# Extreme Weather Events in Chhattisgarh State affecting CROP Production : Mitigation and Adaptation Strategies

***J.L. Chaudhary, N. Manikandan, S.R. Patel, R.Khavse and S. Bhelawe***
*Department of Agrometeorology*
*College of Agriculture*
*Indira Gandhi Krishi Vishwa Vidyalaya*
*Krishak Nagar, Raipur*
*Email: rpr.aicrpam@gmail.com*

**ABSTRACT**

*Extreme weather, in the most obvious sense, is weather that lies outside a locale's normal range of weather intensity. Here, in this paper an attempt has been made to study extreme weather events induced stress particularly with reference to rice based production system for Chhattisgarh state where rice based cropping system is pre-dominant. An effort has been made to study extreme events like drought and dry spells, flooding and wet spells, heat waves, cold waves and hail storms etc. When these extremes exceed the tolerance limits, the impact can be severe in terms of production and farm economics. Dry spell / drought impact can be mitigated by indigenous water harvesting structures, RCC, OFR and local traditional techniques like trenching, indigenous drip method and the benefit attained by farmers have been explained through case studies. Adaptation and mitigation strategies fecommended against flooding are indigenous broad bed furrow maker through tractor as crop management technique and secondary reservoir techniques. Impact of some weather aberrations like hailstorms, cold wave, heat wave and dust storms on crops and animals have also been documented.*

***Key words:*** *Extreme weather, Adaptation, Water harvesting structures, Agromet advisory, Contingent planning.*

## 1. Introduction

Agro-climatic inventory is very vital in crop planning especially in rainfed agriculture. Other georeferenced inventory along with climatic data becomes a strong base not only for planning but also for developing strategies for alleviating the different stresses that come during crop season. Due to some unpredicted extreme events, the farmer suffers loss in the field. Extreme weather in the most obvious sense is the weather that lies outside a locale's normal range of weather intensity. It is therefore by definition, infrequent or rare. Extreme weather is also potentially destructive although not all extreme weather events end in disasters. For some weather events, the idea of what constitutes an extreme could vary from place to place. It often depends on what a region is used to experiencing and what it is prepared for. Extreme events such as hurricanes, tornadoes, and ice storms often require the presence of a number of special circumstances before they could take place. Many extreme events also come about as a result of a combination of factors such as the merging of two weather systems or the occurrence of a severe weather event in tandem with some other factors that intensifies its impact.

Rainfed agriculture constitutes 80% of global agriculture and plays a vital role in achieving food security. These rainfed areas are vulnerable to poverty, malnutrition, water scarcity, severe land degradation and poor physical and social infrastructure. To eliminate all these severe problems, it is very important to conduct basic and applied research that will contribute to the development of sustainable rainfed farming systems dedicated for every agro-climatic zones separately (Thakur *et al.* 2014). The production of rainfed rice (*Oryza sativa* L.) in drought-prone areas such as eastern India is highly variable and risky due to temporal and spatial variability in rainfall. Rice yields in eastern India is only 1.0-2.4 t/ ha (Tomar, 2002). When these extremes exceed the tolerance limits, the impact can be severe on plant performance and even its survival capacity often leading to plant damage and mortality. Extreme weather events induce stress on plant growth and performance. Heat waves and cold waves are such climatic aberrations of a short period that can cause severe stress on plant survival and performance. Significant losses have been experienced year after year due to increased

occurrence of weather extremes which could be significant part of climate change impact. Both the extremes of maximum and minimum temperatures cause stress to plant productivity (Ramakrishna, 2013). Although water is availble freely and right at the site where it is to be used, yet so tenuous and delicate is the balance between the demand for water by crops and its supply by precipitation that even short term deficit periods often reduce the production significantly (Gupta *et al.* 1990). Even in areas where rainfall is ample, uneven distribution affects the crop yields due to excess water at one time and due to water stress at the other. In rainfed agriculture, the importance of rainfall over-rides all other climatic factors which determine the yields. With almost negligible irrigation facilities in rainfed regions, rain water shortages often lead to moisture stress causing substantial reduction in crop yields. This is also true for Chhattisgarh state as the onset of monsoon at the initial stage, break monsoon conditions among the crop growth stages and cessation of rainfall at the terminal stage determine the productivity of rice and other *kharif* crops. Interpretation of climatic variables is essential because of these variations (Subramaniam and Raju, 1988). This will also help in adopting and developing risk management strategy. Hence, this study has been undertaken looking into the changing environmental scenarios in the State.

## 2. Data and Methodology

The present study was conducted at Department of Agrometeorology, Raipur, Chhattisgarh by using available meteorological data of Raipur centre. Dry and wet spell analysis are worked out using weather cock software developed by Central Research Institute for Dryland Agriculture, Hyderabad (Rao *et al.,* 2011). Experimental data from All India Co-ordinated Research Project on Agrometeorology running at Raipur centre was utilised to compute yield reduction due to hailstorms.

### 2.1. Criteria used in this study :

Delayed onset: Under Raipur condition, normal onset of monsoon is 17 June and for Chhattisgarh state, onset of monsoon is around 13-14 June starting from southern part of the state. Accordingly terms like delay by 2 weeks, 4 weeks have been taken into account.

Early season drought: This is the term which is taken into account when rainless spells in early part of season particularly in the month of June affect the crucial sowing operations of major kharif crops like rice, maize, soybean, pigeon pea etc.,

Normal onset: This is the term used when there are widespread rains over a particular agro-climatic zone. This is extended to state level for our study purpose.

Mid-season drought: This is the term when there is prolonged rainless spell due to which crop growth and development is affected. Generally this duration is of minimum 10 days and prolonged up to 3 weeks with total rainfall quantity less than 25 mm.

Terminal drought: This is the situation which arises when after 25 September, there is continuous rainless spell which affect the proper completion of lifecycle of rice crop and also other oilseed and pulse crops.

Drought: This is calculated as per criterion laid down by India Meteorological Department (IMD). Meteorological drought is a situation when the deficiency of rainfall of a region is 25% or more of the long-term average (LTA) of that region for a given period.

## 3. Results and Discussion

### 3.1. Extent of sensitive area and periodicity of drought and dry spells

Whole of Chhattisgarh state is affected due to intermittent dry spells and the *kharif* crops mainly rice, maize, pigeon pea get affected during one part or other part of the life cycle of crops. High water requirement crops like rice during *kharif* season get affected severely as compared to other low water requirement crops like soybean and minor millets. Generally terminal drought and dry spells are common in rice crop, which cause low yields in Chhattisgarh State. In recent times (2002, 2007, 2009, 2011) dry spells occurred almost every year in this State and a case study is presented for Raipur in Table 1. Longest dry-spells in different years during 2000 - 2013 at Raipur during monsoon

season have been documented and it was found that the longest first dry spell was 18 days in 2002 (26 June – 13 July). This was followed by 15 days in 2011 (25 Sept - 09 Oct), 11 days in 2001 (29 July – 08 Aug) and 10 days in 2009 (31 July - 09 Aug).

**Delayed onset of monsoon** (By 2 weeks) under midland inceptisol (matasi-sandy loam/shallow lowland alfisols (dorsa-clay loam or vertisols (kanhar-clayey)/ Bahra lowland vertisols (kanhar-clayey)

**Table 1**
**Longest dry spells during monsoon season**

| Year | Dry spell-I | | | Dry-Spell-II | | |
|---|---|---|---|---|---|---|
| | From | To | No. of days | From | To | No. of days |
| 2000 | 21 Aug | 27 Aug | 07 | 1 Sep | 8 Sep | 08 |
| 2001 | 29 Jul | 08 Aug | 11 | 15 Sep | 25 Sep | 11 |
| 2002 | 26 Jun | 13 Jul | 18 | 19 Jul | 30 Jul | 12 |
| 2003 | 16 Jun | 24 Jun | 09 | 14 Sep | 18 Sep | 04 |
| 2004 | 19 Jun | 26 Jun | 08 | 14 Sep | 25 Sep | 12 |
| 2005 | 8 Aug | 14 Aug | 07 | 24 Aug | 03 Sep | 11 |
| 2006 | 6 Jul | 14 Jul | 09 | 7 Aug | 11 Aug | 05 |
| 2007 | 19 Jul | 26 Jul | 08 | 14 Aug | 19 Aug | 06 |
| 2008 | 30 Jun | 06 Jul | 07 | 18 Jul | 28 Jul | 11 |
| 2009 | 31 Jul | 09 Aug | 10 | 23 Jul | 26 Jul | 04 |
| 2010 | 11 Aug | 14 Aug | 04 | 21 Sep | 26 Sep | 06 |
| 2011 | 24 Jul | 29 Jul | 06 | 25 Sep | 09 Oct | 15 |
| 2012 | 11 Jul | 14 Jul | 04 | 24 Sep | 29 Sep | 06 |
| 2013 | 17 Jun | 21 Jun | 05 | 10 Sep | 15 Sep | 06 |

### 3.1.1. Recommended adaptation and mitigation strategies

Restructured Concrete Cement (RCC) wells and embankment type ponds are some techniques which can be adopted for drought mitigation. As far as economics of the technology is concerned, these are low cost technologies with one time investment and cost can be recovered by increased output and profitability in only few years. Other traditional low cost technologies like indigenous drip irrigation can also be adopted. RCC wells are picking up through watershed projects and already tested in ICAR funded National Agricultural Innovative Project (NAIP) and National Initiative on Climate Resilient Agriculture (NICRA) projects in tribal region of Bastar division. Details of economic benefit attained by farmers by following improved techniques during 2000-01 to 2003-04 under NAIP is shown in Table 2. Dry spells can be mitigated in different situations through some contingent planning as follows:

It is advised that farmers go for direct dry seeding in line technique for better crop yield and double cropping. Line sowing technique is advised to avoid mortality of germinating seed in case drought follows after scanty rainfall events. Under this situation, application of post emergence herbicides should be promoted for timely weed management and avoiding *biasi* operation.

**Early season drought:** monsoon delay by 4 weeks (July 3rd week)

Under this situation, 25 % higher seed rate in mung, urad, sesamum, groundnut (varieties like GG-5 / GG-20) under bharri situation is recommended. Rice crop can be replaced by groundnut or sesamum/ soybean (Indira Soy-9, JS93-05, JS-335, JS80-21) as these crops are having low water requirements. If the farmers are willing to go for rice crop, varieties like Tulsi, Indira barani dhan-1, Annada should be chosen in upland unbunded *bharri* situation.

**Table 2**

**Effect of water harvesting structures (WHS) on productivity and returns from rainfed rice production system under real farming situations using farmers' practices (FP) and improved practices (IP) at Baghbahra, Chhattisgarh (After Pali *et al.* 2012)**

| Year | Rainfall (June to Sept.) (mm) | Area served by WHS (ha) | | Yield of un-milled rice (q/ ha.) | | | Net returns over control ('000 Rs.) | | Net returns to cost on WHS (%) | | Cropping intensity (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rice | Rabi Crops | Without WHS Control | With WHS FP | With WHS IP | FP | IP | FP | IP | Without WHS | With WHS |
| 2000-01 | 573 | 37.1 | 4.1 | 5.3 | 30.5 | # | 378 | 408 | 70 | 76 | 100 | 111 |
| 2001-02 | 1144 | 39.6 | 15.4 | 32.0 | 42.0 | 56.2 | 163 | 567 | 30 | 105 | 105 | 139 |
| 2002-03 | 452 | 45.4 | 11.8 | 2.4 | 39.3 | 51.2 | 391 | 759 | 73 | 141 | 100 | 126 |
| 2003-04 | 1359 | 39.6 | 15.0 | 30.4 | 40.5 | 48.6 | 163 | 380 | 30 | 70 | 105 | 138 |
| | Total / average | 40.4 | 11.6 | 17.2 | 38.2 | 52.0 | 1096 | 2113 | 203 | 392 | 103 | 128 |

FP= Farmers' practices, IP= Improved practice , WHS = Water harvesting structures # IP was not included for 2000 *kharif* season and therefore the yield of rice was assumed to be equal to that for farmers' practices for calculation of net returns for that season; Cost of WHS Rs. 539 thousands

**Early season drought:** Monsoon delay by 6 weeks (August first week)

Under this extreme situation which is also a rare situation, farmers are advised that instead of mung and urad crops, horse gram and niger crops should be chosen for sowing under upland unbunded *bharri* situation as these crops can be cultivated with very less water. In groundnut growing regions, urad should be grown replacing groundnut. Varieties suitable for urad crop are PTU4, TU94-2, Pant-U31, KU96-3, TAU2. Further, mung should be taken instead of seasmum. Management practices can also be included that in bunded upland *bharri* situation, sowing of sprouted seed (*lai-chaupa*) adopting lehi method of rice cultivation should be adopted. Rice varieties like Indira barani dhan-1, Samleshwari, Danteshwari, MTU-1010, Purnima should be selected in midland / lowland condition. If farmers prefer to replace rice crop at this stage, mixed or intercropping of pigeon pea and mung (4:2) or mixed / intercropping of sesamum and mung (4:2) can also be taken. Further, coriander crop should be chosen instead of lathyrus and safflower.

**Normal onset of monsoon, mid-season and terminal drought**

Under this situation, inter-tilling for soil mulch should be followed. Mulching with paddy straw should be done or plastic mulch or other locally available material can also be used. Compartmental bunding in vertisols can be followed. Further, ridge and furrows, tied ridges to conserve rainwater during *kharif* for regular sowing of *rabi* crops can also be followed. Gap filling, sowing of sprouted seed (*lai-chaupa*) adopting lehi method of rice cultivation and sowing of relatively early varieties like Chandrahasni, Bamleshwari, Karma mahsuri, Indira Barani Dhan, Samleshwari and Sahbhagi Dhan in midland and lowland farming situations should be done.

**Mid-season drought** (long dry spell, consecutive 2 weeks rainless (<2.5 mm period) at vegetative stage in all soil types for rice and any other crop grown viz. mung, urad etc. :

Weeding and protection against insect and pests are the priority practices which should be followed and advised to the farmers. Further, it should be advised to avoid top dressing of urea. Supplemental irrigation from water harvesting structures using micro irrigation *i.e.* drip and sprinklers can be followed by the farmers who are having this kind of facility. Farmers should be advised to increase 25 percent seed rate of *rabi*

crop and sowing of *rabi* crops adopting zero tillage technique so that there is additional income from second cropping.

**Terminal drought (Early withdrawal of monsoon)**

Farmers should be advised to harvest mature plants, thin out plant population, lifesaving irrigation if available as crop management practices and mulching and inter-tilling as agronomic measure.

**Drought - Irrigated situation or delayed release of water in canals due to low rainfall**

Direct seeding of rice preferably dry seeding in line should be followed under this situation. In case of failure of crop or poor crop stand, sowing of sprouted seed (lai-chaupa) adopting lehi method of rice cultivation can be practised. Further looking into delayed release of water, transplanting of rice should be avoided. Weed control by post-emergence herbicides should be done.

## 3.2. Flood and submergence, water-logging and wet spells

Mainly districts of Bijapur, Konta, Sukma of Godavari plains are affected by floods though temporary waterlogging phenomenon in low lying areas is a routine feature in all the districts. Jowar and maize crops are getting affected in areas of stream banks during July-Aug when water table is high and situation is aggravated when overflowing occurs. During the monsoon season, two longest wet spells were calculated from the period 2000 to 2013 and list of wet spell duration is shown for Raipur in Table 3. It was found that the longest first wet spell was 40 in 2003 (01 Aug – 09 Sept). During this year, a total rainfall of 670.6 mm was received. This was followed by 23 days in 2006 (15 Jul – 06 Aug) and 17 days in 2005 (23 June – 09 July). The longest wet Spell II was 18 days in 2005 (21 July –

**Table 3**

**Longest wet-spells in different years (2000 -2013) at Raipur during monsoon season**

| Year | Longest wet spell during monsoon season | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Wet spell-I | | | | Wet Spell-II | | | |
| | From | To | No. of days | Rainfall (mm) | From | To | No. of days | Rainfall (mm) |
| 2000 | 12 Jun | 22 Jun | 11 | 146.1 | 11 Jul | 20 Jul | 10 | 182.6 |
| 2001 | 05 Jul | 20 Jul | 16 | 221.6 | 09 Jun | 15 Jun | 07 | 161.8 |
| 2002 | 13 Aug | 24 Aug | 12 | 208.9 | 21 Jun | 26 Jun | 06 | 166.6 |
| 2003 | 01 Aug | 09 Sep | 40 | 670.6 | 22 Jul | 28 Jul | 07 | 265.6 |
| 2004 | 21 Jul | 30 Jul | 10 | 135.2 | 09 Jul | 17 Jul | 09 | 197.6 |
| 2005 | 23 Jun | 09 Jul | 17 | 218.9 | 21 Jul | 07 Aug | 18 | 501.8 |
| 2006 | 15 Jul | 06 Aug | 23 | 215.4 | 12 Aug | 18 Aug | 07 | 271.6 |
| 2007 | 18 Jun | 02 Jul | 15 | 690.2 | 27 Aug | 06 Sep | 11 | 139.8 |
| 2008 | 26 Jun | 30 Jun | 05 | 143.2 | 15 Sep | 19 Sep | 05 | 186.6 |
| 2009 | 08 Jul | 22 Jul | 15 | 587.2 | 10 Aug | 16 Aug | 07 | 148.8 |
| 2010 | 21 Jul | 28 Jul | 08 | 303.8 | 14 Sep | 20 Sep | 07 | 190.4 |
| 2011 | 13 Jul | 23 Jul | 11 | 314.6 | 06 Sep | 10 Sep | 05 | 217.2 |
| 2012 | 19 Jul | 23 Jul | 05 | 324.6 | 30 Jul | 06 Aug | 08 | 336.7 |
| 2013 | 20 Jul | 03 Aug | 15 | 332.8 | 16 Aug | 24 Aug | 09 | 202.8 |

07 Aug) followed by 11 days in 2007 (27 Aug – 06 Sept) and 10 days in 2000 (11 – 20 July). The rainfall received during these periods was 501.8 mm, 139.8 mm and 182.6 mm, respectively.

Recommended adaptation and mitigation strategies against flooding are indigenous broad bed furrow maker through tractor as crop management technique and secondary reservoir techniques to store excess rain water. SRI marker for grid making, tractor drawn raised bed planter, tractor drawn ridger, SRI technique for drainage. Some suggested techniques during heavy rainfall / flooded condition for different crops are shown in Table 4. In the case of vegetable crops (tomato / brinjal / coriander / garlic / onion) it is recommended to go for surface drainage.

## 3.3. Hailstorms

Hailstorms are occasionally observed and it did not occur earlier at Raipur but in recent years, some places are experiencing hailstones particularly in the month of March. Latest such instance in Raipur was in 2006 and 2014. The diameter of hailstones was as much as 3-4 cm. The intensity has been observed very high as the fields and lawns were covered with 2-3 cm layer of ice within 10-15 minutes. Severe crop damage was reported in chickpea, wheat, mustard, lentil and linseed crops which were in maturity stage. During this period 14.0 mm rainfall was received at Agromet observatory, IGKV, Raipur. The hailstorm has been observed in 4-5 km radius of Raipur city while the weather remains clear in other parts of the state. Hailstorm occurred on 07.03.06 in between 2.05 to 2.20 p.m. Losses in wheat crop were estimated using wheat experiment data under All India Co-ordinated Research Project on Agrometeorology during 2004-05 and 2005-06 and reported in Table 5. Losses to the extent of 30-40 per cent was reported in mustard, gram, linseed and tall varieties of wheat. Vegetables like cabbage, cauliflower, onion and leafy vegetables also get affected.

**Table 4**

**Adaptation strategies in unusual rains/ floods including transient water logging / partial inundation, continuous submergence for more than 2 days for both rainfed and irrigated situations** (Continuous high rainfall in a short span leading to water logging or heavy rainfall coupled with high speed winds in a short span)

| Crop Type | Suggested contingency measures | | | |
|---|---|---|---|---|
| | **Vegetative stage** | **Flowering stage** | **Crop maturity stage** | **Post-harvest** |
| Urad / Mung / Maize | Drain out excess water | Earthing up in maize | Picking of matured pods. Harvesting and drying of cobs | To cover produce with plastic sheet or shift produces to farm shed |
| Groundnut / Sesamum / Pigeon pea | Drain out excess water | Earthing in groundnut Drain out excess water | Drain out excess water Harvesting and drying of plants | To cover produce with plastic sheet or shift produces to farm shed |
| Rice | Drain excess water | Drain excess water | Drain excess water. Harvest the crop and put on bunds | To cover produce with plastic sheet or shift produces to farm shed |
| *Rabi* oilseed and pulses | Drain excess water | Drain excess water | Drain excess water. Harvest the crop and put on bunds | To cover produce with plastic sheet or shift produces to farm shed |
| Wheat | Surface drainage | Surface drainage | Surface drainage | * To cover produce with plastic sheet or shift produces to farm shed. To supply tarpaulin to farmers |

**Table 5**

**Losses in wheat yield (kg/ ha) due to hailstorm**

| Varieties | D1 | | | D2 | | | D3 | | | D4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004-2005 | 2005-2006 | % reduction | 2004-2005 | 2005-2006 | % reduction | 2004-2005 | 2005-2006 | % reduction | 2004-2005 | 2005-2006 | % reduction |
| Kanchan | 4205 | 808 | -81 | 2386 | 1898 | -20 | 3864 | 1389 | -64 | 1705 | 1035 | -39 |
| Arpa | 3674 | 682 | -81 | 1799 | 1370 | -24 | 2841 | 1268 | -55 | 1686 | 1362 | -19 |
| Bilasa | 3125 | 679 | -78 | 1951 | 1357 | -30 | 2955 | 1309 | -56 | 1534 | 780 | -49 |
| GW-273 | 4015 | 725 | -82 | 2027 | 1759 | -13 | 3220 | 1648 | -49 | 1553 | 1143 | -26 |
| Mean | 3755 | 724 | -81 | 2041 | 1596 | -22 | 3220 | 1404 | -56 | 1620 | 1080 | -33 |

Villages Jarod, Mahubhata, Nawagaon, Chanderi, Ghatoli, Dongaria, Khapradih, Khokhli, Diggi, Suhaila (District Baloda Bazar) were affected by hailstones in 2014. Gram, wheat, mustard and fieldpea are mainly affected as the crops in physiological maturity stage are affected by grain shattering, fungal infection and sprouting. Wheat crop which is in soft dough stage have shown fungal infection, affected severely due to lodging effect in these villages. Vegetables like chillies, cabbage, capsicum and tomato are affected due to fruit dropping and rotten in the field. Fruit and vegetable crops *viz.,* papaya, banana, onion, okra are also affected in these villages. Animal fodder mainly paddy straw is damaged. Harvested produce which is kept in the field is damaged significantly. Summer fruits like watermelon, muskmelon and vegetables like cucumber and cowpea are also damaged. Agromet advisory issued was that apply booster dose of fertilizer in standing crops where lodging and uprooting has been observed and to postpone the harvesting operation. It was also advised to the farmers for preponing the plucking of vegetables.

## 3.4. Cold wave

Surguja district in Northern Hill agro-climatic zone and sometimes some districts in Chhattisgarh plains agro-climatic zone in Chhattisgarh state during winter season get affected by cold wave. *Rabi* crops like chickpea, linseed, lathyrus get affected to different degrees. Cold wave effect is mainly due to metabolic action and physiological mechanism. History of lowest minimum temperature observed at Raipur is shown in Table 6. Extent of damage reported is not assessed and very less effect and that too on few crops. Use of heaters, sprinkler / light flood irrigation to *rabi* crops have been recommended as adaptation strategies.

**Table 6**

**Lowest minimum temperature recorded during different years (2000-2013) at Raipur**

| Year | Lowest minimum temperature during the season | |
|---|---|---|
| | Temperature (°C) | Date of observation |
| 2000-01 | 5.0 | 26 January 2001 |
| 2001-02 | 5.5 | 03 January 2002 |
| 2002-03 | 3.8 | 17 January 2003 |
| 2003-04 | 6.6 | 08 February 2004 |
| 2004-05 | 6.8 | 21 January 2005 |
| 2005-06 | 5.8 | 26 January 2006 |
| 2006-07 | 7.6 | 25 January 2007 |
| 2007-08 | 6.0 | 02 February 2008 |
| 2008-09 | 8.1 | 27 December, 2008 |
| 2009-10 | 6.3 | 22 January, 2010 |
| 2010-11 | 5.0 | 07 January 2011 |
| 2011-12 | 5.0 | 14 January 2012 |
| 2012-13 | 5.7 | 09 January 2013 |

## 3.5. Duststorms

It is very occasional feature and there is general crop damage as per severity. The crop losses was not assessed and the effect is very less and that too on few crops.

## 3.6. Heatwave

It is routine feature in districts of Chhattisgarh

plains zone and there is general crop damage as per severity. Horticultural crops and vegetable are more seriously damaged. Poultry and livestock get affected due to shortage of drinking water. Moderate effect on crops but poultry and livestock get affected extensively. To mitigate this stress, adaptation strategies like selecting heat tolerant varieties in vegetables and fruit crops, sprinkler irrigation or indigenous shade structures, mulching are being recommended.

## 4. Conclusion

Study of weather extremes in rainfed agriculture is a vital issue for increasing production and productivity of major crops for livelihood security, employment generation and productivity increase looking into the increasing population pressure. An attempt has been made to study the weather extremes in the state of Chhattisgarh under All India Co-ordinated Research Project on Agrometeorology, so that adaptation and mitigation strategies can be documented and applied under field conditions as model testing for its implementation at wider scales. Longest dry and wet spells in different years at Raipur during 2000-2013 have been documented in monsoon season. Dry spell / drought impact can be mitigated by indigenous water harvesting structures, RCC, OFRs (On Farm Reservoirs) and local traditional techniques like trenching, indigenous drip method etc. and these techniques can be applied for mitigation of this extreme event. Adaptation and mitigation strategies against flooding recommended are indigenous broad bed furrow maker through tractor as crop management technique and secondary reservoir techniques. Impact of some weather aberrations like hailstorms, cold wave, heat wave and dust storms on crops and animals have also been documented.

## References

1. Gupta S. K., Rao G. G. S. N. and Rajput R. K., 1990: 'Rainfall characteristics and rainwater management strategy for crop production' *Mausam* 41: pp 357-264.

2. Pali G.P., Vikas Pali, Sharma G.K., Chaudhary J.L., Rajput R.S. and Savu, R.M., 2012: 'Water harvesting for drought alleviation: lesson from Chhattisgarh' *J. Agricultural Issues*, Vol 17 (1 &2) pp 7-13.

3. Ramakrishana Y. S., 2013: 'Heat and cold waves their effect on agriculture and allied sectors' Proc. of DST training on Agrometeorological aspects of extreme weather events, Central Research Institute for Dryland Agriculture, Hyderabad, pp137.

4. Rao V.U.M., Rao A.V.M.S., Rao G.G.S.N., Satyanaryana T., Manikandan N., Venkateswarlu B. and Ramamohan I., 2011: *'WeatherCock software'* Central Research Institute for Dryland Agriculture, Hyderabad.

5. Subramaniam A.R. and Raju P.A.N. 1988: 'Rainfall variability and crop production in south coastal Andhra' *Fertilizer News*, 33 (4): pp 39-49.

6. Thakur D.S., Sharma G.K., Naik R.K., Kahlkho D., Chaudhary J.L. and Patil S.K., 2014: 'Evaluation of rice establishment methods with nutrient and weed management options under rainfed farming situations of Bastar Plateau'. *J. soil and water conservation* 13 (1): pp 36-41.

7. Tomar V.S., 2002: 'The beushening system of rice crop establishment in eastern India' In: Direct seeding: Research strategies and opportunities, Ed. Pandey S., Mortimer M., Wade L., Tuong T.P., Lopez K and Hardy B., International Rice Research Institute, Los Banos, Philippines, pp 53-73.