

Economic analysis of climate change impact, adaptation and mitigation on potato farming in India with special reference to Agra district

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Abstract

Background: Climate change, the most threatening issue is hitting almost all spheres of life. Agriculture, being an open field activity, is directly affected by climate change and also most vulnerable to this problem. Worldwide, potato is the fourth largest source of food and India is the second largest producer of potato in the world. Its production is greatly affected by uncertainty of rainfall and temperature.

Objectives: This study analyzes impact of climate change on potato yield and examines the awareness of potato farmers about climate change impact, adaptation and mitigation measures of Agra district, the major potato producing district of Western Uttar Pradesh.

Methodology: The impact of climate change variables (rainfall and temperature) on potato yield is analyzed by using OLS estimation on annual data spanning from 1998 to 2017. The awareness of potato farmers about climate change impact, adaptation and mitigation measures is examined through analysis of primary information gathered through structured group interview of 72 potato farmers randomly selected from 3 villages of Khandauli block of Agra district.

Findings: The results of survey conducted on potato farmers of selected villages of Agra district indicate that though farmers are aware of the problem and are trying at their level best to mitigate adverse impact of climate change on agriculture productivity by adapting various measures to maintain agriculture yield and quality of produce. But, they are facing problems associated with government support, non-availability of subsidized inputs and unaffordable cost of adaptation measures. Farmers' income is either uncertain or lowering year over year and they are getting highly indebted. As a result some potato farmers are thinking about crop replacement and a few are planning to quit from agriculture occupation.

Implications: The study observed that though government is aware of the severity of the problem and is trying to tackle the issue, but the present measures do not seem sufficient. It suggests that government should think seriously about the problem and rationalize the agriculture support system to ensure self-sufficiency in agriculture production and welfare of all.

Keywords: Climate change, Potato, Rainfall, Temperature, Mitigation, Adaptation.

1. Introduction

Climate change is one of the vital issues facing almost all spheres of life in the present century. The problem of climate change is more severe to agriculture and particularly the agriculture practices in developing and low-income countries because of high and more vulnerable population. The studies conducted on impact of climate change on agriculture sector in past few decades' indicate adverse effects of increase in temperature and change in pattern and timing of rainfall on yield and quality of major crops in developing countries. Potato is one of the major crops of the world and is fourth largest source of food worldwide [1]. China, India and European Union are the major producers of potato. India is second biggest potato producing country and contributes around 8% of global potato production (FAO, 2005). Potato is mild climate flora that comfortably adjusts to divergent climatic environments.

In past few decades the vulnerable climate like other crops has affected potato yield in terms of quality, quantity, agricultural practices and adaptation. Hijmans observed that in India climate change may affect potato yield by 23.1% without adaptation measures and with adaptation this effects can be reduced by 1% [2]. Climate change affects agriculture in various ways; it may affect the quality of crop or may reduce the crop yield. Different researchers in the past discussed about potential effects of climate change on agriculture crops under different climatic scenarios. Gebremedhin & Berhe predicted significant loss of potato crop in selected locations under different scenarios [3]. The predictions made by Saue & Kadaja also indicate that global warming may have negative impact on early potato growth [4]. Hijmans forecasted that the potato yield will fall down by 10 to 19% in 2010-2039. It may further come down by 18 to 32% till 2050 under different climatic scenarios globally.

The awareness of farmers is quite necessary to cope up with the problem of climate change and by knowing about the severity of the problem of climate change farmers can take possible steps to reduce the effects of climate change and can frame an adaptation and mitigation plan also to increase their crop yield and income [5]. The awareness of farmers regarding climate change depends on the various factors but education level of farmers is supreme of them.

2. Present state of knowledge

A number of researchers assessed the impact of climate change on agriculture by considering various crops produced in famous plains of the world known for their agriculture suitability. Kumar et al. observed that climate change has negative impact on selected crops in coastal region; the rain fed rice particularly faces extremely unfavorable conditions [6]. Guiteras stated that due to change in climatic variables the yield of selected crops will decline by 2.5% in short run (between 2010 and 2039) and in the long run (between 2070 and 2099) the yield may decline by 25% if no adaptation measures will be taken [7]. Observed that in short run, increase in temperature has negative impact on wheat crop, while in long run it may have some positive effects. The increase in precipitation has negative impact on crop yield [8]. Stated that increase in temperature has a negative impact on wheat crop yield. He further mentioned that in India climate change has a positive impact on maize yield as it is a winter crop and increase in temperature provides favorable conditions for this crop [9]. A survey observed 95% farmers claiming that climate change has affected their farming activities, reduced crop yield, water resources and biomass for animals due to low rainfall and frequent dry spells in last ten years. The effect is more on small poor farmers because of small landholdings, lack of awareness and resources to cope up with climate change [10]. Poor rural households, whose livelihood depend predominantly on agriculture and natural resources bear a disproportionate burden of adverse effects of climate change.

Adaptation to climate change implies alteration or modification in system to diminish the adverse impact and ameliorate the positive impacts of climate change. It is a process that may take place at different levels of government from national to local or at farm level [11]. Hijmans viewed that adaptation is a need of time in the field of agriculture; it helps in maintaining crop yields or minimizing the effects of climate change on crop yield. Tripathi & Mishra, while discussing the process of adaptation, mentioned that it start from awareness of farmers about the climate change and ends on farmer's adaptation at specific farm site. The adaptation by farmers is governed by severity of climate change at the specific site along with other factors like education level, land holding etc. Kamruzzaman also studied the awareness and adaptation of farmers regarding climate change and observed that though majority of farmers are aware of climate change, but the level of their awareness is different. His study revealed that about 22.7% farmers are highly aware, a half are moderately aware and remaining have low level awareness about climate change [12]. In a study Tsojon observed that farmers are aware of effects of changes in climatic variables, like temperature and the pattern of rainfall [13]. Sarkar & Padaria mentioned that temperature and pattern of rainfall negatively affect the crops yield [14]. Made an attempt to examine farmers' perception about climate change in different regions of the globe. He observed that most of farmers are aware of changes in climatic trends, year over year increase in temperature and the unusual pattern of rainfall [15]. It is noteworthy that climatic data of these areas also supported information provided by farmers of the areas under consideration.

To overcome from the situation, Indian farmers in Odisha are adapting different strategies, such as changes in crop mix, modification in plating of crop, increase in the irrigation facilities, developing alternative irrigation and energy sources etc [16] mentioned that farmers of South Africa rely on insurance as an adaptation measure [17]. The farmers of developed countries, such as America are using in-field-conversation practices along with new technologies [18]. The study is organized in various sections. Section one is about introduction, section two confers the pertinent studies which focus on effects of climate change and particularly, the awareness of farmers about climate change and the adaptation measures. Section three portrays a brief account of the government policies and programs on climate change, and section four presents the impact of climate change on potato agriculture in Agra district. Section five expounds the methodology and discusses the findings of the survey conducted in Agra district. Section six concludes the paper and talks about policy implications.

3. Government policies on climate change

Climate change and agriculture are reticulated. Agriculture is source as well as sink of greenhouses gases (GHGs), which are supreme contributor to climate change. Climate change affects the agriculture and agriculture contributes in changing the climate, so both are interrelated. The government of India and State government of Uttar Pradesh have taken various steps to minimize the effects of climate change. The central government launched National Mission on Sustainable Agriculture in 2013 as a part of National Action plan on Climate change. This focuses on 10 key dimensions related to a chain of adaptation procedure, which are better quality of seeds, live stock and fish culture, water use efficiency, pest management, improved farm practices, nutrient management, agriculture insurance, credit support, markets, access to information and livelihood diversification strategy. Government of India also launched irrigation schemes to provide better irrigation facilities to farmers as the ground water level falls down in recent years. Uttar Pradesh is the first state of country to establish climate change authority; it has announced budget of Rs. 102.75 crore under the Sustainable Agriculture Mission for the period 2014-2018. The Government of Uttar Pradesh has taken various initiatives, which include:

1. Constitution of Crop Whether Watch Group (CWWG) under the chairmanship of Director General, U.P. Council of Agricultural Research (UPCAR) which provides information about the fluctuations in weather conditions in different agro-climatic zones of the State.
2. Established Farmers Field Schools under Diversified Agriculture Support Project (DASP) and U.P. Solid Land Reclamation Program (UPSLRP) to enhance the knowledge of farmers about climate change and other aspects of agriculture, such as soil, water management, agro-chemicals etc. These schools also help in adaptation and mitigation by collecting the information of farmers at specific farm site.
3. Started Climate Responsive Research Programs executed by the Indian Council of Agriculture Research (ICAR), UPCAR etc. The government is also trying to diversify the cropping systems and promoting the stress tolerant crop varieties to maintain the yield of crops in the state.
4. Proposed to establish a Climate Change and Agriculture Cell (CCAC) under UPCAR to accumulate and organize data of agriculture and climate change to boost the present understanding of the issue and also works to build capacity to increase the resilience of agriculture towards the climate change.

4. Impact of climate change on potato agriculture

In last few decades climatic variables have changed significantly in western Uttar Pradesh. In Agra district too, considerable variations in temperature and pattern of rainfall are observed. The vulnerable temperature and rainfall have affected yield of potato crop in the district. The analysis of the impact of climate variables (temperature and rainfall) on potato crop yield is carried out by using secondary data. Climate data on rainfall and temperature is collected from website of India Meteorological Department (IMD) and the data on potato crop yield is extracted from website of the Department of Economics & Statistics, Government of Uttar Pradesh and Open Government Data (OGD) platform.

Table 1 depicts mean, standard deviation, skewness, kurtosis, Jarque-Bera statistics and its associated probabilities during the study period from 1997-98 to 2016-17.

The mean values indicate that yield of potato in Agra district is good, rainfall is also good and the temperature, though slightly high, but, approximately equal to other parts of the country. The values of standard deviation indicate petite fluctuation in potato yield, temperature is almost constant, but, rainfall is highly fluctuated in the region. The value of Jarque-Bera and its associated probabilities (>0.05) indicate that the distribution of all the variables under consideration is approximately normal.

Table 1. Descriptive statistics

Particulars	Potato Yield (Tones/ Hectare)	Rainfall	Temperature (Degree Celsius)
Mean	26.935	37.727	25.725
Standard Deviation	3.418	17.936	0.3624
Skewness	1.198	0.583	-0.111
Kurtosis	0.543	-0.106	2.258
Jarque-Bera	5.026	1.145	4.293
Probability	0.081	0.564	0.117

Source: Authors' own compilation

The results of ordinary least square applied to examine the impact of change in climatic variables (temperature and rainfall) on potato yield are presented in Table 2. The results indicate coefficients of temperature and rainfall 0.07 and 3.87 respectively; their associated probabilities are also significant. It means potato yield in Agra district is more sensitive to temperature. The value of R^2 (0.32) indicates that 32% variations in potato yield in Agra district are due to changes in temperature and rainfall.

Table 2. Results of OLS estimation

Dependent Variable: Potato Yield (Y)			Period: 1998 - 2017			
	Coefficient	Prob.	R^2	Adj. r^2	F	F (Prob.)
Constant (α)	- 75.26	0.139	0.323	0.244	4.062	0.036
Rainfall (β_r)	0.07	0.077				
Temperature (β_t)	3.87	0.056				

Source: Authors' own calculations

5. Farmers' survey: methodology and results

In order to examine awareness of potato farmers about climate change impact, adaptation and mitigation measures, researchers used primary information gathered through structured group interview of potato farmers. For this purpose focus group method (FGM), a supreme method of collecting information about the respondents' pensive, understanding and perception is used. The survey was conducted in three villages of Agra district of Uttar Pradesh, a part of Indo-Gangatic plains, which is known as food bowl of Indian subcontinent. It is the largest potato producing state of India which contributes 30% of total potato production of country. Further, Agra district is well known for suitability and quality of potato crop all around the country. Climate of Agra is semi-Agrid having rainfall in monsoon and mild winter and is one the hottest city of country. The demography and socio-economic background of focus groups (selected villages of Khandauli block of Agra) is shown in Table 3.

Table 3. Demography, socioeconomic profile of focus groups of Khandauli block

Attribute	Group 1	Group 2	Group 3
Name of Village	AnwalKhera	Khandauli	Kheriya
Age Group	45-50 Years	45-50 Years	45-50 Years
Land Holding	Medium & Large	Medium & Large	Medium & Large
Education Level	Primary & Secondary	Primary & Secondary	Primary only
Farming Experience	Around 20 years	Around 25 years	Around 20 years
Socioeconomic Status	Middle Class	Middle Class	Middle Class

The survey was conducted on 72 farmers (24 farmers of Anwalkhera, 27 farmers of Khandauli and 21 farmers of Kheria village) of Khandauli block, more vulnerable to climate change specially during potato crop (Second Crop Acreage and Yield Estimation Report–Agra, Agriculture Research Group). The respondents include all castes, though, dominated by general and backward caste. Sample does not include female respondents because female do not have land holding, they are not directly engaged in agriculture activities. Effort has been made to maintain homogeneity among groups and the members of the groups so that similar view about the objective of study may be obtained. The observations drawn from primary survey are validated from data on climate and crop yield of the district. The survey observations recorded and compiled reveal following.

1. All the farmers are aware of climatic variables, but their level of awareness about climate change is moderate. The awareness level of 21% farmers is good as they have secondary level education and read newspapers either daily or on regular intervals.
2. Almost all the farmers are facing problems associated with temperature and rainfall, but, they are not exactly aware the term climate change. Among farmers who are aware of the term, majority got knowledge from their own observation. Some farmers stated that government agencies also help them to raise their level of awareness through discussion, radio, television and newspapers.
3. Majority of farmers (78%) reported that temperature has risen in last two decades and the timing of rainfall is not static. Rainfall occurs in the gape of one year, particularly at the time of potato harvesting. They also viewed that shirking and untimely monsoon year over year has resulted into loss of humidity of soil in the fields. Hence, their depended on alternative irrigation sources has increased significantly.
4. Most of the farmers (77%) viewed that main indicators of climate change at local level include increase in temperature, decrease in rainfall and winters days. The crop productivity, (particularly potato yield) is coming down due to reduction in winter days and shift in the timing of rainfall.
5. Respondents also viewed that humidity and fog which are necessary conditions for better quality of potato are declining year over year because of variation in number of winter and rainfall days in the area.
6. The farmers of the selected villages have different views about reasons of climate change. A half of the respondents are of the view that deforestation is the main reason of climate change, while remaining argue that climate change is an outcome of increasing population, urbanization, rapid industrialization and increased transport. All these developments are resulting into shrinking forest area and producing harmful gases.

Regarding climate change adaptation and mitigation measures, respondents were asked to express their views on strategies adopted by them to minimize the negative effects of climate change. Their responses on the issue are as follows.

1. In order to maintain adequate level of humidity of the soil, almost all the farmers of the selected villages are dependent on alternative sources of irrigation, either from surface water (canal and minor) or ground water (tube well); for maintaining crop yield majority of potato farmers are using pesticides and fertilizers.
2. Regarding cost of adaptation and mitigation, respondents viewed that the cost alternative sources of irrigation, pesticides, fertilizers and the warehousing of harvested crops for safe storage near the fields is around 5000 per hectare.
3. They also viewed that though government provides for subsidy on the fertilizers, it is hardly available perhaps because of insufficient stock. Hence, they are bound to buy fertilizers from private dealers, which further enhance cost of production, thus, economically not feasible.
4. Due to vulnerability of potato yield and high cost of production, a few farmers are thinking about crop replacement, i.e., from potato to wheat, while some (especially youth) are planning to quit from agriculture occupation.

6. Conclusion

Climate change is the biggest problem of present era, it has significant impact on agriculture productivity; thus resulting into adverse effects on farmers' income. Farmers, now-a-days are struggling hard to earn their livelihood. The results of survey conducted on potato farmers of selected villages of Agra district indicate that though farmers are aware of the problem and are trying at their level best to mitigate adverse impact of climate change on agriculture productivity by adapting various measures to maintain agriculture yield and quality of produce. But, they are facing problems associated with government support, non-availability of subsidized inputs and unaffordable cost of adaptation measures. Farmers' income is either uncertain or lowering year over year and they are getting highly indebted. As a result some potato farmers are thinking about crop replacement and a few are planning to quit from agriculture occupation. Though, government is aware of severity of the problem and is trying to tackle the issue, but the present measures do not seem to be sufficient. It is suggested that government should think seriously about this problem and rationalize the agriculture support system so that we may ensure self sufficiency in agriculture production and welfare of all.

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