Assessment of Vulnerability towards Climate Change and Climate Induced Natural Disasters in Odisha

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Abstract

Odisha is a coastal state situated at the head of the Bay of Bengal in the eastern coast of India. Agriculture is the largest employer in this state as majority of its population work in this sector either as farmers or agricultural labourers. Odisha has a 482-km long coastline which exposes the state to flood, cyclones and storm surges. The performance of the Agricultural Sector continues to be highly volatile mainly due to adverse impact of natural shocks such as cyclones, droughts and floods which visit the state with unfailing regularity. It is fast gaining the status of being India's disaster capital. A state where farmers have accepted the natural disaster and low productivity as an inherent part of agriculture, demands attention to be shifted to aid the farmers in ways, where they can successfully adapt and cope with the climatic disturbances. The lop-sided growth that the agricultural sector is facing, can be attributed to the steep differences in the agro-climatic environments existing in the state. Weather-adjusted growth rates, geographical targeting in agricultural policy formulation can be a right foot towards equipping the most burnt section of the society i.e. the farming society, with proper adaptive and coping measures towards climate change and recurrent CINDs.**]**

Key words: Climate Change, CINDs, Weather Adjusted Growth Rate.

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Introduction

Climate is the general weather in a region over a long period. The changes in climate by the forces of nature are the driving force behind evolution of life on our planet. Life, general habits and sources of livelihood of people in any region have been shaped in accordance with the climate of that place. But while moving towards development and modernisation, human activities have hastened the process of climate change. The pace of atmospheric emission from industries and transport, urbanisation and deforestation has fastened and has contributed to the rise in global temperature. For the first time the Stockholm conference recognised the necessity to address climate change. Many human activities like excessive and non-scientific industrialisation, unplanned and non-regulated land use etc. contribute to the emission of greenhouse gases like CO_2, chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs) etc. and other pollutants which results in serious environmental problems like ozone layer depletion, global warming etc. A Synthesis Report based on the reports of the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC) reported that, “Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen “(IPCC, 2012). Anthropogenic greenhouse gas emissions have increased since the pre-industrial era. It has been driven largely by economic and population growth and are now higher than ever (IPCC, 2014). The threats posed by climate change has been realised across the globe. The survival of many species including human is at stake. The frequency of geophysical disasters (earthquakes, tsunamis, volcanic eruptions and mass movements) remained broadly constant throughout this period, but a sustained rise in climate-related events (mainly floods and storms) pushed total occurrences significantly higher (CRED, 2015). The most pressing impacts of climate change are increase in mean temperature, adverse change in precipitation, rise in sea level, erratic pattern of rainfall and the frequent occurrence of extreme climatic events or the CINDs (climate induced natural disasters) like drought, flood and coastal storms. As reported in Science Daily, “mounting scientific evidence indicates climate change will lead to more frequent and intense extreme weather that affects larger and larger areas and lasts longer” (Science daily, Feb-2016). “The scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response. The most vulnerable – the poorest countries and populations – will suffer earliest and most, even though they have contributed least to the causes of climate change. The costs of extreme weather, including floods, droughts and storms, are already rising, including for rich countries" (Stern review: The Economics of Climate Change). Yet capacity to adapt to climate change is much greater in developed than in developing countries, due to differences in expertise, technology, institutional capacity and wealth. Ironically, the regions that have contributed least to rising greenhouse gases will suffer the greatest consequences (Maarten K. van Aalst, 2004).

The disaster management sector is very much deprived in case of developing countries because of the lack of adequate financial and technological resources. This makes the developing countries the worst sufferers. Rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse impacts.

Odisha is a coastal state situated at the head of the Bay of Bengal in the eastern coast of India. Agriculture is the largest employer in this state as majority of its population work in this sector either as farmers or agricultural labourers." Agriculture holds a predominant position in the state's economy. About 80-85 percent of the state's population is rural and depends on agriculture. In recent years, wide fluctuation in climate has been observed and irregular rainfall causing both floods and droughts is a major concern. The impact of droughts on farmers has been crippling in some areas (Odisha climate change action plan).

The disaster management report published by the Department of Agriculture, Odisha reports," out of 52 years only 13 years have been normal years which puts our state with a 75% probability of being visited by natural calamity of any kind". Erratic and insufficient rainfall often cause drought and flood situations in this state. Being a costal state it faces cyclonic storms almost every year. Crop loss and poor productivity of agriculture often leave the farmers in this state as worse sufferers. Farmer suicide has been witnessed in many parts of this state.

The Vulnerability Scenario in Odisha towards Climate Change and CINDs:

The economic survey of Odisha (2014-15) has reported that, "The share of agriculture & animal husbandry sector to GSDP of Odisha remained 15.1 percent, 13.1 percent and 12.3 percent in 2012-13, 2013-14 and 2014-15 respectively. Major factors like natural shocks of floods, droughts, severe cyclone etc. and price variations in agricultural products contributed significantly to the varying degrees of growth rates, mostly negative growth rates in the last decade between 2004-05 and 2014-15. The performance of the Agricultural Sector continues to be highly volatile mainly due to adverse impact of natural shocks such as cyclones, droughts and floods."

This state has a tropical climate, characterised by high temperature, high humidity, and medium to high rainfall. Situated on the eastern coast, Odisha has a 482-km long coastline. The vast coastline of Orissa exposes the State to flood, cyclones and storm surges. Five major rivers run through the state (Government of Odisha, “Odisha at a Glance”). Agro climatically, Odisha is prone to extreme weather events such as floods, droughts and cyclones (Orissa Climate Change Action Plan: 2010-2015). Flood, cyclone and droughts occur in this state in almost every year at varying intensities. The actual rainfall received, vary from district to district. Heavy rainfall during monsoon causes floods in the rivers. Flow of water from neighbouring States of Jharkhand and Chhattisgarh also contributes to flooding. The flat coastal belts with poor drainage, high degree of siltation of the rivers cause severe floods in the river basin and delta areas (OSDMA: “Floods in Odisha”). As reported in The Indian Express,” farmer suicides have been reported from across the state, but a large percentage has occurred in the western Odisha districts of Bargarh, Bolangir and Sambalpur. All three districts lack irrigation facilities — in Bolangir, just about 3 per cent of the land is irrigated. Most of those who have killed themselves were sharecroppers, a few were marginal farmers” (The Indian Express, 28 March, 2016). Its resilience and infrastructural capacity to cope with extreme weather events, however, is undermined by steep imbalances in its region-wise growth and economy (Business Standard, “Lopsided growth stalks Orissa’s economy”, February 24, 2012).

Thomalla et al precise that to reduce vulnerability to extreme natural phenomena successfully, there needs to be clear understanding of who is most vulnerable to the impacts and how the interactions between nature and society shape the underlying factors that contribute to vulnerability. Pandey and Bhandari (2009) documented the vulnerability of drought by carrying out a cross country comparative study about the impacts of drought and farmer’s coping mechanism. In the states of eastern India drought results in an additional 13 million people falling back to poverty. It explains that of people who fall in the poverty trap in the drought years, not all of them can escape the trap when weather returns to normal. Khan et al (2009), presses on understanding the regional and local dimension of vulnerability in India, which according to them is essential to develop the targeted adaption effect. Patnaik and Narayan (2009) studied the vulnerability scenario in the eastern coastal districts of India. They observed that districts in Odisha and Andhra Pradesh are more exposed to CINDs than other states. Their result showed that Kendrapara and Jagatsinghpur ate the most affected areas and ranked first in their vulnerability index.

"Orissa is fast gaining the status of being India's disaster capital. Year after year, the state has been ravaged by natural calamities and the present flood rampage therefore comes as no surprise. Flood, drought and cyclones visit the state with unfailing regularity. In the last 100 years' nature, had spared the state in 10 years only. According to official statistics, floods topped the list by devastating the state in a total of 49 years, followed by droughts (30 years) and cyclones (11 years). Moreover, since 1965, calamities are becoming more frequent. Between 1834 and 1926, Orissa experienced a flood once in four years. This rose to once in two years after 1926. The state experienced nine floods within 15 days in 2001. This was an all-time high, damaging 2.12 million hectares of standing crops. The 2001 floods submerged 25 out of the 30 districts of Orissa, many of which had never witnessed floods before. It even inundated hilly areas like Kalahandi and Phulbani. Experts said this year's floods are almost a repeat of 2001" (The Economic Times, 24/09/2016). "In the 1970s, an approximate value of property loss was about Rs 105 crore, in the 1980s it moved up nearly seven times and in the 1990s it increased by more than 10 times" (Disaster analysis Odisha)[2]

As a consequence, CINDs have become a setback for the already marginalised people of Odisha. The situation has resulted in severe fiscal imbalances by putting intense stress on revenue expenditure, i.e., costs of restoring property and cutback of revenue in terms of taxes and duties for the crop loss and property loss suffered by people.

"Between 1868 to1967, i.e. within a span of hundred years, there were 262 flood inundations in the state, of which 68 were high floods. 77 of them were medium floods and 117 low floods. Among the rivers, Mahanadi experienced the highest number of floods i.e. 99 times. In other major rivers of Orissa, Brahmani experienced such floods 77 times whereas Baitarani caused floods for the 86th time. However, the scale of grimness of the floods of 1881, 1894, 1896, 1907, 1920, 1926, 1927, 1934, 1940, 1941, 1943, 1955, 1960, 1961 surpassed the previous ones. To add to the plight of its people, in between 1967 to 2003, floods of periodic nature occurred almost every year in between 1967-1975, 1977, each year between 1980-82, 1985, 1990, 1992, 1994, 1995, 2001 and 2003. The number of such destructive i.e. flood occurs equalled 20 times. Total of all such chronic, periodic and yearly occurrences of floods in Orissa during 1886-2003 i.e. during the last one hundred thirty-six years are as many as 282" (Sarangi and Penthoi, 2005). The data shows that that vulnerability due to flood has hastened over time, as it has not only been causing human and livestock casualties, but has also been affecting life, property and livelihood of people through years.

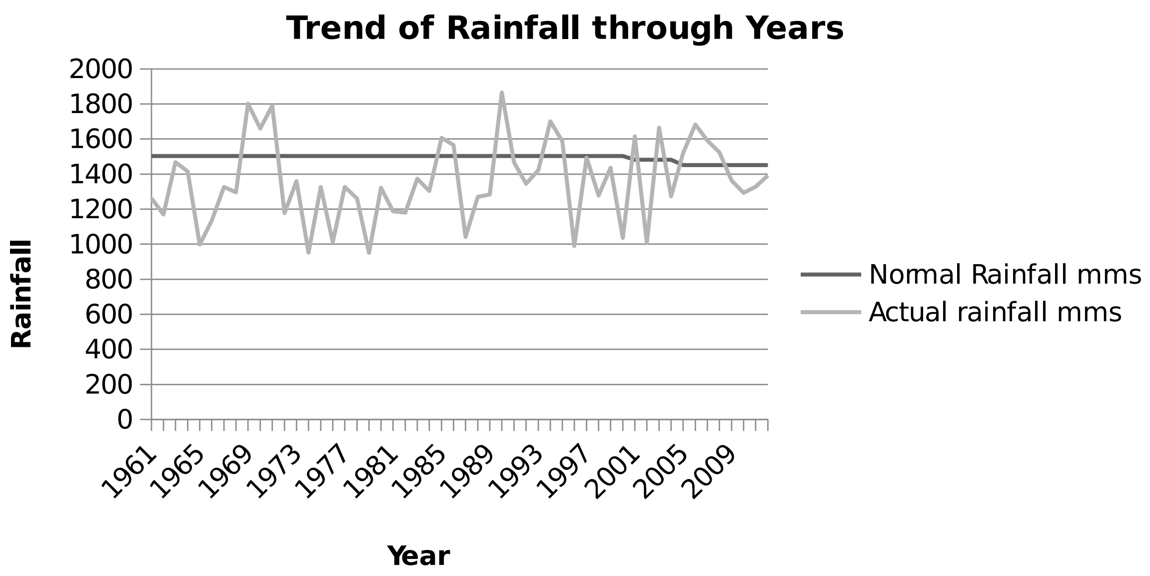
2 www.odisha.gov.in/pc/humandevelopment/hdr/chap07.pdf

"The 1999 Super Cyclone, with speeds up to 300 km per hour, hit as many as 97 blocks, 28 urban local bodies, 1827 Gram Panchayats (GPs), and 15,676 villages with a total population of 1.26 crore. Nearly 10,000 human lives were lost, 15.80 lakh houses damaged, and 17.86 lakh hectares' agricultural land affected. More than three lakh cattle were lost and over 90 per cent of school buildings, dispensaries, offices, government buildings, and roads in rural areas were damaged. The total loss due to the Super Cyclone was estimated to be Rs 50,000 crore" (Disaster analysis Odisha).

"Our state has suffered from drought conditions in most of the years in the second half of the 1990s. During the period of 1996 to 1997, almost all the districts were affected by drought. The situation got severe as more than half of the villages in Odisha suffered from crop loss of 50 per cent and more. The severity of the drought situation kept on increasing thereafter. This called for a concerted and intensive to address this problem from a long-term perspective" (Odisha disaster analysis).

These are the disturbances that directly affect agriculture the most. Our state being an agricultural economy faces the brunt of these climatic factors and the small and marginal farmers who depend on agriculture to meet their ends are the pawns who face the severity of this scenario.
To discuss the situation further the data on rain fall, crop productivity and number of disasters in our state has been collected from various sources and discussed below.

Figure 1: Trend of Rainfall through Years



(Source: Status of Agriculture in Odisha, Directorate of Agriculture, Odisha)

Figure 1 gives an idea about the erratic nature of rainfall in our state. In almost every year actual rain fall deviates from normal rain fall. It provides data on the actual rainfall in mms, the natural rainfall in mms, kharif rice production in lakh MT and the natural disaster suffered by our state from 1961 to 2012. It can be observed that in the data of 51 years only 13 years are there where there has not been any natural disaster. Rest 31 years have witnessed natural disaster of some kind. This leaves our state with 75% probability of facing natural disaster in any year. The exact nature of deviation can be further analysed by finding the percentage deviation of actual rainfall from normal rain fall.

Table 6: Year Wise Percentage Deviation of Actual Rainfall from Normal Rainfall

Year	percentage Deviation of Actual Rainfall from Normal Rainfall	Remarks
1961	-15.953	
1962	-22.136	
1963	-2.3627	
1964	-5.8835	
1965	-33.637	Severe drought
1966	-24.466	Drought
1967	-11.7	Cyclone & Flood
1968	-13.737	Cyclone & Flood

1969	19.9401	Flood
1970	10.4958	Flood
1971	19.2346	Flood, Severe Cyclone
1972	-21.657	Drought, flood
1973	-9.4775	Flood
1974	-36.692	Flood, severe drought
1975	-11.774	Flood
1976	-32.612	Severe drought
1977	-11.687	Flood
1978	-16.053	Tornados, hail storm
1979	-36.725	Severe drought
1980	-12.033	Flood, drought
1981	-20.972	Flood, drought, Tornado
1982	-21.471	High flood, drought, cyclone
1983	-8.5458	
1984	-13.291	Drought
1985	6.94176	Flood
1986	4.23295	
1987	-30.729	Severe drought
1988	-15.441	
1989	-14.549	
1990	24.1797	Flood
1991	-2.4493	
1992	-10.542	Flood, drought
1993	-5.3844	
1994	13.1581	
1995	5.69052	
1996	-34.103	Severe drought
1997	-0.6323	

1998	-14.975	Severe drought
1999	-4.4459	Severe Cyclone
2000	-31.108	Drought & Flood
2001	9.04062	Flood
2002	-32.006	Severe drought
2003	12.2318	Flood
2004	-14.074	Moisture stress
2005	4.70645	Moisture stress
2006	15.9592	Moisture stress/Flood
2007	9.66786	Flood
2008	4.98897	Flood, Moisture Stress
2009	-6.1053	Flood/ Moisture stress/ Pest attack.
2010	-10.901	Drought/ Un-seasonal rain
2011	-8.5033	Flood/ Drought
2012	-4.1276	Drought in Balasore, Bhadrak,
		Mayurbhanj & Nuapada districts

This derived table gives us an idea that the years in which % deviation of actual rainfall from normal rain fall is high is the year with drought or severe drought. The year 1965 observes a high negative percentage deviation of actual rain fall from normal rain fall and is the year of severe drought. 1974, 1976, 1979, 1987.1996,1998 and 2002 has witnessed severe fluctuations in the rainfall pattern and has witnessed severe drought. 23 years out of 51 years has suffered from flood situation and all these years either had positive % deviation of actual rainfall from normal rain fall or very less negative deviation from normal rainfall. This can be observed here that fluctuation in the climatic variables like rainfall lead to natural disasters like flood and drought, which are therefore also known as climate induced natural disaster.

To give shape to our analysis a line graph has been derive from the above table as below-

Figure 2: Year Wise Percentage Deviation of Actual Rainfall from Normal Rainfall:

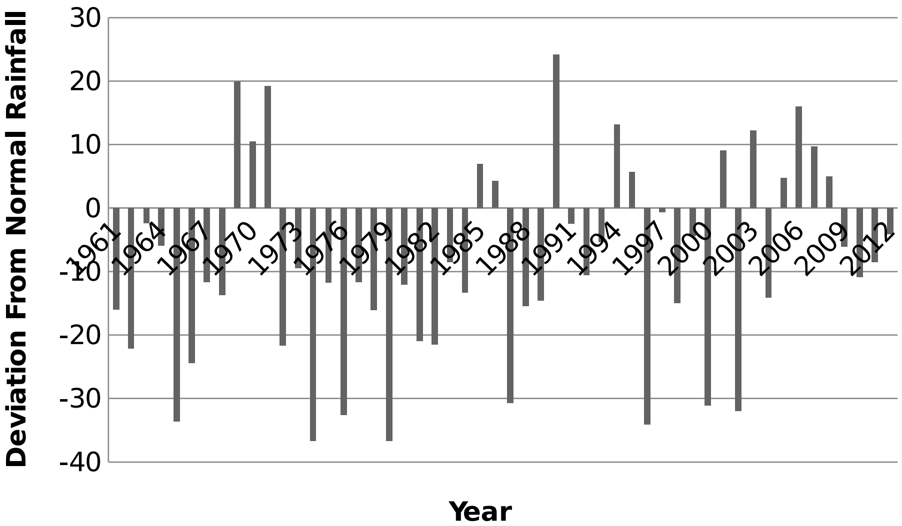
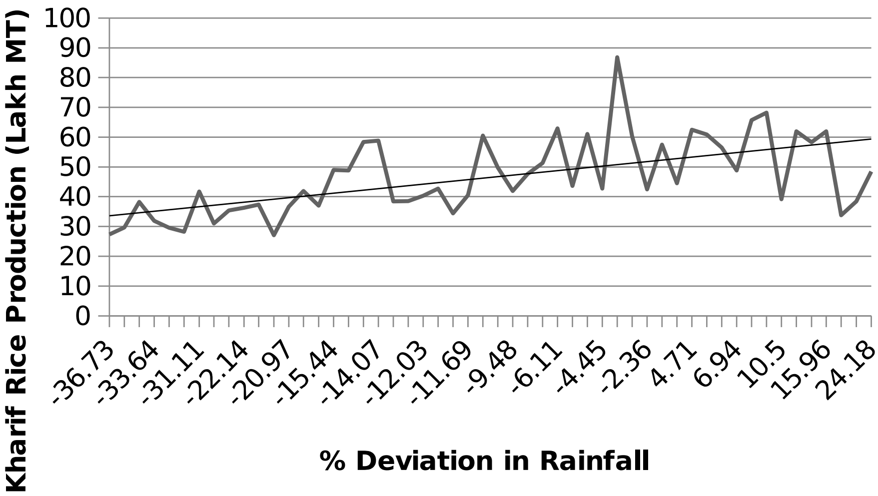


Figure 2 depicts the year wise % deviation of actual rainfall from normal rain fall from 1961 to 2012. It shows among the 51 years only in 14 years' actual rain fall is more than normal rain fall. Alternatively, it can be said that in 37 years our state received deficient rain or less rain fall than the normal rainfall. As already mentioned above our state has an agricultural economy and most of the cropping are rain fed. When rain fall remains deficient the productivity of agriculture is severely affected.

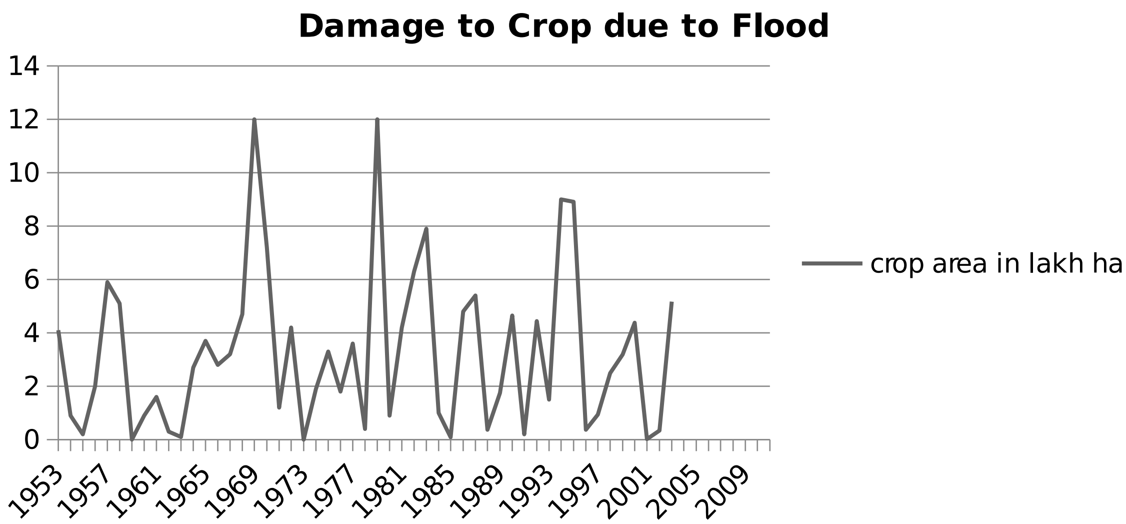
This can be better portrayed through graph showing the relationship between % deviations in rain fall data and Kharif Rice Production –

Figure 3: Percentage Deviations in Rain Fall Data and Kharif Rice Production:



The line graph is plotted by arranging the data on % deviation in actual rain fall from normal rain fall in an ascending order to better explain its impact on kharif rice production. It can be observed that kharif rice production is better when % deviation in actual rainfall from normal rain fall is less. Deficient rainfall leads to less crop productivity due to drought condition in the state. The trend line shows that production increases with quantity of rain fall, but when rain fall is too high or is surplus than the normal rain fall production decreases due to flood condition in the state.

Figure 4: Year Wise Damage to Crop due to Flood:



(Source: State wise flood damage statistics, Flood Forecast Monitoring Directorate, Central Water Commission, GoI, 27 Nov'2012)

The maximum area i.e. 12 lakh hector got affected due to flood in our state in the year 1972 and 1982. The maximum value of property i.e. 641.25 crore got affected in the year 2008. In these 57 years of data only except in 17 years, every year vast crop area is affected by flood. The value of crop loss is 31.62 crores in average every year, which is mostly borne by the small and marginal farmers.

Impact of Climate Variables (Rainfall and Temperature) on Production:

After analysing the of vulnerability scenario of Odisha in terms of the natural disasters, we considered climate variables like rainfall and temperature and their impact on state's agriculture, by relating them with crop output. This study will estimate weather-adjusted trend growth rates for crop production for 13 districts of Odisha. The green revolution period and the following periods are taken in to account here. During the green revolution period, some technological advances were introduced in the then existing farming system. On farm assistances were also made available to the farmers. Climate change repercussions were realized in the form of rainfall and temperature variations. The weather adjusted growth rates and elasticities of crop output to the variations in the climatic variables will help explaining whether these advances and aids helped the situation or there exists variation in the sensitivity in different parts of our district. The weather adjusted growth rate gives the real growth rate scenario as it takes data on weather variables for only the months in which the crop was produced rather than taking the data for the whole year. Thereby it takes in to account the climatic disturbances while finding out the growth rate.

Data and Methodology-

The rainfall and temperature data were collected form www.indiawaterportal.org for district level rainfall and temperature data. We will analyse growth of crop output for 10 crops in selected 13 districts from various agro-climatic zones in Odisha. Here the pre-green revolution period has been ignored due to lack of availability of district-wise data for all these parameters. Data has been analysed for the growth and sensitivity of crop output from 1967-68 to 2013-14 (green revolution and post green revolution period) for district-wise analysis. The weather adjusted growth rates in crop production were estimated based on the approach of A.Senapati by introducing appropriate intercept and slope dummies as shown below:

$$\ln Q_t = b_0 + b_1 D + b_2 T + b_3 (TD) + b_4 \ln(rt) + b_5 (D \ln rt) + b_6 \ln tt + b_7 (D \ln tt)$$

Where Q_t = Production of crop, rt = Crop specific rainfall index, tt= Crop specific temperature index

D = 0 for 1967-68 to 1987-88

= 1 for 1987-88 to 2013-14.

And b_2: estimated growth rate for the period 1967-68 to 1987-88, (b_2+b_3) represents estimated growth rate for the period of 1987-88 to 2013-14. b_4 represents elasticity of production with respect to rainfall for the period 1967-68 to 1987-88, (b_4+b_5) represents elasticity of production to rainfall variation for the period 1987-88 to 2013-14. Similarly, b_6 represents elasticity of production with respect to temperature variation for the period of 1967-68 to 1987-88, (b_6+b_7) represents elasticity of production to temperature variation for the period of 1987-88 to 2013-14.

Crop specific rainfall index has been calculated based on the following procedure:

Rainfall index (year x) = monthly rainfall (year x) – normal mean rainfall/s.d.

Crop specific rainfall index = rainfall index (year x) multiplied by area under crop cultivation. In notation:

$$RI\ of\ crop_{it} = \frac{\sum_{j=1}^{\leq 12} \left(MR_j - \overline{m}\right)}{S.D(MR)} \tag{7}$$

MR = Monthly rainfall of month j where monthly data of only cultivated months are considered. For example, if rice is cultivated for 8 months in a year, then n=8.

(Crop specific rainfall index)$_t$ = (RI of crop$_{it}$) × (GCA of crop$_{it}$).

Similarly, Crop specific temperature index has been calculated based on the following procedure:

Temperature index (year x) = monthly temperature (year x) – normal mean temperature /s.d.

Crop specific temperature index = temperature index (year x) multiplied by area under crop cultivation. In notation:

$$TI\ of\ crop_{it} = \frac{\sum_{j=1}^{\leq 12} \left(MT_j - \overline{m}\right)}{S.D(MT)} \tag{7}$$

MT = Monthly temperature of month j where monthly data of only cultivated months are considered. For example, if rice is cultivated for 8 months in a year, then n=8.

$(\text{Crop specific temperature index})_t = (\text{TI of crop}_{it}) \times (\text{GCA of crop}_{it})$.

Results and Discussion:

Weather Adjusted Growth Rate of Production of Selected Crops in 13 Districts of Odisha

Crops\Districts	1	2	3	4	5	6	7	8	9	10	11	12	13
Rice 1	-1.34	1.24	0.24	0.87	0.33	1.78	-0.66	-0.49	1.21	1.51	0.46	0.21	0.35
Rice 2	0.37	3.56	0.75	-5.94	4.04	-1.69	2.78	2.26	0.36	2.39	0.98	-0.66	0.52
Potato 1	4.12	4.41	-7.62	-0.54	1.09	-2.27	10.87	2.24	1.26	-1.27	-2.94	-0.98	0.32
Potato 2	-0.54	0.42	-1.94	0.57	1.19	-1.34	-1.94	0.02	0.71	2.09	-1.47	-1.81	1.81
Maize 1	7.55	-1.53	6.27	2.33	1.98	3.21	1.25	-0.29	0.59	0.20	2.74	-1.43	1.55
Maize 2	-2.55	1.34	9.50	0.44	27.85	0.89	3.57	1.54	3.51	1.23	-1.58	-0.77	0.50
Groundnut 1	14.68	-1.25	6.62	5.63	-1.89	-1.45	2.02	-0.87	-3.56	1.91	-1.40	3.58	-4.45
Groundnut 2	-0.14	1.29	-2.88	5.99	6.84	1.21	2.96	0.82	2.38	-0.55	3.17	1.35	2.10

Gram 1	0.77	-0.67	0.81	-0.65	-1.70	-0.52	-4.99	-3.73	2.63	-2.35	0.77	3.44	2.92
Gram 2	-10.4	-1.49	7.02	1.88	-58.0	1.18	6.47	2.33	-0.74	4.22	-1.15	0.79	2.23
Sugarcane 1	-1.56	6.10	4.23	-0.30	10.06	2.14	-0.82	1.19	3.24	0.24	2.29	2.58	0.94
Sugarcane 2	8.91	17.17	11.44	10.37	10.10	10.07	7.25	9.85	17.95	8.00	10.44	15.19	15.09
Total food grains 1	1.37	0.77	-0.30	0.61	0.36	0.19	-0.89	0.41	0.38	1.16	-0.07	0.41	0.15
Total food grains 2	0.09	1.93	1.32	-0.75	4.54	-1.91	3.42	0.36	-0.04	2.19	1.20	0.87	0.78
Total cereals 1	1.53	0.38	0.99	0.97	0.16	0.58	-0.35	-0.94	1.45	0.53	0.48	1.05	-0.21
Total cereals 2	-0.07	1.03	1.24	2.67	3.99	-1.93	2.66	1.36	0.21	1.85	0.63	-2.22	0.95
Total pulses 1	3.81	4.30	-2.21	1.73	0.55	0.73	-1.86	-0.62	-1.25	5.66	-0.10	-3.17	1.70
Total pulses 2	-1.86	-1.00	1.40	-0.03	2.67	2.05	3.25	-2.48	1.41	0.59	-0.88	-2.42	0.62
Total oilseeds 1	9.16	0.04	3.36	0.97	-1.14	-0.66	5.21	2.36	2.86	1.31	5.67	4.11	0.38
Total oilseeds 2	0.27	-0.53	2.41	2.67	-4.10	-0.64	4.09	-3.93	-6.97	2.26	2.84	-0.33	-1.41

Note: Authors calculation based on ASO data. Period1 (1966-67 to 1987-88), and period 2 (1988-89 to 2013-14), 1, 2, …….13 are the serial numbers of 13 districts.

The weather-adjusted growth rate figures give us knowledge on whether crop output is sensitive to variations in weather variables i.e. variations in rainfall and temperature. In case of rice production, all the districts out of the 13 have realized a significant increase in sensitivity of output to weather variation in the post green revolution period except for Cuttack, Ganjam, Koraput and Sambalpur. In case of production of potato, except for Balasore, Bargarh, Kalahandi, Keonjhar, Koraput and Sambalpur, rest other districts have experienced a significant rise in sensitivity of output to weather variation in the post green revolution period. But in case of production of maize all the districts except Bargarh, Bolangir, Dhenkanal, Koraput, Mayurbhanj and Sambalpur districts have experienced a significant decline in the sensitivity of output to weather variation in the post green revolution period. In case of ground nut there has been a significant decline in sensitivity of output in Balasore, Bolangir, Mayurbhanj and Smabalpur to the variation in weather. In case of gram a significant decline in sensitivity of output to weather variation has been realized in all the districts except in Cuttack, Dhenkanal, Ganjam, Kalahandi, Keonjhar and Mayurbhanj. In case of sugarcane a significant increase was observed in sensitivity of output to weather variation in all the districts. In case of total food grains all the districts saw a significant rise in sensitivity of output to weather variation except for Balasore, Cuttack, Ganjam, Keonjhar and Koraput. In case of total cereals all the districts experienced a significant rise in sensitivity of output to weather variation except in Balasore, Ganjam, Koraput and Sambalpur. In case of total pulses a significant rise in sensitivity of output to temperature variation was observed in Bolangir, Dhenkanal, Ganjam, Kalahandi, Koraput and Sambalpur. In case of total oilseeds all the districts saw a significant decline in sensitivity of output to variation in weather except in Cuttack, Ganjam and Mayurbhanj.

Sensitivity of Crop Output to Rainfall Variations of Selected Crops in 13 Districts of Odisha

	Elasticity of Crop Output with respect to Rainfall												
Crops\Districts	1	2	3	4	5	6	7	8	9	10	11	12	13
Rice 1	0.11	0.56	0.36	0.96	0.68	0.71	0.76	-0.49	0.56	0.53	0.66	0.62	1.70
Rice 2	0.03	1.03	0.04	-0.04	1.24	0.06	0.12	2.26	0.05	0.31	0.42	0.90	0.75

Potato 1	0.96	0.31	1.25	-0.23	0.77	0.29	-2.50	2.24	0.31	0.22	0.04	0.38	0.40
Potato 2	0.01	0.00	1.38	0.41	-0.11	0.49	0.95	0.02	0.16	0.21	0.06	-0.01	-0.19
Maize 1	0.53	-0.23	0.76	-0.81	1.17	-0.13	0.60	0.57	0.97	0.18	-1.01	0.10	-0.22
Maize 2	0.08	0.56	0.66	0.54	1.21	-0.02	0.10	-0.40	-0.28	0.79	0.18	0.18	0.27
Groundnut 1	-0.31	1.13	-0.02	0.06	0.98	0.47	1.24	1.35	0.25	1.18	0.42	0.32	0.80
Groundnut 2	0.16	1.00	0.06	0.60	0.56	0.06	0.35	0.35	0.34	0.74	0.12	0.95	0.79
Gram 1	-0.06	0.56	0.74	0.62	0.19	0.32	0.54	1.63	0.87	0.60	-0.07	0.28	1.50
Gram 2	0.12	0.75	0.34	0.48	0.92	0.24	-0.04	0.28	9.56	0.35	0.41	0.55	0.50
Sugarcane 1	0.51	0.52	0.11	1.34	1.52	1.12	-0.04	0.64	49.84	0.99	0.80	0.30	0.27
Sugarcane 2	-0.06	-0.13	-0.01	-0.33	0.00	-0.31	-0.32	0.08	-36.8	-0.03	0.05	-0.42	-0.08
Total food grains 1	0.03	0.58	0.69	0.61	0.62	0.36	0.22	1.11	0.25	0.95	0.52	1.41	0.43
Total food grains 2	0.09	-0.09	0.19	0.65	1.30	0.10	0.31	0.29	-0.19	0.53	0.47	0.89	-0.05
Total cereals 1	0.09	0.42	0.38	1.07	0.86	0.69	0.38	1.16	0.48	0.56	0.65	0.75	0.96
Total cereals 2	0.10	-0.1	0.06	0.49	1.22	0.04	-0.1	0.20	-0.0	0.04	0.50	-0.1	0.12

		3					3		4			8	
Total pulses 1	0.10	0.32	0.53	0.22	0.35	-0.02	0.71	1.16	0.22	-0.08	-0.30	0.93	0.78
Total pulses 2	0.05	0.99	0.57	0.34	0.75	0.23	-0.15	0.27	0.50	-0.16	1.01	0.52	1.39
Total oilseeds 1	-0.12	0.54	0.51	-0.01	0.92	0.47	0.25	0.76	9.56	0.62	0.19	0.28	0.56
Total oilseeds 2	0.15	0.72	0.47	0.39	0.64	-0.14	1.07	0.36	59.40	0.65	0.27	-0.06	0.78

Note: Authors calculation based on ASO data. Period1 (1966-67 to 1987-88), and period 2 (1988-89 to 2013-14), 1, 2,………, 13 are the serial numbers of 13 districts.

The above table explains the elasticities of crop output with respect to rainfall i.e. percent deviations in production from its trend due to 1% deviation in rainfall from its normal level. In case of rice production, 8 districts out of the 13 studied have experienced a significant decline in sensitivity of output to rainfall variation in the post green revolution period except for Bargarh, Keonjhar, Dhenkanal, Sambalpur and Sundargarh. In case of production of potato, except for Bolangir, Cuttack, Ganjam, Kalahandi and Sambalpur rest other districts have experienced a significant decline in in sensitivity of output to rainfall variation in the post green revolution period. But in case of production of maize all the districts except Balasore, Bolangir, Kalahandi, keonjhar and Koraput districts have experienced a significant increase in the sensitivity of output to rainfall variation in the post green revolution period. In case of ground nut there has been a significant decline in sensitivity of output in all districts except in Balasore, Bolangir, Koraput and Sambalpur to the variation in rainfall. In case of gram a significant increase in sensitivity of output to rainfall variation has been realized in Dhenkanal, Koraput and Puri. Mild increase was observed in Balasore, Bargarh and Sambalpur and significant decline was observed in all other districts. In case of sugarcane a significant decline was observed in sensitivity output to rainfall variation in all the districts. In case of total food grains all the districts saw a significant decline in sensitivity of output to rainfall variation except for Balasore Bargarh, Cuttack, Dhenkanal and Kalahandi. In case of total cereals all the districts experienced a significant decline in sensitivity of output to rainfall variation except in Balasore and Dhenkanal. In case of total pulses a mild decrease in sensitivity of output to rainfall variation was observed in Balasore, Kalahandi, Keonjhar, Mayurbhanj and Sambalpur, the other districts observed a significant increase in sensitivity of output to rainfall variation. In case of total oilseeds all the districts saw a significant decline in sensitivity of output to variation in rainfall except in Bolangir, Dhenkanal, Keonjhar and Sambalpur.

Sensitivity of Crop Output to Temperature Variations of Selected Crops in 13 Districts of Odisha

	Elasticity of Crop Output with Respect to Temperature												
Crops\Districts	1	2	3	4	5	6	7	8	9	10	11	12	13
Rice 1	-0.37	0.23	0.37	-0.23	0.19	0.68	0.64	-0.30	0.49	-0.59	0.24	-0.62	-0.40
Rice 2	0.61	0.04	0.81	0.01	0.10	1.12	0.43	0.00	0.64	0.36	0.79	-0.52	1.19
Potato 1	0.13	0.29	1.83	1.30	-0.04	0.77	3.95	0.38	0.48	0.25	0.89	0.24	0.56
Potato 2	0.55	0.35	-3.34	0.74	1.18	0.29	0.10	0.72	0.72	0.88	0.66	0.22	0.55
Maize 1	0.10	1.25	-0.67	1.69	-0.18	0.84	0.34	0.32	0.04	0.78	1.75	0.84	1.04
Maize 2	0.54	0.38	-0.38	0.46	0.48	0.45	1.09	0.26	1.77	0.34	0.79	0.75	-0.03
Groundnut 1	0.79	-0.13	0.20	0.45	0.23	0.64	-0.37	-0.27	0.86	-0.18	0.77	0.14	0.75
Groundnut 2	0.92	-0.35	0.12	0.72	1.09	0.86	0.66	1.08	0.81	0.38	0.68	0.10	0.74
Gram 1	0.9	0.4	0.3	0.5	0.8	0.5	0.9	-	0.2	0.1	0.9	0.3	-

	8	7	2	5	5	7	6	0.18	1	8	9	4	0.12
Gram 2	0.28	0.66	1.14	0.62	0.04	0.66	0.00	0.43	1.02	0.52	0.48	0.63	0.84
Sugarcane 1	1.72	-0.44	0.40	0.15	-1.09	-0.16	0.61	0.37	-0.07	-0.30	0.07	-0.31	0.87
Sugarcane 2	0.52	1.47	0.42	0.45	0.73	0.36	0.01	0.73	0.99	0.73	0.89	1.43	1.37
Total food grains 1	0.04	0.06	0.45	-0.26	0.16	0.11	0.79	-0.11	0.66	0.04	0.78	-0.01	0.73
Total food grains 2	0.66	-0.14	0.98	0.06	0.21	1.32	0.79	0.77	0.95	0.83	0.64	-0.20	0.04
Total cereals 1	0.47	0.25	0.24	-0.06	-0.14	0.09	0.55	-0.38	0.39	0.24	0.15	-0.06	-0.09
Total cereals 2	0.66	0.01	0.94	0.77	0.32	1.59	0.38	0.38	0.83	-0.13	0.78	0.45	0.76
Total pulses 1	0.33	0.46	0.70	0.37	0.59	1.04	0.46	-0.35	0.92	0.13	1.50	0.93	0.31
Total pulses 2	0.91	0.31	0.64	0.94	1.17	-0.14	1.61	1.06	1.04	1.51	-0.04	1.16	0.86
Total oilseeds 1	0.74	0.36	0.09	0.52	0.36	0.82	0.06	-0.40	0.48	0.07	0.52	0.07	0.51
Total oilseeds 2	0.75	-0.07	0.72	1.19	-0.46	1.07	0.06	0.48	1.43	1.08	0.31	1.12	0.39

Note: Authors calculation based on ASO data. Period1 (1966-67 to 1987-88), and period 2 (1988-89 to 2010-11), 1, 2,………, 13 are the serial numbers of 13 districts.

The above table explains the elasticities of crop output with respect to temperature i.e. percent deviations in production from its trend due to 1% deviation in temperature from its normal level. In case of rice production, 10 districts out of the 13 studied have experienced a significant increase in sensitivity of output to temperature variation in the post green revolution period except for Bargarh, Dhenkanal, and Kalahandi. In case of production of potato, except for Balasore, Bargarh, Dhenkanal, Keonjhar, Koraput and Mayurbhanj, rest other districts have experienced a significant decline in sensitivity of output to temperature variation in the post green revolution period. But in case of production of maize all the districts except Balasore, Bolangir, Dhenkanal, Kalahandi and Koraput districts have experienced a significant decline in the sensitivity of output to temperature variation in the post green revolution period. In case of ground nut there has been a significant decline in sensitivity of output in Koraput and mild decline in Bargarh, Bolangir, Puri, Smabalpur and Sundargarh to the variation in temperature. In case of gram a significant increase in sensitivity of output to temperature variation has been realized in all the districts except in Balasore, Dhenkanal, Kalahandi and Puri. In case of sugarcane a significant increase was observed in sensitivity of output to temperature variation in all the districts except in Balasore and Kalahandi. In case of total food grains all the districts saw a significant rise in sensitivity of output to temperature variation except for Bargarh, Puri, Sambalpur and Sundargarh. In case of total cereals all the districts experienced a significant rise in sensitivity of output to temperature variation except in Bargarh and Kalahandi. In case of total pulses a significant rise in sensitivity of output to temperature variation was observed in all the districts except in Bargarh, Bolangir, Ganjam, Puri. In case of total oilseeds all the districts saw a significant rise in sensitivity of output to variation in temperature except in Bargarh, Dhenkanal, Puri and Sundargarh.

Conclusion

Odisha- which can also be termed as the disaster capital of our country, faces disasters with a regularity which is evident from the above discussion. The western part of Odisha containing the major hilly segment of this state suffers from drought on a regular basis, forcing the farmers to commit suicide due to severe crop loss. The vast coastal belt of this state exposes the coastal districts to frequent cyclones and floods causing severe agricultural stress in the farming community, by making people homeless, helpless and leads to crop loss by the nature’s fury. The sensitivity of the crop outputs to the variations in the climate variables gives a picture of the extent of vulnerability to which the agricultural production is exposed. The different agro-climatic environment in the different districts of this state exposes the districts to different kinds of vulnerabilities. The sensitivity varies from district to district and from crop to crop. Despite the same technological aid and financial support in all the districts the output sensitivity varies depending on the local climatic environment. Different geographical areas which are prone to different kind of CINDs require different policy and different aid. Farmers are to be trained and aided with different technology, strategy and support to deal with these adversities in different geographic zones. This situation calls for geographical targeting in the aiding process. The farmers in different agro-climatic zones of Odisha need help in adapting and coping to the climate change and CINDs in the form of methods and technology suitable for their area.

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