

## Impact of Extreme Weather Events in relation to Floods over Maharashtra in Recent Years

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### ABSTRACT

About 400 million hectares of land in India are susceptible to floods of which about 30.8 million hectares have been protected by undertaking both structural and non-structural methods of flood control. On an average, in a year, about 8 million hectares are liable to flood. In India, about 1500 human lives are lost annually due to floods and heavy rains. On an average, about 10 million hectares of crop land is devastated in each year due to impact of flood. We cannot avoid natural hazards (like flood) and disasters, but can minimize their impact on environment by preparedness & planning. Study of extreme rainfall is essential for designing the water related structure, in Agriculture planning, in weather modification, water management, also in monitoring climate changes. Moreover, knowledge of spatial and temporal variability of extreme rainfall event is very much useful for the design of Dam and hydrological planning.

In view of the above, to find the impact of extreme / heavy rainfall in Maharashtra, rainfall data for the period 1951 to 2015 for three subdivisions of Maharashtra viz. Madhya Maharashtra, Marathwada and Vidarbha have been utilized for the study. Trends in number of incidences of excess rainfall have been determined by using standard statistical methods and the results discussed. Casualties due to extreme rainfall have also been discussed. Incidences of natural hazards reports prepared by India Met. Deptt., for the period 1981-2015 have been used in the study. Only those cases have been included for the study, which caused human fatalities and significant economic losses. The consecutive years of excess/deficient rainfall and their relation with El Nino/La Nina years have also been worked out and discussed as they have significant impact on hydrological area.

The cases of excess/deficient rainfall are almost same over Madhya Maharashtra (17/17) & Marathwada (17/19), over Vidarbha it is less (11/13) as compared to other two sub divisions in study period. The probability of excess rainfall in Marathwada is 16% followed by Madhya Maharashtra (15 %) and in Vidarbha (13%). The coefficient of variability for Vidarbha(19.9%) is least as compared to Madhya Maharashtra (23.3 %) & Marathwada (28.6 %). In Madhya Maharashtra region there were chances of 12%, in Marathwada 24% and in Vidarbha 25% of excess rainfall years in relation with La-Nina and 6 %, 21% & 33% of chances with El-Nino being correlated with deficient years.

**Keywords:** Natural hazards, extreme events, trends, El Nino and La Nina etc.

### 1. Introduction

The plain region of India is affected by floods almost every year during the monsoon season associated with heavy rainfall. Thus, the inter-annual fluctuations in the summer monsoon rainfall over India are sufficiently large to cause devastating floods or serious droughts. Chowdhury and Mhasawade (1991) found flood to be frequent phenomenon over India. Mega cities often encounter natural disasters caused by adverse weather phenomena particularly heavy rainfall. From the meteorological point of view, a flood is defined as a quantum of rainfall received over an area in excess of its long period average over that area during the period when it is

expected to occur. A study by Sinha Ray and Srivastava (2000) showed a decreasing trend in the frequency of heavy rainfall (rainfall  $\geq 65$  mm in 24 hrs) during the winter season at most of the stations in India. During the summer monsoon season (June- September) they found an increasing trend in heavy rainfall in a number of stations on the west coast. However, a few stations in Marathwada, Telangana, Rayalseema and Tamilnadu did not show any significant trend. These heavy rains and associated flooding in and around urban centres bring untold miseries on the local population and is the main cause of increasing deaths in the area affected.

Floods can threaten human life and property and it is estimated that about 1.5 billion people were affected in the world during the last decade of the twentieth century [Khole & De (2001)]. Floods are a major disaster in India in term of occurrences (41% of total disaster) as well as in casualties (De et al 2002). De et al (2005) presented a factual and brief review of extreme weather events that occurred in India during last 100 years (1901-2004), discussed specially the major rainstorm causing sever flood situations. Recent studies have confirmed an increasing trend in extreme rainfall events around the world. Floods in many parts of the India, particularly in urban areas are often devastating. Urban flooding has become a major source of socio-economic threat to cities. Last few decades have seen rise in the damage caused by natural hazards. On 26/27<sup>th</sup> July 2005, Mumbai (Santacruz) experienced heaviest rainfall recorded with an accumulated total of 944 mm with huge losses to life and property (De et al 2006). Extreme weather events over the last decade have shown that flooding is becoming more extreme, more frequent and more wide-spread [Tongdi Jamir et al. (2008)]

During monsoon season very heavy rain often lead to street flooding, disruption of traffic and telecommunication channels in the metropolitan cities like Delhi, Kolkata and Mumbai. Heavy rains also results in landslides and collapse of buildings in the slums located in the cities (De et al 2013). Singh et al (2015), observed from their study that urban flooding results mainly from two causes in India; firstly because of prolonged heavy rainfall and secondly, urban areas which are situated close to the flood plain of rivers. They also found that by and large though there is no significant trend, location specific heavy to very rainfalls are matter of concern for sustainable urban growth. The purpose of the study is to analyze and determine trends in the occurrence of heavy rainfall over subdivisions of Maharashtra in India. Fatal casualties and economic loss due to heavy rainfall and associated floods have also been determine and discussed.

## 2. Data and Methodology

The monthly rainfall data for the period 1951 to 2015 for three subdivisions of Maharashtra viz. Madhya Maharashtra, Marathwada and

Vidarbha have been utilized for the study. The rainfall departures are used as per IMD criteria i.e. Excess ( $\geq 20\%$  of the normal); Normal (lying between  $-19\%$  and  $+19\%$  of the normal); Deficient (lying between  $-20\%$  and  $-59\%$  of the normal). Trends in number of incidences of excess rainfall have been determined using standard statistical methods and the results discussed. Casualties due to heavy/extreme rainfall have been discussed. Incidences of natural hazards reports prepared by India Met Department for the period 1981-2015 have been used in the study. Synoptic situations responsible for heavy/very heavy rainfall have also been discussed. Only those cases have been included for the study, which can cause human fatalities and significant economic losses. The consecutive years of excess/deficient rainfall and their relation with El Nino/La Nina years have also been worked out and discussed as they have significant impact on hydrological area.

## 3. Results and Discussion

The summer monsoon season in India is characterized by incidences of heavy to very heavy rainfalls over most parts. They generally occur in association with certain favorable synoptic situations such as depressions, cyclonic storms, low-pressure episodes etc. Such rainfall episodes often lead to street flooding, disruption of traffic and telecommunication lines. These heavy rainfall events, occurring over certain area for a number of days continuously, often give rise to floods and cause various types of human hardship in general and threaten the safety of hydraulic structure in particular like dams, reservoirs, hydroelectric power set-up etc. It is observed from Table 1, that heavy rains results in landslides, collapse of buildings/ houses, extensively damages to property and disruption of traffic. From Fig.1 it is observed that during the period for which the data has been analyzed, the deaths over Maharashtra due to heavy rainfall during monsoon season having decreasing trend, though it is not statistically significant. This may be due to increase in awareness regarding government warnings about disaster amongst the people. It is observed from Fig.2 (a,b,c) that the trend in excess rainfall for all the three subdivisions is increasing though it is not statistically significant. Economic losses in terms of Indian currency were not available for urban

flooding at regional levels and hence could not be discussed.

The mean rainfall for the study period over Vidarbha is highest (918.7mm) followed by Marathwada (705.5 mm) and Madhya Maharashtra (696.1 mm). From Fig.3 (a,b,c), it is seen that the cases of excess rainfall are highest in Madhya Maharashtra (17) & Marathwada (17) as compared with Vidarbha (11). The ratios of excess/deficient rainfall are almost same over Madhya Maharashtra (17/17) & Marathwada (17/19), over Vidarbha, it is less (11/13) as compared to other two sub divisions in study period. The coefficient of variability for Vidarbha is 19.9%, which is least as compared to Madhya Maharashtra (23.3 %) & Marathwada (28.6 %). It means that rainfall distribution over Vidharbha is more homogeneous, more stable and more consistent as compared with other two sub-divisions. These results are in the agreement of earlier result by Gore & Potdar (2007). The probability of excess rainfall in Marathwada is 16% followed by Madhya Maharashtra (15 %) and in Vidarbha (13%). This implies that the chances of heavy rainfall over Vidarbha are less as compared to other two subdivisions. Synoptic situations which favour heavy rainfall over Maharashtra is due to presence of one or more of the following systems.

- i) Presence of off-shore west coast trough from south Gujarat / north Konkan southwards.
- ii) Embedded vortex in this trough off- Konkan coast.
- iii) Presence of mid-tropospheric cyclone over south Gujarat.
- iv) Presence of a depression or low pressure area over Orissa and / or central India (Agashe & Padgalwar, 2005)

The consecutive years of Excess/deficient rainfall have been worked out as they have significant impact on the hydrology of the area.

Two consecutive years have occurred three times (1958-59, 1979-80, 2005-06) and four consecutive years one time (1953,54,55&56), for excess rainfall whereas in deficient rainfall four consecutive years have occurred twice (1984,85,86,87 & 2000,01,02,03) and

two consecutive years (1992-1993) once in Madhya Maharashtra. In this region there are chances of 12% of excess rainfall years in relation with La-Nina and 6 % of chances with El-Nino in relation with deficient years. There were three consecutive years twice (1988, 89, 90 & 2005, 06, 07) in excess rainfall and two consecutive years have occurred once (1958, 1959) in deficient rainfall years. Whereas there were two consecutive years have occurred thrice (1951-52, 1971-72 & 2014-2015) and three consecutive once (1984, 85, 86) in deficient rainfall in Marathwada. In this region there are chances of 24% of excess rainfall years in relation with La-Nina and 21% of chances with El-Nino in relation with deficient years. In Vidarbha only in deficient rainfall two consecutive years have occurred thrice (1971-72, 1984-85 & 1996-97). In this region there were chances of 25% of excess rainfall years in relation with La-Nina and 33% of chances with El-Nino in relation with deficient years. Above analysis indicates that, Vidarbha region, which is central part of India, is more sensitive with El Nino/La Nina events as compared to other two regions.

#### 4. Conclusions

The following conclusions emerge from the analysis:

- i) The deaths over Maharashtra due to heavy rainfall during monsoon season having decreasing trend, though it is not statistically significant.
- ii) The excess rainfall cases for all the three subdivisions are increasing though it is not statistically significant.
- iii) The ratio of excess/deficient rainfall are almost same over Madhya Maharashtra (17/17) & Marathwada (17/19), over Vidarbha it is less (12/13) as compared to other two sub divisions in study period.
- iv) The coefficient of variability for Vidarbha (19.9%) which is least as compared to Madhya Maharashtra (23.3%) & Marathwada (28.6 %).
- v) Presence of favourable synoptic situations like depression or low-pressure area near the location are mainly responsible for causing heavy to very heavy rainfall.

- vi) Vidarbha region is more sensitive with El Nino/La Nina events as compared to other two regions.

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**Table 1. Impact of flood over Maharashtra**

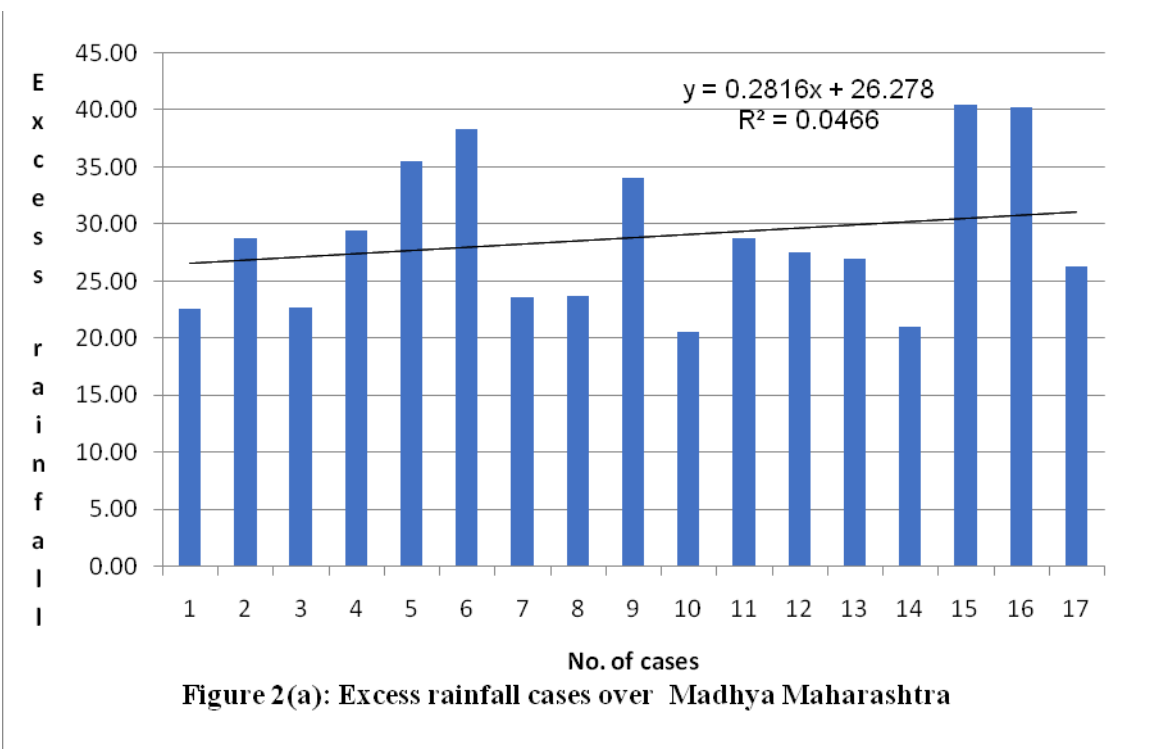
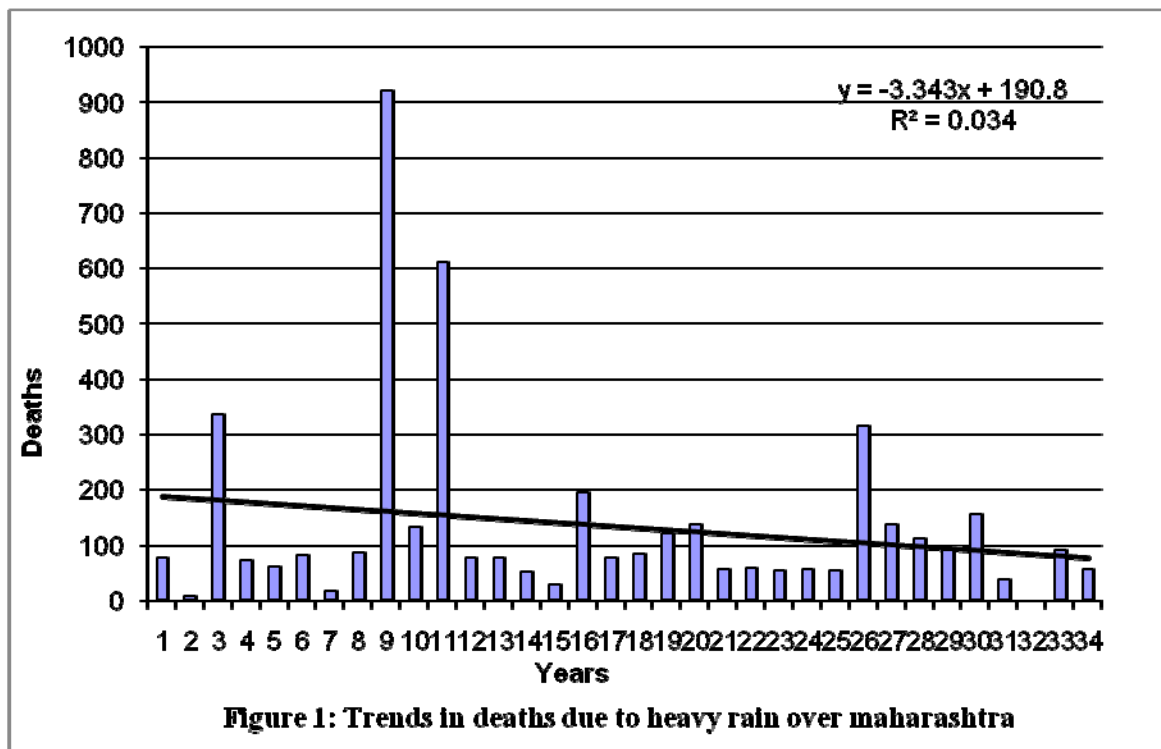
S.No.	Period/ Date	Area/District affected	Death/Missing (Casualties)	Area affected
1.	11-17 Aug. 1983	Konkan, North Madhya Maharashtra, Marathwada and Vidarbha	87 persons died and 21 reported missing.	Hundreds of villages in 19 districts badly affected. Several houses either collapsed or damaged. Extensive damage to crop and property. Road traffic disrupted.
2.	17, 18 Aug. 1983	Pandharpur (Solapur)	117 persons died.	The swollen Bhima swept through the pilgrimage centre Pandharpur in Solapur dist. 6 villages marooned. Pandharpur and several nearby villages remained under water for 2 days. Some temples submerged. Flood water invaded Pradakshinamarg of Vithoba temple, Kalikamandir and vegetable market which remained under 60 cm deep water. Water level was 6 meter above the crossway bridge and 3 meter above the Gopalpur bridge. 9000 people shifted to safer place. Vehicular traffic in and out of the town suspended.
3.	Aug. 1986 (1st & 2nd week)	Vidarbha	32 persons died. 575 cattleheads perished.	Chandrapur and Gadchiroli districts worst affected. 2,35,000 people of over 1835 villages affected. 10,000 houses swept away and 6000 houses damaged. In Chandrapur district 1000 houses collapsed. Crop in 2000 hectares in Hinganghat and Samandarpur tehsils in Wardha district swept away. Estimated loss of property worth Rs. 10 crore reported in Chandrapur district while Rs. 61 lakhs and Rs. 5 lakhs reported in Yavatmal and Wardha districts respectively. The total loss estimated worth Rs. 16 crore. A bridge near Ashti village connecting Aheri to Chandrapur washed away. In Nagpur city, a two storeyed building in Sitabuldi area razed to ground. Road traffic in Chandrapur and Gadchiroli district completely disrupted. In Amravati district, 14 villages in Chandur and Dhamangaon tehsils badly affected. 46 houses collapsed and 402 houses partially damaged. Telecommunication network completely broke down even Police wireless system became ineffective. IAF helicopters airdropped food packets.

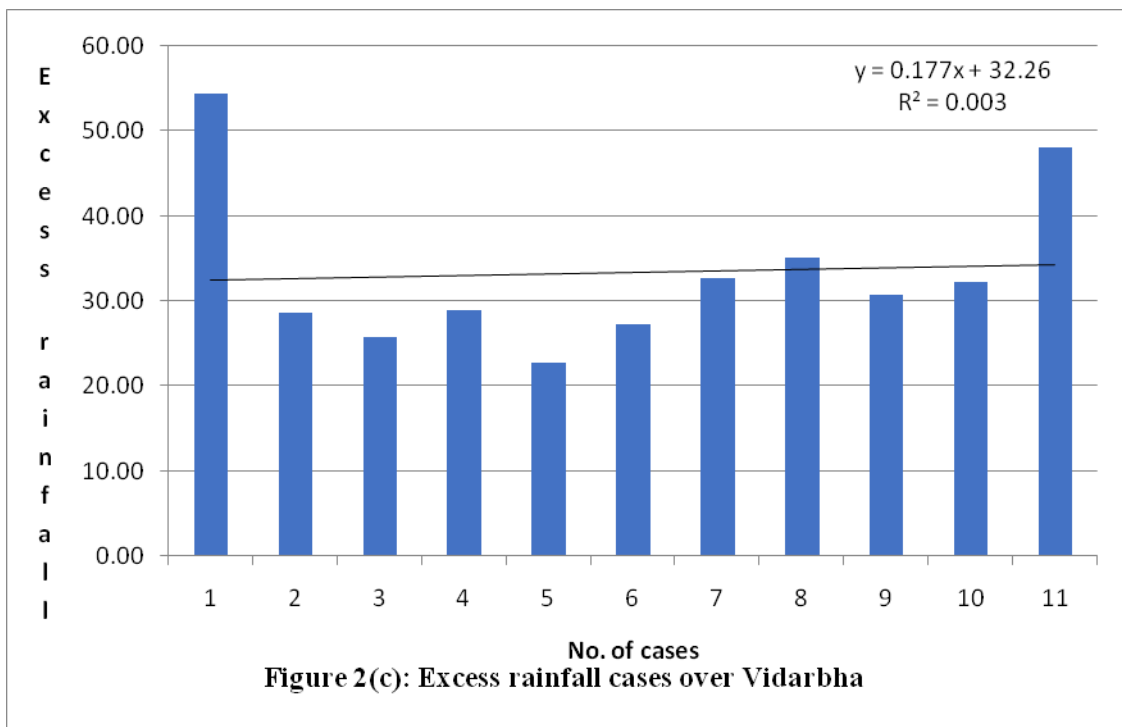
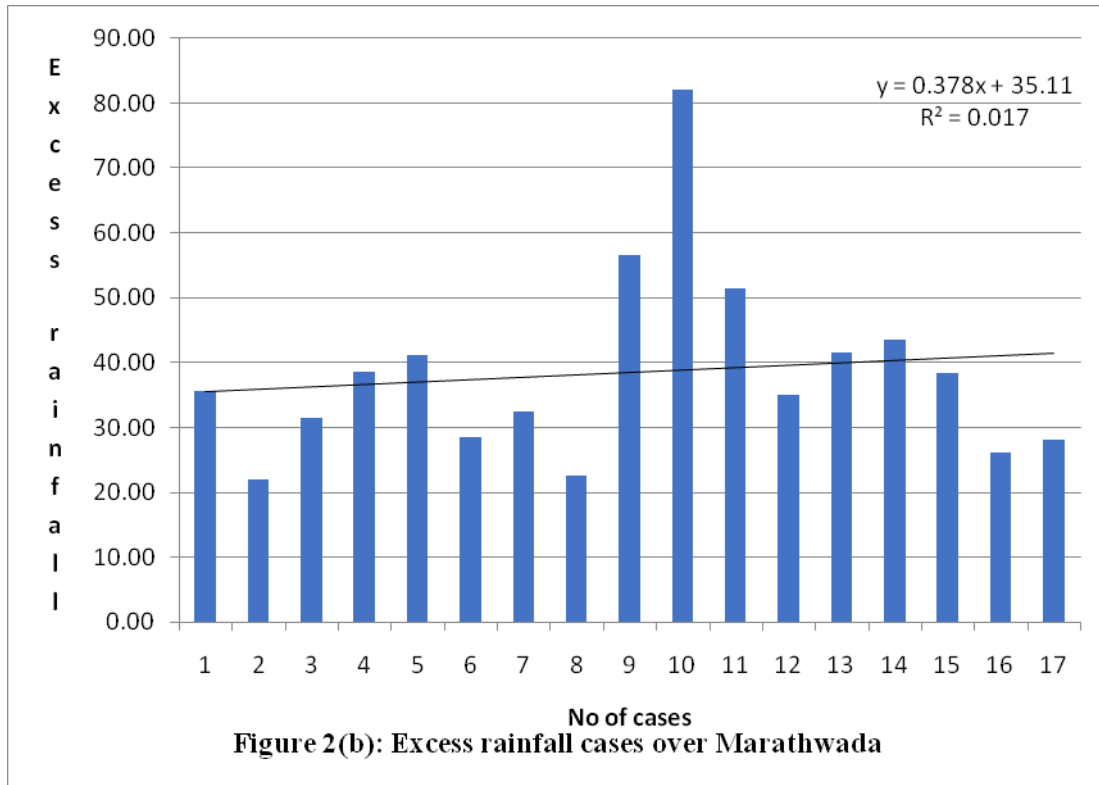
4.	23-25 Jul. 1989	Aurangabad, Beed, Mumbai, Jalna, Kolhapur, Nanded, Osmanabad, parbhani, Pune, Raigarh, Ratnagiri and Sangli	917 people died. 14,000 cattleheads perished	1.1 lakh houses either fully or partially damaged. 2 lakh families rendered homeless. 50 villages in Beed, Nanded and Raigarh marooned. Damage to building road and power stations estimated to be worth Rs. 91 crores. In Raigarh district, entire hutment colony on the bank of Patalganga river completely wiped out. 72 cms of rain in 24 hours period reported. In Mumbai, local train services as well as long distance trains cancelled. Bombay recorded highest rainfall since 1984. In Beed district, Beed town razed to ground. In Pune district, Bhaje village completely wiped out due to landslide. Pune- Mumbai train services suspended.
5.	22-24 Aug. 1990	Akola, Amravati, Bhandara, Buldhana, Chandrapur, Gadchizoli, Nagpur, Wardha and Yavatmal	46 persons died.	Yavatmal and Wardha worst affected. In Yavatmal district, 1305 houses completely and 2600 houses partially collapsed. Amravati town cut off as bridge on Wardha river on Nagpur Amravati road washed away. A bridge on Chandrabhaga river damaged.
6.	18-30 Jul. 1991	Amravati and Nagpur	500 people killed at Mowad when embankment of Wardha river breached. 1,916 cattleheads perished.	Mowad village of 1,500 population in Narkhed tehsil washed away. 2,000 houses razed to ground. Property worth Rs. 250 crore damaged. 19 villages completely destroyed. 10,969 houses either partially or completely damaged. 10,000 people rendered homeless. 40,000 hectares of crop land washed away. Communication system completely suspended.
7.	2 & 3 Jun 2000	Pune	105 livestock died	Low lying areas inundated. For almost 18 hours traffic on Pune- Mumbai highway remained standstill. Tribal population in hilly areas of Ambegaon tehsil – Aahape, Nhaved, Pimparne affected; farming and related jobs had to be stopped. Milk supply halted.
8.	12 Jul	a) Mubai city and Mubai Suburb	65 persons died and 50 injured seriously in Ghatkopar. 2 children drowned in Wakola and one person died in Deonar.	Due to landslides in Ghatkopar, people residing at the foot of the hill were buried alive, hutments crushed. Long distance as well as local trains completely stopped, flights from Mumbai cancelled. Commuters stranded everywhere as elevated areas were also flooded, water entered upto first floor in low-lying areas. Electricity supply to several substations and feeders was switched off as a safety measure. Fire brigade reported 25 major tree falls

9.	Jun. (4 <sup>th</sup> week) 2004	Amravati, Bhandara, Buldhana, Dhule, Jalgaon, Mumbai, Nagpur, Nashik, Pune and Thane	94 persons died.500 animals perished.	Bhiwandi, Dahanu and Palghar tehsils in Thane district worst affected. Many houses collapsed. Irrigation bund at Pargaon near Daund breached. Long distance trains departing from Mumbai Central and Western railways cancelled, routes of many trains like Amritsar-Mumbai, Jaipur-Mumbai etc. diverted. Railway bridge between Palghar and Bhoisar (Thane) damaged completely. Tomato crop in various tehsils like Junnar, Umbraj and Narayangaon infested with fungal growths causing heavy losses.
10.	26-27 Jul.2005	Mumbai	1094 persons died. 1000 cattleheads perished.	5000 people evacuated to safer places.
11.	Jul. (4 <sup>th</sup> week) 2005	Beed, Kolhapur, Nanded, Parbhani, Pune, Raigad, Ratnagiri, Sindhudurg Thane and Yavatmal	527 persons died. 15,000 cattleheads perished.	Crops in 30 lakh hectares damaged. 2853 houses collapsed in Raigad.
12.	Aug. (1 <sup>st</sup> week) 2005	Aurangabad, Beed, Hingoli, Jalna, Kolhapur, Nanded, Parbhani, Pune, Raigad, Satara and Thane	302 persons died and 24 other injured. 10,000 cattleheads perished.	2025 houses completely and 85 houses partially damaged. Rice crop in 23,330 hectares damaged. 53,302 people affected. • 10,000 people evacuated to safer places.
13.	1-7 Jul.2006	Amravati, Chandrapur, Dhule, Gadchiroli, Jalgaon, Kolhapur, Mumbai, Nagpur, Nasik, Pune, Raigad, Satara, Thane and Washim	131 persons died and 9 injured. Many cattleheads perished.	Low lying areas, bridges inundated. About 185 villages cut off. Road/rail /air traffic disrupted. Extensive damage to agriculture & vegetable crop reported Many houses and trees collapsed.
14.	5-9 Aug.2006	Ahmednagar, Akola, Aurangabad, Beed, Buldhana, Chandrapur, Dhule, Hingoli, Jalgaon, Jalna, Kolhapur, Latur, Manmad, Nanded, Nasik,	149 persons died.	Damage to 3458 houses reported. Extensive damage to crops reported. Railway bridge damaged near Manmad. Ahmednagar-Shirdi stretch of NH 10 inundated by Godavari water. 500 villages affected. 1.5 lakh people evacuated to safer places.

		Parbhani, Pune, Sangli, Satara, Satana, Wardha, Washim and Yavatmal		
15.	1 & 2 Jul.2007	Amravati, Chandrapur, Gondiya, Nagpur and Thane	70 persons died and 9 persons injured due to wall collapse.	Railway bridge and 50 houses washed away. Trees uprooted.
16.	14-19 July13	Amaravati, Chandrapur, Gondia, Nagpur, Wardha, Washim, yavatmal	i)About 30 Persons died,16 drowned,1 swept away. ii)About 1000 live stock perished	i) 330 houses were completely &2000 kuchcha houses partially damaged. ii) Extensive damage of the Soyabean, Cotton, Tur,Rice in thousands of hectares were reported. iii) Many areas submerged. iv) No, of families were shifted
17.	08 August 2014	Pune(Malin village) AmbegaonTaluk	144 People buried under landslide	Most of the houses of the village were hit by landslide.







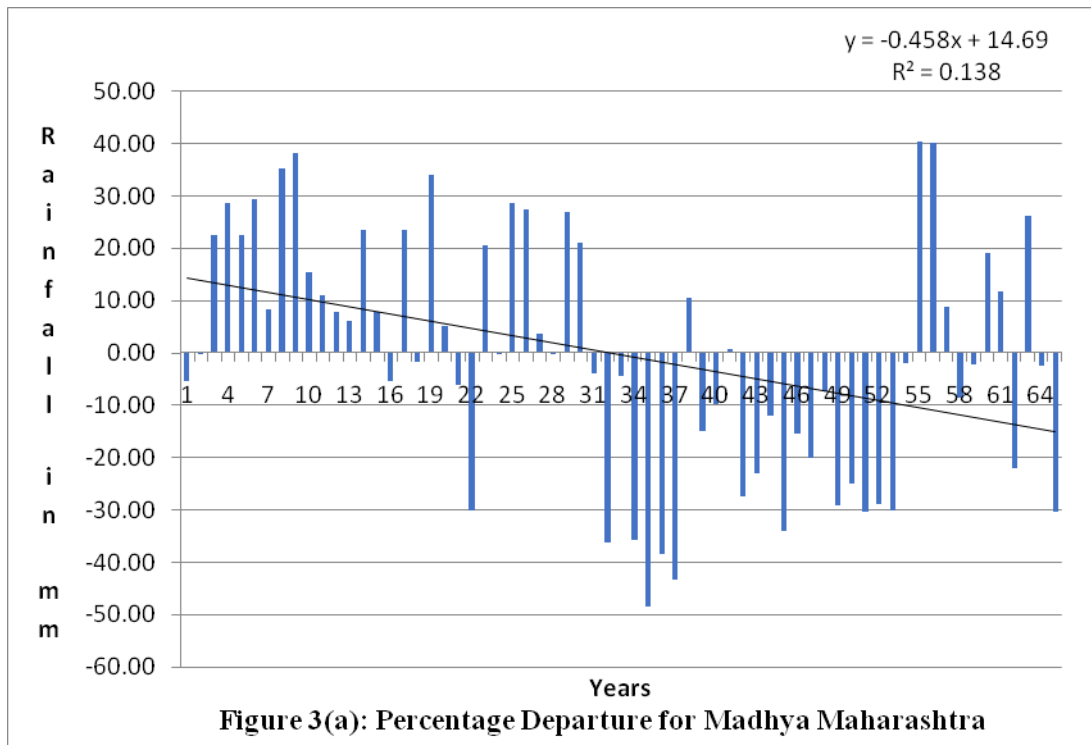


Figure 3(a): Percentage Departure for Madhya Maharashtra

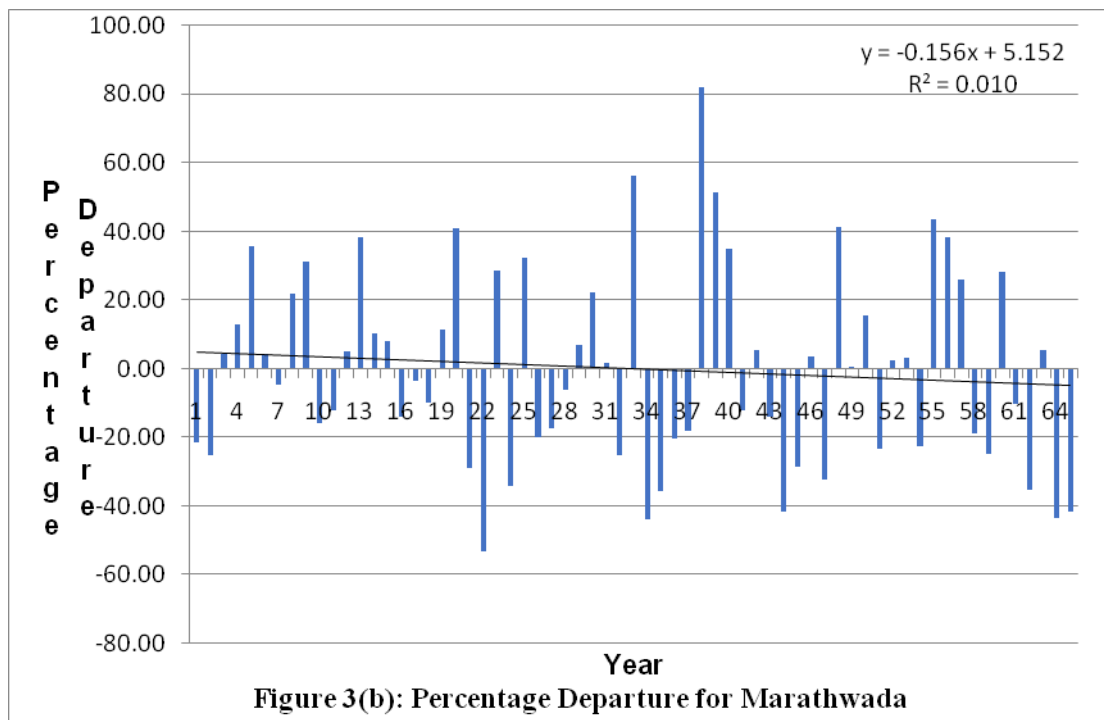


Figure 3(b): Percentage Departure for Marathwada

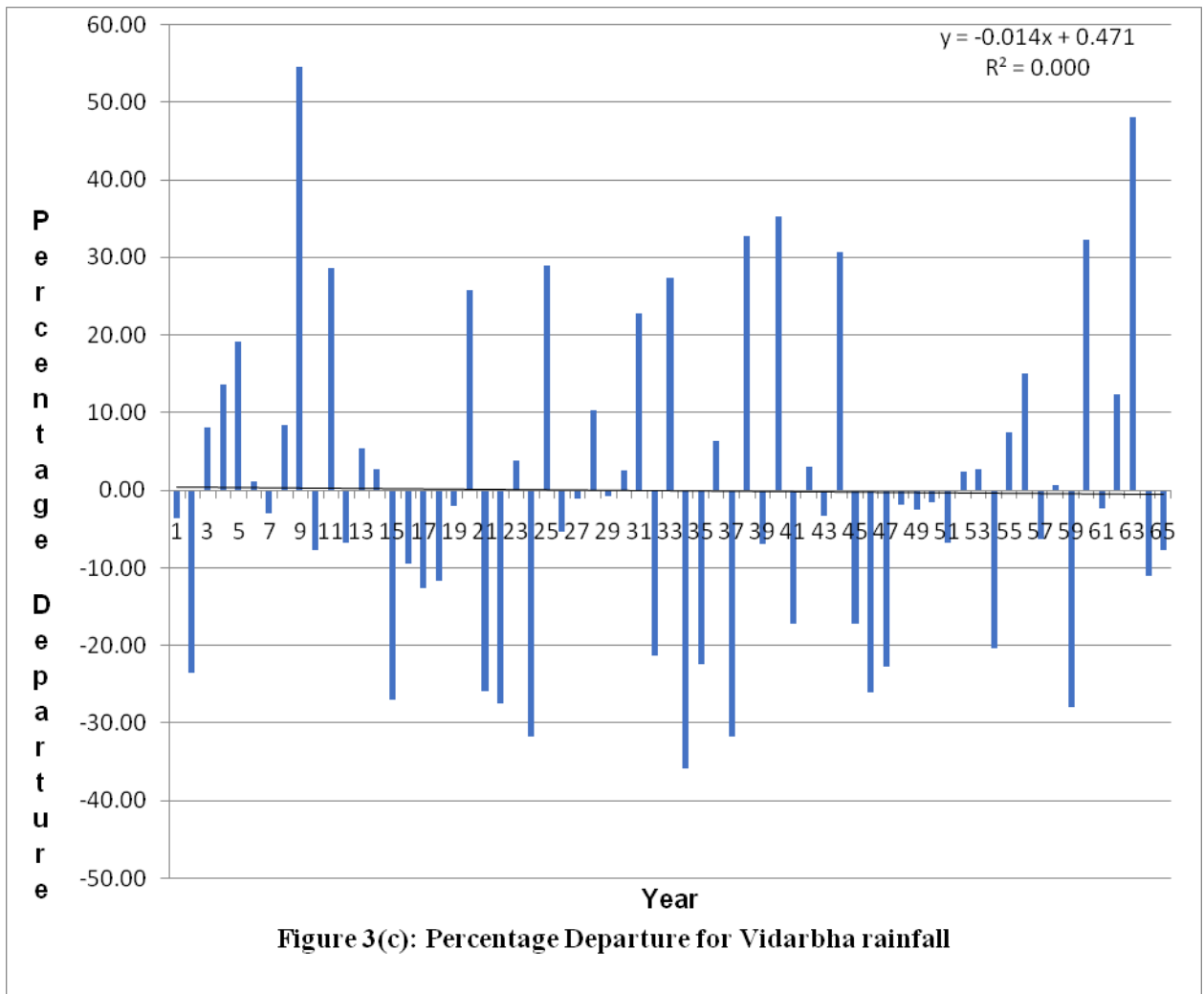


Figure 3(c): Percentage Departure for Vidarbha rainfall