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Impacts of Climate Change on Agricultural Yield: Evidence from Odisha, India

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Abstract
This paper explores the impact of climate variables such as temperature and rainfall on yields of seven selected crops such as rice, maize, groundnuts, rapeseed & mustard, chickpea, Pigeonpea and sesame during the period 1970-2014. We used panel data for 45 years to assess the impact of climate change on agriculture yield. In the presence of auto-correlation and Heteroscedasticity we estimate the panel corrected standard error with a fixed effect panel regression. The regression results reinforce that crop yields of the selected crops are susceptible to climate change. The relative magnitude of rainfall and temperature changes appears to play a pivotal role in determining the direction of change in the yield. It is also observed that the rainfall has significant positive effects on the yields of all the selected crops under study. In case of temperature, we observed mix results for the selected crops under study. However, the extent of increase in the temperature appears to be more harmful for the crop yields. Further, the non-climatic factors like irrigation and fertilizers were found to be very instrumental in increasing the yields of the selected crops. In the light of negative effects of climate change, appropriate mitigation and adaptation strategies are required to delve with the deteriorative effects of climate change.
Keywords: Climate Change, Crop Yield, Agriculture
JEL Classification: Q18, Q51, Q54

1. Backdrops

Climate change is the buzz word which has received considerable attention in this century due to its potential impacts on the whole Earth system. It is the greatest challenge that the human civilization is ever facing in the 21st century with various implications on agriculture, industry, natural resources, human habitations, and health status. Since the climate change alters temperature and precipitation worldwide with variation from place to place, these changes required to be quantified regionally and locally for its understanding and better management at local level. Odisha is one of the coastal states of India and its economy closely tied to its natural resource base and climate-sensitive sectors like agriculture, the state may face a major economic threat because of the projected climate change. Wide variability in rainfall has already brought about a significant level of instability in crop production in the certain region of Odisha with considerable effects on the income, expenditure and savings of rural households (Swain and Swain, 2006). Significant impacts of changing rainfall pattern and rising temperature on cereals, pulses and oilseed production in Odisha has observed in the last five decades (Das, 2016). Thus, in the changing climate as predicted it is bound to affect agricultural production and related sectors with concomitant negative implications for sustainable food security (Nelson & Mensbrugghe, 2014). Therefore, a proper understanding of the impacts of climate change on various crops yield is required to withstand adapt the concomitant negative effects of its on agriculture. On the above background, this paper investigates the impacts of climate variables such as rainfall and temperature on the yields of selected crops in Odisha.

2. Brief Review of Literature

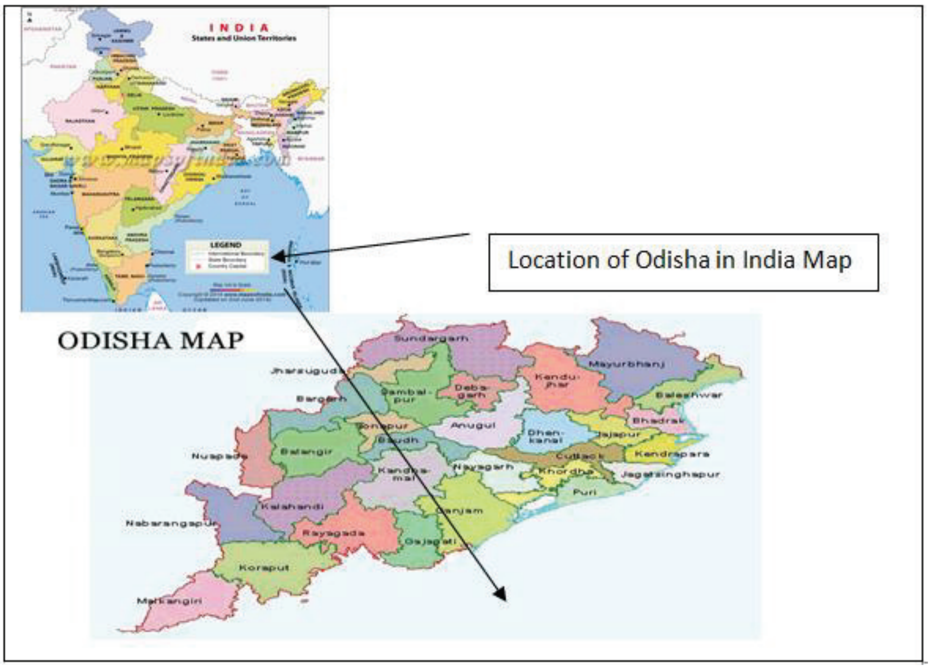
The effects of climate change are very pervasive and those in low-income countries who contribute least to climate change are most vulnerable to its effects . Climate impact studies have consistently predicted extensive impacts to the agricultural sector across the globe (Tol, 2009). Climatic changes and increasing climatic variability are likely to aggravate the problems of future food security by exerting pressure on agriculture. Agriculture is one of the sectors that are most likely to be sensitive to the primary effects of climate change, such as changes in growing season, temperature, and precipitation (Torvanger, Twena and Romstad, 2004). Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems (Adams, Hurd, Lenhart, & Leary, 1998). There are evidences that global climatic changes are influencing agriculture through direct and indirect effects on the crops, soils, livestock and pests (Pathak, et al. 2012). The increase in temperature is reducing crop duration and crop yield (Ashfaq, et al. 2011). Indirectly, there are considerable effects on land use due to soil erosion, availability of irrigation water, frequency and intensity droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to submergence of coastal lands, and availability of energy (Pathak, et al. 2012).

Further, in India, numerous studies have given empirical evidence that climate change has caused decline in the agricultural productivity. Kumar and Parikh (2001) shown for rice and wheat crop that projected large scale changes in the climate would lead to significant reductions in their crop yields, which in turn would adversely affect agricultural production by 2060 and may affect the food security of more than one billion people in India. Kumar et al. (2011) mentioned that decline in irrigated area for maize, wheat, mustard, rice, sorghum and maize may cause loss of production due to climate change in India. Hundal and Kaur (2007) concluded that an increase in minimum temperature up to 1.0 to 3.0 degrees Celsius above normal has led to decline in productivity of rice and wheat by 3% and 10% respectively in Punjab. Kaul and Ram (2009) found that excessive rains and extreme variation in temperature has adversely affected the productivity of Jowar crop, thereby this has affected the incomes as well as food security of farming families in Karnataka (India). Thus, the productivity of different crops gets affected by climate change due to changes in the rainfall pattern and temperature.

3. Study region

The study is carried out in the state of Odisha, India. Area wise Odisha is the ninth largest state of India, with an area of 1, 55,842 Sq. Km. It is one of the coastal states of India lies on the eastern seaboard of India with 480 Km. long coastline. Geographically Odisha is located between 17°49′ to 22°36' North latitudes and 81°36' to 87°18' East longitudes. As per the 2011 census the population of the state was 4,19,47,358 with the average density of 269 per sq km. It is surrounded by Jharkhand in the north, West Bengal in the northeast, Telangana and Andhra Pradesh in the south, Chhattisgarh in the west, and Bay of Bengal in the east. The climatic condition of the state is influenced by the sea as it is located on the east coast belt. The region is represented by tropical climate with high temperature, humid weather, medium to high rainfall and 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. The average annual temperature of the state is 26.89°C with a wide variation in the average annual maximum and minimum temperature. Further the state is characterized by fragile environment, prone to drought, flood and cyclone, low and highly variable rainfall. A majority of population (82%) of the state live in rural areas and agriculture is the main occupation of the people. 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 climate factors in the state to understand their impact on the growth in agriculture and socio-economic development of the state. Below figure shows the location of Odisha in the map.

Figure-1 Location Map Odisha



4. Data and Materials.

To accomplish the stated objective of studying the impacts of climate change on agricultural yield, two climate variables such as rainfall and temperature have been used. Data on climate variables over the period 1970-2014 are obtained from IMD Pune, various issues of Odisha Agricultural Statistics and various issues of Climatology Data of Odisha.

To analyse the impact of climate change on agriculture, we have considered seven selected crops such as rice, maize, chickpea, pigeonpea, rapeseed and mustard, groundnut and sesame. The data on the agricultural variables span the time period 1970-2014 and have been collected from the ICRISAT VDSA (Village Dynamics in South Asia) Apportioned Meso database. This is a district-level database, from where we have extracted data on crop area and production of selected crops, gross crop area, gross irrigated area, and total fertilezers used. The boundaries of the districts included in this database are defined as of 1970, i.e. any data on districts that were created after 1970 are given 'back' to the parent districts from which the newer districts were created. Therefore, here in our analysis we have considered all the data for 13 parent/undivided districts of Odisha though as of now Odisha has 30 districts. The parent/undivided districts are Balasore, Balangir, Cuttack, Dhenkanal, Ganjam, Kalahandi, Keonjhar, Koraput, Mayurbhanj, Phulbani, Puri, Sambalpur and Sundergarh. Same approach has also been done for data on climate variables.

5. Methodology

Two climate variable and three non-climatic variables are taken as independent variables to study the impact on agricultural yield. Climate variables such as rainfall and average temperature along with their quadratic form (defined as rainfall2 and avgt2) are used, to understand the incremental impact of rainfall and temperature on the yield of the selected crops. The square terms are used to account for the non-linear effects of the climate variables. Three non-climatic factors i.e fertilizers consumption, agriculture labour, and irrigation are used in the model. Information on fertiliser consumption is available at the district level in overall form (i.e. for all crops combined). Thus to make fertilizer relevant to the particular crop we weighed total fertiliser consumption in a district by the ratio of area under the crop to the gross cropped area of that district (assuming uniform distribution of fertilisers over the cropped area) i.e. $FUx = (ACx/GCA)TF$. Where FUx stands for the fertilizer used for the crop x in the district, ACx stands for the area under the crop x in the district, GCA stands for the gross crop area in the district and TF stands for the total fertilizer used in the district. Similarly, data on agriculture labour is also available at the overall level for each district. The data on agricultural labour is only available for the census years in the relevant range (1971, 1981, 1991, 2001 and 2011). For the other years in the sample, the agriculture labour data has been interpolated (by fitting a linear trend on decadal agriculture labour growth of the districts). Then we assigned same weight to total agriculture labour in the district as applied for the fertilisers to create the relevant labour variables for the crops i.e. $LUx = (ACx/GCA)TL$. Where LUx stands for the agriculture labour for the crop x in the district, ACx stands for the area under the crop x in the district, GCA stands for the gross crop area in the district and TL stands for the total agriculture labour in the district. The relevant irrigation variable has also been created by taking the ratio of area under the crop to the gross cropped area in the entire district. Then obtained relevant variables i.e fertilizer consumption, agriculture labour and irrigation, in turn, have been divided by the total area under the specific crop to find out the use of the relevant variable per hector as we have used the dependent variable 'yield' per hector.

After the specification of the variables, we estimated crop production functions using panel data for the selected seven crops such as rice, maize, chickpea, pigeonpea, groundnut, sesame, and rape & mustard. In the presence of AR (1) serial autocorrelation (i.e the outcomes are correlated across years for a given district) and cross-sectional dependence (i.e the outcomes are correlated across districts in a given year) along with heteroscedasticity, fixed effect panel-corrected standard error (PCSE) estimates are obtained, where the parameters are estimated using a Prais-Winsten regression. The regression equations which are estimated for all crops are as follows:

$$Y_{it} = c + a_i + \beta_1 R_{it} + \beta_2 R_{it}^2 + \beta_3 T_{it} + \beta_4 T_{it}^2 + \beta_5 L_{it} + \beta_6 F_{it} + \beta_7 I_{it} + u_{it}$$

Where,

Y_{it} is crop yield i.e crop production per hectare in district '*i*' in year'*t*';

a_i represents the district-level fixed effects, which are quite useful in capturing unobserved heterogeneity across districts and it absorbs all the unobserved district specific time-invariant factors; for example, soil and water quality that influence crop yields, and it also reduce bias due to omitted variables (Deschenes and Greenstone, 2007);

R_{it} is the rainfall measured in millimeter (mm) and R_{it}^2 is the square-term of rainfall;

T_{it} is the average temperature measured in degree Celsius (°C) and T_{it}^2 is the square-term of average

temperature;
L_{it} is the agriculture labour used for the selected crop per hector;
F_{it} is the fertilers used for the selected crop per hector;
I_{it} is the irrigated crop area per hector;
U_{it} is the error term and C and β_1 *to* β_7 are the estimated parameters.

6. Results and Discussion

Agricultural production, being sensitive to climate change and weather shocks, it may suffer from climate change if no adaptive actions are taken. To understand the impact of climate change on agriculture, we estimate crop production functions using panel data for seven selected crops such as rice, maize, chickpea, pigeonpea, groundnut, sesame, rape and mustard. In the presence of AR (1) serial autocorrelation and cross-sectional dependence along with heteroscedasticity the panel-corrected standard error (PCSE) estimates are obtained, where the parameters are estimated using a Prais-Winsten (or OLS) regression. The impacts of climate change on different selected crops are discussed below.

Impact of Climate Change on Rice Yield

In the case of rice, we observed that the errors exhibited the presence of heteroscedasticity, serial autocorrelation, and also contemporaneous correlation. Thus Prais-Winsten (OLS) regression is estimated with panel-corrected standard error (PCSE) estimates under the assumptions that within panels, there is AR (1) autocorrelation and that the coefficient of the AR(1) process is common to all of the panels (i.e. common AR(1) autocorrelation). The regression result with district fixed effects for rice is presented in table 1. The coefficients on the district fixed effects have been suppressed. The results are robust under the autocorrelation assumption.

Table 1. Impacts of Climate Change on Rice Yield

Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	1.473621	.2421898	6.08	0.000	.9989378	1.948304
rainfall2	-.0004286	.0000898	-4.78	0.000	-.0006045	-.000252
avgt	-153.5185	212.787	-0.72	0.471	-570.5733	263.5364
avgt2	3.501628	4.080118	0.86	0.391	-4.495257	11.49851
fertilizer	4.494765	1.021393	4.40	0.000	2.492871	6.496659
irrigation	1043.214	249.9032	4.17	0.000	553.4126	1533.015
labour	216.2562	122.3423	1.77	0.077	-23.5304	456.0428
_cons	987.0933	2789.787	0.35	0.723	-4480.789	6454.976
Number of obs= 585; R-squared =0.6084 ; Wald chi2(19) = 612.14; Prob > chi2 = 0.0000						
Source: Calculated by Author						

Table 1 shows the results of effects of climatic and non-climatic factor on rice productivity. The R^2 value is 0.6048, which indicates that the explanatory variables included in the model explain more than 60% of variations in yield. The regression coefficients for rainfall indicate that it has a quadratic (an inverted U-shaped) relation with rice yield. The first-order term of rainfall is statistically significant at 1 percent level and has a positive sign, while the square term of rainfall is also statistically significant at 1 percent level and but has a negative sign. This means higher rainfall leads to higher yield, but at a decreasing rate and thus higher rainfall increases crop yield up to a threshold level but rainfall beyond the threshold has a negative impact on rice yield. On the other hand, the regression coefficient for temperature is negative but the coefficient on the quadratic term for temperature is positive which means higher temperatures leads to lower yield rates. As the quadratic term shows positive sign for temperature the incremental impact of a one unit increase in the temperature variable becomes more severe as the temperature increases. Non-climatic factors such as fertilizer and irrigation variables are highly significant. The significant results for these variables were expected as rice production is highly input driven in large parts of the country, and the signs are intuitive (higher the proportion of land under rice irrigated, higher is the yield, and higher the fertilizer consumption used for rice, higher is the yield of rice). Agricultural labour is also found to have a significant (at 10% level) positive impact on the yield of rice.

Impact of Climate Change on Maize Yield

The regression result with district fixed effects for maize is presented in table 2. The coefficients on the district fixed effects have been suppressed.

Table 2: Impacts of Climate Change on Maize Yield						
Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	.5927765	.1953523	3.03	0.002	.209893	.9756599
rainfall2	-.0002271	.0000771	-2.95	0.003	-.0003782	-.0000761
avgt	3.328881	248.116	0.01	0.989	-482.9695	489.6273
avgt2	-.0700638	4.704424	-0.01	0.988	-9.290565	9.150437
fertilizer	.6857364	1.666617	3.41	0.002	.952247	.980774
irrigation	716.8776	297.1847	2.41	0.016	134.4062	1299.349
labour	712.6847	215.9783	3.30	0.001	289.3751	1135.994
_cons	144.5282	3286.807	0.04	0.965	-6297.495	6586.552
Number of obs= 585; R-squared = 0.4277; Wald chi2(19) =192.63; Prob > chi2 = 0.0000						
Source: Calculated by Author						

The R^2 value is 0.4277, which indicates that the explanatory variables included in the model explain more than 42% of variations in the maize yield. Regression for maize produces similar results as for rice except average temperature. Table 2 reveals similar impact of higher rainfall on maize yield, as in case of rice (greater the rainfall, higher the yield). The coefficients are also found to be highly significant. The average temperature variable is statistically insignificant and the coefficient sign is positive. The sign of the temperature quadratic is negative which indicates higher temperatures mean that the incremental impact of temperatures on maize yield is dampened. It is also highly insignificant. The impact of the other factors such as labour, fertilizer and irrigations are found to be highly significantly with positive impact on maize.

Impact of Climate Change on Chickpea Yield

Like other crops, Prais-Winsten (OLS) regression with panel-corrected standard error (PCSE) estimates under the panel-specific AR (1) serial autocorrelation with district fixed effect is employed for Chickpea. The regression results for chickpea are shown in table 3.

Table 3: Impacts of Climate Change on Chickpea Yield						
Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	.2174366	.071884	3.02	0.002	.0765466	.3583267
rainfall2	-.000061	.0000248	-2.46	0.014	-.0001096	-.0000124
avgt	-4.402052	90.0091	-0.05	0.961	-180.8167	172.0125
avgt2	.0357587	1.70857	0.02	0.983	- 3.312977	3.384494
fertilizer	-1.076641	.6223785	-1.73	0.084	-2.29648	.1431985
irrigation	299.6768	96.26984	3.11	0.002	110.9914	488.3622
labour	141.0919	62.06003	2.27	0.023	19.45647	262.7273
_cons	397.0986	1188.103	0.33	0.738	-1931.541	2725.738
Number of obs = 585; R-squared =0.5660; Wald chi2(19) = 80.72; Prob > chi2 = 0.0000						
Source: Calculated by Author						

The table 3 shows that the R^2 value is 0.566 which indicates that the explanatory variables included in the model explain more than 56% of variations in the chickpea yield. Rainfall and rainfall quadratic term are found to be statistically significant at 1% and 5% level respectively. Thus the regression coefficients for rainfall indicate that it has a quadratic (an inverted U-shaped) relation with chickpea yield. The first-order term of rainfall has a positive sign, while the square term of rainfall has a negative sign. This means higher rainfall leads to higher yield, but at a decreasing rate and thus higher rainfall increases chickpea yield up to a threshold level but rainfall beyond the threshold has a negative impact on chickpea yield. Further, empirical results shows that temperature has also quadratic relationship with chickpea yield with positive sign for first term and negative sign for quadratic term but it is found to be statistically insignificant at 10% level. On the other hand all the non-climatic factors included in the model are found to be statistically significant. Labour and irrigation are found to be important factors to increase the chickpea productivity. Because labour and irrigation has positive regression coefficients at 5% and 1% significance level respectively. It is interesting to observe that the increasing application of fertilizers in chickpea cultivation would be harmful. This is because the estimated regression coefficient of fertilizers has a negative and statistically significant (at 10% level) impact on chickpea yield.

Impact of Climate Change on Pigeonpea Yield

For Pigoeonpea we have also used Prais-Winsten (OLS) regression with panel-corrected standard error (PCSE) estimates with district fixed effect under panel specific AR (1) serial autocorrelation. The regression results are shown in table 4.

Table 4: Impacts of Climate Change on Pigeonpea Yield

Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	.3693271	.1037423	3.56	0.000	.1659959	.5726583
rainfall2	-.0001113	.0000346	-3.22	0.001	-.0001791	-.0000435
avgt	38.98605	124.0991	0.31	0.753	-204.2438	282.2159
avgt2	-.7525259	2.366866	-0.32	0.751	-5.391498	3.886447
fertilizer	-.2736095	.6916972	-0.40	0.692	-1.629311	1.082092
irrigation	628.624	145.8736	4.31	0.000	342.7169	914.5311
labour	167.9437	82.60913	2.03	0.042	6.032812	329.8547
_cons	-466.212	1630.079	-0.29	0.775	-3661.108	2728.684
Number of obs = 585; R-squared = 0.6413; Wald chi2(19) = 166.37; Prob > chi2 =0.0000						
Source: Calculated by Author						

The table 4 shows that the R^2 value is 0.6413 which indicates that the explanatory variables included in the model explain more than 64% of variations in the pigeonpea yield. Like chickpea, we have also observed statistically significant quadratic relationship between rainfall and pigeonpea yield with intuitive positive sign for first term and negative sign for quadratic term. For pigeonpea regression coefficients of temperature are also found to be statistically insignificant at 10% level with negative sign for first term and positive sign for quadratic term. As far as non-climatic factors are concerned labour and irrigation are found to be positively influencing the pigeonpea productivity at 5% and 1% level of significance. But regression coefficient of fertilizers is found to be statistically insignificant with negative sign.

Impact of Climate Change on Groundnut Yield

For groundnuts same econometrics model has been used as used for other crops like Rice. The regression result with district fixed effects for groundnut is presented in table 5. The coefficients on the district fixed effects have been suppressed.

Table 5: Impacts of Climate Change on Groundnut Yield

Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	.910954	.1819983	5.01	0.000	.5542439	1.267664
rainfall2	-.0002649	.0000715	-3.71	0.000	-.000405	-.0001248
avgt	92.27285	245.3218	0.38	0.707	-388.5491	573.0948
avgt2	-1.358354	4.70391	-0.29	0.773	-10.57785	7.86114
fertilizer	-.7679629	1.159121	-0.66	0.508	-3.039798	1.503873
irrigation	493.7592	213.9325	2.31	0.021	74.45911	913.0593
labour	212.0621	123.6542	1.71	0.086	-30.29581	454.4199
_cons	-874.6734	3200.565	-0.27	0.785	-7147.666	5398.32
Number of obs = 585; R-squared =0.5797; Wald chi2(19) =225.07; Prob > chi2=0.0000						
Source: Calculated by Author						

The table 5 shows that the R^2 value is 0.5797 which indicates that the explanatory variables included in the model explain more than 57% of variations in the pulses yield. Like other crops, groundnuts also reveal similar results. More specifically, we also observed regression coefficients of rainfall are statistically significant (at 1% level) and have a quadratic (an inverted U-shaped) relation with groundnut yield. This means higher rainfall leads to higher groundnut yield, but at a decreasing rate. Further the regression coefficients of temperature are found to be statistically insignificant at 10% level with negative sign for first term and positive sign for quadratic term. Non-climatic variables like labour and irrigation are found to be statistically significant and have positive regression coefficients. On the other hand increasing application of fertilizers in groundnut cultivation indicates negative impact on groundnut yield. However, the estimated negative regression coefficient of fertilizers found to be statistically not significant (at 10% level).

Impact of Climate Change on Sesame Yield

Here we have also used the Prais-Winsten (OLS) regression with panel-corrected standard error (PCSE) estimates under the panel-specific AR (1) serial autocorrelation with district fixed effect and the results are shown in table 6.

Table 6: Impacts of Climate Change on Sesame Yield

Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	.2849496	.0795353	3.58	0.000	.1290632	.440836
rainfall2	-.0000816	.0000266	-3.07	0.002	-.0001337	-.0000296
avgt	-45.24469	88.04576	-0.51	0.607	-217.8112	127.3218
avgt2	.6681669	1.695012	0.39	0.693	-2.653995	3.990328
fertilizer	.8516738	.3774107	2.26	0.024	.1119625	1.591385
irrigation	108.8361	65.42328	1.66	0.096	-19.39123	237.0633
labour	-250.9003	54.63078	-4.59	0.000	-357.9746	-143.8259
_cons	969.08	1151.477	0.84	0.400	-1287.773	3225.933
Number of obs=585; R-squared = 0.5433; Wald chi2(19) = 44.47; Prob > chi2 =0.0000						
Source: Calculated by Author						

The R^2 value is 0.5433 which indicates that the explanatory variables included in the model explain more than 54% of variations in the sesame yield. Empirical results show that rainfall has positive and statistically significant impact on sesame productivity at 1% significance level. So the sesame crop will get benefits with increasing rainfall but at a decreasing rate as the coefficients of quadratic rainfall term is negative and statistically significant at 1% level. On the other hand regression coefficients of temperature indicate negative and statistically insignificant effect on sesame productivity. Further regression coefficients of irrigation and fertilizers are found to be positive and statistically significant effect on sesame productivity. The regression coefficient of agricultural labour found to be negative and statistically significant at 1% level. More to say the negative sign of labour coefficient shows negative effect on sesame productivity.

Impact of Climate Change on Rapeseed and Mustard Yield

For Rapeseed and mustard we used same econometrics model as used for other crops. The results of the regression for rapeseed and mustard are presented in table 7.

Table 7: Impacts of Climate Change on Rapeseed & Mustard Yield

Cereals yield	Coef.	Panel-corrected Std. Err.	z	P>|z|	[95% Conf. Interval]	
rainfall	.2653017	.0617335	4.30	0.000	.1443062	.3862971
rainfall2	-.0000812	.0000216	-3.75	0.000	-.0001235	-.0000388
avgt	-56.43204	84.3021	-0.67	0.503	-221.6611	108.797
avgt2	.9344681	1.605263	0.58	0.560	-2.21179	4.080726
fertilizer	.8044898	.4623244	1.74	0.082	-.1016493	1.710629
irrigation	156.9332	76.5605	2.05	0.040	6.87739	306.989
labour	-291.7017	49.21768	-5.93	0.000	-388.1666	-195.2368
_cons	1161.553	1110.553	1.05	0.296	-1015.09	3338.197
Number of obs=585; R-squared =0.4728; Wald chi2(19) =166.54; Prob > chi2= 0.0000						
Source: Calculated by Author						

The table 7 reveals that explanatory variables included in the model explain more than 47% of variations in the rapeseed and mustard yield. The impact of climate variable such as rainfall and temperature are found to have a non-linear relationship with rapeseed and mustard yields. The results show that yields are sensitive and statistically significant (at 1% level) to increases in rainfall. However it also observed that yields are harmed because of increased temperature but the coefficients are not statistically significant (at 10% level). All the non-climatic factors such as agricultural labour, irrigation and fertilizers are found to be significantly influencing the rapeseed and mustard yield. Irrigation and fertilizers are positively impacting the yield while agriculture labour negatively impacting the rapeseed and mustard productivity. This implies increase in irrigated area and fertilizers use will cause increase in rapeseed and mustard productivity while increasing use of agriculture will harm rapeseed and mustard productivity.

7. Conclusion

Odisha being one of the agricultural dependent states, the state is thus facing a major economic threat because of the projected climate change. These regression results reinforce some of the results of crop yield which are susceptible to climate change. The relative magnitude of rainfall and temperature changes appears to play a pivotal role in determining the direction of change in the yield. Further, the growth rates of area, production and yield of the selected crops are showing very erratic pattern and there is prevalence of instability in production and yield across the crops under study during 1970-2014. It is also observed that the rainfall has significant positive effects on the yields of all the selected crops under study. Since annual and monsoon rainfall is showing decreasing trends across the state, to adapt this change more irrigation facilities are required for all the crops. In case of temperature, we observed mix results for the selected crops under study. However, the extent of increase in the temperature appears to be more harmful for the crop yields. Further, irrigation and fertilizers were found to be very instrumental in increasing the yields of the selected crops. Thus while dealing with the negative effects of climate change, proper provisioning of irrigation and use of fertilizers is required for increasing the crop productivity or crop yields. Therefore, appropriate mitigation and adaptation strategies are required to delve with the deteriorative effects of climate change.

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