Research Article

Indian Journal of Extension Education
Vol. 59, No. 3 (July–September), 2023, (32-37)

ISSN 0537-1996 (Print)
ISSN 2454-552X (Online)

Effectiveness of Adaptation Mechanisms of Farmers in Flood Prone Area of Bihar

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ARTICLE INFO

Keywords: Flood, Farm livelihoods, Adaptation, Technological innovation, Institutional innovation

http://doi.org/10.48165/IJEE.2023.59306

Conflict of Interest: None

ABSTRACT

The state of Bihar is most vulnerable to floods in India and farmers in flood-prone areas have undergone adaptation through a combination of technological and institutional innovations. The present study aimed to explore the effectiveness of adaptation mechanisms as perceived by the farmers to mitigate the negative effects of flooding on their livelihoods covering a random sample of 80 farmers in flood-prone areas of Bhagalpur district in Bihar during 2022. The findings suggest that farmers have developed a range of adaptation strategies to cope with the impacts of flooding, the most effective being the changes in cropping patterns, adoption of flood-resistant paddy varieties, pest and disease resistance vegetable varieties, vaccination of livestock and management of fish ponds. Institutional innovations like self-help group, farmers interest group, farmers club, seed bank, village level weather advisories were also found crucial to enabling farmers to adapt to floods. Income, cultivated land, information availability, and use of communication sources have explained about 50 per cent variation in the perceived effectiveness of adaptation by farmers. Future extension efforts need to strengthen the institutional infrastructure to promote the flood resilient technologies to reduce the vulnerability of farm livelihoods.

INTRODUCTION

Worldwide flood damage to agriculture, households, livelihood systems, infrastructure, and public utilities each year. India is highly vulnerable to the impacts of climate change due to its reliance on agriculture, which provides livelihoods for 58 per cent of the country's population (Yadav et al., 2022). Flooding constitutes the largest share of natural disasters in India since 2008, and as much as 40 million hectares of land are regularly exposed to floods, making flooding one of the highest-priority disasters to be handled by regional authorities (National Disaster Mitigation Authority, Government of India, 2022). Numerous steps are taken by the Indian government to manage natural flood occurrences and minimize the resulting damage to manageable limits. Some of these steps include flood task forces, working groups, committees for water resource management, emergency action plans, dam safety organizations, Rashtriya Barh Aayogh (National Commission on Floods), and other such bodies (Mohanty et al., 2020). Indian states, which are in the Indo-Gangetic plains and northeastern part of India, are facing severe flood problems. Bihar is India's most flood-prone state. About 76 per cent (79.11 million) of Bihar's population lives in flood-prone areas, and over 73 per cent (68800 square kilometers) of the state's land area is classed as flood-prone (WRD, 2015).

Climate change has disrupted the balance of agriculture, food, and livelihood systems, putting them in jeopardy (Das and Ghosh, 2018). However, when farmers embrace technologies that help to tackle climate change, they can enhance their resilience to natural risks and restore equilibrium to the system (Das et al., 2020). Adaptation strategies are necessary to mitigate and cope with the effects of climate change. These strategies are designed to help individuals, communities, and organizations adjust their behavior,

Received 03-05-2023; Accepted 31-05-2023

practices, and infrastructure to reduce the negative impacts of climate change and increase their resilience to future changes (Shanabhoga et al., 2023). Agricultural adaptation entails adjustments of agronomic and agro-management practices towards the prevailing climate conditions to reduce the vulnerability and ensure a climate-resilient farming system (Jha et al., 2017). The farm households adapt by adopting on-farm and non-farm strategies (Thennakoon et al., 2020). Successful adaptation will require multiple stakeholders, including farmers, policymakers, extension agents, NGOs, researchers, communities, and the private sector (Bryan et al., 2009, 2013; Fraser et al., 2011). Interventions that provide long-term and sustainable benefits while also addressing resource conservation and strengthening local institutions have been found to be most effective. An approach has been developed to promote climate resilient interventions in natural resource management, crop production, livestock and fishery, and institutional mechanisms (Prasad et al., 2015). Resilient technologies related to crop production, crop protection, crop improvement, land and water management, breeding, feeding, health care and management practices of livestock help in attaining sustainable productivity and bringing resilience to agriculture and farm livelihoods in crop-livestock based agricultural production systems (Aryal et al., 2018). On this backdrop, the present study was undertaken to assess the effectiveness of adaptation mechanisms to tackle the flood from farmers' perspectives and unravel the determinants of perceived effectiveness of adaption to flood by the farmers in Bihar.

METHODOLOGY

Bihar is the most flood-affected state in India having 16.5 per cent of the total flood area and 56.5 per cent of the total flood-affected people of the country. Therefore, the present study was purposively conducted in Bihar. Amongst the eight highly flood prone districts of Bihar, Bhagalpur district was selected from where two blocks, namely Sabour & Sultanganj, four villages from each block and 10 farmers from each village were sampled using a simple random sampling technique. Thus, a total of 80 farmers were chosen as the respondents for present study. The farmers' socio-personal, socioeconomic, and communicational attributes were taken into account as predictor variables or independent variables, which were measured with a schedule developed for the purpose. The effectiveness of adaptation mechanisms in terms of technological and institutional interventions as perceived by the farmers was measured as dependent variables. The technological interventions were categorized as natural resource management (soil and water), crop farming, livestock farming, and fish farming technologies/ practices. A 5-point continuum scale was used to record the farmers' responses on each intervention that was ranging from Very highly effective (5) to very low effective (1). Data were gathered from the selected respondents through an interview schedule that was developed and pretested before administration. The collected data were compiled and analyzed to obtain descriptive statistics like frequency, percentage, mean, standard deviation, and range, as well as relational statistics such as correlation and multiple regression models.

RESULTS AND DISCUSSION

The perceptions of farmers on flood resilient technological interventions were categorized under natural resources management, crop farming, livestock farming and fish farming (Table 1). The natural resource management innovations adopted by the farmers

Table 1. Adaptation of technological innovations for flood resilient farming

S. No.	Flood resilient technological intervention	% of respondents adopted	Mean perceived effectiveness score (SD)	Effectiveness index (%)
Natural Resource Management (NRM) interventions				
1.	Broad bed furrow	21.25	2.59 (0.87)	51.80
2.	Conservation tillage	10.00	3.25 (0.71)	65.00
3.	Land modification	28.75	2.77 (0.75)	55.40
4.	Water harvesting	3.75	3.33 (0.58)	66.60
Crop farming interventions				
1.	Flood resistant variety of paddy (Swarna Sub-1)	27.50	3.18 (0.96)	63.60
2.	Early maturity variety of maize (Sabour Shankar Makka-1)	10.00	3.50 (0.53)	70.00
3.	Pest and disease resistant variety of vegetables	38.75	3.23 (0.76)	64.60
4.	Short duration variety of paddy (Prabhat)	26.25	3.24 (0.54)	64.80
5.	Crop diversification (through growing of oilseed, pulses etc.)	45.00	3.42 (0.73)	68.40
6.	Cultivation of maize	15.00	3.17 (0.72)	63.40
7.	High yielding variety of paddy (Rajendra Sweta)	6.25	3.20 (0.84)	64.00
8.	Mentha cultivation	2.50	3.50 (0.71)	70.00
Livestock farming interventions				
1.	Preventive vaccination for FMD, goat pox etc. in livestock	73.75	3.86 (0.71)	77.20
2.	Cattle feed i.e., mineral mix	8.75	2.86 (0.69)	57.20
3.	Community land for fodder production	11.25	2.78 (0.83)	55.60
Fish farming interventions				
1.	Fish feed i.e., mineral mixture	5.00	3.25 (0.50)	65.00
2.	Management of fish ponds/tanks during water scarcity & excess water situation	8.75	3.43 (0.53)	68.60

of the flood prone areas in Bhagalpur district were water harvesting, conservation tillage (zero tillage in wheat, and maize), land modification and broad bed furrow (water-saving irrigation method) with mean perceived effectiveness index scores 3.33, 3.25, 2.77 and 2.59, respectively. The effectiveness index of different flood resilient natural resource management technologies ranged from 51.80 per cent to 66.60 per cent. Even though water harvesting and conservation tillage were perceived as more effective very few farmers adopted those which may be attributed to the high cost and unavailability of required infrastructure and extension advisory services. Land modification and broad bed furrow were adopted by more than 20 per cent respondents, adoption of these practices is also required to be increased.

With respect to the adaptation mechanisms in terms of crop farming technologies adopted by the respondent farmers, the most effective crop farming technologies include cultivation of early maturity variety of maize and Mentha cultivation followed by crop diversification, growing of short duration variety of paddy, pest and disease resistant vegetable varieties, high yielding variety of paddy, flood resistant Swarna-Sub1 variety of paddy, and, cultivation of maize with mean perceived effectiveness scores of >3.0 indicating the high level of effectiveness of flood resistant crop farming technologies. The effectiveness index ranged from 63.40 per cent to 70 per cent for aforesaid technological innovations related to flood resilient crop farming. Crop diversification, pest and disease resistant vegetable varieties, flood resistant Swarna-Sub1 variety of paddy, and short duration variety of paddy (Prabhat) were adopted by many of the respondents while rest were practiced by very few. Extension advisory services need to promote the technologies like cultivation of early maturity variety of maize and Mentha cultivation which were perceived highly effective but low adoption.

The most adopted livestock farming technology was preventive vaccination in livestock with a high perceived effectiveness (77%). Use of community land for fodder production in flood prone areas and cattle feed was adopted by very few with relatively low perceived effectiveness (56-57%). Livestock farming technologies like preventive vaccination in livestock (BQ, FMD, HS, for bovines, goat pox, etc.) and cattle feed (mineral mix, urea and molasses, etc.) were promoted by Block Veterinary Clinic; however, community land for fodder production during or after the flood was self-promoted practices by the farmers. Flood resilient fish farming practices were adopted by very few respondents despite both were perceived as highly effective (65-68%). Management of fish ponds and use of fish feed were promoted by Krishi Vigyan Kendra and Office of Fisheries Development Officer at block level.

The institutional innovations were adopted by the respondents to combat the negative impact of the flood in their farming practice. Most of the respondents were associated with SHGs/ FIGs and Kisan club/farmers club with the highest perceived effectiveness of 68.80 per cent and 64 per cent, respectively. The other two institutional innovations preferred by the respondents were seed bank and weather-based agro-advisory at the village level with a perceived effectiveness index of 55.40 per cent and 57 per cent, respectively. Effectiveness as well as availing the services of fodder bank and village climate resilience development committee was quite low. Institutional innovations like SHGs and FIGs were promoted by Agriculture Technology Management Agency (ATMA) whereas Kisan club/Farmers club were promoted by the National Bank for Agriculture and Rural Development (NABARD) and institutional innovations like seed bank, weather-based agro-advisory at the village level, fodder bank and Village Climate Resilience Development Committee were promoted by Krishi Vigyan Kendra. Perceived effectiveness scores indicate a medium level of effectiveness of most of the institutional interventions to adapt with floods that require strengthening.

The influence of socio-personal, socio-economic, and communicational attributes of respondent-farmers as independent variables and effectiveness of technological adaptation and institutional innovation as dependent variables were assessed through correlation and multiple regression analyses (backward elimination method). It is evident that monthly income, annual family income, farming expenditure, resource position, total land, cultivated land, financial safety, and information availability are significantly and positively correlated with the perceived effectiveness of technological adaptation of farmers in flood prone areas (Table 3). While, the perceived effectiveness of institutional innovations of the farmers was having significant association with the attributes of farmers like monthly income, farming expenditure, resource position, total land, cultivated land, financial awareness, financial safety, mass media exposure, use of personal localite source of information, overall communicational sources use and information availability with significant and positive correlation coefficient values.

The multiple regression analysis was conducted following backward elimination methods (Table 4) in which nineteen models were generated eliminating eighteen out of 20 attributes over

Table 2. Adaptation through institutional innovations in flood prone area

S.No.	Institutional innovation	Percent of respondents adopted	Mean perceived effectiveness score (SD)	Effectiveness index (%)
1.	SHGs/ FIGs	93.75	3.44 (0.66)	68.80
2.	Kisan club/Farmers club, etc.	83.25	3.20 (0.77)	64.00
3.	Seed bank	48.75	2.77 (0.74)	55.40
4.	Weather based agro-advisory at village level/ climate literacy through a village level weather station	42.50	2.85 (0.78)	57.00
5.	Fodder bank	6.25	2.20 (0.84)	44.00
6.	Village Climate Resilience Development Committee / Village Climate Risk Management Committee	3.75	2.67 (0.58)	53.40

Table 3. Correlation between attributes of farmers and their perceived effectiveness of adaptation to floods

S.No.	Attributes of farmers	Correlation Coefficient (r) Effectiveness of adaptation	
		Technological innovation	Institutional innovation
1.	Age	-0.098	-0.066
2.	Level of education	0.156	0.192
3.	No. of earning member in the family	0.057	0.030
4.	Organizational participation	0.120	0.127
5.	Monthly income	.340**	.253*
6.	Annual family income	.345**	0.218
7.	Monthly expenditure	0.135	0.084
8.	Farming expenditure	.340**	.374**
9.	Resource position	.339**	.252*
10.	Total land	.606**	.532**
11.	Cultivated land	.745**	.720**
12.	Credit behaviour	-0.047	-0.098
13.	Financial awareness	0.060	.256*
14.	Financial safety	.295**	.357**
15.	Use of mass media source of information	0.128	.242*
16.	Use of personal cosmopolite source of information	-0.039	0.057
17.	Use of personal localite source of information	0.156	.269*
18.	Overall communication source use	0.091	.260*
19.	Information availability	.351**	.533**
20.	Perceived flood intensity during last 10 years	0.008	-0.027

** Significant at 1% level and * Significant at 5% level

Table 4. Multiple regression (backward method) between perceived effectiveness of technological and institutional innovations, and attributes of farmers

S.No.	Attributes of farmers (independent variables)	Standard error	Beta coefficient	t-value	Significance
Perceived effectiveness of technological innovations (dependent variable)					
	(Constant)	3.090	(59.873)	19.377	0.000
1	Cultivated land	0.475	0.787	10.102	0.000
2	Overall communication source use	0.066	0.1419	1.810	0.074
	R=0.757, R square= 0.574, F value= 51.771**				
Perceived effectiveness of institutional innovations (dependent variable)					
	(Constant)	1.823	(49.716)	27.266	0.000
1	Monthly income	0.000	-0.214	-2.489	0.015
2	Cultivated land	0.537	0.705	7.681	0.000
3	Information availability	0.041	0.276	3.341	0.001
	R= 0.775, R square =0.601, F value= 38.089**				

nineteen steps. The analysis revealed that farmers cultivated land and overall communicational sources use explained 57.4 per cent (R^2=0.574) of variation in the perceived effectiveness of technological innovation. Multiple regression (backward elimination method) analyses were also carried out between attributes of farmers as independent variables and the perceived effectiveness of institutional innovations as dependent variables (Table 4). The analysis revealed that monthly income, cultivated land and information availability collectively determined the 60 per cent (R^2=0.601) variations on the perceived effectiveness of institutional innovations. The regression coefficient of monthly income (-0.214) is found negative which implies better-perceived effectiveness of institutional innovations by relatively poor farmers having less income. It reiterates that small and marginal farmers/ poor farmers require empowerment and capacity building through their involvement in SHGs, FIGs, Farmers Clubs, farmer producer organization (FPOs) etc.

In this present study adaptation of technological innovations is broadly categorized under NRM, crop farming, livestock farming and fish farming. Similar classifications are made by Venkateswarlu et al., (2012) & Prasad et al., (2014). Adjustment in sowing time, crop diversification, crop rotation and shifting to new crops are some of the on-farm practices adopted by farmers (Sehgal et al., 2013). Sharma et al., (2019) reported several location-specific climate-smart crop production technologies as a subset of resilient measures, viz. stress-tolerant rice varieties (e.g., Swarna sub-1, MTU-1001 and MTU-1140) in flood-prone areas, lodging-resistant paddy cultivar (Bina Dhan), resource-saving through non-puddled transplanted rice, direct-seeded rice, diversification with green gram and ground nut, and improved maize production practices for plateau ecology. In another study in Odisha, the major interventions prioritized are mainly flood tolerant varieties of paddy, disease resistant varieties of pulses, intercropping, preventive vaccination in livestock, high yielding breeds of livestock, cattle feed mixture (Das et al., 2022). Branca et al., (2021) have mentioned that technologies like minimum tillage, crop residues incorporation, use of cover crops, and inclusion of legumes has relatively higher economic returns. Conservation agriculture, rainwater harvesting, drought tolerant and early maturity seed varieties are the most suited climate resilient technologies for smallholder South African farmers; however, due to initial costs and management intensity, the adoption of first two practices is low while the seed varieties are widely preferred (Senyolo et al., 2018). The present study shows a relatively low level of adoption of flood resilient technologies despite being perceived as highly effective. The low rate of adoption and/ or non-adoption of climate smart agriculture technologies is attributed to the lack of involvement of farmers. It is also emphasized that prioritization and upscaling of climate smart agriculture require farmers' involvement (Shitu et al., 2018; Das et al., 2022; Azadi et al., 2021; Branca et al., 2021; Das & Ghosh, 2019).

To make technological innovations useful respondent farmers of present study frequently adopted institutional innovations such as the memberships in SHGs, farmers clubs, and the establishment of the seed bank, which are promoted by different organizations like KVK, State line departments functioning at Block level, etc. Venkateswarlu et al., (2012) also specified the importance of institutional interventions such as village-level weather advisory committees, seed banks, fodder banks, customs hiring centers, nursery enterprises, crop insurance systems for increasing farmers' resilience, FPOs and so on to establish at grass root level / village level with the participation of all stakeholders to put the flood resilient technologies into practices. Institutional innovations are key in putting scientific technologies in practice; therefore, the present research also focuses on institutional innovations. Tanti et al., (2022) in their study in the eastern Indian state of Odisha have reported the role of institutional factors in climate smart technology adoption, which are government extension service, farmer field school, subsidies, access to energy, and perception of climate shocks. Promotion and capacity building of farmers' groups to sustain climate smart agricultural system is also mentioned. It underlines the importance of agricultural policies to improve institutional support for upscaling climate resilient technologies.

CONCLUSION

The adaptation of farmers in flood-affected areas of Bihar highlights their resilience and ability to cope with the frequent flooding. One key adaptation strategy has been the adoption of flood-tolerant crop varieties and farming practices that can withstand the waterlogging and soil erosion caused by floods. Farmers have also diversified their income sources by engaging in diversified farming activities such as livestock rearing. Additionally, many farmers have availed community-based flood early warning systems, which help them to prepare for floods and reduce the risk of crop and livestock loss. Overall, the farmers have perceived adaptation strategies in flood-affected areas effective; however, the extent of adoption requires improvement. Therefore, climate smart extension through capacity building of farmers and institutional strengthening would improve farmers' abilities to innovate and adapt to changing environmental conditions. The resilience and adaptability of farmers is the key for sustainable development in the face of climate extremes.

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