | 14                | 10   | 3    |
| 37       | 32      | 68   | 35                      | 65   | 69   | 31   | 51                | 31    | 22    | 24                | 8    | 5    |
| 38       | 41      | 59   | 74                      | 26   | 75   | 25   | 36                | 26    | 21    | 14                | 8    | 2    |
| 39       | 37      | 63   | 33                      | 67   | 60   | 40   | 46                | 37    | 33    | 22                | 6    | 0    |
| 40       | 39      | 61   | 59                      | 41   | 73   | 27   | 49                | 44    | 41    | 10                | 0    | 0    |
| 41       | 22      | 78   | 26                      | 74   | 81   | 19   | 69                | 66    | 63    | 0                 | 0    | 0    |
| 42       | 8       | 92   | 0                       | 100  | 89   | 11   | 86                | 83    | 79    | 2                 | 0    | 0    |
| 43       | 7       | 93   | 20                      | 80   | 94   | 6    | 90                | 85    | 79    | 2                 | 0    | 0    |
| 44       | 5       | 95   | 25                      | 75   | 96   | 4    | 90                | 83    | 76    | 0                 | 0    | 0    |
| 45       | 5       | 95   | 0                       | 100  | 95   | 5    | 88                | 80    | 74    | 2                 | 0    | 0    |
| 46       | 8       | 92   | 33                      | 67   | 93   | 7    | 83                | 77    | 76    | 0                 | 0    | 0    |
| 47       | 8       | 92   | 0                       | 100  | 91   | 9    | 85                | 83    | 80    | 0                 | 0    | 0    |
| 48       | 7       | 93   | 0                       | 100  | 93   | 7    | 92                | 88    | 88    | 0                 | 0    | 0    |
| 49       | 2       | 98   | 0                       | 100  | 98   | 2    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 50       | 3       | 97   | 0                       | 100  | 97   | 3    | 97                | 97    | 0     | 0                 | 0    | 0    |
| 51       | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52       | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

Table 4.48: Dry and wet week probability during crop growth period in Nandgaon Tehsil

| Nandgaon |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|----------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M        | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|          | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1        | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 2        | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9        | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 13       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 14       | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 15       | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 95    | 0                 | 0    | 0    |
| 16       | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 97    | 93    | 0                 | 0    | 0    |
| 17       | 0       | 100  | 0                       | 0    | 100  | 0    | 97                | 93    | 92    | 0                 | 0    | 0    |
| 18       | 3       | 97   | 0                       | 0    | 97   | 3    | 93                | 92    | 85    | 0                 | 0    | 0    |
| 19       | 3       | 97   | 0                       | 100  | 96   | 4    | 95                | 88    | 82    | 0                 | 0    | 0    |
| 20       | 2       | 98   | 0                       | 100  | 98   | 2    | 92                | 85    | 52    | 0                 | 0    | 0    |
| 21       | 7       | 93   | 0                       | 100  | 93   | 7    | 86                | 53    | 31    | 2                 | 1    | 0    |
| 22       | 8       | 92   | 25                      | 75   | 93   | 7    | 56                | 33    | 20    | 7                 | 2    | 1    |
| 23       | 42      | 58   | 80                      | 20   | 61   | 39   | 34                | 21    | 12    | 14                | 5    | 1    |
| 24       | 37      | 63   | 32                      | 68   | 59   | 41   | 39                | 22    | 13    | 14                | 3    | 2    |
| 25       | 37      | 63   | 36                      | 64   | 62   | 38   | 36                | 21    | 13    | 8                 | 5    | 2    |
| 26       | 36      | 64   | 23                      | 77   | 57   | 43   | 37                | 23    | 15    | 20                | 7    | 3    |
| 27       | 47      | 53   | 57                      | 43   | 58   | 42   | 32                | 21    | 11    | 17                | 7    | 4    |
| 28       | 37      | 63   | 36                      | 64   | 61   | 39   | 41                | 22    | 15    | 15                | 8    | 3    |
| 29       | 37      | 63   | 41                      | 59   | 65   | 35   | 34                | 24    | 14    | 20                | 8    | 3    |
| 30       | 49      | 51   | 55                      | 45   | 54   | 46   | 36                | 22    | 15    | 20                | 7    | 2    |
| 31       | 36      | 64   | 41                      | 59   | 70   | 30   | 39                | 27    | 17    | 12                | 4    | 2    |
| 32       | 37      | 63   | 33                      | 67   | 61   | 39   | 44                | 28    | 16    | 12                | 7    | 4    |
| 33       | 31      | 69   | 32                      | 68   | 70   | 30   | 44                | 25    | 17    | 19                | 9    | 7    |
| 34       | 44      | 56   | 61                      | 39   | 63   | 37   | 32                | 21    | 16    | 22                | 16   | 9    |
| 35       | 46      | 54   | 50                      | 50   | 58   | 42   | 36                | 27    | 18    | 34                | 19   | 12   |
| 36       | 53      | 47   | 74                      | 26   | 66   | 34   | 36                | 24    | 15    | 29                | 18   | 10   |
| 37       | 41      | 59   | 55                      | 45   | 75   | 25   | 41                | 25    | 18    | 25                | 14   | 6    |
| 38       | 44      | 56   | 63                      | 38   | 69   | 31   | 34                | 24    | 22    | 24                | 10   | 4    |
| 39       | 46      | 54   | 54                      | 46   | 61   | 39   | 39                | 35    | 31    | 19                | 7    | 2    |
| 40       | 34      | 66   | 41                      | 59   | 72   | 28   | 59                | 53    | 47    | 14                | 3    | 0    |
| 41       | 20      | 80   | 40                      | 60   | 90   | 10   | 71                | 63    | 57    | 5                 | 1    | 0    |
| 42       | 14      | 86   | 25                      | 75   | 89   | 11   | 76                | 69    | 64    | 2                 | 0    | 0    |
| 43       | 12      | 88   | 13                      | 88   | 88   | 12   | 80                | 74    | 66    | 2                 | 0    | 0    |
| 44       | 10      | 90   | 14                      | 86   | 90   | 10   | 83                | 74    | 70    | 0                 | 0    | 0    |
| 45       | 7       | 93   | 0                       | 100  | 92   | 8    | 83                | 78    | 68    | 2                 | 0    | 0    |
| 46       | 12      | 88   | 25                      | 75   | 89   | 11   | 83                | 72    | 70    | 2                 | 0    | 0    |
| 47       | 7       | 93   | 14                      | 86   | 94   | 6    | 81                | 78    | 75    | 0                 | 0    | 0    |
| 48       | 12      | 88   | 0                       | 100  | 87   | 13   | 85                | 82    | 82    | 2                 | 0    | 0    |
| 49       | 5       | 95   | 14                      | 86   | 96   | 4    | 92                | 92    | 90    | 0                 | 0    | 0    |
| 50       | 3       | 97   | 0                       | 100  | 96   | 4    | 97                | 95    | 0     | 0                 | 0    | 0    |
| 51       | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 0     | 0     | 0                 | 0    | 0    |
| 52       | 2       | 98   | 0                       | 0    | 98   | 2    |                   |       |       |                   |      |      |

Table 4.49: Dry and wet week probability during crop growth period in Nashik Tehsil

| Nashik |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|--------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M      | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|        | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 95    | 0                 | 0    | 0    |
| 12     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 95    | 95    | 0                 | 0    | 0    |
| 13     | 0       | 100  | 0                       | 0    | 100  | 0    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 14     | 5       | 95   | 0                       | 0    | 95   | 5    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 15     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 16     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 91    | 0                 | 0    | 0    |
| 17     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 91    | 86    | 0                 | 0    | 0    |
| 18     | 0       | 100  | 0                       | 0    | 100  | 0    | 91                | 86    | 86    | 0                 | 0    | 0    |
| 19     | 9       | 91   | 0                       | 0    | 91   | 9    | 86                | 86    | 71    | 0                 | 0    | 0    |
| 20     | 5       | 95   | 0                       | 100  | 95   | 5    | 95                | 78    | 52    | 0                 | 0    | 0    |
| 21     | 0       | 100  | 0                       | 100  | 100  | 0    | 82                | 55    | 43    | 0                 | 0    | 0    |
| 22     | 18      | 82   | 0                       | 0    | 82   | 18   | 55                | 43    | 26    | 9                 | 7    | 5    |
| 23     | 36      | 64   | 50                      | 50   | 67   | 33   | 50                | 31    | 11    | 27                | 18   | 10   |
| 24     | 41      | 59   | 75                      | 25   | 79   | 21   | 36                | 13    | 4     | 27                | 15   | 13   |
| 25     | 50      | 50   | 67                      | 33   | 62   | 38   | 18                | 6     | 2     | 27                | 23   | 15   |
| 26     | 59      | 41   | 55                      | 45   | 36   | 64   | 14                | 5     | 3     | 50                | 32   | 18   |
| 27     | 77      | 23   | 85                      | 15   | 33   | 67   | 9                 | 5     | 1     | 50                | 29   | 19   |
| 28     | 64      | 36   | 65                      | 35   | 40   | 60   | 18                | 5     | 3     | 36                | 24   | 18   |
| 29     | 55      | 45   | 57                      | 43   | 50   | 50   | 14                | 8     | 4     | 36                | 27   | 23   |
| 30     | 68      | 32   | 67                      | 33   | 30   | 70   | 18                | 9     | 5     | 50                | 43   | 19   |
| 31     | 64      | 36   | 73                      | 27   | 57   | 43   | 18                | 9     | 6     | 55                | 24   | 12   |
| 32     | 73      | 27   | 86                      | 14   | 50   | 50   | 14                | 9     | 7     | 32                | 16   | 9    |
| 33     | 45      | 55   | 44                      | 56   | 50   | 50   | 36                | 28    | 22    | 23                | 13   | 8    |
| 34     | 41      | 59   | 50                      | 50   | 67   | 33   | 45                | 36    | 23    | 23                | 14   | 5    |
| 35     | 36      | 64   | 56                      | 44   | 77   | 23   | 50                | 32    | 18    | 23                | 9    | 6    |
| 36     | 36      | 64   | 63                      | 38   | 79   | 21   | 41                | 23    | 12    | 14                | 10   | 4    |
| 37     | 36      | 64   | 38                      | 63   | 64   | 36   | 36                | 18    | 6     | 27                | 11   | 6    |
| 38     | 55      | 45   | 75                      | 25   | 57   | 43   | 23                | 8     | 3     | 23                | 11   | 4    |
| 39     | 45      | 55   | 42                      | 58   | 50   | 50   | 18                | 8     | 7     | 23                | 7    | 1    |
| 40     | 59      | 41   | 50                      | 50   | 33   | 67   | 18                | 15    | 15    | 18                | 2    | 0    |
| 41     | 41      | 59   | 31                      | 69   | 44   | 56   | 50                | 47    | 43    | 5                 | 0    | 0    |
| 42     | 14      | 86   | 11                      | 89   | 85   | 15   | 82                | 74    | 66    | 0                 | 0    | 0    |
| 43     | 5       | 95   | 0                       | 100  | 95   | 5    | 86                | 77    | 69    | 5                 | 2    | 1    |
| 44     | 14      | 86   | 100                     | 0    | 90   | 10   | 77                | 69    | 66    | 5                 | 2    | 1    |
| 45     | 14      | 86   | 33                      | 67   | 89   | 11   | 77                | 73    | 73    | 5                 | 2    | 0    |
| 46     | 14      | 86   | 33                      | 67   | 89   | 11   | 82                | 82    | 82    | 5                 | 0    | 0    |
| 47     | 9       | 91   | 33                      | 67   | 95   | 5    | 91                | 91    | 91    | 0                 | 0    | 0    |
| 48     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 49     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 50     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 0     | 0                 | 0    | 0    |
| 51     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52     | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

**Table 4.50: Dry and wet week probability during crop growth period in Niphad Tehsil**

| Niphad |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|--------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M      | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|        | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1      | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 2      | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 3      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 97    | 0                 | 0    | 0    |
| 4      | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 5      | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 6      | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 98    | 97    | 0                 | 0    | 0    |
| 7      | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 8      | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 9      | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 10     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 14     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 15     | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 97    | 0                 | 0    | 0    |
| 16     | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 97    | 92    | 0                 | 0    | 0    |
| 17     | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 93    | 93    | 0                 | 0    | 0    |
| 18     | 2       | 98   | 0                       | 0    | 98   | 2    | 93                | 93    | 92    | 0                 | 0    | 0    |
| 19     | 5       | 95   | 0                       | 100  | 95   | 5    | 95                | 93    | 80    | 0                 | 0    | 0    |
| 20     | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 85    | 65    | 0                 | 0    | 0    |
| 21     | 2       | 98   | 0                       | 0    | 98   | 2    | 85                | 65    | 41    | 0                 | 0    | 0    |
| 22     | 14      | 86   | 0                       | 100  | 86   | 14   | 66                | 41    | 32    | 12                | 5    | 2    |
| 23     | 32      | 68   | 88                      | 13   | 76   | 24   | 42                | 33    | 21    | 14                | 5    | 2    |
| 24     | 39      | 61   | 42                      | 58   | 63   | 38   | 47                | 31    | 15    | 14                | 5    | 3    |
| 25     | 27      | 73   | 35                      | 65   | 78   | 22   | 47                | 24    | 17    | 10                | 5    | 2    |
| 26     | 36      | 64   | 38                      | 63   | 65   | 35   | 32                | 23    | 13    | 19                | 6    | 2    |
| 27     | 51      | 49   | 52                      | 48   | 50   | 50   | 36                | 19    | 10    | 17                | 6    | 3    |
| 28     | 31      | 69   | 33                      | 67   | 72   | 28   | 37                | 19    | 10    | 10                | 5    | 3    |
| 29     | 42      | 58   | 33                      | 67   | 54   | 46   | 29                | 16    | 10    | 22                | 12   | 8    |
| 30     | 51      | 49   | 52                      | 48   | 50   | 50   | 27                | 18    | 12    | 29                | 19   | 5    |
| 31     | 51      | 49   | 57                      | 43   | 55   | 45   | 32                | 21    | 14    | 34                | 9    | 4    |
| 32     | 51      | 49   | 67                      | 33   | 66   | 34   | 32                | 22    | 15    | 14                | 5    | 3    |
| 33     | 31      | 69   | 27                      | 73   | 66   | 34   | 47                | 32    | 23    | 12                | 7    | 4    |
| 34     | 34      | 66   | 39                      | 61   | 68   | 32   | 44                | 31    | 19    | 19                | 11   | 5    |
| 35     | 41      | 59   | 55                      | 45   | 67   | 33   | 42                | 25    | 15    | 24                | 12   | 7    |
| 36     | 41      | 59   | 58                      | 42   | 71   | 29   | 36                | 22    | 15    | 20                | 12   | 7    |
| 37     | 44      | 56   | 50                      | 50   | 60   | 40   | 34                | 23    | 13    | 25                | 15   | 7    |
| 38     | 47      | 53   | 58                      | 42   | 61   | 39   | 36                | 20    | 12    | 27                | 14   | 4    |
| 39     | 44      | 56   | 57                      | 43   | 68   | 32   | 32                | 19    | 19    | 22                | 7    | 2    |
| 40     | 46      | 54   | 50                      | 50   | 58   | 42   | 32                | 31    | 30    | 14                | 4    | 1    |
| 41     | 36      | 64   | 30                      | 70   | 59   | 41   | 63                | 59    | 58    | 10                | 3    | 1    |
| 42     | 12      | 88   | 29                      | 71   | 97   | 3    | 83                | 82    | 74    | 3                 | 1    | 0    |
| 43     | 8       | 92   | 29                      | 71   | 94   | 6    | 90                | 82    | 77    | 3                 | 0    | 0    |
| 44     | 5       | 95   | 40                      | 60   | 98   | 2    | 86                | 82    | 76    | 0                 | 0    | 0    |
| 45     | 8       | 92   | 0                       | 100  | 91   | 9    | 86                | 80    | 76    | 3                 | 1    | 0    |
| 46     | 8       | 92   | 40                      | 60   | 94   | 6    | 85                | 80    | 79    | 2                 | 0    | 0    |
| 47     | 8       | 92   | 20                      | 80   | 93   | 7    | 86                | 85    | 83    | 0                 | 0    | 0    |
| 48     | 5       | 95   | 0                       | 100  | 94   | 6    | 93                | 92    | 92    | 2                 | 0    | 0    |
| 49     | 3       | 97   | 33                      | 67   | 98   | 2    | 95                | 95    | 93    | 0                 | 0    | 0    |
| 50     | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 97    | 0     | 0                 | 0    | 0    |
| 51     | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 0     | 0     | 0                 | 0    | 0    |
| 52     | 2       | 98   | 0                       | 0    | 98   | 2    |                   |       |       |                   |      |      |

**Table 4.51: Dry and wet week probability during crop growth period in Peth Tehsil**

| Peth |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
|      | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
| M    | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1    | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 2    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 15   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 16   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 17   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 18   | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 97    | 0                 | 0    | 0    |
| 19   | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 97    | 77    | 0                 | 0    | 0    |
| 20   | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 77    | 55    | 0                 | 0    | 0    |
| 21   | 2       | 98   | 0                       | 100  | 98   | 2    | 78                | 56    | 32    | 0                 | 0    | 0    |
| 22   | 20      | 80   | 0                       | 100  | 79   | 21   | 58                | 32    | 7     | 8                 | 7    | 5    |
| 23   | 31      | 69   | 42                      | 58   | 72   | 28   | 39                | 9     | 1     | 25                | 18   | 15   |
| 24   | 56      | 44   | 83                      | 17   | 56   | 44   | 10                | 1     | 0     | 39                | 34   | 29   |
| 25   | 73      | 27   | 70                      | 30   | 23   | 77   | 3                 | 1     | 0     | 63                | 54   | 51   |
| 26   | 86      | 14   | 86                      | 14   | 13   | 88   | 5                 | 1     | 0     | 75                | 70   | 66   |
| 27   | 83      | 17   | 86                      | 14   | 38   | 63   | 3                 | 0     | 0     | 78                | 74   | 70   |
| 28   | 92      | 8    | 94                      | 6    | 20   | 80   | 0                 | 0     | 0     | 86                | 82   | 77   |
| 29   | 95      | 5    | 94                      | 6    | 0    | 100  | 2                 | 0     | 0     | 90                | 85   | 82   |
| 30   | 93      | 7    | 95                      | 5    | 33   | 67   | 2                 | 0     | 0     | 88                | 85   | 82   |
| 31   | 93      | 7    | 95                      | 5    | 25   | 75   | 0                 | 0     | 0     | 90                | 87   | 82   |
| 32   | 97      | 3    | 96                      | 4    | 0    | 100  | 2                 | 1     | 0     | 93                | 88   | 79   |
| 33   | 95      | 5    | 96                      | 4    | 50   | 50   | 2                 | 1     | 0     | 90                | 80   | 69   |
| 34   | 93      | 7    | 95                      | 5    | 33   | 67   | 3                 | 1     | 0     | 83                | 72   | 57   |
| 35   | 86      | 14   | 89                      | 11   | 50   | 50   | 3                 | 1     | 1     | 75                | 60   | 33   |
| 36   | 85      | 15   | 86                      | 14   | 25   | 75   | 3                 | 3     | 2     | 68                | 38   | 27   |
| 37   | 80      | 20   | 80                      | 20   | 22   | 78   | 15                | 9     | 6     | 44                | 32   | 17   |
| 38   | 49      | 51   | 55                      | 45   | 75   | 25   | 31                | 20    | 16    | 36                | 19   | 4    |
| 39   | 56      | 44   | 72                      | 28   | 60   | 40   | 29                | 23    | 20    | 31                | 6    | 1    |
| 40   | 46      | 54   | 55                      | 45   | 65   | 35   | 44                | 38    | 36    | 8                 | 2    | 0    |
| 41   | 19      | 81   | 19                      | 81   | 81   | 19   | 69                | 67    | 66    | 3                 | 0    | 0    |
| 42   | 15      | 85   | 18                      | 82   | 85   | 15   | 81                | 80    | 72    | 2                 | 0    | 0    |
| 43   | 5       | 95   | 11                      | 89   | 96   | 4    | 93                | 84    | 82    | 0                 | 0    | 0    |
| 44   | 2       | 98   | 0                       | 100  | 98   | 2    | 88                | 86    | 79    | 0                 | 0    | 0    |
| 45   | 10      | 90   | 0                       | 100  | 90   | 10   | 88                | 80    | 76    | 5                 | 0    | 0    |
| 46   | 7       | 93   | 50                      | 50   | 98   | 2    | 85                | 80    | 79    | 0                 | 0    | 0    |
| 47   | 8       | 92   | 0                       | 100  | 91   | 9    | 86                | 85    | 85    | 2                 | 0    | 0    |
| 48   | 7       | 93   | 20                      | 80   | 94   | 6    | 92                | 92    | 90    | 0                 | 0    | 0    |
| 49   | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 50   | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 0     | 0                 | 0    | 0    |
| 51   | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 0     | 0     | 0                 | 0    | 0    |
| 52   | 0       | 100  | 0                       | 100  | 100  | 0    |                   |       |       |                   |      |      |

Table 4.52: Dry and wet week probability during crop growth period in Sinnar Tehsil

| Sinnar |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|--------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M      | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|        | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1      | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 2      | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 3      | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 6      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 97    | 0                 | 0    | 0    |
| 7      | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 8      | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 9      | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 10     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 11     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 12     | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 13     | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 97    | 0                 | 0    | 0    |
| 14     | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 98    | 97    | 0                 | 0    | 0    |
| 15     | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 97    | 93    | 0                 | 0    | 0    |
| 16     | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 93    | 90    | 0                 | 0    | 0    |
| 17     | 2       | 98   | 0                       | 100  | 98   | 2    | 95                | 92    | 90    | 0                 | 0    | 0    |
| 18     | 3       | 97   | 0                       | 100  | 97   | 3    | 93                | 92    | 87    | 0                 | 0    | 0    |
| 19     | 3       | 97   | 0                       | 100  | 96   | 4    | 95                | 90    | 75    | 3                 | 0    | 0    |
| 20     | 5       | 95   | 100                     | 0    | 98   | 2    | 90                | 75    | 57    | 0                 | 0    | 0    |
| 21     | 5       | 95   | 0                       | 100  | 95   | 5    | 80                | 60    | 34    | 2                 | 1    | 0    |
| 22     | 17      | 83   | 33                      | 67   | 84   | 16   | 63                | 35    | 24    | 7                 | 2    | 1    |
| 23     | 27      | 73   | 40                      | 60   | 76   | 24   | 41                | 28    | 15    | 8                 | 3    | 1    |
| 24     | 41      | 59   | 31                      | 69   | 56   | 44   | 41                | 21    | 15    | 14                | 6    | 3    |
| 25     | 32      | 68   | 33                      | 67   | 69   | 31   | 36                | 24    | 13    | 14                | 8    | 3    |
| 26     | 46      | 54   | 42                      | 58   | 53   | 48   | 37                | 20    | 12    | 27                | 11   | 7    |
| 27     | 44      | 56   | 59                      | 41   | 69   | 31   | 31                | 18    | 7     | 19                | 11   | 4    |
| 28     | 44      | 56   | 42                      | 58   | 55   | 45   | 34                | 13    | 8     | 25                | 9    | 5    |
| 29     | 47      | 53   | 58                      | 42   | 61   | 39   | 20                | 12    | 8     | 17                | 9    | 6    |
| 30     | 49      | 51   | 36                      | 64   | 39   | 61   | 31                | 19    | 15    | 25                | 16   | 7    |
| 31     | 46      | 54   | 52                      | 48   | 60   | 40   | 34                | 26    | 20    | 29                | 12   | 4    |
| 32     | 49      | 51   | 63                      | 37   | 63   | 38   | 39                | 30    | 19    | 20                | 6    | 3    |
| 33     | 32      | 68   | 41                      | 59   | 77   | 23   | 53                | 32    | 22    | 10                | 4    | 2    |
| 34     | 25      | 75   | 32                      | 68   | 78   | 23   | 46                | 32    | 18    | 10                | 5    | 2    |
| 35     | 39      | 61   | 40                      | 60   | 61   | 39   | 42                | 24    | 13    | 20                | 7    | 4    |
| 36     | 39      | 61   | 52                      | 48   | 69   | 31   | 34                | 18    | 9     | 14                | 8    | 5    |
| 37     | 41      | 59   | 35                      | 65   | 56   | 44   | 32                | 16    | 11    | 25                | 14   | 6    |
| 38     | 53      | 47   | 63                      | 38   | 54   | 46   | 24                | 16    | 12    | 29                | 12   | 3    |
| 39     | 53      | 47   | 55                      | 45   | 50   | 50   | 32                | 24    | 21    | 22                | 6    | 2    |
| 40     | 37      | 63   | 42                      | 58   | 68   | 32   | 47                | 41    | 33    | 10                | 3    | 1    |
| 41     | 25      | 75   | 27                      | 73   | 76   | 24   | 64                | 53    | 48    | 7                 | 2    | 0    |
| 42     | 17      | 83   | 27                      | 73   | 86   | 14   | 68                | 62    | 54    | 5                 | 1    | 0    |
| 43     | 20      | 80   | 30                      | 70   | 82   | 18   | 73                | 63    | 57    | 3                 | 0    | 0    |
| 44     | 10      | 90   | 17                      | 83   | 91   | 9    | 78                | 70    | 68    | 0                 | 0    | 0    |
| 45     | 12      | 88   | 0                       | 100  | 87   | 13   | 80                | 77    | 71    | 3                 | 1    | 0    |
| 46     | 12      | 88   | 29                      | 71   | 90   | 10   | 85                | 78    | 74    | 5                 | 0    | 0    |
| 47     | 8       | 92   | 43                      | 57   | 96   | 4    | 85                | 80    | 77    | 0                 | 0    | 0    |
| 48     | 7       | 93   | 0                       | 100  | 93   | 7    | 88                | 85    | 85    | 2                 | 0    | 0    |
| 49     | 7       | 93   | 25                      | 75   | 95   | 5    | 90                | 90    | 88    | 0                 | 0    | 0    |
| 50     | 3       | 97   | 0                       | 100  | 96   | 4    | 97                | 95    | 0     | 0                 | 0    | 0    |
| 51     | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 0     | 0     | 0                 | 0    | 0    |
| 52     | 2       | 98   | 0                       | 0    | 98   | 2    |                   |       |       |                   |      |      |

Table 4.53: Dry and wet week probability during crop growth period in Surgana Tehsil

| Surgana |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|---------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M       | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|         | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1       | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9       | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 15      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 97    | 0                 | 0    | 0    |
| 16      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 97    | 97    | 0                 | 0    | 0    |
| 17      | 0       | 100  | 0                       | 0    | 100  | 0    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 18      | 3       | 97   | 0                       | 0    | 97   | 3    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 19      | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 86    | 0                 | 0    | 0    |
| 20      | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 86    | 58    | 0                 | 0    | 0    |
| 21      | 0       | 100  | 0                       | 0    | 100  | 0    | 86                | 58    | 32    | 0                 | 0    | 0    |
| 22      | 14      | 86   | 0                       | 0    | 86   | 14   | 58                | 32    | 9     | 7                 | 5    | 4    |
| 23      | 36      | 64   | 50                      | 50   | 67   | 33   | 36                | 10    | 4     | 29                | 19   | 18   |
| 24      | 58      | 42   | 81                      | 19   | 55   | 45   | 12                | 5     | 1     | 39                | 35   | 31   |
| 25      | 69      | 31   | 68                      | 32   | 28   | 72   | 14                | 2     | 1     | 63                | 56   | 55   |
| 26      | 80      | 20   | 90                      | 10   | 44   | 56   | 3                 | 2     | 0     | 71                | 70   | 66   |
| 27      | 88      | 12   | 89                      | 11   | 17   | 83   | 7                 | 0     | 0     | 86                | 82   | 77   |
| 28      | 92      | 8    | 98                      | 2    | 57   | 43   | 0                 | 0     | 0     | 86                | 82   | 79   |
| 29      | 95      | 5    | 94                      | 6    | 0    | 100  | 0                 | 0     | 0     | 90                | 87   | 77   |
| 30      | 95      | 5    | 95                      | 5    | 0    | 100  | 2                 | 1     | 0     | 92                | 82   | 77   |
| 31      | 95      | 5    | 96                      | 4    | 33   | 67   | 2                 | 0     | 0     | 85                | 80   | 74   |
| 32      | 88      | 12   | 89                      | 11   | 33   | 67   | 3                 | 1     | 0     | 83                | 77   | 67   |
| 33      | 92      | 8    | 94                      | 6    | 29   | 71   | 3                 | 1     | 0     | 85                | 74   | 56   |
| 34      | 90      | 10   | 93                      | 7    | 40   | 60   | 2                 | 1     | 0     | 78                | 60   | 39   |
| 35      | 86      | 14   | 87                      | 13   | 17   | 83   | 7                 | 2     | 1     | 66                | 43   | 30   |
| 36      | 73      | 27   | 76                      | 24   | 50   | 50   | 8                 | 5     | 3     | 47                | 33   | 21   |
| 37      | 66      | 34   | 65                      | 35   | 31   | 69   | 19                | 11    | 8     | 46                | 29   | 16   |
| 38      | 61      | 39   | 69                      | 31   | 55   | 45   | 24                | 17    | 13    | 39                | 21   | 8    |
| 39      | 54      | 46   | 64                      | 36   | 61   | 39   | 32                | 26    | 23    | 29                | 12   | 2    |
| 40      | 42      | 58   | 53                      | 47   | 70   | 30   | 46                | 40    | 37    | 17                | 3    | 1    |
| 41      | 29      | 71   | 40                      | 60   | 79   | 21   | 63                | 58    | 55    | 5                 | 1    | 0    |
| 42      | 14      | 86   | 18                      | 82   | 88   | 12   | 80                | 75    | 72    | 3                 | 1    | 0    |
| 43      | 10      | 90   | 25                      | 75   | 92   | 8    | 85                | 82    | 77    | 2                 | 0    | 0    |
| 44      | 7       | 93   | 17                      | 83   | 94   | 6    | 90                | 85    | 80    | 0                 | 0    | 0    |
| 45      | 3       | 97   | 0                       | 100  | 96   | 4    | 92                | 87    | 83    | 2                 | 0    | 0    |
| 46      | 7       | 93   | 50                      | 50   | 95   | 5    | 88                | 85    | 82    | 2                 | 0    | 0    |
| 47      | 7       | 93   | 25                      | 75   | 95   | 5    | 90                | 87    | 84    | 0                 | 0    | 0    |
| 48      | 3       | 97   | 0                       | 100  | 96   | 4    | 93                | 90    | 88    | 0                 | 0    | 0    |
| 49      | 3       | 97   | 0                       | 100  | 96   | 4    | 93                | 92    | 90    | 0                 | 0    | 0    |
| 50      | 3       | 97   | 0                       | 100  | 96   | 4    | 95                | 93    | 0     | 0                 | 0    | 0    |
| 51      | 2       | 98   | 0                       | 100  | 98   | 2    | 97                | 0     | 0     | 0                 | 0    | 0    |
| 52      | 2       | 98   | 0                       | 100  | 98   | 2    |                   |       |       |                   |      |      |

Table 4.54: Dry and wet week probability during crop growth period in Trimbakeshwar Tehsil

| Trimbakeshwar |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|---------------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M             | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|               | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1             | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2             | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3             | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 4             | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 5             | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 97    | 0                 | 0    | 0    |
| 6             | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 7             | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 8             | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 98    | 98    | 0                 | 0    | 0    |
| 9             | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 12            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 13            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 14            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 15            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 98    | 0                 | 0    | 0    |
| 16            | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 98    | 98    | 0                 | 0    | 0    |
| 17            | 0       | 100  | 0                       | 0    | 100  | 0    | 98                | 98    | 97    | 0                 | 0    | 0    |
| 18            | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 19            | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 98    | 88    | 0                 | 0    | 0    |
| 20            | 2       | 98   | 0                       | 0    | 98   | 2    | 98                | 88    | 53    | 0                 | 0    | 0    |
| 21            | 0       | 100  | 0                       | 100  | 100  | 0    | 90                | 54    | 24    | 0                 | 0    | 0    |
| 22            | 10      | 90   | 0                       | 0    | 90   | 10   | 54                | 24    | 5     | 3                 | 3    | 2    |
| 23            | 39      | 61   | 33                      | 67   | 60   | 40   | 27                | 5     | 2     | 39                | 25   | 22   |
| 24            | 73      | 27   | 100                     | 0    | 44   | 56   | 5                 | 2     | 0     | 47                | 42   | 35   |
| 25            | 69      | 31   | 65                      | 35   | 19   | 81   | 12                | 2     | 1     | 61                | 52   | 52   |
| 26            | 80      | 20   | 88                      | 12   | 39   | 61   | 3                 | 1     | 0     | 68                | 68   | 62   |
| 27            | 85      | 15   | 85                      | 15   | 17   | 83   | 5                 | 0     | 0     | 85                | 77   | 74   |
| 28            | 95      | 5    | 100                     | 0    | 33   | 67   | 0                 | 0     | 0     | 86                | 83   | 74   |
| 29            | 92      | 8    | 91                      | 9    | 0    | 100  | 3                 | 1     | 0     | 88                | 79   | 77   |
| 30            | 93      | 7    | 96                      | 4    | 40   | 60   | 2                 | 0     | 0     | 83                | 81   | 71   |
| 31            | 88      | 12   | 89                      | 11   | 25   | 75   | 2                 | 0     | 0     | 86                | 76   | 70   |
| 32            | 97      | 3    | 98                      | 2    | 14   | 86   | 0                 | 0     | 0     | 85                | 78   | 67   |
| 33            | 88      | 12   | 88                      | 12   | 0    | 100  | 0                 | 0     | 0     | 81                | 70   | 53   |
| 34            | 93      | 7    | 92                      | 8    | 0    | 100  | 0                 | 0     | 0     | 80                | 61   | 40   |
| 35            | 86      | 14   | 85                      | 15   | 0    | 100  | 5                 | 2     | 1     | 66                | 44   | 25   |
| 36            | 75      | 25   | 76                      | 24   | 38   | 63   | 10                | 4     | 2     | 49                | 28   | 21   |
| 37            | 64      | 36   | 66                      | 34   | 40   | 60   | 14                | 6     | 3     | 37                | 28   | 16   |
| 38            | 59      | 41   | 58                      | 42   | 38   | 62   | 19                | 8     | 6     | 44                | 26   | 10   |
| 39            | 66      | 34   | 74                      | 26   | 46   | 54   | 15                | 11    | 10    | 39                | 15   | 4    |
| 40            | 58      | 42   | 59                      | 41   | 45   | 55   | 31                | 27    | 26    | 22                | 6    | 1    |
| 41            | 34      | 66   | 38                      | 62   | 72   | 28   | 58                | 56    | 55    | 8                 | 1    | 0    |
| 42            | 17      | 83   | 25                      | 75   | 87   | 13   | 81                | 80    | 74    | 2                 | 0    | 0    |
| 43            | 3       | 97   | 10                      | 90   | 98   | 2    | 95                | 88    | 87    | 0                 | 0    | 0    |
| 44            | 2       | 98   | 0                       | 100  | 98   | 2    | 92                | 90    | 87    | 0                 | 0    | 0    |
| 45            | 7       | 93   | 0                       | 100  | 93   | 7    | 92                | 88    | 88    | 7                 | 3    | 0    |
| 46            | 8       | 92   | 100                     | 0    | 98   | 2    | 88                | 88    | 87    | 3                 | 0    | 0    |
| 47            | 7       | 93   | 40                      | 60   | 96   | 4    | 93                | 92    | 90    | 0                 | 0    | 0    |
| 48            | 0       | 100  | 0                       | 100  | 100  | 0    | 98                | 97    | 97    | 0                 | 0    | 0    |
| 49            | 2       | 98   | 0                       | 0    | 98   | 2    | 97                | 97    | 97    | 0                 | 0    | 0    |
| 50            | 2       | 98   | 0                       | 100  | 98   | 2    | 98                | 98    | 0     | 0                 | 0    | 0    |
| 51            | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52            | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

**Table 4.55: Dry and wet week probability during crop growth period in Yevla Tehsil**

| Yevla |         |      |                         |      |      |      |                   |       |       |                   |      |      |
|-------|---------|------|-------------------------|------|------|------|-------------------|-------|-------|-------------------|------|------|
| M     | Initial |      | Conditional probability |      |      |      | Dry probabilities |       |       | Wet probabilities |      |      |
|       | P(W)    | P(D) | P(W/                    | P(D/ | P(D/ | P(W/ | P(2D)             | P(3D) | P(4D) | P(2)              | P(3) | P(4) |
| 1     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 2     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 3     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 4     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 5     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 6     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 7     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 8     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 9     | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 10    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 11    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 95    | 0                 | 0    | 0    |
| 12    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 95    | 95    | 0                 | 0    | 0    |
| 13    | 0       | 100  | 0                       | 0    | 100  | 0    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 14    | 5       | 95   | 0                       | 0    | 95   | 5    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 15    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 16    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 91    | 0                 | 0    | 0    |
| 17    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 91    | 91    | 0                 | 0    | 0    |
| 18    | 0       | 100  | 0                       | 0    | 100  | 0    | 91                | 91    | 91    | 0                 | 0    | 0    |
| 19    | 9       | 91   | 0                       | 0    | 91   | 9    | 91                | 91    | 74    | 0                 | 0    | 0    |
| 20    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 82    | 64    | 0                 | 0    | 0    |
| 21    | 0       | 100  | 0                       | 0    | 100  | 0    | 82                | 64    | 47    | 0                 | 0    | 0    |
| 22    | 18      | 82   | 0                       | 0    | 82   | 18   | 64                | 47    | 25    | 14                | 10   | 4    |
| 23    | 32      | 68   | 75                      | 25   | 78   | 22   | 50                | 27    | 20    | 23                | 10   | 5    |
| 24    | 41      | 59   | 71                      | 29   | 73   | 27   | 32                | 24    | 10    | 18                | 9    | 6    |
| 25    | 45      | 55   | 44                      | 56   | 54   | 46   | 41                | 18    | 14    | 23                | 14   | 3    |
| 26    | 36      | 64   | 50                      | 50   | 75   | 25   | 27                | 21    | 15    | 23                | 5    | 2    |
| 27    | 59      | 41   | 63                      | 38   | 43   | 57   | 32                | 22    | 9     | 14                | 5    | 4    |
| 28    | 23      | 77   | 23                      | 77   | 78   | 22   | 55                | 22    | 14    | 9                 | 6    | 3    |
| 29    | 32      | 68   | 40                      | 60   | 71   | 29   | 27                | 17    | 9     | 23                | 11   | 5    |
| 30    | 64      | 36   | 71                      | 29   | 40   | 60   | 23                | 11    | 10    | 32                | 13   | 1    |
| 31    | 45      | 55   | 50                      | 50   | 63   | 38   | 27                | 25    | 13    | 18                | 2    | 1    |
| 32    | 45      | 55   | 40                      | 60   | 50   | 50   | 50                | 25    | 16    | 5                 | 2    | 1    |
| 33    | 9       | 91   | 10                      | 90   | 92   | 8    | 45                | 29    | 17    | 5                 | 1    | 1    |
| 34    | 50      | 50   | 50                      | 50   | 50   | 50   | 32                | 19    | 10    | 14                | 8    | 3    |
| 35    | 32      | 68   | 27                      | 73   | 64   | 36   | 41                | 20    | 10    | 18                | 7    | 7    |
| 36    | 45      | 55   | 57                      | 43   | 60   | 40   | 27                | 14    | 8     | 18                | 16   | 8    |
| 37    | 45      | 55   | 40                      | 60   | 50   | 50   | 27                | 16    | 12    | 41                | 19   | 10   |
| 38    | 68      | 32   | 90                      | 10   | 50   | 50   | 18                | 14    | 11    | 32                | 16   | 6    |
| 39    | 45      | 55   | 47                      | 53   | 57   | 43   | 41                | 32    | 24    | 23                | 9    | 1    |
| 40    | 36      | 64   | 50                      | 50   | 75   | 25   | 50                | 38    | 38    | 14                | 2    | 0    |
| 41    | 27      | 73   | 38                      | 63   | 79   | 21   | 55                | 55    | 52    | 5                 | 1    | 1    |
| 42    | 23      | 77   | 17                      | 83   | 75   | 25   | 77                | 74    | 59    | 5                 | 5    | 0    |
| 43    | 5       | 95   | 20                      | 80   | 100  | 0    | 91                | 73    | 69    | 5                 | 0    | 0    |
| 44    | 9       | 91   | 100                     | 0    | 95   | 5    | 73                | 69    | 69    | 0                 | 0    | 0    |
| 45    | 18      | 82   | 0                       | 100  | 80   | 20   | 77                | 77    | 77    | 9                 | 3    | 0    |
| 46    | 14      | 86   | 50                      | 50   | 94   | 6    | 86                | 86    | 86    | 5                 | 0    | 0    |
| 47    | 5       | 95   | 33                      | 67   | 100  | 0    | 95                | 95    | 95    | 0                 | 0    | 0    |
| 48    | 0       | 100  | 0                       | 100  | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 49    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 100   | 0                 | 0    | 0    |
| 50    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 100   | 0     | 0                 | 0    | 0    |
| 51    | 0       | 100  | 0                       | 0    | 100  | 0    | 100               | 0     | 0     | 0                 | 0    | 0    |
| 52    | 0       | 100  | 0                       | 0    | 100  | 0    |                   |       |       |                   |      |      |

#### 4.6. Contingency Crop Management and Planning Based on Rainfall Analysis

Nashik districts Western part is fall under wester ghat zone and sub mountain zone while eastern part is fall under scarcity zone as classified under National Agril. Research Project (NARP). Tehsil wise historical rainfall data of 59 years (1961 to 2019) of Nashik district were collected and processed by using Weather cock software which revealed that the total mean annual rainfall of the district is 1066.80 mm. Nashik receives almost 86.55% of mean annual rainfall during SW monsoon .The knowledge and information on the rainfall dynamics and its distribution over the cropping seasons are very important for selection of crop varieties and choice of cropping pattern. Monsoon starts effectively from 26 MW (18<sup>th</sup> June to 24<sup>th</sup> June) in Nashik district which shows sudden rise in the rainfall assuring sufficient moisture for crop germination and remain active up to 45 MW (9<sup>th</sup> October to 13<sup>th</sup> October) with a total length of 19 weeks (133 days).Therefore, we expected good monsoon shower during monsoon period of 20 weeks (24 to 44 MW) ie region .The major *kharif* crops viz.Pearl millet, and rice and finger millet , Maize and major *rabi* crops are *rabi* sorghum, gram, wheat which are considered for planning. Forward and backward accumulation methods were used for computation of onset and withdrawal of rainy season from weekly rainfall data.

By considering the overall situation of the onset and withdrawal of monsoon, initial, conditional and consecutive dry and wet weeks probability, Standardized Precipitation Index, and Precipitation Deciles, the tehsil wise cropping pattern is suggested for different tehsils in Nashik district. Initial, conditional and consecutive dry and wet week probabilities showed that chances of occurrence of a week getting dry is high during early part of the season and chances of occurrence of a week getting wet is high from 30 week onwards upto 37 week. The initial rainfall probability {P (W)} of getting 20 mm rainfall per week was >30% at the beginning of *Kharif* season indicates that summer ploughing and initial seed bed preparations shall be taken up in the 20 – 22 MW (14 May - 3<sup>rd</sup> June) at Nashik district, hence field preparation should be done during this period. The initial as well as conditional probability of wet week followed by wet week {P (W/W)} of getting 20 mm rainfall was more than 50% in 23 MW, this week is more suitable for sowing of *kharif* crop. Hence, sowing operations can be taken up since 23 MW (4<sup>th</sup> – 10<sup>th</sup> June).On the basis of initial, conditional and consecutive dry and wet weeks probability MWs with adequate rainfall availability are found out.

For any particular area the crop irrigation planning should be based on the date of onset of monsoon. This rainfall coincides with reproductive stage of *kharif* crops as well as timely sowing of *rabi* crops. It was observed that maximum rainfall received between **37 MW to 40 MW** which can be conserved for *rabi* season crops. This indicated that there was sufficient moisture for growing *rabi* crops in tehsils in scarcity zone. Therefore, some Tehsils of the Nashik district are found to be *rabi* dominated. Chances of rainfall variation are more during

*kharif* season. Hence some short duration and medium duration crops can also be grown on stored soil moisture in this region. However, for most of the crops provision of supplementary irrigation is needed. The rescheduling of protective irrigation can be carried out accordingly. Study on coincidence of critical growth stages of main seasonal crops of the district and initial and conditional wet weeks probabilities are considered as a tool for protective irrigation planning. Similar results were reported by (Singh *et al*; 2004 and Admasu *et al*; 2014).

Based on mean onset and withdrawal of monsoon, initial and conditional probability, Standardized Precipitation Index and Precipitation Deciles the tehsil wise contingency planning measures *viz.*, MW for sowing, protective irrigation and hoeing operation for main seasonal *kharif* and *rabi* crops of different tehsils of Nashik district is given in Table 4.56-4.62

#### 4.6.1 Contingency Crop Management for Baglan

It is observed that the mean week of onset of monsoon is **26** meteorological week (MW) (*i.e.*, 25<sup>th</sup> June – 1<sup>st</sup> July) in Baglan Tehsil of Nashik district. Hence, sowing of *kharif* crop (Pearl millet, maize) can be undertaken during this week or following this week *i.e.* 25 and 27 MW. The land preparation operation can be done during the summer in 22 to 23 MW. The 28, 29, 31, 32, 34, 35, 37 MW coincides with critical growth stages of *kharif* crop during which the probability of dry weeks *i.e.*, P(D) is 59,59,64,54,63,66 and 58% and the probability of getting dry week preceded by another dry week (PDD) is 46,77,64,61,61,78,48 respectively which is greater than 50%, hence irrigation can be given during this period. As 28 and 29 MW coincides with panicle emergence stage which decides the number of grains in the panicle and tillering decides the number of panicles and hence capacity for higher yield, 32 MW coincides with Silking stage of Maize crop, the availability of water during these periods is critical. It is important to ensure availability of irrigation water during the period to these crops. Hence contingency measures like hoeing, mulching, foliar spray, organic straw application, in-situ soil moisture conservation practices to be taken to reduce the impact of dry spell. Give protective irrigation to pearl millet crop in this week.

Baglan tehsil has more probability of at least 20 mm rainfall in **30, 36, 38, 40** MW. Water harvesting and moisture conservation can be taken during this period that will help to irrigate crops during critical growth stages. Conserved moisture during these weeks can be used for sowing of *rabi* crops. The 34-35 MW and 37 which coincides with grain filling stage of bajara and grain filling stage of Maize crop respectively. Hence protective irrigation can be given during this critical stage using previously harvested rain water without which yield will be reduced to large extent.

As maximum rainfall received between **37 MW to 40 MW**. During is period sufficient moisture present in soil which can be used for sowing of *rabi* season crops. Hence sowing *rabi* sorghum and gram can be undertaken during 38 and 40 MW respectively. The 43, 44, 45, 46,

47, 48, 49 and 51 MW coincides with critical growth stages of *rabi* crops (*rabi* sorghum, gram). During these weeks probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) is greater than 50%. Hence protective irrigation and moisture conservation practices can be undertaken during this period without which yield will be reduced to large extent.

#### 4.6.2 Contingency Crop Management for Chandwad:

It is observed that the mean week of onset of monsoon is **26** standard meteorological week (MW) (25<sup>th</sup> June – 1<sup>st</sup> July) in Chandwad Tehsil of Nashik district. Hence, sowing of *kharif* crop (Pearl millet, finger millet) can be undertaken during this week or following this week i.e. 25 and 27 MW. In *kharif* season, it is observed that the probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) is greater than 50% in 31, 32, 34, 35, 37, 35 MW which coincides with critical growth stages of *kharif* crop (pearl millet, finger millet). while in 28<sup>th</sup>, 29<sup>th</sup> MWs these are less than 50 percent so there is more scope for water harvesting.

Chandwad tehsil has more probability of at least 20 mm rainfall in **27, 29-30, 38** MWs. Hence water harvesting and moisture conservation can be taken during this period that will help to irrigate crops during their critical growth stages and sowing of *rabi* crops can also be undertaken by utilizing it. In *rabi* season, it is observed that P(D) and PDD is greater than 50% in 39, 40, 43 to 49 and 51 MW which coincides with critical growth stages of *rabi* crop (*rabi* Sorghum and Gram). So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### 4.6.3 Contingency Crop Management for Deola:

It is observed that the mean week of onset of monsoon is **26** standard meteorological week (MW) (i.e., 25<sup>th</sup> June – 1<sup>st</sup> July) in Deola. Hence, sowing of *kharif* crop (Pearl millet, Maize) can be undertaken during this week or following this week i.e. 25<sup>th</sup> and 27<sup>th</sup> MW. In *kharif* season, It is observed that the probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) is greater than 50% in 28, 29, 31, 32, 34, 35 and 37 MW which coincides with critical growth stages of *kharif* crop (pearl millet, maize, finger millet). so protective irrigation is provide in these weeks. Deola tehsil has more probability of at least 20 mm rainfall in **30, 38- 40** MW. Hence water harvesting and moisture conservation can be taken during this period that will help to irrigate crops during their critical growth stages and sowing of *rabi* crops can also be undertaken by utilizing it. In *rabi* season, it is observed that P(D) and PDD is greater than 50% in 39, 40, 43 to 49 and 51, 6, 8 MW which coincides with critical growth stages of *rabi* crop (*rabi* Sorghum and Wheat). So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### 4.6.4 Contingency Crop Management for Dindori:

It is observed that the mean week of onset of monsoon is **25** standard meteorological week (MW) (*i.e.*, 18<sup>th</sup> June – 24<sup>th</sup> June) in Dindori. Hence, sowing of *kharif* crop (finger millet, Maize) can be undertaken during this week or following this week *i.e.* 24 and 26 MW. Dindori tehsil has more probability of at least 20 mm rainfall in **25-33, 39** MW. Hence water harvesting and moisture conservation can be taken during this period that will help to irrigate crops during their critical growth stages and also sowing of *rabi* crops can be undertaken by conserving it. It is observed that 34 to 42 MW in *kharif* season and from 43 to 52 and 6-8 MW in *rabi* season have probability of dry weeks *i.e.*, P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (finger millet, Maize) and *rabi* crops (Gram and wheat) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period. 28, 29 MWs P(D) and PDD are less than 50% so there is more scope for water harvesting for future need.

#### 4.6.5 Contingency Crop Management for Igatpuri:

It is observed that the mean week of onset of monsoon is **24** standard meteorological week (MW) (*i.e.*, 12<sup>th</sup> June – 17<sup>th</sup> June) in Igatpuri. Hence, sowing of *kharif* crop (finger millet, Rice) can be undertaken during this week or following this week *i.e.* 23<sup>rd</sup> and 25<sup>th</sup> MW. Igatpuri tehsil has more probability of at least 20 mm rainfall in **23 to 39** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 39 MW in *kharif* season P(D) and PDD are less than 50% (more chances of water harvesting) and from 43 to 49 and 51 MW in *rabi* season have probability of dry weeks *i.e.*, P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (finger millet, Rice) and *rabi* crops (*rabi* Sorghum and Gram) respectively. So availability of water is crucial to *rabi* crops during this period. Hence, it is important to ensure availability of irrigation water to crops during *rabi* period.

#### 4.6.6 Contingency Crop Management for Kalwan:

It is observed that the mean week of onset of monsoon is **26** standard meteorological week (MW) (*i.e.*, 25<sup>th</sup> June – 1<sup>st</sup> July) in Kalwan. Hence, sowing of *kharif* crop (Pearl millet, Maize) can be undertaken during this week or following this week *i.e.* 25 and 27 MW. Kalwan tehsil has more probability of at least 20 mm rainfall in **27-30 and 32, 36** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 31, 33 to 37 MW in *kharif* season and from 43 to 49 MW in *rabi* season have

probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (pearl millet, Maize) and *rabi* crops (*rabi* Sorghum and Gram) respectively. So availability of water is crucial to crops during this period. but there is no moisture stages at critical growth stages in 28 and 29 MWs as probabilities are less than 50%. Hence, it is important to ensure availability of irrigation water to crops during dry period.

#### **4.6.7 Contingency Crop Management for Malegaon:**

It is observed that the mean week of onset of monsoon is 26 standard meteorological week (MW) (i.e., 24<sup>th</sup> June – 1<sup>st</sup> July) in Malegaon. Hence, sowing of *kharif* crop (Pearl millet, Maize) can be undertaken during this week or following this week i.e. 25<sup>th</sup> and 27<sup>th</sup> MW. Malegaon tehsil has more probability of at least 20 mm rainfall in 30 MW. Hence there are more chances of water harvesting and moisture conservation during that week. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 31, 34 to 35 and 37 MW in *kharif* season and from 43 to 49 and 52, 6 to 8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (pearl millet, Maize) and *rabi* crops (*rabi* Sorghum and wheat) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### **4.6.8 Contingency Crop Management for Nandgaon:**

It is observed that the mean week of onset of monsoon is 26 standard meteorological week (MW) (i.e., 24<sup>th</sup> June – 1<sup>st</sup> July) in Nandgaon. Hence, sowing of *kharif* crop (Pearl millet, Finger millet) can be undertaken during this week or following this week i.e. 25 and 27 MW. Nandgaon tehsil has more probability of at least 20 mm rainfall in 36 MW. Hence there are more chances of water harvesting and moisture conservation during that week. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 35 MW in *kharif* season and 48 to 52 and 6 to 8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (pearl millet, finger millet) and *rabi* crops (*rabi* Sorghum and Wheat) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### **4.6.9 Contingency Crop Management for Nashik :**

It is observed that the mean week of onset of monsoon is 26<sup>t</sup> standard meteorological week (MW) (i.e., 18<sup>th</sup> June – 24<sup>th</sup> June) in Nashik. Hence, sowing of *kharif* crop

(Pearl millet, Maize) can be undertaken during this week or following this week i.e. 27 MW. Nashik tehsil has more probability of at least 20 mm rainfall in **25 -32 ,38-39** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks which can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 39, in *kharif* season and from 43 to 49 and 52 ,6-8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (pearl millet, Maize) and *rabi* crops (Wheat and Gram) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### **4.6.10 Contingency Crop Management for Niphad:**

It is observed that the mean week of onset of monsoon is **26** standard meteorological week (MW) (i.e., 24 June – 1<sup>st</sup> July) in Niphad. Hence, sowing of *kharif* crop (Pearl millet, Maize) can be undertaken during this week or following this week i.e. 25 and 27 MW. Niphad tehsil has more probability of at least 20 mm rainfall in **27-32** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks which can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 31, 34 to 35 and 37 MW in *kharif* season and from 43 to 49 and 52 ,6-8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (pearl millet, Maize) and *rabi* crops (wheat and Gram) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### **4.6.11 Contingency Crop Management for Peth:**

It is observed that the mean week of onset of monsoon is **25** standard meteorological week (MW) (i.e., 18<sup>th</sup> June – 24<sup>th</sup> June) in Peth. Hence, sowing of *kharif* crop (Finger millet, rice) can be undertaken during this week or following this week i.e. 24 -26 MW. Peth tehsil has more probability of at least 20 mm rainfall in **24-37 , 49** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 31 and 37 MWs have P(D) and PDD less than 50% so water harvesting measures should be take at these critical growth stages in *kharif*. 35 MW in *kharif* season and from 43 to 49 and 52 ,6- 8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (rice, finger millet) and *rabi* crops (Wheat and Gram) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure

availability of irrigation water to crops during this period.

#### **4.6.12. Contingency Crop Management for Sinnar:**

It is observed that the mean week of onset of monsoon is **26** standard meteorological week (MW) (*i.e.*, 24 June – 1<sup>st</sup> July) in Sinnar. Hence, sowing of *kharif* crop (finger millet, Maize) can be undertaken during this week or following this week *i.e.* 25 and 27 MW. Sinnar tehsil has more probability of at least 20 mm rainfall in **38-39** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 31 and 37 MW in *kharif* season and from 43 to 49 and 52, 6-8 MW in *rabi* season have probability of dry weeks *i.e.*, P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (Finger millet, Maize) and *rabi* crops (wheat and Gram) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### **4.6.13 Contingency Crop Management for Surgana:**

It is observed that the mean week of onset of monsoon is **25** standard meteorological week (MW) (*i.e.*, 18 June – 24 June) in Surgana. Hence, sowing of *kharif* crop (finger millet, rice) can be undertaken during this week or following this week *i.e.* 24 and 26 MW. Surgana tehsil has more probability of at least 20 mm rainfall in **24-39** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 31 and 35-37 MW in *kharif* season have probability of dry weeks *i.e.*, P(D) and probability of getting dry week preceded by another dry week (PDD) less than 50%. So no moisture stress is observed. and from 43 to 49 and 52, 6-8 MW in *rabi* season have probability of dry weeks *i.e.*, P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *rabi* crops (wheat and Gram). So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### **4.6.14 Contingency Crop Management for Trimbakeshwar**

It is observed that the mean week of onset of monsoon is **25** standard meteorological week (MW) (18<sup>th</sup> June – 24<sup>th</sup> June) in Trimbakeshwar

. Hence, sowing of *kharif* crop (finger millet, rice and Maize) can be undertaken during this week or following this week *i.e.* 26 MW. Trimbakeshwar tehsil has more probability of at least 20 mm rainfall in **24-40** MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilize during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 31 and 35-37 MW in *kharif* season

have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) less than 50% so no need of supplementary irrigation. From 43 to 49 and 52-6-8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *rabi* crops (wheat and Gram). So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

#### 4.6.15 Contingency Crop Management for Yevla

It is observed that the mean week of onset of monsoon is 26 standard meteorological week (MW) (i.e., 24 June – 1<sup>st</sup> July) in Yevla. Hence, sowing of *kharif* crop (Pearl millet, maize) can be undertaken during this week or following this week i.e. 27 MW. Yevla tehsil has more probability of at least 20 mm rainfall in 27, 30, 34, 38 MW. Hence there are more chances of water harvesting and moisture conservation during these weeks. This can be utilized during critical growth stages of crops and for sowing of *rabi* crops. It is observed that 28 to 35 and 37 MW in *kharif* season and from 43 to 49 and 52, 6-8 MW in *rabi* season have probability of dry weeks i.e., P(D) and probability of getting dry week preceded by another dry week (PDD) greater than 50% which coincides with critical growth stages of *kharif* crop (pearl millet, Maize and *rabi* crops (*rabi* Sorghum and wheat) respectively. So availability of water is crucial to crops during this period. Hence, it is important to ensure availability of irrigation water to crops during this period.

As per Standardized Precipitation Index and Precipitation Deciles the frequency of drought is increasing gradually in some Tehsils (Baglan, Igatpuri, Nashik, Yevla) while more severity observed in other Tehsils (Chandwad, Deola, Malegaon, Nandgaon, Surgana). So appropriate conservation measures need to be taken. Traditional water harvesting structures like ponds and tanks should be rejuvenated to enhance storage of runoff water and increase groundwater recharge. Water harvesting measures such as farm pond, tube well recharging, on farm contour bunding, ridges and furrows and tied ridges can be necessarily carried out before the commencement of monsoon in the study area. Different in-situ soil moisture conservation practices need to be undertaken like hoeing, harrowing after effective rainfall, broad bed furrows, mulching, organic residue application or vertical mulching, vegetative barriers, minimum tillage, foliar spray in case of extreme situation and storing excess rain water received during the monsoon season, etc., which can be utilized during critical growth stages of field crops and for production of *rabi* crops. Judicious utilization of harvested water for protective and supplemental irrigation will assure availability of moisture in the soil for sustainable crop production.

Balanced fertilizer application i.e., application of phosphorus and potash along with

nitrogen (urea) can give the crop a certain extent of drought tolerance. By ensuring the release of irrigation water during the critical phases the crop failure and yield reduction can be avoided.

Table 4.56 Contingency Crop Management and Planning of pearl millet crop

| Crop- Pearl millet  |                         |              |  |  |  |
|---|-------------------------|--------------|--|--|--|
| Package of Practices  | Days After Sowing       | MW           | Tehsils  |  |  |
|   |                         |              | Baglan   | Chandwad   | Deola  |
| Ploughing& land preparation   | 2-3 Weeks               | 22-23        | 22-23  | 22-23  | 22-23  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15July</b> | <b>24-28</b> | 26   | 26   | 26   |
| Fertilizer application  | At the time of          | 25           | 26   | 26   | 26   |
| Pre emergence spraying of herbicide   | 1-2 DAS                 | 25           | 26   | 26   | 26   |
| Thinning 1 <sup>st</sup>  | 10 DAS                  | 27           | 28   | 28   | 28   |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                  | 28           | 29   | 29   | 29   |
| <b>Panicle emergence stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>14 -21 DAS</b>       | <b>28-29</b> | 29-30* (water harvesting)  | 29*-30* (water harvesting)                                 | 29-30*(water harvesting)                                   |
| Thinning 2 <sup>nd</sup>  | 20 DAS                  | 28-29        | 29-30  | 29-30  | 29-30  |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS               | 29           | 31   | 31   | 31   |
| fertilizer application (Half N)   | 25-30 DAS               | 29-30        | 31-32  | 31-32  | 31-32  |
| <b>Booting stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>           | <b>28-35 DAS</b>        | <b>31</b>    | 32 ( protective irrigation)  | 32 (Hoeing, mulching, protective irrigation )              | 32 (Hoeing, mulching, protective irrigation )              |
| Plant protection spray  | 30 DAS                  | 31           | 32   | 32   | 32   |
| 50% flowering   | 35-45                   | 32           | 33   | 33   | 33   |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>     | <b>60-65 DAS</b>        | <b>35</b>    | 36*  | 36 (Use conserved monsoon water for protective irrigation) | 36 (Use conserved monsoon water for protective irrigation) |
| Maturity/Harvesting   | 80-85 DAS               | 39           | 40-41  | 40-41  | 40-41  |
| Varieties: Phule Adishakti(80-85 days), Phule mahashakti(85-90 days), Dhanshakti (Hybrid 74-78 days)  |                         |              | Diseases: Ergot, Downy mildew, smut;Pest: Shoot fly                            |  |  |
| Spacing: 45×15 cmSeed rate: 3-4kg/ha  |                         |              | Production: 25-30 Qtl/ha, Fodder: 5-7 Ton/ha                                   |  |  |
| Fertilizer dose: 50:25:25 Kg NPK/ha   |                         |              | Suitable for Intercropping with Pigeon pea(2:1) with 30 cm Row to Row spacing. |  |  |

| Table 4.56 Continue...  |                          |              |  |  |  |
|---|--------------------------|--------------|--|--|--|
| Crop- Pearl millet  |                          |              |  |  |  |
| Package of Practices  | Days After Sowing        | MW           | Tehsils  |  |  |
|   |                          |              | Kalwan   | Malegon  | Nandgaon   |
| Ploughing& land preparation   | 2-3 Weeks before sowing  | 22-23        | 22-23  | 22-23  | 22-23  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 26   | 26   | 26   |
| Fertilizer application  | At the time of sowing    | 25           | 26   | 26   | 26   |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 26   | 26   | 26   |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 28   | 28   | 28   |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 29   | 29   | 29   |
| <b>Panicle emergence stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>14 -21 DAS</b>        | <b>28-29</b> | 29-30* (rain water conservation)   | 29-30* ( rain water conservation )                         | 29-30 (Hoeing, Mulching, broad bed furrows, residue      |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 29-30  | 29-30  | 29-30  |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 30   | 30   | 30   |
| fertilizer application (Half N)   | 25-30 DAS                | 29-30        | 30-31  | 30-31  | 30-31  |
| <b>Booting stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>           | <b>28-35 DAS</b>         | <b>31</b>    | 32* (rain water conservation)  | 32 (Hoeing, mulching, protective irrigation)               | 32 (Hoeing, mulching, protective irrigation)             |
| Plant protection spray  | 30 DAS                   | 31           | 32   | 32   | 32   |
| 50% flowering   | 35-45                    | 32           | 33   | 33   | 33   |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>     | <b>60-65 DAS</b>         | <b>35</b>    | 36* (conserved monsoon water for protective irrigation                         | 36 (Use conserved monsoon water for protective irrigation) | 36* (conserved monsoon water for protective irrigation ) |
| Maturity/Harvesting   | 80-85 DAS                | 39           | 40-41  | 40-41  | 40-41  |
| Varieties: Phule Adishakti(80-85 days), Phule mahashakti(85-90 days), Dhanshakti (Hybrid 74-78 days)  |                          |              | Diseases: Ergot, Downy mildew, smut  |  |  |
| Spacing: 45×15 cmSeed rate: 3-4kg/ha  |                          |              | Production: 25-30 Qtl/ha, Fodder: 5-7 Ton/ha                                   |  |  |
| Fertilizer dose: 50:25:25 Kg NPK/ha   |                          |              | Suitable for Intercropping with Pigeon pea(2:1) with 30 cm Row to Row spacing. |  |  |

Table 4.56 Continue...

| Crop- Pearl millet  |                          |              |  |  |  |
|---|--------------------------|--------------|--|--|--|
| Package of Practices  | Days After Sowing(DAS)   | MW           | Tehsils  |  |  |
|   |                          |              | Nashik   | Niphad   | Yevla  |
| Ploughing& land preparation   | 2-3 Weeks before sowing  | 22-23        | 22-23  | 22-23  | 22-23  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 25   | 26   | 26   |
| Fertilizer application  | At the time of sowing    | 25           | 26   | 26   | 26   |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 26   | 26   | 26   |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 28   | 28   | 28   |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 29   | 29   | 29   |
| <b>Panicle emergence stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>14 -21 DAS</b>        | <b>28-29</b> | 29*-30* (rain water conservation)  | 29*-30* (rain water conservation )                         | 29-30* (rain water conservation )                          |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 29-30  | 29-30  | 29-30  |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 30   | 30   | 30   |
| fertilizer application (Half N)   | 25-30 DAS                | 29-30        | 30-31  | 30-31  | 30-31  |
| <b>Booting stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>           | <b>28-35 DAS</b>         | <b>31</b>    | 32* (rain water conservation )   | 32* (rain water conservation )                             | 32 (Hoeing, mulching, protective irrigation)               |
| Plant protection spray  | 30 DAS                   | 31           | 32   | 32   | 32   |
| 50% flowering   | 35-45                    | 32           | 33   | 33   | 33   |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>     | <b>60-65 DAS</b>         | <b>35</b>    | 36 (Use conserved monsoon water for protective irrigation)                     | 36 (Use conserved monsoon water for protective irrigation) | 36 (Use conserved monsoon water for protective irrigation) |
| Maturity/Harvesting   | 80-85 DAS                | 39           | 40-41  | 40-41  | 40-41  |
| Varieties: Phule Adishakti(80-85 days), Phule mahashakti(85-90 days), Dhanshakti (Hybrid 74-78 days)  |                          |              | Diseases: Ergot, Downy mildew, smut ;Pest: Shoot fly                           |  |  |
| Spacing: 45×15 cmSeed rate: 3-4kg/ha  |                          |              | Production: 25-30 Qtl/ha, Fodder: 5-7 Ton/ha                                   |  |  |
| Fertilizer dose: 50:25:25 Kg NPK/ha   |                          |              | Suitable for Intercropping with Pigeon pea(2:1) with 30 cm Row to Row spacing. |  |  |

Table 4.57 Contingency Crop Management and Planning of Maize crop

| Crop- Maize   |                          |              |  |   |                                    |  |
|---|--------------------------|--------------|--|---|------------------------------------|--|
| Package of Practices  | Days After Sowing        | MW           | Tehsils  |   |                                    |  |
|   |                          |              | Baglan   | Devla   | Dindori                            | Kalwan   |
| Ploughing& land preparation   | 2-3 Weeks before         | 22-23        | 22-23  | 22-23   | 22-23                              | 22-23  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 26   | 26  | 25                                 | 26   |
| Fertilizer application  | At the time of           | 25           | 26   | 26  | 25                                 | 26   |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 26   | 26  | 25                                 | 26   |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 28   | 28  | 27                                 | 28   |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 29   | 29  | 28                                 | 29   |
| <b>Seedling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>      | <b>25 -30 DAS</b>        | <b>29-30</b> | 30*-31 (rain water conservation )                            | 30*-31 (rain water conservation )                       | 29*-30* (rain water conservation ) | 30*-31(Supplemental irrigation)                    |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 29-30  | 29-30   | 28-29                              | 29-30  |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 30   | 30  | 29                                 | 30   |
| fertilizer application (1/3N)   | 25-30 DAS                | 29-30        | 30-31  | 30-31   | 29-30                              | 30-31  |
| <b>Silking stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>      | <b>45-50 DAS</b>         | <b>32</b>    | 33 (Hoeing, protective irrigation)                           | 33 (Hoeing, mulching, protective irrigation)            | 32*( Supplemental irrigation)      | 33(Hoeing, mulching, protective irrigation)        |
| Plant protection spray  | 30 DAS                   | 31           | 32   | 32  | 31                                 | 32   |
| fertilizer application (1/3N)   | 40-45 DAS                | 32           | 33   | 33  | 32                                 | 33   |
| <b>Flowering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>     | <b>60-65 DAS</b>         | <b>35</b>    | 36*( Supplemental irrigation)                                | 36( protective irrigation)                              | 35( protective irrigation)         | 36*( Supplemental irrigation)                      |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>75-80 DAS</b>         | <b>37</b>    | 38* (supplementary irrigation )                              | 38* (rain water conservation, supplementary irrigation) | 37(protective irrigation)          | 38(Protective irrigation, using conserved monsoon) |
| Maturity/Harvesting   | 100-110 DAS              | 40-41        | 41-42  | 41-42   | 40-41                              | 41-42  |
| Varieties: Phule Maharshi(90-100 days), Sangam(100-110 days), Maharaia( 60-65 days)               |                          |              | Diseases: wilt, Downy mildew, rust                           |   |                                    |  |
| Spacing: 75×20 cm or 60×20cm .Seed rate: 15-20kg/ha   |                          |              | Production: 60-80 Qtl/ha, Fodder: 60-70 Ton/ha(African tall) |   |                                    |  |
| Fertilisers:120:60:40 Kg\Ha.  |                          |              |  |   |                                    |  |

| Table 4.57 Continue...  |                          |              |  |  |                             |
|---|--------------------------|--------------|--|--|-----------------------------|
| Crop- Maize   |                          |              |  |  |                             |
| Package of Practices  | Days After Sowing(DAS)   | MW           | Tehsils  |  |                             |
|   |                          |              | Malegaon   | Nashik                                   | Niphad                      |
| Ploughing& land preparation   | 2-3 Weeks before         | 22-23        | 22-23  | 22-23                                    | 22-23                       |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 26   | 25                                       | 26                          |
| Fertilizer application  | At the time of sowing    | 25           | 26   | 25                                       | 26                          |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 26   | 25                                       | 26                          |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 28   | 27                                       | 28                          |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 29   | 28                                       | 29                          |
| <b>Seedling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>      | <b>25 -30 DAS</b>        | <b>29-30</b> | 30*-31(, supplementary irrigation)                           | 29*-30* (water harvesting, supplementary | 30*-31* (water harvesting)  |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 29-30  | 28-29                                    | 29-30                       |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 30   | 29                                       | 30                          |
| fertilizer application (1/3N)   | 25-30 DAS                | 29-30        | 30-31  | 29-30                                    | 30-31                       |
| <b>Silking stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>      | <b>45-50 DAS</b>         | <b>32</b>    | 33 (Hoeing, mulching,  | 32* (Hoeing, mulching,                   | 33 (Hoeing, mulching,       |
| Plant protection spray  | 30 DAS                   | 31           | 32   | 31                                       | 32                          |
| fertilizer application (1/3N)   | 40-45 DAS                | 32           | 33   | 32                                       | 33                          |
| <b>Flowering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>     | <b>60-65 DAS</b>         | <b>35</b>    | 36( Protective irrigation)                                   | 35 (Protective irrigation)               | 36 (Protective irrigation)  |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>75-80 DAS</b>         | <b>37</b>    | 38 (protective irrigation )                                  | 37 (Protective irrigation, )             | 38 (Protective irrigation,) |
| Maturity/Harvesting   | 100-110 DAS              | 40-41        | 41-42  | 40-41                                    | 41-42                       |
| Varieties: Phule Maharshi(90-100 days), Sangam(100-110 days), Maharaja( 60-65 days)               |                          |              | Diseases: wilt, Downy mildew, rust                           |  |                             |
| Spacing: 75×20 cm or 60×20cm .Seed rate: 15-20kg/ha   |                          |              | Production: 60-80 Qtl/ha, Fodder: 60-70 Ton/ha(African tall) |  |                             |
| Fertilisers:120:60:40 Kg\Ha.  |                          |              |  |  |                             |

| Table 4.57 Continue...  |                          |              |  |                                 |                                      |
|---|--------------------------|--------------|--|---------------------------------|--------------------------------------|
| Crop- Maize   |                          |              |  |                                 |                                      |
| Package of Practices  | Days After Sowing(DAS)   | MW           | Tehsils  |                                 |                                      |
|   |                          |              | Sinnar   | Trimbakeshwar                   | Yevla                                |
| Ploughing& land preparation   | 2-3 Weeks before         | 22-23        | 22-23  | 22-23                           | 22-23                                |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 26   | 25                              | 26                                   |
| Fertilizer application  | At the time of sowing    | 25           | 26   | 25                              | 26                                   |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 26   | 25                              | 26                                   |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 28   | 27                              | 28                                   |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 29   | 28                              | 29                                   |
| <b>Seedling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>      | <b>25 -30 DAS</b>        | <b>29-30</b> | 30-31 (mulching, protective irrigation)                      | 29*-30* (water harvesting)      | 30*-31 (Hoeing, water harvesting)    |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 29-30  | 28-29                           | 29-30                                |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 30   | 29                              | 30                                   |
| fertilizer application (1/3N)   | 25-30 DAS                | 29-30        | 30-31  | 29-30                           | 30-31                                |
| <b>Silking stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>       | <b>45-50 DAS</b>         | <b>32</b>    | 33 ( mulching, protective irrigation)                        | 32* ( Supplemental irrigation)  | 33 (mulching, protective irrigation) |
| Plant protection spray  | 30 DAS                   | 31           | 32   | 31                              | 32                                   |
| fertilizer application (1/3N)   | 40-45 DAS                | 32           | 33   | 32                              | 33                                   |
| <b>Flowering stage Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>     | <b>60-65 DAS</b>         | <b>35</b>    | 36(protective irrigation)                                    | 35*                             | 36(protective irrigation)            |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>75-80 DAS</b>         | <b>37</b>    | 38* (supplementary irrigation as wet probability is more)    | 37* ( supplementary irrigation) | 38* (supplementary irrigation)       |
| Maturity/Harvesting   | 100-110 DAS              | 40-41        | 41-42  | 40-41                           | 41-42                                |
| Varieties: Phule Maharshi(90-100 days), Sangam(100-110 days), Maharaja( 60-65 days)               |                          |              | Diseases: wilt, Downy mildew, rust                           |                                 |                                      |
| Spacing: 75×20 cm or 60×20cm .Seed rate: 15-20kg/ha   |                          |              | Production: 60-80 Qtl/ha, Fodder: 60-70 Ton/ha(African tall) |                                 |                                      |
| Fertilisers:120:60:40 Kg/ha.  |                          |              |  |                                 |                                      |

**Table 4.58 Contingency Crop Management and Planning of Finger millet crop**

| <b>Crop- Finger millet</b>  |                               |              |   |  |                            |
|---|-------------------------------|--------------|---|--|----------------------------|
| <b>Package of Practices</b>   | <b>Days After Sowing(DAS)</b> | <b>MW</b>    | <b>Tehsils</b>  |  |                            |
|   |                               |              | <b>Chandwad</b>   | <b>Devla</b>                               | <b>Dindori</b>             |
| Ploughing& land preparation   | 2-3 Weeks before sowing       | 22-23        | 22-23   | 22-23                                      | 22-23                      |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b>      | <b>24-28</b> | 26  | 26   | 25                         |
| Fertilizer application  | At the time of sowing         | 25           | 26  | 26   | 25                         |
| Pre emergence spraying of herbicide   | 1-2 DAS                       | 25           | 26  | 26   | 25                         |
| Thinning 1 <sup>st</sup>  | 10 DAS                        | 27           | 28  | 28   | 27                         |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                        | 28           | 29  | 29   | 28                         |
| <b>Tillering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>25 -30 DAS</b>             | <b>29-30</b> | 30*-31 (Hoeing, supplementary irrigation)   | 30*-31 (Hoeing, ,supplementary irrigation) | 29*-30* (water harvesting) |
| Thinning 2 <sup>nd</sup>  | 20 DAS                        | 28-29        | 29-30   | 29-30                                      | 28-29                      |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                     | 29           | 30  | 30   | 29                         |
| fertilizer application (1/2N)   | 25-30 DAS                     | 29-30        | 30-31   | 30-31                                      | 29-30                      |
| Plant protection spray  | 30 DAS                        | 31           | 32  | 32   | 31                         |
| <b>Flowering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>60-65 DAS</b>              | <b>35</b>    | 36(protective irrigation)   | 36(protective irrigation)                  | 35(protective irrigation)  |
| Maturity/Harvesting   | 120-135 DAS                   | 40-41        | 41-42   | 41-42                                      | 40-41                      |
| Varieties: Phule Nachani(115-120days), phule kasari(100-105 days).                            |                               |              | Diseases: Seedling blight, Blast, Downy mildew. Pest: Stem borer,Army worm,Leaf aphids. |  |                            |
| Spacing: 20×8 cm or 22.5×10cm .Seed rate: 4-5 kg/ha   |                               |              | Production: 20-25 Qtl/ha,.  |  |                            |
| Fertilizer dose: 60:30:30 Kg NPK/ha   |                               |              |   |  |                            |

| Table 4.58 Continue...  |                          |              |  |  |                            |
|---|--------------------------|--------------|--|--|----------------------------|
| Crop- Finger millet   |                          |              |  |  |                            |
| Package of Practices  | Days After Sowing(DAS)   | MW           | Tehsils  |  |                            |
|   |                          |              | Igatpuri   | Sinnar   | Surgana                    |
| Ploughing& land preparation   | 2-3 Weeks before sowing  | 22-23        | 22-23  | 22-23  | 22-23                      |
| <b>Sowing (with seed cum fert seed)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 24   | 26   | 25                         |
| Fertilizer application  | At the time of sowing    | 25           | 24   | 26   | 25                         |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 24   | 26   | 25                         |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 26   | 28   | 27                         |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 27   | 29   | 28                         |
| <b>Tillering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>25 -30 DAS</b>        | <b>29-30</b> | 28*-29* (water harvesting)   | 30-31 (Hoeing, mulching, protective irrigation, residue cover) | 29*-30* (water harvesting) |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 27-38  | 29-30  | 28-29                      |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 28   | 30   | 29                         |
| fertilizer application (1/2N)   | 25-30 DAS                | 29-30        | 28-29  | 30-31  | 29-30                      |
| Plant protection spray  | 30 DAS                   | 31           | 30   | 32   | 31                         |
| <b>Flowering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>60-65 DAS</b>         | <b>35</b>    | 34*(supplementary irrigation)  | 36 (protective irrigation)                                     | 35*( water harvesting)     |
| Maturity/Harvesting   | 120-135 DAS              | 40-41        | 39-40  | 41-42  | 40-41                      |
| Varieties: Phule Nachani(115-120days), phule kasari(100-105 days).                            |                          |              | Diseases: Seedling blight, Blast, Downy mildew.Pest: Stem borer,Army worm,Leaf aphids. |  |                            |
| Spacing: 20×8 cm or 22.5×10cm .Seed rate: 4-5 kg/ha   |                          |              | Production: 20-25 Qtl/ha,.   |  |                            |
| Fertilizer dose: 60:30:30 Kg NPK/ha   |                          |              |  |  |                            |

| Table 4.58 Continue...  |                          |              |  |                               |                             |
|---|--------------------------|--------------|--|-------------------------------|-----------------------------|
| Crop- Finger millet   |                          |              |  |                               |                             |
| Package of Practices  | Days After Sowing(DAS)   | MW           | Tehsils  |                               |                             |
|   |                          |              | Nandgaon   | Peth                          | Trimbakeshwar               |
| Ploughing& land preparation   | 2-3 Weeks before sowing  | 22-23        | 22-23  | 22-23                         | 22-23                       |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 June - 15 July</b> | <b>24-28</b> | 26   | 25                            | 25                          |
| Fertilizer application  | At the time of sowing    | 25           | 26   | 25                            | 25                          |
| Pre emergence spraying of herbicide   | 1-2 DAS                  | 25           | 26   | 25                            | 25                          |
| Thinning 1 <sup>st</sup>  | 10 DAS                   | 27           | 28   | 27                            | 27                          |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                   | 28           | 29   | 28                            | 28                          |
| <b>Tillering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>25 -30 DAS</b>        | <b>29-30</b> | 30-31 (Hoeing mulching, protective irrigation)   | 29*-30* (water harvesting)    | 28*-29* ( water harvesting) |
| Thinning 2 <sup>nd</sup>  | 20 DAS                   | 28-29        | 29-30  | 28-29                         | 28-29                       |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS                | 29           | 30   | 29                            | 29                          |
| fertilizer application (1/2N)   | 25-30 DAS                | 29-30        | 30-31  | 29-30                         | 29-30                       |
| Plant protection spray  | 30 DAS                   | 31           | 32   | 31                            | 31                          |
| <b>Flowering stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>60-65 DAS</b>         | <b>35</b>    | 36*( water harvesting)   | 35*(supplementary irrigation) | 35*( water harvesting)      |
| Maturity/Harvesting   | 120-135 DAS              | 40-41        | 41-42  | 40-41                         | 40-41                       |
| Varieties: Phule Nachani(115-120days), phule kasari(100-105 days).                            |                          |              | Diseases: Seedling blight, Blast, Downy mildew.Pest: Stem borer,Army worm,Leaf aphids. |                               |                             |
| Spacing: 20×8 cm or 22.5×10cm .Seed rate: 4-5 kg/ha   |                          |              | Production: 20-25 Qtl/ha,.   |                               |                             |
| Fertilizer dose: 60:30:30 Kg NPK/ha   |                          |              |  |                               |                             |

Table 4.59 Contingency Crop Management and Planning of Rice crop

| Crop- Rice  |                              |              |                            |                               |
|---|------------------------------|--------------|----------------------------|-------------------------------|
| Package of Practices  | Days After Sowing(DAS)       | MW           | Tehsils                    |                               |
|   |                              |              | Igatpuri                   | Surgana                       |
| Ploughing & land preparation  | 2-3 Weeks before sowing      | 22-23        | 22-23                      | 22-23                         |
| <b>Sowing (on seed bed, nursery)</b>  | <b>25 May - 30 June</b>      | <b>21-25</b> | 24                         | 25                            |
| Fertilizer application  | At the time of sowing        | 25           | 24                         | 25                            |
| Puddling  | 20-25 DAS                    | 28           | 27                         | 28                            |
| Transplanting   | 25-30 DAS                    | 28           | 27                         | 28                            |
| Weeding 1 <sup>st</sup>   | 25-30 DAS                    | 29           | 28                         | 29                            |
| <b>Tillering stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>          | <b>30-35 DAS (2to 5 DAT)</b> | <b>30</b>    | 29* (water harvesting)     | <b>30*</b> (water harvesting) |
| 1 <sup>st</sup> Plant protection spray  | 35-45 DAS                    | 31-32        | 30-31                      | 31-32                         |
| Weeding 2 <sup>nd</sup>   | 45-50 DAS                    | 32           | 31                         | 32                            |
| <b>Panicle initiation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>70-80 DAS</b>             | <b>34-35</b> | 33*-34* (water harvesting) | 34*-35* (water harvesting)    |
| 2 <sup>nd</sup> protection spray (50% flowering )   | 60-70 DAS                    | 34-35        | 33                         | 34-35                         |
| <b>milking</b>  | <b>90-100 DAS</b>            | 37-38        | 36*-37*(water harvesting)  | 37*-38*(water harvesting)     |
| Maturity/Harvesting   | 110-145 DAS                  | 41-42        | 40-41                      | 41-42                         |
| Varities-Karjat-4,Ratna,Phule Radha , Indrayani, Bhogawati, Basmati 370                                 |                              |              | Pest: BPH, Stem borers     |                               |
| transplanting: 30-40kg/ha, Spacing: - 15×15 cm,20×15 cm.  |                              |              | Production: 30-60 Qtl/ha   |                               |
| Fertilizer dose: 100:50:50 Kg NPK/ha  |                              |              |                            |                               |

| Table 4.59 Continue...  |                              |              |                            |                            |
|---|------------------------------|--------------|----------------------------|----------------------------|
| Crop- Rice  |                              |              |                            |                            |
| Package of Practices  | Days After Sowing(DAS)       | MW           | Tehsils                    |                            |
|   |                              |              | Peth                       | Trimbakeshwar              |
| Ploughing& land preparation   | 2-3 Weeks before sowing      | 22-23        | 22-23                      | 22-23                      |
| <b>Sowing (on seed bed, nursery)</b>  | <b>25 May - 30June</b>       | <b>21-25</b> | 25                         | 25                         |
| Fertilizer application  | At the time of sowing        | 25           | 25                         | 25                         |
| Puddling  | 20-25 DAS                    | 28           | 28                         | 28                         |
| Transplanting   | 25-30 DAS                    | 28           | 28                         | 28                         |
| Weeding 1 <sup>st</sup>   | 25-30 DAS                    | 29           | 29                         | 29                         |
| <b>Tillering stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>          | <b>30-35 DAS (2to 5 DAT)</b> | <b>30</b>    | 30* (water harvesting)     | 30*(water harvesting)      |
| 1 <sup>st</sup> Plant protection spray  | 35-45 DAS                    | 31-32        | 31-32                      | 31-32                      |
| Weeding 2 <sup>nd</sup>   | 45-50 DAS                    | 32           | 32                         | 32                         |
| <b>Panicle initiation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>60-70 DAS</b>             | <b>34-35</b> | 34*-35* (water harvesting) | 34*-35* (water harvesting) |
| 2 <sup>nd</sup> protection spray (50% flowering )   | 60-70 DAS                    | 34-35        | 35                         | 35                         |
| <b>milking (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>                  | <b>90-100 DAS</b>            | 37-38        | 37*-38(water harvesting)   | 37*-38*(water harvesting)  |
| Maturity/Harvesting   | 110-145 DAS                  | 41-42        | 41-42                      | 41-42                      |
| Varities-Karjat-4,Ratna,Phule Radha , Indrayani, Bhogawati, Basmati 370                                 |                              |              | Pest: BPH, Stem borers     |                            |
| transplanting: 30-40kg/ha, Spacing: - 15×15 cm,20×15 cm.  |                              |              | Production: 30-60 Qtl/ha   |                            |
| Fertilizer dose: 100:50:50 Kg NPK/ha  |                              |              |                            |                            |

(\* Indicates that MW week coincides with critical growth stage of crop but station has sufficient moisture for that week as probability of wet is more in that week)

Table 4.60 Contingency Crop Management and Planning of rabi sorghum crop

| Crop- Rabi Sorghum  |   |              |                        |                       |                        |
|---|---|--------------|------------------------|-----------------------|------------------------|
| Package of Practices  | Days After Sowing (DAS)   | MW           | Tehsils                |                       |                        |
|   |   |              | Baglan                 | Chandwad              | Devla                  |
| Ploughing& land preparation   | In Summer   | 22-23        | 22-23                  | 22-23                 | 22-23                  |
| In situ moisture conservation practices viz., Compartmental                             | 45 days before  | 31-32        | 31-32                  | 31-32                 | 31-32                  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 Sep - 15 Oct</b>  | <b>37-42</b> | 38                     | 38                    | 38                     |
| Fertilizer application(Half N:full P:full K)  | At sowing   | 38           | 38                     | 38                    | 38                     |
| Pre emergence spraying  | 1-2 DAS   | 38           | 38                     | 38                    | 38                     |
| <b>Emergence of seedling</b>  | <b>3-14 DAS</b>   | <b>39</b>    | 38*-40*                | 38*-40                | 38*-40*                |
| Plant protection spray 1 <sup>st</sup>  | 10 DAS  | 39           | 39                     | 39                    | 39                     |
| Hoeing & Weeding 1 <sup>st</sup>  | 21 DAS  | 41           | 41                     | 41                    | 41                     |
| fertilizer application (Half N)   | 30 DAS  | 43           | 43                     | 43                    | 43                     |
| <b>Growing Point Differentiation (GPD) stage</b>  | <b>30-40 DAS</b>  | <b>43-44</b> | 43-44 (Hoeing, org.    | 43-44 (Hoeing, org.   | 43-44 (Hoeing, org.    |
| Plant protection spray 2 <sup>nd</sup>  | 30 DAS  | 43           | 43                     | 43                    | 43                     |
| Hoeing & Weeding 2 <sup>nd</sup>  | 35 DAS  | 43           | 43                     | 43                    | 43                     |
| <b>Booting stage</b>  | <b>50-55 DAS</b>  | <b>45-46</b> | 45-46 (Hoeing,         | 45-46 (Hoeing,        | 45-46(Hoeing,          |
| Hoeing 3 <sup>rd</sup>  | 56 DAS  | 46           | 46                     | 46                    | 46                     |
| 2% Potassium spray  | 55 DAS  | 46           | 46                     | 46                    | 46                     |
| Panicle initiation  | 58-60 DAS   | 47           | 47                     | 47                    | 47                     |
| <b>Flowering(Protective irrigation)</b>   | <b>70-75 DAS</b>  | <b>48-49</b> | 48-49 (Supplemental    | 48-49 (Supplemental   | 48-49 (Supplemental    |
| <b>Grain filling stage(Protective irrigation )</b>                                      | <b>90-95 DAS</b>  | <b>51</b>    | 51 (Supplemental irri. | 51(Supplemental irri. | 51 (Supplemental irri. |
| Maturity/Harvesting   | 110-130 DAS   | 02           | 02                     | 02                    | 02                     |
| Drying  | 120-140 DAS   | 03-04        | 03-04                  | 03-04                 | 03-04                  |
| Varieties: 1)Medium soil- Phule Suchitra, Phule Chitra, Maldandi 35-1, Parbhani Moti 2) | Diseases: Head smut, Grain smut, Leaf rust, Downy mildew                |              |                        |                       |                        |
| Spacing: 45×15 cm(1.48 lakh Plant population)      Seed rate: 10-12 kg/ha               | Fertilizer dose: 40:20:00, 60:30:00 kg NPK/ha                           |              |                        |                       |                        |
| Production: A) Under drylandcondition: On medium soil - 20-25 qtl/ha                    | Suitable for Intercropping with Pearl millet and Safflower (4:2 or 6:3) |              |                        |                       |                        |

| Table 4.60 Continue...  |                         |              |   |                       |                        |
|---|-------------------------|--------------|---|-----------------------|------------------------|
| Crop- Rabi Sorghum  |                         |              |   |                       |                        |
| Package of Practices  | Days After Sowing (DAS) | MW           | Tehsils   |                       |                        |
|   |                         |              | Igatpuri  | Kalwan                | Malegaon               |
| Ploughing& land preparation   | In Summer               | 22-23        | 22-23   | 22-23                 | 22-23                  |
| In situ moisture conservation practices viz., Compartmental                             | 45 days before          | 31-32        | 31-32   | 31-32                 | 31-32                  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 Sep - 15 Oct</b>  | <b>37-42</b> | 38  | 38                    | 38                     |
| Fertilizer application(Half N:full P:full K)  | At sowing               | 38           | 38  | 38                    | 38                     |
| Pre emergence spraying  | 1-2 DAS                 | 38           | 38  | 38                    | 38                     |
| <b>Emergence of seedling</b>  | <b>3-14 DAS</b>         | <b>39</b>    | 38*-40*   | 38-40                 | 38-40                  |
| Plant protection spray 1 <sup>st</sup>  | 10 DAS                  | 39           | 39  | 39                    | 39                     |
| Hoeing & Weeding 1 <sup>st</sup>  | 21 DAS                  | 41           | 41  | 41                    | 41                     |
| fertilizer application (Half N)   | 30 DAS                  | 43           | 43  | 43                    | 43                     |
| <b>Growing Point Differentiation (GPD) stage</b>  | <b>30-40 DAS</b>        | <b>43-44</b> | 43-44 (Hoeing, org.   | 43-44 (Hoeing, org.   | 43-44 (Hoeing, org.    |
| Plant protection spray 2 <sup>nd</sup>  | 30 DAS                  | 43           | 43  | 43                    | 43                     |
| Hoeing & Weeding 2 <sup>nd</sup>  | 35 DAS                  | 43           | 43  | 43                    | 43                     |
| <b>Booting stage</b>  | <b>50-55 DAS</b>        | <b>45-46</b> | 45-46 (Hoeing,  | 45-46 (Hoeing,        | 45-46(Hoeing,          |
| Hoeing 3 <sup>rd</sup>  | 56 DAS                  | 46           | 46  | 46                    | 46                     |
| 2% Potassium spray  | 55 DAS                  | 46           | 46  | 46                    | 46                     |
| Panicle initiation  | 58-60 DAS               | 47           | 47  | 47                    | 47                     |
| <b>Flowering(Protective irrigation-)</b>  | <b>70-75 DAS</b>        | <b>48-49</b> | 48-49 (Supplemental   | 48-49 (Supplemental   | 48-49 (Supplemental    |
| <b>Grain filling stage(Protective irrigation)</b>                                       | <b>90-95 DAS</b>        | <b>51</b>    | 51 (Supplemental irri.  | 51(Supplemental irri. | 51 (Supplemental irri. |
| Maturity/Harvesting   | 110-130 DAS             | 02           | 02  | 02                    | 02                     |
| Drying  | 120-140 DAS             | 03-04        | 03-04   | 03-04                 | 03-04                  |
| Varieties: 1)Medium soil- Phule Suchitra, Phule Chitra, Maldandi 35-1, Parbhani Moti 2) |                         |              | Diseases: Head smut, Grain smut, Leaf rust, Downy mildew                |                       |                        |
| Spacing: 45×15 cm(1.48 lakh Plant population) Seed rate: 10-12 kg/ha                    |                         |              | Fertilizer dose: 40:20:00, 60:30:00 kg NPK/ha                           |                       |                        |
| Production: A) Under drylandcondition: On medium soil - 20-25 qtl/ha                    |                         |              | Suitable for Intercropping with Pearl millet and Safflower (4:2 or 6:3) |                       |                        |

| Table 4.60 Continue...  |                         |                        |   |                       |                        |
|---|-------------------------|------------------------|---|-----------------------|------------------------|
| Crop- Rabi Sorghum  |                         |                        |   |                       |                        |
| Package of Practices  | Days After Sowing (DAS) | MW                     | Tehsils   |                       |                        |
|   |                         |                        | Nandgaon  | Niphad                | Yevla                  |
| Ploughing& land preparation   | In Summer               | 22-23                  | 22-23   | 22-23                 | 22-23                  |
| In situ moisture conservation practices viz.,<br>Compartmental bunds (3.6×3.6m, 6×2m, 10×10m) | 45 days before sowing   | 31-32                  | 31-32   | 31-32                 | 31-32                  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>15 Sep - 15 Oct</b>  | <b>37-42</b>           | 38  | 38                    | 38                     |
| Fertilizer application(Half N:full P:full K)  | At sowing               | 38                     | 38  | 38                    | 38                     |
| Pre emergence spraying  | 1-2 DAS                 | 38                     | 38  | 38                    | 38                     |
| <b>Emergence of seedling</b>  | <b>3-14 DAS</b>         | <b>39</b>              | 38-40   | 38-40                 | 38*-40                 |
| Plant protection spray 1 <sup>st</sup>  | 10 DAS                  | 39                     | 39  | 39                    | 39                     |
| Hoeing & Weeding 1 <sup>st</sup>  | 21 DAS                  | 41                     | 41  | 41                    | 41                     |
| fertilizer application (Half N)   | 30 DAS                  | 43                     | 43  | 43                    | 43                     |
| <b>Growing Point Differentiation (GPD) stage</b>  | <b>30-40 DAS</b>        | <b>43-44</b>           | 43-44 (Hoeing, org.   | 43-44 (Hoeing, org.   | 43-44 (Hoeing, org.    |
| Plant protection spray 2 <sup>nd</sup>  | 30 DAS                  | 43                     | 43  | 43                    | 43                     |
| Hoeing & Weeding 2 <sup>nd</sup>  | 35 DAS                  | 43                     | 43  | 43                    | 43                     |
| <b>Booting stage</b>  | <b>50-55 DAS</b>        | <b>45-46</b>           | 45-46 (Hoeing,  | 45-46 (Hoeing,        | 45-46(Hoeing,          |
| Hoeing 3 <sup>rd</sup>  | 56 DAS                  | 46                     | 46  | 46                    | 46                     |
| 2% Potassium spray  | 55 DAS                  | 46                     | 46  | 46                    | 46                     |
| Panicle initiation  | 58-60 DAS               | 47                     | 47  | 47                    | 47                     |
| <b>Flowering(Protective irrigation-If Probability of P(D)</b>                                 | <b>70-75 DAS</b>        | <b>48-49</b>           | 48-49 (Supplemental   | 48-49 (Supplemental   | 48-49 (Supplemental    |
| <b>Grain filling stage(Protective irrigation-If Probability</b>                               | <b>90-95 DAS</b>        | <b>51</b>              | 51 (Supplemental irri.  | 51(Supplemental irri. | 51 (Supplemental irri. |
| Maturity/Harvesting   | 110-130 DAS             | 02                     | 02  | 02                    | 02                     |
| Drying  | 120-140 DAS             | 03-04                  | 03-04   | 03-04                 | 03-04                  |
| Varieties: 1)Medium soil- Phule Suchitra, Phule Chitra, Maldandi 35-1, Parbhani Moti 2)       |                         |                        | Diseases: Head smut, Grain smut, Leaf rust, Downy mildew                |                       |                        |
| Spacing: 45×15 cm(1.48 lakh Plant population)   |                         | Seed rate: 10-12 kg/ha | Fertilizer dose: 40:20:00, 60:30:00 kg NPK/ha                           |                       |                        |
| Production: A) Under drylandcondition: On medium soil - 20-25 qtl/ha                          |                         |                        | Suitable for Intercropping with Pearl millet and Safflower (4:2 or 6:3) |                       |                        |

| <b>Table 4.61 Contingency Crop Management and Planning of Gram crop</b>                                     |   |                      |   |   |   |
|---|---|----------------------|---|---|---|
| <b>Crop- Gram</b>   |   |                      |   |   |   |
| <b>Package of Practices</b>   | <b>Days After Sowing(DAS)</b>                         | <b>MW</b>            | <b>Tehsils</b>  |   |   |
|   |   |                      | <b>Baglan</b>   | <b>Chandwad</b>   | <b>Dindori</b>  |
| Land preparation & ploughing  | 2 <sup>nd</sup> Fortnight of September                | 38-39                | 37  | 37  | 37  |
| <b>Sowing</b>   | <b>Last week of Sep to 1<sup>st</sup> week of Oct</b> | <b>39-40</b>         | 40  | 40  | 39  |
| Fertilizer application  | At the time of sowing                                 | 39                   | 39  | 39  | 38  |
| Thinning and gap filling  | 10 DAS  | 41                   | 41  | 41  | 40  |
| Hoeing & Weeding 1 <sup>st</sup>  | 25-30 DAS   | 43-44                | 43-44   | 43-44   | 42-43   |
| <b>Pre Flowering stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>          | <b>40-50 DAS</b>                                      | <b>45-47</b>         | 45-47 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective | 45-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective | 44-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective |
| Hoeing & Weeding 2 <sup>nd</sup>  | 60 DAS  | 48                   | 48  | 48  | 47  |
| fertilizer application (2% urea   | 70 DAS  | 50                   | 50  | 50  | 49  |
| <b>Pod development stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>        | <b>75-80 DAS</b>                                      | <b>51</b>            | 51-52 (Protective irrigation with harvested NE rain water)                                  | 51-52 (Protective irrigation with harvested NE rain water)                                  | 50-51 (Protective irrigation with harvested NE rain water)                                  |
| Maturity and Harvesting   | 90-100 DAS  | 52-01                | 52-01   | 52-01   | 51-52   |
| Varieties: Phule Vijay (85-90 days), Phule Digvijay (90-95 days), Phule Vishal (110-115 days), PKV-2, PKV-4 |   |                      | Pest: Gram pod borer, Gram cut worm Diseases: Fusarium wilt, Ascochyta blight, Dry root rot |   |   |
| Spacing: 30×10 cm   |   | Seed rate: 100 kg/ha |   | Fertizer dose: 25:50:30 Kg NPK/ha   |   |
| Production: 25-30 Qtl/ha  |   |                      |   |   |   |

| Table 4.61 Continue...   |   |                      |   |   |   |
|--|---|----------------------|---|---|---|
| Crop- Gram   |   |                      |   |   |   |
| Package of Practices   | Days After Sowing(DAS)                                | MW                   | Tehsils   |   |   |
|  |   |                      | Kalwan  | Igatpuri  | Nashik  |
| Land preparation & ploughing   | 2 <sup>nd</sup> Fortnight of September                | 38-39                | 37  | 37  | 37  |
| <b>Sowing</b>  | <b>Last week of Sep to 1<sup>st</sup> week of Oct</b> | <b>39-40</b>         | 40  | 40  | 39  |
| Fertilizer application   | At the time of sowing                                 | 39                   | 39  | 39  | 38  |
| Thinning and gap filling   | 10 DAS  | 41                   | 41  | 41  | 40  |
| Hoeing & Weeding 1 <sup>st</sup>   | 25-30 DAS   | 43-44                | 43-44   | 43-44   | 42-43   |
| <b>Pre Flowering stage</b><br><b>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-50 DAS</b>                                      | <b>45-47</b>         | 45-47 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) | 45-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) | 44-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) |
| Hoeing & Weeding 2 <sup>nd</sup>   | 60 DAS  | 48                   | 48  | 48  | 47  |
| fertilizer application (2% urea  | 70 DAS  | 50                   | 50  | 50  | 49  |
| <b>Pod development stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>         | <b>75-80 DAS</b>                                      | <b>51</b>            | 51-52 (Protective irrigation with harvested NE rain water)  | 51-52 (Protective irrigation with harvested NE rain water)  | 50-51 (Protective irrigation with harvested NE rain water)  |
| Maturity and Harvesting  | 90-100 DAS  | 52-01                | 52-01   | 52-01   | 51-52   |
| Varieties: Phule Vijay (85-90 days), Phule Digvijay (90-95 days), Phule Vishal (110-115 days), PKV-2, PKV-4  |   |                      | Pest: Gram pod borer, Gram cut worm Diseases: Fusarium wilt, Ascochyta blight, Dry root rot             |   |   |
| Spacing: 30×10 cm  |   | Seed rate: 100 kg/ha |   | Fertizer dose: 25:50:30 Kg NPK/ha   |   |
| Production: 25-30 Qtl/ha   |   |                      |   |   |   |

| Table 4.61 Continue...   |   |                      |   |   |   |
|--|---|----------------------|---|---|---|
| Crop- Gram   |   |                      |   |   |   |
| Package of Practices   | Days After Sowing(DAS)                                | MW                   | Tehsils   |   |   |
|  |   |                      | Niphad  | Sinnar  | Yeola   |
| Land preparation & ploughing   | 2 <sup>nd</sup> Fortnight of September                | 38-39                | 37  | 37  | 37  |
| <b>Sowing</b>  | <b>Last week of Sep to 1<sup>st</sup> week of Oct</b> | <b>39-40</b>         | 40  | 40  | 39  |
| Fertilizer application   | At the time of  | 39                   | 39  | 39  | 38  |
| Thinning and gap filling   | 10 DAS  | 41                   | 41  | 41  | 40  |
| Hoeing & Weeding 1 <sup>st</sup>   | 25-30 DAS   | 43-44                | 43-44   | 43-44   | 42-43   |
| <b>Pre Flowering stage</b><br><b>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-50 DAS</b>                                      | <b>45-47</b>         | 45-47 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) | 45-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) | 44-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) |
| Hoeing & Weeding 2 <sup>nd</sup>   | 60 DAS  | 48                   | 48  | 48  | 47  |
| fertilizer application (2% urea  | 70 DAS  | 50                   | 50  | 50  | 49  |
| <b>Pod development stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>          | <b>75-80 DAS</b>                                      | <b>51</b>            | 51-52 (Protective irrigation with harvested NE rain water)  | 51-52 (Protective irrigation with harvested NE rain water)  | 50-51 (Protective irrigation with harvested NE rain water)  |
| Maturity and Harvesting  | 90-100 DAS  | 52-01                | 52-01   | 52-01   | 51-52   |
| Varieties: Phule Vijay (85-90 days), Phule Digvijay (90-95 days), Phule Vishal (110-115 days), PKV-2, PKV-4  |   |                      | Pest: Gram pod borer, Gram cut worm Diseases: Fusarium wilt, Ascochyta blight, Dry root rot             |   |   |
| Spacing: 30×10 cm  |   | Seed rate: 100 kg/ha | Fertizer dose: 25:50:30 Kg NPK/ha   |   |   |
| Production: 25-30 Qtl/ha   |   |                      |   |   |   |

| Table 4.61 Continue...  |   |                      |   |   |   |
|---|---|----------------------|---|---|---|
| Crop- Gram  |   |                      |   |   |   |
| Package of Practices  | Days After Sowing(DAS)                                | MW                   | Tehsils   |   |   |
|   |   |                      | Peth  | Surgana   | Trimbakeshwar   |
| Land preparation & ploughing  | 2 <sup>nd</sup> Fortnight of September                | 38-39                | 37  | 37  | 37  |
| <b>Sowing</b>   | <b>Last week of Sep to 1<sup>st</sup> week of Oct</b> | <b>39-40</b>         | 40  | 40  | 39  |
| Fertilizer application  | At the time of  | 39                   | 39  | 39  | 38  |
| Thinning and gap filling  | 10 DAS  | 41                   | 41  | 41  | 40  |
| Hoeing & Weeding 1 <sup>st</sup>  | 25-30 DAS   | 43-44                | 43-44   | 43-44   | 42-43   |
| <b>Pre Flowering stage Protective irrigation-If Probability of P(D) and P(D/D) more than 50%</b>            | <b>40-50 DAS</b>                                      | <b>45-47</b>         | 45-47 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) | 45-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) | 44-46 (Hoeing, mulching, foliar spray of KNO <sub>3</sub> , reduce no of leaves, protective irrigation) |
| Hoeing & Weeding 2 <sup>nd</sup>  | 60 DAS  | 48                   | 48  | 48  | 47  |
| fertilizer application (2% urea   | 70 DAS  | 50                   | 50  | 50  | 49  |
| <b>Pod development stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>        | <b>75-80 DAS</b>                                      | <b>51</b>            | 51-52 (Protective irrigation with harvested NE rain water)  | 51-52 (Protective irrigation with harvested NE rain water)  | 50-51 (Protective irrigation with harvested NE rain water)  |
| Maturity and Harvesting   | 90-100 DAS  | 52-01                | 52-01   | 52-01   | 51-52   |
| Varieties: Phule Vijay (85-90 days), Phule Digvijay (90-95 days), Phule Vishal (110-115 days), PKV-2, PKV-4 |   |                      | Pest: Gram pod borer, Gram cut worm : Fusarium wilt, Ascochyta blight, Dry root rot                     |   |   |
| Spacing: 30×10 cm   |   | Seed rate: 100 kg/ha | Fertizer dose: 25:50:30 Kg NPK/ha   |   |   |
| Production: 25-30 Qtl/ha  |   |                      |   |   |   |

| Table 4.62 Contingency Crop Management and Planning of Wheat crop  |                            |              |  |  |   |
|--|----------------------------|--------------|--|--|---|
| Crop Wheat   |                            |              |  |  |   |
| Package of Practices   | Days After Sowing<br>(DAS) | MW           | Tehsils  |  |   |
|  |                            |              | Baglan   | Devla  | Dindori   |
| Ploughing & land preparation   | 2-3 Weeks before sowing    | 41-42        | 41-42  | 41-42  | 41-42   |
| <b>Sowing (with seed cum fert seed drill)</b>  | <b>1 Nov - 10 Nov</b>      | <b>44-45</b> | 45   | 45   | 45  |
| Fertilizer application   | At the time of sowing      | 45           | 45   | 45   | 45  |
| Pre emergence spraying of herbicide  | 1-2 DAS                    | 45           | 45   | 45   | 45  |
| Thinning 1 <sup>st</sup>   | 10 DAS                     | 47           | 47   | 47   | 47  |
| Hoeing & Weeding 1 <sup>st</sup>   | 15 DAS                     | 48           | 48   | 48   | 48  |
| <b>Crown root initiation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>         | <b>18 -21 DAS</b>          | <b>48-49</b> | 48-49 (Hoeing mulching, straw application)                 | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover) | 48-49 (Hoeing, Mulching, broad bed furrows, residue)        |
| Thinning 2 <sup>nd</sup>   | 20 DAS                     | 48-49        | 48-49  | 48-49  | 48-49   |
| Hoeing & Weeding 2 <sup>nd</sup>   | 25-30 DAS                  | 49           | 49   | 49   | 49  |
| fertilizer application (Half N)  | 25-30 DAS                  | 49-50        | 49-50  | 49-50  | 49-50   |
| <b>Tillering and stem elongation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-65 DAS</b>           | <b>52-54</b> | 52-54 (Hoeing, mulching, Supplemental irrigation)          | 52-54 (Hoeing, mulching, Supplemental irrigation)          | 52-54 (Hoeing, mulching, Supplemental)                      |
| Plant protection spray   | 40 DAS                     | 52           | 52   | 52   | 52  |
| <b>Flowering and miking stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>           | <b>80-100DAS</b>           | 6-7          | 6-7  | 6-7  | 6-7   |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>                  | <b>115-120 DAS</b>         | <b>8-9</b>   | 8-9 Use conserved monsoon water for protective irrigation) | 8-9 (Use conserved water for protective irrigation)        | 8-9 (Use conserved monsoon water for protective irrigation) |
| Maturity/Harvesting  | 125-130 DAS                | 10-12        | 10-12  | 10-12  | 10-12   |
| Varieties: NIDW-1415(Netrawati), Phule Samadhan(rust resistant), NIDW-15(panchawati), NIDW-917(tapowan),Niphad-34. |                            |              | Diseases: Rust.  |  |   |
| Spacing: 25×30 cm (5to 6 cm depth)Seed rate: 100kg/ha  |                            |              | Production: 12-14(rainfed) Qtl/ha.                         |  |   |
| Fertilizer dose: 120:60:40 Kg NPK/ha   |                            |              |  |  |   |

Table 4.62 Continue...

| Crop Wheat   |                         |              |   |  |   |
|--|-------------------------|--------------|---|--|---|
| Package of Practices   | Days After Sowing(DAS)  | MW           | Tehsils   |  |   |
|  |                         |              | Nandgaon  | Malegaon   | Nashik  |
| Ploughing& land preparation  | 2-3 Weeks before sowing | 41-42        | 41-42   | 41-42  | 41-42   |
| <b>Sowing (with seed cum fert seed drill)</b>  | <b>1 Nov - 10 Nov</b>   | <b>44-45</b> | 45  | 45   | 45  |
| Fertilizer application   | At the time of sowing   | 45           | 45  | 45   | 45  |
| Pre emergence spraying of herbicide  | 1-2 DAS                 | 45           | 45  | 45   | 45  |
| Thinning 1 <sup>st</sup>   | 10 DAS                  | 47           | 47  | 47   | 47  |
| Hoeing & Weeding 1 <sup>st</sup>   | 15 DAS                  | 48           | 48  | 48   | 48  |
| <b>Crown root initiation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>         | <b>18 -21 DAS</b>       | <b>48-49</b> | 48-49 (Hoeing mulching, straw application)                  | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover) | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover)  |
| Thinning 2 <sup>nd</sup>   | 20 DAS                  | 48-49        | 48-49   | 48-49  | 48-49   |
| Hoeing & Weeding 2 <sup>nd</sup>   | 25-30 DAS               | 49           | 49  | 49   | 49  |
| fertilizer application (Half N)  | 25-30 DAS               | 49-50        | 49-50   | 49-50  | 49-50   |
| <b>Tillering and stem elongation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-65 DAS</b>        | <b>52-54</b> | 52-54(Hoeing, mulching, Supplemental irrigation)            | 52-54 (Hoeing, mulching, Supplemental irrigation)          | 52-54 (Hoeing, mulching, Supplemental irrigation)           |
| Plant protection spray   | 40 DAS                  | 52           | 52  | 52   | 52  |
| <b>Flowering and miking stage</b>  | <b>80-100DAS</b>        | 6-7          | 6-7   | 6-7  | 6-7   |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>                  | <b>115-120 DAS</b>      | <b>8-9</b>   | 8-9 (Use conserved monsoon water for protective irrigation) | 8-9(Use conserved monsoon water for protective irrigation) | 8-9 (Use conserved monsoon water for protective irrigation) |
| Maturity/Harvesting  | 125-130 DAS             | 10-12        | 10-12   | 10-12  | 10-12   |
| Varieties: NIDW-1415(Netrawati), Phule Samadhan(rust resistant), NIDW-15(panchawati), NIDW-917(tapowan),Niphad-34. |                         |              | Diseases: Rust.   |  |   |
| Spacing: 25×30 cm (5to 6 cm depth)Seed rate: 100kg/ha  |                         |              | Production: 12-14(rainfed) Qtl/ha.                          |  |   |
| Fertilizer dose: 120:60:40 Kg NPK/ha   |                         |              |   |  |   |

Table 4.62 Continue...

| Crop Wheat   |                         |              |  |  |  |
|--|-------------------------|--------------|--|--|--|
| Package of Practices   | Days After Sowing(DAS)  | MW           | Tehsils  |  |  |
|  |                         |              | Niphad   | Sinnar   | Yeola  |
| Ploughing& land preparation  | 2-3 Weeks before sowing | 41-42        | 41-42  | 41-42  | 41-42  |
| <b>Sowing (with seed cum fert seed)</b>  | <b>1 Nov - 10 Nov</b>   | <b>44-45</b> | 45   | 45   | 45   |
| Fertilizer application   | At the time of sowing   | 45           | 45   | 45   | 45   |
| Pre emergence spraying of herbicide  | 1-2 DAS                 | 45           | 45   | 45   | 45   |
| Thinning 1 <sup>st</sup>   | 10 DAS                  | 47           | 47   | 47   | 47   |
| Hoeing & Weeding 1 <sup>st</sup>   | 15 DAS                  | 48           | 48   | 48   | 48   |
| <b>Crown root initiation stage<br/>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>         | <b>18 -21 DAS</b>       | <b>48-49</b> | 48-49 (Hoeing mulching, straw application)         | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover) | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover) |
| Thinning 2 <sup>nd</sup>   | 20 DAS                  | 48-49        | 48-49  | 48-49  | 48-49  |
| Hoeing & Weeding 2 <sup>nd</sup>   | 25-30 DAS               | 49           | 49   | 49   | 49   |
| fertilizer application (Half N)  | 25-30 DAS               | 49-50        | 49-50  | 49-50  | 49-50  |
| <b>Tillering and stem elongation stage<br/>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-65 DAS</b>        | <b>52-54</b> | 52-54 (Hoeing, mulching, Supplemental              | 52-54 (Hoeing, mulching, Supplemental                      | 52-54 (Hoeing, mulching, Supplemental irrigation)          |
| Plant protection spray   | 40 DAS                  | 52           | 52   | 52   | 52   |
| <b>Flowering and miking stage(Protective irrigation-If</b>   | <b>80-100DAS</b>        | 6-7          | 6-7  | 6-7  | 6-7  |
| <b>Grain filling stage(Protective irrigation-If Probability of P(D) and</b>  | <b>115-120 DAS</b>      | <b>8-9</b>   | 8-9 (Use conserved monsoon water                   | 8-9(Use conserved monsoon water                            | 8-9 (Use conserved monsoon water                           |
| Maturity/Harvesting  | 125-130 DAS             | 10-12        | 10-12  | 10-12  | 10-12  |
| Varieties: NIDW-1415(Netrawati), Phule Samadhan(rust resistant), NIDW-15(panchawati), NIDW-917(tapowan),Niphad-34.     |                         |              | Diseases: Rust. Pest: stem borer,Chenopodium album |  |  |
| Spacing: 25×30 cm (5to 6 cm depth)Seed rate: 100kg/ha<br>Fertilizer dose: 120:60:40 Kg NPK/ha                          |                         |              | Production: 12-14(rainfed) Qtl/ha.                 |  |  |

| Table 4.62 Continue...  |                         |              |  |  |  |
|---|-------------------------|--------------|--|--|--|
| Crop Wheat  |                         |              |  |  |  |
| Package of Practices  | Days After Sowing(DAS)  | MW           | Tehsils  |  |  |
|   |                         |              | Baglan   | Devla  | Dindori  |
| Ploughing& land preparation   | 2-3 Weeks before sowing | 41-42        | 41-42  | 41-42  | 41-42  |
| <b>Sowing (with seed cum fert seed drill)</b>   | <b>1 Nov - 10 Nov</b>   | <b>44-45</b> | 45   | 45   | 45   |
| Fertilizer application  | At the time of sowing   | 45           | 45   | 45   | 45   |
| Pre emergence spraying of herbicide   | 1-2 DAS                 | 45           | 45   | 45   | 45   |
| Thinning 1 <sup>st</sup>  | 10 DAS                  | 47           | 47   | 47   | 47   |
| Hoeing & Weeding 1 <sup>st</sup>  | 15 DAS                  | 48           | 48   | 48   | 48   |
| <b>Crown root initiation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>          | <b>18 -21 DAS</b>       | <b>48-49</b> | 48-49 (Hoeing mulching, straw application)         | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover) | 48-49 (Hoeing, Mulching, broad bed furrows, residue cover) |
| Thinning 2 <sup>nd</sup>  | 20 DAS                  | 48-49        | 48-49  | 48-49  | 48-49  |
| Hoeing & Weeding 2 <sup>nd</sup>  | 25-30 DAS               | 49           | 49   | 49   | 49   |
| fertilizer application (Half N)   | 25-30 DAS               | 49-50        | 49-50  | 49-50  | 49-50  |
| <b>Tillering and stem elongation stage (Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>  | <b>40-65 DAS</b>        | <b>52-54</b> | 52-54 (Hoeing, mulching, Supplemental irrigation)  | 52-54 (Hoeing, mulching, Supplemental irrigation)          | 52-54 (Hoeing, mulching, Supplemental irrigation)          |
| Plant protection spray  | 40 DAS                  | 52           | 52   | 52   | 52   |
| <b>Flowering and miking stage</b>   | <b>80-100DAS</b>        | 6-7          | 6-7  | 6-7  | 6-7  |
| <b>Grain filling stage</b>  | <b>115-120 DAS</b>      | <b>8-9</b>   | 8-9 Use conserved water for protective irrigation) | 8-9 (Use conserved water for protective irrigation)        | 8-9 (Use conserved water for protective irrigation)        |
| Maturity/Harvesting   | 125-130 DAS             | 10-12        | 10-12  | 10-12  | 10-12  |
| Varieties: NIDW-1415(Netrawati), Phule Samadhan(rust resistant), NIDW-15(panchawati), NIDW-917(tanowan), Ninhad-34. |                         |              | Diseases: Rust.                                    |  |  |
| Spacing: 25×30 cm (5to 6 cm depth)Seed rate: 100kg/ha   |                         |              | Production: 12-14(rainfed) Qtl/ha.                 |  |  |
| Fertilizer dose: 120:60:40 Kg NPK/ha  |                         |              |  |  |  |

| <b>Table 4.62 Continue...</b>  |                               |              |   |  |   |
|--|-------------------------------|--------------|---|--|---|
| <b>Crop Wheat</b>  |                               |              |   |  |   |
| <b>Package of Practices</b>  | <b>Days After Sowing(DAS)</b> | <b>MW</b>    | <b>Tehsils</b>                                      |  |   |
|  |                               |              | <b>Nandgaon</b>                                     | <b>Malegaon</b>                                    | <b>Nashik</b>                                       |
| Ploughing& land preparation  | 2-3 Weeks before              | 41-42        | 41-42   | 41-42  | 41-42   |
| <b>Sowing (with seed cum fert seed)</b>  | <b>1 Nov - 10 Nov</b>         | <b>44-45</b> | 45  | 45   | 45  |
| Fertilizer application   | At the time of sowing         | 45           | 45  | 45   | 45  |
| Pre emergence spraying of herbicide  | 1-2 DAS                       | 45           | 45  | 45   | 45  |
| Thinning 1 <sup>st</sup>   | 10 DAS                        | 47           | 47  | 47   | 47  |
| Hoeing & Weeding 1 <sup>st</sup>   | 15 DAS                        | 48           | 48  | 48   | 48  |
| <b>Crown root initiation stage<br/>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>         | <b>18 -21 DAS</b>             | <b>48-49</b> | 48-49 (Hoeing straw application)                    | 48-49 (Hoeing, broad bed furrows, residue cover)   | 48-49 (Hoeing, broad bed furrows, residue cover)    |
| Thinning 2 <sup>nd</sup>   | 20 DAS                        | 48-49        | 48-49   | 48-49  | 48-49   |
| Hoeing & Weeding 2 <sup>nd</sup>   | 25-30 DAS                     | 49           | 49  | 49   | 49  |
| fertilizer application (Half N)  | 25-30 DAS                     | 49-50        | 49-50   | 49-50  | 49-50   |
| <b>Tillering and stem elongation stage<br/>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-65 DAS</b>              | <b>52-54</b> | 52-54(Hoeing, Supplemental irrigation)              | 52-54 (Hoeing, Supplemental irrigation)            | 52-54 (Hoeing, Supplemental irrigation)             |
| Plant protection spray   | 40 DAS                        | 52           | 52  | 52   | 52  |
| <b>Flowering and miking</b>  | <b>80-100DAS</b>              | 6-7          | 6-7   | 6-7  | 6-7   |
| <b>Grain filling stage</b>   | <b>115-120 DAS</b>            | <b>8-9</b>   | 8-9 (Use conserved water for protective irrigation) | 8-9(Use conserved water for protective irrigation) | 8-9 (Use conserved water for protective irrigation) |
| Maturity/Harvesting  | 125-130 DAS                   | 10-12        | 10-12   | 10-12  | 10-12   |
| Varieties: NIDW-1415(Netrawati), Phule Samadhan(rust resistant), NIDW-15(nanchawati) NIDW-917(tanowan) Ninhad-34       |                               |              | Diseases: Rust.                                     |  |   |
| Spacing: 25×30 cm (5to 6 cm depth)Seed rate: 100kg/ha  |                               |              | Production: 12-14(rainfed) Qtl/ha.                  |  |   |
| Fertilizer dose: 120:60:40 Kg NPK/ha   |                               |              |   |  |   |

Table 4.62 Continue...

| Crop Wheat   |                        |              |  |   |   |
|--|------------------------|--------------|--|---|---|
| Package of Practices   | Days After Sowing(DAS) | MW           | Tehsils                                    |   |   |
|  |                        |              | Peth                                       | Surgana   | Trimbakeshwar   |
| Ploughing& land preparation  | 2-3 Weeks before       | 41-42        | 41-42                                      | 41-42   | 41-42   |
| <b>Sowing (with seed cum fert seed)</b>  | <b>1 Nov - 10 Nov</b>  | <b>44-45</b> | 45   | 45  | 45  |
| Fertilizer application   | At the time of sowing  | 45           | 45   | 45  | 45  |
| Pre emergence spraying of herbicide  | 1-2 DAS                | 45           | 45   | 45  | 45  |
| Thinning 1 <sup>st</sup>   | 10 DAS                 | 47           | 47   | 47  | 47  |
| Hoeing & Weeding 1 <sup>st</sup>   | 15 DAS                 | 48           | 48   | 48  | 48  |
| <b>Crown root initiation stage<br/>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b>         | <b>18 -21 DAS</b>      | <b>48-49</b> | 48-49 (Hoeing mulching, straw application) | 48-49 (Hoeing, Mulching, broad bed furrows residue cover) | 48-49 (Hoeing, Mulching, broad bed furrows residue cover) |
| Thinning 2 <sup>nd</sup>   | 20 DAS                 | 48-49        | 48-49                                      | 48-49   | 48-49   |
| Hoeing & Weeding 2 <sup>nd</sup>   | 25-30 DAS              | 49           | 49   | 49  | 49  |
| fertilizer application (Half N)  | 25-30 DAS              | 49-50        | 49-50                                      | 49-50   | 49-50   |
| <b>Tillering and stem elongation stage<br/>(Protective irrigation-If Probability of P(D) and P(D/D) more than 50%)</b> | <b>40-65 DAS</b>       | <b>52-54</b> | 52-54 (Hoeing, mulching, Supplemental      | 52-54 (Hoeing, mulching, Supplemental                     | 52-54 (Hoeing, mulching, Supplemental                     |
| Plant protection spray   | 40 DAS                 | 52           | 52   | 52  | 52  |
| <b>Flowering and miking stage(</b>   | <b>80-100DAS</b>       | 6-7          | 6-7  | 6-7   | 6-7   |
| <b>Grain filling stage</b>   | <b>115-120 DAS</b>     | <b>8-9</b>   | 8-9 (Use conserved water for protective    | 8-9(Use conserved water for protective                    | 8-9 (Use conserved water for protective                   |
| Maturity/Harvesting  | 125-130 DAS            | 10-12        | 10-12                                      | 10-12   | 10-12   |
| Varieties: NIDW-1415(Netrawati), Phule Samadhan(rust resistant), NIDW-15(panchawati), NIDW-917(tapowan),Niphad-34.     |                        |              | Diseases: Rust.                            |   |   |
| Spacing: 25×30 cm (5to 6 cm depth)Seed rate: 100kg/ha  |                        |              | Production: 12-14(rainfed) Qtl/ha.         |   |   |
| Fertilizer dose: 120:60:40 Kg NPK/ha   |                        |              |  |   |   |

## 5. SUMMARY AND CONCLUSIONS

### 5.1. Summary

The present study entitled 'Assessment of Drought in the Nashik district using Standardized Precipitation Index (SPI)' is undertaken to determine annual drought, extreme events and variation through Standardized Precipitation Index (SPI) and Precipitation Deciles (PD). Determination of Onset and withdrawal of monsoon based on forward and backward accumulation method as per the procedure suggested by Babu and Lakshminarayana (1997), Dry and wet weeks probabilities by using Markov chain model for suggesting tehsilwise crop planning and management based on rainfall analysis. The summary of results obtained by analyzing long term daily rainfall data of different tehsils in Nashik district are given below.

The long term daily rainfall data of 59 years (for some tehsils 22 years) were used to compute annual and monthly rainfall and rainy days of fifteen tehsils of Nashik district. The statistical parameters *viz.*, mean, standard deviation, coefficient of variation, meteorological drought, extreme events and initial, conditional and consecutive probabilities of dry and wet week were estimated from the Weather Cock, computerized programme developed by CRIDA, Hyderabad.

#### 5.1.1 Rainfall analysis:

The Nashik district is having 1066.80 mm mean average annual rainfall. It was varied from 522.6 mm at Deola with 29.91 per cent variation to 2991.58 mm at Igatpuri with 26.79 per cent variation. The average annual rainfall of Nashik district was received in 50 mean rainy days with the highest (112) rainy days during 1963 at Igatpuri tehsil with 14.56 per cent variation and the lowest (9) rainy days during 1972 at Nandgaon tehsil with 27.32 per cent variation.

According to study, mean average annual rainfall of Nashik district was 1066.80 mm in which July month contributes highest amount of mean rainfall 328.9 mm with 48.86 per cent variation. Followed by August, June, September, October, November, May, December, April, March, February and lowest amount of mean rainfall in the month of January 0.75 mm with 475.8 per cent variation.

The average mean annual rainy days of Nashik district was 50 days in which July month contributes the highest amount of mean rainy days (13.8 days) with 32.7 per cent variation followed by August, September, June, October, November, May, December, April, March, February and lowest amount of mean rainy days in the month of January 0.064 day with 420.9 per cent variation.

#### 5.1.2 Standardized Precipitation Index (SPI):

In this study meteorological drought was analyzed by using Standardized Precipitation Index (SPI). Any drought including meteorological and agriculture is a result of deficient rainfall. The SPI

has been used widely to quantify the deficit of precipitation. It could be computed at different time scales from less than 1 month to 48 months or more. The 59 (1961-2019) years of rainfall data of all stations except Deola, Chandwad, Nashik, Yevla {22 years (1998-2019)} is used for determination of Standardized Precipitation Index. Meteorological drought for various stations of Nashik district is assessed for 12 month's timescales (SPI 12). The negative value of SPI indicated drought (dry) condition and positive value indicated wet condition.

Baglan station have 9 wet years, 39 near normal years and remaining 11 years shows dry or extreme drought condition. which includes 8 moderately dry (-1 to -1.49) years, 2 severely dry years and 1 extreme dry year for 59 years. Chandwad station have 3 wet years, 16 near normal years and remaining 3 years shows dry or extreme drought years which include 3 moderately dry year, 0 severely dry years and 0 extreme dry year from 22 years of observed data. Similarly, Deola station have 4 wet years, 14 near normal years and remaining 4 years shows dry or extreme drought condition (2 moderately dry years, 2 severely dry year and 0 extreme dry year) for 22 years. Dindori station have 12 wet years, 40 near normal years and remaining 7 years shows dry or extreme drought condition (2 moderately dry years. 3 severely dry year and 2 extreme dry years). Igatpuri station have 10 wet years, 39 near normal years and remaining 10 years shows dry or extreme drought condition (6 moderately dry years, 2 severely dry year and 2 extreme dry year).

Kalwan station have 8 wet years, 46 near normal years and remaining 5 years shows dry or extreme drought condition (3 moderately dry years, 2 severely dry years and 0 extreme dry year) for 59 years. Malegaon station have 11 wet years, 40 near normal years and remaining 8 years shows dry or extreme drought condition (3 moderately dry years, 3 severely dry years and 2 extreme dry year). Nandgaon station have 9 wet years, 40 near normal years and remaining 10 years shows dry or extreme drought condition (5 moderately dry year, 3 severely dry and 2 extreme dry year). Nashik station have 5 wet years, 12 near normal years and remaining 5 years shows dry or extreme drought condition (3 moderately dry years, 2 severely dry year and 0 extreme dry year) for 22 years. Niphad station have 9 wet years, 45 near normal years and remaining 5 years shows dry or extreme drought condition (1 moderately dry years, 3 severely dry year and 1 extreme dry year) for 59 years. Peth station have 8 wet years, 42 near normal years and remaining 9 years shows dry or extreme drought condition (5 moderately dry years, 1 severely dry year, 3 extremely dry years). Sinnar station have 8 wet years, 42 near normal years and remaining 9 years shows dry or extreme drought condition (5 moderately dry years, 2 severely dry year, 2 extreme dry year). Surgana station have 9 wet years, 41 near normal years and remaining 9 years shows dry or extreme drought condition (5 moderately dry years, 3 severely dry year, 1 extreme dry year). Trimbakeshwar station have 8 wet years, 44 near normal years and remaining 7 years shows dry or extreme drought condition (4

moderately dry years,1 severely dry year,2 extreme dry year) for 59 years. Yevla station have 4 wet years, 14 near normal years and remaining 4 years shows dry or extreme drought condition(2 moderately dry years,2 severely dry year,0 extreme dry year) for 22 years.

Comparison of the changes trend and the frequency of droughts in selected stations showed that in decade the two or three wet years happen, two or three dry years happens and four or five normal years happens. But it was observed that in Kalwan, Nandgaon and Peth tehsils during the last two decade period (2001-2010, 2011-2019) the frequency of drought increased severely. In all other tehsils of Nashik district, the 2001-2010 decade showed near normal condition for maximum times with one or two moderately dry condition year and/or one extreme year. The 2011-2019 decade showed frequent rise number of drought years for all stations except Dindori. This indicated that that a SPI value becomes more negative with increase in time scales in recent times. This is due to the non-uniform, irregular and erratic pattern of rainfall which may have had adverse impact on the cropping system.

### **5.1.3 Precipitation deciles (PD):**

In this study Precipitation decile (PD), one of the simplest meteorological drought indices was also used for drought assessment. DrinC (Drought Indices Calculator) is a software package used for the calculation of drought indices like precipitation deciles. Decile is a meteorological drought measurement tool which uses rainfall. In this study deciles 1-2 and deciles 3-4 were considered as drought event. The advantage of the method of deciles is its computational ease, but its simplicity can lead to conceptual difficulties. The precipitation deciles for different tehsils of Nashik district is calculated from the long term historical rainfall data of 59 years (1961-2019) of all tehasils except Deola & Nashik, Yeola{22 years (1998-2019)} and Chandwad (42 years 1978-2019).

In Baglan, It was observed that there were 24 drought events in the period of 1961-2019 where much below normal (Deciles 1-2) condition was observed for 12 years (1970,1971,1982,1985,1987,1994,1998,2000,2001,2012,2015,2018) and much above normal (Deciles 9-10) condition was observed for 12 years (1963,1976,1977,1983,1988,1990,1991,1993,1997,2006,2007,2019). Similarly for Dindori, Igatpuri, Kalwan, Malegaon, Nandgaon, Niphad, Peth ,Sinnar, Surgana and Trimbakeshwar tehsils 24 drought events were observed during the period of 1961-2019. Whereas, in the Deola, Nashik & Yevla tehsils 09 drought events were observed during the period of 1998-2019. While in Chandwad 13 drought events were observed during the period of 1978-2019. In case of Deola, Kalwan, Igatpuri, Nandgaon, Malegaon, Peth, Yeola tehasils, it was observed that the frequency of the drought event was increased during the last decade (2011-2019) as compared to previous decades.

Whereas in remaining tehsils the frequency of the drought event was increased in the last two decade (2001-2010, 2011-2019) as compared to previous decades.while in Dindori and Niphad Freuency of wet years increased in last two decades. In all other tehsils of Nashik district frequency of drought events was increased in recent decade which may become very severe in the upcoming decade. As severity of drought is more in recent decade, more efforts are needed for in situ moisture conservation.

#### **5.1.4 Onset and withdrawal of monsoon season:**

The onset and withdrawal of rainy season was computed from mean weekly rainfall data by forward and backward accumulation methods as per the procedure suggested by Babu and Lakshminarayana (1997). By considering prevailing rainfall condition of selected area, 70 millimeter of rainfall accumulation has been considered as the onset time and 20 millimeter rainfall accumulation has been considered as the withdrawal time. For all tehsils of Nashik district 70 mm rainfall accumulation has been considered for deciding the onset of monsoon. Whereas, 20 mm of rainfall accumulation was chosen for the end of rainy season, which is sufficient for ploughing of fields after harvesting the crops.

From the analysis of 59 years (1961 – 2019) weekly rainfall data, it was observed that the mean week of onset of monsoon was 26 standard meteorological week (MW) (*i.e.*, 25 June – 1<sup>st</sup> July) for all tehasils of Nashik district except Dindori, Nashik, Peth, Surgana, Trimbakeshwar tehsil where mean onset was 25 standard meteorological week (MW) (*i.e.*, 18<sup>th</sup> June – 24<sup>th</sup> June)and 24 for Igatpuri. The earliest week of onset of rainy season was 23 MW (4<sup>th</sup> June – 10<sup>th</sup> June) for whole Nashik district except Dindori on 22 MW(28<sup>th</sup> May-3<sup>rd</sup> June) and delayed week of onset of rainy season was 28 (9 July-15 July) MW for Igatpuri, 29 MW(16 July-22July) for Peth,Surgana,Trimbakeshwar, 30<sup>th</sup> MW (23<sup>rd</sup> – 29<sup>th</sup>July)for Dindori and Nashik,31 MW(30<sup>th</sup> July-5<sup>th</sup> August) for chandwad and Kalwan, 32<sup>nd</sup>(6<sup>th</sup> August-12<sup>th</sup> August)for Baglan,Deol aand Yeola,33 MW(13<sup>th</sup> August-19<sup>th</sup> August) for Sinnar ,34<sup>th</sup> MW(20<sup>th</sup> August-26<sup>th</sup> August) for Malegaon and Nandgaon, 38 MW(17<sup>th</sup> September-23<sup>rd</sup> September) for Niphad.

The mean week of withdrawal of monsoon was observed to be 42 MW (*i.e.*, 15<sup>th</sup> October– 21<sup>st</sup> October) for all tehsils except 43 MW(22 October-28 October)for Chandwad, Igatpuri, Nandgaon, Sinnar tehsils and 41 MW(8 October-14 October) for Trimbakeshwar. tehsil. The earliest week of withdrawal of rainy season was 33 MW(13<sup>th</sup> – 19<sup>th</sup> August) for Peth tehsil, 35 MW for Kalwan, Malegaon, Nandgaon. 36 for Chandwad, Deola, Dindori, Nashik, Sinnar, Surgana, Trimbakeshwar tehsils, 37 MW for Igatpuri, Niphad, Yevla tehsils and 38 MW for Baglan tehsil. The delayed week of withdrawal of rainy season for Nashik & Yevla tehsils (47 MW);Baglan

,Deola ,Kalwan ,Malegaon ,Trimbakeshwar tehsils (50<sup>th</sup>MW);Chandwad .Igatpuri, Peth tehsils (51<sup>st</sup> MW) and 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) for all remaining tehsils of Nashik district .

The mean length of rainy season was found to be 16 weeks (112 days) for Baglan, Deola, Kalwan, Malegaon, Niphad and Yevla, It was 19 weeks(133) for Igatpuri tehsil and 17 weeks(119) for remaining tehsils of Nashik district . which include rainfall of both south west and north east monsoon. Maximum mean length of rainy season was observed at Deola *i.e.*, 22 weeks (154 days) and at Nashik and Yevla *i.e.*, 23 weeks (161 days),Baglan and Malegaon *i.e* 24 weeks(168 days),Trimbakeshwar *i.e* 26 weeks(182 days),Chandwad,Kalwan,Nandgaon,Niphad *i.e.*27 weeks(189 days)and 28 weeks(196 days) for remaining tehsil of Nashik district. Minimum length of rainy season was observed at Niphad and Sinnar *i.e.*, 4 weeks (28 days) and Malegaon and Yevla *i.e.*, 6 weeks (42 days). Based on the onset and withdrawal of rainy season various operations can be performed on the field.

#### **5.1.5 Markov-chain initial, conditional and consecutive probabilities of dry and wet weeks:**

The initial, conditional and consecutive probability of dry and wet week at threshold limit 20 mm of rainfall during the crop growth period (MW 22 to 42) is calculated using ‘Weather Cock’ software. From this it was observed that Baglan tehsil has more probability of at least 20 mm rainfall in 27, 30 36 , 40 ,38 MWs. Similarly, chandwad tehsil has more probability of at least 20 mm rainfall in 27,29 -30,32 , 38 MWs, Deola tehsil in 30, 38 -40 MWs, Dindori in 25–33<sup>rd</sup> ,39 MWs, Igatpuri tehsil in 23<sup>rd</sup>–39 MWs, kalwan tehsil in 27 –30, 32 ,36 MWs, Malegaon tehsil in 30 MWs, Nandgaon tehsil in 36 MWs, Nashik tehsil 25–32, 38-39 MWs, Niphad tehsil in 27-32 MWs and Peth tehsil in24-37 , 39 MWs, Sinnar tehsil in 38 -39 MWs, Surgana tehsil in 24-39 MWs,Trimbakeshwar tehsil in 24-40 MWs andYevla tehsil has more probability of at least 20 mm rainfall in 27, 30,34 ,38 MWs. Hence there are more chances of water harvesting and moisture conservation during these weeks which can be utilize for critical growth stages of crops and for sowing of *kharif* and *rabi* crops.

#### **5.1.6 Contingency crop planning:**

Based on the analysis of rainfall, Standardized Precipitation Index (SPI), Precipitation Deciles (PD), Onset and withdrawal of rainy season, Initial and conditional probability and consecutive dry and wet weeks probability the suitable cropping pattern is suggested for effective utilization of soil moisture, nutrients with minimum loss of soil sustainable production, to find out optimum sowing window, hoeing operation and protective irrigation and to raise the economic condition of dryland farmers. MW 26 is considered as sowing week for Pearl millet, Maize, Rice and Finger Millet crop in most tehsils of Nashik District. While in *Rabi* season crops like Gram,

*Rabi* sorghum, wheat can be grown on conserved soil moisture & water in wet weeks of *kharip* season. Rice crop is suitable for tehsils of Peth, Surgana, Trimbakeshwar, Igatpuri as Mean rainfall is more than 1200mm in year. While for scarcity zone district like Nandgaon, Malegaon, Kalwan, Deola, Yevla pearl millet is most suitable *kharip* crop along with Maize.

## 5.2 Conclusions

The following conclusions were drawn based on the results of study at various tehsils as follows,

1. Study period revealed that the Nashik district has 1066.80 mm average annual rainfall and it received in 50 rainy days.
2. maximum monthly rainfall was observed in July month followed by August, June, September, October, November, May, December, April, March, February and lowest amount of mean rainfall in the month of January.
3. Drought analysis using Standardized Precipitation Index (SPI) in selected tehsils of Nashik district at 12 month's timescale showed that in each decade the two or three wet years happen, two or three dry years happens and four or five normal years happens. It was observed that the frequency of drought in Kalwan, Nandgaon and Peth tehsils during the last two decade (2001-2010, 2011-2019) was increased. Whereas, the 2011-2019 decade showed frequent rise in number of drought years in all other tehsils of Nashik district.
4. Drought analysis using Precipitation deciles (PD) showed that there were 24 drought events during the period of 1961-2019 for all tehsils of Nashik district except in the Deola, Nashik & Yevla tehsils 09 drought events were observed during the period of 1998-2019. While in Chandwad 13 drought events were observed during the period of 1978-2019.
5. Study revealed that in Nashik district, the mean week of onset of monsoon was 26 meteorological week (MW) (25<sup>th</sup> June – 1<sup>st</sup> July) for all tehsils of Nashik district except Dindori, Nashik, Peth, Surgana, Trimbakeshwar tehsil where mean onset was 25 meteorological week (MW) 18<sup>th</sup> June – 24<sup>th</sup> June) and 24 MW for Igatpuri.
6. The mean week of withdrawal of monsoon was observed to be 42 MW (15<sup>th</sup> October – 21<sup>th</sup> October). The earliest week of withdrawal of rainy season was 36 MW (10<sup>th</sup> – 16<sup>th</sup> September) observed in many tehsil whereas the delayed week of withdrawal of rainy season was 52 MW (24<sup>th</sup> – 31<sup>st</sup> December) for all tehsils of Nashik district except Nashik & Yevla tehsils (47 MW); Baglan, Deola, Kalwan, Malegaon, Trimbakeshwar tehsils (50MW); Chandwad, Igatpuri, Peth tehsils (51 MW).

7. The mean length of rainy season was found to be 17 weeks (119 days), Maximum mean length of rainy season was observed at Dindori, Igatpuri, Peth, Sinnar, Surgana *i.e.*, 28 weeks (196 days) and minimum length of rainy season was observed at Niphad & Sinnar *i.e.*, 7 weeks (28 days). Based on the onset and withdrawal of monsoon various farm operations can be performed in the field.
8. The Markov-chain probability analysis showed that probability of getting more wet weeks is observed in Baglan tehsil in 27, 30, 36, 40, 38 MWs. Similarly, Chandwad tehsil in 27, 29, 30, 32, 38 MWs, Deola tehsil in 30, 38, 40 MWs, Dindori in 25–33, 39 MWs, Igatpuri tehsil in 23–39 MWs, Kalwan tehsil in 27–30, 32, 36 MWs, Malegaon tehsil in 30 MWs, Nandgaon tehsil in 36 MWs, Nashik tehsil 25–32, 38–39 MWs, Niphad tehsil in 27–32 MWs and Peth tehsil in 24–37, 39 MWs, Sinnar tehsil in 38–39 MWs, Surgana tehsil in 24–39 MWs, Trimbakeshwar tehsil in 24–40 MWs and Yevla tehsil in 27, 30, 34, 38 MWs.
9. Based on the analysis of rainfall, Standardized Precipitation Index (SPI), Precipitation Deciles (PD), Onset and withdrawal of rainy season, Initial and conditional probability and consecutive dry and wet weeks probability the suitable cropping pattern is suggested for effective utilization of soil moisture, nutrients with minimum loss of soil sustainable production, to find out optimum sowing window, hoeing operation and protective irrigation and to raise the economic condition of dryland farmers..

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## APPENDIX- I

## Standard Meteorological Weeks

| <b>MW</b> | <b>Calendar Month</b> | <b>Date (From-To)</b> | <b>MW</b> | <b>Calendar Month</b> | <b>Date (From-To)</b> |
|-----------|-----------------------|-----------------------|-----------|-----------------------|-----------------------|
| 1         | January               | 01-07                 | 27        | July                  | 02-08                 |
| 2         | ”                     | 08-14                 | 28        | ”                     | 09-15                 |
| 3         | ”                     | 15-21                 | 29        | ”                     | 16-22                 |
| 4         | ”                     | 22-28                 | 30        | ”                     | 23-29                 |
| 5         | ”                     | 29-04                 | 31        | ”                     | 30-05 Aug.            |
| 6         | February              | 05-11 Feb             | 32        | August                | 06-12                 |
| 7         | ”                     | 12-18                 | 33        | ”                     | 13-19                 |
| 8         | ”                     | 19-25                 | 34        | ”                     | 20-26                 |
| 9*        | ”                     | 26-04 March           | 35        | ”                     | 27-02                 |
| 10        | March                 | 05-11                 | 36        | September             | 03-09 Sept.           |
| 11        | ”                     | 12-18                 | 37        | ”                     | 10-16                 |
| 12        | ”                     | 19-25                 | 38        | ”                     | 17-23                 |
| 13        | ”                     | 26-01 April           | 39        | ”                     | 24-30                 |
| 14        | April                 | 02-08                 | 40        | October               | 01-07                 |
| 15        | ”                     | 09-15                 | 41        | ”                     | 08-14                 |
| 16        | ”                     | 16-22                 | 42        | ”                     | 15-21                 |
| 17        | ”                     | 23-29                 | 43        | ”                     | 22-28                 |
| 18        | ”                     | 30-06 May             | 44        | ”                     | 29-04                 |
| 19        | May                   | 07-13                 | 45        | November              | 05-11 Nov.            |
| 20        | ”                     | 14-20                 | 46        | ”                     | 12-18                 |
| 21        | ”                     | 21-27                 | 47        | ”                     | 19-25                 |
| 22        | ”                     | 28-03 June            | 48        | ”                     | 26-02 Dec.            |
| 23        | June                  | 04-10                 | 49        | December              | 03-09                 |
| 24        | ”                     | 11-17                 | 50        | ”                     | 10-16                 |
| 25        | ”                     | 18-24                 | 51        | ”                     | 17-23                 |
| 26        | ”                     | 25-01 July            | 52**      | ”                     | 24-31                 |

## VITAE

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A candidate for the degree of

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