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Weather Variability and Instability in Agricultural Production: Evidence from Odisha

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

This study focused on exploring the weather variability induced instability in agriculture in the Odisha, India. In this study, growth and instability in ten major crops are analysed, followed by a depiction of weather variability in Odisha and then the association between weather variability and instability in selected crops are analysed using regression analysis. It is observed that weather variability is a major concern in the state of Odisha. In the context of agrarian economy of Odisha, the dimensions, magnitude and erratic nature of the weather variability and extreme weather events have made the situation more complex. Wide variations are observed in the rainfall both across time and space in the state. The long term average rainfall is indicating a declining trend. The weather variability has produced profound negative effects on agricultural production and yields in the state, causing agricultural fluctuations and has been a serious threat to the agrarian economy. Empirical findings lend credence to the negative effects of weather variability on agricultural yield and the regression analyses of yield instability on weather variability have only reaffirmed the same. The negative effects of weather variability on crop yield leads to a clear policy implication of proper provisioning of irrigation and weather variability resistance crop for increasing the crop yields and reduce the crop yield instability.

Keywords: Weather variability; yield instability; agriculture; rice; oilseed.

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1. INTRODUCTION

Agriculture is a crucial sector of the Indian economy as it provides and supports large share in employment and livelihood creation. In spite of declining share in Gross Domestic Product (GDP) over the years, agriculture still supports 52 percent of the employment and shares 18 percent in the India's GDP [1]. Majority of low income, poor and vulnerable sections of society, heavily depend on agriculture for employment and livelihood. The economic prosperity of majority of population, thus, in India is intertwined with agricultural performance. Agricultural growth has immense potential to reduce poverty, contain inflation, and generate employment [2].The linkage between agriculture and industrial sectors are widely recognized in the literature. So, rapid growth in agriculture led by increased productivity and production is the key to augment income of people largely depend on agriculture. So far as, Odisha is concerned, area wise it is the ninth largest state of India, with an area of 1,55,842 Km^2. In Odisha, agriculture also plays a dominant role in the economy with contribution of more than 20% to Net State Domestic Product. In the state, agriculture is largely rainfed. Being one of the coastal states of India, Odisha is frequently bearing the destructive effects of natural calamities like flood, cyclone and drought. Thus the economic history of Odisha is a story of ravages of the recurrent floods, cyclones and droughts that have created and still creating havoc in the economic and social life of the people in the State. These are climate shocks and weather variability that are crucial factors which have pushed back the progress of the economy of the state. Further, with advance in global warming and climate change as is being forecast, the state will bear the burden of such devastating effects on livelihoods, ecology and economy. Therefore, it is pertinent to understand the impact of climate change and weather variability on the agricultural production and instability in crop yields. A large number of studies have carried out to understand the impact of climate change on agricultural production. However, a very scanty literature have been found that focus on understanding the impact of weather variability on agriculture production and instability. Thus, the present study makes a modest attempt to explore the impact of weather variability on agricultural production instability.

A number of studies have been conducted on various aspects of instability in agriculture including its trend, technology impact and factors contributing towards agricultural instability. Basically, instability in agriculture measures the variation or fluctuation in different dimensions with respect to agriculture production, yield, or area of cultivation. The agricultural production risk increases with the instability and it also makes farmers vulnerable to fluctuating income and vulnerable to inability to take appropriate decision to adopt technologies and make investment decisions. Further, the instability in agriculture and food productions has important implication on macroeconomic instability and agriculture production management [3]. Though the agricultural production and growth drives economic prosperity, the instability in agriculture adversely affects it. After the introduction of green revolution, agricultural growth in India have achieved a paradigm shift but at the same time a wide range of fluctuations have also been observed in agriculture production. Though the adoption of new technology helps achieving higher production, the effects of technological advancement on instability in agriculture has not been crystallised in-spite of intense debate and discussion. Studies conducted in the early part of green revolution show that instability in agriculture has increased with the adoption of green revolution technologies [4-7]. However, another set of studies found that instability in agriculture has marginally declined at all India level with a mixed outcome at the state level [8,3]. The studies conducted during post reform period reveals that instability in agriculture has been increasing with concomitant negative effects on farmers' vulnerability [9-11]. While exploring the possible reasons of agricultural instability in post reform period, it is observed that studies have identified factors like lack of irrigation facilities, lack of rural infrastructure and climatic factors are the leading determinants of instability in agriculture [9,12,13]. But still there is a need to study agricultural instability at the spatial and disaggregated level to draw more relevant policy implications. Further there is very scanty literature on weather variability induced instability in agriculture at the state level. Therefore, the present study focused on exploring the weather variability induced instability in agriculture in Odisha. In this paper, growth and instability in major crops are analysed followed by a depiction of weather variability in Odisha and then the association between weather variability and instability in agriculture is analysed

2. MATERIALS AND METHODS

The study is conducted in the state of Odisha, India. Odisha which is area wise the ninth largest state of India have a total geographical area of 1, 55,842 km^2. Geographically, Odisha is located between $17^0 49'$ to $22^0 36'$ North latitudes and $81^0 36'$ to $87^0 18'$ East longitudes. The total population of the state is 4,19,47,358 with the average density of 269 per km^2 (Census 2011). The State usually has a tropical climate with high temperature, humid weather, medium to high rainfall, short and mild winters. South-west monsoon is the major contributors (80%) of the annual rainfall and the state has annual average rainfall of 150 cm with 100cm to 198cm variation across the state. Majority of population (82%) of the state live in rural areas and agriculture is the main occupation in the state. Natural calamities such as cyclones, droughts, and floods occur almost every year with varying intensity which is negatively affecting the agricultural production in the state. Therefore, it is imperative to study the weather variability in the state to understand their impact on the crop instability.

To study the weather variability, rainfall data has been collected from IMD Pune, various issues of Odisha Agricultural Statistics and different issues of Climatology Data of Odisha. The district level monthly average rainfall data have been first aggregated and then averaged to obtain rainfall data at the state level and monthly average rainfall data have been used to obtain annual and seasonal average rainfall for the state. The agriculture data related to ten selected crops such as rice, maize, cereals, chickpea, pigeonpea, pulses, rapeseed and mustard, groundnut, sesame and oilseeds have been obtained for the time period 1970-2016 from the ICRISAT VDSA (Village Dynamics in South Asia) Apportioned Meso database.

To have a better understanding on the weather variability, we have constructed weather variability index to know whether a particular year has experienced drought, flood or normal year, taking rainfall data over a period time of 1901-2016. The detailed formula and method of weather variability index is explained in the results and discussion section where the weather variability index is discussed to get the synchronized interpretation without losing the connection with the methods.

To analyse the performance of agriculture, decade wise compound annual growth rates of area, production and yield of 10 selected crops have been estimated for the period of 1970-2016. Similarly, instability of area, production and yield of the 10 selected crops has been estimated to capture variability over the period of 1970-2016. Instability has been estimated by using the following index:

Instability index of a particular crop = Standard deviation of natural logarithm (X_{t+1} / X_t) (i)

Where, X_t refers to area (A) under the crop, production (P) of the crop, yield (Y) of the crop in the year "t" and X_{t+1} denotes these for the next year. This index is unit free and robust.

Regression analysis is used to assess the quantitative effect of the weather variability upon the instability in crop yield and the statistical significance of the approximate relationships is also determined. The regression model used for this is given as follows:

$$I = \alpha + \beta E + \varepsilon \qquad \text{(ii)}$$

I= Instability score in crop yield under study
α = Constant
β=effect/coefficient
E=Weather index
ε=stochastic term

Here we have used decadal yield instability index of Rice, pulses and oilseed as dependent variables. The average decadal weather variability index has been used as independent variable. The regression results are obtained to know the causal effect of weather variability on yield instability of the selected crop under the study.

3. RESULTS AND DISCUSSION

3.1 Analysis of Weather Variability in the Study Area

Analysis of weather variability is important as it is the direct inputs for agriculture. Rainfall is the most important indicators of weather variability followed by temperature. The analysis of rainfall would help to understand the impact of weather variability on agriculture sector. To understand the weather variability we considered only the rainfall variability, focusing on its characteristics, variability and accordingly construct a weather index to find-out the variability in weather. This is because given the tropical climatic condition in the state of Odisha, agriculture production is largely determined by the rainfall in the state, other things remaining the same. The rainfall characteristics along with the coefficient of variation (CV) are given in Table 1.

Table 1 shows the characteristics of rainfall pattern in Odisha over two time period- one covering a time period of 50 years (1901-1950) and second covering a time period of 66 years (1951-2016). The characteristics of rainfall includes monthly and seasonal average rainfall, coefficient of variation (CV), percentage contribution to annual rainfall and percentage change in rainfall during the above mentioned periods.

Table 1 reveals that the long term annual average rainfall is declining. Average annual rainfall during 1901-1950 was 1163.53mm which declined to 1103.34mm during 1951-2016 with coefficient of variation of 10.65% and 14.68% respectively. The increasing value of CV during the periods indicates that rainfall variability is increasing over the periods. The decline in long term annual average rainfall can be attributed to the decline in long term monsoon season and winter season average rainfall. The long term monsoon and winter season average rainfall during 1901-1950 was 923.94mm and 34.60mm respectively which declined to 865.14mm and 28.24mm during the period 1951-2016. It is also evident that monsoon contributes most of the rainfall in the state which is about 78 % of the annual rainfall. The variability in monsoon rainfall is comparatively less as the CV value is low compared to rainfall of other seasons. The monsoon rainfall and average annual rainfall as declining over the periods, is a major threat to the agrarian economy in Odisha as the agriculture is largely rainfed in the state. Further, the decline in annual average rainfall is attributed to the decline in the monthly average rainfall for the months of January, February, July and December. Regarding pre-monsoon and post-monsoon seasons the change in long term average rainfall is erratic in the state which is revealing an uncertain pattern of rainfall during the specified seasons. For the months of May and October there is increase in long term monthly average rainfall. For October, the average rainfall during 1901-1950 was 89.65mm and that increased to 92.99 mm during 1951-2016. As the month of October is a principal month of tropical cyclones formed in the Bay of Bengal, it is more likely that during recent years more tropical cyclones are hitting the coastal area causing increase in average rainfall in the state during October. So far as the change in rainfall during the period 1901-1950 and 1951-2016 is concerned, it is observed that the rainfall has declined steadily for the months of December (-24.37%), January (-19.81%), November (-17.94%), February (-16.20%) and July (-12.63%). The declining rainfall necessitates additional provisioning of irrigation facilities for agricultural activities in the state.

3.2 Weather Variability Index and Categorization of Drought and Flood Years

To have a better understanding on the variability of rainfall we have constructed weather variability index to know whether a particular year has experienced drought, flood or normal year. The most negative aspect of weather variability is that it causes different types of extreme weather events such as droughts, floods, cyclones, heat waves, frosts etc. IPCC defines extreme events or climate shocks as "the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable." The extreme weather events are those natural disaster events that outstrip the capacity of a society to cope with it. Besides weather variability, climate shocks are also reinforcing wider risks and vulnerabilities leading to long-term setbacks for human development. The increasing frequency of extreme events also affects the agriculture sector in a negative way. These events immediately affect agriculture production and thereby influence the livelihood of the people dependent on agriculture.

Extreme events such as flood, cyclone and drought are by and large, regular phenomena in Odisha. Drought is a contraction period of rainfall resulting in severe damage to crops and hydrological imbalance. Flood is caused due to excess rainfall and has a damaging effect on agriculture production. These two climate shocks have not only led to colossal damage and loss of property but also posed threat to food security in the state. In most of the years, droughts and floods are experienced simultaneously because of excessive rainfall in some parts of the catchment basins and low rainfall in other regions. Every alternate year, either a drought or flood has become a recurring phenomenon in the State. During last five decades only 13 years have been found to be normal years and in all other years the state had to bear the brunt of

Table 1. Rainfall characteristics in the study area

Months	1901-1950 Average Rainfall (mm)	1901-1950 Contribution to Annual (%)	1901-1950 CV (%)	1951-2016 Average Rainfall (mm)	1951-2016 Contribution to Annual (%)	1951-2016 CV (%)	% Change of average rainfall between 1901-50 and 1951-2016
Jan	10.30	0.89	131.44	8.26	0.74	118.64	-19.81
Feb	19.14	1.64	104.81	16.04	1.45	109.03	-16.20
Mar	15.47	1.33	109.67	17.73	1.60	106.09	14.61
Apr	23.95	2.06	82.21	25.40	2.30	68.54	6.05
May	47.18	4.06	61.54	50.50	4.58	92.56	7.04
Jun	167.46	14.39	44.03	157.74	14.30	33.74	-5.80
Jul	288.46	24.79	27.79	252.04	22.85	25.08	-12.63
Aug	285.10	24.50	25.03	274.60	24.88	25.83	-3.68
Sep	182.92	15.72	25.74	180.80	16.38	31.82	-1.16
Oct	89.65	7.71	67.39	92.99	8.44	60.46	3.73
Nov	28.77	2.47	127.98	23.61	2.14	128.04	-17.94
Dec	5.17	0.44	198.72	3.91	0.35	226.64	-24.37
Annual	1163.53	100.0	10.65	1103.34	100.00	14.68	-5.17
Pre-Monsoon	86.61	7.44	43.93	93.55	8.48	58.57	8.01
Monsoon	923.94	79.41	12.11	865.14	78.41	14.17	-6.36
Post-Monsoon	118.42	10.18	56.12	116.61	10.56	60.07	-1.53
Winter	34.60	2.97	74.10	28.24	2.55	74.82	-18.38

Sources: Rainfall data of Odisha

different ravaging extreme weather events with a 76% probability of being attacked by these events of any kind in a year [10].

Odisha has the heaviest seasonal concentration of rainfall. The variability of monsoon rainfall affects different part of the state with different intensity. For the purpose of constructing weather variability index, all the dry and wet years have been separated by applying a commonly used classification formula [14]. A year is classified as wet year when

$$R_i \geq R_m + S_d \quad \text{(iii)}$$

Further, a year is classified as deficient or dry year when

$$R_i \leq R_m + S_d \quad \text{(iv)}$$

Where: R_i= monsoon rainfall amount of year i
R_m= long term mean monsoon rainfall, and
S_d = Standard deviation of monsoon rainfalls

The rainfall departure time series is calculated by transforming rainfall departures using long-term mean and standard deviation. For obtaining the transformed series of rainfall departures the following formula has been used.

$$N_i = \frac{R_i - R_m}{S_d} \quad \text{(v)}$$

Where: N_i is the transformed/normalized annual rainfall departure value of R_i.The obtained series has mean =0 and standard deviation =1. The year with below normal monsoon rainfall quantity is designated as a drought year and the excess as the flood year. The standardized values are used as the indices of severity of meteorological drought and flood. The values of -0.99 to 0.99 are considered as 'normal' condition, the values of -1.0 (+1.0) to -1.49 (+1.49) are considered as moderate drought (flood), the values of -1.5 (+1.5) to -1.99 (+1.99) as severe drought (flood) and the values below (above) -2.0 (+2.0) as extreme drought (flood). To investigate the changes weather index, drought and flood indices are constructed and linear trends are fitted using OLS technique as shown in Figs 1 and 2.

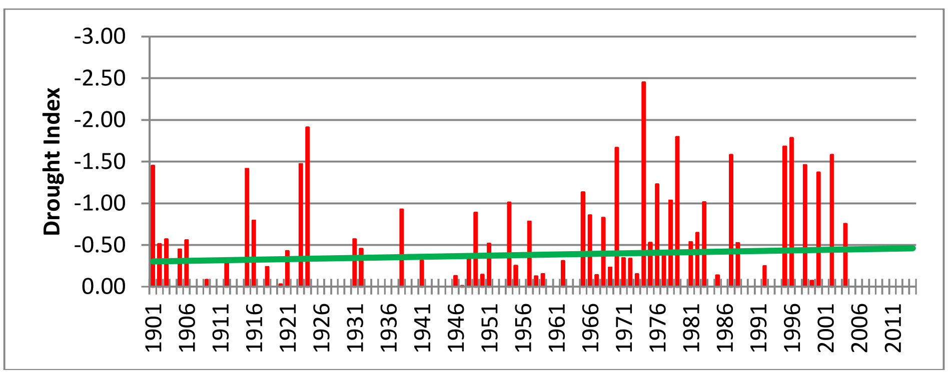

Fig. 1. Weather Index for Drought years and its trend in Odisha

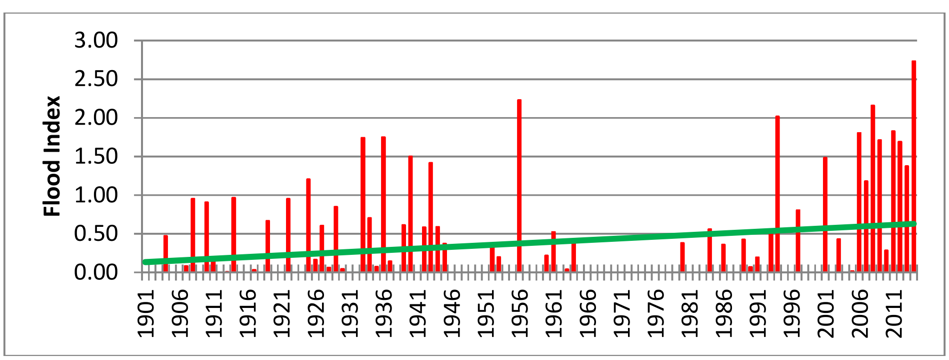

Fig. 2. Weather Index for flood years and its trend in Odisha

Figs 1 and 2 displays the weather index with respect to drought and flood years as meteorological classification along with their trend lines. Both the drought and flood years of the weather index are exhibiting increasing trends during the study period. This is a matter of concern that both droughts and floods are increasing in the state over the long period of time showing erratic pattern of weather condition particularly with respect to rainfall pattern. However, the figures reveal no clear picture of the trends of different specific types of meteorological droughts and floods in the state of Odisha. Therefore, a summary of the occurrences of the meteorological floods and droughts according to their severities are displayed in Tables 2 and 3 for a better understanding of the weather variability.

Tables 2 and 3 display occurrence of different type of meteorological droughts and floods in Odisha during 1901 to 2016. The numbers of moderate droughts are found to be more than any other type of drought in Odisha. Severe droughts are also happening in Odisha as is evident from Table 2. As far as the severity of flood is concerned, the Table 3 reveals that Odisha is highly exposed to severe and extreme floods. Thus it is quite clear that the extreme weather events are regularly happening in Odisha and given the predicted climate change, these extreme events may increase in the coming years with concomitant negative effects on agricultural production. The weather variability index, thus, reveals that the state is highly exposed to the erratic weather events and the agriculture sector is bound to bear its severity.

3.3 Performance of Agricultural Output in Odisha

Understanding agricultural performance is crucial for policy making and designing strategies for Up-liftment of overall economic development. An attempt is made here to analyse the growth performance of agriculture in Odisha during the last four and half decades. The growth of production of agricultural crops depends on various factors such as growth of area, yield, irrigation facilities, farm mechanization, fertilizer consumption and use of high yielding seeds. However, the major sources of growth of production are growth in area and yield. Table 4 shows compound annual growth rate in production of selected crops which is decomposed into growth rate in area and in yield of the crops during 1970-2016.

It is evident from the Table 4 that production of rapeseed and mustard have registered negative growth rate of -0.03% during 1970-2016. The negative growth rate in rapeseed and mustard is attributed exclusively to the decline in yield rate by -0.63%. So far as decadal annual compound growth rate is concerned, rapeseed and mustard have registered negative compound growth rate during the decade 1990-99 and in all other decades the growth rate in production were positive.

It is very interesting to note that all the crops have registered a negative growth rate in area, production and yield during the decade 1990-99. This is the worst performing period for agriculture in the state of Odisha during last four and half decades. This is due to the devastating impact of the 1999 super cyclone. During 1970-79 all the selected crops except rice and cereals have registered positive compound growth rates in production due to positive growth rate in area under cultivation which is more than the neutralized negative growth rate in yield rate. During 1980-89 all the selected crops have registered positive compound growth rate in production due to positive growth rate in yield. But crops like cereals, chickpea, and rapeseed and mustard have registered negative growth rate in area under cultivation during the same period. This means that the yield effect is relatively more than the offsetting area effect. During the decade 2000-2009, all the selected crops have shown positive growth rate in area, production and yield while only rice and Pigeonpea have registered negative growth rate in area under cultivation. During the period 2010-2016 all the crops except rice and sugarcane have registered negative growth rate in yield having concomitant negative effects on the growth rate of overall production.

Table 2. List of meteorological drought years according to their severity indices

Moderate Droughts	Severe Droughts	Extreme Droughts
1901, 1923, 1998, 1915, 2000, 1976, 1965, 1978, 1983, 1954	1924, 1979, 1996, 1995, 1970, 1987 ,2002	1974

Table 3. List of meteorological flood years according to their severity indices

Moderate Flood	Severe Flood	Extreme Flood
1925, 1943, 2001, 2007, 2013	1933, 1936, 1940, 2006, 2009, 2011, 2012	1956, 1994, 2008, 2014

Table 4. Compound annual growth rate of area, production and yield of selected crops during 1970-2016

Crops	1970-1979			1980-1989			1990-1999			2000-2009			2010-2014			1970-2016		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Rice	-0.57	-0.38	0.19	0.81	3.97	3.14	-0.10	-1.29	-1.19	-0.03	4.96	4.99	1.84	2.19	0.34	-0.03	1.64	1.66
Maize	7.83	8.41	0.54	0.05	0.91	0.85	-0.33	1.23	1.57	3.97	13.72	9.38	-2.44	-11.86	-9.66	1.95	4.28	2.28
Cereals	-0.05	-0.82	-0.77	-0.43	2.96	3.40	-0.14	-1.49	-1.35	0.05	5.22	5.17	1.48	0.95	-0.52	-0.13	1.50	1.65
Chickpea	8.34	4.94	-3.13	-0.33	0.22	0.55	-2.31	-4.10	-1.83	7.95	9.53	1.46	-0.78	-4.84	-4.09	0.35	1.06	0.68
Pigeonpea	3.66	0.87	-2.69	6.58	8.06	1.39	-2.63	-6.54	-4.02	-0.21	3.46	3.67	7.83	3.31	-4.19	2.44	3.57	1.07
Pulses	7.71	5.03	-2.49	1.48	1.90	0.41	-3.94	-7.89	-4.12	4.55	8.14	3.43	2.28	0.81	-1.43	1.42	1.04	-0.40
Groundnut	9.10	5.97	-2.87	8.35	8.84	0.45	-5.07	-6.89	-1.91	2.06	6.88	4.72	9.03	5.00	-3.69	2.15	2.82	0.63
Sesame	7.20	2.86	-4.05	6.41	7.80	1.31	-2.81	-7.14	-4.46	4.35	8.37	3.85	11.16	9.64	-1.37	2.46	1.66	-0.82
Rape and mustard	10.75	7.00	-3.38	-1.00	0.06	1.07	-5.18	-10.33	-5.43	1.28	5.12	3.79	5.74	5.20	-0.51	0.61	-0.03	-0.63
Oilseeds	8.90	4.27	-4.26	4.52	5.95	1.37	-3.80	-7.21	-3.55	1.75	6.70	4.86	10.07	5.56	-4.10	1.49	1.76	0.27

Note: A= Area: P= Production; Y=Yield

Table 5. Instability in area, production and yield of selected crops in Odisha

Crops	1970-1979			1980-1989			1990-1999			2000-2009			2010-2016			1970-2016		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Rice	4.67	29.63	26.18	9.18	29.83	22.58	2.55	21.18	19.73	2.76	38.86	36.39	6.24	13.22	7.33	5.32	28.23	24.83
Maize	23.47	32.13	29.38	12.76	14.30	8.96	6.14	12.95	14.42	5.67	16.49	12.69	7.65	20.64	13.66	13.56	20.65	17.54
Cereals	5.24	30.03	25.76	5.37	26.47	21.58	2.63	20.28	18.63	2.73	36.38	33.88	5.46	10.82	5.96	4.15	26.64	23.61
Chickpea	14.84	25.16	13.98	13.55	12.41	14.26	19.91	24.88	12.10	19.86	22.44	4.68	4.09	6.72	6.48	17.12	21.38	11.28
Pigeonpea	13.75	30.78	20.01	9.57	18.26	14.42	12.21	22.74	11.84	9.77	13.42	4.67	8.57	8.20	5.98	11.33	21.06	13.20
Pulses	12.68	28.84	21.86	13.40	14.03	6.47	15.05	26.51	11.84	14.35	21.14	7.90	4.89	6.07	1.95	13.41	22.24	12.56
Groundnut	8.32	28.45	32.09	9.00	13.39	8.83	6.28	24.13	22.19	12.35	24.43	13.23	11.42	4.43	7.19	10.82	22.58	19.58
Sesame	17.04	29.84	30.86	10.38	18.13	10.42	15.11	32.00	22.28	31.45	40.05	13.18	21.70	16.71	5.22	19.89	29.77	19.37
Rape and mustard	25.07	40.44	25.69	14.31	19.24	10.82	17.13	26.85	14.71	16.07	23.16	10.42	6.06	10.74	7.14	17.97	27.39	15.56
Oilseeds	11.16	27.35	25.94	7.76	8.73	4.64	9.14	23.93	16.31	17.32	25.93	9.85	15.19	5.76	9.80	12.64	21.96	15.47

Note: A=Area; P=Production; Y=Yield

Thus it is quite clear that the growth rates of agricultural production have been highly erratic and irregular in Odisha. This is due to either decline in yield rate or decline in area under cultivation. Further, the yield rates of various crops have been highly erratic which may be attributed to bad weather, natural calamities or factors specific to the local area conditions.

3.4 Instability in Area, Production and Yield of Selected Crops in Odisha

Instability in agriculture is caused by factors like climate change, weather variability and disaster. Instability in the area, production and yield of the major crops are calculated to understand the agricultural variation in Odisha during 1970-2016 as presented in Table 5.

It is evident from Table 5 that instability in the production of all the selected crops were found to be high during 1970-2016. The instability was highest in the production of sesame (29.77%) followed by rice production (28.23%) and rapeseed mustard production (27.39%) during 1970-2016. Similarly, the instability in area and yield were found to be highest for sesame and rice during 1970-2016. During the period under the study (1970-2016), instability in area under cultivation for rapeseed and mustard and maize also found to be very high relative to other crops.

So, far as decadal instability is concerned, during 1970-79, 1980-89, 1990-99, 2000-2009 and 2010-2016 varied instability is observed in all the crop production, yield and area under cultivation. As the total instability in production is explained by instability in area and yield of the crop, it is observed that the instability in production is largely explained by instability in yield during various periods under study. The instability in yield that drives the instability in production may be attributed to different factors including weather variability.

Thus, it is amply clear that the instability in area, production, and yield of selected crops are there in different intensities in Odisha. The instability in the above major crops may be attributed to many factors including weather variability and extreme events. This is because weather variability is extreme in Odisha in terms of change in rainfall pattern which is increasing the chances of extreme weather events.

3.5 Weather Variability and Instability in Crop Production and Yield

Weather variability is a very important factor that determines instability in crop production and yield. The degree of fluctuations in crop production and yield is directly associated with the rainfall. During the years of rainfall deficit, crop production and yields are negatively affected. The variability in yield caused by weather variability is mainly driven by rainfall fluctuations. Here, we have studied the impact of weather variability on three crops such as rice, pulses and oilseed. Rice is the most important crop in case of cereal, constituting almost four fifth of total cereal production. Pulses include the major group of crops belonging to pulses group and oilseeds include major groups of oilseed variety produced in the state. Here we have studied the impact of weather variability on the selected crop production and yield instability and accordingly regressed the yield instability on weather variability as shown in Table 6.

Table 6 shows regression analysis results where dependent variables are rice, pulses and oilseeds yield instability, and independent variables are weather variability. Here, we have suppressed the coefficients of the constant term while running the linear regression models in STATA 14. The results show that weather variability plays an important and significant role in determining rice, pulses and oilseed yield instability. The results are statistically significant at 5% level of significance. Further the R square value for rice is 0.733, for pulses 0.561 and for oilseed 0.511which makes the analysis more representative. In other words, 73%, 56% and 51% variations in rice, pulses and oilseeds respectively are attributed to weather variability.

Table 6. Regression results of yield instability on weather variability

Crop	Constant	Weather Variability Index	Beta	Adj R^2	*P Value*
Rice	Suppressed	0.857	0.857	0.733	.019
Pulses	Suppressed	0.743	0.743	0.561	.041
Oilseed	Suppressed	0.513	0.513	0.511	.032

4. CONCLUSION

Weather variability index shows fluctuating trend, which is a major concern for agriculture in the state of Odisha. In the context of agrarian economy of Odisha, the dimensions, magnitude and erratic nature of the weather variability and extreme weather events have made agricultural situation more complex and vulnerable. There is wide variation in the rainfall both across time and space in the state. The long term average rainfalls have shown a declining trend and therefore, proper irrigation facilities are required for sustaining agricultural production. Further, it is observed that the distribution of rainfall is erratic and its variability is increasing over the years, as a result of which agriculture sector is becoming more vulnerable in the state of Odisha. Agriculture, being weather dependent, it has become the first and worst causality. The weather variability has produced profound negative effects on agricultural production and yields in the state causing agricultural fluctuations and has been a serious threat to its agrarian economy. The regression analysis lends credence to the negative effects of weather variability on agriculture and warns us about the future precautionary steps to withstand from further negative effects of weather variability. As a precautionary measure to withstand from the negative effects of weather variability, proper provisioning of irrigation and credit facilities is highly essential for increasing the crop productivity or crop yields. Further, provisioning of research and development is required to produce weather variability resistance crops for sustainable agriculture and increasing the production and yields of the agricultural.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Das MK. Impacts of Climate Change on Agricultural Yield in India: Evidence from Odisha the Indian Economic Journal, Special Issues. 2016;519-525
2. Cervantes-Godoy D, Dewbre J. Economic Importance of Agriculture for Poverty Reduction, OECD Food, Agriculture and Fisheries Working Papers, No.23. 2010.OECD Publishing.
   DOI: 10.1787/5kmmv9s20944-en
3. Chand R, Raju SS. Instability in Indian agriculture during different phases of technology and policy. Indian Journal of Agricultural Economics. 2009;64(2):187-207
4. Mehra S. Instability in Indian agriculture in the context of the New Technology, Research Report No.25, International Food Policy Research Institute, Washington, D.C., U.S.A; 1982.
5. Hazell PBR. Instability in Indian Foodgrains Production. Research Report No. 30, International Food Policy Research Institute, Washington D.C; 1982.
6. Ray SK. An empirical investigation of the nature and causes for growth and instability in Indian agriculture. 1950-80. Indian Journal of Agricultural Economics. 1982;**38**(4):459-474.
7. Rao CHH, Ray SK, Subbarao K. Unstable Agriculture and Droughts: Implications for Policy, Vikas Publishing House Pvt. Ltd, New Delhi; 1988.
8. Mahendradev S. Growth and instability in foodgrains production: An interstate analysis. Economic and Political Weekly. 1987;22(39): A82-A92.
9. Paltasingh KR, Goyari P. Analyzing Growth and Instability in Subsistence Agricultureof Odisha: Evidence from Major Crops. Agricultural Economics Research Review. 2013;26(Conference Number):67-78
10. Das MK, Mishra P. Vulnerability of Agriculture to Climate Shocks in Odisha, India. International Journal of African and Asian Studie. 2017;40: 27-35
11. Samal et. al. (2017) Growth and Instability in Food Grains Production in Odisha: A district level analysis. SSRG International Journal of Economics and Management Studies (SSRG – IJEMS. 2017;4 (11): 1-7
12. Das MK, Mishra P. Impacts of Climate Change on Agricultural Yield: Evidence from Odisha, India. International Journal of African and Asian Studie. 2017;38: 58-65

13. Senapati AK, Goyari P. Growth and instability in agricultural productivity in Odisha. Agricultural Economics Research Review. 2019;32(1):55-65

14. Pant GB, Kumar KR. Climates of South Asia. John Wiley, Chichester, UK; 1997.

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