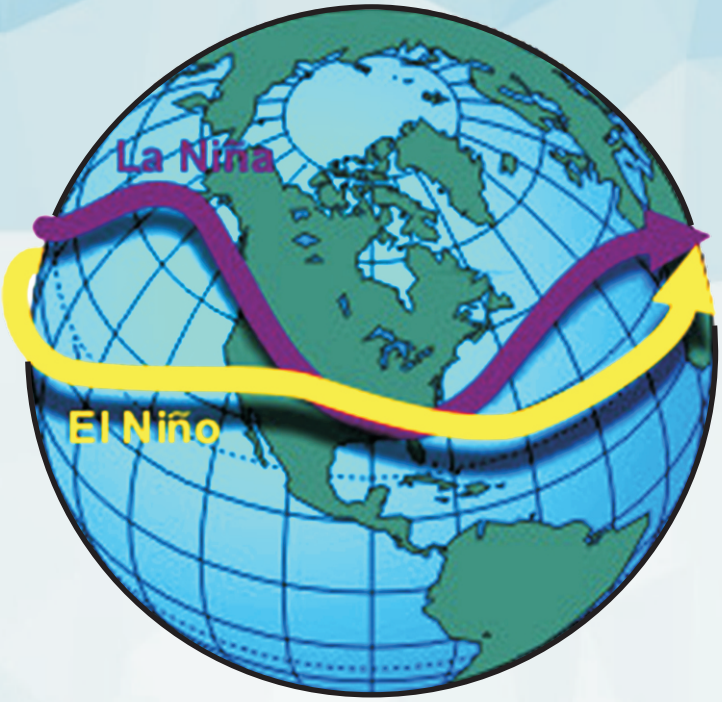
El Niño Effect on Climatic Variability and Crop Production : A Case Study for Maharashtra



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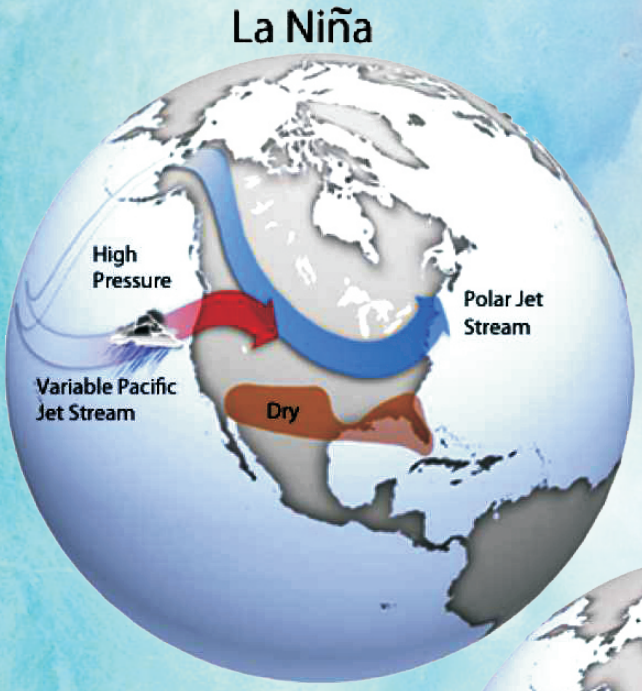

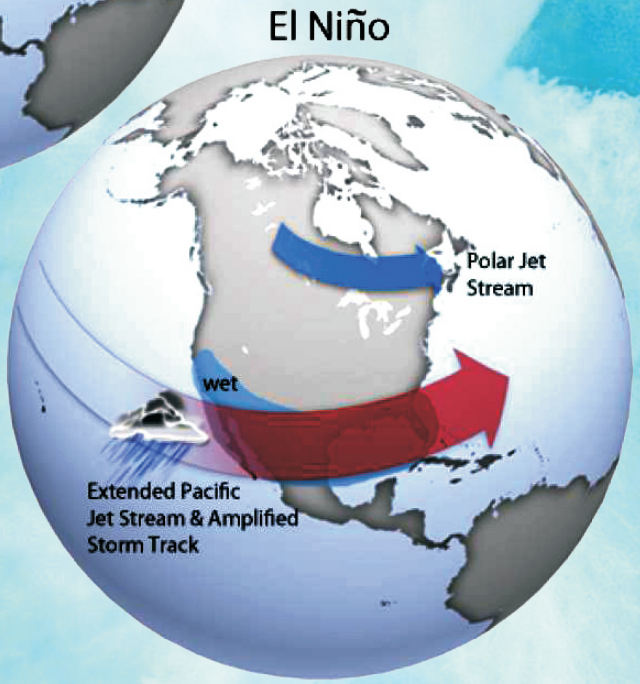

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PREFACE

The inter-annual variability of Indian monsoon rainfall has profound influence on agriculture and national economy. Occurrences of droughts and floods associated with the inter-annual variability of Indian monsoon affects the agriculture, water resources and even price rise. This inter-annual variability of Indian monsoon is largely affected by the occurrence of El Niño episodes. A strong El Niño can cause drought like conditions. The intra seasonal variability in crop yields is largely driven by the two parameters, rainfall and thermal regime in tropical dry land areas. The relative impact of these two parameters on crop productivity was not evaluated systematically. Therefore, a study was undertaken to assess the impact of varying rainfall and increasing seasonal temperature on the productivity of rainfed crop. Maharashtra receives rainfall mainly through SW monsoon which is likely to be affected by El Niño event and so the crop production. The relationship between El Niño and its associated influence on rainfall of Maharashtra and agricultural production has not been established so far.

The book "**El Nino Effect on Climatic Variability and Crop Production: A Case Study for Maharashtra**" brought out by AICRP on Agrometeorology, VNMKV, Parbhani, gains significance in this context. Even though this publication is not all-pervasive, the ideas put forth will help in furthering our research programmers to deal with fluctuations in weather and climate. Untimely and adverse weather conditions have taken their toll on the crop in recent years and identification of suitable management practices for such events is also indeed essential required. Another aspect which needs to be looked into study on weather based crop insurance. Scientists will need to look into various aspects to develop multiple methods and tools including a decision support system that would boost farmers' sustainability against the fluctuating weather.

The work on this aspect has been undertaken by the AICRP on Agrometeorology, VNMKV, Parbhani. The efforts of the team of All India Coordinated Research Project on Agrometeorology of VNMKV, Parbhani in bring out this bulletin on "El Nino Effect on Climatic Variability and Crop Production: A Case Study for Maharashtra" are really praise-worthy. I congratulate them and hope that this publication will be of immense use to scientists, farmers and planners.

Parbhani
26 January, 2019

(A.S.Dhawan)
Vice-Chancellor
VNMKV, Parbhani

FOREWORD

Rainfall is a major concern for agriculture in India, more so in Maharashtra where agriculture is mainly rainfed. The inter-annual variability of Indian monsoon rainfall has profound influence on agriculture and national economy. Indian agriculture is predominantly dependent on monsoon rainfall. About 75% of the country's annual rainfall is received in four months (June to September) which is critical to the *kharif* crop season. Any variation in rainfall therefore directly affects *kharif* crop performance. Studies indicate that the negative impacts of deficit rainfall are more pronounced than the positive impacts of excess rainfall during the *kharif* season. Substantial decrease in *kharif* crop yields is often associated with drought years. The methodology attempted to isolate the impact of variability in rainfall regime and increasing temperature individually and in combination provides an opportunity to identify the research and extension priorities required to deal with the problem of climatic variability and probable adaptation strategies.

The information on the anticipated fluctuations in monsoon rainfall and resultant agricultural production prior to the start of growing season has wider implications on decision making at the farm. In this context, the first step is to analyze and document the El Nino episode of different districts of the Maharashtra state which will then enable for scientific crop planning and risk mitigation. I am happy to note that the AICRP an Agrometeorology, VNMKV, Parbhani prepared the technical bulletin "**El Nino Effect on Climatic Variability and Crop Production : A Case Study for Maharashtra**". The bulletin provide districtwise and divisionwise rainfall and crop production data of different category wise El Nino years as well as normal years. I am sure this publication will serve as a reference guide to different Agrometeorologist, Agronomist, extension personnel and industry and all other Stakeholders. I congratulate the authors for their efforts in bringing out this document.

Parbhani
26 January, 2019

(D.P.Waskar)
Director of Research
VNMKV,Parbhani

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Summary

Rainfall is a seasonal phenomenon in tropical monsoonal climates and occurs in spells. The start and end of the rainy season, frequency, rainfall amount, rainfall intensity and duration of wet spells and duration and severity of intervening (between two rain spells) dry spells are characterized by large spatial and temporal variations. Climatology and variability of the parameters of the rainy season and the wet and dry spells are valuable information for scientists, engineers, planners and managers working in water-related sectors (agriculture, ecology, hydrology and water resources). Determination of year-wise starting and ending dates of the rainy season and identification of wet and dry spells during the season is important. In this study, we attempted to demarcation of the start and end of the rainy season, and identification of wet/dry spells. Understanding climatic and hydro climatic features of wet and dry spell is essential for effective agricultural and hydrological operations. In the face of global climate wet and dry spells assumed greater importance for increasing agricultural production.

Therefore, an attempt has been made to examine the effect of El Niño for

- Identifying changes in seasonal rainfall as well as annual rainfall in different
  districts of Maharashtra.
- Quantifying the changes in monthly, seasonal and annual temperature of Maharashtra state.
- Assessing the changes in crop production as well as productivity of
  some of the crops rice, *Kharif* sorghum, cotton, pigeon pea, black gram and Green gram
- Suggesting the possible strategies to enhance agricultural production in the event of adverse climate situations.

The study brought out some of the interesting findings as detailed below

The average southwest monsoon rainfall received during the years with El Niño was found to be less compared to normal years and the average rainfall during the post monsoon is higher in Aurangabad division. In general, it was observed that either the southwest monsoon rainfall or the annual rainfall will be less during the years with El Niño.

Average annual rainfall during years with El Niño was not only higher but also had more likelihood of getting above average rains during subsequent year. Rainfall during the year was higher in 3 out of 34 selected districts of the state.

Influence of El Niño episodes on agricultural productivity of different crops of Maharashtra state when analyzed has indicated that paddy was highly influenced by El Niño episodes. The impact was more pronounced in Pune, Latur and Amravati division probably due to more area being under upland cultivation. In majority of the districts, paddy productivity declined during strong El Niño years. *Kharif* sorghum productivity appears to be more sensitive to El Niño in division like Aurangabad, Latur and Amravati. Soybean production and productivity in Aurangabad, Latur, Amravati and Nagpur division were more sensitive compared to other division. soybean productivity during strong El Niño years were more influenced compared to weak and moderate years. Among the different categories of El Niño, strong events exerted more negative impact on cotton yields all the districts in Maharashtra state. Strong El Niño events influenced pigeon pea productivity in Latur division. Black gram production declined by about 43.8% in the El Niño years compared to normal years. Productivity of green gram was largely influenced by strong El Niño events.

Therefore, there is need to enhance the agricultural production and productivity during the years with El Niño and the possible strategies are as follows:

As the southwest monsoon rainfall is likely to be less and the post monsoon is likely to be more than normal in Jalgaon, Akola, wasim, wardha and chandrapur districts and most of districts in Pune and Aurangabad division inter cropping systems with long duration base crop and short duration intercrop can be adopted in traditional rainfed mono-cropping areas.

The authors consider that the study may not be very exhaustive and is only intended to enlighten the utility of using signals like El Niño as a possible option to understand climate variability and use it for taking strategic decisions for enhancing agricultural production during the seasons with adverse climate to a certain extent.

CHAPTER-1

INTRODUCTION

India accounts for about 20% of the world population and (still) about 50% of the Indian workforce is employed in the agricultural sector (Cagliarini & Rush 2011). Agriculture is the main source of livelihood for more than 58% of the population of this country. In Indian Scenario, agriculture is contributing 17% of national growth domestic product (GDP) (World Bank 2016), Agriculture provides bulk of wage goods required by non-agricultural sectors and most of the raw materials for industrial sector. Maharashtra is predominately an agricultural state, where agriculture is the main source of income as well as employment which provides direct employment to about 64.14% of the total population. About 18-20% area is irrigated and rest is rainfed (Anonymous, 2016). The major crops grown in the state are *Kharif* sorghum, cotton, black gram, green gram, pigeon pea and rice. Konkan division, Kolhapur division and to some extent the Nagpur division are the major producers of the rice, while *Kharif* sorghum is mostly cultivated in Marathwada region (Anonymous, 2016).

Maharashtra occupies the western and central parts of the country and has a long coastline stretching nearly 720 kilometers along the Arabian Sea. The Sahyadri mountain ranges provide a physical barrier to the State on the west, while the Satpuda hills along the north and Bhamragad-Chiroli-Gaikhuri ranges on the east serve as it's natural borders. The State is surrounded by Gujarat to the northwest, Madhya Pradesh to the north, Chhattisgarh to the east, Andhra Pradesh to the southeast, Karnataka to the south and Goa to the southwest. Maharashtra State has a geographical area of 3,07,713 sq. km and it extends from latitude 15° 40' N to 22° 00' N and Longitudes 72°30' E to 80° 30' E .

The State enjoys tropical monsoon climate.The hot scorching summer from March onwards is followed by monsoon in early June. The rich green cover of the

monsoon season persists during the mild winter that follows through an unpleasant October transition. The Western Ghats hill ranges run north to south separating the coastal districts of Thane, Mumbai, Raigad, Ratnagiri and Sindhudurg from rest of the State. The average height of these ranges is about 1000 m AMSL and form an important climatic divide. **Maharashtra** has a tropical, climate with hot, rainy and cold weather seasons. March to May is the summer season followed by rainy season from June to September. The post monsoon season is October and November. December to February is the winter season. The state has humid to per humid climatic type in Konkan and Western ghats, semi arid type in central and western Maharashtra and sub humid type in the eastern part of the state. The maximum and minimum temperature varies between 27 °C and 40 °C and 14 °C and 27 °C respectively. The maximum summer temperature varies between 36°C and 41°C and during winter the temperature fluctuates between 10°C and 16°C. Rainfall starts in the first week of June and July is the wettest month. Rainfall in Maharashtra differs from region to region. The State experiences extremes of rainfall ranging from 6000 mm over the western Ghats to less than 500 mm in the rain shadow semi arid areas of western and central Maharashtra. The Konkan sub-division comprising of coastal districts and Western Ghats receive the heaviest rains, the Ghats receive more than 6000 mm and the plains 2500 mm. Rainfall decreases rapidly towards eastern slopes and plateau areas where it is minimum (less than 500 mm). It again increases towards east *i.e.* in the direction of Marathwada and Vidarbha and attains a second maximum of 1500 mm in the eastern parts of Vidarbha. Thus, the Cetral Maharashtra sub-division is the region of the lowest rainfall in the State. (Dakhore *et al*, 2017).

The unpredictable rainfall and scarcity of rain in many areas of Maharashtra continues to be a hurdle in the agricultural development in the state.

Many measures have been adopted to fight the menace of deficit in food production such as hybrid seed use, irrigation pumps electrification, and cultivation in an efficient manner and farmers being given incentives. In India, the state has the distinction of having occupy major cropped area in the state the largest production of sugarcane. Pulses, millet and sorghum. Rice is found in regions receiving more than 40 inches of rainfall. In regions where rainfall is heavy, the important crops are peanuts, tobacco and cotton. Orchard crops of popularity are cashew nuts, oranges, bananas and mangoes.

The El Niño/Southern Oscillation (ENSO) is a naturally occurring phenomenon involving fluctuating ocean temperatures in the central and eastern equatorial Pacific, coupled with changes in the atmosphere. This phenomenon has a major influence on climate patterns in various parts of the world. Scientific progress on the understanding and modelling of ENSO has improved prediction skills within a range of one to nine months in advance, helping society to prepare for the associated hazards such as heavy rains, floods and drought. The value of these predictions can translate into hundreds of millions, if not billions, of dollars in potential savings. El Niño and La Niña are the oceanic components while the Southern Oscillation is the atmospheric counterpart, thus giving rise to the term El Niño/Southern Oscillation. The El Niño/Southern Oscillation comprises three phases: El Niño, La Niña and neutral. El Niño, meaning "little boy" refers to christ in Spanish, was first used in the nineteenth century by fishermen in Peru and Ecuador to refer to the unusually warm waters that reduced their catch just before Christmas. El Niño events often begin in the middle of the year with large-scale warming of surface water in the central and eastern equatorial Pacific Ocean and changes in the tropical atmospheric circulation (i.e. winds, pressure and rainfall). In general, El Niño reaches a peak during November–January and then decays over the first half of the following year. It occurs every two to seven years and can last

up to 18 months. Strong and moderate El Niño events have a warming effect on average global surface temperatures. The opposite of El Niño within the ENSO cycle is known as La Niña, which means "little girl" and refers to the large-scale cooling of the ocean surface temperatures in the same region in the equatorial Pacific, coupled with a reversal of the overlying atmospheric conditions. In many locations, especially in the tropics, La Niña (or cold episodes) produces the opposite climate variations to El Niño. During ENSO-neutral phases, atmospheric patterns are controlled more by other climate drivers. The World Meteorological Organization (WMO) issues regular El Niño/La Niña Updates based on observational monitoring of the current situation, seasonal predictions through climate model simulations performed by advanced centres around the world, and input from top international experts.

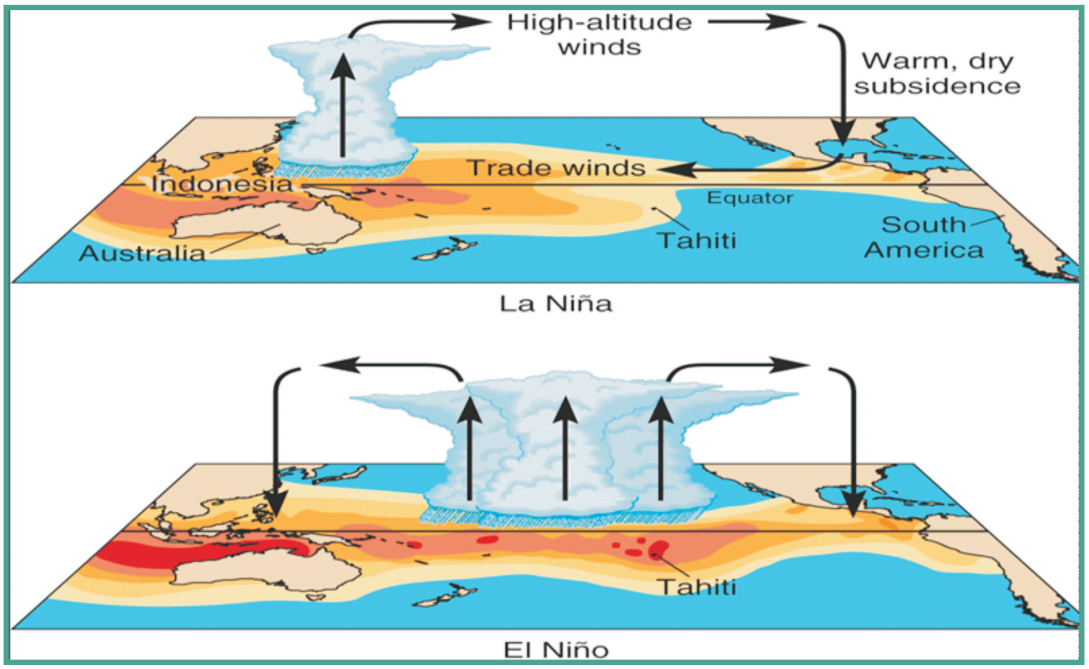

Fig.1. The oscillation between El Nino and La Nina conditions in the equatorial eastern pacific ocean.

Ocean–Atmosphere Interaction

El Niño events begin with large-scale warming of surface water in the central and eastern equatorial Pacific Ocean. La Niña events are associated with large-scale cooling of the ocean surface temperatures in the same region in the equatorial Pacific. The fluctuations in ocean temperatures during El Niño and La Niña are accompanied by even larger-scale fluctuations in air pressure known as the Southern Oscillation. This is an east–west see-saw-like movement of air masses between the Pacific and the Indo-Australian areas. These changes in atmospheric circulation occur in response to changing ocean surface temperatures and at the same time influence El Niño or La Niña ocean temperature patterns. The negative phase of the Southern Oscillation occurs during El Niño episodes, and refers to the situation when abnormally high air pressure covers Indonesia and abnormally low air pressure covers the central and/or eastern tropical Pacific. In an El Niño event, the low-level surface trade winds, which normally blow from east to west along the equator ("easterly winds"), weaken or in some cases start blowing in the opposite direction. The positive phase of the Southern Oscillation occurs during La Niña episodes, when abnormally low air pressure covers Indonesia and abnormally high air pressure covers the central and/or eastern tropical Pacific. This difference in average air pressure patterns across the Pacific is traditionally measured using the Southern Oscillation Index (SOI), based on pressure measured at two stations: one at Darwin, Australia (south of Indonesia) and the other at Tahiti (east-central tropical Pacific). A negative SOI indicates that pressure is higher than average at Darwin and lower than average at Tahiti. Another index named Equatorial SOI, measures the difference in pressure between larger regions over Indonesia and the eastern equatorial Pacific.

Regional Climate Effects of El Niño

During El Niño events, pool of warm water in the central or eastern tropical Pacific heats the overlying atmosphere, causing the air to rise. As it rises, the air cools and produces rain. In contrast, on the western side of the Pacific, the ocean surface tends to cool and there is less rising motion. These changing patterns of ascending and descending air are part of the Southern Oscillation component of ENSO as explained above. This means that El Niño is often associated with warm and dry conditions in southern and eastern inland areas of Australia, as well as Indonesia, Philippines, Malaysia and central Pacific islands such as Fiji, Tonga and Papua New Guinea. During the summer season of northern hemisphere, the Indian monsoon rainfall generally tends to be less than normal, especially in the north-west of India in El Nino years. The magnitude and scale of the changes in atmospheric circulation associated with El Niño are such that the effects on regional climate extend beyond the tropical Pacific basin. In northern hemisphere winter, drier than normal conditions are observed over south-eastern Africa and northern Brazil. Wetter than normal conditions are typically observed along the Gulf Coast of the United States, the west coast of tropical South America (Colombia, Ecuador and Peru) and from southern Brazil to central Argentina. Parts of eastern Africa also usually receive above-normal rainfall. El Niño is associated with milder winters in north-western Canada and Alaska due to fewer cold air surges from the Arctic a result of a large-scale region of lower pressure centered on the Gulf of Alaska/ North Pacific Ocean. It is important to stress that these are usual effects not specific forecasts and that actual conditions vary according to the strength and timing of the El Niño event. Other factors (such as the Indian Ocean Dipole or the North Atlantic Oscillation/Arctic Oscillation) can also have an important influence on seasonal climate. Regional Climate Outlook Forums in

different parts of the world factor the likely development of El Niño or La Niña events into their seasonal predictions for users in the sectors of agriculture and food security, water management, health, disaster risk reduction and energy (WMO,2014).

Objectives

1. To study the effect of El Nino on climatic conditions in different districts of Maharashtra state
2. To assess the impact of different El Nino interaction on area, production and productivity of major *Kharif* crops in different districts of Maharashtra state

CHAPTER-2

Methodology

The districtwise daily rainfall data for the districts of Maharashtra recorded during the years 1985-2017 as available in the database of India Meteorological Department (IMD), Pune and Department of Agriculture Maharashtra websites were used in the present study.

The rainfall total for all the calendar months and seasons *viz.* Summer (March to May), Southwest monsoon (June to September), Post monsoon (October to December) and Winter (January to February) were computed yearwise for all the districts, divisions and state of Maharashtra.

Fig 2. Location map of districts boundary of Maharashtra state

According to Jan Null (2011), the Oceanic Niño Index (ONI) has become the de-facto standard that NOAA uses for identifying El Niño (Warm) and La Niña (Cool) events in the tropical Pacific for the Nino 3.4 region (i.e., 5° N to 5°6, 120°-170 °W). Events with five consecutive months having equal to or above +0.5°C anomaly are defined as warm (El Niño) events. The El Niño years were classified into weak (0.5 to 0.9 °C), moderate (1.0 to 1.4 °C) and strong (above 1.5 °C), based on the threshold values that persisted for at least three months and group the rainfall years accordingly (Table 1). The rainfall years were then categorized as years with non El Niño years (normal rainfall), weak El Niño years, moderate El Niño years and strong El Niño years. During the years 1985 to 2017 there were 3 weak El Niño years, 4 moderate El Niño years and 4 strong El Niño years. The mean rainfall for different El Niño years and years with normal rainfall for each district were classified as follows.

Table 1. Classification of El Nino years based on SST anomaly

Intensity	Years
Weak	2004, 2006, 2014
Moderate	1986, 1994, 2002, 2009
Strong	1987, 1991, 1997, 2015
Non El Nino	Remaining 22 years (years with normal rainfall)

Crop data :-

Districtwise database of area, production and productivity of 7 major field crops i.e *Kharif* sorghum, rice, soybean, cotton, pigeon pea, black gram and green gram in all districts of Maharashtra for the years 1985 to 2017 has been collected and compiled from the government approved websites *viz.,* www.apy.dacnet.nic.in and www.mahaagri.gov.in. and various outputs were generated in both tabular and graphical forms.

The time series data on area, production and productivity may feature strong trends that mask seasonal fluctuations likely to be associated with year to year variation in weather. Researchers have isolated these seasonal fluctuations by fitting and removing trends with polynomial and other parametric functions. For example, Parthasarathy *et al*. (1992) employed an exponential function to filter the All India Food grain Production Statistics. Bapuji Rao *et al*. (2014) used a fourth degree polynomial to remove the technology trend in paddy yields at country level. We have used anomalies to remove the technology trend in production and productivity of various crops.

CHAPTER-3

El Niño Effect on Rainfall and Thermal Regime

Rainfall

The average annual and seasonal rainfall for the years with weak, strong and moderate El Niño was calculated and compared with the normal rainfall for the years 1985 to 2017 (Table 2). The percentage change in seasonal rainfall during the El Niño years compared to normal rainfall was also computed for Winter season, Summer season, Southwest monsoon, Post monsoon and Annual in different districts. From Table 2, it can be observed that

1. The average winter season rainfall during El Niño years from Jan to Feb was less than the normal rainfall in Konkan, Nasik, Pune, Amravati and Nagpur divisions by over 50 per cent while Aurangabad division received -10.2 per cent deficient rainfall However, Ratnagiri, Jalna, beed and Parbhani districts received more rainfall in El Nino years as compared to normal years.
2. The average summer season rainfall during El Niño years from March to May was less than the normal rainfall in Konkan, Nasik, Pune, Amravati and Nagpur divisions by 17.8 to 41.2 per cent while Aurangabad division received 33.8 per cent more rainfall in El Nino years as compared to normal years.
3. The average southwest monsoon season rainfall during El Niño years from June to Sept was less than the normal rainfall in Konkan, Aurangabad and Nagpur division by over 10 per cent while Nasik division (0.6), Pune division (0.5) and Amravati division (6.1) received less rainfall in El Nino years as compared to normal years.

4. The average post monsoon season rainfall during El Niño years from October to December was less than the normal rainfall in Konkan, Nasik, Pune, Amravati and Nagpur division except Aurangabad division.

5. Aurangabad division which received most of its rainfall during summer and post monsoon season is receiving 32.8 per cent and 8.3 per cent more rainfall during summer and post monsoon season respectively in El Nino years as compared to normal years.

Therefore, it is obvious that the rainfall is likely to be less than normal during southwest monsoon season throughout the state and more than normal during *rabi* season in Maharashtra.

The percentage change in monthly rainfall of southwest monsoon season during the El Niño years compared to normal monthly rainfall in different districts of Maharashtra is given in Table 3.The average monthly rainfall of July and September received less rainfall of all the division while in the June month received more rainfall in Nasik, Pune and Amravati division during El Nino years as compared to normal years. In the Maharashtra state average monthly rainfall of July and September month received 13.1 per cent and 12.7 per cent less rainfall during El Nino years as compared to normal years.

The percentage change in average annual rainfall during the El Niño years compared to normal annual rainfall in different districts of Maharashtra is given in Table 4. The average annual rainfall during El Niño years is less than normal by more than 10 per cent in Konkan, Aurangabad and Nagpur divisions and less than 10 per cent in Nasik, Pune and Amravati divisions. It was only 1.7 per cent in Nasik division. The average annual rainfall was less than normal by more than 10 per cent in most districts of Pune and Nagpur divisions and some district in Aurangabad division. The departure was less than 10 per cent in all the districts of Nasik division.

The year to year variability of rainfall during the southwest monsoon season for the state is show in Figure 2. It can be seen from the figure 2. that the southwest rainfall was below normal in the years 1985 to 1988 and 1995, 2014 and 2015 years which were 7 out of the 11 total El Nino years during the period 1985 to 2017. However, rainfall was more than normal in the years 1994, 2004 and 2006 which were also El Nino years. Therefore, the chances of getting above normal rainfall during the El Nino years are less with a probability of 35 percent.

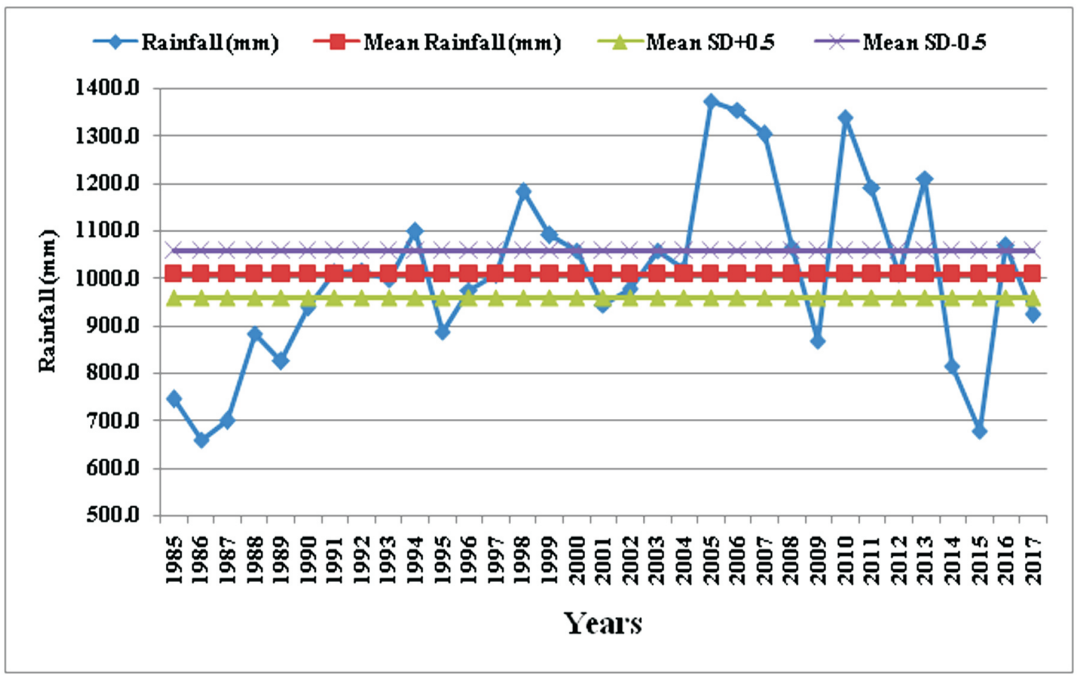

Fig 3. Year-wise average southwest monsoon rainfall (mm) in Maharashtra (1985-2017)

Table 2 : Percent change (PC) in districtwise average seasonal rainfall during El Nino years compared to normal rainfall (mm) in Maharashtra (1985-2017)

District	Winter			Summer			Southwest monsoon			Post monsoon		
	El Nino (mm)	Normal (mm)	PC (%)	El Nino (mm)	Normal (mm)	PC (%)	El Nino (mm)	Normal (mm)	PC (%)	El Nino (mm)	Normal (mm)	PC (%)
Thane	0.6	3.2	-80.3	9.0	19.1	-53.1	2398.5	2422.6	-1.0	88.2	113.7	-22.5
Raigadh	1.1	1.5	-28.3	20.4	29.0	-29.5	2279.4	3038.2	-25.0	105.8	132.5	-20.1
Ratnagiri	2.0	1.8	13.3	36.8	44.3	-16.9	3159.8	3364.2	-6.1	164.2	181.1	-9.3
Sindhudurg	1.0	1.4	-28.6	39.5	72.8	-45.8	2112.7	3336.5	-36.7	151.8	185.4	-18.1
Palghar	0.2	2.2	-89.1	5.2	17.9	-70.8	2345.6	2458.2	-4.6	68.7	96.9	-29.1
Konkan	**1.0**	**2.0**	**-50.6**	**22.2**	**36.6**	**-39.4**	**2459.2**	**2923.9**	**-15.9**	**115.7**	**141.9**	**-18.4**
Nasik	3.2	3.9	-17.1	17.8	26.8	-33.6	1005.7	1013.0	-0.7	87.9	90.8	-3.2
Dhule	2.5	7.3	-65.5	12.2	15.7	-22.4	541.0	530.5	2.0	54.8	58.9	-6.9
Nandurbar	0.6	5.0	-88.9	11.0	11.2	-1.8	849.9	835.8	1.7	40.4	55.7	-27.4
Jalgaon	6.1	9.3	-34.2	18.9	16.7	13.3	644.0	663.3	-2.9	78.8	66.3	18.8
Ahmednagar	1.6	5.7	-71.4	23.0	30.5	-24.5	416.9	436.3	-4.4	100.1	99.5	0.6
Nasik	**2.8**	**6.2**	**-54.9**	**16.6**	**20.2**	**-17.8**	**691.5**	**695.8**	**-0.6**	**72.4**	**74.2**	**-2.5**
Pune	0.3	3.5	-91.9	25.2	43.2	-41.6	643.7	752.8	-14.5	117.6	115.0	2.2
Solapur	3.8	6.2	-38.9	29.0	41.7	-30.3	412.9	488.8	-15.5	118.6	105.1	12.8
Satara	0.8	4.1	-79.4	45.7	61.8	-26.0	1168.6	834.2	40.1	136.4	133.3	2.3
Sangli	3.0	3.6	-17.8	63.6	66.8	-4.8	511.7	418.4	22.3	133.2	135.1	-1.4
Kolhapur	0.8	2.4	-67.5	66.1	106.8	-38.1	1509.4	1772.4	-14.8	133.6	175.5	-23.9
Pune	**1.7**	**4.0**	**-56.3**	**45.9**	**64.1**	**-28.3**	**849.3**	**853.3**	**-0.5**	**127.9**	**132.8**	**-3.7**

Aurangabad	3.7	3.8	-2.0	29.9	23.3	28.3	578.2	623.5	-7.3	100.1	83.5	19.8
Jalna	10.1	5.2	93.7	52.3	26.6	96.5	568.8	634.1	-10.3	95.6	84.5	13.1
Beed	10.0	6.5	54.5	42.3	37.1	14.0	564.2	605.4	-6.8	102.6	94.4	8.7
Latur	4.7	6.8	-30.5	46.5	45.2	2.8	572.3	725.3	-21.1	90.6	87.9	3.1
Osmanabad	2.8	4.0	-30.5	48.8	41.7	16.9	513.5	675.4	-24.0	83.2	86.1	-3.4
Nanded	4.9	12.3	-60.3	79.3	39.9	98.7	639.7	882.8	-27.5	54.7	82.5	-33.7
Parbhani	9.1	8.6	5.2	31.9	20.7	53.9	683.0	721.6	-5.3	102.6	79.4	29.2
Hingoli	7.2	11.3	-35.9	19.2	27.1	-29.0	774.6	838.5	-7.6	104.8	79.4	31.9
Aurangabad	**6.6**	**7.3**	**-10.2**	**43.8**	**32.8**	**33.8**	**611.8**	**713.3**	**-14.2**	**91.8**	**84.7**	**8.3**
Buldhana	7.9	15.5	-48.9	13.7	24.2	-43.5	685.3	668.2	2.6	74.3	78.0	-4.8
Akola	12.1	19.1	-36.5	15.8	23.9	-34.0	716.1	697.3	2.7	71.1	68.6	3.7
Washim	8.4	19.7	-57.5	25.0	30.6	-18.4	746.2	798.7	-6.6	83.4	75.3	10.8
Amravati	12.3	24.2	-49.2	16.9	28.1	-40.0	767.0	814.5	-5.8	69.2	75.5	-8.4
Yavatmal	6.4	22.6	-71.6	16.2	42.1	-61.4	738.3	911.4	-19.0	70.9	75.5	-6.1
Amravati	**9.4**	**20.2**	**-53.4**	**17.5**	**29.8**	**-41.2**	**730.6**	**778.0**	**-6.1**	**73.8**	**74.6**	**-1.1**
Wardha	11.2	24.9	-55.1	37.7	38.6	-2.3	815.7	920.7	-11.4	82.5	72.7	13.5
Nagpur	14.8	29.3	-49.6	25.8	47.2	-45.3	909.2	988.5	-8.0	71.0	74.4	-4.6
Bhandara	10.4	36.1	-71.3	28.2	50.2	-43.8	1117.6	1280.2	-12.7	55.1	73.3	-24.9
Gondia	7.6	39.1	-80.6	25.3	43.5	-41.8	946.2	1349.5	-29.9	40.3	85.3	-52.7
Chandrapur	6.9	24.5	-71.7	30.4	42.5	-28.6	1025.9	1142.1	-10.2	71.4	67.7	5.5
Gadchiroli	5.5	24.1	-77.0	30.1	44.3	-32.0	1364.1	1354.7	0.7	76.6	79.2	-3.3
Nagpur	**9.4**	**29.7**	**-68.3**	**29.6**	**44.4**	**-33.3**	**1029.8**	**1172.6**	**-12.2**	**66.1**	**75.4**	**-12.3**
State	**5.4**	**11.9**	**-54.6**	**30.5**	**38.8**	**-21.3**	**1021.3**	**1131.3**	**-9.7**	**90.6**	**96.1**	**-5.7**

Table 3 : Percent change (PC) in districtwise average monthly rainfall during El Nino years compared to normal rainfall (mm) in Maharashtra (1985-2017)

District	June			July			Aug			Sept		
	El Nino (mm)	Normal (mm)	PC (%)	El Nino (mm)	Normal (mm)	PC (%)	El Nino (mm)	Normal (mm)	PC (%)	El Nino (mm)	Normal (mm)	PC (%)
Thane	499.5	455.5	9.7	945.5	1003.6	-5.8	717.7	640.3	12.1	367.7	323.2	13.8
Raigadh	466.9	650.6	-28.2	897.9	1181.2	-24.0	633.3	818.2	-22.6	322.0	388.2	-17.1
Ratnagiri	868.3	817.9	6.2	1204.0	1286.4	-6.4	848.4	829	2.3	436.4	430.9	1.3
Sindhudurg	645.0	913.8	-29.4	840.4	1254.5	-33.0	489.9	794.3	-38.3	243.0	373.9	-35.0
Palghar	502.3	426.6	17.7	931.9	1047.8	-11.1	702.8	626.7	12.1	369.5	357.1	3.5
Konkan	**596.4**	**652.9**	**-8.6**	**963.9**	**1154.7**	**-16.5**	**678.4**	**741.7**	**-8.5**	**347.7**	**374.7**	**-7.2**
Nasik	176.5	154.4	14.3	350.4	378.1	-7.3	301.0	282	6.7	192.5	198.5	-3.0
Dhule	115.3	116.7	-1.2	168.9	168.7	0.1	119.7	131.8	-9.2	119.5	113.3	5.4
Nandurbar	151.2	123.8	22.1	290.4	305.9	-5.1	232.6	243.6	-4.5	146.8	162.5	-9.6
Jalgaon	120.8	130	-7.1	190.4	206.8	-7.9	182.9	187.3	-2.4	128.0	139.2	-8.0
Ahmednagar	113.6	101.4	12.1	103.8	102.5	1.3	100.6	84.3	19.3	145.8	148.1	-1.5
Nasik	**135.5**	**125.3**	**8.1**	**220.8**	**232.4**	**-5.0**	**187.3**	**185.8**	**0.8**	**146.5**	**152.3**	**-3.8**
Pune	157.4	139.9	12.5	204.1	286.6	-28.8	158.0	181.4	-12.9	157.4	144.9	8.6
Solapur	104.5	102	2.4	89.6	101.1	-11.3	108.7	104.3	4.2	156.0	181.4	-14.0
Satara	264.1	149.3	76.9	422.3	339.9	24.2	319.8	204.5	56.4	187.8	140.5	33.6
Sangli	139.7	85.2	64.0	154.7	122.3	26.5	125.3	89.8	39.5	115.0	121.1	-5.0
Kolhapur	349.8	337.8	3.6	615.5	757.4	-18.7	419.3	477.9	-12.3	184.0	199.3	-7.7
Pune	**203.1**	**162.8**	**24.7**	**297.3**	**321.5**	**-7.5**	**226.2**	**211.6**	**6.9**	**160.0**	**157.4**	**1.6**

Aurangabad	140.3	131.4	6.8	167.3	168.1	-0.5	158.8	166.7	-4.8	136.5	157.3	-13.2
Jalna	123.4	138.9	-11.2	182.6	171.8	6.3	163.7	166.7	-1.8	128.4	156.7	-18.1
Beed	132.3	128	3.3	140.3	161	-12.8	155.8	138.8	12.2	195.3	177.6	9.9
Latur	116.8	145.6	-19.8	181.3	192.7	-5.9	179.9	181.8	-1.1	155.2	205.2	-24.4
Osmanabad	113.9	163.3	-30.2	156.0	141.6	10.2	155.7	221.9	-29.8	155.0	148.6	4.3
Nanded	187.7	164.8	13.9	191.1	273.9	-30.2	186.4	246.9	-24.5	97.8	197.2	-50.4
Parabhani	157.8	126.6	24.6	209.5	210.8	-0.6	214.5	203.5	5.4	158.5	180.7	-12.3
Hingoli	194.5	168.5	15.4	236.2	258.9	-8.8	225.9	251	-10.0	127.4	160.1	-20.4
Aurangabad	**145.8**	**145.9**	**0.0**	**183.0**	**197.4**	**-7.2**	**180.1**	**197.2**	**-8.7**	**144.3**	**172.9**	**-16.6**
Buldhana	145.3	141.8	2.5	197.6	203.7	-3.0	195.9	173.9	12.7	121.8	148.8	-18.2
Akola	152.0	135.2	12.4	223.3	231.3	-3.5	213.1	182.8	16.6	113.5	148	-23.3
Washim	182.9	164	11.5	233.9	258.1	-9.4	208.3	209.7	-0.7	132.2	166.9	-20.8
Amravati	149.9	146	2.6	247.3	276.5	-10.6	245.4	219.8	11.6	130.3	172.2	-24.3
Yavatmal	170.2	175.8	-3.2	243.4	308.1	-21.0	238.5	243	-1.9	120.7	184.5	-34.6
Amravati	**160.1**	**152.6**	**4.9**	**229.1**	**255.5**	**-10.3**	**220.2**	**205.8**	**7.0**	**123.7**	**164.1**	**-24.6**
Wardha	172.2	171.4	0.5	266.6	321.6	-17.1	255.3	245.1	4.2	144.9	182.6	-20.6
Nagpur	173.7	173.4	0.2	316.6	346.5	-8.6	280.3	274.4	2.2	158.5	194.2	-18.4
Bhandara	191.2	195.9	-2.4	360.6	443	-18.6	369.1	413.2	-10.7	183.2	228.1	-19.7
Gondia	156.3	200.5	-22.0	300.6	488.3	-38.4	286.8	436.2	-34.3	138.6	224.5	-38.3
Chandrapur	178.2	185.9	-4.1	350.5	397.8	-11.9	351.9	343.2	2.5	159.3	215.2	-26.0
Gadchiroli	226.4	203.2	11.4	462.6	498.9	-7.3	457.3	435.2	5.1	184.3	217.4	-15.2
Nagpur	**183.0**	**188.4**	**-2.9**	**342.9**	**416.0**	**-17.6**	**333.4**	**357.9**	**-6.8**	**161.5**	**210.3**	**-23.2**
State	**227.6**	**228.4**	**-0.3**	**355.2**	**408.7**	**-13.1**	**294.2**	**307.3**	**-4.3**	**176.8**	**202.6**	**-12.7**

Table 4: Percent change (PC) in district wise average annual rainfall during El Nino years compared to normal rainfall (mm) in Maharashtra (1985-2017)

District	Annual		
	El Nino (mm)	Normal (mm)	PC (%)
Thane	2496.2	2558.6	-2.4
Raigadh	2406.8	3201.2	-24.8
Ratnagiri	3362.9	3591.4	-6.4
Sindhudurg	2305.0	3596.1	-35.9
Palghar	2419.8	2575.2	-6.0
Konkan	**2598.1**	**3104.5**	**-16.3**
Nasik	1114.6	1134.5	-1.8
Dhule	610.6	612.4	-0.3
Nandurbar	901.9	907.7	-0.6
Jalgaon	747.8	755.6	-1.0
Ahmednagar	541.6	572.0	-5.3
Nasik	**783.3**	**796.4**	**-1.7**
Pune	786.8	914.5	-14.0
Solapur	564.3	641.8	-12.1
Satara	1351.5	1033.4	30.8
Sangli	711.4	623.9	14.0
Kolhapur	1709.9	2057.1	-16.9
Pune	**1024.8**	**1054.1**	**-2.8**
Aurangabad	711.9	734.1	-3.0
Jalna	726.7	750.4	-3.2
Beed	719.1	743.4	-3.3
Latur	714.1	865.2	-17.5
Osmanabad	648.2	807.2	-19.7
Nanded	778.5	1017.5	-23.5
Parbhani	826.5	830.3	-0.5

Hingoli	905.8	956.3	-5.3
Aurangabad	**753.9**	**838.1**	**-10.0**
Buldhana	781.2	785.9	-0.6
Akola	815.1	808.9	0.8
Washim	863.0	924.3	-6.6
Amravati	865.3	942.3	-8.2
Yavatmal	831.8	1051.6	-20.9
Amravati	**831.3**	**902.6**	**-7.9**
Wardha	947.1	1056.9	-10.4
Nagpur	1020.7	1139.4	-10.4
Bhandara	1211.2	1439.8	-15.9
Gondia	1019.4	1517.4	-32.8
Chandrapur	1134.7	1276.8	-11.1
Gadchiroli	1476.4	1502.3	-1.7
Nagpur	**1134.9**	**1322.1**	**-14.2**
State	**1147.9**	**1278.1**	**-10.2**

The yearwise annual rainfall for the state during the years 1985 to 2017 (Figure 3) showed below normal annual rainfall in the years 1985 to 1997 , 2014 and 2015 years which were 7 out of the 11 total El Nino years during 1985-2017. Rainfall was more than normal in rest of 4 El Nino years 1994, 2002, 2004 and 2006. Therefore, the chances of getting above normal rainfall during the El Nino years are less with a probability of 35 percent. In the recent decade two consecutive years was severe deficit rainfall event in association with El Nino have occurred.

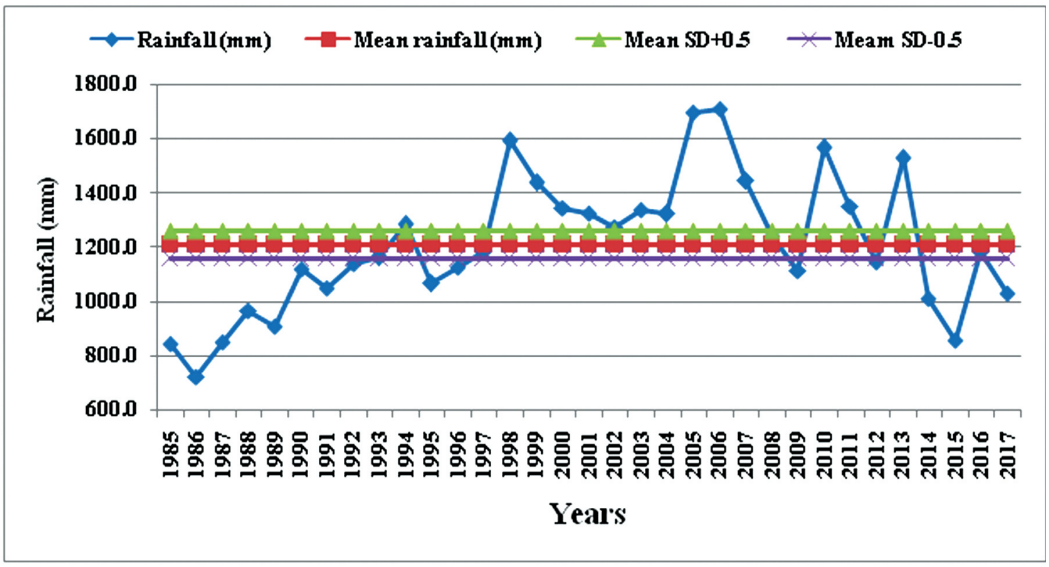

Fig 4. Year-wise Average annual rainfall (mm) in Maharashtra (1985-2017)

Therefore, it may be possible that either the annual rainfall or the southwest monsoon season rainfall is likely to be less than normal during the years with El Nino. Hence, El Nino unambiguously serves as a signal of deficit rainfall for the state during the southwest monsoon season or deficit annual rainfall.

Thermal Regime

The temperature data (1985 to 2015) for all districts in Maharashtra was collected and compared to El Nino years to normal years temperature of monthly, seasonal and annual. The data shown in table 5. there is slight increase in mean monthly maximum temperature by 0.1 to 0.3 °C February, March, July and September month while January and April month record more mean monthly maximum temperature during El Nino years compared to normal year. Similarly during Summer, Southwest, Post monsoon and annual mean maximum temperature was more during El Nino yeas as compared to normal year. The mean monthly minimum temperature in Post monsoon and annual 0.9 ° C and 0.1° C more during El Nino years compared to normal year.

Table 5. Maximum (T_{max}), Minimum (T_{min}) and Mean temperature (T_{mean}) (^{o}C) during El Nino years compared to normal years in Maharashtra.

Month and Season	T_{max} (^{o}C)			T_{min} (^{o}C)			T_{mean} (^{o}C)		
	El Nino	Normal	Difference	El Nino	Normal	Difference	El Nino	Normal	Difference
January	29.7	30.2	-0.5	11.3	11.5	-0.2	20.5	20.8	-0.4
February	33.1	32.8	0.3	13.6	13.5	0.1	23.3	23.1	0.2
March	37.1	36.7	0.4	17.6	17.3	0.3	27.4	27.0	0.3
April	40	40.1	-0.1	21.2	21.8	-0.7	30.6	31.0	-0.4
May	41.4	41.4	0.0	24.5	25.2	-0.6	33.0	33.3	-0.3
June	36.1	35.8	0.3	23.8	24.0	-0.2	30.0	29.9	0.1
July	32.4	31.7	0.7	22.9	22.6	0.3	27.6	27.1	0.5
August	30.9	30.5	0.4	22.1	22.3	-0.2	26.5	26.4	0.1
September	32.5	31.5	1.0	21.8	21.7	0.1	27.1	26.6	0.5
October	33.2	32.3	0.9	18.3	18.6	-0.2	25.8	25.4	0.3
November	31	31	0.0	15.5	13.8	1.7	23.3	22.4	0.9
December	29.7	29.7	0.0	11.5	10.3	1.1	20.6	20.0	0.6
Winter	31.3	31.4	-0.1	12.4	12.5	-0.1	21.9	22.0	-0.1
Summer	39.5	39.4	0.1	21.1	21.4	-0.3	30.3	30.4	-0.1
Southwest	32.9	32.3	0.6	22.7	22.6	0.0	27.8	27.5	0.3
Post monsoon	31.3	30.9	0.4	15.1	14.2	0.9	23.2	22.6	0.6
Annual	33.9	33.6	0.3	18.7	18.5	0.1	26.3	26.1	0.2

Mean monthly, seasonal and annual temperature was more in all months except January, April and May during El Nino years compared to normal year. In same fashion seasonal temperature was more during El Nino years compared to normal year viz. Southwest monsoon (0.3 ^{o}C) , Post monsoon (0.6 ^{o}C) and annual (0.2 ^{o}C) for Maharashtra.

Chapter-4

Impact of El Nino on production and productivity of major crops in Maharashtra

Although Maharashtra is one of the economically most developed states in the country, it is not counted among the advanced states in India in terms of agricultural production. During last four decades, the agricultural sector of Maharashtra has undergone lot of changes with modest agriculture production. Agricultural progress was not sustained and showed wide fluctuations. The important characteristics of Maharashtra agriculture are instability in crop production and significant regional variations in the performance of agriculture in the state. There are number of factors which limit the growth of agriculture over the years. It is, therefore, necessary to look into the factors affecting agricultural growth in Maharashtra. Rainfall during monsoon season plays a critical role in the agricultural development of the Maharashtra state, with 83 per cent of cropped area cultivated under rainfed condition. The state receives highest amount of rainfall during south-west monsoon but, its spatial and temporal distribution is uneven. Though the average rainfall of the state is relatively higher than many states in India, its erratic and uneven distribution across months as well as different regions is not much favorable for better agriculture production. While the normal rainfall of the konkan division is about 135 per cent higher than the average normal rainfall of the state (1254 mm), the same is less by about 40 per cent in Aurangabad division. Moreover, except 10 districts it is less than the state's average normal rainfall in rest of the districts. Nearly one third of the cultivated area falls under rain-shadow region where the rains are scanty and erratic. In these areas, dry land cultivation is widely undertaken. The study was undertaken in the selected major crops grown in Maharashtra. The Major crops of Maharashtra are cotton, sorghum, soybean, black gram, green gram, pigeon pea and rice during *Kharif* season. In these above mentioned crops, detailed analysis was carried out to find the changes in area, production and productivity of some major crops in different districts of the state due to El Nino effect. The results were presented and discussed as follows.

Rice

Rice is the major cereal crop of Maharashtra, with respect to area and production. This crop is mostly cultivated in Konkan, Kolhapur and Nagpur divisions accounting for about two thirds of rice area and production in the state. Rice is a dominant *kharif* season crop occupying an area of over 14.68 lakh ha with production of 34.19 lakh tons and productivity of 2333 kg/ha (Anonymous, 2016). Rice is cultivated under diverse agro-climatic conditions. The changes in district-wise average area, production and productivity of rice during the El Niño years compared to the normal years is given in Table 6.

The observations made from Table 6 were

- During El Niño years average area under rice decreased by 3.5 per cent and the production and productivity decreased by 18.1 and 18.2 per cent in the state The cultivated area of rice was not affected in Kolhapur division as predominantly it was under irrigated condition,
- The decrease in production and productivity was more in both Nagpur (26.2 percent) and Latur (30.5 percent) divisions.
- The average production of rice during *kharif* season decreased by more than 20 per cent in Nasik, Latur and Nagpur divisions of Maharashtra.
- The average productivity of rice during *kharif* season decreased by more than 25 per cent in Latur and Nagpur divisions of Maharashtra.

The change in production and productivity of rice under different categories of El Niño years is presented in Table7. The interaction from table 7. shows that

- Weak El Niño years negatively affected the rice production in all the divisions except Pune (6 %) and Kolhapur (7.1 %) divisions. The productivity in konkan division only showed increase (8%) in week El Nino years.

- Moderate El Niño years negatively affected the rice production and productivity in all the divisions except Amravati division.
- Strong El Niño years negatively affected the rice production and productivity in all the divisions of the state.

The percent change in average production and productivity of rice over Maharashtra state most impact in moderate El Nino years (20.1 and 18.1 %) as compared to strong El Nino years (16.1 and 18.4 %) and weak El Nino years (10.0 and 10.4 %) respectively

Table 6 : Percent change (PC) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of rice during El Nino years compared to normal years in Maharashtra (1985-2017).

Districts	Area			Production			Productivity		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Ratnagiri	774.0	787.4	-1.7	1671.6	1996.8	-16.3	2146.3	2544.0	-15.6
Raigad	1271.7	1292.9	-1.6	2916.3	3035.7	-3.9	2266.9	2364.5	-4.1
Thane	1257.1	1377.6	-8.7	2369.1	2936.4	-19.3	1810.5	2168.2	-16.5
Sindudurg	732.9	740.2	-1.0	1664.4	1871.7	-11.1	2266.4	2533.5	-10.5
Konkan	**1008.9**	**1049.5**	**-3.9**	**2155.3**	**2460.1**	**-12.4**	**2122.5**	**2402.6**	**-11.7**
Nasik	501.2	503.5	-0.5	452.6	599.6	-24.5	931.0	1172.9	-20.6
Dhule	152.6	184.7	-17.4	138.5	140.3	-1.3	693.0	858.0	-19.2
Jalgaon	26.0	18.1	44.2	29.5	17.1	73.0	796.6	923.5	-13.7
Nandurbar	193.2	213.3	-9.4	155.0	230.4	-32.7	815.5	1088.6	-25.1
Nasik	**218.2**	**229.9**	**-5.1**	**193.9**	**246.8**	**-21.4**	**809.0**	**1010.8**	**-20.0**
Pune	640.1	619.6	3.3	680.1	850.1	-20.0	1136.5	1371.6	-17.1
Ahmednagar	83.9	77.6	8.2	73.8	89.6	-17.7	848.1	1139.4	-25.6
Solapur	13.6	19.8	-31.4	15.0	19.4	-22.5	638.4	815.7	-21.7
Pune	**245.9**	**239.0**	**2.9**	**256.3**	**319.7**	**-19.8**	**874.3**	**1108.9**	**-21.2**
Kolhapur	1069.3	1064.0	0.5	2382.1	2776.9	-14.2	2255.5	2604.6	-13.4
Satara	439.1	440.3	-0.3	671.9	776.0	-13.4	1600.0	1780.9	-10.2
Sangli	175.2	171.7	2.0	304.0	383.7	-20.8	1706.5	2235.0	-23.6
Kolhapur	**561.2**	**558.7**	**0.5**	**1119.3**	**1312.2**	**-14.7**	**1854.0**	**2206.8**	**-16.0**
Aurangabad	11.8	17.5	-32.8	8.7	10.8	-19.8	567.0	611.4	-7.3
Beed	35.8	36.3	-1.3	18.4	22.0	-16.6	359.4	551.4	-34.8
Jalna.	14.7	18.9	-22.5	9.3	12.3	-24.2	456.2	606.8	-24.8
Aurangabad	**20.8**	**24.2**	**-14.4**	**12.1**	**15.0**	**-19.4**	**460.8**	**589.9**	**-21.9**
Parbhani	141.9	161.4	-12.1	106.5	103.5	2.9	540.7	528.0	2.4

Nanded	186.9	204.7	-8.7	115.5	148.1	-22.0	467.8	665.1	-29.7
Osmanabad	135.6	131.2	3.4	44.1	61.6	-28.3	353.6	454.0	-22.1
Latur	160.6	167.5	-4.2	56.8	107.0	-47.0	307.4	589.0	-47.8
Hingoli	41.9	55.7	-24.7	24.3	31.3	-22.6	221.8	484.8	-54.3
Latur	**133.4**	**144.1**	**-7.4**	**69.4**	**90.3**	**-23.1**	**378.2**	**544.2**	**-30.5**
Buldhana	15.5	16.9	-8.7	7.7	12.5	-38.5	516.4	776.2	-33.5
Akola	52.5	42.7	23.0	33.8	28.7	18.0	631.7	591.8	6.7
Amrawati	92.0	91.7	0.3	63.0	55.2	14.1	687.1	602.0	14.1
Yavatmal	47.5	42.5	11.8	37.3	30.6	21.7	726.8	628.5	15.6
Wasim	2.8	7.0	-60.3	2.3	4.1	-45.7	568.8	676.0	-15.9
Amravati	**42.0**	**40.2**	**4.7**	**28.8**	**26.2**	**9.8**	**626.1**	**654.9**	**-4.4**
Wardha	20.3	19.0	6.7	17.5	17.3	1.4	583.5	925.4	-36.9
Nagpur	511.3	493.7	3.6	533.0	671.0	-20.6	1024.8	1327.7	-22.8
Bhandara	2359.9	2569.5	-8.2	2875.1	3566.0	-19.4	1081.1	1434.3	-24.6
Chandrapur	1391.9	1461.5	-4.8	1368.1	2015.0	-32.1	975.6	1390.0	-29.8
Gadchiroli	1406.9	1421.9	-1.1	1171.3	1815.3	-35.5	853.9	1272.2	-32.9
Nagpur	**1138.1**	**1193.1**	**-4.6**	**1193.0**	**1616.9**	**-26.2**	**903.8**	**1269.9**	**-28.8**
State	**436.2**	**452.2**	**-3.5**	**625.5**	**763.6**	**-18.1**	**963.6**	**1178.6**	**-18.2**

Table 7 : Anomalies (%) in average area sown (00'ha), production (00' tons) and productivity (kg/ha) of Rice during El Nino years compared to normal years in Maharashtra (1985-2017).

Districts	Weak			Moderate			Strong		
	Area	Production	Productivity (Kg/ha)	Area	Production	Productivity (Kg/ha)	Area	Production	Productivity (Kg/ha)
Ratnagiri	-2.8	3.2	6.2	-0.6	-22.1	-22.1	-1.7	-10.4	-9.1
Raigad	-6.1	-2.5	3.3	0.5	-10.2	-10.6	0.7	2.3	2.3
Thane	-19.8	-19.0	1.7	3.2	-24.4	-28.1	-9.6	-14.2	-4.9
Sindudurg	-2.5	16.4	19.5	1.5	-10.8	-12.3	-2.0	-11.3	-8.8
Konkan	**-9.3**	**-2.7**	**8.0**	**1.4**	**-17.0**	**-18.0**	**-3.6**	**-7.8**	**-5.3**
Nasik	13.2	14.8	2.7	-9.6	-41.8	-35.0	-5.0	-7.2	-6.2
Dhule	-81.4	-82.2	-23.7	22.1	3.5	-30.0	7.2	-6.1	-8.5
Jalgaon	-86.2	-85.3	6.0	39.8	-0.3	-18.5	178.8	146.3	-8.9
Nandurbar	-7.2	-48.5	-44.9	-9.7	-40.5	-34.7	-11.4	-24.9	-15.5
Nasik	**-12.5**	**-15.5**	**-15.0**	**-2.3**	**-34.4**	**-30.1**	**-0.4**	**-8.5**	**-9.8**
Pune	14.9	13.8	-2.9	0.8	-31.8	-32.8	-5.8	-8.2	-1.5
Ahmednagar	7.4	-45.7	-48.3	10.2	-43.1	-50.8	7.0	7.7	-0.3
Solapur	-79.8	-94.8	-73.4	-25.5	-40.6	-28.5	11.1	-4.4	-14.9
Pune	**11.5**	**6.0**	**-35.7**	**1.1**	**-33.0**	**-37.9**	**-4.0**	**-6.7**	**-4.4**
Kolhapur	3.8	7.9	4.2	0.1	-14.6	-14.9	-2.3	-13.8	-11.9
Satara	7.5	12.1	3.2	-3.9	-17.7	-15.5	-4.4	-9.1	-4.8
Sangli	-0.4	-9.2	-8.8	2.5	-30.9	-33.3	4.0	-10.7	-14.0
Kolhapur	**4.3**	**7.1**	**-0.4**	**-0.7**	**-16.8**	**-21.3**	**-2.2**	**-12.6**	**-10.7**
Aurangabad	-88.6	-86.1	16.4	-18.3	-32.1	-21.3	8.4	-7.4	6.7
Beed	-56.8	-66.7	-27.3	17.8	-16.0	-30.0	35.0	-17.2	-39.7
Jalna.	-73.6	-83.8	-34.1	-3.1	-16.0	-21.7	9.2	-32.3	-27.9
Aurangabad	**-68.8**	**-76.0**	**-14.5**	**3.7**	**-19.9**	**-24.1**	**21.9**	**-19.0**	**-19.6**

Parbhani	-62.8	-79.7	-45.9	16.5	20.3	13.8	10.1	-14.5	-9.0
Nanded	-46.6	-60.2	-35.8	15.6	-5.2	-19.9	4.9	-38.9	-39.4
Osmanabad	24.8	-13.9	-31.6	-3.2	-13.5	-6.9	-11.4	-43.2	-37.3
Latur	-17.2	-56.7	-48.0	3.0	-39.7	-36.6	1.8	-54.2	-59.0
Hingoli	-27.5	-59.6	-52.8	53.6	54.8	-8.5	-100	-100	-100
Latur	**-28.9**	**-57.5**	**-42.7**	**12.4**	**-4.5**	**-12.8**	**-5.7**	**-41.8**	**-48.2**
Buldhana	-	-	-	-19.3	-46.8	-21.2	1.9	-30.2	-45.8
Akola	-	-	-	15.6	32.6	23.0	30.5	3.5	-9.5
Amrawati	-15.0	-37.2	-28.8	1.7	33.5	50.4	14.2	-5.4	-22.1
Yavatmal	-64.7	-82.0	-32.4	14.8	15.9	51.7	85.3	27.4	-20.4
Wasim	-66.7	-75.9	-53.7	-14.3	8.6	68.3	-100	-100	-100
Amravati	**-32.5**	**-54.3**	**-38.8**	**5.1**	**20.7**	**32.4**	**27.7**	**-1.2**	**-41.2**
Wardha	-92.1	-91.3	19.1	89.5	48.8	-18.2	22.8	-45.9	-55.7
Nagpur	13.4	2.2	-7.9	-1.9	-15.4	-11.1	-0.8	-25.7	-34.5
Bhandara	-31.4	-36.4	-11.7	9.7	-14.5	-23.5	-2.7	-24.2	-25.8
Chandrapur	-4.1	-33.4	-30.7	-6.3	-33.0	-30.7	-4.0	-31.3	-29.0
Gadchiroli	2.7	-2.1	-4.3	-3.0	-35.5	-32.5	-2.8	-35.5	-33.3
Nagpur	**-13.1**	**-24.9**	**-9.1**	**2.0**	**-23.8**	**-23.5**	**-2.8**	**-28.7**	**-34.2**
State	**-10.0**	**-10.0**	**-10.4**	**1.8**	**-20.1**	**-18.1**	**-2.5**	**-16.1**	**-18.4**

Kharif Sorghum

Kharif sorghum is a very important crop for the state. It occupies about 72 thousand ha area with average productivity of nearly 1150 kg/ha. The area under *Kharif* sorghum is more in Latur division but productivity is more in Kolhapur and Nasik divisions. It is predominantly grown as rainfed crop of 120 to 130 days duration and is sown with the onset of monsoon in typical shallow soils and alfisols and provides an opportunity to examine the effect of El Niño on the crop grown under rainfed conditions. The districtwise averages of area, production and productivity of *Kharif* sorghum during the years with El Niño compared to the normal years are given in Table 8.

The main findings emerging from the interpretation in Table 8 are:

- Production and productivity of *kharif* sorghum are negatively influenced during El Nino years in all the division of Maharashtra state.
- During El Niño years area of *kharif* sorghum is negatively influenced in all the divisions except pune division.
- Average area under *kharif* sorghum decreased by 3.3 per cent but the production and productivity decreased by 20.7 and 18.5 per cent, respectively in the state during El Niño years.
- During El Niño years negatively influence on production and productivity of *Kharif* sorghum is more in Aurangabad, Latur Amravati and Nagpur divisions.

The change in production and productivity of *kharif* sorghum under different categories El Niño years of (Table 9) brought out the following salient findings.

- Weak El Niño years negatively affected the *kharif* sorghum production of all the division, Productivity was also affected negatively in all divisions except Nagpur divisions during week El Nino years.

- Moderate El Niño years positively affected the *kharif* sorghum production in Nasik, Pune and Aurangabad divisions while productivity was negatively affected in all the divisions.

- Strong El Niño years positively influenced the *kharif* sorghum production in Pune division only but productivity was decreased as compared to normal years in all the divisions.

- The percent decrease in average production and productivity of *Kharif* sorghum in Maharashtra state was 9.2 % and 26.9 % in strong El Nino years, 7.1 % and 12.3 % with moderate El Nino years and 45.8 % and 16.2 % in El Nino years.

- In weak El Nino years average production of *kharif* sorghum was more negatively influenced as compare to moderate and strong El Nino years.

Table 8 : Percent change (PC) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of sorghum during El Nino years compared to normal years in Maharashtra (1985-2017).

Districts	Area			Production			Productivity (Kg/ha)		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Nasik	120.0	133.5	-10.1	121.8	170.6	-28.6	996.1	1292.8	-22.9
Dhule	515.6	591.2	-12.8	533.8	738.3	-27.7	1130.4	1335.5	-15.4
Nandurbar	290.9	267.3	8.8	319.2	461.2	-30.8	1101.9	1716.4	-35.8
Jalgaon	1473.5	1476.2	-0.2	2527.6	2664.0	-5.1	1770.8	1876.1	-5.6
Nasik	**600.0**	**617.1**	**-2.8**	**875.6**	**1008.5**	**-13.2**	**1249.8**	**1555.2**	**-19.6**
Ahmednagar	54.3	32.5	67.1	55.1	49.1	12.0	835.9	1089.8	-23.3
pune	89.4	86.5	3.3	91.8	99.3	-7.6	894.6	1039.7	-14.0
Solapur	25.1	24.0	4.4	20.9	23.9	-12.5	654.8	780.9	-16.1
Pune	**56.2**	**47.7**	**18.0**	**55.9**	**57.5**	**-2.7**	**795.1**	**970.1**	**-18.0**
Satara	624.9	639.7	-2.3	863.0	1015.7	-15.0	1372.3	1594.3	-13.9
Sangli	1067.7	1055.4	1.2	1180.7	1238.1	-4.6	1071.3	1083.3	-1.1
Kolhapur	187.4	193.4	-3.1	330.2	408.6	-19.2	1750.8	2014.6	-13.1
Kolhapur	**626.7**	**629.5**	**-0.4**	**791.3**	**887.5**	**-10.8**	**1398.2**	**1564.1**	**-10.6**
Aurangabad	259.9	271.6	-4.3	292.0	324.5	-10.0	1118.4	1341.1	-16.6
Jalna	306.9	323.1	-5.0	316.8	385.8	-17.9	929.8	1193.5	-22.1
Beed	660.0	691.8	-4.6	498.6	682.4	-26.9	727.1	972.9	-25.3
Aurangabad	**408.9**	**428.8**	**-4.6**	**369.1**	**464.2**	**-20.5**	**925.1**	**1169.2**	**-20.9**
Latur	1498.5	1549.4	-3.3	1427.6	2122.9	-32.7	959.8	1366.4	-29.8
Osmanabad	791.5	785.4	0.8	512.0	705.9	-27.5	598.6	858.2	-30.3
Nanded	1781.5	1840.7	-3.2	1778.7	2169.0	-18.0	853.8	1135.4	-24.8
Parbhani	1324.6	1427.0	-7.2	1271.7	1720.6	-26.1	862.0	1199.0	-28.1
Hingoli	494.0	500.1	-1.2	363.9	617.2	-41.0	740.9	1214.1	-39.0
Latur	**1178.0**	**1220.5**	**-3.5**	**1070.8**	**1467.1**	**-27.0**	**803.0**	**1154.6**	**-30.5**

Buldhana	1167.1	1209.5	-3.5	1535.8	2043.7	-24.9	1277.7	1625.0	-21.4
Akola	1434.5	1498.9	-4.3	1911.4	2467.0	-22.5	1407.4	1703.8	-17.4
Washim	243.0	290.7	-16.4	283.8	357.1	-20.5	994.8	1133.8	-12.3
Amrawati	1055.0	1096.2	-3.8	1296.7	1517.0	-14.5	1117.7	1330.7	-16.0
Yavatmal	1333.9	1408.0	-5.3	1326.6	1754.5	-24.4	875.9	1131.0	-22.6
Amravati	**1046.7**	**1100.6**	**-4.9**	**1270.8**	**1627.9**	**-21.9**	**1134.7**	**1384.9**	**-18.1**
Wardha	445.9	458.5	-2.8	343.5	507.4	-32.3	720.3	906.2	-20.5
Nagpur	548.5	550.2	-0.3	483.4	587.1	-17.7	837.3	952.3	-12.1
Chandrapur	180.2	182.3	-1.1	150.4	183.7	-18.1	1191.9	976.2	22.1
Nagpur	**391.5**	**397.0**	**-1.4**	**325.8**	**426.1**	**-23.5**	**916.5**	**944.9**	**-3.0**
State	**691.3**	**714.7**	**-3.3**	**763.0**	**962.1**	**-20.7**	**1030.5**	**1264.0**	**-18.5**

Table 9 : Anomalies (%) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of sorghum during El Nino years compared to normal years in Maharashtra (1985-2017).

Districts	Weak			Moderate			Strong		
	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)
Nasik	-66.3	-70.7	-22.3	12.9	-16.6	-27.2	23.1	1.5	-19.3
Dhule	-56.6	-54.0	-2.2	-5.4	-3.4	-18.2	23.6	-25.6	-25.7
Nandurbar	11.3	-35.7	-42.0	3.6	-21.5	-23.8	11.5	-35.2	-41.6
Jalgaon	-28.8	-23.9	6.0	18.5	13.3	-4.3	9.7	-4.7	-18.6
Nasik	**-33.1**	**-32.8**	**-14.9**	**10.9**	**5.0**	**-17.4**	**13.9**	**-11.7**	**-26.6**
Ahmednagar	-96.9	-98.0	-40.8	193.5	98.7	-14.5	104.8	35.3	-14.6
Pune	-62.6	-76.5	-29.8	42.2	26.3	-12.9	30.4	27.3	0.8
Solapur	-84.7	-91.6	-21.0	16.7	-14.2	-18.0	81.3	68.4	-9.4
Pune	**-74.1**	**-84.7**	**-31.6**	**72.3**	**41.4**	**-14.8**	**55.8**	**35.3**	**-7.7**
Satara	-23.6	-39.7	-18.6	8.1	-5.0	-11.9	8.6	-0.4	-11.3
Sangli	-11.9	-6.6	12.1	6.5	-13.4	-13.1	8.9	6.1	-2.3
Kolhapur	-60.2	-69.1	-16.4	11.3	-2.7	-6.2	39.6	14.2	-16.6
Kolhapur	**-20.8**	**-28.8**	**-10.6**	**7.5**	**-8.5**	**-9.7**	**11.9**	**4.8**	**-11.5**
Aurangabad	-72.6	-70.5	-14.6	24.5	26.1	-1.0	35.2	14.3	-34.2
Jalna	-69.6	-71.4	-26.8	15.2	8.6	-3.2	39.3	9.1	-36.4
Beed	-39.2	-51.5	-23.8	10.2	-16.9	-17.9	15.3	-12.4	-34.1
Aurangabad	**-53.9**	**-61.5**	**-21.3**	**14.5**	**0.2**	**-6.4**	**25.5**	**-0.2**	**-34.9**
Latur	-21.2	-35.1	-17.9	4.7	-30.5	-30.4	6.6	-32.6	-40.9
Osmanabad	-16.8	-41.8	-32.4	14.3	-26.3	-29.5	4.8	-14.3	-28.8
Nanded	-23.3	-38.0	-24.8	5.9	-2.4	-2.5	7.7	-13.6	-47.1
Parbhani	-40.3	-64.9	-42.4	7.3	-2.5	-11.2	11.6	-10.9	-30.8
Hingoli	11.2	-33.8	-40.3	-10.4	-19.6	-8.9	-4.4	-69.7	-67.7

Latur	**-23.1**	**-43.5**	**-31.2**	**5.7**	**-14.3**	**-16.3**	**7.0**	**-23.3**	**-43.9**
Buldhana	-46.5	-61.1	-25.8	13.3	1.2	-2.2	22.7	-14.6	-36.1
Akola	-60.1	-55.5	-2.9	16.8	-17.0	-21.6	30.5	4.9	-27.6
Washim	29.7	17.4	-10.4	-11.9	8.9	34.1	-67.0	-88.0	-60.4
Amrawati	-34.8	-50.0	-21.0	4.6	6.7	-9.0	19.0	-0.3	-18.1
Yavatmal	-42.8	-59.3	-29.0	10.8	-18.5	-22.5	16.2	4.6	-16.2
Amravati	**-42.9**	**-53.5**	**-17.3**	**10.5**	**-7.2**	**-5.7**	**17.7**	**-5.1**	**-31.3**
Wardha	-67.4	-75.3	-19.9	20.6	-29.4	-26.3	38.5	7.8	-15.3
Nagpur	-53.1	-62.5	-17.6	19.3	-4.0	-11.0	32.9	13.5	-7.7
Chandrapur	-61.2	-42.6	113.7	19.9	-9.8	-17.9	38.0	-1.9	-29.6
Nagpur	**-59.9**	**-64.7**	**26.9**	**19.9**	**-14.9**	**-18.2**	**35.9**	**9.1**	**-17.7**
State	**-34.9**	**-45.8**	**-16.2**	**10.0**	**-7.1**	**-12.3**	**15.1**	**-9.2**	**-26.9**

Cotton

Cotton is one of the most important fiber and cash crop of Maharashtra and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry. In Maharashtra , there are twenty major cotton growing districts which are divided into four divisions, viz. Nasik, Aurangabad , Latur and Amravati division. In these four division, cotton cultivation has gained momentum in the State of Maharashtra. Cotton is also cultivated in small areas of non-traditional districts. Maharashtra was major cotton growing state. Cotton crop is of 150-180 days of crop duration. The area under cotton in Maharashtra is nearly 41.25 lakh hectares with production of 74.75 lakh bales and productivity of 318 kg of lint ha^{-1}. Cotton is a *kharif* crop in major parts of the state *viz.* Marathwada and vidarbha regions. In these areas the irrigated crop is sown in March-May and the rainfed crop in June-July with the commencement of the monsoon. Cotton crop requires minimum temperature of 15 ^{0}C for better germination in field conditions. The optimum temperature for vegetative growth is 21^{0}C to 27 ^{0}C and it can tolerate temperature to the extent of 43^{0}C but temperature below 21^{0}C is detrimental to the crop.

Cotton area, production and productivity in El Niño years compared to normal years are presented in Table 10. It can be seen clearly from the date that during El Nino years the area under cotton average area, production and productivity decreased, 2.3, 31.2 and 26.9 per cent respectively in the state. Therefore, it is obvious that El Nino is exerting greater influence on productivity of rainfed crops as a result of decreasing tendency of southwest monsoon rainfall. All the division in Maharashtra except Nasik showed decline in average production more than 30 per cent and productivity declined more than 20 per cent in all division except pune.

The change in cotton production and productivity during different category of El Nino years is (Table 11) brought out the following salient finding.

- The production and productivity of cotton over the state was more negatively influenced by strong El Nino years as compared to weak and moderate El Nino years.

- The average production and productivity of cotton decreased by 13.0 & 17.2 per cent , 32.6 & 23.3 per cent and 48.0 & 40.2 per cent during weak, moderate and strong El Nino years, respectively in the state.

- In the weak El Nino years productivity of cotton was positively influenced in Aurangabad division.

- The average production of cotton was positively influenced in Nasik and Aurangabad divisions in weak El Nino years.

Table 10 : Percent change in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of Cotton during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Area			Production			Productivity		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Nasik	190.6	172.6	10.4	218.2	344.7	-36.7	189.4	259.0	-26.9
Dhule	1060.4	987.6	7.4	1116.4	1184.8	-5.8	164.5	206.2	-20.2
Nandurbar	749.2	560.8	33.6	771.3	857.5	-10.1	178.6	248.3	-28.1
Jalgaon	3443.9	3624.7	-5.0	4993.2	5982.8	-16.5	212.2	255.0	-16.8
Nasik	**1361.0**	**1336.4**	**1.8**	**1774.8**	**2092.4**	**-15.2**	**186.1**	**242.1**	**-23.1**
Punc	1.3	1.6	-16.9	2.5	3.5	-28.3	272.0	305.1	-10.9
Ahmednagar	305.6	354.4	-13.8	341.1	585.2	-41.7	220.1	275.8	-20.2
Solapur	23.5	27.5	-14.4	33.7	42.3	-20.4	253.6	298.6	-15.0
Pune	**110.1**	**127.8**	**-13.8**	**125.8**	**210.4**	**-40.2**	**248.6**	**293.2**	**-15.2**
Kolhapur	0.9	1.2	-24.4	0.9	1.4	-32.2	136.6	191.4	-28.7
Satara	20.4	22.7	-10.2	31.7	39.8	-20.4	219.4	306.5	-28.4
Sangli	18.4	22.0	-16.0	23.5	38.7	-39.3	196.0	304.7	-35.7
Kolhapur	**13.2**	**15.3**	**-13.4**	**18.7**	**26.6**	**-29.7**	**184.0**	**267.5**	**-31.2**
Aurangabad	2073.2	1975.5	4.9	2036.9	3085.8	-34.0	154.6	212.1	-27.1
Beed	1435.2	1444.4	-0.6	1058.7	1704.4	-37.9	134.8	170.0	-20.7
Jalna.	1920.5	1921.4	0.0	2036.4	2731.0	-25.4	171.8	208.6	-17.6
Aurangabad	**1809.6**	**1780.4**	**1.6**	**1710.7**	**2507.0**	**-31.8**	**153.8**	**196.9**	**-21.9**
Parbhani	2479.8	2504.0	-1.0	1983.4	3101.6	-36.1	143.1	226.5	-36.8
Hingoli	834.3	862.4	-3.3	873.9	1508.2	-42.1	180.8	301.8	-40.1
Nanded	2583.5	2639.7	-2.1	1457.4	2474.2	-41.1	96.6	152.1	-36.5
Osmanabad	82.9	85.5	-3.1	60.9	131.9	-53.9	131.8	183.6	-28.2
Latur	137.0	167.4	-18.2	77.3	144.8	-46.6	125.2	240.3	-47.9
Latur	**1223.5**	**1251.8**	**-2.3**	**890.6**	**1472.1**	**-39.5**	**135.5**	**220.9**	**-38.7**
Buldhana	2201.4	2355.8	-6.6	1693.0	2770.0	-38.9	134.8	207.3	-35.0

Akola	2536.3	2632.3	-3.6	2072.2	2852.7	-27.4	161.5	208.2	-22.4
Wasim	447.6	631.1	-29.1	430.4	785.4	-45.2	170.0	231.7	-26.6
Amrawati	2808.7	2815.3	-0.2	2154.0	3183.2	-32.3	148.6	225.7	-34.1
Yavatmal	4100.8	4279.4	-4.2	3107.7	4894.2	-36.5	130.2	194.6	-33.1
Amravati	**2418.9**	**2542.8**	**-4.9**	**1891.4**	**2897.1**	**-34.7**	**149.0**	**213.5**	**-30.2**
Wardha	1318.9	1451.4	-9.1	1216.9	2029.2	-40.0	164.5	227.2	-27.6
Nagpur	728.9	720.3	1.2	808.4	1094.6	-26.1	176.3	233.1	-24.4
Chandrapur	708.9	709.0	0.0	724.7	1053.7	-31.2	167.2	218.0	-23.3
Gadchiroli	13.0	15.8	-17.6	20.4	29.4	-30.6	182.4	225.2	-19.0
Nagpur	**692.4**	**724.1**	**-4.4**	**692.6**	**1051.7**	**-34.1**	**172.6**	**225.9**	**-23.6**
State	**1193.5**	**1221.7**	**-2.3**	**1086.9**	**1579.8**	**-31.2**	**171.0**	**233.9**	**-26.9**

Table 11 : Anomalies (%) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of Cotton during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Weak			Moderate			Strong		
	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)
Nasik	82.3	10.0	-16.5	-21.2	-43.1	-13.7	-29.9	-76.9	-50.5
Dhule	23.3	32.4	8.5	-15.4	-31.1	-30.9	14.3	-18.5	-38.3
Nandurbar	13.8	-35.1	-39.3	-20.9	-24.0	-9.8	107.9	29.0	-35.2
Jalgaon	18.4	22.0	13.3	-13.7	-34.5	-24.2	-19.7	-37.1	-39.5
Nasik	**20.9**	**17.1**	**-9.2**	**-15.0**	**-33.3**	**-19.1**	**-0.4**	**-29.3**	**-41.1**
Pune	-57.6	-62.2	-26.4	27.3	6.4	-5.9	-20.5	-29.1	-0.3
Ahmednagar	30.8	-8.9	-9.8	-32.3	-41.3	-21.8	-39.9	-74.9	-29.0
Solapur	-69.7	-63.8	4.4	13.7	4.6	-18.5	12.8	-1.9	-31.0
Pune	**23.3**	**-12.9**	**-10.7**	**-28.7**	**-38.0**	**-15.2**	**-36.0**	**-69.7**	**-19.7**
Kolhapur	-43.3	-26.1	-20.2	6.3	-26.1	-11.1	-36.3	-44.6	-54.7
Satara	-31.0	-57.3	-43.1	36.5	13.0	-33.5	-36.2	-16.9	-8.6
Sangli	-34.7	-69.8	-57.0	1.4	-32.1	-30.8	-14.6	-15.9	-19.2
Kolhapur	**-33.1**	**-62.8**	**-42.9**	**18.9**	**-9.5**	**-27.1**	**-25.8**	**-16.9**	**-23.6**
Aurangabad	54.3	7.4	-4.9	-29.8	-43.1	-22.3	-9.6	-66.2	-54.0
Beed	45.4	-3.1	-1.5	-30.2	-38.2	-15.4	-17.1	-72.4	-45.1
Jalna.	21.7	7.4	6.9	-10.2	-21.0	-11.3	-11.6	-62.8	-48.5
Aurangabad	**40.2**	**5.0**	**0.2**	**-22.9**	**-34.0**	**-16.4**	**-12.4**	**-66.4**	**-49.5**
Parbhani	-11.3	-27.3	-21.1	-5.2	-24.5	-24.9	13.6	-56.3	-64.5
Hingoli	-11.9	-38.1	-26.7	4.5	-18.9	-24.8	-2.4	-69.2	-68.9
Nanded	-0.1	-32.5	-27.2	-10.4	-46.3	-38.0	4.1	-44.5	-44.3
Osmanabad	56.3	-16.1	-17.2	-64.3	-73.9	-8.8	-1.2	-71.6	-58.6
Latur	-73.3	-72.6	-38.0	-4.1	-32.0	-38.8	22.9	-35.3	-66.9

Latur	**-7.4**	**-32.0**	**-26.5**	**-6.8**	**-31.7**	**-27.0**	**7.4**	**-54.8**	**-62.4**
Buldhana	-14.1	-30.7	-24.3	-3.5	-28.6	-25.8	-2.1	-57.4	-54.9
Akola	-29.1	-18.1	-0.7	2.9	-25.7	-23.7	15.3	-38.3	-42.8
Wasim	-20.7	-45.5	-37.4	3.8	-15.0	-19.3	-70.4	-75.0	-23.2
Amrawati	-16.4	-34.5	-32.5	3.7	-30.7	-33.2	12.0	-31.9	-36.7
Yavatmal	-9.1	-27.4	-20.5	-3.3	-37.1	-33.7	-0.1	-45.0	-45.0
Amrawati	**-16.3**	**-28.7**	**-23.6**	**-0.2**	**-30.6**	**-27.0**	**1.9**	**-44.8**	**-40.0**
Wardha	-10.1	-30.1	-12.4	2.8	-25.3	-23.2	-20.0	-64.7	-47.2
Nagpur	17.6	3.1	-3.3	-17.4	-41.5	-25.5	3.4	-40.0	-44.3
Chandrapur	3.9	-11.9	2.9	-21.4	-53.9	-31.6	17.4	-27.9	-41.2
Gadchiroli	-4.8	-9.2	6.3	-47.6	-64.3	-32.4	-0.5	-18.3	-30.9
Nagpur	**0.2**	**-16.8**	**-1.7**	**-8.4**	**-36.9**	**-28.1**	**-4.9**	**-48.7**	**-40.9**
State	**2.4**	**-13.0**	**-17.2**	**-8.5**	**-32.6**	**-23.3**	**-0.8**	**-48.0**	**-40.2**

Pigeon pea

About 96% area under pigeon pea is rain dependent. Most often Pigeon pea is a part of the intercropping or traditional mixed cropping systems, providing the much needed resilience to the production system. Pigeon pea, particularly due to its long duration is often intercropped with cereals, short duration pulses and oilseeds. Pulse production is also benign to long-term sustainability of natural resources. Pigeon pea ranks second after chickpea among important pulse crops in India. Pigeon pea is one of the major pulse crops of Maharashtra grown in *kharif* season. Pigeon pea is also an indeterminate crop of more than 150 days duration and yield of Pigeon pea mostly depends upon the post monsoon rainfall as the crop will be under reproductive stage during this period. Productivity of Pigeon pea is nearly 600 kg/ha in Maharashtra state. Large area under pigeon pea is in Aurangabad, Latur and Amravati divisions.

Area, production and productivity of Pigeon pea in El Niño years compared to normal years presented in Table 12 revealed the following important observation;.

- The production and productivity of the pigeon pea in Maharashtra state was highly affected by El Nino years.

- The production in the state was declined by 30.1 per cent and productivity 22.2 percent during El Nino years.

- The reduction in productivity during El Nino years was 22.4 , 34.3, and 36.2 per cent in Aurangabad, Latur and Nagpur divisions respectively.

- The average area under Pigeon pea decreased only marginally by 2.2 per cent in the state during El Nino years.

The change in Pigeon pea production and productivity during different category of El Nino years (table 13) revealed the following :

- Weak El Nino years influenced the pigeon pea production negatively in all the divisions.

- Pigeon pea productivity during weak and strong El Nino years appears to be more negatively influenced compared to moderate El Nino years.

- Strong El Nino years more negatively affected the pigeon pea production of the state averaged all the districts (-45.3%) as compared to weak (-28.4%) and moderate (-16.6%) El Nino years.

- The productivity of pigeon pea during strong El Nino years declined more than 20 per cent in Nasik, Pune, Aurangabad, Latur, Amravati and Nagpur divisions.

Table 12 : Percent change in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of Pigeon pea during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Area			Production			Productivity		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Ratnagiri	5.5	5.2	5.6	3.0	3.0	-1.7	597.7	567.6	5.3
Raigad	13.1	12.4	5.4	7.3	7.5	-2.5	558.1	593.0	-5.9
Thane	27.2	30.1	-9.8	16.5	17.8	-7.4	566.0	586.0	-3.4
Sindudurg	1.0	1.1	-2.5	0.5	0.7	-29.2	224.6	217.6	3.2
Konkan	**11.7**	**12.2**	**-4.2**	**6.8**	**7.3**	**-6.1**	**486.6**	**491.0**	**-0.9**
Nasik	79.3	84.9	-6.5	45.9	55.0	-16.5	561.0	649.1	-13.6
Dhule	162.9	155.2	4.9	79.6	93.6	-15.0	509.2	599.6	-15.1
Jalgaon	214.8	218.5	-1.7	138.0	161.9	-14.8	645.6	749.2	-13.8
Nasik	**152.3**	**152.9**	**-0.4**	**87.8**	**103.5**	**-15.1**	**571.9**	**666.0**	**-14.1**
Pune	39.8	40.1	-0.7	20.3	21.3	-5.0	515.0	544.5	-5.4
Ahmednagar	140.6	162.4	-13.4	50.4	85.0	-40.7	346.8	512.5	-32.3
Solapur	246.8	303.1	-18.6	72.2	94.6	-23.7	301.8	356.0	-15.2
Pune	**142.4**	**168.5**	**-15.5**	**-**	**-**	**-**	**-**	**-**	**-**
Kolhapur	31.2	31.9	-2.3	13.9	14.9	-6.8	438.3	432.2	1.4
Satara	58.8	58.5	0.4	26.6	27.1	-2.0	439.2	430.3	2.1
Sangli	118.0	113.5	3.9	51.9	51.6	0.4	435.4	432.2	0.7
Kolhapur	**69.3**	**68.0**	**1.9**	**30.8**	**31.2**	**-1.4**	**437.6**	**431.6**	**1.4**
Aurangabad	398.1	425.5	-6.4	158.8	211.3	-24.8	390.6	487.2	-19.8
Beed	518.8	522.6	-0.7	182.4	272.5	-33.1	361.0	501.5	-28.0
Jalna.	440.0	443.0	-0.7	209.2	257.4	-18.7	458.9	570.8	-19.6
Aurangabad	**452.3**	**463.7**	**-2.5**	**183.5**	**247.0**	**-25.7**	**403.5**	**519.8**	**-22.4**
Parbhani	666.2	650.6	2.4	263.4	391.1	-32.6	406.5	604.6	-32.8
Nanded	541.7	547.6	-1.1	288.6	380.7	-24.2	551.1	683.2	-19.3
Osmanabad	771.7	788.7	-2.2	282.9	457.2	-38.1	358.4	554.4	-35.3

Latur	757.7	781.9	-3.1	351.7	797.3	-55.9	468.8	897.6	-47.8
Hingoli	346.8	340.1	2.0	186.7	319.5	-41.6	611.3	906.5	-32.6
Latur	**616.8**	**621.8**	**-0.8**	**274.7**	**469.2**	**-41.5**	**479.2**	**729.3**	**-34.3**
Buldhana	594.2	605.9	-1.9	363.6	437.8	-16.9	619.6	730.4	-15.2
Akola	677.0	651.0	4.0	500.6	621.0	-19.4	728.4	944.6	-22.9
Washim	500.2	499.4	0.2	374.6	362.9	3.2	761.0	730.5	4.2
Amrawati	894.3	942.0	-5.1	637.1	883.7	-27.9	723.7	940.8	-23.1
Yavatmal	1070.7	1113.7	-3.9	746.9	1058.4	-29.4	700.1	932.1	-24.9
Amravati	**747.3**	**762.4**	**-2.0**	**524.5**	**672.7**	**-22.0**	**706.6**	**855.7**	**-17.4**
Wardha	555.3	562.7	-1.3	338.0	551.0	-38.7	655.4	966.0	-32.2
Nagpur	525.6	541.4	-2.9	249.8	424.6	-41.2	480.6	766.0	-37.3
Bhandara	92.6	90.0	2.9	49.7	76.4	-35.0	546.5	833.3	-34.4
Chandrapur	270.7	276.6	-2.2	140.2	216.6	-35.3	498.7	730.8	-31.8
Gadchiroli	25.2	27.8	-9.4	12.9	25.2	-48.6	479.1	835.7	-42.7
Gondia	55.4	53.1	4.4	30.8	51.6	-40.3	583.7	951.7	-38.7
Nagpur	**254.1**	**258.6**	**-1.7**	**136.9**	**224.2**	**-39.0**	**540.6**	**847.2**	**-36.2**
State	**338.8**	**346.3**	**-2.2**	**184.2**	**263.4**	**-30.1**	**516.3**	**663.7**	**-22.2**

Table 13 : Anomalies (%) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of pigeon pea during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Weak			Moderate			Strong		
	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)
Ratnagiri	9.4	-11.8	-7.6	6.2	15.8	15.3	1.3	-9.0	8.2
Raigad	-11.4	-24.4	-11.5	4.8	10.1	10.3	22.9	6.7	-16.4
Thane	-33.6	-34.4	-10.5	9.5	22.2	11.6	-5.4	-10.1	-11.4
Sindudurg	-68.4	-100.0	-39.6	-76.3	-64.6	-30.4	137.2	76.9	79.7
Konkan	**-24.1**	**-31.1**	**-13.2**	**6.1**	**16.3**	**7.6**	**5.6**	**-3.5**	**2.8**
Nasik	-3.4	-6.7	-11.0	-1.9	-8.2	-5.9	-14.3	-34.6	-23.9
Dhule	-37.3	-48.7	-16.3	27.1	-4.6	-15.1	25.0	8.5	-13.8
Jalgaon	10.8	3.8	-11.1	-5.6	-8.7	-5.7	-10.3	-39.3	-24.7
Nasik	**-8.1**	**-13.9**	**-12.6**	**6.1**	**-7.4**	**-8.6**	**0.9**	**-24.1**	**-21.2**
Pune	-11.0	-1.4	4.3	10.4	-7.3	-10.8	-1.5	-6.1	-9.7
Ahmednagar	-29.6	-48.2	-29.0	0.8	-23.5	-24.4	-11.5	-50.3	-43.7
Solapur	-30.8	2.2	25.7	-20.9	-25.8	-27.7	-4.0	-47.4	-43.7
Pune	**-28.9**	**-19.5**	**-2.4**	**-11.4**	**-22.8**	**-20.0**	**-6.2**	**-44.2**	**-30.6**
Kolhapur	-21.7	-28.4	-4.2	3.4	2.3	21.3	11.2	5.7	-12.9
Satara	-24.8	-26.3	-3.8	12.0	10.6	22.0	14.1	9.6	-12.0
Sangli	-0.8	-4.5	-4.2	3.1	5.1	21.5	9.4	0.7	-15.0
Kolhapur	**-10.9**	**-14.6**	**-4.1**	**5.7**	**6.2**	**21.6**	**11.1**	**4.1**	**-13.3**
Aurangabad	-12.5	-2.0	10.1	-3.5	-19.9	-21.8	-3.3	-52.5	-47.9
Beed	0.8	-3.5	2.9	-5.7	-38.1	-32.8	2.7	-57.6	-54.1
Jalna.	12.9	5.9	-7.7	-3.5	-7.1	-6.4	-11.5	-54.9	-44.6
Aurangabad	**0.6**	**0.2**	**1.3**	**-4.3**	**-22.1**	**-19.7**	**-3.7**	**-55.2**	**-48.7**
Parbhani	-2.4	-43.2	-40.6	3.1	-7.0	-9.9	6.5	-47.7	-47.8

Nanded	9.1	-11.5	-11.5	-6.2	-9.6	-5.7	-6.2	-51.5	-40.8
Osmanabad	18.5	-12.0	-21.3	-10.1	-32.6	-25.6	-14.8	-69.8	-59.1
Latur	6.4	-50.8	-42.4	-12.6	-41.3	-30.5	-3.2	-75.6	-70.3
Hingoli	-10.2	-31.8	-15.8	-22.1	-35.5	-14.0	38.2	-57.4	-67.9
Latur	**6.3**	**-33.0**	**-26.5**	**-8.6**	**-27.9**	**-17.6**	**-0.1**	**-63.4**	**-58.7**
Buldhana	5.3	-20.0	-23.0	-5.8	3.8	5.9	-5.3	-34.6	-28.4
Akola	-19.7	-47.2	-34.4	24.2	9.1	-11.2	7.4	-20.1	-23.0
Washim	1.1	0.4	-0.6	-8.7	27.7	38.1	8.1	-18.4	-25.0
Amrawati	2.7	-31.2	-32.1	-8.2	-14.4	-7.9	-9.6	-38.1	-29.2
Yavatmal	5.6	-30.8	-33.5	-6.1	-17.2	-10.8	-11.1	-40.3	-30.4
Amravati	**-0.1**	**-29.2**	**-26.0**	**-1.7**	**-4.0**	**1.0**	**-4.1**	**-32.9**	**-27.2**
Wardha	9.8	-41.1	-42.3	-8.5	-27.0	-17.0	-5.3	-47.9	-37.1
Nagpur	3.1	-34.5	-33.7	-13.2	-32.1	-21.2	1.4	-56.9	-56.9
Bhandara	-1.1	-43.7	-38.7	1.2	-18.9	-19.8	8.7	-42.4	-44.8
Chandrapur	4.8	-41.8	-42.3	-10.1	-30.0	-23.6	-1.2	-34.0	-29.3
Gadchiroli	4.4	-47.0	-62.7	-14.5	-35.4	-20.0	-18.1	-63.2	-45.3
Gondia	1.2	-49.0	-46.3	-10.5	-28.3	-16.9	22.5	-43.8	-52.8
Nagpur	**5.6**	**-39.7**	**-44.5**	**-10.1**	**-28.9**	**-19.5**	**-0.7**	**-48.3**	**-44.5**
State	**0.6**	**-28.4**	**-23.2**	**-5.1**	**-16.6**	**-9.1**	**-2.0**	**-45.3**	**-34.4**

Soybean

Soybean has emerged as one of the important oilseed crop meeting the domestic demand for edible oil,. Maharashtra is a major soybean producing state with higher productivity. Soybean (Glycine max (L.) Merill). is an important oil yielding commercial crop useful not only for oil extraction but also for oil cake very useful for animal feed and human diet. Now a days Soybean crop cultivation is increasing especially in Vidharba and Marathwada regions of Maharashtra state. In Maharashtra especially in Marathwada region; Parbhani, Hingoli, Nanded, Latur and Osmanabad are the major Soybean producing districts.

The districtwise averages of area, production and productivity of soybean during the years of El Niño compared to the normal years are given in Table 14.

The main findings emerging from the analysis of data in (Table 14) are :

- Average area under the soybean crop increased during El Nino years in all the divisions.
- However production and productivity of soybean crop were negatively influenced by El Nino years in all the divisions.
- The decline in production by 21.6 per cent and productivity 20.1 per cent was observed during El Niño years in the state.
- The productivity of soybean was more negatively influenced by El Nino years as compared to production and area.
- Production and productivity of soybean crop was more declined in Aurangabad, Latur, Amravati and Nagpur divisions during the El Nino years as compared to normal years.

The change in soybean production and productivity during different category of El Nino years (Table 15) revealed as

- The production and productivity of soybean was more negatively influenced by strong El Nino years as compared to weak and moderate El Nino years in all the divisions.

- The average production and productivity of soybean during weak, moderate and strong El Nino years was decreased by 3.1 & 16.5 per cent, 31.6 & 13.2 per cent and 30.0 & 30.5 per cent respectively in the state.

- In the weak El Nino years productivity of soybean was increased compared to normal in Nasik and Pune divisions.

- The average production and productivity of soybean declined by more than 50 per cent in Nagpur division in strong El Nino years.

Table 14 : Percent change in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of soybean during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Area			Production			Productivity (kg/ha)		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Nasik	268.9	250.1	7.5	356.8	372.9	-4.3	1227.6	1458.3	-15.8
Dhule	77.0	67.1	14.7	76.3	96.9	-21.3	1134.8	1314.0	-13.6
Jalgaon	135.2	79.3	70.5	202.7	142.5	42.2	1601.7	1522.0	5.2
Nandurbar	190.0	182.6	4.0	202.7	283.1	-28.4	1151.6	1437.3	-19.9
Nasik	**167.8**	**144.8**	**15.9**	**209.6**	**223.9**	**-6.4**	**1278.9**	**1432.9**	**-10.7**
Pune	35.3	59.9	-41.0	81.0	100.1	-19.0	1704.2	1750.3	-2.6
Ahmednagar	289.7	240.6	20.4	274.8	277.4	-1.0	938.0	1114.2	-15.8
Solapur	33.9	35.9	-5.7	25.0	37.4	-33.1	980.8	1305.6	-24.9
Pune	**119.6**	**112.1**	**6.7**	**126.9**	**138.3**	**-8.2**	**1207.7**	**1390.0**	**-13.1**
Kolhapur	543.1	500.9	8.4	886.3	1075.1	-17.6	1613.4	1941.8	-16.9
Satara	265.0	248.4	6.7	431.7	444.3	-2.8	1461.2	1658.1	-11.9
Sangli	520.9	477.1	9.2	791.7	901.2	-12.2	1470.4	1789.7	-17.8
Kolhapur	**443.0**	**408.8**	**8.4**	**703.2**	**806.9**	**-12.8**	**1515.0**	**1796.5**	**-15.7**
Aurangabad	66.2	69.5	-4.8	65.0	83.9	-22.5	1108.1	1219.2	-9.1
Beed	402.7	381.7	5.5	329.2	428.6	-23.2	819.3	1150.2	-28.8
Jalna.	332.5	314.0	5.9	319.7	398.9	-19.9	965.7	1188.5	-18.7
Aurangabad	**267.1**	**255.1**	**4.7**	**238.0**	**303.8**	**-21.7**	**964.4**	**1186.0**	**-18.7**
Parbhani	650.7	576.5	12.9	581.3	706.5	-17.7	995.2	1243.6	-20.0
Nanded	1018.3	977.0	4.2	743.1	1035.8	-28.3	872.6	1212.3	-28.0
Osmanabad	429.3	398.2	7.8	395.4	474.2	-16.6	828.5	928.8	-10.8
Latur	1443.9	1253.1	15.2	1342.4	1876.2	-28.5	853.3	1302.1	-34.5
Hingoli	1213.7	1212.5	0.1	1252.2	1639.5	-23.6	1083.7	1354.2	-20.0
Latur	**951.2**	**883.5**	**7.7**	**862.9**	**1146.4**	**-24.7**	**926.7**	**1208.2**	**-23.3**

Buldhana	1512.6	1129.7	33.9	1115.2	1655.1	-32.6	874.8	1096.0	-20.2
Akola	996.9	843.7	18.2	739.0	1098.6	-32.7	891.2	1126.2	-20.9
Amrawati	2010.8	1683.7	19.4	1404.7	1824.7	-23.0	771.1	1067.8	-27.8
Yavatmal	1687.0	1101.9	53.1	1058.6	1227.4	-13.8	776.6	1153.4	-32.7
Wasim	2293.2	1921.9	19.3	1489.3	2333.7	-36.2	742.4	1233.8	-39.8
Amravati	**1700.1**	**1336.2**	**27.2**	**1161.3**	**1627.9**	**-28.7**	**811.2**	**1135.4**	**-28.6**
Wardha	1409.2	1108.9	27.1	1183.9	1143.3	3.6	807.0	1043.1	-22.6
Nagpur	2130.8	1869.6	14.0	1640.1	1763.3	-7.0	744.0	963.0	-22.7
Bhandara	92.7	175.2	-47.1	69.9	254.6	-72.5	730.4	1092.1	-33.1
Chandrapur	982.3	833.0	17.9	780.3	944.2	-17.4	651.2	971.7	-33.0
Gadchiroli	31.2	111.2	-72.0	22.8	153.9	-85.2	627.1	927.4	-32.4
Nagpur	**929.2**	**819.6**	**13.4**	**739.4**	**851.8**	**-13.2**	**711.9**	**999.4**	**-28.8**
State	**752.2**	**646.5**	**16.4**	**637.9**	**813.3**	**-21.6**	**1015.2**	**1270.2**	**-20.1**

Table 15 : Anomalies (%) in average area sown (00'ha), production (00' tons) and productivity (kg/ha) of Soybean during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Weak			Moderate			Strong		
	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)
Nasik	48.8	51.7	9.0	-12.4	-31.4	-23.0	-13.8	-33.3	-33.4
Dhule	0.8	-12.0	-1.8	25.7	-9.2	-3.2	17.7	-42.6	-35.9
Jalgaon	154.7	145.0	18.8	10.1	33.1	43.3	46.7	-51.3	-46.4
Nandurbar	-25.5	-52.4	-26.8	-13.5	-25.3	1.0	51.1	-7.5	-33.8
Nasik	**34.3**	**26.7**	**0.1**	**-5.3**	**-16.8**	**5.2**	**18.6**	**-29.0**	**-37.5**
Pune	-43.2	-37.0	24.4	-75.0	-80.0	-28.3	-4.8	59.9	-4.0
Ahmednagar	97.7	82.9	1.5	2.8	-12.3	-8.8	-39.3	-73.4	-40.1
Solapur	-2.6	37.4	27.5	-55.5	-66.1	-47.7	41.0	-70.6	-54.5
Pune	**61.9**	**49.9**	**19.2**	**-17.3**	**-33.5**	**-29.2**	**-24.6**	**-41.0**	**-29.4**
Kolhapur	25.5	-0.8	-11.6	13.1	-10.5	-14.3	-13.3	-41.4	-24.8
Satara	45.5	27.8	-7.0	-25.7	-23.5	-3.0	0.2	-12.9	-25.6
Sangli	25.8	6.4	-14.3	14.2	-5.1	-12.6	-12.4	-37.7	-26.6
Kolhapur	**29.7**	**7.1**	**-11.1**	**5.7**	**-10.9**	**-10.3**	**-10.2**	**-34.8**	**-25.6**
Aurangabad	64.9	17.2	-18.9	-31.0	-47.5	0.1	-48.2	-37.2	-8.5
Beed	67.3	-11.3	-34.2	-22.2	-52.8	-24.2	-28.6	-5.5	-27.9
Jalna.	65.4	-23.0	-29.5	-46.6	-49.7	4.3	-1.1	13.2	-31.0
Aurangabad	**66.3**	**-13.8**	**-27.4**	**-33.0**	**-51.0**	**-6.3**	**-19.1**	**-0.2**	**-22.3**
Parbhani	62.8	-19.2	-43.3	-3.5	-10.6	3.8	-20.7	-23.4	-20.3
Nanded	70.0	-7.7	-46.8	-21.1	-53.6	-21.4	-36.2	-23.4	-15.9
Osmanabad	61.6	-16.8	-16.9	-54.1	-78.6	-16.8	15.9	45.5	1.3
Latur	71.6	-39.2	-62.0	-33.1	-63.3	-35.3	7.2	17.2	-6.1
Hingoli	9.4	-48.0	-52.1	-30.1	-47.4	-10.6	21.0	24.6	2.8

Latur	**52.1**	**-31.7**	**-45.9**	**-27.7**	**-51.8**	**-16.1**	**-1.5**	**9.3**	**-7.9**
Buldhana	96.6	8.4	-17.0	-7.6	-44.4	-3.2	12.7	-61.9	-40.3
Akola	35.6	-39.6	-24.2	14.9	-2.7	-8.6	4.0	-55.9	-29.8
Amrawati	49.4	-2.8	-27.6	6.4	-14.6	-14.9	2.5	-51.7	-40.8
Yavatmal	127.0	31.9	-43.6	25.0	-30.8	-22.9	7.3	-42.3	-31.5
Wasim	19.0	-23.0	-31.5	-18.4	-57.6	-33.1	57.3	-27.9	-54.9
Amravati	**59.7**	**-6.1**	**-29.0**	**1.1**	**-33.8**	**-17.0**	**21.0**	**-46.1**	**-39.7**
Wardha	74.4	59.5	-14.6	22.3	-3.3	-20.2	-15.5	-45.5	-33.1
Nagpur	28.1	13.1	-16.6	16.9	8.1	-8.7	-3.1	-42.1	-42.9
Bhandara	-50.1	-74.1	-31.5	-49.6	-69.9	-20.7	-41.6	-73.7	-47.2
Chandrapur	85.4	54.3	-6.8	21.3	-27.4	-26.4	-52.9	-79.0	-65.7
Gadchiroli	-67.3	-77.7	4.8	-65.2	-87.7	-31.7	-83.4	-90.3	-70.2
Nagpur	**46.4**	**26.2**	**-13.6**	**14.2**	**-11.0**	**-21.4**	**-20.4**	**-54.8**	**-51.3**
State	**52.3**	**-3.1**	**-16.5**	**-4.7**	**-31.6**	**-13.2**	**1.4**	**-30.0**	**-30.5**

Black gram

Among pulses, black gram is one of the most important crop in the state. Black gram has been distributed mainly in tropical to subtropical countries where it is grown in *Kharif* and summer seasons. In India, black gram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh and Karnataka. In Maharashtra it occupies an area of 3.37 lakh ha with total production of 1.83 lakh tonnes and the productivity of 542 kg ha^{-1} (Anonymous, 2016).

From the districtwise averages of area, production and productivity of black gram during the years with El Niño compared to the normal years (Table16) The following conclusions could be drawn :

- Production and productivity of black gram crop are negatively influenced during El Nino years in all the divisions of the state.
- In most of the districts production of black gram decreased by more than 20 per cent in El Nino years as compared to normal.
- The productivity of black gram declined by more than 40 per cent in El Nino years as compared to normal in the state averaged over all the districts.
- Average area under black gram decreased by 6.2 per cent but the production and productivity decreased by 27.3 and 43.8 per cent respectively during El Niño years in the state.

From the change in production and productivity of pigeon pea during different category of El Nino years (Table 17) The following interpretations were as

- The productivity of black gram during strong El Nino years declined more than 30 per cent in Nasik, Pune, Aurangabad, Latur, Amravati and Nagpur divisions.

- Strong El Nino years more negatively affected the black gram production and productivity of all the divisions in the state.

- The average production and productivity of black gram during weak, moderate and strong El Nino years decreased by 37.7 & 11.7, 9.1 per cent & 11.9 per cent and 35.3 & 33.5 per cent respectively in the state.

- The production of black gram was declined by more than 50 per cent in strong El Nino years as compared to normal in Pune and Amravati divisions.

Table 16 : Percent change in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of black gram during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Area			Production			Productivity		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Thane	40.7	47.5	-14.4	29.4	33.5	-12.2	429.7	702.1	-38.8
Raigad	6.4	7.1	-9.8	4.4	4.4	-0.9	393.4	663.5	-40.7
Ratnagiri	3.8	3.5	9.0	2.8	2.4	16.4	407.7	600.7	-32.1
Sindudurg	3.4	3.5	-3.3	2.6	2.1	23.4	399.9	665.7	-39.9
Konkan	**13.6**	**15.4**	**-11.9**	**9.8**	**10.6**	**-7.7**	**407.6**	**658.0**	**-38.0**
Nasik	105.4	123.9	-14.9	63.9	91.8	-30.5	390.1	727.2	-46.4
Dhule	206.5	223.6	-7.6	113.6	140.1	-19.0	366.4	606.4	-39.6
Nandurbar	271.8	166.2	63.5	65.2	108.6	-40.0	304.6	648.7	-53.1
Jalgaon	539.0	640.0	-15.8	273.8	312.9	-12.5	467.2	574.8	-18.7
Nasik	**280.7**	**288.4**	**-2.7**	**129.1**	**163.3**	**-21.0**	**382.1**	**639.3**	**-40.2**
Ahmednagar	50.4	44.6	13.0	22.1	21.2	4.2	271.3	430.0	-36.9
Pune	26.7	26.9	-0.9	15.3	16.1	-5.4	371.2	689.0	-46.1
Solapur	42.4	42.2	0.5	18.3	25.6	-28.4	281.9	516.5	-45.4
Pune	**39.8**	**37.9**	**5.1**	**18.6**	**21.0**	**-11.5**	**308.1**	**545.2**	**-43.5**
Satara	46.9	46.1	1.7	28.4	28.3	0.3	377.6	618.1	-38.9
Sangli	68.4	74.6	-8.3	36.2	44.7	-19.1	311.2	549.6	-43.4
Kolhapur	21.6	24.0	-10.4	12.3	13.3	-7.5	346.5	507.6	-31.7
Kolhapur	**45.6**	**48.2**	**-5.5**	**25.6**	**28.8**	**-11.0**	**345.1**	**558.4**	**-38.2**
Aurangabad	93.9	81.6	15.1	36.0	46.4	-22.5	294.7	630.7	-53.3
Jalna.	175.4	165.4	6.1	62.9	85.0	-26.0	271.6	498.0	-45.5
Beed	103.1	93.4	10.4	36.4	46.5	-21.6	264.3	470.7	-43.8
Aurangabad	**124.1**	**113.4**	**9.4**	**45.1**	**59.3**	**-23.9**	**276.9**	**533.1**	**-48.1**
Latur	483.0	522.3	-7.5	200.4	223.4	-10.3	292.5	465.9	-37.2
Osmanabad	335.7	342.8	-2.1	110.1	141.6	-22.2	243.4	418.1	-41.8

Nanded	424.3	438.4	-3.2	146.4	230.0	-36.4	306.3	507.1	-39.6
Parbhani	223.9	216.5	3.4	63.2	86.4	-26.9	202.2	408.3	-50.5
Hingoli	151.2	157.0	-3.7	51.8	86.5	-40.1	216.4	538.6	-59.8
Latur	**323.6**	**335.4**	**-3.5**	**114.4**	**153.6**	**-25.5**	**252.2**	**467.6**	**-46.1**
Buldhana	518.8	556.6	-6.8	184.8	296.3	-37.6	355.0	542.7	-34.6
Akola	384.3	463.0	-17.0	165.6	248.1	-33.3	335.3	508.4	-34.1
Washim	268.3	371.3	-27.7	136.8	226.7	-39.6	350.3	596.8	-41.3
Amrawati	76.6	84.7	-9.5	21.9	38.5	-43.1	206.1	433.0	-52.4
Yavatmal	153.2	174.8	-12.4	48.5	85.4	-43.2	223.1	472.1	-52.7
Amravati	**280.3**	**330.1**	**-15.1**	**111.5**	**179.0**	**-37.7**	**294.0**	**510.6**	**-42.4**
Wardha	7.0	8.8	-20.2	1.8	5.0	-64.9	195.2	511.0	-61.8
Nagpur	20.2	22.6	-10.5	6.4	9.9	-35.0	209.0	464.1	-55.0
Bhandara	3.9	4.3	-9.1	2.4	2.2	11.6	236.3	467.7	-49.5
Gondia	1.4	1.7	-16.8	0.7	0.8	-14.3	254.2	496.6	-48.8
Chandrapur	6.4	8.1	-21.7	2.8	4.1	-31.6	237.5	486.2	-51.1
Gadchiroli	1.6	1.4	9.3	1.0	0.9	14.1	238.3	458.0	-48.0
Nagpur	**6.7**	**7.8**	**-13.8**	**2.5**	**3.8**	**-33.9**	**228.4**	**480.6**	**-52.5**
State	**147.4**	**157.2**	**-6.2**	**59.6**	**82.1**	**-27.3**	**304.6**	**541.6**	**-43.8**

Table 17 : Anomalies (%) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of black gram during El Nino years compared to normal years in Maharashtra (1985-2017).

District	Weak			Moderate			Strong		
	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)
Thane	-26.4	-4.5	16.5	4.7	-2.2	-7.7	-21.6	-29.8	-12.8
Raigad	-25.3	5.4	21.5	1.5	12.9	-7.0	-5.5	-20.9	-19.7
Ratnagiri	-14.7	27.0	34.2	-0.4	-15.3	3.1	42.2	37.6	0.9
Sindudurg	-23.9	28.8	21.1	28.4	32.8	-3.4	-14.4	8.7	-18.3
Konkan	**-25.4**	**-0.1**	**23.0**	**5.4**	**0.3**	**-4.0**	**-15.7**	**-23.3**	**-12.8**
Nasik	-23.0	-14.7	3.9	-0.1	-29.0	-26.4	-21.5	-47.7	-32.6
Dhule	-58.6	-71.7	-30.1	18.9	14.4	-7.2	16.7	0.5	-13.3
Nandurbar	-4.7	-44.7	-41.5	224.3	-5.6	-18.1	-29.0	-69.6	-57.6
Jalgaon	-24.6	-23.8	-10.5	-6.2	13.4	2.5	-16.6	-27.0	-26.9
Nasik	**-28.1**	**-36.3**	**-18.9**	**32.5**	**4.5**	**-13.2**	**-12.4**	**-31.1**	**-33.1**
Ahmednagar	36.0	80.7	43.1	-0.2	-4.5	-2.6	3.1	-63.5	-41.9
Pune	16.3	38.3	2.3	-8.1	-0.9	1.2	-10.9	-53.5	-40.1
Solapur	54.7	32.7	20.0	-46.7	-55.1	-6.6	-6.5	-62.9	-52.3
Pune	**38.3**	**50.3**	**18.6**	**-19.4**	**-24.2**	**-2.3**	**-3.7**	**-60.7**	**-44.4**
Satara	-3.1	-16.4	-12.6	-1.3	6.9	5.6	9.6	10.4	0.3
Sangli	-2.6	16.2	30.6	-21.9	-59.2	-42.0	-0.5	-14.5	-24.5
Kolhapur	-9.9	5.0	29.6	4.0	-10.0	-0.5	-25.1	-17.5	5.5
Kolhapur	**-4.0**	**3.8**	**14.4**	**-11.0**	**-29.9**	**-11.9**	**-1.4**	**-6.8**	**-6.3**
Aurangabad	-55.1	-59.8	-27.6	50.5	-1.4	-16.4	49.8	-6.2	-43.0
Jalna.	15.3	-24.3	-30.4	-2.9	-7.7	-7.4	5.8	-45.9	-37.4
Beed	15.0	7.6	9.1	1.8	-16.6	-10.3	14.6	-55.9	-47.7
Aurangabad	**-1.7**	**-25.2**	**-17.7**	**11.2**	**-8.4**	**-11.8**	**18.8**	**-38.2**	**-42.6**

Latur	-8.9	-69.4	-53.4	10.7	-20.3	-49.4	-24.4	58.9	-29.9
Osmanabad	33.9	-2.8	-30.2	-7.6	-30.1	-37.0	-32.5	-33.8	-48.4
Nanded	7.4	-33.3	-36.7	5.0	-12.3	-24.9	-22.0	-63.5	-48.9
Parbhani	-22.7	-63.0	-52.8	19.1	6.7	-26.4	13.9	-24.5	-43.4
Hingoli	-11.5	-45.3	-44.5	20.0	4.1	-18.1	-19.8	-79.2	-74.2
Latur	**2.1**	**-42.9**	**-43.5**	**7.4**	**-13.9**	**-30.7**	**-20.1**	**-19.8**	**-49.9**
Buldhana	-15.4	-29.2	-22.3	8.8	-23.7	-28.4	-13.7	-59.9	-52.0
Akola	-69.4	-80.8	-35.8	17.4	3.1	-13.1	1.0	-22.0	-29.5
Washim	-21.6	-30.3	-17.7	15.3	-5.0	-27.8	-76.8	-83.7	-29.0
Amrawati	-34.3	-55.9	-32.1	-19.4	-38.3	-15.9	25.2	-35.1	-36.8
Yavatmal	-41.6	-63.7	-37.1	2.3	-22.4	-26.1	2.3	-43.5	-43.2
Amravati	**-35.7**	**-48.2**	**-28.3**	**10.5**	**-12.0**	**-22.7**	**-20.1**	**-52.8**	**-37.9**
Wardha	-54.4	-80.0	-44.7	-17.3	-54.9	-11.0	11.2	-59.9	-55.0
Nagpur	-18.8	-46.2	-30.1	-10.3	-21.9	-8.4	-2.5	-37.0	-42.1
Bhandara	-53.6	-69.3	-13.2	-24.6	-7.9	5.1	50.8	111.9	-40.7
Gondia	34.4	28.6	-18.2	-42.4	28.6	26.7	-42.4	-100.0	-52.9
Chandrapur	-59.0	-59.4	-16.5	-1.5	-8.6	-3.6	-4.6	-26.8	-37.5
Gadchiroli	17.1	14.1	-30.4	-29.7	14.1	0.3	40.5	14.1	-10.3
Nagpur	**-32.5**	**-53.3**	**-25.7**	**-13.2**	**-22.3**	**1.6**	**4.4**	**-26.2**	**-40.2**
State	**-16.9**	**-37.7**	**-11.7**	**12.9**	**-9.1**	**-11.9**	**-14.7**	**-35.3**	**-33.5**

Green gram

Green gram (Vigna radiata L. Wilczek) is one of the most important pulse crops of global economic importance. Green gram has originated in India and is a native of India and central Asia. It is grown in these areas since prehistoric period. Green gram ranks third among all the pulses in India after chickpea and Pigeon pea. In Maharashtra green gram is grown to the extent of 5.11 lakhs ha, with production of 2.89 lakh tones and productivity of 566 kg ha^{-1} (Anonymous, 2016).

The districtwise averages of area, production and productivity of green gram during the years with El Niño compared to the normal years are given in Table 18.

The interference drawn from the data shown in table 18 are :

- The production and productivity of the green gram for the state was highly negatively affected by El Nino years.
- The production in the state was declined by 33.5 per cent and productivity 16.9 percent during El Nino years as compared to normal years.
- The reduction in production during El Nino years compared to normal was more than 20 per cent in all the divisions of Maharashtra state.
- The production of green gram was more negatively influenced as compared to area and productivity in all the divisions.

The change in green gram production and productivity during different category of El Nino years presented in Table 19 showed that.

- The production and productivity of green gram in the state averaged over all the districts was more negatively influenced by strong El Nino years as compared to weak and moderate El Nino years.

- The average production and productivity of green gram during weak, moderate and strong El Nino year was decreased by 42.1 & 6.9 per cent , 14.3 & 10.6 per cent and 44.2 & 33.1 per cent respectively in the state.

- In the weak El Nino years productivity of green gram was positively influenced in all districts of Nagpur division .

- In the strong El Nino years average production and productivity of green gram was declined more than 30 per cent in most of the districts of Maharashtra state.

Table 18 : Percent change in average area sown (00'ha), production (00' tons) and productivity (kg/ha) of green gram during El Nino years compared to normal years in Maharashtra (1985-2017).

Districts	Area			Production			Productivity (Kg/ha)		
	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)	El Nino	Normal	PC (%)
Ratnagiri	1.4	1.8	-19.8	0.7	0.9	-23.4	505.9	466.3	8.5
Raigad	2.2	3.2	-30.4	1.0	1.6	-38.5	492.1	511.2	-3.7
Thane	5.9	7.2	-18.5	3.0	3.8	-21.7	514.6	556.6	-7.6
Sindudurg	1.1	1.0	14.4	0.6	0.9	-35.3	481.9	582.0	-17.2
Konkan	**2.7**	**3.3**	**-19.1**	**1.3**	**1.8**	**-27.4**	**498.6**	**529.0**	**-5.7**
Nasik	80.1	83.8	-4.4	55.3	55.7	-0.7	650.3	637.0	2.1
Dhule	310.3	318.7	-2.6	160.3	204.3	-21.6	490.9	609.1	-19.4
Nandurbar	112.3	145.1	-22.6	54.5	88.6	-38.5	436.8	612.1	-28.6
Jalgaon	369.9	392.9	-5.9	166.7	208.7	-20.1	449.0	543.9	-17.4
Nasik	**218.2**	**235.1**	**-7.2**	**109.2**	**139.3**	**-21.6**	**506.7**	**600.5**	**-15.6**
Pune	63.7	75.1	-15.2	23.4	35.8	-34.5	430.8	466.9	-7.7
Ahmednagar	155.3	144.3	7.6	56.4	65.6	-14.0	459.6	416.8	10.3
Solapur	26.5	29.9	-11.4	10.6	14.7	-27.7	408.0	506.0	-19.4
Pune	**81.8**	**83.1**	**-1.6**	**30.2**	**38.7**	**-22.0**	**432.8**	**463.2**	**-6.6**
Kolhapur	18.6	21.1	-11.7	8.6	10.9	-21.0	461.9	518.3	-10.9
Satara	61.3	51.2	19.8	22.7	28.9	-21.4	461.3	564.6	-18.3
Sangli	53.2	56.2	-5.4	22.7	28.5	-20.4	409.5	451.6	-9.3
Kolhapur	**44.4**	**42.8**	**3.6**	**18.0**	**22.8**	**-20.9**	**444.2**	**511.5**	**-13.2**
Aurangabad	137.2	151.6	-9.5	57.3	71.9	-20.4	415.9	529.9	-21.5
Jalna.	492.3	487.2	1.0	142.3	229.7	-38.0	288.0	461.5	-37.6
Beed	150.9	161.6	-6.6	58.8	63.4	-7.2	401.5	427.3	-6.0
Aurangabad	**260.1**	**266.8**	**-2.5**	**86.1**	**121.7**	**-29.2**	**368.5**	**472.9**	**-22.1**
Nanded	323.0	335.1	-3.6	105.4	161.0	-34.6	314.4	484.9	-35.2

Osmanabad	157.4	150.4	4.7	42.6	49.9	-14.7	243.9	331.0	-26.3
Parbhani	708.3	720.4	-1.7	195.4	276.0	-29.2	246.9	408.0	-39.5
Latur	212.9	225.1	-5.4	52.7	84.7	-37.8	243.4	392.8	-38.0
Hingoli	198.6	214.5	-7.4	62.2	105.1	-40.8	283.1	479.3	-40.9
Latur	**320.0**	**329.1**	**-2.8**	**91.7**	**135.4**	**-32.3**	**266.3**	**419.2**	**-36.5**
Buldhana	539.1	598.7	-10.0	182.6	320.0	-42.9	335.8	542.3	-38.1
Akola	715.3	826.2	-13.4	233.1	424.7	-45.1	300.8	494.3	-39.1
Amrawati	487.9	532.7	-8.4	145.9	224.3	-35.0	295.8	433.0	-31.7
Yavatmal	297.8	347.5	-14.3	98.9	166.0	-40.4	276.1	466.2	-40.8
Washim	257.1	364.7	-29.5	106.9	192.6	-44.5	363.5	533.1	-31.8
Amravati	**459.4**	**534.0**	**-14.0**	**153.5**	**265.5**	**-42.2**	**314.4**	**493.8**	**-36.3**
Wardha	18.4	16.8	9.5	4.6	6.6	-30.5	417.0	409.6	1.8
Nagpur	27.3	31.4	-13.1	8.9	12.1	-26.1	384.6	391.4	-1.8
Bhandara	2.5	3.6	-30.8	1.3	1.6	-19.1	447.6	426.8	4.9
Chandrapur	19.4	24.2	-19.8	7.4	10.5	-29.1	446.9	407.4	9.7
Gadchiroli	1.3	1.8	-24.6	1.0	1.0	-0.7	534.5	376.4	42.0
Gondia	2.9	0.9	226.4	1.1	0.8	38.5	277.1	404.4	-31.5
Nagpur	**10.7**	**12.4**	**-13.6**	**4.0**	**5.2**	**-23.9**	**418.1**	**401.3**	**4.2**
State	**182.2**	**197.8**	**-7.9**	**63.5**	**95.5**	**-33.5**	**399.1**	**480.1**	**-16.9**

Table 19 : Anomalies (%) in average area sown (00'ha), production (00'tons) and productivity (kg/ha) of Green gram during El Nino years compared to normal years in Maharashtra (1985-2017).

Districts	Weak			Moderate			Strong		
	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)	Area	Production	Productivity (kg/ha)
Ratnagiri	-24.5	-26.5	6.2	-29.3	-17.3	7.9	-5.7	-26.5	11.4
Raigad	-58.2	-59.0	-3.2	-47.8	-38.5	10.1	14.9	-18.0	-18.1
Thane	-16.9	-21.7	-11.1	-12.3	-4.3	1.1	-26.2	-39.1	-12.7
Sindudurg	3.0	-29.5	-14.9	3.0	-47.1	-13.3	37.3	-29.5	-23.3
Konkan	**-26.5**	**-31.6**	**-6.4**	**-22.1**	**-19.1**	**0.8**	**-8.8**	**-31.6**	**-11.6**
Nasik	1.9	26.9	27.6	-2.4	11.3	8.8	-12.6	-40.3	-30.1
Dhule	-32.0	-48.1	-21.3	14.2	3.9	-6.1	9.9	-20.5	-30.8
Nandurbar	-13.9	-41.3	-31.4	10.3	7.8	-6.0	-64.2	-81.9	-48.5
Jalgaon	-10.7	-23.8	-16.3	-2.2	0.5	-1.3	-4.7	-37.1	-34.7
Nasik	**-17.3**	**-30.4**	**-9.8**	**5.3**	**4.0**	**-1.0**	**-9.6**	**-38.4**	**-36.0**
Pune	-28.6	-30.1	8.7	-24.8	-19.6	8.8	7.8	-53.9	-40.6
Ahmednagar	-18.3	-11.6	20.1	15.0	33.4	24.7	25.9	-63.8	-13.9
Solapur	-0.7	20.1	20.6	-43.9	-59.2	-32.7	10.5	-43.9	-46.0
Pune	**-19.3**	**-13.3**	**16.5**	**-4.1**	**5.3**	**-1.6**	**18.6**	**-58.2**	**-34.6**
Kolhapur	7.4	-2.5	-9.6	-8.8	-17.7	-11.7	-33.7	-42.9	-11.4
Satara	-2.3	-22.7	-19.5	43.6	-25.6	-9.3	18.1	-15.8	-26.2
Sangli	27.4	19.4	4.2	-26.2	-42.1	-8.7	-17.3	-38.6	-23.5
Kolhapur	**12.3**	**-1.9**	**-9.2**	**4.5**	**-31.2**	**-9.9**	**-5.9**	**-29.6**	**-20.4**
Aurangabad	-47.9	-43.0	-10.7	20.5	-2.3	-19.7	-1.2	-15.9	-34.1
Jalna.	-6.6	-33.8	-27.2	7.7	-20.9	-25.1	2.1	-59.4	-60.5
Beed	-52.1	-25.3	31.6	11.4	4.2	-1.0	20.9	-0.6	-48.7
Aurangabad	**-23.6**	**-34.2**	**-3.3**	**10.9**	**-12.9**	**-15.8**	**5.3**	**-40.6**	**-47.1**

Nanded	-12.8	-44.5	-38.5	5.7	-12.9	-21.6	-3.8	-46.3	-45.3
Osmanabad	26.3	5.5	-20.9	-1.3	-27.9	-32.5	-11.1	-21.9	-25.5
Parbhani	-24.3	-52.1	-43.1	14.6	3.3	-23.3	4.7	-38.9	-52.0
Latur	-5.8	-56.7	-48.3	0.5	-32.1	-43.8	-10.9	-24.5	-22.0
Hingoli	-13.0	-49.6	-42.5	1.2	-1.5	-13.1	-10.5	-71.4	-67.2
Latur	**-13.3**	**-46.2**	**-39.4**	**7.6**	**-8.0**	**-25.9**	**-2.6**	**-42.6**	**-44.1**
Buldhana	-10.3	-37.3	-31.8	4.0	-31.8	-34.8	-23.6	-59.7	-47.7
Akola	-45.5	-66.2	-40.7	6.1	-31.4	-37.7	-0.8	-37.8	-39.1
Amrawati	-7.2	-51.3	-53.4	-10.0	-17.2	-13.1	-8.1	-36.5	-28.5
Yavatmal	-48.2	-67.9	-35.9	-1.7	-27.9	-31.8	7.0	-25.4	-54.6
Washim	-23.7	-29.6	-14.8	14.1	-15.9	-35.4	-78.9	-88.1	-45.2
Amravati	**-27.3**	**-51.6**	**-34.5**	**2.5**	**-26.4**	**-31.1**	**-17.0**	**-48.6**	**-43.4**
Wardha	-68.2	-49.7	48.3	5.8	-32.1	1.6	90.8	-9.5	-44.6
Nagpur	-42.8	-39.4	10.0	-7.0	-11.2	14.7	10.5	-27.7	-30.0
Bhandara	-25.4	-19.1	29.9	-37.1	1.1	20.0	-30.1	-39.3	-35.3
Chandrapur	-69.7	-61.8	36.1	-4.1	-6.8	22.4	14.5	-18.8	-29.4
Gadchiroli	-15.2	-0.7	66.4	-15.2	-0.7	52.8	-43.5	-0.7	6.8
Gondia	201.3	66.1	37.1	-100.	-100.0	-100.0	578.0	149.2	-31.5
Nagpur	**-48.0**	**-42.4**	**35.6**	**-9.1**	**-11.0**	**1.4**	**16.3**	**-18.3**	**-24.4**
State	**-21.1**	**-42.1**	**-6.9**	**4.9**	**-14.3**	**-10.6**	**-7.4**	**-44.2**	**-33.1**

CHAPTER-5

Possible Option for Enhancing Agricultural Production

Reliable climate predictions may not be available immediately and it might take some more time and until then, the necessity arises to identify some of the global parameters like El Niño, which can be used as a signal to climate variability at least during some of the years, even if not for all the years.

By knowing that either the southwest monsoon rainfall or annual rainfall is likely to decrease and with a possibility of increased post monsoon rainfall in some of the districts the following strategies may be useful for improving agricultural production of the state during the years with El Niño. Raigadh, Sindhudurg, Satara, Nanded, Yavatmal and Gondia districts of the state higher El Nino impact and required special attention.

- As southwest monsoon rainfall has a tendency to have low impact as compared to post monsoon, Summer and Winter season rainfall in these districts, it is important to advocate intercropping systems with long duration base crop and medium to short duration companion crop in mono cropped areas.

- Study also points out that the state must be fully geared up to capitalize on a possible good rains on the onset of rainfall *i.e* June month but also be ready with contingency measures.

- The southwest, post monsoon and annual mean temperature was more during El Niño years while winter and summer season it was less as compared to normal year.

- Under the event late onset of monsoon, *Kharif* sorghum should not be sown after 15th of July, instead of that pearl millet, Maize , should be grown as fodder crops.

- During El Niño years, rice should only be cultivated in areas having assured irrigation facilities or in low lying fields having reasonably large catchment areas. Rice should not be cultivated in truly upland areas during these El Nino years.

- Since there is a projection for higher Southwest rains after El Niño, it is advised that the farmers should complete sowing of all their *Kharif* crops between 15th June to 2nd week of July. The delay in sowing beyond that date, results in reduction grain yield of crops.

- Use conservation tillage and mulching for proper utilization of stored soil moisture.

- In double cropping areas under rainfed conditions better yields can be expected during *rabi* season by adopting in situ moisture conservation practices and judicious use of fertilizers with regard to timing and quantum.

As the data considered up till now indicates greater vulnerability of crop production during years with strong and moderate El Niño events, farmers have to be cautioned on judicious use of irrigation water so that the available water can be spared for use in larger areas.

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