Chapter 17
Climate Change Adaptation in Indian Agriculture- Assessing Farmers' Perception and Adaptive Choices

Chandan Kumar Jha and Vijaya Gupta

Abstract The impacts of climate change are expected to be the most devastating market failure in modern times. India's vulnerability to climate change is apparent with the frequent occurrence of flood, drought and cyclones in the recent past. Agriculture being one of the primary sources of livelihood of the country and the most climate centric activity, climate change is likely to significantly affect the key outcomes of agriculture systems and economic development. The most practical way to manage the undesirable climatic consequences is adaptation. Therefore, farm-level analysis of adaptive endeavors is prime requisite to understand the dynamics of adaptation to climate change.

This paper, tries to identify the major parameters which determine Indian farmers' awareness and expectation of climate change and the factors affecting their adaptive choices. The study also attempts to assess the key adaptive strategies which farmers intend to adapt depending upon agro-climatic conditions and constrained by their socio-economic situations. The observations of this paper will help in identification of micro-level barriers to adaptation and will facilitate appropriate policy formulation to ensure maximum returns out of the changing climatic conditions.

Keywords Climate Change • Vulnerability • Agriculture • Adaptation Strategies • Socio-economic condition

Introduction

Climate change is a continuous process and its reparation is becoming prominent with due course of time. Agriculture being the most climate centric economic activity, the sector is highly vulnerable to environmental shocks. Unpredicted

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fluctuations in climatic factors like changes in temperature, the level and timing of precipitation, humidity etc. pose serious risks to global food production (Adams et al. 1998; Stern 2007); further raising complex challenges like food insecurity, malnutrition, rural poverty and environmental degradation especially for developing countries lying in the tropical and sub-tropical regions (Parry et al. 2007; Porter et al. 2014; Stern 2007; Mendelsohn and Dinar 1999; Adams et al. 1998; Mendelsohn 2008). Agriculture serves to be the primary source of livelihood in most of the developing countries (Mendelsohn 2008) like India and therefore assessment of climate change impacts is of utmost importance. Agriculture plays a key role in Indian economy, particularly in providing livelihood to about 60 % of the population. The sector contributes about 13 % to the economy (Ministry of Indian Agriculture 2014) however; continuous decline this trend is raising serious concerns for rural livelihood. Increasing population pressure, land-use change, shrinking natural resource base etc. is pressing the need for sustainable agricultural practices which requires that climate change is endogenously tackled within the production boundary.

Indian agriculture is highly vulnerable to climate change as agriculture output depends on vagaries of monsoon (Kumar and Parikh 2001). India's exposure to climate change is apparent with the frequent occurrence of flood, drought and cyclones in the recent past. The climate forecasts of Indian Meteorological Department (IMD) suggest a surge of 0.56 °C in annual mean temperature for the period of 1901–2009 for the country against the global warming of about 0.74 °C (IPCC 2007, referred as Parry et al. 2007). Spatially most part of the country experienced an increasing trend of mean annual temperature with maximum rise by 0.77 °C in post-monsoon season and in winter season by 0.70 °C. However, the annual and monsoon rainfall do not show any significant trend. According to Kavikumar (2009), India is set to experience an overall temperature increase of about 2–4 °C by 2100. Whereas, seasonal predictions suggest an increase in mean temperature by 0.4–2.0 °C during Kharif and 1.1–4.5 °C in Rabi season, with only a 10 % increase in mean rainfall during by 2070 (Khan et al. 2009).

Climate change impacts on agriculture mainly result in loss in farm net revenue or agricultural yield. A surge in temperature by 2 °C and 8 % increase in precipitation are likely to reduce agricultural net revenue by 12 % in India without carbon fertilization resulting into an annual damage of about 4–26 % (Sanghi and Mendelsohn 2008). Long-term projection suggests an estimated loss of about 30 % in agricultural productivity by 2080 for India (Pearce et al. 1996). Specifically, the most prominent impact of climate change is likely to be on rice and wheat yield which serves to be a staple food for the country (Jha and Tripathi 2011). The intensity of climate change impact however differs spatially within the country depending upon agro-ecological settings at regional scale and most importantly farmer's adaptation at farm level. The eastern wet regions of the country are expected to gain advantage from warming whereas the dry western regions are expected to witness huge losses (Mendelsohn 2008). Hijioka et al. (2014) suggest a decrease of about 50 % of wheat yield in the Indo-Gangetic plains due to surge in temperature.

The economic and agronomic impact of climate change mainly depends on variations in climate variables and the ability of agricultural systems to adapt to such changes. Adaptation entails local coping practices to restrain vulnerability of agro ecosystem to climate variations and extremes and ensure long-term resilience to future climatic turbulences. Guiteras (2009) find that crop yields in India are expected to reduce by 4.5–9 % over medium term (2010–2039) while in the long-run (2070–2099), no adaptation is likely to reduce yield by 25 %. Indian agriculture is primarily rainfed and therefore is more prone to climate risks as people dependent on rainfed agriculture lack adaptive capacity. Farmers being the key actors in agricultural system; their behavioral attitudes towards climate change are often complex and poorly understood (de Jalón et al. 2015) therefore, a clear understanding of farmers perception on climate change and their willingness to adapt is important (Arbuckle et al. 2013). Farmer's adaptation to climate change can ensure sustainable economic returns by taking benefits from changing climatic conditions. Farmers generally make rational choices from a set of adaptation strategies in the form of farm practices and technologies; available in their regions (Gbetibouo 2009). However, timely recognition of climate variations, incentive and most importantly, ability to adapt serves to be the three critical component of successful adaptation (Fankhauser et al. 1999).

Extensive research has been carried out to identify different adaptation strategies adopted by farmers. However, how socio-economic and other factors determine choices of adaptation strategies and adaptive capacity, especially for India has been seldom attended. Therefore, this study tries to understand the adaptation behavior of the Indian farmers and the key factors affecting their adaptive capacity and choice of adaptation strategies. This paper is arranged in four sections. The second section briefly discusses the methodology adopted for the study. The third section identifies the socio-economic factors determining farmers' adaptive capacity and evaluates how these factors play in Indian context. The last section concludes the critical findings of the study.

Methodology

This study has attempted to identify the key socio-economic variables and other factors determining adaptive capacity of farmers based on review of adaptation literature and how these factors affect Indian farmers. With a view to empirically support the selected farm and household characteristics specifically under Indian setting, the study has used secondary data Indian National Sample Survey (NSS) and Census (2011) for demographic details. This study has used the 70th Round of NSS conducted to assess the state of affairs of Indian farmers in the annual year of 2013 (January–December, 2013) covering rural India. The survey was found suitable for this study as the survey results gave detailed information on several facets of farming practices and socio-economic characteristics like income and expenditure of households, ownership of land and assets, access to agricultural

resources including technology, agricultural awareness and extension services and credit availability and indebtedness of Indian farmers or agricultural households. The observations of the survey depicted an overall state of Indian farmers on parameters. Data from Census 2011 was used to get the demographic details of rural India.

Results and Discussions

Key Factors Affecting Adaptive Capacity of Farmers

Farm level adaptation strategies includes changes in farm inputs, managing crop sowing and tilling timings, alternate irrigation practices, strategic crop choices such as inclusion of warmer season crops, crop switching, livestock management, use of fertilizers and pesticides, improved weather forecasts, diversification to off-farm activities and soil and water conservation (Mendelsohn et al. 1996; Cline 2007; Adams et al. 1998; Darwin 1999; Mendelsohn and Dinar 2003; Gbetibouo 2009; Nhemachena and Hassan 2007; Kurukulasuriya and Mendelsohn 2008; Bryan et al. 2009; Below et al. 2010). Adaptation to climate change primarily requires that farmers perceive that climate is changing (Deressa et al. 2009; Maddison 2007; Below et al.; 2010). Education, access to extension services, external forces such as their peer's awareness, societal ethics, social capital, wealth, climate information and age of household head establish farmer's perception. However, farmers' perception on climate events does not guarantee taking adaptation measures (Bryan et al. 2009). In this respect, farmer's incentive and ability to adapt determines farmer's responses towards climate change. Farmers' decision making is an individual response often guided by intra household factors such as uncertain flow of income and environmental perceptions (Smit and Skinner 2002). The final response of adapting to climate change is determined by their adaptive capacity often determined by farmers' skill, education and personal ability (Tarleton and Ramsey 2008). Several studies have emphasized on farmer's household and socio economic characteristics as an important factor in determining farm-level adaptation capacities and decisions (Nhemachena and Hassan 2007; Deressa et al. 2009; Below et al. 2010; Falco and Veronesi 2013).

Socio-Economic Factors

- ***Age of the farmer:*** Age of the farmer or household head can determine farmer's perception, willingness to adapt and adaptive choices in two ways. Age of the farmer embodies farm experience which induces climate change perception and technological adoption (Maddison 2007; Nhemachena and Hassan 2007). Years of farm experience is expected to be related to the ability of farmer to attain;

process and use relevant information in better way and can therefore augment farmer's perception (Adesina and Zinnah 1993). More experience of farming system associated with age of the peasant increases the likeliness of perceiving soil erosion problem and its economic impact (Shiferaw and Holden 1998) and the possibility of crop diversification, changing planting dates and area under production (Gbetibouo 2009). However, aged farmers might often be reluctant to adopt conservation practices once they perceive the problem due to their attachment to traditional farm practices which they have been following for long. Younger farmers are more knowledgeable and aggressive about adoption of new technologies and risk taking (Adesina and Zinnah 1993) and are more prepared for long-term farm management such as irrigation and crop-livestock system.

- ***Gender:*** Usually there exists a positive relation between gender (male farmers or male head of the household) and farmer's decision to adapt. The head of the family is usually the main decision maker of the family and chiefly handles intra-household resource allocation and farm decisions. Gender of the farmer determines farmers' choice of adaptation strategies such as crops diversification strategies (Yegbemey et al. 2013) and agricultural technology as it influences access to forecasts and information (Bryan et al. 2009). The gender effect on adaptation however depends upon socio-cultural settings of the region, alternate sources of income for the females and type of family labour allocation. Ownership of assets is often gender biased as women usually lack ownership rights over land although they may have user rights thus limiting their decision making power. In rural Tanzania, women are restricted from access to land and credit which in turn limits their access to education (Below et al. 2010). Udry (1996) finds prominent gender division of labor in Africa as crop choice systematically differs by gender.
- ***Household size*:** The effect of household size has mixed impacts on farmers' adaptation responses (Nhemachena and Hassan 2007; Bryan et al. 2009; Gbetibouo 2009). Household size signifies intra-family labor supply which facilitates adoption of labor intensive adaptation measures in large households. Households with larger human capital invest more in conservation (Shiferaw and Holden 1998) and may also divert part of their labor to non-farm activities for income security (Gbetibouo 2009; Hisali et al. 2011) and cover up for weather uncertainty. As far as adaptation strategies are concerned, strategies like land allocation (Kokoye et al. 2013) double sowing instead of single sowing (Yegbemey et al. 2013), mixed farming systems, irrigation being more labor intensive; large family size facilitates adoption of such tactics.
- ***Education of the farmer*:** Several studies have established a positive relation between education and farmer's ability to perceive climate change and the likelihood of technological adoption (Norris and Batie 1987; Deressa et al. 2009; Gbetibouo 2009; Yegbemey 2013). Decision-making is a decentralized process and education can have intra-household spill-over effect on adaptation decision i.e. flow of knowledge from other family members to household head (Asfaw and Admassie 2004). Education enhances the ability of farmers to acquire, synthesize and respond to innovations such as chemical

fertilizer, farmer's perception on rainfall patterns (Gandure et al. 2013) and soil erosion.

- ***Off-farm income source:*** Occupational structure of the household; both primary and secondary also has major implication on adaptation decisions and choices. Off-farm income make farmers risk-averse as they can diversifying their livelihood source and helps in consumption smoothening in case of adverse weather and production outcomes, especially for households with large family in rural areas. Off-farm income has positive effects on adoption of fertilizer and pesticide technologies (Lamb 2003), ease liquidity constraint needed for soil conservation investments (Shiferaw and Holden 1998) and also helps in proper livestock management (Gbetibouo 2009). However, on the negative side, due to the assurance of income from non-farm activities, less knowledgeable farmers may be reluctant to adopt improved farm techniques as they might consider changes to be costly with uncertain returns and also contend for on-farm managerial time which may in turn increase reliance on crop insurance (Smit and Skinner 2002).
- ***Farm size:*** Farm-level adaptive response majorly depends on farm size as it determines the feasibility of adopting any particular strategy. Farm size is often considered as wealth indicator (Deressa et al. 2009) and may help ease liquidity constraint. Farm size can have both negative and positive consequence on adaptive decisions (Bradshaw et al. 2004). On positive side, advanced land management practices, farm mechanization and adoption of an innovation has proved to ensure more returns when applied to large farm size. A general perception prevails that farmers with large land holding are more willing and capable of adopting best suited farm strategies such as crop diversification, extensive irrigational arrangements, crop switching, adoption of pesticides and fertilizer technology. Although large farms can give lower yields at an initial stage but in the long run economies of scale is expected to lower the large fixed transaction costs of innovation. Small farm size may also often cause conflicts among household members with large family size and may affect individual decision making.

Institutional Factors

- **Extension services-** Farm extension services enunciate the process of 'social-learning' (Tazeze et al. 2012) among farmers and fasten ex-ante process of adaptation. Provision of free extension services have strong positive influence on the probability of choosing adaptation measures (Maddison 2007; Deressa et al. 2009). Extension services help overcome the problem of asymmetric information and generate distinct welfare effects through better flow of knowledge. Education and access to information can reduce costs of adaptation and risks enabling early responses (Wozniak 1987). Agriculture extension services can be in form of government extension services, farmer-to-farmer and information from radio, television or mobile phones (Falco and Veronesi 2013).

Farmers in villages usually observe farming activities of fellow farmers, including those experimenting with new technologies and accordingly update their own perceptions and decide on cultivation for the next season. Bandiera and Rasul (2006) find that in Mozambique, individual technology adoption decisions of farmers usually depend upon the others choices in the same social network and the network effect is stronger for farmers who engage in conversation with other farmers.

- **Access to Credit-** Financial access in form of credit and insurance from different agencies and individual cash holdings is an important catalyst for adaptation. Financial well being determines the adaptive capacity of farmers as it provides a sense of security to combat unpredicted impacts of climate extremes. Access to credit has been considered as a serious barrier to adaptation by several studies (Napier 1991; Deressa et al. 2009) especially for developing countries. Financial access induces farmers to change their management practices and increases the likelihood of adopting strategies like soil conservation, changing planting dates, irrigation, adoption of technology, use of high variety seeds, acquiring transportation, and hiring agricultural workers. In contrast, Hisali et al. (2011) find households without access to credit in Uganda are more open to technology adoption to adapt to livestock epidemic; probably due to availability of loan repayment options.

Socioeconomic Factors Affecting Farmers' Adaptation in Indian Context

Farm-level decisions in India are made over short-run and is by and large affected by inter annual or seasonal variations in climate elements. Indian farmer's adaptation to climate change is mainly dependent on their motive to minimize the risks associated with crop failure due to weather shocks. Farmer's usually adapt to maintain sustained flow of income throughout the year. Since farmers also utilize a certain part of their agricultural produce for household purpose; consumption smoothening is another objective of adaptation. However, it is often the case that even if farmers are willing to adapt they do not, due lack of adaptive capacity. Indian farmers usually are less capable of adapting to sudden shocks in climate and production system due to their dependence on natural inputs, the lack of technological know-how and limited access to institutional support systems. The basic adaptation rule followed by farmer's in India is maximization of net revenue constrained by their socio-economic situations (household size, age of the farmer, gender, education level, off-farm income and farm size), access extension services and access to credit.

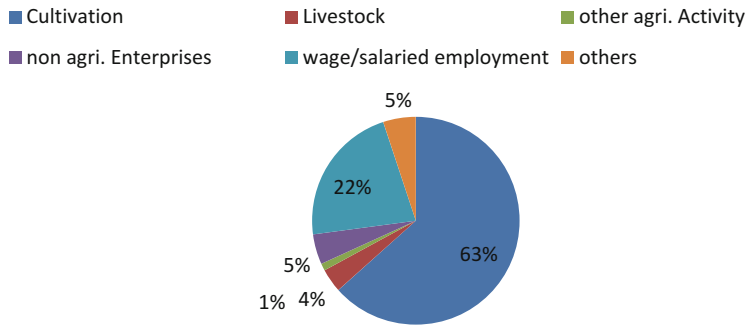

Fig. 17.1 Percentage distribution of agricultural household by principle source of Income. *Source*: National Sample Survey (NSS), 70th Round, 2014, NSSO

According to the 70th Round of NSS there were about 90.2 million agricultural households[1] in India comprising of about 57.8 % of total estimated rural households in the agricultural year of July, 2012 to June, 2013. Majority of agricultural households i.e. 63.5 % take up cultivation as their primary activity for livelihood followed by wage or salaried employment[2] i.e. 22 % (Fig. 17.1).

Agriculture being the primary source of income for the rural population; agricultural households are highly vulnerable to loss of livelihood due to climate shocks. On the other hand, population pressure is leading to frequent changes in land use arrangements. According to 2011 Census figures of India; the average household in rural area mainly lies in medium to large range. About 21 % of the rural households have four household members, 18.9 % five household members, 26.9 % have six to eight household members and 7.2 % have household members above nine. Households with large family size but small farm size often lead to clashes between household members due to property rights.

Principal source of income of agricultural households is largely determined by the extent of land possession. Table 17.1 shows that, among the agricultural households having less than 0.01 ha land (which included landless agricultural households also) about 56 % reported wage/salary employment as their principal source of income and another 23 % reported livestock as their principal source of income. Majority of the agricultural households which possessed more than 0.40 ha land reported cultivation as their principal source of income. The group of agricultural households which possessed little land (0.01–0.04 ha) earned their income both from cultivation (42 %) and wage/salary employment (35 %). Non-agricultural

[1]The 70th Round of NSS Survey India defines agricultural households as households receiving some value of their produce from agricultural activities including cultivation of crops, horticulture, fodder, plantation, livestock management including poultry and fishing.

[2]The different sources of income considered under 70th NSS survey are cultivation, livestock, other agricultural activity, wage/salaried employment, non-agricultural enterprises, pension, remittances, interest and dividends and others.

Table 17.1 Per 1000 distribution of agricultural households by principal source of income during last 365 days for each size class of land possessed

Size class of land possessed (ha)	Per 1000 distribution of households by principal source of income					
	Cultivation	Livestock	Other agricultural activity	Non agricultural enterprises	Wage/ salaried employment	Others[a]
<0.01	16	229	27	108	564	55
0.01–0.40	421	48	12	75	352	93
0.41–1.00	692	23	9	36	200	41
1.01–2.00	830	25	9	32	86	18
2.01–4.00	859	24	11	16	71	18
4.01–10.00	879	27	5	9	59	20
10.00 +	894	55	5	18	17	1
All sizes	635	37	11	47	220	51

[a]'others' includes pension and remittance also
Source: National Sample Survey (NSS) 70th Round, 2014, NSSO

enterprises were principal source of income for about 8 % and 11 % of the agricultural households, respectively, of bottom two size classes of land possessed.

Indian agriculture is majorly characterized by small and marginal operational holdings. As per Agricultural Census of 2010–11, average size of operational holding declined from 1.23 ha in 2005–06 to 1.15 ha in 2010–11 although the number of operational holdings in total increased from 129.22 million in 2005–06 to 138.35 million in 2010–11, an increase of about 7.06 %. Figures on share of operational holdings by size suggest 85.01 % of small and marginal holdings (below 2.00 ha.), 14.29 % of semi-medium and medium (2.00–10.00 ha.) and only 0.70 % large (10.00 ha. & above) operational holding in 2010–11 as compared to 83.29 %, 15.86 % and 11.82 % respectively in 2005–06 due to fragmentation of land holding after the distribution of land amongst siblings of the farmer. Another prominent outcome of Census 2011, suggests an increase from 11.70 % in 2005–06 to 12.78 % in 2010–11 in female owned operational holding. According to NSS survey estimates of India 93 % of the agricultural households possessed land other than just homestead land and only 7 % owned only homestead land while only 0.1 % of rural agricultural household were landless. In addition about 78.5 % of agricultural household owned land only in their residing village. Households holding small patches of land in India often opt for non-agricultural income source and are often reluctant in applying modern technologies, crop diversification and soil and water conservation as they consider it risky due to diseconomies of scale.

Agriculture in India is a traditional activity and therefore aged farmers upgrade their perceptions based on their past experience or follow their fellow farmers and accordingly adopt traditional farming practices. They follow risk-averse decisions and are often rigid in accepting new and advanced methods of climate forecasts and farming technology. According to Census 2011, in rural India 30.9 % population belongs to age group of 0–14 years, 61 % of 15–59 years and 8.1 % population are beyond 60 years of age. Although considering 15–59 years as middle age group for

agricultural activity is misleading; these figures suggest that majority of rural population belongs to the middle age group. With the ongoing technological upgradation in the country; educated younger members of households are more open to risks and readily uptake modern agricultural practices and also show good entrepreneurial ability. Moreover, large households with educated members can develop information network and also contribute to family income by engaging in non-farm activities.

The rural female and male literacy rate for country is about 57.93 % and 77.15 % respectively according to Census 2011. Education builds decision making power and in India due to lower female literacy rate men dominate household decision-making. Farmers and head of the household are mostly men and women only assist their male counterparts. Small and marginal farmers are usually faced with increasing costs of production required for new modern agriculture. Under such cases, farmers often cut costs on labour and try to engage females of the household on farm. Moreover, men often switch from farm to non-farm jobs and because women cannot migrate as easily as men; they engage themselves in farm activities especially during sowing and harvesting seasons to support their family income.

Indian farm households usually belong to vulnerable social strata with limited access to institutional safeguards. The arrangements of agricultural extension in India have evolved since Green Revolution of 1966, in terms of activities, organizational structure and available human capital. The extension activities include farmer training, conducting exhibitions, capacity building aids and dissemination of information technology and are provided both at district and state level (Ministry of Agriculture, India; 2006–07). Although at the district level, Agricultural Technology Management Agency (ATMA) model which is a bottom-up approach is being followed in six districts of India, it has been criticized for its inability to reach the farmers. The outcome of NSS survey suggests that only 41 % of agricultural households had access to technical assistance from any agencies in period July, 2012- December, 2012 although they found radio, television, newspaper and internet were useful sources of technical information. Glendenning et al. (2010) observes that regardless of provision of various extension services, at the ground level Indian farmers have limited access to agricultural information as public extension services dominating the provisional arrangement largely focus on on-farm activities although farmers need information on entire food value chain.

Access to credit critically affects adaptive behavior of farmers in India as most of the agricultural households are poor. Absence of formal lending sources forces farmers towards informal credit sources at higher interest burden. Since majority of Indian farmers operate on small to medium scale; credit availability and crop insurance can encourage them to respond to sudden climate shocks, opting for new and advanced technology. In India, financial schemes like Kisan Credit Card, Agricultural Debt Waiver and Debt Relief Scheme are implemented to safeguard farmers from informal credit sources, to relieve them from previous agricultural debt and to bring small and marginal farmers, leaseholders, and share croppers under institutional credit coverage. However, the objectives of such scheme are yet far from achievement as around 52 % of agricultural households in India are still

indebted and the average amount of outstanding loan is about Rs. 47,000 (USD 751.82) per agricultural household (70th Round, NSS India). Moreover, only a small proportion of farmers have their crops insured against crop losses mainly due to unawareness of such schemes.

Conclusion

The primary objective of this study was to identify the key socio-economic variables which determine farmers' adaptive capacity and how these factors affect farmers' decision making in India through country level secondary information. To conclude, farmers in India usually try to maximize their farm returns through adaptation and their decisions are often constrained by their socio-economic situations and regional institutional arrangements. The study identified farmer's age, gender, household size, education, off-farm income, farm size, extension services and credit as important factors affecting farmers' adaptive capacity in India. Factors like age, gender and household size are often beyond farmer's control and establish other factors like education, off-farm income, access to extension services and credit. These factors do not determine adaptation responses in isolation rather; decisions are outcome of how they interact with each other. The study finds that agricultural households in rural India usually have medium to large family size and operational holding. Farming serves to be the primary source of livelihood for the households and income from farm increases with the increase in farm size. Farmers mainly rely on farmer to farmer extension services and also find information through television and radio useful if effectively provided. However, the most serious barrier to adaptation in India as identified by this study is lack of credit facilities, less effective extension services and lack of awareness. In this respect, education can prove to be an efficient way to improve awareness among farmers about climate change and the effectiveness of agricultural extension services.

This study is however limited in several context. Firstly, the approach of the study is purely based on secondary data analysis and gives a general idea of Indian farmers' adaptive capacity and therefore, fails to capture the regional and agro-ecological differences within the country. Secondly, although other developing countries can draw similarities, there might be several economic, social and political differences and therefore the importance and relevance of factors might differ.

The study also finds that effective governance is crucial to foster sustainable agricultural practices. Policies should encourage farmers to take up adaptation and enhance farmers' individual adaptive capacities. Well targeted extension services spanning across different stakeholders engaged in agriculture value chain, appropriate credit and crop insurance arrangements, farmers' education and awareness can restrain vulnerability of farmers to climate variations and extremes and ensure long-term resilience to future climatic turbulences.

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