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Economic Impacts of Climate Change in Odisha: Adaptations Strategies and Policy Options

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I. INTRODUCTION

The established meaning of climate is the measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind precipitation and other meteorological variables in a given region over a long period of time. It is different from weather, and describes the short term conditions of these variables in a given region. In narrow sense climate is average weather at least for a period of 30 years as per the World Metrological organization.

Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

What is climate change?

IPPC fourth Assessment Report summarizes that the Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat. With the abrupt end of the last ice age about 7,000 years ago, making the beginning of the modern climate era-and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives. The current warming trend is of particular significance because most of it is very likely human induced and proceeding at a rate that is unprecedented in the past 1, 3000 years.

Earth orbiting satellites and other technological advances has enabled scientists to see the big picture, collecting many different types of information about our planet and its climate on a global scale. Studying these climate data collected over many years reveal the signals of a changing climate.

Causes of climate change

The major cause of climate changes has been ascribed to global warming, which is unequivocal, as evident from the 11 warmest years out of 12 years between 1995 and 2006 and 0.74^{o}C increases between 1906 and 2005. Increased level of greenhouse gases (GHG) such as carbon dioxide, nitrous oxide, methane and carbon monoxide has led the global warming. Uncontrolled human activities, such as burning of fossil fuels, use of refrigerants, and changed land use patterns and related practices are the major sources of GHGs.[1]

Most climate scientist agree that main cause of current global warming trend is human expansion of the "greenhouse effect" warming the results when the atmosphere traps heat radiating from Earth towards space. Certain gases in the atmosphere block heat from escaping. Long lived gases that remain semi permanently in the atmosphere and do not respond physically or chemically to changes in temperature are described as "forcing" climate change. Gases such as water vapour, which respond physically or chemically to changes in temperature are seen as "feedbacks"[2]

Effects

Global temperate are believed to rise for decades to come, largely due to greenhouse gases produced by human activities. The Intergovernmental panel on Climate Change (IPPC) forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century. According to the IPPC extend of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change.

[1] *Pasupalak,S. Climate Change and Agriculture in Odisha,Odisha Review,2009.*
[2] *Oreskes,N. The Scientific Consensus on Climate Change. Science, Vol.306, no.5702 p.1686,2004*

The IPPC also predicts that increases in global mean temperature of 1 to 3 degrees Celsius above 1990 levels will produce beneficial impacts in some regions and harmful ones in others. Net annual costs will increase over time as global temperature increase.

ODISHA'S VULNERABLE TO CLIMATE CHANGE:

The climate as observed is now subject to significant change. The Climate of Odisha as set up since ages and the seasons are monsoon, winter, summer, spring and autumn, occur at constant time and continues for certain period. This climate of the state has been determined due to a number of factors such as location, ocean currents, forests, direction of prevailing winds, shape of land and influenced by human to a great extend.

i. Location:

Odisha lies between North Eastern part of the Indian Peninsula with Latitude of 170 31N to 200 31N and Longitude of 810 31E to 870 30E. Distance from the equator is the prime factor to determine the climate. The state is located comparatively closer to the equator implying less difference between summer and winter day lengths.

ii. Ocean currents:

Ocean currents can increase or reduce temperature. The high fluctuating currents of the Bay of Bengal causes high velocity winds over the state.

iii. Forests:

The total coverage of the state acts as carbon sink with stronger conservation. The state has now a total recorded forest area of 58,140 sq km constituting 31 percent of the geographical area. Since the beginning of five year plans the percentage of area under forest in on decline from 58% which is setting the climate. The forest management is a significant determining factor of the climate.

iv. Direction of Prevailing winds:

The winds that flow from the sea often bring rain to the coast and dry weather to inland areas. Low presence created in Bay of Bengal with varying intensity shapes the climate of the state.

v. Shape of the land:

The climate has been determined by the existing mountain hills and slope of the land. The South –eastern hills and mountains at Koraput bring more rainfall than low lying areas because as air is forced over the higher ground it cools causing moist air to condense and fall out as rain fall. The higher the place is above sea level the colder it will be. It happens because as altitude increases, air becomes thinner and is less able to absorb heat. Because of dense forests area receives more rainfall.

vi. Human Influence:

We can't forget the influence of human beings on our climate. The rampant destruction of forest for terrace farming and smuggling of forest timbers is shaping the climate from time to time. Due to change in cropping pattern and adoption of more of inorganic farming the organic carbon level and moisture in the soil go down while the incidence of run out erosion increases. The availability of the crop undergoes a change with lower levels of nitrogen and protein. In paddy zinc and Iron content go down which impact reproduction health of animals. Insect life cycle increases which raises the incidence of pest attacks and virulence. Burning of dry by-products and wastages in the open field add more carbon dioxide to the area and air is polluted.

The above factors have changed the climate of the state to a great extent recently. Climate change has become a matter of great concern. Odisha's seasons have all but vanished, its trees have altered their flowering time, and the farmers have changed their farming practices. Not only this, of the six seasons prevalent there seems only two summer and rain that have their effects on Lands of the state. Autumn, spring and winters have slowly vanished from the memory of the people. While summers have become longer, winters have become warmer and rains have shortened from above 120 to 90 days while becoming erratic beyond point.

EXTENT OF CLIMATE CHANGE & ITS IMPACT

The change in climate causes variations in rainfall:

Variation in Rainfall (mm), 1990-2016 in Odisha

(Standard Rainfall is 1482.2mm)

Table: 1

Year	Normal rainfall	Actaul Rainfall	Increase (+) or decrease(-) from Normal rainfall	Change in Percentage	Remarks
1990	1482.2mm	1865.8	(+)383.6	(+)25.9	Flood
1991	1482.2mm	1462.2	(-)20.0	(-)1.3	Normal
1992	1482.2mm	1344.1	(-)138.1	(-)9.3	Flood, drought
1993	1482.2mm	1416.0	(-)66.2	(-)4.5	Normal

1994	1482.2mm	1700.2	(+)218.0	(+)14.7	Normal
1995	1482.2mm	1471.5	(-)10.7	(-)0.7	Normal
1996	1482.2mm	988.9	(-)493.3	(-)33.3	Severe drought
1997	1482.2mm	1463.3	(-)18.9	(-)1.3	Normal
1998	1482.2mm	1279.8	(-)202.4	(-)13.7	Severe drought
1999	1482.2mm	1433.8	(-)48.4	(-)3.3	Severe cyclone
2000	1482.2mm	1022.8	(-)459.4	(-)31.0	Drought and Flood
2001	1482.2mm	1611.0	(+)128.8	(+)8.7	Flood
2002	1482.2mm	1005.5	(-)467.7	(-)32.2	Severe drought
2003	1482.2mm	1658.7	(+)176.5	(+)11.9	Flood
2004	1482.2mm	1273.6	(-) 208.6	(-)14.0737	Moisture stress
2005	1482.2mm	1519.5	(+) 37.3	(+)2.516529	Moisture stress
2006	1482.2mm	1682.8	(+) 200.6	(+)13.53394	Moisture stress/Flood
2007	1482.2mm	1591.5	(+)109.3	(+)7.374174	Flood
2008	1482.2mm	1523.6	(+)41.4	(+)2.793145	Moisture stress, Flood
2009	1482.2mm	1362.6	(-) 119.6	(-) 8.06909	Moisture stress/Flood/pest attack
2010	1482.2mm	1293	(-) 189.2	(-) 12.7648	Drought/ Un-seasonal rain
2011	1482.2mm	1327.8	(-) 154.4	(-) 10.4169	Flood/Drought
2012	1482.2mm	1391.3	(-) 90.9	(-) 6.13278	Drought in Balasore, Bhadrak,Mayurbhanj &Nuapada
2013	1482.2mm	1414	(-)68.2	(-) 4.60127	Flood(unseasonal rain)Drought(4 districts)
2014	1482.2mm	1609.6	(+)127.4	(+)8.595331	Flood
2015	1482.2mm	1223.8	(-)258.4	(-) 17.4335	Drought affecting Kharif
2016	1482.2mm	1282.6	(-)199.6	(-) 13.4665	Drought

The change in climate has serious impact on variation in annual rainfall. The table No-1 shows the pattern of variation in rainfall during the years 1990-2016. Against the normal annual normal rainfall of 1482.2 mm, the percentages increases in rainfall of 25.9, 14.7, 8.7, 11.9 and 13.53are observed respectively in the years of 1990, 1994, 2001, 2003 and 2006. In the rest of the years, there are deficit in rainfall, from 0.7 percentages in 1995 to 32.2 percent in 2002. There was also deficit rainfall in from the year 2009 to 2016 except in the year 2014. During this period of 26 years since 1990 deficit in rainfall in varying degrees are observed in 10 years, resulting frequent droughts in the state, 12 times flood had been experienced with one super cyclone in the year 1999.

Odisha's Vulnerability to Climate Change:

Odisha has experienced around 952 small and 451 tornadoes between 1891 and 1970. From 1901 to 1981 there were 380 cyclones, of which 272 resulted from depressions in the Bay of Bengal. 29 of these cyclones have been devastating. A conservative study of the effects of natural disaster reveals that between 1963 and 1999, Odisha experienced 13 major disaster, which killed 22,228 people (state government figure, non government figure puts the toll at around 40,000) and rendered 34,21,000 people homeless[3]. The 1999 super cyclone affected places like Bhubaneswar and Nayagarh, which were never traditionally cyclone prone. While 2001 drought parched fields in coastal districts, the unprecedented floods of 2001 submerged 25 states of the state's 30 districts.

Frequency of Natural disasters:

Floods: Between 1834 and 1926, floods occurred at an average interval of 3.84 years. Between 1961 and 2000, floods became an annual affair.

Drought: During the 1950's only three districts were drought-prone. By the 1980's the whole of western Odisha, consisting of five districts became drought prone. During the 1990's, 25 of the 30 districts became drought prone.

[3] *Mahapatra, R.Disaster dossier: The impact of climate change on Odisha, Infochange Environment ,2014*

Cyclones: During the 1970s and 1980s only two severe cyclones hit the state. During the 1990s two severe cyclones hit the state and the number of cyclonic conditions rose. With 13 severe cyclones in the last 100 years, Odisha is the worst affected state in India.

It is not only natural disaster, but the rise in sea level and Bay of Bengal expanding towards the coastal landscape taking away may villages, farm land into it have become more a problem of the villages who live along a coast line and derive most of their livelihood from the sea[4].

The impact of future climate change on Indian summer monsoon revealed that there is a possibility of decline in all India rainfall in the winter season, which may lead to drought. Also the possibility of increase in summer /monsoon rainfall is predicted in that analysis[5].

Odisha has a coastline of 450 KMs long sensitive coastline which a periodic recipient of climate risks such as cyclone and coastal erosion. Odisha is also rainfall dependent for its most non-irrigated land. The State has cultivable land of 64.09 lakh hectares. By the end of 2013-14,Gross irrigated area is about 49.31 lakh hectares(33.12 hectares during Kharif season and 16.19 hectare during Rabi season) through major, medium and minor (lift and flow) irrigation projects. During 2010-11 the percentage share of irrigation provided to principal crops in Odisha was 28.3 while it was 44.9 at all India level. Punjab has the highest percent of 98[6]. Rice is a major crop produced in Odisha, being the mainstay food for the people and is a water dependent crop is also dependent on rainfall due to lack of proper irrigation.

Vulnerability of Agriculture to Climate Shock in Odisha:

Nearly 85 percent of the people live in rural areas and depend mostly on agriculture for their livelihood. Agriculture plays a dominant role in the economy of the state with contributing of more than 20 percent of Net State Domestic Product. But in Odisha agriculture is largely rain fed. The normal rainfall of the state is 1482.2 mm of which 75-80 percent is received from June to September by the impact of South West monsoon. But data shows a wide range of rainfall variability across the state which visible from the table 1. The economic history of Odisha is a story of ravages of the recurrent floods, cyclones and drought and have created and still creating havoc in the economic and social life of the people of the State. These climate shocks are the crucial factors that have pushed back the progress of the economy. The losses of economic values in agriculture sector are shown in the table 2.

Orissa Vulnerability to Different Disasters:

Table:2

Year	**Nature of calamities**	**No of District affected**	**No of Blocks affected**	**No of Villages affected**	**Cropped Area affected(Lakh Ha)**
1999	Super Cyclone & Flood	12	97		17.86
2000	Drought	29	216	16857	10.59
2001	Flood		219	18790	7.16
2002	Drought	29	290	32603	28.48
2003	Flood	23	128	6846	9.17
2004	Flood	5	20	564	0.37
2005	Flood	14	72	4228	0.14
2006	Flood	27	245	18912	4.85
2007	Flood	15	100	5677	3.18
2008	Flood	21	157	9265	
2009	Flood	14	45	1446	1.25
2010					
2011	Flood	10	71	4060	2.52
2013	Unseasonal Rain & Drought	4	10	314	
2014	Flood	23	176	9675	2.48
2015	Drought	28	235	29176	15.35
2016	Drought	27	233	29040	

Source:SRC, Odisha

4 *Basudev, ODISHA "The worst victims of Global Warming and Climate Change" http://creative.sulekha.com/orissa-the-worst-victim-of-global-warming-and-climate-change_317177_blog*

5 *Lal,M et.al., Future climate change :Implications for Indian Summer monsoon and its viability. Curr.Sci., 81,1196-1207,2001.*

6 *Odisha Economic Survey, 2014-15.*

Table 2 above shows that within the period from 1999 to 2016 that is within these 18 years Odisha has suffered from natural calamities in 16 years. Thus Odisha is frequently bearing the destructive effects of these natural calamities. Further with advance in global warming and climate change, if sea storm acquire greater destructive power as is being forecast, the state will be required to bear the burden of such storms which means devastating effects on livelihood, ecology and economy of the state.

Climate Shocks and loss of Rice Production in the State:

Rice is the principal food crop in the state occupying about 40.27 lakh ha annually (37.48 lakh ha. during Kharif season + 2.79 lakh ha. during Rabi season). The Kharif Paddy area consists of 6.06 lakh ha of high land 16.51 lakh ha of medium land and 14.91 lakh ha of low land. The entire Rabi area is irrigated & covered by HYV Paddy where as 42% of Kharif Paddy area is covered under irrigation. The yield rate of rice is 2.44 tones/ ha as against national average of 2.46 tonnes / ha.

The actual rainfall received, vary from district to district. About 84% of rainfall is received during the period from June to September. Even though the quantum of rainfall is quite high, its distribution during the monsoon period is highly uneven and erratic. Flood, drought and cyclone visit regularly with varying intensity. Due to frequent occurrence of these natural calamities there is always reduction in the yield of Kharif rice, the major crop of the State. Similarly, in drought years, there is considerable loss in production of Pulses and Oilseeds both during Kharif and Rabi. The following table indicates the frequency of natural calamities over the years and the production of Kharif rice. The year wise position is indicated in the table 3.

Year wise production of Kharif Rice

Table: 3

Sl. No	Year	Kharif Rice Production (In lakh MTs.)	Remarks
1	1961	36.99	
2	1962	36.32	
3	1963	42.47	
4	1964	43.59	
5	1965	31.89	Severe drought
6	1966	35.37	Drought
7	1967	34.43	Cyclone & Flood
8	1968	38.48	Cyclone & Flood
9	1969	38.39	Flood
10	1970	39.13	Flood
11	1971	33.76	Flood Severe Cyclone
12	1972	37.35	Drought fl ood
13	1973	41.91	Flood
14	1974	29.67	Flood, severe drought
15	1975	42.74	Flood
16	1976	29.58	Severe drought
17	1977	40.50	Flood
18	1978	41.89	Tornados ,hail storm
19	1979	27.34	Severe drought
20	1980	40.31	Flood, drought
21	1981	36.63	Flood, drought, Tornado
22	1982	27.07	High fl ood, drought, cyclone
23	1983	47.63	
24	1984	38.50	Drought
25	1985	48.80	Flood
26	1986	44.56	
27	1987	31.03	Severe drought
28	1988	48.96	
29	1989	58.40	
30	1990	48.42	Flood
31	1991	60.30	
32	1992	49.76	Flood, drought
33	1993	61.02	
34	1994	58.31	
35	1995	56.48	
36	1996	38.27	Severe drought
37	1997	57.51	
38	1998	48.85	Severe drought
39	1999	42.75	Severe Cyclone
40	2000	41.72	Drought & Flood
41	2001	65.71	Flood

42	2002	28.26	Severe drought
43	2003	61.99	Flood
44	2004	58.84	Moisture stress
45	2005	62.49	Moisture stress
46	2006	61.96	Moisture stress/Flood
47	2007	68.26	Flood
48	2008	60.92	Flood , Moisture Stress
49	2009	62.93	Flood/ Moisture stress/ Pest attack.
50	2010	60.51	Drought/ Un-seasonal rain
51	2011	51.27	Drought & Flood
52	2012	86.29	Drought in Balasore, Bhadrak, Mayurbhanj & Nowapara districts.
53	2013	65.85 .	Flood & Cyclone in 18 districts due to Phailin
54	2014	85.78 (Prov.)	Cyclone in 8 districts due to Hud Hud

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

The table reveals that out of 52 years only 13 years have been normal years and in all other years the state has been bear the impact of climate shocks. This almost puts the state with a 75 percent probability of being visited by these climate shocks of any kind. And it is observed that there is a consistent loss of rice production because of these calamities.

District wise analysis of cropped area affected due to climate shock:

District wise maximum area affected from 2001-2008

Table: 4

Sl :no	District	Maximum Area affected by flood (in'000 ha) (from 2001-2008)				
		Year	**Paddy**	**Year**	**Non paddy**	**Total**
1.	Anugul	2001	11.10	2001	10.47	21.57
2.	Balasore	2007	71.35	2007	6.81	78.16
3.	Bhadrak	2003	60.62	2005	3.13	63.75
4.	Bolangir	2001	22.68	2001	6.39	29.07
5.	Bargarh	2003	1.31	2003	8.86	2.17
6.	Boudh	2008	4.64	2008	0.79	5.43
7.	Cuttack	2001	80.59	2008	13.87	94.46
8.	Dhenkanal	2001	4.69	2001	1.85	6.54
9.	Deogarh	2001	1.92	2001	0.76	2.68
10.	Ganjam	2003	56.01	2003	17.10	73.11
11.	Gajapati	2003	1.14	2006	0.71	1.85
12.	Jharsuguda	2001	7.00	2001	1.76	8.76
13.	Jagatsingpur	2001	66.23	2001	5.30	7.53
14.	Jaipur	2001	56.18	2003	7.44	63.62
15.	Kendrapara	2001	58.39	2006	11.84	70.23
16.	Kalahandi	2001	67.87	2001	15.25	83.22
17.	Keonjhar	2003	2.09	2003	0.98	3.07
18.	Koraput	2001	7.54	2001	7.61	15.15
19.	Khurda	2001	41.02	2001	1.96	42.98
20.	Malkangiri	2006	3.85	2006	1.53	5.38
21.	Mayurbhanj	2007	9.74	2007	2.58	12.32
22.	Nuapada	2001	15.35	2008	0.61	15.96
23.	Nawarangapur	2006	1.93	2006	1.13	3.06
24.	Nayagarh	2001	9.31	2001	3.02	12.33
25.	Phulbani	2006	0.53	2001	0.65	1.18
26.	Puri	2001	87.37	2006	3.69	91.06
27.	Rayagada	2006	2.00	2006	2.31	4.31
28.	Sonepur	2001	28.53	2001	2.52	31.05
29.	Sambalpur	2001	3.19	2001	0.58	3.77
30.	Sundargarh	2001	0.80	2003	0.39	1.19
	Total					**918.96**

From the table 4 it can be inferred that about 918.96 lakh hectares of cropped area are exposed to damage by flood and submergence during the period of 8 years. However the degree of crop damaged greatly varies basing on the duration of submergence and intensity of flood coupled with the time of occurrence and stage of the crops. From the above table 4 it is confirmed that climate shocks are affecting Odisha's economy.

Adaptations Strategies:

Prevention to these climate shocks is almost difficult. Prevention is often long term and would require integrated interventions by the state or national governments. However some measures are to be taken to for prevention. Adaptation to climate change is typically characterized as an adjustment in ecology, social or economic systems in response to observed or expected changes in climate stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. Two main types of adaptation are autonomous and planned adaptation. Autonomous adaptation is the reaction of for example; a farmer to changing precipitation patterns, in that s/he changes crops or uses different harvest and planting/sowing dates. Planned adaptation measures are conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, deliberate crops selection and distribution strategies across different agri-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity.[7] Farm level analyses have shown that large reductions in adverse impacts from climate change are possible when adaptation is fully implemented[8]. Short-term adjustments are seen as autonomous in the sense that no other sectors (e.g. policy, research etc.) are needed in their development and implementation. Long-term adaptations are major structural changes to overcome adversity such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques.

Policy Options:

Odisha is most vulnerable to climate change. Odisha was the one of the first states to begin work on a Climate Change Action Plan in 2009.[9] Government of Odisha has established 11 different sectors which are relevant to climate change. They are (1) Agriculture (2) Coastal Zones and Disaster (3) Energy (4) Fisheries and Animal Resources (5) Forestry (6) Health (7) Industries (8) Mining (9) Transport (10) Urban Planning (11) Water Resources. On September 4, 2014, the Chief Secretary of Odisha convened a meeting to review the progress of State Action Plan on Climate Change (2010-2015). The presentations and discussions resulted in the announcement of the need to develop the second State Climate Change Action Plan for 2015-2020 to address the drivers of climate change, to prepare for its likely impacts in Odisha, and to establish goals and timetables for implementation of a sound operational action plan for the next five years.

Odisha Climate Change Action Plan (2015-20):

The prioritized activities proposed by the agricultural departments are outlined as follows. Agriculture – Key Priorities

1. Continue the livelihood-focused, people-centric integrated watershed development programmes in rain-fed areas vulnerable to climatic variations.
2. Establish an institutional delivery mechanism to promote best practices on climate change
3. Capacity building of extension personnel
4. Increase the area under fruit crops to help cope with uncertain weather patterns
5. Develop water-efficient micro irrigation methods: individual and community farm ponds
6. Ensure coordination by the National Mission on Sustainable Agriculture (NMSA) of climate change adaptation initiatives
7. Create awareness among farmers of climate change adaptation.
8. Establish an automated weather station
9. Establish a seed bank at the village level.
10. Promote SRI.
11. Encourage the adoption of climate resilient cropping techniques.
12. Document Indigenous Technical Knowledge (ITK) in agriculture.
13. Green energy efficient models for farmers[10]

[7] *Easterling, W.E.: 1996, Adapting North American Agriculture to Climate Change in Review, Agricultural and Forest Meteorology 80 (1), 1-54.*

[8] *Mendelsohn R., Dinar A. 1999. Climate Change, Agriculture, and Developing Countries: Does Adaptation Matter? World Bank Research Observer (14), 277-293.*

[9] *http://www.cprindia.org/sites/default/files/working_papers/jogesh__dubash_mainstreaming_climate_in_state_planning_odisha_climate_plan_feb_2014.pdf*

[10] *http://climatechangecellodisha.org/pdf/Odisha_SAPCC_2016-2020.pdf*

II. CONCLUSION

Agriculture sector facing climate change is subject to multiple stress and many other factors that limit the ability to adapt. Enhancing adaptive capacity, particularly that of disadvantage rural agricultural population, is likely to be more fruitful than identifying specifically how a given group in a particular area will be affected by climate change. Then knowledge based cropping strategy and promoting agricultural insurance scheme is the key to enable the farmers to cope up with the climate change effects.

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