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## Farm level adaptation strategies to climate change in India: An overview

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**Abstract**

Climate change is the most intricate environmental problem faced by the world today. Agriculture sector is vulnerable to climate change due to its immense dependence on climate. Therefore, implementing adaptation strategies by farmer becomes indispensable in order to minimize the effects of climate change. From this review, it is concluded that farmers have been adapting to the impacts of climate change in their own ways. Different methods are being used by farmers; the major ones include the use of different crop varieties, shifting cropping patterns, delayed sowing etc. It was observed that high cost of adaptation, limited knowledge on adaptation measures and lack of improved technology were found to be the major hindrance towards adapting to climate change. Therefore it is recommended that timely information dispersion should be done about early warnings of climate change and also awareness campaigns and trainings must be organised to enhance the farmers' adaptive capacity.

**Keywords:** Climate change, agriculture, adaptation, adaptation strategies

**Introduction**

Climate change is one of the most alarming issues of the century posing threats to mankind worldwide. Climate change is any significant long term change in the expected patterns of average weather of a region (or the whole earth) over a significant period of time. Sectors that rely strongly on climate like certain temperatures, precipitation levels and rainfall such as agriculture, forestry, energy and tourism are particularly affected. Agriculture is extremely vulnerable to climate change. It affects agriculture in several ways, for example weed and pest proliferation is increased due to high temperature eventually leading to low yields of desirable crops. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Climate change may cause gains in some crops in some regions of the world, but the overall impacts of climate change on agriculture are expected to be negative (Nelson *et al.* 2009) [20].

India is experiencing adverse climatic conditions with negative impacts on livelihood of the people. It is amongst the most vulnerable countries due to its large agricultural sector, vast population, rich biodiversity, long coastline, and high poverty levels (Chaturvedi 2015) [3]. Climate change impacts differ from region to region in the country, as parts of western Rajasthan, southern Gujarat, Madhya Pradesh, Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are more vulnerable in terms of extreme events (Mall *et al.*, 2006) [18].

Rural people are often vulnerable to the direct impacts of adverse weather, climate variations and change as they are largely dependent on agriculture for sustenance and livelihood (Molnar, 2010) [19]. The negative consequences of climate change like increased crop failure, loss of livestock, and reduced availability of marine, aquaculture and forest products and new patterns of pests and diseases outbreak etc. are faced by rural communities. People living in fragile ecosystems such as coasts, floodplains, mountain areas and semi-arid landscapes are most at risk (FAO, 2009). It is predominantly the poor who will be affected disproportionately. Climate change affects the livelihoods of people, resulting in a need for adaptation in key development sectors (World Bank, 2010) [35].

Climate change adaptation strategies are now a matter of urgency (FAO, 2009). Therefore in order to help communities adapt to the impact of climate change it is necessary to adopt effective adaptation strategies. Such adaptation strategies must be environmentally friendly, sustainable, and easy for farmers to adopt and economically viable (ATPS, 2013). Informing about climate change impacts, vulnerability patterns, coping and adaptive capacity as well as facilitating location specific adaptation and mitigation practices are of central concern as this can help farmers in prevention of negative consequences of climate change. Therefore, this

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Paper is aimed at reviewing current literature on farm level adaptation strategies to climate change among farmers in India.

### Concept of Adaptation to Climate Change

Adaptation to climate change simply means adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities (IPCC, 2001) <sup>[10]</sup>. UKCIP (2003) <sup>[32]</sup> defined it as “a process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with climate variability and climate change”.

The main aim of adaptation is to minimize the vulnerability and enhance the adaptive capacity, or resilience, of people whose livelihoods are basically dependent on natural resources. In order to respond and cope up to the changing and difficult climatic conditions in agriculture sector adaptation needs to use good agricultural, forestry and fisheries practices.

Adaption to changing climatic conditions is an ongoing process; both men and women based on their needs, knowledge and access to resources continuously reshape their agricultural practices to deal with the changing climatic events. It helps communities, regions, countries and societies to get ready for the adverse effects of the climate change. It is a procedure of evaluating the conditions and information associated to climate change impacts and the factors due to which people are unable to adopt and it is not merely an option between reducing general vulnerability and preparing for the environmental hazards or risks (Khajuria and Rabindranath, 2012) <sup>[9]</sup>.

Adaption is a process that consists of two steps. In the first step farmer understands what is climate change? And what are the risks related to it. In the second step farmer then acts to the perceived changes, to diminish its unfavourable impacts. It was also observed that farmers were passively taking initiatives to adapt to climate change (Tripathi and Mishra, 2017) <sup>[30]</sup>.

There are several types of climate change adaptation summarised by IPCC (2001) <sup>[1]</sup>

- Anticipatory or proactive climate change adaptation: Adaptation that take place before impacts of climate change is observed,
- Autonomous or spontaneous climate change adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but triggered by ecological changes in natural systems and by market or welfare changes in human systems,
- Planned climate change adaptation: Adaptation that takes place as a result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Some Other types of climate change adaption were also conceptualised,

- Private climate change adaption which is initiated and implemented by individuals, households or private companies,
- Public climate change adaption which is initiated and implemented by governments at all levels and
- Reactive climate change adaptation that takes place after impacts of climate change have been observed (Nzeh and Ogugua, 2011) <sup>[22]</sup>.

No single strategy could be able to address the intricate impacts of the climate change therefore a combination technology and policy related interventions are needed (Venkateswarlu and Shankar, 2009) <sup>[33]</sup>. Different disciplines and sectors of economy need to collaborate at local, regional and global level so as to develop adaptation strategies for responding to the effects of climate change (Parikh, 2006) <sup>[24]</sup>. Every region needs to have different adaptation strategies based on the socio-economic background of the people in the region and the extent and range of climate change or the exposure of the region to climate change (Sahu and Mishra, 2013) <sup>[26]</sup>. Government and agencies can play a crucial role in improving farmers' adaptive capacity through disseminating agro-meteorological data and tools, conducting vulnerability assessments and providing policy advice to strengthen institutional approaches to disaster risk reduction so that farmers could respond to the immediate risks of climate change and make optimal use of climate variability (FAO, 2007). Adaptation strategies are undertaken by farmers in each country but they differ with the extent and magnitude of climate change on that region.

### Adaptation Strategies Practiced by Farmers

All around the country farmers have been developing and practicing adaptation strategies passively or actively in one or the other way to respond to the impacts of changing climate. For example the vulnerability and adaptation to climate variability and water stress in Uttarakhand were examined and it was found that majority of households dealt with poor rainfall years by using less water-intensive crops or looking after other sources of employment. During the low income periods they usually took loans from traditional moneylenders or acquaintances or sell their assets (Kelkar *et al.*, 2008) <sup>[13]</sup>. While other study in Uttarakhand on analysis of farmers' perceptions and adaptation practices about climate change reported that farmers had shifted the sowing season of some crops because of the warmer climate and had resorted to intercropping with vegetables, spices and fruit trees in order to address the unpredictability of weather (Sogani, 2011) <sup>[29]</sup>.

After analysing the farmers' perceptions and adaptation measures towards changing climate in south India it was found that the major adaptation measures followed by farmers' towards changing climate in Andhra Pradesh were early sowings, salt water spray for harvested paddy stalks, strengthening of river banks and improved drainage, survey number wise insurance, and loans to tenant farmers (Shankar *et al.*, 2013) <sup>[27]</sup>.

A study on knowledge and passive adaptation of farmers to climate change in Uttar Pradesh was conducted. It was reported that farmers in the study villages adopted a range of practices to cope with the extreme weather events. These ranged from more use of ground water for irrigation, use of PVC pipes to carry water on farms, change in timing of crop sowing and harvesting, higher use of high-yield crop varieties, more use of short-duration cultivars, growing short duration crops, mix-cropping (inter-cropping), agro-forestry, and crop diversification. It was reported that farmers unintentionally (passively) adapt to climate change by undertaking several changes in agricultural practices (Tripathi and Mishra, 2017) <sup>[30]</sup>.

While a different study was conducted in Maharashtra State to analyse farmers' perception of drought impacts, local adaptation and administrative mitigation measures it was revealed that majority (61%) of the farmers interviewed changing their crop calendar or adjusting cropping dates as an

adaptation strategy against changes in the climate. 53 per cent reported using drought tolerant–less water consuming crops respectively to mitigate the drought impacts. About 53 per cent farmers highly preferred not to sow crops if the soil moisture is insufficient for a successful crop. Further it was observed that during drought years, about 56 per cent farmers reduced wastage of water to high to very high extent. These adaptation practices were widely used as these practices do not need extra financial cost and are easier to implement. Only 40 per cent of farmers rated as high or very high use of water harvesting and in-situ water conservation practices (Udmale *et al.*, 2014) [31].

Analysis of adaptation strategies adopted at different level of organization in states of Andhra Pradesh and Maharashtra of India was done. Adaptation practices were characterized by (i) risk-taking ability based on their resource base (ii) short and long term adaptation mechanisms that may have evolved due to actual past weather patterns experienced in the region and (iii) frequency of occurrence of extreme events such as severe droughts and floods. At the household level farmers preferred to adopt improved varieties and short duration crops, substitute cash crops for cereals, drought tolerant crops, dug tube wells to supplement water supply, improved short varieties duration crops, reduce high water requiring rice cultivation, adopt mixed cropping, shifting to mono-cropping of soybeans, increase sugar cane or other high value cultivation (canal irrigation), delayed cultivation to conserve rain water, income diversification (dairy, fish farming), wheat cultivation during Rabi season with supplementary irrigation, diversification to non-farm income source, migration and reduction of personal expenses and at community level their opinion was to establish self-help micro-credit groups, establishing milk collecting centres and enhance leadership (ICRISAT, 2012) [9].

While examining farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi-arid region of south India (Tamil Nadu) it was found that there were specific adaptation options proposed by the farmers. Majority of them adapt by cultivating short-duration heat tolerant crops. 82.6 per cent of the respondents proposed construction of small check dams to facilitate their irrigation needs. Around 60.2 per cent of the farmers proposed conserving the existing farm ponds, and changing the farm operations and crop calendar to deal with increasing unpredictability of monsoon rainfall. Farmers had uniformity in the opinion to promote diversified livelihood options so as to secure their livelihood as there are risks such as crop damage, pest and insects attack associated with climate change. These four adaptations were highly preferred by the farmers due to their specific needs. It was suggested that other adaptation options such as crop weather insurances and early warning systems, drought/salt-tolerant seeds should be more popularised to fulfil their adaptation requirements (Dhanya and Ramachandran, 2015) [5].

Other study in Solapur district of Maharashtra on impact of environmental change on agriculture production and groundwater depletion in different adaptation strategies adopted by farmers indicated that majority 64 per cent farmers adopted use of micro-irrigation technology. About 56 per cent farmers reported changing the crop pattern, using low water consuming crops, using improved irrigation practices and reducing wastage of water during drought and depletion of water for adapting against impacts of climate change. Use of water harvesting and conservation practice was preferred by 38 per cent of the farmers. Udmale *et al.* (2014) [31]

analysed adopted adaptations and drought mitigation measures of farmers in Maharashtra and found that widely used adaptation strategies are cultivation of less water intensive and drought tolerant crops, and intercropping. It was observed that only a small number of farmers adopted modern micro-irrigation technologies such as sprinkler and drip irrigation to cope up with drought (Kamble and Honrao, 2015) [12].

While exploring the adaptation measures by crop farmers in the mid-hills of Himachal Pradesh to climate change it was observed that adaptations for changing rainfall patterns differed from those for changing temperature. Farmers responded to the increasing temperature by adopting a new crop variety, while building water-harvesting schemes was a popular adaptation strategy for the effects of decreased precipitation. The other adaptation options preferred by farmers for increased temperature in the region included change of crop variety (61.6%), planting early maturing crops (50%), change of planting dates (47.4%), practicing mixed cropping (39.9%) and planting of drought resistant crops (32.5%), irrigation (18.7%), reusing water (32.8%), use of water harvesting schemes (31%), changing from crops to livestock (4.9%) and reducing the number of livestock (5.6%). Out of the total farmers who have adapted to changing climatic situation like rainfall, 52.4 per cent have gone for early maturing crops, 52.4 per cent build water harvesting schemes, 40 per cent irrigate more, 47.4 per cent change planting dates, 39.9 per cent mixed cropping and 33 per cent implement soil conservation techniques. Farmers have also adopted growth of drought resistant crops (32.5%), mix crops and livestock (32.8%), change from crops to livestock (4.9%) and reduce number of livestock (5.6%) (Kimani and Bhardwaj, 2015) [15].

Different strategies adopted by farmers of the Himanchal Pradesh to cope with the climatic change were explored which included investment on storage structure (90%), bringing more honey bees hive for pollination (70%), planting of more golden apple plant for pollinations (60%), cultivation of short duration low chill variety (30%), cultivation of new vegetable crops (30%) and harvesting of rain and snow water (20%). The field studies conducted indicated that soil moisture conservation is one of the potential and important adaptation strategies to reduce the climate change impacts particularly in water scarce/limited condition. Other adaptation strategies for rice wheat, maize and chickpea crops involves management practices like shifting of sowing date and minimizing the requirement of water and nitrogen to achieve the maximum benefit with the limited resources (CRIDA, 2010) [4].

A study undertaken to find out the role of indigenous knowledge in climate change adaptation strategies in North-western India, revealed that people of this region had well traditional knowledge to fight against the challenges of local climatic variations. Various adaptation strategies were implemented which include cultivation of less water intensive crops and use of all available bio-diversity of this region. In terms of animal rearing buffalo was not preferred to rear because it was a well-established fact that animals of dark colour would not survive in hot and dry climate of this region, therefore camel, goat and sheep were reared instead (Kumar 2014) [17]. While analysing the perception and adaptability strategies of the farmers to climate change in Odisha, India, it was observed that out of the total respondents 59 per cent of farmers were going for some adaptation strategies. The major adaptation strategies followed by the farmers in the study area

were double seeding (for some crops), changing crop mix, different planting dates and increase in irrigation (Sahu and Mishra, 2013) [26].

In a different study conducted in Mewat district in Haryana, on adaptation of farming community to climatic risk following intervention were explored for adaptation to climate change for minimizing climatic risks and enhancing livelihood security: Heat and drought tolerant varieties and short duration varieties, crop diversification, change in cropping pattern, water saving technologies, crop management, growing horticultural and fruit plants for carbon sequestration, value addition, secondary skill development, information and weather-forecasting through Pusa-m-Krishi mobile based information system (Kumar *et al.*, 2013) [16].

Adaptation of small scale farmers to climatic risks in India were examined while conducting case study of five states of India, namely, Rajasthan, Uttarakhand, Maharashtra, Andhra Pradesh and Orissa that focused on the potential of traditional adaptation measures practiced by small farmers. It was reported that in Rajasthan major adaptation strategies for agriculture sector were sustainable soil and crop management, adoption of biodiversity based organic farming, use of indigenous seeds and crop varieties, shifting cropping patterns and delayed sowing, stocking food and fodder, diversification of income, summer ploughing and reintroduction of native grasses for pasturelands. Whereas in Andhra Pradesh mixed cropping was a promising adaptation strategy for small-scale farmers to reduce risk of complete crop failure. Other adaptation strategies used by farmers were delayed sowing, changing cropping patterns, income diversification and input reduction. In Uttarakhand diverse cropping systems, cultivation of drought-resistant crops, practice of low input agriculture, mixed cropping system, growing of hardy crops like millets and pseudo cereals and traditional method of growing paddy were major adaptation strategies utilised. Farmers of Orissa were adopting contour ploughing, contour planting, terracing, close spacing crops and other practices of soil conservation on their land in order to minimize erosion. Also diversification & mixed cropping systems, traditional rice varieties, community land management, horticulture, income from fruit trees are used. In Maharashtra farmers used adaptation strategies like shift to traditional dry land crops (also adaptation to water shortage), Self-Reliance Farming" as adaptation to climatic variation, combination of cash and food crops, fruits & vegetables, growing drought resistant varieties and income diversification (Pande and Akermann, 2009) [23].

While assessing farmers perceptions and adaptation about changing climate and its variability in UKP area of Karnataka it was found that all the respondents used Far Yard Manure (FYM) in farming, whereas more than two-third (84.20%) of the respondents adopted improved technology in farmland. Majority of the respondents (84.20%) were interested to use Green House Plastic, compost and in-situ manure. About 83.20 per cent used chemical fertilizer, 73.30 per cent used pesticides, water source protection was used by 68.30 per cent and 67.30 per cent respondents were ready to adopt improved practice in soil conservation activities (Shashidhra and Reddy, 2016) [28].

Different adaptation strategies were carried out by farmers according to their adaptive capacity in accordance with the extent and magnitude of the climate change in that region. The common strategies included mixed cropping, change in planting and sowing dates, sustainable soil and crop management, crop diversification and planting of crops varieties that are resistant to climate change.

### Constraints to Climate Change Adaptation

Farmers face various constraints to adaptation to climate change which harness the adaptation procedure. IPCC Fourth Assessment Report mentioned technological and financial limits as the major barrier posed to Climate Change adaptation. While funding and implementation limits were also pointed out to be major obstacle to the required scale of adaptation (FAO, 2011).

The constraints faced by people of mid-hills of Himachal Pradesh while adapting to climate change were reported. Around 95.60 per cent people indicated high cost of adaptation as one of the barriers to adaptation to climate change. This perception was followed by limited knowledge on adaptation measures (93.8%), lack of early warning information (87.2%), unreliability of seasonal forecast (88%), and lack of access to technology (89.1%), lack of labour (72%), steep terrain (79.9%) and poor communication infrastructure (65%). About 34% of the respondents cited lack of access to water as barrier to adaptation. Lack of extension services (47.4%), improved crops/seeds (50%) and irrigation facilities were also perceived as main barriers to adaptation (Kimani and Bhardwaj, 2015) [15].

A glimpse of the major problems faced by people to resilient adaptation to climate change was given which states that the constraints included non-availability of stress tolerant varieties, lack of improved technology and uncontrolled widespread use of groundwater extraction technologies, minimum incentives to adopt soil and water conservation practices, inadequate support to diversify income from agriculture, inefficient safety nets, absence of efficient collective action and poor infrastructure development, limited access to credit, markets, information, non-farm income opportunities, labor and natural resources, efficient collective action, and poor infrastructure development (Bantilan *et al.*, 2012) [2]. In a different study the barriers to the adaptations in Mid-Hills of Himachal Pradesh were studied and it was observed that the main barriers to the adoption of strategies were age and household capabilities (i.e. access to land, assets and diversified income). Barriers which still exist for other groups like women and minorities are the traditional socioeconomic status, unequal access to land and assets which in turn increases the vulnerability of the majority of the household (Ravera *et al.*, 2016) [25].

### Conclusion and Way Forward

Adaptation strategies become indispensable in order to minimize the effects of climate change and in preparing the nation for climate change. From this extensive review, it is concluded that farmers have been adapting the impacts of climate change in their own way actively or passively. Different methods are used by farmers, the major ones include the use of different crop varieties, mixed cropping, use of irrigation and soil conservation techniques.

It was observed that high cost of adaptation, limited knowledge on adaptation measures, non-availability of stress tolerant varieties and lack of improved technology were found to be the major hindrance towards adapting to climate change. Therefore it is recommended that,

- As most of the farmers are ignorant about the scientific measures to be taken towards climate change therefore awareness campaigns, trainings must be provided to enhance the farmers' adaptive capacity for better adaptations opportunities.

- While the government must provide subsidies, loans and insurances to encourage environmentally sound farming practices.
- There is a need of making available the climate stress tolerant varieties to the farmers' location specific and at low cost.
- Extension personnel can help in development of SHGs, FIGs, Farmers field schools which will help farms to collectively meet and come up with new adaptation strategies, while SHGs can help them to improve their financial condition.
- The junction of traditional and local knowledge of the farmers and scientific practices and technology would be beneficial in evolving new improved and scientifically proven adaptation strategies.
- Timely information dissemination about the weather early warning is necessary therefore both electronic and print media must be utilised in strengthening climate change awareness and in communicating effective response strategies.
- The state agricultural universities and regional research centres will have to play major role in adaptation research and technology generation which is more region and location specific.
- Finally, the government must adopt strategies and policies that will encourage improved farming practices and agricultural methods, and that will protect our cherished agricultural activities which is the mainstay of our economy.

To conclude, under the new realities of climate change, which is really causing alarming threats for agriculture as well as for a major chunk of the population. It is required to test the effectiveness of adaptation strategies that are practised by farmers and to disseminate the information of innovative adaptation strategies of successful farmers to other farmers of similar region.

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