



Impact of climate services on the operational decision and economic outcome of wheat (*Triticum aestivum*) and rice (*Oryza sativa*) cultivation in Haryana

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ABSTRACT

The management of weather and climate risks in agriculture has become an important issue. Application of weather forecast and related advisories offer a great potential to make better-informed decisions and help farmers in adapting climate change. In the present study, weekly forecast-based crop advisories were prepared and disseminated among the farmers of Jind, Rothak and Hisar districts of Haryana. From each block, three experimental villages i.e., one each village receiving weather based advisory services through either of Whatsapp, Text SMS and Mobile Application and one control village (not receiving weekly advisory services) were chosen and thus resulting in 18 experimental villages and 6 control villages. Difference in Difference (DiD) research design was used to study the impact of advisories on farm operational decision making as well as economic outcome of the wheat (*Triticum aestivum* L.) and paddy (*Oryza sativa* L.) cultivation. Average treatment effect of advisories in both crops was found to be significant in all the farm operational decisions except weed management. Reduced seed rate of 3.47, 3.99 and 3.84 kg/acre, reduction in 14.93, 16.92 and 20.23 kg/acre of fertilizer application and saving 0.25, 0.31, 0.34 number of sprays in wheat crop and similarly reduced seed rate of 1.05, 1.15 and 1.27 kg/acre, reduction in fertilizer usage by 18.52, 20.00 and 20.91 kg/acre, and also saving 0.96, 1.02 and 1.15 number of sprays in paddy crop was observed from Text SMS, WhatsApp and Mobile App treatment groups, respectively. The study has also indicated reduced input cost of ₹943.45, 1026.05 and 1168.33/acre in wheat and similarly ₹1439.98, 1566.86 and 1670.22/acre in paddy from Text SMS, WhatsApp and Mobile App treatment groups, respectively. The provision of seamless weather-based advisories for agriculture need to become a national adaptation priority in adapting to changing climate of today and of the future.

Keywords: Adaptation, Climate change, DiD, Impact, Weather based advisory services

Indian agriculture in general and food security, in particular, are under threat from climate change (Rao *et al.* 2016). Given its location, relatively low level of development, and large population, India is highly vulnerable to climate change (INCCA 2010, Mehajan *et al.* 2019). Studies revealed a marked temperature rise, a recurrence of heat waves, extreme rainfall events, droughts and strong cyclonic events (Rohini *et al.* 2016, Sharma and Majumder 2017, Ray *et al.* 2019). At present, around 20–80% of the inter-annual variability of crop yields is associated with weather phenomena and 5–10% of agricultural production losses are associated with climate variability (FAO 2019). According to Aggarwal and Mall (2002), the yield loss of the rice (*Oryza sativa* L.) crop due to temperature increase of 1–2°C could range from 3–17% in various regions of the nation. Global warming may change the dynamics and

severity of crop damage caused by insects, plant pathogens, and other pests and diseases (Cannon 1998, Scherm 2004). Around 87% of the variation in the rice yield and 93% of the variation in the wheat (*Triticum aestivum* L.) yield is explained by climate variables in India (Guntukula 2019). Hence, the weather is one of the key factors of agricultural production (Iizumi and Ramankutty 2015). The weather varies with space and time, so its forecast can help to reduce farm losses (Javaid *et al.* 2023). An agriculturally applicable forecast is helpful not only for effective farm input management, (Gadgil 1989) but also allows farmers to plan their farm-level operations and is useful in making decisions about planting, harvesting dates, and investment in farm inputs, reducing cost and crop losses (Rathore and Maini 2008, Singh *et al.* 2019). Therefore, possible adaptation strategies like weather-based service are need of the hour to make the agriculture sector climate resilient.

Weather based advisory services are the decision-making support tools developed by transforming climate information into relevant advisory services that assist decision-making by individuals and organizations of society.

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(Tall and Njinga 2014). Such services meet the real-time needs of farmers and contribute to weather-based crop management operations thereby by assisting farmers in taking advantage of benevolent weather and in minimizing the adverse impact of malevolent weather (Rathore and Chattopadhyay 2016, Chattopadhyay and Chandras 2018). Provision of accurate and locally-appropriate climate and weather information play a vital building block for increasing the resilience of communities to climate change, diseases, and disasters (Stigter 2007, Chattopadhyay and Chandras 2018). In India, agro-meteorological service bulletins at the district level, containing weather-based crop advisories rendered by the India Meteorological Department (IMD), Ministry of Earth Sciences in collaboration with, the Indian Council of Agricultural Research and State Agricultural Universities is a step towards information-based crop/livestock to contribute to weather management strategies geared to help farmers maximize output and avert crop damage or loss (Chattopadhyay and Chandras 2018, Chaubey *et al.* 2018).

Therefore, to address these alarming changes in climate taking place at present and the predicted changes for the future which have considerable influence on farmers, possible adaptation strategies like climate/weather services in making the agriculture sector a climate-smart and its role on farmers' decision-making and economic outcome for proper policy formulation and implementation is need of the hour. Thus, the study made an effort to assess the impact of weather based advisory services on the operational decision-making by the respondents as well as economic outcome of the farm in Haryana state. The climate/weather services will help the famers to adapt to the changing climatic scenario and also policy makers to consider these services as an effective and efficient adaptation stagey in the midst of climate change to maintain the sustainable production.

MATERIALS AND METHODS

Sampling and sample size: Multi-stage sampling technique was used in this study to select the required sample size. Initially, Haryana state was selected purposively as the state is one of the leading producers of paddy and wheat crops as well as highly prone to climate extremes as mentioned above. Secondly, three districts from Haryana i.e. Rohtak, Hisar and Jind were selected randomly. From each selected district two blocks were chosen randomly. As a result, the present study covered a total of six blocks, viz. Agroha and Barwala in the Hisar district, Pillukhera and Safindo in the Jind district, and Meham and Rohtak in the Rohtak district. Further from each block, four villages were selected randomly. So, a total of 24 villages were included in the study. Finally, farmers who were growing at least 2 major crops of the state i.e. paddy and wheat for last 10 years were considered as the sample for the study and were identified with the help of key communicators i.e., sarpanch and agriculture officers. A total of 15 farmers were selected randomly from each selected village. Thus, the sample size for the study was a total of 360 farmers.

Research design: Impact assessment, study the changes that can be attributed to a particular intervention such as a program or service or project. In this study, Difference in difference (DiD) quasi-experimental research design (Fig. 1 and 2) was used to compare the changes in outcomes over time between units that are enrolled in a programme (the treatment group) and units those are not (the comparison group). Pre-treatment and post-treatment measurement of the treatment group and control group done in different time periods. This allows us to correct for any differences between the treatment and comparison groups that are constant over time. After-before difference in outcomes in the treatment group was calculated, and from this difference the after-before difference in the control group was subtracted.

If pre intervention outcome of the treatment group is D_0 , Post intervention outcome is D_1 and Pre intervention and Post intervention out comes of control group is C_0 and C_1 respectively then,

$$\text{IMPACT} = (D_1 - D_0) - (C_1 - C_0)$$

Difference in difference quasi experimental research design was usually implemented as an interaction term between time and treatment group dummy variables in a regression model which is as follows:

$$Y = \beta_0 + \beta_1[\text{Time}] + \beta_2[\text{Intervention}] + \beta_3[\text{Time} \times \text{Intervention}] + \epsilon$$

Randomization of the mode of the interventions: Initially, we conducted a baseline survey from all the randomly selected villages of the study region and after which randomization was done at village level i.e., villages from each block were randomly assigned to treatment and control group. So, out of four villages from each block, three villages were selected as experimental villages i.e., each village was receiving weekly agromet advisory services through either of mobile application, Text SMS, WhatsApp and one control village (not receiving weekly agromet advisory services). Thus, resulting in 18 experimental villages (6 each of Mobile Application, Text SMS and WhatsApp) and 6 control villages from the three districts of Haryana.

Treatment groups: An exclusive mobile application developed for the present study "NDRI climate services" was installed in the mobile devices of the respondents from the experimental villages meant for the mobile application. The android application developed using java language is available to download from the Google Play store and the content of the app is available in two languages english and hindi. The major objective of this mobile application is to provide district specific weekly weather advisory services to promote climate resilient practices. The advisories include weekly weather forecast on 8 climatic parameters (maximum temperature, minimum temperature, relative humidity, rainfall etc.). The developed mobile application was validated through expert consultation and farmers' feedback on the initial prototype. Further, the mobile application was upgraded based on the feedback. The trained

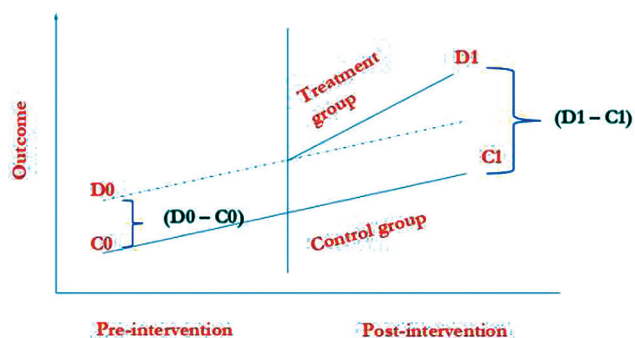


Fig. 1 Difference-in-difference research design.

field staffs were used to guide the farmers in installing the Mobile App, registration process and how to use the mobile application was also demonstrated. For all the WhatsApp selected treatment villages, separate district wise WhatsApp groups were created by using the mobile numbers of the respondents that were collected during baseline survey. Similarly, Text SMS broadcast groups were created.

Intervention: After the finalization of all treatment and control groups, the weekly agromet advisory bulletin of IMD was extracted for each selected district. The bulletins containing the weather data, summary of weather along with extreme weather alerts, brief summary of crop advisory and a detailed crop advisory of both wheat and paddy based on the weather forecasting was prepared by extracting from AAS bulletin of IMD. These bulletins were sent every week to the respondents of all three sets of treatment groups i.e., advisory bulletins were uploaded in WhatsApp groups of each respective districts, Text SMS crop advisory services were sent to the registered mobile numbers of respondents using broadcast-based SMS portal. Similarly, every week these district specific crop advisory services were uploaded in the Mobile App through web domain of the application. This process of intervention i.e., agromet advisory services

preparation and dissemination has been carried out for one full cycle of the paddy and wheat crops. After the completion of an intervention period, again there was an endline survey of all the treatment and control group village respondents to measure the impact of the advisory services.

Impact of the advisories was assessed with following indicators:

- A. Operational decision related to crop cultivation practices
 - i. Farm plans: time of ploughing/land preparation, crop choices/varieties, sowing/transplanting, inter-cultivation operations.
 - ii. Investment in inputs: Seeds, fertilizers, pesticides, herbicides.
 - iii. Irrigation schedule.
 - iv. Harvest time.
- B. Economic outcome of the farm
 - i. Yield of major crops.
 - ii. Reduction in input cost.

RESULTS AND DISCUSSION

Farmers' demographic profile: The average age of the respondents was 44.94 years and who had an average farming experience of 23 years. Most of them (40.28%) were having an education level up to secondary education. The respondents (39.44%) were having a medium level of knowledge regarding climate change and its impact on crop-livestock farming in the study region. Subsequently most of them (41.39%) have reported that weather based advisory services are highly useful in their day-to-day farming activities. Nearly half (47.50%) of the respondents were having medium level of mass media exposure, where they used different mass media sources to know about the various information related to agriculture and also to sometimes to follow the weather forecast information. Most of them admitted to having extension contact with at least one of the following sources: Agricultural Officer, Assistant

Agricultural Officer, Cooperative official, Veterinary Officer, Veterinary and Livestock Development Assistant, and KVK-Research Personnel for seeking various types of information on agriculture and livestock farming. Average operational land holding of the respondents was 2.55 ha and average cropping intensity of the study region was 178.81% with farmers growing minimum of two crops in a year. Paddy, wheat, mustard, cotton, sugarcane are the major crops being grown in the region.

Impact of the climate services on operational decision making in cultivation of wheat crop: Results (Table 1) indicates that there was a positive treatment effect of the climate services on almost all the operational decisions of wheat cultivation apart

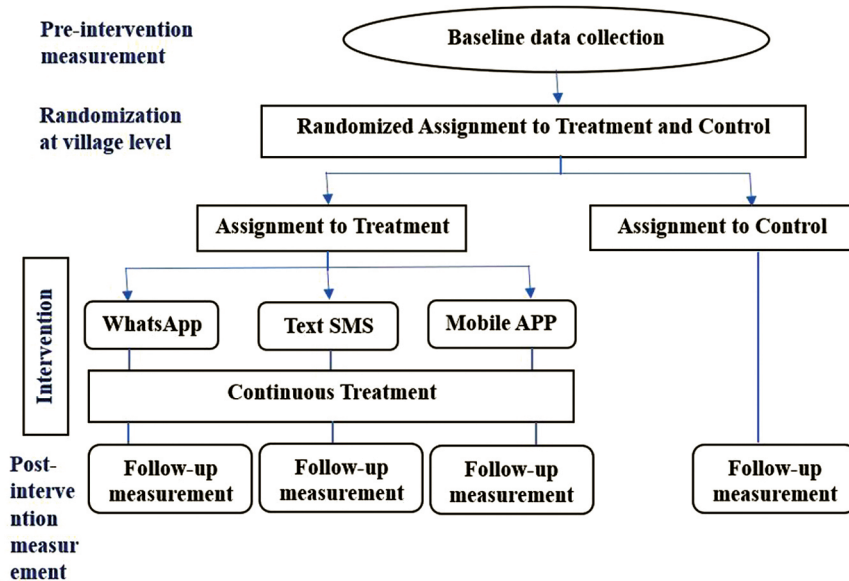


Fig. 2 Experimental design used in the study.

from the selection of variety and weed management in all the three modes of intervention i.e. Text SMS, WhatsApp and Mobile App. The treatment effect on seed rate and fertilizer application was found significant at 1% level in all three modes of intervention i.e. Text SMS, WhatsApp, and Mobile App, respectively. Treatment effect on irrigation schedule was also found significant at 1% level in Text SMS and Mobile App groups whereas significant at 5% level in WhatsApp group. The treatment effect of climate services on spraying plant protection chemicals was found significant at 5% in Mobile App groups.

The wheat crop requires congenial weather for germination, a suitable maximum temperature of 25–27°C, and a minimum temperature of 11.5–13°C (Pandey *et al.* 2022) along with a clear sky without rainfall. Rainfall immediately after sowing hampers germination and causes seedling blight (Amein *et al.* 2008). Therefore, timely advisories on land preparation and sowing of wheat crop were found highly useful by the farmers. Since farmers were using slightly more than the recommended seed rates, advisories were found useful in sowing the recommended seed rate in turn saving their seed cost. Van Campenhout *et al.* (2021) have found the positive effect of advisory services disseminated through interactive voice response (IVR) on optimizing the use of hybrid maize seed rate. Since the winter rainfalls have been highly unpredictable with time, intensity, and duration, timely advisories based on rainfall forecast were found useful in scheduling the timely irrigation of wheat fields. Results of the study by Altobelli *et al.* (2021) found that farmers preferred receiving weather forecast-based irrigation advisory services.

Cloudy weather, with high humidity and low temperatures is conducive for rust attack (Rodríguez-Moreno *et al.* 2020) and similarly humid weather, including light

rain and heavy dew will increase the loose smut infestation of wheat crop (Prescott *et al.* 1986). As a result, farmers found that advisories based on weather forecasting, crop growth stage, the severity of the infestation, and the spread of pests and diseases helped them make timely decisions about their prophylactic plant protection measures. As also reported by Chattopadhyay *et al.* (2011), the weather-based forecasting for operational crop protection to minimize crop losses due to pest and diseases is gaining importance. As shown results, advisories had a significant effect on the fertilizer application, since farmers were applying excessive fertilizers specially urea/nitrogen, whose results were more prominent and obvious with lush green growth of plants after application. Hence, advisories have helped the farmers to cut down on the use of the extra quantity of fertilizers. Also, fertilizer application and spraying plant protection chemicals based on weather/rainfall forecast have helped in making timely operational decisions as well as cut down their extra input costs. A study by Singh (2011) has also reported that, significant losses of farm inputs like seeds, water, pesticides, and fertilizers could be saved by the use of agromet advisory services.

The wheat yields are highly affected due to the early onset of heatwaves and high temperatures in March month (Bal *et al.* 2022). So, the weather forecast of likely temperatures, and untimely rainfall has been found useful by wheat farmers for the timely harvest of the crop. A study by Rathore and Maini (2008) has also found that the wheat farmers have followed and utilized the agromet advisories starting from land preparation to till harvesting, which has resulted in reduced input usage of seeds, fertilizers, pesticides, herbicides, irrigation and also labour which has ultimately reduced input cost and increased net income for the wheat farmers.

Table 1 Impact of the climate services on the operational decision in the cultivation of wheat crop

Practices	Measurement	Control (n=90)	Mobile App (n=90)	Text SMS (n=90)	WhatsApp (n=90)
Seed rate (kg/acre)	Pre-intervention	44.77	45.76	45.61	46.25
	Post-intervention	44.55	41.70	41.91	42.03
	Treatment effect		-3.84**	-3.48**	-4.00**
Number of irrigations	Pre-intervention	4.56	4.85	4.72	5.03
	Post-intervention	4.71	4.30	4.26	4.60
	Treatment effect		-0.70**	-0.62**	-0.58*
Fertilizer application (kg/acre)	Pre-intervention	173.63	182.55	179.76	185.17
	Post-intervention	178.86	167.55	170.05	173.48
	Treatment effect		-20.23**	-14.94**	-16.92**
Spraying of plant protection chemicals (number)	Pre-intervention	2.20	2.83	2.34	2.42
	Post-intervention	2.26	2.53	2.14	2.16
	Treatment effect		-0.35*	-0.26	-0.32
Weed management (number of herbicide application)	Pre-intervention	2.02	2.21	2.18	1.97
	Post-intervention	1.99	2.12	2.11	1.87
	Treatment effect		-0.06	-0.04	-0.07

** and * indicate significance at 1% and 5% level of significance, respectively.

Impact of the climate services on operational decision making in cultivation of the paddy crop: Results (Table 2) reveal that there was a positive treatment effect of the climate services on almost all the operational decisions of paddy cultivation apart from weed management in all the three modes of intervention i.e. Text SMS, WhatsApp and Mobile App. Findings of regression analysis further revealed that treatment effect on seed rate was found significant at 1% level in both WhatsApp and Mobile App treatment groups whereas 5% significance in Text SMS group. Treatment effect of climate services on the operations of both irrigation and spraying plant protection chemicals in paddy crop were found significant at 1% level in all the three modes of intervention. Results also revealed that fertilizer application was found significant at 5% level in all the three modes of intervention i.e. Text SMS, WhatsApp, Mobile App.

Chauhan *et al.* (2022) has reported that the pre-monsoon season has shown high deviations, and also Haryana has witnessed declining trend in rainfall during the winter, post-monsoon, and summer monsoon seasons from 1981–2020. While on the other hand important operations like paddy nursery preparation, puddled soil preparation and seedling transplantation were highly dependent on the monsoon rainfall, hence advisories disseminated on predicted rainfall and land preparation were found useful by the respondents in the aforementioned operations. Since the farmers were using more than a recommended level of seed rate in nursery preparation, they have reported to the usefulness of advisories in cutting down the seed rate levels. Regular assured supply of canal water in the region led to over flooding of the paddy fields. So, advisories were found highly useful in reducing the extra irrigations being given to crop.

With paddy being grown during the *kharif* season and

the pre and post monsoon fluctuations in Haryana over the decades as reported by Chauhan *et al.* (2022) advisories disseminated to farmers has also helped them in deciding timing of fertilizer application. Farmers of the study region were also applying more than the recommended dosages particularly urea, advisories regarding their dosage and schedule of application had assisted the farmers in reducing fertilizer quantity and cost (Table 2). Study by Maini and Rathore (2011) has also found that weather forecast advisories will increase the effectiveness of inputs like fertiliser, pesticides, etc., reduce the cost of cultivation, and protect crop from adverse weather. They reported that drop in mean temperature in association with heavy rainfall led to outbreak of paddy stem borer. So prophylactic advisories on plant protection based on weather forecast and crop growth stages was found highly useful by the farmers in timely operations. Study by Gupta *et al.* (2021) has also reported that farmers' effective crop management practises, such as land preparation, recommended seed rate, irrigation schedule, timely weeding, and applying pesticides in accordance with agro advisory bulletins, has resulted in more profits in both paddy and wheat crop (Gupta *et al.* 2021).

A study conducted at multiple locations of Hyderabad, Raipur, Thrissur, Kalyani, Bhubaneswar, Ludhiana and Pantnagar by Rathore and Maini (2008) has reported similar findings where the paddy farmers have found the advisories useful and followed them in their operational decision making at all stages starting from land preparation to till harvesting which has saved their input cost and also improved their returns. Similarly study by Kumar *et al.* (2022) at Karnal region has also found similar results of farmers utilizing the agromet advisories in both wheat and paddy crop in their operational decision making at all stages

Table 2 Impact of the climate services on the operational decision in the cultivation of paddy crop

Practices	Measurement	Control (n=90)	Mobile App (n=90)	Text SMS (n=90)	WhatsApp (n=90)
Seed rate (kg/acre)	Pre-intervention	12.02	12.57	11.98	12.11
	Post-intervention	12.16	11.44	11.06	11.11
	Treatment effect		-1.27**	-1.06*	-1.15**
Number of irrigations	Pre-intervention	18.27	19.08	18.87	18.66
	Post-intervention	18.43	17.66	17.48	17.20
	Treatment effect		-1.58**	-1.55**	-1.58**
Fertilizer application (kg/acre)	Pre-intervention	220.76	230.40	212.75	216.01
	Post-intervention	216.44	205.16	189.91	191.69
	Treatment effect		-20.92*	-18.52*	-20.92*
Spraying of plant protection chemicals (number)	Pre-intervention	3.93	4.64	3.98	4.07
	Post-intervention	4.14	3.70	3.23	3.26
	Treatment effect		-1.15**	-0.96**	-1.02**
Weed management (number of herbicide application)	Pre-intervention	2.94	3.31	3.20	3.07
	Post-intervention	2.98	3.20	3.15	2.94
	Treatment effect		-0.15	-0.09	-0.17

** and * indicate significance at 1% and 5% level of significance, respectively

of crop growth which reduced weather associated crop losses, reduced input cost and increased returns.

Impact of the climate services on economic outcome of the farm

Impact of the climate services on the reduction in input cost of wheat and paddy cultivation: Results (Table 3) show that there was a positive and significant treatment effect of the climate services on reduction in input cost of both wheat and paddy, respectively in all three modes of intervention i.e. Text SMS, WhatsApp and Mobile App. Farmers perceived that advisories were highly useful and implemented in their crop farming at all the crop growth stages from land preparation to till harvesting. The judicious and efficient application of inputs as per the advisories has resulted in reduced input costs. Optimizing the seed rate as per advisories has decreased seed cost in return. Timely advisories based on rainfall forecast have helped the farmer's timely application of fertilizers in required quantities avoiding leaching losses and also input cost on plant protection chemicals as well as human labour was reduced considerably as farmer have expressed that, on an average 0.5 to 1 spraying was reduced in crops due to timely forecast-based advisories. Irrigations in the crops were also optimised as per the advisories, saving irrigation cost. An overall better management of their crops in their day-to-day operations as per the advisories taking advantage of benevolent weather and minimizing the adverse impact of malevolent weather on crops has reduced the input cost.

A study by Kumar *et al.* (2022) has reported that the cost of cultivation in wheat and paddy crops was less for beneficiary farmers as compared to non-beneficiary farmers and it was around ₹3000–4000/acre. The maximum cost saving was recorded on irrigation and pest management for all the beneficiary farmers. Similar findings of reduced cost of cultivation was also reported by Dupdal *et al.* (2020) in crops like maize, groundnut, *rabi* sorghum, sunflower,

bajra and castor + redgram, by the AAS adopter farmers. Maini and Rathore (2011) in their study on major crops like food grains, oilseeds, cash crops, fruit and vegetable have reported a reduction by 2–5% in cost of cultivation of AAS farmer over non-AAS farmers.

Impact of climate services on the yield of the wheat and paddy crop: Timely weather-based advisory services to the farmers have resulted in the more efficient usage of inputs resulting in reduced input cost as discussed previously. Weather-based management practices such as timely pest and disease control, weed control, sowing and harvesting time as well as other cultural operations had rather helped the farmers in taking preventive and or control measures and reducing/minimizing the impacts of weather-based losses on their crops which ultimately contributed to their net incomes whereas the yield of crops depends on other factors like crop varieties, soil health status, productivity of the lands/area etc. Therefore, climate services had no significant impact on the yield of both wheat and paddy crops. Similar results were reported by Kumar *et al.* (2022) in their study from Haryana on wheat and paddy crops that, agromet advisories had resulted in better crop improved crop management practices which have reduced crop losses and also input costs ultimately contributing to their net incomes but the yield levels of both paddy and wheat crop have almost remained same.

Conclusion and policy implications

The study analysed the impact of agromet advisory services on operational decision making as well as the economic outcome of the wheat and paddy farms of Haryana. Advisories had a significant treatment effect on almost all the operational decisions of both wheat and paddy crops, except the weed management. The excess seed rate was optimised as per nearly recommended rates thereby saving the seed cost. Similarly, timely field operations as per the advisories disseminate helped in making timely decisions

Table 3 Impact of the climate services on the reduction in input cost of wheat and paddy cultivation

Economic indicators	Measurement	Control (n=90)	Mobile App (n=90)	Text SMS (n=90)	WhatsApp (n=90)
Input cost (₹) of wheat cultivation	Pre-intervention	13,759.03	13,820.22	12,602.35	14,000.00
	Post-intervention	14,006.02	12898.88	11,905.88	13,220.93
	Treatment effect		-1168.09**	-943.46**	-1026.06**
Input cost (₹) of paddy cultivation	Pre-intervention	22,724.13	23,357.14	22719.29	23,025.42
	Post-intervention	23,068.96	22,031.75	21,624.14	21,803.38
	Treatment effect		-1670.22	-1439.98	-1566.87
Yield of wheat crop (q/acre)	Pre-intervention	21.57	21.59	22.01	22.45
	Post-intervention	21.78	22.16	22.50	23.00
	Treatment Effect		0.36	0.27	0.34
Yield of paddy crop (q/acre)	Pre-intervention	24.12	23.95	24.83	23.77
	Post-intervention	23.63	23.70	24.47	23.48
	Treatment effect		0.24	0.13	0.20

** and * indicate significance at 1% and 5% level of significance, respectively.

on the irrigation schedule, dosage, and time of fertilizer application, prophylactic spray of plant protection chemicals has not only led to reduced losses of the crop yields, but also a more efficient use of the inputs thereby saving their operational costs. Farmers implemented advisories at all the crop growth stages from land preparation to harvesting, which has led to the judicious and efficient application of inputs resulting in reduced input cost. The treatment effect on crop yields was not significant though the results were positive. The study helped to create climate literacy and awareness among the farmers about the pivotal role of weather-based advisory services in their day-to-day farming activities.

Provision of seamless climate services for crop cultivation can be used as a climate adaptation option. Crop specific advisories may be prepared as granular level as possible or may be at least block level for increased uptake and utilization by the farming community. With a range of lead times, a seamless suite of forecast, advisory and early warning products enables farmers to manage evolving risks throughout the season. Integration of the local indigenous knowledge with the meteorological data will increase trust as well as local relevancy and use of the developed climate services. Co-production processes, in which end users are involved in the development of climate services, can be tried instead of only top-down pushes of information to users.

Ethical statement

The data pertaining to this study was collected ethically with well-informed farmers about the ultimate outcomes of this study. Farmers opted to remain anonymous.

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