How to Encourage Farmers to Adapt to Climate Change?

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ABSTRACT

This study is an attempt to use group information collected from different farmers (e.g. marginal, small, and medium farmers and tenants) in eastern Uttar Pradesh in India to address a question relevant to climate policy: How to encourage farmers to adapt to climate change? First, group information collected on farmers' perception of and adaptation to climate change was analysed using content analysis. Then, the findings were compared with climatic and agriculture information collected from secondary sources. The results suggest that though farmers are aware of long-term changes in climatic factors, they are unable to identify these changes as climate change. Farmers are also aware of risks generated by climate variability and extreme climate events. Despite perceiving changes in climate factors, farmers are doing nothing to deal with these changes. But they are changing their agriculture and farming practices to deal with socioeconomic changes, and some of these changes (e.g. changing sowing and harvesting timing, cultivation of crops of short maturity period, inter-cropping, changing cropping pattern, investment in irrigation, and agroforestry) help in adapting agriculture to climate change. So, it may be concluded that farmers are implicitly taking initiatives to adapt climate change. Finally, the paper suggests some policy interventions to scale up adaptation to climate change in agriculture.

Keywords: Climate change adaptation; farmers; climate information service; agriculture

JEl Code: Q15, Q54

1 INTRODUCTION

Climate change is no more a distant problem. We have been experiencing changes in climatic variables and the consequent effects (Lobell et al. 2012; Auffhammer et al. 2011), and have almost failed to reach a global consensus on the mitigation of greenhouse gas (GHG) emissions (Sharma 2014). Because of this slow mitigation response, climate change has not been arrested properly. If mitigation responses now start picking up pace, these will not reduce the adverse impact of GHGs already in the atmosphere (although these will help to cut the future rate of acceleration of global warming) (Fussel 2007). To deal with this situation, adaptation to climate change is required, along with a fast mitigation response. Adaptation is not a new phenomenon   it has been in practice since the beginning of life. The theory of evolution is its best example.

Since agriculture is one of the most vulnerable sectors to climate change (Porter et al. 2014), the present study focuses on it. Adapting agriculture to climate change is a major challenge, especially in a developing country like India, where most farmers are marginal and small farmers and have low adaptive capacity. In these circumstances, one cannot expect autonomous adaptation. Even if it were possible, it would not be sufficient to offset losses from climate change (McCarthy et al. 2001). The only way out is planned or policy-driven adaptation, for which the government has to come up with certain policy solutions. What these policy solutions should be is the big question, which is addressed by this paper.

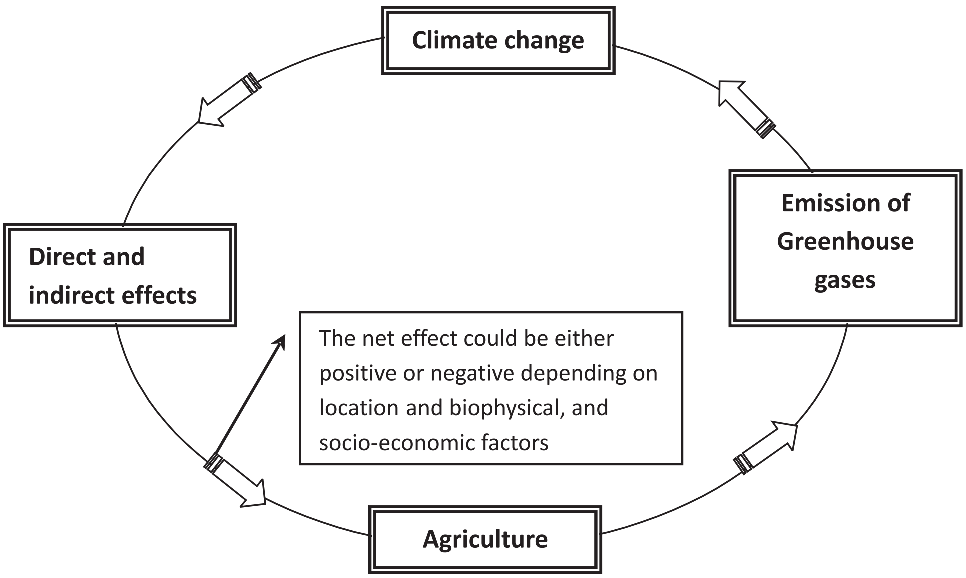
This study is exploratory; therefore, the focus group research approach was used here to study farmers in three villages, and then the observations were compared with available studies conducted in both India and abroad. The selected villages (Sariyawa, Gauhaniya, and Kinauli) are located in Faizabad, a district in the eastern part of the state of Uttar Pradesh (UP) in India, and chosen because it is likely to be severely affected by climate change, characterised as it is by low per capita income, high population density, and the dominance of small and marginal resource-poor farmers (Tripathi 2016).

The remainder of this paper is organised as follows. Section 2 discusses the inter-relationship between climate change and agriculture, and also highlights initiatives taken by the Government of India to address issues in agriculture related to climate change. This section also reviews relevant studies that focus on the impact of climate change on Indian agriculture and discusses their findings briefly. Section 3 describes the study area and methods used in data collection and analyses. Section 4 discusses the results. Section 5 concludes the paper and discusses policy implications.

2 CLIMATE CHANGE, AGRICULTURE, AND POLICY INITIATIVES

Climate change and agriculture are inter-related (Figure 1). On the one hand, agriculture and land cover changes emit GHGs and contribute significantly to climate change. Several reliable and well recognised estimates (for example, EPA (2011) and Vermeulen et al. (2012)) suggest that the food system contributes 19 to 29 per cent of total GHG emissions. Direct emissions from agriculture (through activities like crop cultivation and livestock) account for 10 to 12 per cent of total GHG emissions (Solomon 2007). Not only the magnitude of agriculture emissions but also its trend is alarming. As per recent data released by the Food and Agriculture Organization (FAO), emissions from agriculture, forestry, and fisheries have nearly doubled over the past 50 years, and could increase an additional 30 per cent by 2050 if greater efforts are not made to reduce them.

Figure 1 Interrelationship between climate change and agriculture



On the other hand, climate change affects agriculture in two ways direct and indirect. Change in climatic factors (temperature, rainfall) affects agriculture productivity through physiological changes in crops (Chakraborty et al. 2000). Apart from this, climate change also affects some factors of agriculture production, such as water availability, soil fertility, and pests (Porter et al. 2014). The overall effect of climate change on agriculture may be positive or negative; similarly, its magnitude can vary from very low to very high, depending on the region's geographical location and socioeconomic development (Mendelsohn et al. 2006; Tol 1995, 2004; Tripathi 2016). Tol (1995, 2004) suggested that whether a little climate change is bad or good depends on one's location. In his two studies, Tol noted that a 1 ^{0}C increase in temperature and a 0.2 metre-rise in sea level had a positive impact in member-countries of the Organisation for Economic Co-operation and Development (OECD), Middle East countries, and China, but a negative impact in other regions. Mendelsohn et al. (2006)

also provided empirical support for the distributional impact of climate change by examining climate change impacts between poor and rich countries. The findings of these studies revealed that the poorest half of the world's nations suffer the bulk of the damages from climate change, whereas the wealthiest nations experience almost no net impact. There are many reasons why this is so, but Mendelsohn et al. (2006) highlighted location as the main reason poor nations bear the brunt of climate change damages primarily because they are located in the low latitudes, which are already very hot. However, it cannot be argued that Mendelsohn et al. (2006) ignored economic reasons: they accepted that the proportion of GDP in agriculture, technology, wealth, and adaptation also contributed to the distributional outcome, but said that these factors play a smaller role. Hartel and Lobell (2014) has also concluded the same and pointed out that the effects of climate change on farming will be most severe in low-income, agriculture-dependent, tropical countries because these countries are least equipped to cope with climate change.

India, where temperatures have already crossed the threshold and which is economically less developed, is of particular interest to this paper. Climate change is likely to have adverse impact on Indian agriculture, as has been empirically proven by several studies (Auffhammer et al. 2011; Haris et al. 2013; Mishra et al. 2013; Dasgupta et al. 2013; Gupta et al. 2014; Jha and Tripathi 2011; Lobell et al. 2012; Pattanayak and Kumar 2014; Rao et al. 2014). To understand the impact of climate change on agriculture, it is worthwhile to discuss the findings of a few important studies.

Using nine years of satellite measurements of wheat growth in northern India, Lobell et al. (2012) examined the rates of wheat senescence following exposure to temperature greater than 34 ^{0}C. This study detected a statistically significant acceleration of senescence from extreme heat above and beyond the effects of increased average temperatures. This result implies that warming presents a greater challenge to wheat. Auffhammer et al. (2011) observed a stronger adverse impact of climate change on rice crop than any previous study; they claimed that rice yield in India has already dropped by 5 to 10 per cent over 1966 to 2002 due to climate change. Study results indicate that monsoon rainfall is not the only weather variable affecting *kharif* rice in India; an even greater impact on yield at the end of the growing season is of nighttime temperature. This observation is supported by a very recent study (Rao et al. 2014), which observed decline in paddy yield by 411 to 859 kg/ha due to rise in 1 ^{0}C in minimum temperature using district-level data for the period between 1971 and 2009. Different stages of crop respond differently to climate change. Its impact is found more conspicuous during the flowering and grain-filling stages of the crop (Jha and Tripathi 2011; Jha and Tripathi 2014).

This negative impact on agriculture further threatens a country's food and nutrition security programme, since declining food production decreases food availability and limits access to food (because food prices increase). There are 842 million undernourished people in the world today 98 per cent of which live in underdeveloped countries (FAO et al. 2014) and this number is likely to increase in the future, in view of global climate change. To prevent that from happening, agriculture practices have to shift towards 'climate-smart agriculture' (CSA), which minimises the adverse effect of climate change and controls GHG emissions from agriculture.

Recently, CSA has become a popular term, and several multi-government organisations (FAO, World Bank, Consultative Group on International Agricultural Research (CGIAR)) have been working in this area. Cooper et al. (2013) have identified 16 success stories of large-scale action in the agriculture and forestry sectors that have adaptation and/or mitigation outcomes. Under its climate change, agriculture, and food security research programme, the CGIAR has been developing climate-smart villages in some parts of the world (East Africa, West Africa, Latin America, Southeast Asia, and South Asia). Some villages in India are also being piloted by the CGIAR under this programme in collaboration with the National Initiative on Climate Change Resilient Agriculture (NICRA), an initiative by the Government of India through its Indian Council of Agriculture Research (ICAR) to enhance the resilience of Indian agriculture to climate change and variability. Strategic research and technology demonstration are major pathways to achieve programme objectives.

In 2013, the Government of India started the National Mission of Sustainable Agriculture (NMSA), one of the eight missions outlined under the National Action Plan on Climate Change. It aims at promoting sustainable agriculture through a series of adaptation measures that focus on 10 key dimensions of Indian agriculture: improved crop seeds, livestock, and fish culture; water use efficiency; pest management; improved farm practices; nutrient management; agriculture insurance; credit support; markets; access to information; and livelihood diversification. Some of these dimensions are already built into other missions or schemes of the Department of Agriculture and Cooperation (for example, National Food Security Mission, Rashtriya Krishi Vikas Yojana); therefore, all ongoing missions or schemes are required to converge to achieve NMSA objectives. The prime emphases of the NMSA are on soil and water conversation, water use efficiency, soil health management, and rain-fed area development. In its budget (2014 15), the Government of India proposed an adaptation fund of Rs 100 crores (GoI 2014). Two other programmes agro-meteorology advisory services and farmers' awareness programmes have been launched; these seem to be scaled-up sustainable agriculture programme.

However, the agro-meteorology advisory service is an old programme, in practice by the Indian Meteorological Department (IMD) since 1945. Initially, this service was provided at the national level only; it was extended to the states in 1976. Despite this improvement, the programme was not able to fulfil the demand of the farming community. During the Eleventh Five Year Plan, the agro-meteorology advisory service was changed significantly; now, an integrated agro-met service is provided through a multi-channel dissemination system at three different levels national, state, and district. Further, along with the ICAR, state agriculture universities, local NGOs, and other stakeholders, the IMD has started organising one-day farmer awareness programmes in different agro-climates of the country to sensitise farmers about weather and climate information and their application in farm management. During 2009 to 2010 and 2010 to 2011, 60 Agroment field units located in agriculture universities / ICAR institutes have organised the programme and approximately 7,000 farmers have attended the programme at these centres (IMD). Such programmes are also being organised under the NICRA project; during 16-30 March 2013, its Raipur centre conducted the awareness programme in eight districts of Chhattisgarh state through Krishi Vigyan Kendra, Indira Gandhi Agriculture University, Raipur.

3 STUDY AREA AND METHODS

3.1 Study Area

This is a field-based study conducted in three villages (Sariyawa, Gauhaniya, and Kinauli) of Faizabad, a district located in eastern UP in India. In terms of agricultural production, UP is the leading state in the country; its comparative advantage stems from a strong agriculture base with the most fertile land masses and a well-connected river network and enables it to play a significant role in the country's food and nutrition security programme. But climate-sensitivity to agriculture is very high (O'Brien et al. 2004), and the recent changes observed in its climate may be an obstacle to development (Tripathi 2016). Moreover, UP, which is India's fifth largest state and its most populous, is diverse in geography and culture. The state is divided into four regions: western, central, eastern, and Bundelkhand. Its eastern region is of particular interest to the present study because it is likely to have larger impacts of climate change than other parts. It is characterised by low per capita income, high population density, and dominance of small and marginal resource-poor farmers.[1] The literature on climate change vulnerability shows that these characteristics are adequate to reflect its high sensitivity and low adaptive capacity to climate change.

Faizabad, situated on the banks of the Ghaghra river (locally known as Saryu), is well known because of Ayodhya, a town of religious significance to Hindus, as it is said that Lord Rama was born there. Faizabad occupies about 1 per cent of UP's total area and about 1.24 per cent of its population and is divided into 11 development blocks. These blocks are Amaniganj, Bikapur, Hartinganj, Masodha, Mavai, Mayabazar, Milkipur, Purabajar, Rudauli, Sohawal, and Taarun. Of these 11 blocks, Masodha and Milkipur blocks were purposely chosen for the study. Masodha is nearer the city than Milkipur and more developed in infrastructure and other services.

[1] Eastern UP's per capita income (Rs 9,859) is significantly lower than that of western UP (Rs 17,273), central (Rs 13,940), and Bundelkhand (Rs 12,737), but around 40 per cent of the state's population lives there. Over 80 per cent of farmers in this region are small and marginal farmers.

The district's total area is 2,341 square kilometre and its total population is 2,470,996, as per the latest Census of India (2011). About 85 per cent of the total population of the district lives in rural areas. In comparison to the previous Census (2001), the population growth has declined in 2011, while sex ratio, average literacy rate, and gender gap in literacy have improved. Despite these improvements, its rank on the Human Development Index has been declining continually since 1991 (Government of Uttar Pradesh, 2007). The main occupation of Faizabad is agriculture, characterised by rice-wheat cropping system (Hobbs et al. 1992). In some parts (particularly Masodha and Bikapur), sugarcane has also been cultivated for a long time because a sugar mill in Masodha block consumes all the sugarcane produced in nearby areas. Recently, however, some of the area previously being used to cultivate sugarcane is now being used to cultivate peppermint, because of these reasons:

1. sugarcane is an annual crop while peppermint takes 3 4 months to grow;
2. peppermint is more remunerative than sugarcane; and
3. payments from the sugar mill are routinely delayed.

Its Sohawal block is known for mango cultivation and some parts of the district also grow guava. A shift in horticulture has been also seen in the district; some areas that have 100 per cent irrigation facility have started growing bananas.

The three villages selected are Sariyawa and Gauhaniya (in Masodha block of Faizabad district) and Kinauli (in Milkipur block of the same district). Of the 41 facilities considered fundamental to quality of life, 14 are available in Sariyawa, 10 in Gauhaniya, and 5 in Kinauli. These villages lack health, transportation, and communication facilities, and Kinauli has only one primary school. The other two villages have primary, junior high, and high schools. Interestingly, Sariyawa village has a separate high school for girls and boys, and an optional education centre, but not a health facility. Gauhaniya has one primary health centre. There is no banking facility in any of the three villages, but Sariyawa village has one post office saving bank.

Considering all this, one may conclude that Sariyawa village is more developed than the other two villages, and this was found true in field visits. Most households are upper-caste *Kshatriya*, and almost all households engage in both farm and non-farm activities and have at least one or two members in government or private jobs or in business. Gauhaniya is similar, except that most of its population is *Kurmi*, an upper backward caste, and engage mainly in farming activity. These villages are interconnected and residents know each other well. But unlike farmers in Sariyawa and Gauhaniya, most people in Kinauli are not resource-endowed, and work as sharecroppers or tenant farmers. Few farmers in Kinauli own tubewells or tractors. Several farmers, particularly tenants, still use animals to plough their fields.

Table 1 Fundamental facilities available in sample villages

Facilities	Kinauli	Gauhaniya Saloni	Sariyawa
Block	0	0	0
Village development office	1	1	1
Fair price shop	1	1	1
Drinking water facility	1	1	1
Agricultural service centre	0	0	0
Market (*Haat)*	0	0	1
Whole sale market	0	0	0
Cold storage	0	0	0
Seed sales centre	0	0	0
Fertiliser sales centre	0	0	0
Pesticides sales centre	0	0	0
Veterinary hospital	0	0	0
Veterinary dispensary (D-Category)	1	0	0
Animal care centre	0	0	0
Artificial insemination centre	0	0	0
Cooperative milk collection centre	0	0	0
Primary agriculture credit cooperative societies	0	0	0
Merchandise cooperative societies	0	0	0
Government sales centre	0	0	0
Primary school (co-added)	1	1	1
Junior high school (boys)	0	1	1
Junior high school (girls)	0	1	1
Secondary school (boys)	0	1	1
Secondary school (girls)	0	0	1
Optional education centre	0	0	1
Primary health centre/dispensary (Allopathic)	0	1	0
Primary health centre/dispensary (Ayurveda)	0	0	0
Primary health centre/dispensary (unani)	0	0	0
Primary health centre/dispensary (Homeopathic)	0	0	0
Family welfare centre	0	0	0
Mother and child care centre	0	0	0
Paved road	0	1	0
Post office	0	0	1
Letter box	0	0	1
Telegraph	0	0	0
Public telephone booth	0	1	1
Railway station holt	0	0	0
Bus stop	0	0	0
Cooperative agriculture and rural development bank	0	0	0
Commercial rural cooperative bank	0	0	0
Post office saving bank	0	0	1
Score	5/41	10/41	14/41

Source: Field Survey

3.2 Methods

This study is based on both primary and secondary information. Primary information was collected through the focus group method, which can be integrated into an overall study design or used individually, depending on the nature of research. In exploratory studies, it is used individually. In the focus group method, group discussions among selected individuals are organised to explore in depth people's thinking, understanding, and perception of the phenomena being studied, and involve both group interviews and group interaction. The focus group method has several advantages over individual interviews: it saves time and money and provides an opportunity to collect diverse information on a particular topic (Morgan 1988).

In this paper, five groups were formed of farmers aged 40 to 60 years with at least 20 years' farming experience (two groups each in Sariyawa and Gauhaniya and one group in Kinauli). Each group had nine farmers, selected with help of the head of each village (*g*ram pradhan). The selection criterion enables us to understand long-term changes in agriculture practices and climate change in the select villages. The focus group discussions were held within each village and facilitated by the researcher himself. Further, observations obtained from farmers were validated using climate data collected from the IMD and agriculture data collected from the Department of Economics and Statistics, Faizabad. These secondary data were analysed using descriptive statistics and trend analysis. In this paper, trend was analysed by fitting different trend equations like linear, quadratic, etc.

3.3 Limitation of the Present Study

This study has limitations that should be borne in mind when its findings are analysed: internal validity cannot be established, due to lack of controls, and findings may not be generalised to other settings, because the sample size is too small. That is why focus groups are suited for exploratory research and not generally used for explanatory or descriptive research. Nevertheless, the present study tries to fix the above limitation by comparing findings of available related studies. Another limitation is selection bias (gender bias): only male farmers participated in focus group discussions as no female farmers were found in the study villages.

4 FINDINGS

4.1 Farmers' Perception of Climate Change and Its Impact

Perception is a necessary prerequisite for adaptation adapting agriculture to climate change depends on whether farmers perceive it but it is not always enough; more important is how farmers perceive the risks associated with climate change, as this perception of risk is essential for motivating farmers to decide to adapt (Grothmann and Patt 2005; Frank et al. 2011). Therefore, the present study attempts to know farmers' perceptions of both climate change and climate risks, and assess the accuracy of such perceptions by comparing observed perceptions with changes observed in climate and agriculture data collected from different sources. Climate data, particularly on temperature and rainfall, is collected from the IMD, while agriculture data, particularly on food grain, rice, and wheat production, is collected from the Department of Economics and Statistics, Government of UP. In focus group discussions, it was noticed that farmers notice changes in warming, rainfall or rainfall variability, and weather or seasonal variability over the preceding 20 years but (barring 2 of the 45 farmers surveyed) do not know that these changes constitute climate change. This finding shows that the farmers surveyed lack education and awareness, and also that agriculture extension services in the study region are weak; otherwise, the farmers would have been able to identify changes in climatic variables as climate change. The role of extension services is very critical in the perception of climate change and in adaptation to it, as has been reported by many studies (for example, Bryan et al. 2013, which observed that farmer households that did not receive visits from extension agents were likely to either not perceive climate change or perceive it wrongly). However, most of these studies have conducted in other countries than India.

The two farmers who recognised that the changes they noticed in warming, rainfall or rainfall variability, and weather or seasonal variability constituted climate change were educated and read the newspaper daily, even though they were in different age groups, which makes them different from other farmers. This observation emphasises the role and importance of the media in raising public awareness of climate change or global warming, as has been noted by many studies (like Sampei and Aoyagi-Usui 2009), and suggests that education and exposure to available evidence help to shape farmers' perception to climate change, along with farming experience (which has been found to be a prominent influence on farmers' perception in many previous studies, such as Maddison (2007), Gbetibouo (2009), and Bryan et al. (2013)). So, increasing access to print or digital media would help in spreading awareness of climate change and associated risks among farmers, as would text and voice messaging services in local languages, as almost all farm households own mobile phones. These observations remind us that climate information services could play critical role in forming correct perception. A very recent study (Habtemariam et al. 2016) conducted in Ethiopia assessed factors that influence smallholder farmers' climate change perceptions and found a statistically significant positive impact of climate change information on farmers' perception of climate change.

Most of the farmers who participated in the focus group discussions reported a trend of gradual increase in warming; less, but more erratic, rainfall; and increasing incidence of strong winds. Farmers agreed strongly that rainfall and wind patterns had changed, but disagreed on the increasing trend of warming; subsequent detailed discussions revealed that this disagreement occurred because of confusion over sunshine and loo[2] (hot wind) and

[2] The loo is a strong, hot and dry summer afternoon wind from the west which blows over the western Indo-Gangetic Plain region of North India and Pakistan. It is especially strong in the months of May and June.

because few perceived a declining trend in warming. Farmers who believed that warming has declined argued that there have been fewer incidences of loo in the preceding few years, but this perception is not borne out by scientific evidence available in the public domain. When asked if they had noticed any change in the weather or the seasons, most farmers claimed that summers had lengthened and winters had shortened, and many reported that winters had become colder and rainier.

Most participating farmers perceived the negative impact of climate change on agriculture, and were aware that climate change reduces grain quality and decreases crop production, which affects their livelihood. Small and marginal farmers and tenants depend on wages for survival. Thus, climate change increases temporary migration from rural areas to urban areas.

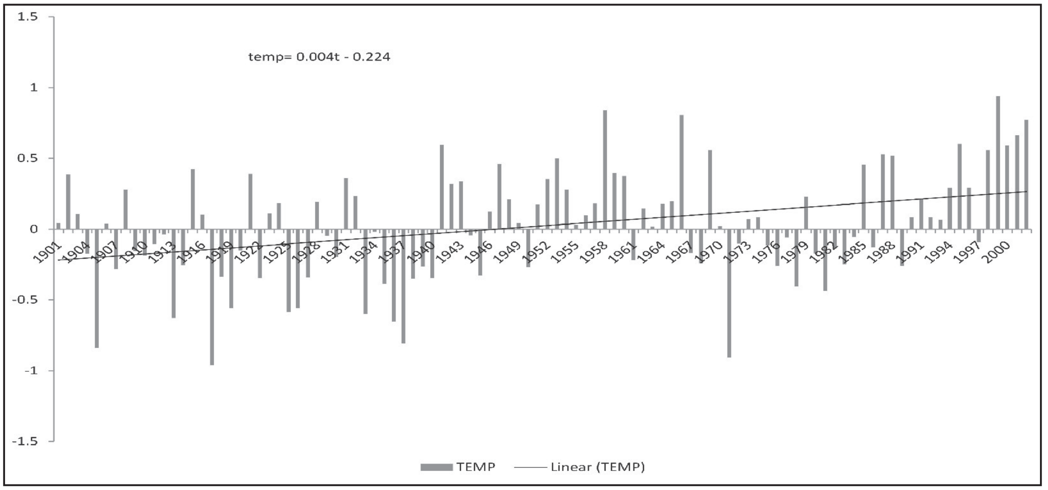
Above perceptions of farmers to climate change are in line with the trend of observed climatic variables. Analyses of climatic data clearly show increasing trend in surface temperature and decreasing annual amount of rainfall in Faizabad district. Figure 2 shows anomalies of average annual surface temperature (*i.e.* average of maximum and minimum temperature) for the period from 1901 to 2002.[3] Temperature anomalies are calculated by taking difference of long period average temperature[4] from actual annual temperature. It seems from figure that there has been increasing trend in annual surface temperature. It has been increasing by 0.004 ^{0}C per year since year 1901, as is estimated by linear trend equation presented in the figure. Though rising trend is observed in both maximum and minimum temperature for the period 1901 to 2002, increasing trend in minimum temperature has been more conspicuous for this period (Figure 3). One may say that minimum temperature has been rising faster than the maximum temperature. Even, similar trend has been maintained in recent period. For period from 1970 to 2002, increasing temperature rate is observed 0.022 and 0.034^{0}C per year for maximum and minimum temperature, respectively (Figure 4). More important, Figure 4 shows that warming trend has been accelerating more quickly in recent years than the previous years. It obviously reflects effect of global warming. Here, recent years mean years counted after 1970 whereas years counted before 1970 is called as previous years. In this exercise, year 1970 is chosen arbitrarily as breaking year. More conspicuous behaviour of minimum temperature than maximum temperature has already been reported in different parts of the country (Jain and Kumar 2012; Jha and Tripathi 2011; Jha and Tripathi 2014). Like temperature, perceived changes in rainfall by farmers are also similar to the behaviour of observed rainfall. Rainfall in Faizabad district shows decreasing trend; it seems from the Figure 6 that rainfall in Faizabad has been decreasing by 1.41 mm per year since year 1901. This rate increases significantly as it is calculated only for recent decades. For last two

[3] Analysis of data on temperature is restricted to year 2002 in both maximum and minimum temperature cases because of limited access to data beyond year 2002.

[4] The long period average temperature is here basically average of temperature of 30 years from 1971 to 1990. The period from 1971 to 1990 is referred as long term period by the World Meteorology Organization.

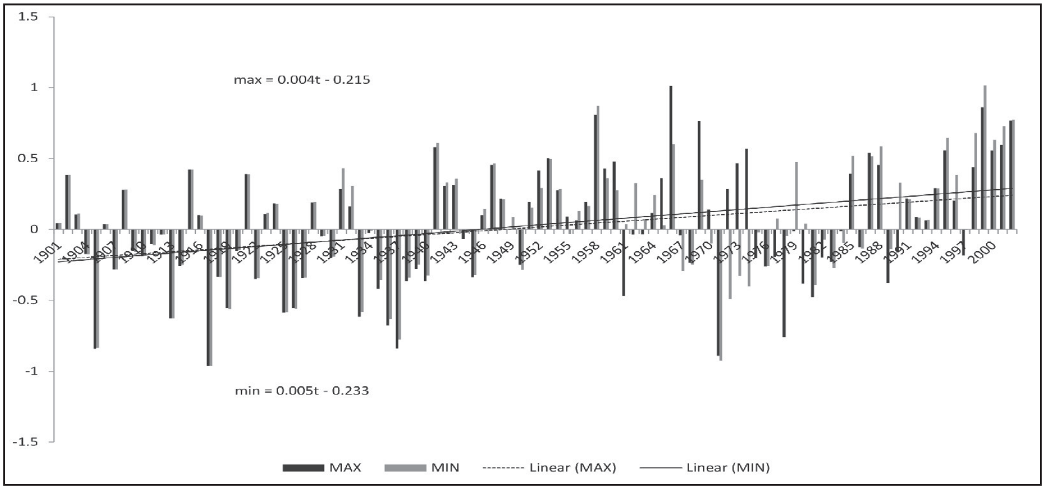
decades except for few years, rainfall in Faizabad district has been much lower than the long-term average rainfall calculated from 30 years from 1971 to 1990.

Figure 2 Temperature anomalies in Faizabad district (1901 onwards)



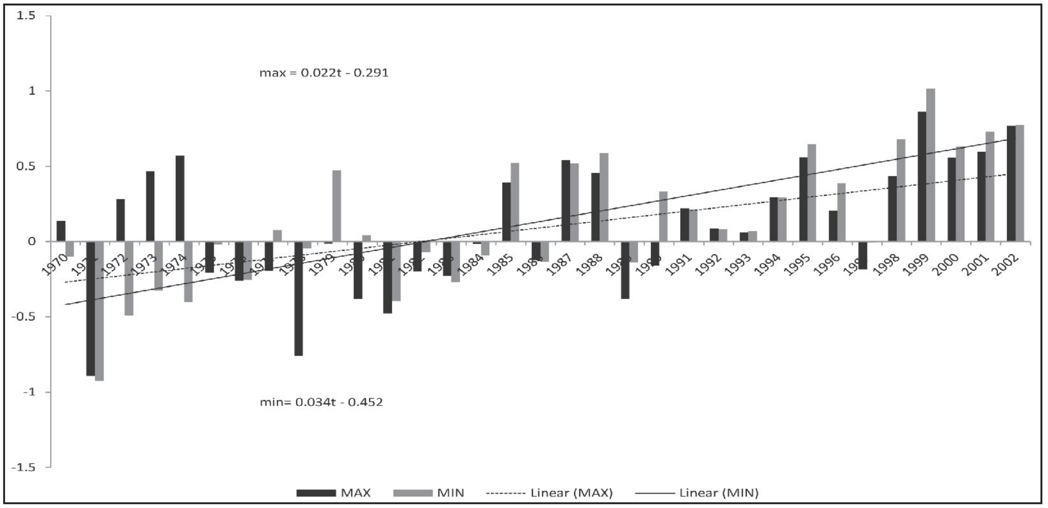
Note: Equation given in the figure is linear trend equation estimated using excel's command called 'add trendline', where TEMP = Temperature, t = time trend, and coefficient of 't' shows annual rate of change.
Source: Author's own calculation based on temperature data collected from Indian Meteorology Department, Government of India, New Delhi.

Figure 3 Maximum and minimum temperature anomalies in Faizabad district (1901 onwards)



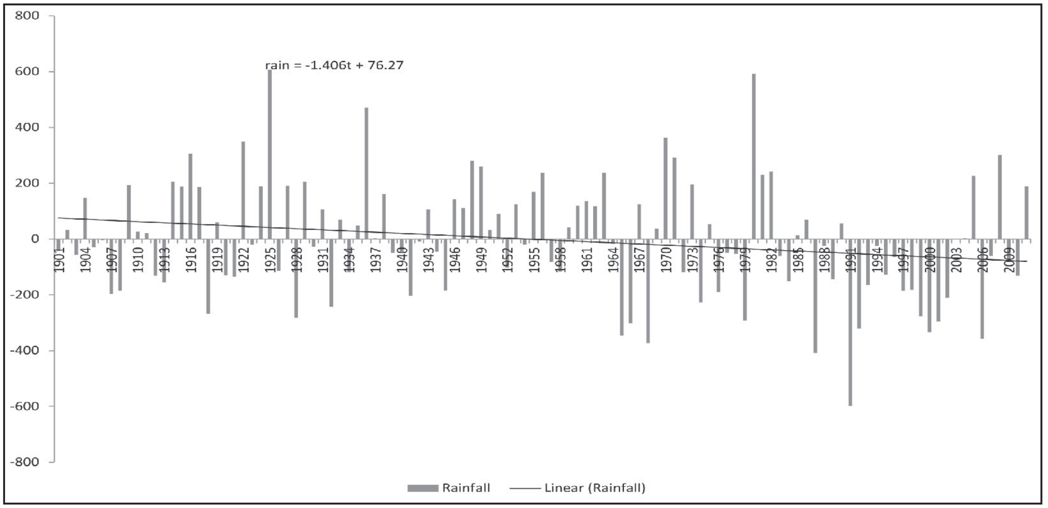
Note: Equations given in the figure are linear trend equations estimated using excel's command called 'add trendline', where max = Maximum temperature, min = minimum temperature, t = time trend, and coefficient of 't' shows annual rate of change.
Source: Author's own calculation based on temperature data collected from Indian Meteorology Department, Government of India, New Delhi.

Figure 4 Maximum and minimum temperature anomalies in Faizabad district (1970 onwards)



Note: Equations given in the figure are linear trend equations estimated using excel's command called 'add trendline', where max = Maximum temperature, min = minimum temperature, t = time trend, and coefficient of 't' shows annual rate of change.
Source: Author's own calculation based on temperature data collected from Indian Meteorology Department, Government of India, New Delhi.

Figure 5 Rainfall anomalies in Faizabad district (1901 onwards)



Note: Equation given in the figure is linear trend equation estimated using excel's command called 'add trendline', where rain = rainfall, t = time trend, and coefficient of 't' shows annual rate of change.

Source: Author's own calculation based on temperature data collected from Indian Meteorology Department, Government of India, New Delhi.

4.2. Adaptation to Climate Change

There have been several changes observed in agriculture practices in study villages. These changes include more use of ground water for irrigation, use of PVC pipes to carry water into farms, change in timing of crop sowing and harvesting, more use of high yield variety of crops, more use of short-duration cultivars, started growing short-duration crops, mix-cropping (inter-cropping), agroforestry, and crop diversification. Besides, farmers have diversified their livelihood from farm to non-farm activities. Some members of farmer households were found working in nearby urban centres as salesmen and security guards. Few of them have opened their own shops (*i.e.* provision store, mobile and its repairing shop etc) in the village. All these changes in agriculture and farming practices and livelihood pattern are mainly triggered by social and economic factors, as is appeared from responses of farmers in FGDs. Even farmers were directly asked about their climate induced responses; they could not ascertain climate change as a driver of above changes. Moreover, some farmers have responded that 'change in climate is a natural disaster, so no one can escape himself or herself from it'.

In order to validate above observation noted in the focus groups, three of above changes in agriculture practices namely increasing use of ground water for irrigation, agroforestry, and crop diversification were further examined in detail by taking personal interviews of farmers. What come out from these personal interviews are presented in Table 2. The table shows that all of these changed are being adopted to secure better income rather than adapt to climate change. Though here singling out climate change as a main driver of changes in agriculture practices identified in this study is not so simple, all these changes are considered as adaptation strategies in agriculture sector to climate change (see Table 3 adapted from IPCC 2014). It suggests that farmers unintentionally adapt to climate change by considering several changes in agriculture practices. Unintentional adaptation to climate change has been also observed by others, for example Mertz et al. (2009) and Apata et al. (2009).

Moreover, several studies focusing on purposeful adaptation to climate change have found a large chunk of farmers do not response or take initiative to reduce negative impact of climate change. This share varies from 16 % to 69 % depending on location and types of farmers (see Table 4). All these studies together indicate either unintentional adaptation or low level of purposeful adaptation to climate change which brings out that agriculture will remain one of the most vulnerable sectors if such farmers' adaptation behaviour continues because there is no any expectation of significant improvement of climate change mitigation.

Agriculture extension services and capacity building programmes seem to be important for encouraging adaptation to climate change in agriculture, as is revealed by talking to the farmers in details. Their importance has already been pointed out in the previous section. Here, I wanted to strengthen the above idea by providing an interesting example of 'soil testing'. When farmers in Kinuali village were asked about 'soil testing and its procedure', none of them even progressive farmers are found aware about it. On other hand, farmers in other two villages were not only found aware about it, while they do soil testing of their farms. One may argue that extension services is basically behind the above significant difference between Kinauli and other two villages because there is one agriculture scientist living in Sariyawa village who help farmers to get soil tested of their farms. Several other studies have also reported importance of agriculture extension services and capacity building in adaptation to climate change (see Table 5). Besides, social infrastructures like education, and physical infrastructure like access to credit, electricity etc have been reported as important factors encouraging adaptation to climate change.

Table 2 Summary of farmers' personal interviews

Issues	Description of responses
Crop diversification	Farmers particularly from Sariyawa and Gohaniya villages are gradually shifting towards cultivation of peppermint from sugarcane and when they were asked about its reason most of them answered that on one hand, peppermint is more profitable crop than sugarcane; on other hand, there is no problem in its marketing. However, there are many problems in sugarcane marketing, for instance farmers do not get output price of their product immediately and some times, farmers are not allowed by one or two local influential persons to sell their output directly to sugar mills. Famers have to sell their produce to these influential people at very low prices.
Agroforestry	Some farmers are found in these villages who begun planting trees particularly mango and eucalyptus on their farms in order to generate more income rather than reduce negative impact of climate change. Even farmers are well known of hydrological consequence of eucalyptus that it lowers water level very rapidly because of high rate of transpiration. Farmers clearly mentioned that they do not bother it because of their prime concern of profit that they get from selling its wood.
Increasing use of ground water for irrigation	Most of interviewed farmers have installed their own tube-well for irrigation purpose. This practice has significantly reduces their dependency on rainfall and helped them to minimise the adverse effect of drought or lack of rainfall. But, the way they irrigate their farms is not appropriate. Farmers basically overuse the water which further depletes water table. Even, they are not aware about efficient irrigation system like sprinkle irrigation and drip irrigation etc.

Note: All above personal interviews were conducted in one village called Gohaniya out of three studied villages during month of April 2013. The reason of selecting farmers from this village only for personal interviews is that farmers from this village were found more skilled and innovative farmers from other two villages.

Table 3 List of adaptation strategies in agriculture sector identified by IPCC 2014

S. No.	List
1	Modifying planting, harvesting, and fertilising practices for crops
2	Changing amount or area of land under cultivation
3	Using different varieties (e.g. early maturing, drought-resistant)
4	Diversifying crops and/ or animal species
5	Commercialisation of agriculture
6	Water control mechanisms (including irrigation and water allocation right)
7	Shading wand wind breaks
8	Conservation agriculture (e.g. soil protection, agroforestry)
9	Modifying grazing patterns for herds
10	Providing supplemental feeding for herds/ storage for animal feed
11	Ensuring optimal herd size
12	Developing new crop and livestock varieties (e.g. biotechnology and breeding)

Source: IPCC (2014)

Table 4 Several estimates of farmers who do not adapt to climate change in India and abroad

S.No.	Study	Percentage of farmers who do not adapt climate change	Country/ Region
1.	Deressa et al. (2009 and 2011)	42	The Nile Basin of Ethiopia
2.	Bryan et al. (2013)	16	Kenya
3.	Bryan et al. (2009)	37 62	Ethiopia South Africa
4.	Gbetibouo et al. (2010)	66	Limpopo Basin, South Africa
5.	Fosu-Mensah et al. (2012)	60	Sekyedumase district in Ghana
6.	Esham and Garforth (2013)	15	Sri Lanka
7.	Alam et al. (2011)	45	Malaysia
8.	Kibue et al. (2016)	53	Yifeng, China
9.	Kibue et al. (2016)	69	Qinxi, China

Table 5 Factors affecting climate change adaptation in agriculture

Study	Factors identified promoting climate change adaptation in agriculture
Kibue et al. (2016)	Access to extension services and climate information, education, Off-farm income
Bryan et al. (2013)	Access to food aid or other assistance, weather forecast, access to irrigation, access to social safety nets (food emergency relief, food subsidies, or other farm support), access to extension services, access to electricity, and farming experience
Esham and Garforth (2013)	Climate change perception and social networking
Fosu-Mensah et al. (2012)	Access to extension services, credits and soil fertility
Below et al. (2012)	Economic potential and infrastructure of area, production factors, Education, gender of household head, and farmers' social and financial capital
Frank et al. (2011)	Social identity
Alam et al. (2011)	Training and government support
Deressa et al. (2011 and 2009)	Household characteristics such as education, farm, and non-farm income etc., extension on crop, and livestock production, access to information, access to credit and social capital
Apata et al. (2009)	Farming Experience and access to education
Hassan and Nhemachena (2008)	Better access to market, extension, and credit services, technologies, farm assets, and information about adaptation to climate change

4.3 Other Striking Behaviours Facilitating Adaptation to Climate Change

Furthermore, two interesting behaviours of farmers that may facilitate adaptation to climate change have been observed in study villages. These are collective action and social networks and learning. Since Mahatma Gandhi Rural Employment Guarantee Act, farmers have been facing the problem of labour shortage in the sample villages which has led to increase costs of cultivation. To overcome this problem and fulfil demand for labour they have started cooperating with each other, as is mentioned in FGDs. Farmers come together and perform agriculture practices collectively in each farmer's farm even disrespect of cast structure.[5] Similarly, strong social network effect was observed in study villages many farmers participated in focus group discussions have reported that they follow their neighbouring farmers in adoption of new technologies, cultivars, and farming practices. First farmers observe the behaviour of neighbouring farmers, including their experimentation with new

[5] It does not mean that social barriers or cast structure is being eliminated. There are still some frictions, for example, caste discrimination.

technology and farming practices. Once a year's harvest is realised, the farmers then update their priors concerning the technology which may increase his probability of adopting the new technology in the subsequent year. In another survey conducted by the Cereals System Initiative of South Asia, farmers have revealed that friends, neighbour, or other farmers are their major source of information. More than 50 per cent of surveyed farmers have reported that they get information about new technologies and seeds from their friends, neighbour, or other farmers.

5 CONCLUSIONS AND POLICY IMPLICATIONS

Addressing climate change has now become essential in the policy domain, as it is no more a distant problem. People can experience it, and its impacts, now. Agriculture which provides food, raw materials, and livelihoods is under great threat from climate change. On the other hand, agriculture itself contributes to climate change by emitting GHGs several estimates suggest that the agriculture and food system emits 15 to 20 per cent of all GHGs. Both these aspects should be considered in addressing climate change and, hence, adaptation to climate change could be a better option. But the main challenge, particularly in developing countries, is that farmers have low adaptive capacity, as most of them are small and marginal farmers. It follows that autonomous adaptation cannot be expected; even if adaptation is autonomous, it would not be sufficient to offset losses from climate change. Hence, policy-driven adaptation is required. Adaptation is a two-step process first, perceiving climate change and its associated risks and, two, responding to perceived changes to minimise their adverse impacts. Perception is a cognitive process that involves receiving sensory information and interpreting it. Accuracy of perception is a necessary condition for meaningful response, which depends on knowledge and experience.

Against the above background, this paper made an attempt to understand farmers' perception of climate change and its associated risks, and the factors that can help in forming perception accurately. It also attempted to identify changes in technology and practices that farmers make to mitigate losses from climate change and assess if climate change drives the observed changes. To accomplish this objective, group information on farmers' perception of climate change and their adaptation to it are collected from three villages located in UP state of India using the focus group method. All group information is analysed using content analysis and compared with findings of other studies carried out in both India and abroad. Besides, observed climate data collected from the IMD are analysed for the study region to see whether farmers perceive changes in climatic factors (temperature, rainfall) correctly or not. The findings of this paper suggest that farmers are aware of changes in climatic variables, especially increasing temperature and changing seasonal pattern, and climate change impacts, particularly declining crop productivity, increasing cost of cultivation, and livelihood insecurity. While farming experience seems to be the major factor in farmers' perception of climate change, this study has observed that the print media contributes significantly to such perception. Despites, it may not be instrumental in spreading climate change information, as few farmers read newspapers or other print media offerings, because of high illiteracy or poor education and limited interest in print media. But most farmers use mobile phones, so sending farmers climate information and advice through text and voice massages could be a better option.

However, despite perceiving climate change, farmers are doing nothing to deal with it, as is reflected from group information collected in this paper. But they are changing their agriculture and farming practices to deal with socioeconomic changes, and some of these changes such as changing sowing and harvesting timing, cultivation of crops of short maturity period, inter-cropping, changing cropping pattern, investment in irrigation, agroforestry help in adapting agriculture to climate change. So, it may be concluded that farmers are implicitly taking initiatives to adapt climate change. It suggests that farmers have the inclination to adapt to climate change and that there are sufficient support systems available in the village that support farmers in adopting new technologies and practices in agriculture for example, the social network effect and collective activities. In sample villages, the study has noted a strong network effect; farmers learn from other progressive farmers and from collective activities where farmers cooperate with each other to resolve common problems like shortage of labour.

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