

Do better agricultural extension and climate information sources enhance adaptive capacity? A micro-level assessment of farm households in rural India

Chandan Kumar Jha and Vijaya Gupta
National Institute of Industrial Engineering, Mumbai, India

Micro-level
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households

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Abstract

Purpose – The farmers used several information sources to gather information about the climatic variability and modern agricultural practices to cope with climate change. The choice of adaptation strategies and the successful implication of adaptation strategies depend on accurate, timely information on the climate variability and precise technical details of adaptation strategies. By keeping the importance of climate information and agricultural extension information in the center, this study aims to conduct a micro-level evaluation of farmers' choice of climate information, agriculture extension services and agricultural credit sources. This study's primary objective is to understand how the different sources of climate information and agricultural extension influence farm household adaptation decisions.

Design/methodology/approach – This study has been conducted in three subs agro-climatic zone of the Middle Gangetic Plain region, which falls in India's Bihar state. This paper has randomly selected seven districts from these three subs agro-climatic zone to collect the data. The analysis of this study is based on survey data collected from 700 farm households. This study has used descriptive statistics and a logistic regression model to assess the sources of climate information, agricultural extension and credit sources and how these sources influence farm households' adaptation decisions.

Findings – The result of this study shows farmers are using different traditional (sharing experience, newspaper and radio), information and communication technology (mobile and TV) and institutional arrangements (agricultural officer and meteorological department) in the study area. The study's finding identifies different farm households' different sources and how these options farming farmers' adaptation decisions. The study further revealed that institutional factors such as extension services and access to information on climate change increase the probability of adopting knowledge-intensive adaptation strategies such as soil conservation, water conservation, crop insurance and planting horticulture and vegetables.

Research limitations/implications – The study has conducted a micro-level assessment of adaptation behavior at the local level to understand the factor influencing the adaptation decision. This study's finding is useful in designing the appropriate policy framework for the farm household's

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capacity building to enhance their technical skills and awareness toward the institutional arrangements.

Originality/value – This paper’s finding pointed out institutional arrangements’ requirement to improve adaptive capacity to make long-term strategic decisions to cope with climate change.

Keywords Agricultural credit, Adaptation strategies, Agricultural extension, Climate information, Farm households

Paper type Research paper

1. Introduction

Climate change is the most significant market failure of all times (Stern and Stern, 2007), at the global level in its causes and consequences. The climate change predicament has driven extensive research of scientific, technical and socio-economic assessment of the complex interactions and changing the likelihood of its diverse impacts, more prominently over the past decade (IPCC, 2014). The commitment to ensure farmers’ well-being and guarantee sustainability under the environmental stress due to climate change necessitates appropriate climate information on time and capacity building through advanced and contemporary agricultural extension services. Agriculture extension services and credit facilities are the two most enabling institutional arrangements that facilitate information delivery on new technologies and new farming practices (Ragasa *et al.*, 2016; Nettle *et al.*, 2017; Dunne *et al.*, 2019). Access to agriculture extension services enhances farmers’ awareness of changing climatic conditions and facilitates individual farmers’ knowledge on different management practices that they can adapt to climate changes (Arbuckle *et al.*, 2015). Thus, it helps farmers be timely, perceive changes in climatic events and modify their agronomic practices accordingly (Ramborun *et al.*, 2019). It is essential to draw out the distinction between climate information sources and sources of agricultural knowledge as both complementary enables efficient adaptation.

The availability of farm extension services in a region depends on several factors such as adequate government intervention, institutional arrangements, technology penetration and personal relations. Mention in a more descriptive way, the government’s active response such as agricultural officers’ appointment, can remove the asymmetric flow of information among the farmers about the changing climate or available management and farm mechanization techniques. The agricultural educator’s role is also vital to enhance rural communities’ knowledge of global climate change in the food system. Technological innovations such as mobile also serve to be an effective medium of the flow of knowledge. How a farmer assembles, process and use climate information determines their adaptation actions. The efficiency and effectiveness of adaptation at the farm level are critically influenced by the level of certainty of climate perception and predictions at the regional scale (Pacey *et al.*, 1989; Carswell and Jones, 2004). Information on climatic conditions is sequentially processed and used in active decision-making by farmers. The institutional arrangements can remove the asymmetric information related to changing climate or available management and farm mechanization techniques. Television, mobile, radio, newspapers are other well-acclaimed sources of information. Also, farmer-to-farmer extension services can play a significant role in deciding on effective adaptation strategies.

In light of the above debate, this paper first tried to identify climate information sources and agricultural extension assesses by farmers in the study area. Education level, land size and land rights are essential for evaluating the same. This paper examines how this medium of climate information and agricultural extension services play a role in adaptation decisions in the second stage. In Section 2, a brief review of the literature has been discussed. A short

description of the study area and methodology has been given in Sections 3 and 4. In Section 5, we have discussed the sources of climate information and agriculture extension assessed by the farm households in the study area and the importance of education level, land size and land rights. Section 6 presents agricultural extension and climate information sources in the farm household's adaptation strategy. The paper has been concluded in Section 6 with significant findings and policy implications.

2. Literature review

The broad spectrum of literature has mainly discussed the factors influencing the farm household's adaptive capacity to minimize climate change (Granjon, 1999; Hansen *et al.*, 2004; Ziervogel *et al.*, 2005; Vogel and O'Brien, 2006). Among these, the large number of literature has pointed out the high significance of agricultural extension, climate information services and credit facility in adaptation decisions among the farmers in a rural area and found to be diffusion tools of social capital into adaptation (Cooper *et al.*, 2008; Deressa *et al.*, 2008; Hammill *et al.*, 2008; McLeman *et al.*, 2008; Keil *et al.*, 2008; Ziervogel *et al.*, 2006; Di Falco *et al.*, 2012 and Di Falco and Veronesi, 2013). These studies have also examined how the farm household's decision-making process is influenced by the use of information and in that the role of local knowledge was most important (Roncoli *et al.*, 2001, 2002; Vogel and O'Brien, 2006). The decision to alter farming practices to cope with climate variability does not only depend on changes in the average condition but also the number of other climate variables such as erratic rainfall, extreme events, flood and drought (Smithers, 1997; Roncoli *et al.*, 2002; Hansen *et al.*, 2004; Thomas *et al.*, 2007). The poor source of climate information and agricultural extension negatively impact farmers' well-being by affecting their capacity to cope with climate change (Roncoli *et al.*, 2002; Hansen, 2007). Among the rural farmers, to improve the adaptive capacity, there is a need to enhance these sources (Vogel and O'Brien, 2006).

The climate information channels are community participation, individual capability and relationships, institutions and technology. The role of "indigenous knowledge" in climate forecasting has been identified by several studies (Roncolli *et al.*, 2001; Ajibade and Shokemi, 2003). Indigenous knowledge involves a participatory approach of farmers or local communities to interpret seasonal fluctuations in climate and extremes such as a flood and drought, which helps in better farm management. Adger *et al.* (2003) has signified social capital as historical evidence and social networks' role in collective action for tackling climate hazards. Their capabilities and household relationship also determine farmer's decisions to adopt. Roncoli *et al.* (2001) observe that elderly male farmers of households often contemplate seasonal rainfall patterns through their experience of natural climate occurrences. The other sources of climate information can be weather information from government sources, nearby weather forecasting stations, television, news from radio and cellular devices. By underlying the importance of the formal and informal institution and social relationship, many studies have highlighted how the former can upscale adaptive capacity and shape the ability of farm households to respond to climate change and the adaptation strategies they choose (Agrawal, 2008; Agrawal and Perrin, 2008; Adger *et al.*, 2003; Isham, 2002; Eakin, 2005). In the process to strengthen the adaptive capacity and the local level adaptation, the potential of institutional arrangements is also found necessary such as government extension services that provide awareness on farming practices in response to climate change (Adger *et al.*, 2003; Agrawal, 2008; Agrawal and Perrin, 2008; Maddison, 2007; Nhemachena and Hassan, 2007).

Much of the literature evaluated socio-economic role in adaptation strategies and adaptive capacity has also empirically attempted to identify climate information and agricultural extension services. These studies have been first discussed theoretically

and then investigate the role of several sources of climate information and agricultural extension as a variable related to improving knowledge regarding modern farming practices. [Di Falco *et al.* \(2012\)](#) found that farmers with better access to credit, along with information about the climate and information on agricultural extension, are more likely to adapt. More extensively, [Di Falco and Veronesi \(2013\)](#) found that better extension services along with climate information services increase the likelihood of adaptation strategies, echoing similar findings by [Shiferaw and Holden \(1998\)](#), [Bekele and Drake \(2003\)](#); [Anley and Bogale \(2007\)](#), [Tesfaye and Brouwer \(2012\)](#). In a more precise way, [Deressa *et al.* \(2008\)](#) found that the access of climate information on temperature and precipitation and credit sources increases the probability of adopting different crop varieties, soil conservation, changing planting dates and using irrigation.

3. Study area

The State of Bihar falls under tropical to a subtropical region where the temperature goes high and mild humidity, rainfall range between medium to high and heavy winter. The river Ganges divides the total geographic area, about 94,200 square km, into two parts, the north and the south Bihar. The States divided into three sub-agro-climatic zones (North West Alluvial Plains, North East Alluvial Plains and South Bihar Alluvial Plains) of the Middle Gangetic plains of India and the surveyed districts fall in all three sub-agro-climatic zones. The natural precipitation varies from 990 to 1,700 mm. Most of the rain is received from July to September. The irony of the situation is that even though the quantum of rainfall is too high and a state is so rich in water bodies, it also suffers from severe droughts that intrinsically lead to famine. Bihar is India's most flood-prone state, with 76% of the population, in the north Bihar living under the flood threat. While the conditions are already experiencing a decreasing volume of rainfall, rainy days and increasing temperature ([Giri, 2015](#)), climate change is likely to worsen the problem with highly uneven and erratic rainfall floods and severe droughts. The study area has several initiatives for an agricultural extension such as Krishi Vigyan Kendra (KVK)-Agricultural Science Center) and Agricultural Technology Management Agency (ATMA). The agricultural officers and other professionals in these departments are responsible for knowledge transfer to farm households on-farm technologies and farming practices.

4. Sampling and methodology

The data collection was self-administered and approached farmers from all land size and ownership (owned or rented) groups. The structured questionnaire has been broadly discussed with the farmer to maintain consistency in responses and data collection. The structured questionnaire was developed to collect the farm household level information that includes socio-economic, Climate Information, agricultural extension services and adaptation strategies used by farm households to cope with climate change. The source of climate information and agricultural extension and adaptation strategies considered in particular question based on the pilot survey conducted before the final data collection and review of existing literature ([Bradshaw *et al.*, 2004](#); [Maddison, 2007](#); [Deressa *et al.*, 2008](#); [Below *et al.*, 2012](#); [Di Falco and Veronesi, 2013](#); [Di Falco and Veronesi, 2013](#); [Smithers, 1997](#); [Roncoli *et al.*, 2002](#); [Hansen *et al.*, 2004](#); [Thomas *et al.*, 2007](#)). The farm households make their adaptation choices in Kharif and Rabi season among different adaptation strategies listed in [Table 1](#). The strategies have been identified through an initial assessment of agricultural practices before the final survey and successfully captured the capital-intensive, labor-intensive and knowledge-intensive techniques. [Table 1](#) provides detail information about the variables for which data was collected.

Variable name	Description	Type
Education	Year of education of the farmer (divided into four categories – no education, primary education, secondary education and higher education)	Continuous
Land size	Total cultivated land by the farmer's in hectare	Continuous
Land right	Land owned by the farmers or taken on rent	Binary (1,0)
Independent variables		
<i>Farmer's choices of the source of climate information</i>		
Own prediction (current year)	Farmer predicting climatic aberrations according to the current year climatic situation	Binary (yes, no)
Own prediction (previous year)	Farmer predicting climatic aberrations according to the previous year climatic situation	Binary (yes, no)
Elder person or head of the family if farmer himself is not	Farmer predicting climatic aberrations according to the view of the elder person of the family because of the expense and affiliation is longer from the particular place	Binary (yes, no)
Group of farmers	Farmer predicting climatic aberrations according to the discussion with the group of farmers	Binary (yes, no)
Government sources	Farmers are getting information about climate aberrations through Krishi Vigyan Kendra, Agricultural officers, Agricultural Universities, IMD, etc.	Binary (yes, no)
Radio	Farmers are getting information about climate aberrations through radio via regional news or agricultural oriented program	Binary (yes, no)
TV	Farmers getting information about climate aberrations through T.V via regional news or agricultural oriented program and channels	Binary (yes, no)
Mobile	Farmers are getting information about climate aberrations through helpline numbers started by the government	Binary (yes, no)
<i>Farmer's choices of the source of agricultural extension services</i>		
Farm to farm extension	Framers getting Information about appropriate and new agricultural practices by discussing among farm groups	Binary (yes, no)
Agricultural field officer	Farmers are getting information about adaptation strategies and practices through government officials assigned to take care of agricultural activity in that particular area	Binary (yes, no)
Newspaper	Framer's getting Information about appropriate and new agricultural practices by reading a newspaper	Binary (yes, no)
TV	Framers getting Information about appropriate and new agricultural practices by watching agricultural-related shows and channels on TV	Binary (yes, no)
Radio	Framer's getting Information about appropriate and new agricultural practices by listening to agricultural-related show and channel on the radio	Binary (yes, no)
Mobile	Framer's getting information about appropriate and new agricultural practices through farmer's helpline numbers and other available numbers from Krishi Vigyan Kendra through mobile phone	Binary (yes, no)
<i>Credit facility available to farmers</i>		
Bank	Weather farmer is getting credit facility from the bank	Binary (yes, no)
Cooperative bank		Binary (yes, no)
		(continued)

Table 1.
Description of
variable queried in
the survey
instrument

Variable name	Description	Type
Informal money lenders	Weather farmer is getting credit facility from a cooperative bank A farmer was taking a loan from local money lenders on interest for agricultural activity	Binary (yes, no)
NGO	Farmers are getting credit facilities for their agricultural activity from NGOs engaged in the same activity	Binary (yes, no)
A problem in availing of loans	Farm households reporting whether they faced problems in availing loans from banks, cooperative banks and NGOs	Binary (yes, no)
Dependent variables		
<i>Adaptation strategies adopted by farm households</i>		
Changing crop varieties	Planting different crops, drought-resistant varieties, high-yield varieties, water-sensitive crops and short-duration varieties	Binary (yes, no)
Changing land under cultivation	Land rotation or altering the area under cultivation	Binary (yes, no)
Irrigation	Increase/decrease the intensity of irrigation to overcome shortage or excess rainfall. Using tube well, water pump, etc.	Binary (yes, no)
Soil conservation	For maintaining soil fertility-like zero-tilling, etc.	Binary (yes, no)
Water conservation	Rainwater harvesting, building tanks or water reservoirs	Binary (yes, no)
Crop insurance	Insure crops to overcome crop losses due to climatic disturbances	Binary (yes, no)
Migration	Migrating to the urban area to diversify their livelihood options	Binary (yes, no)
Farm to non-farm activities	Changing land from farm to non-farm activities mainly in non-climate sensitive activities	Binary (yes, no)
Leasing land	Leasing land for other non-farm activities	Binary (yes, no)
Planting horticulture crop	Planting fruits such as mango, litchi, banana and guava and nuts, seeds, herbs, sprouts, mushrooms, flowers, seaweeds and non-food crops such as grass and ornamental trees and plants	Binary (yes, no)
Planting vegetables	Planting vegetables such as potato, brinjal/eggplant, cauliflower, cabbage, tomatoes and chili	Binary (yes, no)

Table 1.

The study has been conducted in the seven districts of India's Bihar state and among these districts, 72 villages were randomly selected for the survey. The distance from the district headquarters has been considered for the selection of the village. The villages close to district headquarter (within 10 km) might have easy market access and institutional arrangements for agricultural support and vice versa (more than 10) subject to the districts' size. From 72 villages, we have surveyed randomly selected 735 households, but at the final stage, the data from 700 farm households were found for statistical analysis based on completeness and consistency. We tried to capture all land-sized groups such as marginal, medium, small and large – the farm household-related preliminary data collected from the village head.

We used descriptive statistics and statistical inference to analyze the climate information, an agricultural extension of the surveyed household. We use the logit model to assess the role of socio-economic characteristics on adaptation strategies. The logistic regression model is given by [Greene \(2017\)](#):

$$\log\left(\frac{P_i}{1 - P_i}\right) = \log(P_i) = \beta_0 + \beta_i X_i$$

where P_i is the probability of adopting particular adaptation strategies from the set of given adaptation strategies, X_i is an independent variable. Therefore, the parameter β_i provides the log with odds for the dependent variable and β_0 is a constant. The odds ratio is the probability of an event happening related to not happening.

$$\frac{P_i}{1 - P_i} = \exp(\beta_0 + \beta_i X_i)$$

5. Results and discussion

5.1 Climate information sources

This study identifies 10 possible mediums through which farmers in the chosen districts of Bihar gather information on climate (Figure 1, Panel A). The respondents were asked, “How do they predict changes in future climate conditions and what are the main sources through which they gather climate information?” The respondents could choose the information they feel are important and commonly use to collect local climate info. The choices are not mutually exclusive, which means that each respondent can choose more than one source.

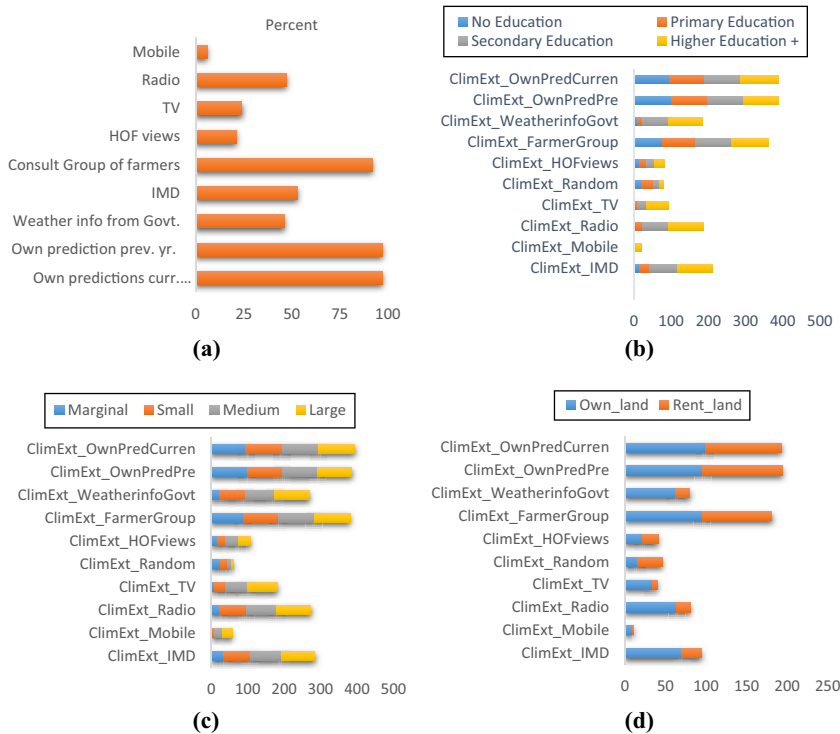


Figure 1.
Sources of climate
information and role
of education, land size
and land rights

The most crucial channel through which farmers predict future climate is their prediction based on current and previous years' climate conditions followed by farmers (92% of farm households). Climate information from local weather (53%) stations and information from government sources (46%) are other important sources. Another critical source of climate information is radio (47%) and television (24%). Views of the household head also hold another useful information source (21%) and information through cellular phones (6%). The spillover of institutional effect has increased mobile use in the rural area, especially for agricultural business purposes, but barely used for climate information to alter agricultural practices.

From the above results, it is evident that farmers are mostly dependent on their mental capacity as an important source of climate information and consultation with fellow farmers. Social relations and community participation in exchanging ideas are perceived as more reliable. Although weather stations and the government's role in providing climate information are limited in this study, policy actions can reduce the uncertainty in farmer's predictions and help in efficient adaptation. The importance of household members' views, especially household heads, signifies personal relationships in climate forecasting. In rural areas, radio serves to be a critical source of entertainment and information, as rural electrification is still a crucial issue in villages. Therefore, using television as a source of climate information has a limited scope. The results show that the farmers in the study area are not using mobile phones to get climate information due to the lack of awareness and their education level that restrict their understanding of the efficient use of mobile phones for agriculture.

The role of education, land size and land rights can be seen in [Figure 1](#). The result shows that farmers from all education groups largely depend on their experience from the current and previous years and discussion among farmers for climate prediction. Simultaneously, highly educated farmers are also accessing T.V., Radio, mobile and government sources for climate information ([Figure 1](#), Panel A). The land size and land rights play an essential role in accessing more reliable sources such as T.V., Radio, mobile and government sources. The result shows that higher educated farmers depend on these sources.

5.2 Agriculture extension and credit sources

To assess and identify the extension services accessible for the farmers in the study area, they were asked to choose the extension options based on how they use such services for their farm management. The extension services were distinctly divided between sources of agricultural knowledge and sources of credit. The farmers were asked to choose between the different sources of agricultural extension and credit. The choices reported by the are not mutually exclusive, implying they revealed for the possible options which they usually use, not the only option.

For this study, farmers enquired upon their extension services choices, which they often cater to for taking farm decisions and adaptations. The farm extension options assessed in this study are farmer's own experience, consult other farmers (farmer to farmer extension services), consult agricultural officers, Newspaper, T.V., Radio and Mobile.

The results of the study show that farmers are mostly dependent on their own experiences (97%, 680 respondents) and farmer to farmer extension (97%, 680 respondents) for deciding on-farm management ([Figure 2](#), Panel A). From the results, farmers have more confidence in information gained from their past experiences and knowledge from their fellow farmers. Farmers often follow the "learning by doing" approach by learning from their past farm management experiences. In farmer-to-farmer extension, farmers habitually try to observe and copy farm activities of fellow farmers, including adopting technological

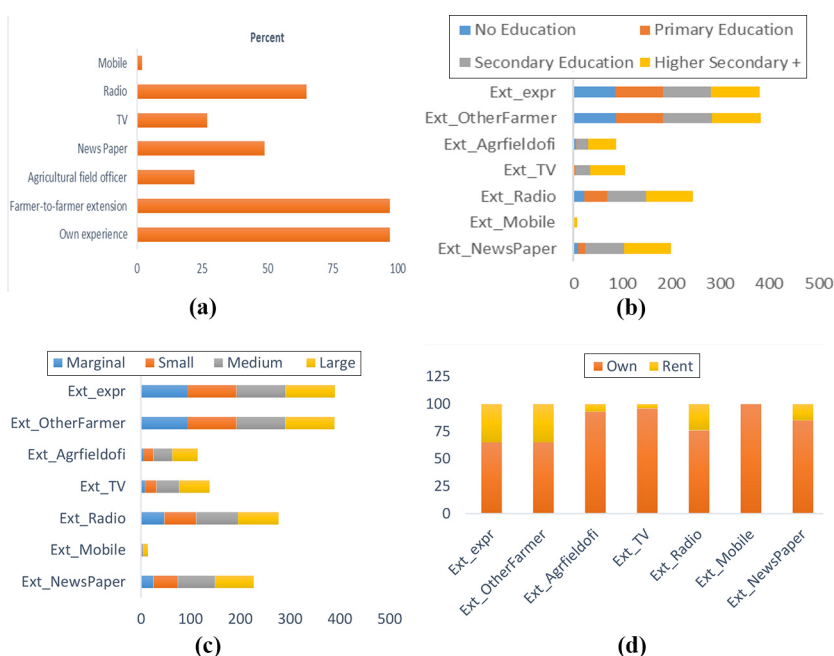
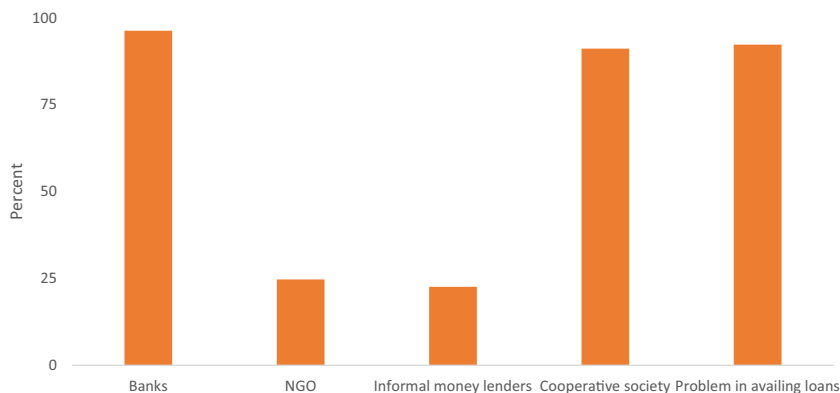


Figure 2.
Sources of
agricultural extension
services and role of
education, land size
and land right

adaptation. In this way, farmers proceed to self-perfection, enabling them to take up minor innovations independently. Here, the importance of farmers' socio-economic conditions as individual agents and the social relationships they share with society cannot ignore. Therefore, it is also critical to identify the main socio-economic factors that augment farmers' behavioral attributes for personal decision-making. The second and third most crucial agricultural extension source is information through radio (65%, 454 respondents) and newspaper (49%, 341 respondents). Agricultural field officers have limited reach in providing farm extension (22%, 152 respondents). The influence of agricultural field officers in the delivery of extension services seems limited in the study region. Agricultural field officers in the study region must arrange for the supply of farm inputs such as seeds and fertilizers by developing direct contact with farmers. Also, they organize training camps and field days and manage the distribution of Soil Health Cards. It is essential to assess here that despite these arrangements for farm management, the farmers have not benefited from learning by instructions. Only 27% (190 respondents) and 2% (15 respondents) of surveyed farmers use television and cellular devices as agricultural extension sources.

The role of education, land size and land rights can be seen in Figure 3. The results show that the traditional extension sources such as own prediction from current and previous year experiences are most common among all education classes. However, the access of agricultural officers, knowledge from T.V., radio, mobile and newspaper highly depend on farmers' education level. It means that more educated farmers are more intended toward these sources. The land size denoted as farm holding size in this study has also been analyzed to see their significance in accessing agricultural extension services. The land size determines the farming community's interest in adopting better farming practices and enhancing their ability to adapt. The results show that large land-sized farm households are consulting agricultural field officers to improve their farming practices to cope with climate

Figure 3.
Access to credit
sources in the study
area accesses by
farmers



change. The large land holding farmers are also getting extension information through T.V., mobile and newspaper, followed by the medium-size farmer. The maximum number of marginal and medium-scale farmers depends on self-experience, farm to farm extension and radio as extension services. The marginal and small farmers have less awareness level but are timelessly motivated because they are left with less surplus production to sell after family consumption.

Along with land size, this study has found land ownership (Panel D) also determines the interest to assess agricultural extension services through all means. Our findings are in line with [Gbetibouo \(2009\)](#), who pointed out that secured positive incentives from farm investment to cope with climate change are high when the land ownership belongs to the farmer. For instance, secure land ownership increases the likelihood of the adoption of conservation technologies. Access to credit often increases the possibility of adaptation. Poverty or lack of financial resources causes severe impediments to adjustments to climate change. For credit extension, farmers were asked to answer the question, “Which credit sources do you opt for meeting the financial requirement for farming?” Also, farmers were asked whether they face any problem in availing of loans. This study tried to assess the different credit sources which the farm household accessed. Farmers were asked to list out their choices on sources of credit, i.e. banks, informal money lenders, co-operative societies and NGOs ([Figure 3](#)).

As per the results, about 96% of the surveyed farmers (674 respondents) avail loans from banks, 91% (638 respondents) avail loans from co-operative society, 25% (173 respondents) from NGO and 23% (158 respondents) from informal money lenders and about 25% from NGOs (173 respondents). The three primary sources of credit in Bihar are commercial banks, regional banks and co-operative banks. Co-operative societies in the form of primary Agricultural Credit Societies (PACS) are the prominent agricultural credit source in the state. Although most of the surveyed farmers take loans from formal lending institutions, credit availability is still a significant issue for Bihar farmers. About 92% of the surveyed farmers reported problems in availing loans. The main issues farmers face in availing loans are an inappropriate attitude of bankers, stringent security norms and high-interest rates. Issues in availing loans from banks and co-operative society force them to take loans from informal credit sources such as agricultural and professional money lenders, relatives and friends, etc. The farmers are usually forced to accept the higher interest from informal sources due to the absence of formal credit sources that affect farming households’ adaptive capacity or decisions, especially small-sized farmers. Credit availability and crop insurance have

positive relations with altered agricultural practices to respond to climate shocks among Indian farmers as they are mostly small to medium scale farmers.

5.3 Role of climate information in adaptation strategies

Information on temperature and rainfall has a significant and positive impact on using different adaptation strategies. The relationship between assessing the additional climate information and adaptation decision is explained in [Tables 2 and 3](#).

The results show that there is a positive relationship between climate information and adaptation strategies. Adopting the different crop varieties negatively correlates with those drawing perceptions regarding climate change through personal experience based on current and previous year climatic situations and the family's elder. The aged members of the family may have emotional attachments with their traditional agricultural system and they push to adopt the same. The study shows that the changing crop varieties have a significant positive relation with getting information about climate change from the discussion among farmers, elders or household heads, government sources and radio in both agricultural seasons. The elders or household head experience helps farmers understand the short-term climate variability in particular agriculture seasons and decide the appropriate crop varieties. The government sources and radio provides climate bulletin from time to time and those who access information from the government determine the crop varieties more appropriately. Changing land area has a significant positive relation with older household members' suggestions and discussion among farmers in Rabi season. Increasing irrigation has a significant positive association with more senior household members in Rabi for temperature and rainfall changes and Kharif for temperature changes. Discussion among farmers and radio as information is also found significant in increasing irrigation in both seasons. Changing land area and irrigation is the traditional management system and older members may appreciate farmers adopting these strategies. This study shows that the likelihood of adopting knowledge-intensive adaptation strategies such as soil conservation water conservation is high if the farmer is accessing government sources, T.V., radio and mobile phones. These are mostly technology-driven information sources, i.e. television, radio and mobile. The implementation of conservation technology needs a proper understanding of the scientific package of the particular strategies. The agricultural officers help them build their capacity to understand the specific conservation strategies' scientific process. The study found that climate information through mobile phones is crucial for appropriate and timely adaptation strategies to cope with climate change and manage the risk. The paper demonstrates that climate information delivered using mobile phones is useful to farmers. Farmers accessing information from these sources are more likely to predict the climate and adopt practices accordingly. Other strategies such as planting horticulture and vegetables are also positively related to government sources, television, radio and mobile. Farm households sometimes chose to cultivate these crops if they correctly perceived variability in climatic factors that could not grow other staple crops. This study has found that getting information on climate variability on time from authentic sources is more likely to change their agricultural practices and adopt strategies to cope with climate change.

5.4 Role of agricultural extension services in adaptation strategies

The better flow of knowledge through extension services generates a dissimilar effect on farmers' well-being and reduces asymmetric information. These services enable farmers to take early responses to reduce the risk and concurrently the cost of adaptation. The relationship between agricultural extension services and adaptation strategies given in [Tables 4 and 5](#).

Table 2.
Logistic regression
model of adaptation
strategies and
climate information-
adaptation-Rabi-
rainfall/temperature

Variables	Own pred. current-Y	Own pred. prev.-Y	Elder or head of HH	Group of farmers	Govt. sources	Random	Television	Radio	Mobile
Crop varieties	-0.489 (0.414)	-1.3975 (0.981)	-0.587 (0.000)***	1.647 (0.000)***	0.961 (0.082)*	0.284 (0.261)	-0.536 (0.271)	1.238 (0.022)**	0.374 (0.634)
	-0.485 (0.418)	-14.276 (0.983)	-0.535 (0.044)**	1.599 (0.000)***	0.995 (0.062)**	0.332 (0.188)	-0.394 (0.401)	1.250 (0.017)**	0.419 (0.689)
Changing land	0.319 (0.678)	0.51501 (0.378)	1.128 (0.000)***	0.880 (0.040)**	1.122 (0.006)**	0.875 (0.000)***	-0.176 (0.568)	1.587 (0.000)***	0.701 (0.634)
	0.763 (0.305)	0.533 (0.357)	1.073 (0.000)***	0.433 (0.257)	1.028 (0.011)**	0.724 (0.002)***	-0.035 (0.909)	1.465 (0.000)***	0.618 (0.252)
Increasing irrigation	-0.538 (0.399)	14.851 (0.989)	1.137 (0.000)***	0.771 (0.000)***	-0.771 (0.255)	-0.274 (0.353)	-0.899 (0.132)	2.398 (0.000)***	0.849 (0.427)
	-0.922 (0.149)	14.059 (0.983)	1.022 (0.001)***	1.851 (0.000)***	-0.316 (0.616)	-0.039 (0.892)	-0.951 (0.095)*	2.524 (0.000)***	0.991 (0.353)
Soil conservation	1.000 (0.440)	-0.771 (0.271)	-0.535 (0.044)**	0.403 (0.455)	1.756 (0.000)***	0.151 (0.008)**	0.598 (0.027)**	0.907 (0.022)**	2.197 (0.006)***
	0.817 (0.509)	-0.507 (0.369)	-0.421 (0.099)*	0.384 (0.472)	1.728 (0.000)***	0.252 (0.003)**	0.426 (0.098)*	0.852 (0.003)***	1.495 (0.010)***
Water conservation	-1.548 (0.179)	0.50 (0.447)	0.495 (0.072)*	0.192 (0.809)	1.318 (0.033)**	-0.774 (0.097)*	1.567 (0.000)***	1.012 (0.001)***	1.437 (0.004)***
	-1.338 (0.248)	0.584 (0.348)	0.598 (0.029)**	0.195 (0.802)	1.821 (0.004)***	-0.842 (0.043)**	1.496 (0.000)***	0.903 (0.035)**	1.423 (0.001)**
Crop insurance	0.422 (0.763)	-0.259 (0.633)	-0.266 (0.262)	3.038 (0.000)***	0.773 (0.051)*	0.394 (0.094)*	0.589 (0.036)**	0.762 (0.046)**	0.901 (0.011)***
	0.354 (0.800)	-0.291 (0.595)	0.358 (0.036)**	3.008 (0.000)***	0.762 (0.054)**	0.296 (0.212)	0.576 (0.042)**	0.805 (0.035)**	0.900 (0.012)**
Migration	-0.001 (0.988)	0.067 (0.889)	0.376 (0.013)**	0.78 (0.020)**	0.114 (0.076)*	0.113 (0.049)**	0.484 (0.047)**	0.497 (0.192)	0.616 (0.091)*
	-0.165 (0.772)	-0.261 (0.622)	-0.306 (0.043)**	1.014 (0.003)**	0.1381 (0.073)*	0.141 (0.052)	0.008 (0.076)**	0.541 (0.165)	0.368 (0.038)**
Farm to non farm	-0.669 (0.664)	-0.853 (0.116)	0.213 (0.442)	1.858 (0.104)	1.106 (0.029)*	0.694 (0.072)	0.556 (0.046)**	2.047 (0.000)***	1.052 (0.003)***
	-0.656 (0.646)	-0.770 (0.152)	0.355 (0.483)	1.901 (0.169)	-951 (0.091)*	-0.479 (0.183)	0.406 (0.038)**	1.993 (0.000)***	1.013 (0.004)***
Leasing land	15.121 (0.992)	-0.824 (0.203)	-0.285 (0.410)	-0.907 (0.178)	0.529 (0.482)	-0.552 (0.006)**	0.937 (0.005)**	1.282 (0.018)**	0.937 (0.091)*
	14.869 (0.991)	-0.940 (0.162)	-0.247 (0.483)	-1.400 (0.049)*	0.582 (0.470)	-1.350 (0.035)**	1.081 (0.002)**	1.546 (0.076)*	0.919 (0.021)**
Planting horticulture	-1.631 (0.320)	0.206 (0.776)	0.378 (0.187)	15.717 (0.989)	0.152 (0.804)	0.579 (0.090)**	1.191 (0.000)***	1.486 (0.020)**	0.354 (0.369)
	-1.756 (0.306)	0.219 (0.765)	0.427 (0.135)	14.848 (0.983)	0.165 (0.798)	0.266 (0.473)**	1.194 (0.000)***	1.608 (0.015)**	0.273 (0.480)
Planting vegetables	-0.395 (0.766)	-0.417 (0.390)	-1.113 (0.000)***	3.333 (0.005)**	0.446 (0.002)***	-0.619 (0.008)***	0.649 (0.046)**	0.699 (0.082)*	1.143 (0.002)***
	-0.358 (0.788)	-0.445 (0.359)	-1.044 (0.000)***	3.284 (0.000)***	0.479 (0.005)***	-0.681 (0.000)***	0.560 (0.021)**	0.685 (0.089)*	1.115 (0.003)***

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Author's own calculation

Variables	Own pred. current-Y	Own pred. prev. - Y	Elder or head of HH	Group of farmers	Govt. sources	Random	Television	Radio	Mobile
Crop varieties	-0.801 (0.245)	0.008 (0.986)	0.067 (0.746)	1.317 (0.005)***	0.366 (0.332)	-0.374 (0.087)*	0.491 (0.038)**	0.443 (0.227)	0.559 (0.158)
Changing land	-1.155 (0.884)*	0.404 (0.397)	0.142 (0.489)	0.831 (0.046)**	0.588 (0.130)	-0.138 (0.540)	0.352 (0.124)	0.195 (0.605)	0.430 (0.227)
Increasing irrigation	0.009 (0.987)	0.230 (0.623)	0.391 (0.049)	0.620 (0.072)	0.749 (0.048)**	0.067 (0.738)	0.040 (0.865)	-0.126 (0.729)	0.962 (0.023)**
	-0.741 (0.266)	0.485 (0.308)	0.166 (0.430)	0.538 (0.208)	0.696 (0.059)*	-0.251 (0.289)	-0.144 (0.537)	0.368 (0.345)	1.029 (0.004)**
	-0.626 (0.285)	1.672 (0.107)	0.402 (0.081)*	1.020 (0.003)***	0.127 (0.780)	0.074 (0.743)	0.003 (0.991)	1.169 (0.008)***	-0.024 (0.969)
	1.039 (-0.081)*	1.616 (0.120)	0.280 (0.236)	1.423 (0.000)***	0.497 (0.297)	0.109 (0.635)	0.109 (0.881)	1.236 (0.006)***	-0.130 (0.791)
Soil conservation	0.390 (0.755)	-0.344 (0.601)	1.828 (0.000)***	1.016 (0.082)*	1.456 (0.008)***	-0.028 (0.941)	1.092 (0.001)***	0.322 (0.002)***	0.623 (0.009)***
	0.363 (0.771)	-0.168 (0.779)	1.906 (0.005)**	1.114 (0.060)*	1.494 (0.000)***	-0.412 (0.317)	0.963 (0.001)***	0.203 (0.040)**	0.737 (0.054)*
Water conservation	-1.486 (0.188)	-0.155 (0.798)	0.227 (0.396)	0.638 (0.405)	1.417 (0.015)**	0.220 (0.333)	1.385 (0.000)***	0.661 (0.223)	1.519 (0.000)***
	-1.301 (0.256)	-0.196 (0.746)	0.200 (0.454)	0.607 (0.427)	1.793 (0.003)***	0.195 (0.576)	1.462 (0.000)***	0.521 (0.339)	1.396 (0.001)***
Crop insurance	0.350 (0.801)	-0.316 (0.562)	-0.373 (0.118)	2.978 (0.000)***	0.727 (0.006)***	0.308 (0.192)	0.595 (0.033)**	0.778 (0.041)**	0.955 (0.091)*
	0.418 (0.763)	-0.250 (0.645)	0.927 (0.019)**	3.046 (0.000)***	0.313 (0.085)*	0.429 (0.067)*	0.529 (0.058)**	0.657 (0.086)*	0.9526 (0.092)*
Migration	-0.609 (0.161)	-0.832 (0.372)	0.336 (0.332)	1.881 (0.019)**	-1.067 (0.476)	-0.597 (0.990)	0.536 (0.594)	1.988 (0.150)	1.044 (0.017)**
	-0.8140 (0.161)	-0.473 (0.372)	0.204 (0.332)	0.799 (0.019)**	-0.288 (0.476)	0.002 (0.990)	-0.018 (0.941)	0.553 (0.150)	-0.846 (0.017)**
Farm to non farm	-0.609 (0.673)	-0.832 (0.123)	0.336 (0.198)	1.881 (0.096)*	-1.067 (0.035)**	-0.597 (0.108)	0.536 (0.055)*	1.986 (0.000)***	1.044 (0.003)***
	-0.682 (0.641)	-0.832 (0.107)	0.229 (0.391)	1.823 (0.113)	-1.131 (0.027)**	-0.814 (0.043)	0.559 (0.046)**	2.097 (0.000)***	1.065 (0.003)***
Leasing land	15.104 (0.982)	-0.923 (0.167)	-0.233 (0.508)	-1.387 (0.051)*	0.621 (0.441)	-1.342 (0.036)**	0.960 (0.005)***	1.574 (0.071)*	0.948 (0.018)**
	13.405 (0.984)	-0.951 (0.158)	-0.213 (0.549)	-0.917 (0.263)	0.463 (0.567)	-1.725 (0.022)**	1.027 (0.003)***	1.601 (0.074)*	0.956 (0.017)**
Planting horticulture	-1.716 (0.304)	0.217 (0.765)	0.338 (0.238)	14.956 (0.983)	0.174 (0.078)*	0.487 (0.173)	1.266 (0.000)***	1.534 (0.018)***	0.285 (0.062)*
	-1.716 (0.304)	0.217 (0.765)	0.338 (0.238)	14.956 (0.983)	0.174 (0.078)*	0.487 (0.173)	1.266 (0.000)***	1.534 (0.018)***	0.285 (0.062)*
Planting vegetables	-0.332 (0.804)	-0.485 (0.302)	-1.054 (0.000)***	3.202 (0.006)***	0.403 (0.036)**	-0.609 (0.015)	0.559 (0.021)**	0.738 (0.062)*	1.151 (0.002)**
	-0.406 (0.761)	-0.471 (0.333)	-1.067 (0.000)***	3.247 (0.006)***	0.487 (0.044)**	-0.624 (0.012)	0.559 (0.021)**	0.685 (0.090)*	1.146 (0.002)**

Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Source: Author's own calculation

Table 3.
Logistic regression
model of adaptation
strategies and
climate information-
adaptation-Kharif-
temperature/rainfall

Variables	Personal Experience	Farm to Farm	Agro-field officer	Newspaper	Television	Radio	Mobile
Crop varieties	2.139	0.351	-0.303	2.396	1.092	10.372	0.935
	(0.009)***	-0.654	-0.568	(0.002)***	(0.000)***	-0.474	(0.000)***
	2.377	0.474	-0.255	2.420	1.126	10.367	0.888
Changing land	(0.007)***	-0.555	-0.629	(0.002)***	(0.000)***	-0.979	(0.005)***
	13.655	14.622	0.254	0.474	1.101	0.769	1.406
	-0.982	-0.982	-0.437	-0.134	(0.000)***	-0.474	(0.000)***
Increasing Irrigation	1.369	1.967	0.235	0.576	1.101	12.909	1.303
	-0.261	-0.119	-0.475	(0.069)*	(0.000)***	-0.976	(0.000)***
	2.713	0.893	0.328	2.713	1.165	11.014	0.310
Soil conservation	(0.001)***	-0.246	-0.627	(0.011)**	(0.000)***	-0.989	-0.4
	2.827	1.006	0.573	1.939	1.032	11.497	0.094
	-0.001	-0.194	-0.396	(0.014)**	(0.001)***	-0.988	-0.79
Water conservation	11.839	13.269	0.724	1.266	0.932	14.455	2.172
	-0.984	-0.983	(0.018)**	(0.000)***	(0.001)***	-0.988	(0.000)***
	12.735	14.200	0.490	1.142	0.944	0.985	2.205
Crop insurance	-0.989	-0.988	(0.088)*	(0.000)***	(0.001)***	-0.358	(0.000)***
	10.449	11.175	1.013	1.529	1.137	1.642	1.256
	-0.986	-0.985	(0.000)***	(0.000)***	(0.011)**	(0.045)*	(0.003)***
Migration	11.487	12.199	1.055	1.616	0.981	1.497	1.302
	-0.991	-0.99	(0.000)***	(0.000)***	(0.023)**	(0.066)*	(0.002)***
	14.489	15.290	0.281	1.523	1.053	15.628	1.270
Farm to non Farm	-0.991	-0.99	-0.381	(0.000)***	(0.000)***	-0.996	(0.000)***
	14.488	15.230	0.419	1.522	1.086	15.593	1.183
	-0.991	-0.99	-0.192	(0.000)***	(0.000)***	-0.996	(0.000)***
Leasing Land	14.768	14.694	0.501	0.503	0.510	0.408	0.258
	-0.979	-0.979	(0.075)***	(0.062)*	(0.012)**	-0.608	-0.258
	2.044	1.045	-0.440999	0.596	0.408	0.665	0.336
Planting Horticulture	-0.023	-0.195	-0.118	(0.035)**	(0.043)**	-0.398	-0.148
	12.366	12.209	1.145	0.506	1.385	1.879	-0.340
	-0.989	-0.989	(0.000)***	(0.014)**	(0.000)***	(0.004)***	-0.314
Planting vegetables	13.333	13.248	1.157	0.480	1.365	1.778	-0.179
	-0.993	-0.993	(0.000)***	(0.023)**	(0.000)***	(0.006)***	-0.59
	12.318	12.744	0.814	0.908	0.731	1.616	0.923
Planting vegetables	-0.994	-0.994	(0.023)**	(0.021)**	-0.178	(0.005)***	(0.089)*
	12.357	13.054	0.775	0.893	0.893	1.698	1.202
	-0.996	-0.996	(0.032)***	(0.025)**	(0.075)*	(0.004)***	(0.049)**
Planting vegetables	12.302	12.262	0.232	1.444	1.330	1.196	0.083
	-0.991	-0.992	(0.075)*	(0.000)***	(0.003)***	(0.036)***	(0.030)**
	12.246	12.207	0.189	1.607	1.265	1.083	0.086
Planting vegetables	-0.991	-0.991	(0.056)*	(0.000)***	(0.005)***	(0.056)*	(0.029)**
	1.097	1.071	0.228	0.993	0.818	0.751	0.082
	-0.338	-0.398	(0.064)*	(0.000)***	(0.000)***	(0.194)	(0.024)**
Planting vegetables	1.074	1.049	0.346	1.074	0.867	0.792	0.079
	-0.4	-0.411	(0.074)*	(0.000)***	(0.000)***	-0.171	(0.034)**

Table 4.
Logistic regression model of adaptation strategies and extension services-adaptation-Rabi-temperature/rainfall

Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$
Source: Author's own calculation

Variables	Personal Experience	Farm to Farm	Agro-field officer	Television	Radio	Mobile	Newspaper
Crop varieties	13.587	13.750	0.826	0.767	0.394	1.391	0.494
	-0.983	-0.983	(0.001)***	(0.002)***	(0.058)*	-0.19	(0.026)**
	1.0561	1.1504	0.8424	0.8934	0.0554	1.0122	0.4010
Changing land	-0.397	-0.357	(0.001)***	(0.000)***	-0.801	-0.19	(0.087)*
	15.495	15.446	0.268	0.768	0.508	0.864	0.765
	-0.988	-0.988	-0.304	(0.002)***	(0.010)**	(0.092)*	-0.449
Increasing irrigation	0.970	1.114	0.965	0.607	-0.696	0.906	0.855
	-0.444	-0.379	(0.000)***	(0.015)**	(0.004)***	(0.076)*	(0.001)***
	16.391	16.376	0.320	1.128	0.627	0.069	-0.050
Soil conservation	-0.988	-0.988	-0.388	(0.002)***	(0.006)***	-0.949	-0.847
	2.531	2.519	0.269	1.073	0.822	1.109	-0.041
	(0.024)**	(0.024)**	-0.47	(0.004)***	(0.000)***	-0.92	-0.876
Water conservation	11.858	12.318	0.652	1.174	1.117	0.889	0.871
	-0.993	-0.992	(0.035)**	(0.001)***	(0.031)**	-0.116	(0.061)*
	11.492	11.811	0.964	1.304	0.556	0.885	0.794
Crop insurance	-0.99	-0.99	(0.002)***	(0.000)***	-0.212	-0.119	(0.085)*
	10.344	11.510	0.833	1.483	0.687	1.481	2.063
	-0.988	-0.986	(0.002)***	(0.000)***	-0.104	(0.063)*	(0.000)***
Migration	10.350	11.530	0.737	1.491	0.684	1.530	2.082
	-0.988	-0.98	(0.005)***	(0.000)***	-0.105	(0.054)*	(0.000)***
	14.497	15.180	0.372	1.615	1.066	15.611	1.117
Farm to non farm	-0.991	-0.99	(0.042)**	(0.000)***	(0.000)***	(0.096)*	(0.000)***
	14.529	15.281	0.297	1.539	1.043	15.627	1.210
	-0.991	-0.99	(0.053)*	(0.000)***	(0.000)***	(0.096)*	0
Leasing land	15.431	15.334	0.130	0.444	0.474	0.271	-0.369
	-0.983	-0.983	-0.626	(0.090)*	(0.022)**	(0.089)*	-0.107
	15.431	15.334	0.130	0.444	0.474	0.271	-0.369
Planting horticulture	-0.983	-0.983	-0.626	(0.090)*	(0.022)**	(0.089)*	-0.107
	13.278	13.176	1.083	0.420	1.510	1.904	-0.203
	-0.992	-0.993	(0.000)***	-0.18	(0.000)***	(0.004)***	-0.541
Planting vegetables	13.026	12.869	1.145	0.506	1.490	1.893	-0.325
	-0.992	-0.992	(0.000)***	-0.114	(0.000)***	(0.004)***	-0.338
	10.501	11.086	0.868	1.011	0.764	1.603	1.202
Planting	-0.991	-0.99	(0.017)**	(0.013)**	-0.2	(0.006)***	(0.054)*
	11.259	11.766	0.914	1.107	0.731	1.592	1.094
	-0.993	-0.993	(0.014)**	(0.009)***	-0.222	(0.006)***	(0.083)*
Horticulture	12.189	12.196	-0.212	1.384	1.493	1.165	0.016
	-0.991	-0.991	-0.511	(0.000)***	(0.002)***	(0.041)**	-0.966
	12.189	12.196	-0.212	1.384	1.493	1.165	0.016
Planting	-0.991	-0.991	-0.511	(0.000)***	(0.002)***	(0.041)**	-0.966
	12.947	12.941	-0.307	1.032	0.904	0.804	-0.015
	-0.982	-0.982	-0.225	(0.000)***	(0.000)***	-1.165	-0.948
Planting	1.029	1.022	-0.303	1.038	0.864	0.799	-0.021
	-0.424	-0.427	-0.232	(0.000)***	(0.000)***	-0.167	-0.927

Table 5.
Logistic regression
model of adaptation
strategies and
extension services-
adaptation-Kharif-
temperature/rainfall

Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Source: Author's own calculation

Potentially the extension services are always defined as the significant factor that can influence the adaptive capacity and enhance the adaptation decision of farm households to cope with climate change (Maddison, 2007; Nhemachena and Hassan, 2007). The introduction and diffusion of new technology depend on the useful information channel to accept the latest technology (Wozniak, 1984). The technological diffusion literature (Adesina and Baidu-Forson, 1995) hypothesized that the better exposure of information and technical skills through efficient extension services is positively related to adaptation. Our results align with the previous studies (Deressa *et al.*, 2008; Keil *et al.*, 2008), indicating a positive relationship between adaptation strategies and agricultural extension services, specifically with institutional arrangements and primary sources (Television, Radio, Mobile and Newspaper). The probability of adopting different crop varieties is significantly high if the farm household accessed T.V. newspaper and radio to enhance their agricultural knowledge. The government provides information about the different varieties such as flood and drought resilience through the agricultural specific program, which helps farmers get information about the suitable varieties. The farmers usually get information about crop varieties through these sources and agricultural officers increase confidence among farmers and provide assistance to harvest these crops. The likelihood of adaptation of changing land under cultivation increased if the information is accessed through an agricultural officer, television, newspaper in Kharif for temperature and rainfall changes. The agricultural officers usually help the farmer maintain their soil nutrition and rotate the land under cultivation. Increasing irrigation is the other important adaptation strategy which highly influenced by the institutional arrangements. The government provides subsidies through agricultural officers to water pumps to increase irrigation. Farmers usually get information about these subsidies through newspapers and radio. The technological and knowledge-intensive strategies such as soil conservation and water conservation are positively correlated with the agricultural officer, Television, Radio, mobile and newspaper in Kharif for both temperature and rainfall changes. Educated farmers assess information about the scientific package of these strategies through the agricultural officer. The government helps them learn about conservative practices through KVK and primary sources. The institutional arrangements also increase the likelihood of crop insurance. This study has found a strong positive relationship between these arrangements and crop insurance. The government used primary sources to improve crop insurance awareness programs and compensate for crop loss through agricultural officers. The income diversification strategies such as leasing land and changing land from farm to non-farm activities are likely to increase in those who are assessing the information through television, radio, newspaper and mobile. Farmers usually get information about these incomes generating non-farm activity through these sources. The large farm landholders divert some of their lands for these activities – the likelihood of planting horticulture and vegetable increases if the farmers were getting assistance from institutional arrangements. The government also provides knowledge about horticultural crops through specialized agricultural programs on television and radio.

6. Conclusion

This study has conducted the micro-level assessment of different climate information sources and agricultural extension services used by the farm household in the study area. The results of this signify that farmers have more confidence in information gained from their past experiences and knowledge gained from their fellow-farmers on-farm management practices, representing the importance of collective actions. The other effective extension services are the radio and newspapers. The study finds the limited influence of

agricultural field officers in enhancing learning benefits by instructions for the farmers. For credit sources, co-operative societies and banks are the most prominent finance sources in the study area. Despite this, farmers reported facing problems in availing loans due to bankers' wrong attitude, stringent security norms and high-interest rates.

The efficiency of extension services is crucial to articulate effective agricultural adaptation and mitigation approaches. The study tried to understand the importance of different extension options in farmers' processes to tackle risks from climatic incidences and other farm management decisions. The study identifies that both climate extension services and agricultural extension services complement the farming decisions of farmers. Therefore, policies in the delivery of extension services should prioritize the two extension types distinctly to enhance the efficacy of extension arrangements in climate change adaptation. One critical inference that the study draws is that the farmers rely more on their own experience and discussion with fellow farmers. The extension service providers need to recognize farmers and villagers as the extension system's main stakeholders by strengthening their social networks through active interactions and community engagements. Our results emphasize the acceleration in rural and agricultural investment to support information sources' channel to enhance households' ability to seasonal and appropriate adaptation decisions that affect the rural well-being. Therefore, policy-makers should extend and improve upon such services, ensuring that they reach small-scale subsistence farmers. Providing support to the most impoverished farmers is critically important, given that this group is the most vulnerable to long-term climate change and least equipped to make the changes needed to sustain their livelihoods in the face of the climate threat. Addressing these market imperfections, lack of access to information and credit and ensuring effective targeting requires strong leadership and government involvement in planning for adaptation and implementing measures to facilitate adaptation at the farm level. Farmers mainly rely on the farmer to farmer extension services and find information through television and radio useful if effectively provided. In a few years to come, mobile phones are likely to become a critical source of agriculture and climate extension services. Increased penetration of low-cost smartphones and decreasing mobile data prices have enhanced mobile phone usage in agricultural management. Digital literacy helps overcome the barriers of education constraints, information asymmetry and cost hurdles and strengthen smallholder farmers' adaptive capacity by establishing direct connections between farmers, state government, agricultural research organizations and extension and technology providers. Digital integration of agriculture actors (farmers) in the agriculture value chain can enhance agriculture management's efficiency and accuracy under climate change conditions by delivering accurate and real-time information for farmers' decision-making. To improve resilience to cope with climate change, there is a need to have more support from the public and private sector in terms of investment in capacity-building programs on anticipatory strategic decision-making. These investments will significantly increase the likelihood of the use of adaptation strategies of farm households. Designing policy aiming at capacity building on the farming system will potentially enhance the appropriate and on-time adaptation decision.

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Corresponding author

Chandan Kumar Jha can be contacted at: chandan1929@gmail.com