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Economic impact of weather advisory services: a case of Varuna Mitra scheme in Karnataka

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Abstract Despite the existence of various forecast services in India, the accuracy in their prediction is limited. To address this, the Karnataka State Natural Disaster Monitoring Centre launched a scheme Varuna Mitra in 2010, which is considered superior to others on two counts: one, it is an interactive service, and two, it provides location specific weather forecast up to the panchayat level for a period of three days on a 12-hour cycle. In this paper, we have assessed the impact of Varuna Mitra from 1350 sample farmers distributed across nine districts of high, moderate and low rainfall regions. Data were collected with and without information from farmers for 2016-17 to examine the impact of the service. The calls were found to have increased at an annual rate of 61.55% from 6,565 in 2011 to 10.42 lakh in 2016. Results indicate a reduction in the cost of cultivation and post-harvest losses, improvements in the crop yields and net incomes. Overall, the farmers could realise incremental net gain of Rs 5,106 per acre from the forecast and Rs 18,005 in terms of per capita income.

Keywords Weather forecast, Varuna Mitra, Yield, Income

JEL classification Q10, Q12, Q15, Q16

1 Background

Provision of agricultural services is one of the critical factors towards achieving a faster and sustainable growth of agricultural sector. Lately, the Information and Communication Technology (ICT) has been playing a major role towards this (Tripathi 2015). Despite this, the information is accessed only by a few farmers. According to the National Sample Survey, only 41% of the farm households access information (IFPRI & CRISP 2015). In particular, ICT applications of weather forecasts have been developed to translate meteorological parameters into understandable agricultural terms through advisories. However, the dissemination of weather-based information has not been adequate as compared to other advisory services. Effective weather information services can influence farmers' decisions and help manage agricultural risks. However, most of the advisories or information dissemination channels are not fully accurate as they cover a wide geographical area rather than being location specific. Location specific forecast is required to take informed decisions. The likelihood of error is higher in the longer range of forecast. As such, the Indian Meteorological Department (IMD) finds it difficult to forecast local weather conditions with full accuracy. Apart from this, the available weather-based information is not directly disseminated to the farmers.

To fill this gap, the "Karnataka State Natural Disaster Monitoring Centre (KSNDMC) launched 'Varuna Mitra' services in 2010 to provide direct information to the farmers in the state through a 24x7 interactive help desk. It is an Interactive Voice Response (IVR) and is location specific. It is superior to other services on two counts; one, as compared to the national weather forecasts that deliver information to farmers through the SMS, media and radio, with no direct link with them, this service is an interactive service; and two, it

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provides gram panchayat level forecasts on rainfall, relative humidity, wind speed, wind direction and temperature for a period of three days on a 12 hour cycle in the local language that can be easily comprehended by farmers. This information assists them to take decisions on agricultural activities from sowing to marketing.

The forecasts disseminated to the farmers at every 15 minutes are generated based on the data and information collected from the Global Positioning Response System (GPRS) enabled and Solar Powered Telemetric Weather Station (TWS) at every 250 sq. km. in 747 hoblis and Telemetric Rain Gauge (TRG) stations covering 25 sq. km. In addition, 179 Telemetric Weather Stations were set up in Sujala - III watershed area (11 districts) during 2015-16 (Watershed Development Department 2016). The jurisdiction of each Telemetric Station is 5 sq. km. (micro-watershed). These are in addition to 26 Automated Weather Stations (AWS) installed in Karnataka by IMD (IMD 2011), 117 by ISRO (Naveen 2009) and a few by Agricultural Universities and Water Resources Department. The Varuna Mitra services covered only a few districts until 2013 (Shashidhar 2014). Post-2013, all the 6073 panchayats and villages with a population of 6175 each have been covered in all the districts. The introduction of this service has replaced indigenous predictions that have frequently been inaccurate. This unique programme has garnered immense attention across the country and 10 States have established either a similar facility or are in the process of setting up a fairly identical system with technical guidance from the KSNDMC.

With this backdrop, the main purpose of the study is to assess the impact of Varuna Mitra help desk services on cost of cultivation, crop yield, farm income and post-harvest losses and provide suggestions for improvement of the existing services. The remainder of the paper is as follows. The second section presents data and methodology. The third section focuses on the performance of Varuna Mitra. While the fourth section concentrates on information seeking behaviour of the farmers, the fifth section includes micro level impact of the service. The sixth and the seventh sections focus on the macro level impacts, and bring forth key findings and policy suggestions.

2 Data and methodology

2.1 Data

The impact of Varuna Mitra help desk services was assessed using both primary and secondary data. Secondary data were obtained from the KSNDMC that include calls made across districts, purpose of calls, coverage of crops, landholding size and irrigation status for the period 2013 to 2017. Impacts of Varuna Mitra services on farm input costs, yields and net incomes were captured through primary data collected from farmers using the multistage random sampling technique. In the first stage, all the districts were categorised into three regions viz., high rainfall (>1200mm), moderate rainfall (600-1200mm) and low rainfall (<600mm), and three districts from each region were selected randomly. These include Dakshin Kannada, Kodagu, and Shivamogga from the high rainfall region; Chikkamagaluru, Hassan, and Kolar from the moderate rainfall region; and Tumakuru, Ballari, and Raichur from the low rainfall region. As adequate sample size was not available from Dakshin Kannada, the neighbouring region viz. Udupi was included. These districts represent 8 of the 10 agro-climatic zones of Karnataka. In the second stage, three taluks were selected from each district, each representing high, medium and low rainfall regions. In the final stage, 50 farmers who had obtained information from Varuna Mitra helpdesk during July 2016 to June 2017 were randomly interviewed using a pre-tested questionnaire. Cumulatively, a total of 1350 farmers were interviewed for the purpose.

2.2 Methodology for estimating the impact

The impact of Varuna Mitra services on cost of cultivation, yield, income and post-harvest losses was estimated considering two situations - with and without weather information. The difference between the decision taken with-information and without-information was expressed in physical and monetary terms, which could be positive or negative depending on the impact indicator. Reduction in the cost of cultivation, increase in income (attributed to increase in yield and price), increase in crop yield and decrease in post-harvest losses are considered gains, whereas increase in cost, decrease in yield and income, and increase in post-harvest losses are considered as losses.

Suppose, a farmer plans to apply plant protection chemicals (PPCs) and wants to know the non-rainy day for its application, the said farmer will call Varuna Mitra help desk for information on rainfall. If the farmer has received accurate information on a particular day as heavy rainfall, then the farmer will postpone the PPCs application for a non-rainy day. By doing so, he could save on cost. Otherwise, without-information the PPCs applied would have washed away presumably due to heavy rains. The saving in cost is a gain to the farmer. In a similar manner, the impact has been estimated with-information and without-information for taking decision at various stages of farming viz., ploughing, sowing/germination, vegetative growth, flowering, fruit setting, fertilizer application, PPCs application, irrigation, tank-filling, harvesting, post-harvest management and marketing.

The overall impact has been estimated by aggregating the stage-wise impacts. Finally, the impacts are presented in terms of two indicators, (i) net gain or loss using the results of cost of cultivation, net income and post-harvest losses and (ii) yield. The impact of Varuna Mitra information specifically on rainfall was estimated for major crops viz., paddy, arecanut, coffee, ragi, jowar, mango, red gram/tur, maize, cotton, tomato and chilli. These crops account for 61% of the cropped area benefitted through Varuna Mitra services. The impact on major crops have been expressed in terms of net gain or loss and yield. The remaining crops have been grouped and the impact estimated only in terms of net gain or loss.

3 Performance of Varuna Mitra

The performance of Varuna Mitra has been quite impressive. The number of calls since its inception in 2011 increased from 6,565 to 10.42 lakh in 2016, growing at an annual rate of 62%, ranging from 93% in Kodagu to 14% in Dakshin Kannada (KSNDMC 2017). Lower rates of growth were observed for Uttara Kannada (38%), Dharwad (33%), Gadag (29%), and Bengaluru Urban (19%) as compared to Mysuru (92%), Kolar (91%), Koppal (89%) and Chikkaballapura (84%). The figures show that the number of calls increased with an increase in the number of districts experiencing drought. If this trend continues, the total calls projected by 2020 are estimated at 63.57 lakhs.

During 2016-17, there were a total of 1.76 lakh callers making 10.42 lakhs calls. It works out to 5,876 beneficiaries per district with an average of 34,724 calls per district and an average of 2,854 calls per day. Ballari accounts for highest share in calls (11%) followed by Tumakuru (9%), Raichur (7%), Chikkaballapura (7%) and Kalaburagi (6%). Almost all the queries were related to rainfall, mostly about current day forecasts (63%). About 52% of the calls were made during the kharif season (July-October), as most areas are rain-dependent. For each season, the initial month (sowing, germination, vegetative growth) and the last month (harvesting and post-harvest operations) received maximum number of calls. This pattern has been associated with farmers' field operations as most of the decisions are taken during these months. A majority of the farmers sought information on agriculture (90%), followed by horticulture (9%), animal husbandry (0.4%) and sericulture (0.6%).

A total of 1.75 lakh farmers owned 56.38 lakh hectares of land, of which irrigated land accounted to be 65%. Of 73 crops for which weather information was obtained, 57 % of the calls pertained to only ten crops viz. cotton, chilli, onion, ground nut, maize, jowar, ragi, paddy, tur and sugarcane. Of the calls reported, a majority were made during the germination stage (37%) followed by harvesting (22%), sowing (12%) and vegetative phase (10%). The least number of calls (0.8%) were received at the transplantation stage.

4 Farmers' information seeking behaviour

4.1 Socioeconomic characteristics

Of all the respondents who made calls, 99.48% were males. Close to 57% of the respondents were in the age group of 36-60 years, and 78% were educated up to secondary school. The total operational land area of sample farmers was 9,588 acres with 55% area under irrigation. The average size works out to be 7.11 acres per farmer, ranging from 3.48 acres in Hassan to 13.64 acres in Raichur. About one-fifth the marginal farmers in the selected sample operated 4.66% of the area; 37% small farmers operated 20% area, 30% medium farmers operated 31% area and 15% large farmers operated 44 % area. This indicates high inequity in the distribution of operational landholdings.

The farmers cultivated as many as 73 different crops, classified into cereals, pulses, oil seeds & cash crops, fruits, vegetables, flowers, plantation and other crops. Around half of the gross irrigated area was occupied

by plantation crops, oil seeds and cash crops. Among unirrigated crops, cereals, pulses and oil seeds and cash crops accounted for around three-fourth of the gross unirrigated area. Considering both irrigated and unirrigated area, cereals occupied 30% of the area followed by plantation crops (28%), cash crops (14%), vegetables (10%) and pulses (9%). At aggregate level, Varuna Mitra information was utilised for 73 % of the area; 80 % for irrigated and 64% for unirrigated.

4.2 Sources of Information

More than 59 % farmers learnt about Varuna Mitra from friends followed by Raitha Samparka Kendras (15%), and relatives (12%). The farmers preferred direct interaction in local language (Kannada) over phone as it facilitates clarifying doubts and provides confidence about the information received. At the state level, each farmer shared rainfall information with at least seven farmers, and passed on the help desk number to five farmers, totalling 12 farmers. Most of the farmers across seasons opined that the quality of calls was good (84%) and only a small number stated it to be of poor quality (1%). The reason for the latter was due to poor network and busy lines. An overwhelming proportion of farmers (63%) have indicated that accurate prediction was realised to an extent ranging from 60 to 90%.

Farmers mostly sought weather-based information at specific time periods to alter decisions on their farming and/or allied activities. The information gathered from farmers clearly show that a majority of them sought information on rainfall forecast in low (99.78%), moderate (93%) and high (91%) rainfall region. The other weather parameter that received queries from farmers is only temperature. At the aggregate, 95 % of the farmers sought information on rainfall. Of the total farmers selected, 3% sought information from Varuna Mitra for purposes other than agriculture. About 22 farmers (2%) asked for scheduling of social functions, 13 farmers enquired for construction purpose, and 4 farmers called for information on wind direction for fishing.

Although the study has not quantified the economic benefits of weather forecast for allied sectors of agriculture, the information appears to be equally important for fishery, sericulture, poultry, livestock and other allied sectors. For instance, the fisher-folk can decide on the schedule of fishing based on wind forecast in the region. In the case of sericulture, optimum temperature and relative humidity is vital for growth of silkworm and formation of cocoons. Therefore, based on the weather forecast, a conducive condition for rearing of worms can be maintained. In the case of rainfall forecast for the next day, mulberry can be harvested beforehand, as increased moisture content levels post rain are not suitable for silkworms.

While poultry requires warm temperature for growth especially in the initial stages of rearing, a fall in temperature and cloudy weather conditions are conducive for the growth of pathogens that affect poultry. With rainfall forecasts, farmers can maintain a warm environment by covering the rearing structures and providing artificial heat as low temperature is fatal for birds at earlier stages of growth. Weather forecast is also crucial in rearing of milch animals. Equipped with forecast information on predicted rain, farmers can safeguard animals in sheds rather than letting them graze in open fields. Incidence of rain while grazing can cause illness among animals drenched by rain. With rain forecast, the farmer can also gather green fodder and stack in advance to avoid moisture and can protect the animal. Thus, forecast information is also a crucial element in agricultural allied activities.

Specific to crops, most of the farmers had called at different stages in the production cycle (figure 1). Of the total farmers who called seeking for information, 29% of the farmers had contacted Varuna Mitra during harvesting followed by sowing (19%), PPC application (12.65%).

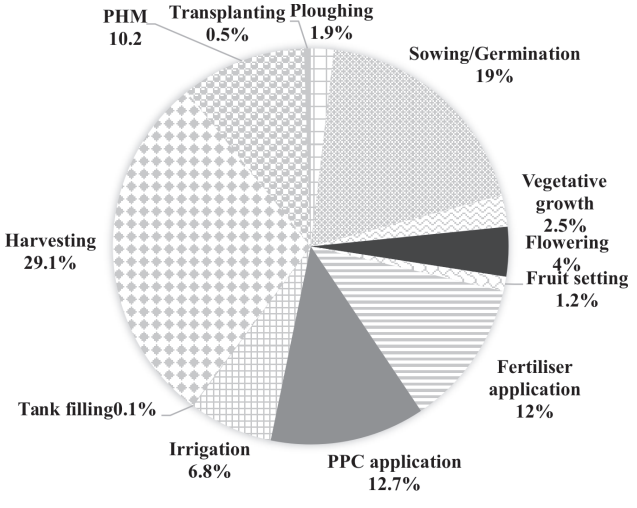

Figure 1. Stage-wise calls made by farmers
Source: Authors' calculations based on KSNDMC database

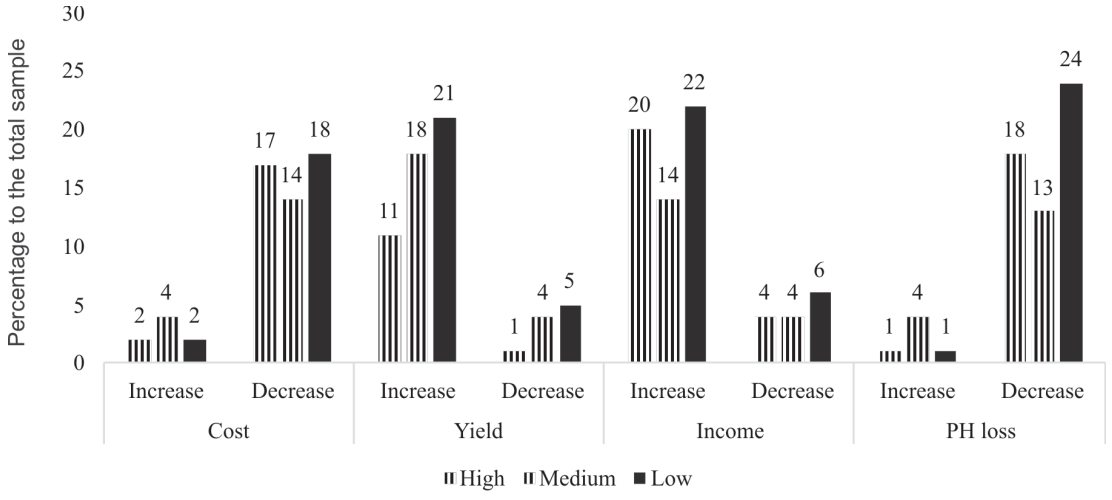

Figure 2. Percentage of farmers who perceived a change in cost of cultivation, yield, net income and post-harvest losses
Source: Authors' calculations

5 Micro level impact of Varuna Mitra

Having utilized information from Varuna Mitra, a significant proportion of farmers have indicated decrease in cost, increase in income, increase in yield and decrease in post-harvest losses (figure 2). On the whole, a decrease in the cost has been reported by 49%, increase in yield by 50%, and net income by 53% and decrease in post-harvest losses by 40% of the farmers. In case of post-harvest stage, the number of calls were highest by arecanut farmers. Post-harvest, arecanut requires 52 days for drying. Incidence of rain during this period can increase the moisture content in arecanut, thereby lowering its price.

In monetary terms, on an average, farmers reported a decrease in cost by 7 % and an increase in income by 2%. Across regions, the highest decrease in cost was reported from high rainfall region (8%), followed by moderate rainfall region (5%). Decrease in post-harvest losses was reported by 17 % farmers in the low rainfall region, followed by moderate (4%) and high rainfall (3%) regions (table 1). Yield improvements were highest in jowar (16%) followed by ragi (9%), coffee (8%).

The highest decrease in cost to an extent of Rs 6,273/ acre was in the case of coffee followed by arecanut (Rs 2,571/acre), tomato (Rs 2,218/acre) and mango (Rs

Table 1. Incremental change in cost of cultivation, yield, income, and post-harvest losses

Components	Impact	Incremental change in percentage		
		High rainfall	Moderate rainfall	Low rainfall
Cost	Increase	7	6	4
	Decrease	8	5	5
Yield	Increase	4	4	4
	Decrease	2	2	2
Income	Increase	2	2	4
	Decrease	1	2	3
Post-harvest losses	Increase	6	5	7
	Decrease	3	4	17

Source: Authors' calculations

1,268/acre). In case of arecanut, reduction in cost was highest in Dakshin Kannada and Udupi (Rs 3,424/acre) followed by Chikkamagaluru (Rs 776/acre) and Hassan (Rs 403/acre). The decrease was mainly due to plant protection and irrigation decisions. The farmers would take up spraying of chemicals to control diseases like foot rot based on the rainfall forecast. With a forecast of rainfall, farmers would cancel irrigating the crop, thereby saving the cost on irrigation. Some farmers have also reported an increase in cost by Rs 703 per acre in irrigated arecanut plantations**.** This occurred when it rained contrary to the forecast, the costs incurred on irrigation were an additional burden to the farmers. In case of tomato, an increase in cost was indicated at the stage of sowing and PPC application. This occurred when a forecast that communicated cloudy weather congenial for the multiplication of disease- causing agents resulted in PPC application by the farmer to protect the crop. A total of 11 farmers of the Kolar district mentioned an increase in cost of Rs 2,687 per acre**.** While a decrease in cost to an extent of Rs 2,217 per acre was indicated by 32 farmers (table 2).

In terms of incremental income, the highest increase was indicated by 42 farmers (3%) in coffee (Rs 3,713/ acre), 112 farmers (8%) growing arecanut (Rs 3,355/ acre), 20 farmers (1%) growing chilli (Rs 1,626/acre) and 16 red gram farmers (1%) (Rs 1,559/acre). There were instances of farmers indicating a decrease in income as well. Decrease in income was also indicated for the same crops for which increase was mentioned that occurred at different stages of the crop cycle. In the case of coffee, it was Rs 3,521/acre, followed by arecanut (Rs 2,658/acre) and chilli (Rs 1,627/acre). However, this was mentioned by a few farmers only (table 2).

The incremental increase in income in arecanut was indicated during harvesting. Scheduling of picking based on the incidence of rainfall can save labour cost and increase income. Several farmers in Dakshin Kannada and Shivamogga districts have mentioned a decrease in income. In the case of Dakshin Kannada, this decrease occurred during PPC application. The cause could be due to failure of forecast and incidence of rain resulting in runoff of PPC that would incur an additional cost on chemicals and labour.

An increase in income in chilli was indicated at stages of ploughing, vegetative growth, flowering, fruit setting, fertilizer application, PPC application and irrigation. Chilli crop is highly responsive to varied weather changes. Cloudy weather is congenial for the multiplication of pathogens. During flowering, incidence of rain can cause dropping of flowers that results in a reduction of yield. Similarly, during harvesting, rainfall incidence can cause fruit drop. Hence, timely application of PPCs, timely harvesting of the crop can increase the yield of chilli that in turn increases the income.

Similarly, in case of post-harvest losses, an increase was of the tune of Rs 4,001 per acre in the moderate rainfall region, whereas the decrease was Rs 3,285 per acre (table 2). But the decrease in loss was informed by 168 farmers whereas an increase was indicated by 31 farmers (2%). The highest decrease in the post-harvest loss was seen in coffee (1.33 quintal/acre) as indicated by 119 farmers (9%). Picked coffee needs to be sun dried for about 15 days. Incidence of rain during this period can reduce the quality of the beans. An accurate rainfall forecast heavily influences the scheduling of coffee harvesting as moisture content in the commonly sun-dried berries result in loss of quality. Also, in times of a forecast predicting heavy rainfall, farmers could save their crop from dispersion and/or moisture saturation caused by rainwater in the drying yard thereby preserving the quality of the beans as well (table 3).

Further, decrease in post-harvest losses was also indicated by 22 cotton farmers (2%) by 0.73 quintal/ acre. Unexpected rain during harvest results in loss in terms of perishability of the crop as well as a fall in the quality of the produce. In order to accurately schedule harvesting of the crop, farmers call Varuna Mitra to enquire about the probability of rainfall in the period considered by them to harvest. If the forecast information provided predicts no rain, farmers go ahead with the harvest. Preponement of the harvesting time due to forecast of heavy rains as well as securing crops in the drying yard from moisture saturation on account of the probability of rain/ cloudy weather has led to decrease in post-harvest losses. With regard to paddy, there has been a decrease in the post-harvest losses to an extent of 0.63 quintal per acre (reported by 74 farmers). With the help of rainfall forecast, farmers can schedule their harvesting operation and safeguard the crop from post-harvest losses. Some of the timely practices during this stage of harvesting would be protecting the crop in the drying yard, postponement

Table 2. Incremental change in cost of cultivation, income and post-harvest losses

Components	Impact	Incremental change (Rs per acre)		
		High rainfall	Moderate Rainfall	Low rainfall
Cost	Increase	2057	1769	789
	Decrease	2225	1596	897
Income	Increase	1783	737	916
	Decrease	800	765	599
Post-harvest losses	Increase	6255	4001	2974
	Decrease	3176	3285	7145

Source: Authors' calculations

of harvesting operation in the case of heavy rain forecast. Incidence of rain during post-harvest operations like threshing can also lead to loss of crop and reduce the quality of grains (table 3).

The highest incremental increase in yield was seen in tomato (2.36 quintal/acre), followed by jowar (1.67 quintal/acre), mango (1.2 quintal/acre), maize (0.85 quintal/acre) coffee (0.77 quintal/acre) and ragi (0.77 quintal/acre). The increase in yield was attributed to appropriate time of sowing, fertilizer application and irrigation operations based on the rain forecast received. Decrease in yield was observed to be 3.41 quintal/acre in the case of tomato which exceeded the average incremental increase in yield. However, this was indicated by only 4 farmers, whereas an increase in yield was mentioned by 26 farmers (table 3).

The results of incremental net gain across crops (table 4) indicated that arecanut had realized the highest incremental gain of Rs 12728 per acre followed by coffee (Rs 11118/acre), chilli (Rs 6818/acre) and tomato (Rs 4338/acre). The highest net gain in the case of arecanut has been due to the high market price of the crop, additional yield realised and the post-harvest losses saved with the rainfall forecast information. Similarly, saving of costs incurred on irrigation, reduction of post-harvest losses and timely application of fertilizers with the rainfall information in advance has led to increased net gain in coffee. The least incremental net gain was in maize (Rs 1071/acre), and jowar (Rs 860/acre). With respect to yield, the highest incremental yield realized was in tomato (1.59 quintal/acre), jowar (1.28 quintal/acre) and mango (1.20 quintal/acre).

Highest net return per acre was observed in Raichur (Rs 8,903) with cotton, red gram and paddy as prominent crops followed by Kodagu (Rs 6,858/acre), and Ballari (Rs 6,477/acre) (table 5). The incremental gain is the result of decrease in cost, increase in income and decrease in post-harvest losses. The net returns per household was highest in Raichur (Rs 60,653) followed by Ballari (Rs 33,629), both districts are in low rainfall region mainly cultivating cotton, paddy and red gram. The highest per household net return in Raichur was due to the high operational land holding

Table 3. Incremental change in yield across major crops

Crop	Impact	Yield (quintal/acre)	Percent of farmers indicated
Arecanut	Increase	0.14	4.44
	Decrease	0.30	0.07
Coffee	Increase	0.77	6.15
	Decrease	0.40	0.96
Cotton	Increase	0.46	7.56
	Decrease	0.57	1.19
Paddy	Increase	0.39	4.07
	Decrease	0.57	0.07
Maize	Increase	0.85	3.93
	Decrease	0.41	1.93
Ragi	Increase	0.77	5.70
	Decrease	0.45	1.85
Red gram	Increase	0.33	0.74
Chilli	Increase	0.37	1.26
	Decrease	0.35	0.44
Mango	Increase	1.20	0.07
Jowar	Increase	1.67	0.37
	Decrease	0.67	0.44
Tomato	Increase	2.36	1.93
	Decrease	3.41	0.30

Source: Authors' calculations

Table 4. Crop-wise incremental change in net returns and yield per acre

Crop	Incremental change in net returns per acre (Rs)	Incremental change in yield per acre
Arecanut	12728	0.40
Coffee	11118	0.61
Cotton	4126	0.32
Paddy	2550	0.37
Maize	1071	0.44
Ragi	3057	0.53
Red gram	1386	0.33
Chilli	6818	0.18
Mango	3619	1.20
Jowar	860	1.28
Tomato	4338	1.59
Others	4132	

Source: Authors' calculations

Table 5. Incremental returns per acre and per farm household

Districts	Incremental return per acre (Rs)	Incremental returns per farm household (Rs)
DK and Udupi	4568	12871
Kodagu	6858	29491
Shivamogga	3913	9393
Chikkamagluru	3472	15066
Hassan	1956	4205
Kolar	4854	12396
Tumakuru	2163	2940
Ballari	6477	33630
Raichur	8903	60653

Source: Authors' calculations

with 6.81 acres per farmer. This was 92 % higher than the average holding of the entire sample farmers (3.53 acres). Among high rainfall regions, households in Kodagu earned relatively higher net returns (Rs 29,490) and in moderate rainfall regions, Chikkamagaluru (Rs 15,066) realised relatively higher net returns**.**

5.1 Opinion of the farmers on accuracy levels of information and risk

An overwhelming proportion of farmers (65.41%) have indicated that the prediction was realised to the extent of above 50 to 100 %. In order to improve the accuracy levels and increase reliability of forecasts, isolation distance between Telemetric Rain Gauge Station and Telemetric Weather Gauge station should be reduced to 10 km and 100 kms respectively in wake of erratic rainfall variation across space and time. Additionally, information from other institutions should be interlinked to validate the weather prediction and enhance farmers' resilience and adaptive capacity.

The weather information obtained from Varuna Mitra has been able to effectively manage risk in taking up farming operations by the farmers. Across rainfall regions, 84 % of farmers from high rainfall districts, 50% of farmers from moderate rainfall districts and 39 % of farmers from low rainfall districts have concurred that information received from Varuna Mitra help-desk reduced their risk on account of rainfall. On the whole, 57 % of the farmers were certain about the benefits of risk reduction from weather forecast services, while 18.30% differed in their opinion on risk reduction and 24.37 % of the farmers were neutral on the subject**.** All the farmers in Kodagu (100%) asserted a reduction in risk followed by 83% farmers in Shivamogga, 78% Chikkamagaluru and 70 % in Dakshin Kannada & Udupi.

6 Impact at macro level

The impact estimated from the primary data was considered as a base for projecting the impact of Varuna Mitra help desk services at the State level. The per farmer net returns realized across 10 districts was considered to arrive at the returns realized for the entire State. The State is divided into 10 agro-climatic zones and it is assumed that the cropping pattern within the districts of a particular agro-climatic zone remains more or less similar. Hence, the average incremental net income in the sample districts in a particular agro-climatic zone was considered as the net income realized in the non-sample district of the same zone. For instance, Gulbarga, Yadgir and Raichur are the districts that fall under North Eastern Dry zone. However, among these districts, only Raichur was the sample district. Therefore, the per farmer incremental income of Raichur district (Rs 60,653) was considered as the incremental income of Gulbarga and Yadgir too. The highest incremental income per farmer was observed in Bidar, Gulbarga, Yadgir, Raichur (Rs 60653), whereas least incremental increase was reported in

Chitradurga, Davanagere, and Tumakuru (Rs 2939). As such, the incremental income per farmer for all the 30 districts was subsequently derived. These values were then multiplied by the number of beneficiaries (1,75,833) from the respective districts who called Varuna Mitra during 2016-17 for rainfall information. A total of all the derivations thus obtained was considered as the projection for the State which amounted to Rs 495.3 crores.

7 Conclusions and policy implications

The weather information extended by the Varuna Mitra help desk service has contributed to enhancing the welfare of the farmers. Specifically, rainfall information provided has helped the farmers to decrease input costs, increase yield, and income and decrease post-harvest losses. The highest incremental net gain was realized by arecanut growing farmers (Rs 12,727/acre) followed by Coffee (Rs 11,118/acre), whereas highest incremental yield was observed in tomato (1.59 quintal), jowar (1.28 quintal) and mango (1.2 quintal). At the State level, forecast information has led to an incremental gain of Rs 495.3 crore for all the area covered under Varuna Mitra.

It is interesting to note that in the wake of climate change and vagaries of monsoon, 84% of farmers from high rainfall districts, 50% of farmers from moderate rainfall districts and 39% of farmers from low rainfall districts have indicated that accurate information received from Varuna Mitra help-desk on rainfall forecast reduced their risk.

Results have also revealed that Varuna Mitra has performed notably well in addressing farmers' queries on weather forecasts and is a successful initiative to be showcased as a best practice in weather management, especially during droughts. However, this impact evaluation has provided insights to improve the existing services as well as highlight the components for its expansion that aim to secure much larger gains to the farming community.

- Presently, Varuna Mitra beneficiaries account for 3% of the cultivators in Karnataka. Therefore, there is a need to increase accessibility and awareness among the farmers. In this direction, efforts of the Departments of Agriculture and Horticulture are crucial. They should alert and give responsibility to the Panchayat Development Officers of the Gram Panchayats or the Raita Samparka Kendras to disseminate weather forecast received from Varuna Mitra in addition to dissemination of the Varuna Mitra helpline number to promote access and use of weather forecasts.
- Special extension efforts are needed from the above said institutions to disseminate information provided by Varuna Mitra including contact numbers. In addition, the contact number may be made toll free. This is essential for coverage of more cultivators in Karnataka as currently only 3% have been covered directly or indirectly under it.
- A significant number of respondents were also not aware about the availability of forecasts for other weather parameters such as wind speed, wind direction, temperature and relative humidity. The tele-advisors may be advised to create awareness on accessibility of forecasts on other parameters.
- Call dropping, irregularity in sending SMSs, busy lines and poor voice clarity were other issues expressed by the farmers interviewed. This could be addressed by increasing the number of telephone lines and employing additional staff, given the fact that the number of calls has been increasing at an annual rate of over 60% during 2013-2017.
- Most of the farmers have opined the need for agri-advisories from the stage of sowing to marketing. The Agriculture and Horticulture Universities should identify a nodal help desk (KVKs) in each district to provide agri-advisories to farmers. In this regard, it is suggested that KSNDMC forward such calls to these nodal centres to cater to the queries immediately. Further, the Department of Marketing and Inspection's Agmarknet may be interfaced with Varuna Mitra for providing information as such integration is bound to benefit farmers. It was further opined by the farmers that Varuna Mitra should make an attempt to provide the forecast on lightening to save lives and crops, as lightening during the monsoon season has affected crops and such accidental deaths have been intermittently reported.

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