National Innovations in Climate Resilient Agriculture (NICRA)

AICRP on Agrometeorology Component

Annual Report
2018-19

All India Coordinated Research Project on Agrometeorology

National Innovations in Climate Resilient Agriculture

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1. Introduction

India's agricultural sector is facing a significant threat from climate change as extreme weather events are on the rise. A study conducted by 29 researchers around the world, published in the *Proceedings of the National Academy of Sciences*, has outlined how climate change is causing lower crop yields around the world. In particular, the study found that "each degree-Celsius increase in global mean temperature would, on average, reduce global yields of wheat by 6.0%, rice by 3.2%, maize by 7.4%, and soybean by 3.1%." A study published in Economic Survey 2017-18 stated that, climate change could reduce farm incomes by 15-18%, and by 20-25% in unirrigated areas. "Extreme shocks have highly divergent effects between un-irrigated and irrigated areas (and consequently between crops that are dependent on rainfall), almost twice as high in the former compared to the latter," the survey said. And given the fact that around 52% (73.2 million hectares area of a total 141.4 million hectares net sown area) of India's total land under agriculture is still un-irrigated and rain-fed, the agricultural sector could be in trouble. Climate change models, such as the ones developed by the Intergovernmental Panel on Climate Change (IPCC), predict that temperatures in India are likely to rise between 3-4°C by the end of the 21st century. "These predictions, combined with the regression estimates showing negative impact of rise in temperature in agricultural crops, imply that in the absence of any adaptation by farmers and any changes in policy (such as irrigation), farm incomes will be lower by around 12% on an average in the coming years, and un-irrigated areas will be the most severely affected, with potential losses amounting to 18% of annual revenue" the survey said.

Realizing the impact of climate change, the Government of India has prioritized the climate change research and a flagship project 'National Innovations in Climate Resilient Agriculture (NICRA)' was initiated in 2010-2011 with the following objectives:

- To enhance the resilience of Indian agriculture (crops, livestock and fisheries) to climatic variability and climate change through development and application of improved production and risk management technologies
- To demonstrate site specific technology packages in farmers' fields for adapting to current climate risks
- To enhance the capacity building of scientists and other stakeholders in climate resilient agricultural research and its application.

In the vulnerable regions, the outcome from the project is expected to bring enhanced resilience of agricultural production systems to climate variability. The project is comprised of four components, viz.,

- Strategic research on adaptation and mitigation
- Technology demonstration on farmers' fields to cope with current climate variability
- Sponsored and competitive research grants to fill critical research gaps
- Capacity building of different stake holders

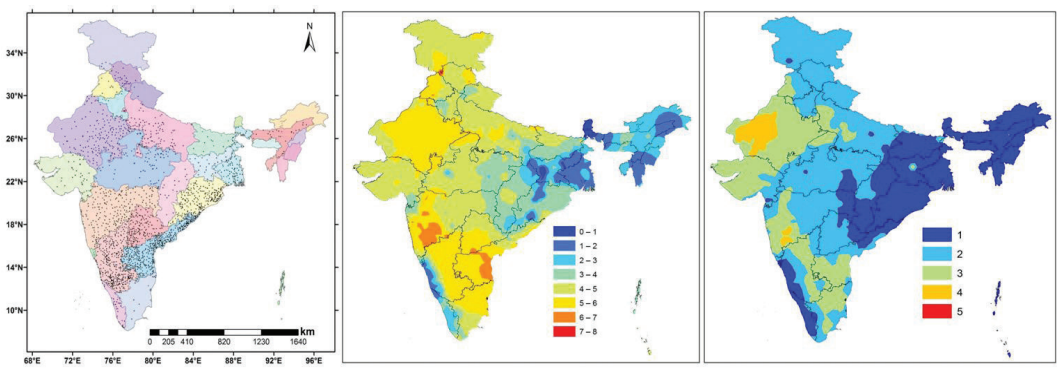
It is a known fact that weather plays a dominant role in year to year fluctuations in crop production, both in rainfed or irrigated agriculture. Though complete avoidance of farm losses due to weather is not possible, losses can be minimized to a considerable extent by making adjustments through timely agricultural operations based on accurate weather forecasts. Generalized forecasts have, however, limited use in farming. Weather information for agricultural operations will be a tailored product that can be effectively used in crop planning and its management. A comprehensive weather based farm advisory is an interpretation of how the weather parameters of the present and in future will affect crops, livestock and farm operations and suggests actions to be taken. In order to make the agromet advisory services more successful and continuous process, it should be supported with Agrometeorological database, crop conditions, real time weather, research results on crop-weather relationships, skilled manpower in multi-disciplinary resources and users interface. AICRPAM-NICRA project was thus initiated to address these issues with the following objectives

- To create weather and crop information acquisition and monitoring system through AWS and Field Information Facilitators' (FIF) network.
- Delineating hotspots for weather anomalies at micro level through benchmark survey and climatic analysis at selected Districts/villages/sites for principal cropping/farming systems.
- Quantification of crop responses to weather and its extremes by integrating statistical and dynamic modeling.
- Customizing micro-level agromet advisories and their dissemination through ICTs.
- Development of strategies to combat weather extremes through field research.
- Conduct awareness/training programs on climate change, and workshops for capacity building on agromet advisories.

2. Data Products Developed

Spatio-temporal variability of 7 and 14-day Dry spells and their trends in India

Change in rainfall pattern confines the performance of the major crops during southwest monsoon season across the country. A crop can with stand the water stress, based on the soil in which it is growing, and it's moisture retaining capacity. In some soils under rainfed conditions, crop can withstand a 7-day dry spell and beyond this period, it will be detrimental for a crop sustenance. In the present study, we analyzed the spatio-temporal variability in dry spells of 7-days and 14-days over entire India using rainfall data obtained from 2103 rainfall measuring stations spread across India. A software was developed for analyzing the weather data as well as to report the summary of the dry spells and GIS maps were generated. Further, Mann Kendall non parametric test was used for looking at the trends of 7 and 14-day dry spells across the country. This study revealed that the occurrence of dry spell of 7-days during monsoon season is highest (6-7 times during the season) over the regions of south-western Andhra Pradesh and Central Maharashtra. In the case of dry spells of 14-day duration during monsoon season (Jun to Sep), north-western India i.e., western Rajasthan is vulnerable to high frequency (more than 4 times during the season) across the country. The trend analysis using Mann Kendall method for dry spells of 7-days during *kharif* season showed significant increase in some pockets of Central Maharashtra, while significant decrease in the same is noticed over major parts of West Bengal. However, no significant increase/decrease was noticed in the dry spells of 14-days during *kharif* season, except few pockets in south-western Maharashtra.



a. Spatial distribution of rainfall stations used in the study

b. Spatial variability of dry spells of 7-day duration during kharif season

c. Variability in dry spells of 14-day during kharif season

3. Micro-level Agroclimatic Characterization

The characterization of crop growing environment is a pre-requisite for crop planning and evolving strategies to overcome climate/weather induced changes in the meso/micro climate. Thus, enhanced understanding of variability in climatic elements needs to be properly done to make agricultural sector resilient to climate change. Thus, historic data on climatic variables have to be analyzed using appropriate statistical tools for the development of location specific technologies/ adaptive strategies. The agroclimatic analysis carried out by different centres using block level weather data is reported here under.

3.1 Agro-climatic Characteristics of NICRA District, Hamirpur (H.P.)

This district falls in sub-humid sub-tropical zone. Bimodal mean annual rainfall of 1313 mm is received in 71 rainy days. A major portion (81.9 per cent) is received during monsoon. July and August are the wettest months. Rainfall during south west monsoon fluctuates from 501-1500 mm in 31 to 60 rainy days. Summer season receives 101-200 mm rainfall in 5-15 rainy days. 75-150 mm rainfall is received during winter in 8-9 rainy days. Post monsoon season witnesses highly variable rainfall (25-100 mm) in 1 to 10 rainy days. The mean annual temperature varies from 24-28°C with summer & winter maximum of 29-34°C & 19-22°C, respectively. The temperature during summer & winter season remains between 13-16°C & 5-7°C, respectively.

The soils of the district belong to group Entisols sub-order Typic Udorthenta with medium deep (50-100 cm) to deep soils (100 cm). Major area is having substantially undulating topography varying from gentle slopes to steeply sloping hills. Most of the district comprises well drained soils with very low available soil water content. Therefore, water is not available for the crops during critical phenophases of the crop (s) resulting in poor growth and yield of the crops.

Number of events and quantum of rainfall received in ≥100 mm rainfall events

Number of events and quantum of rainfall received in different rainfall categories 25<50, 50<75, 75<100 & ≥100 mm were assessed for three blocks (Bhoranj, Nadaun & Hamirpur). It was found in the analysis that the number of heavy rainfall events with ≥100 mm and the rainfall amount received in these events increased decade after decade in two out of three blocks viz. Bhoranj and Hamirpur (Table 3.1 & Fig. 1). However, the increase in number of extreme rainfall events and quantum of rainfall in those events is manyfolds higher at Hamirpur than at Bhoranj.

Table 3.1: Quantum of rainfall received in events with >100 mm rainfall in three blocks of NICRA district, Hamirpur

Decade/Rainfall/Block	Rainfall (mm)			No. of events		
	Bhoranj	Nadaun	Hamirpur	Bhoranj	Nadaun	Hamirpur
1992-2000	510	1698	105	4	13	1
2001-2010	1263	1435	373	8	11	3
2011-2018	1437	1490	1549	10	11	12

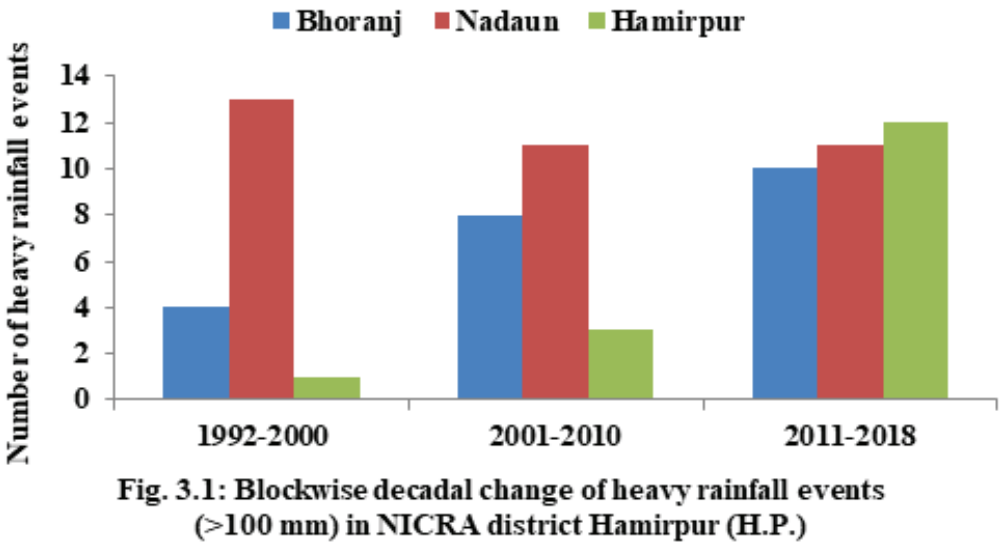


Fig. 3.1: Blockwise decadal change of heavy rainfall events (>100 mm) in NICRA district Hamirpur (H.P.)

During 2018, two heavy rainfall events ≥100 mm category each occurred on 13 August, 2018 (208.8 mm) and 06 Aug. 2018 (145.2 mm) in Bhoranj block and three in Hamirpur block, on 23 Sep. 2018 (112.6 mm), 25 Sep. 2018 (105.0 mm) and 04 Aug. 2018 (100.4 mm). These rainfall events caused heavy lodging of standing crops viz., maize, paddy and vegetables.

On the other hand, the longest dry spell was also observed during 15 Nov. 2018 to 4 Jan 2019 (51 days) in all the blocks. The late rains also delayed the sowing of potato and vegetable crops in the district. This dry spell affected the germination of *rabi* crops in the NICRA district. Analysis shows that the extreme rainfall events are on rise and hence proper water management through water harvesting techniques is suggested.

3.2 Extreme event analysis in Mahasamund district of Chhattisgarh

Dry and wet spell analysis was worked out alongwith the variability and trends of rainfall in different blocks of Mahasamund, the selected NICRA-AICRPAM district in Chhattisgarh. Weather data from 1973 to 2017 of 5 blocks were used for this analysis.

Dry spells

Trend analysis of dry spells has been undertaken for different blocks of Mahasamund district (Table 3.2). It can be very well seen that longest spell <critical value (less than 2.5 mm for 10 days) has shown decreasing trend for Bagbahara. But the most important parameter is total number of days <critical value (2.5 mm). This has shown increasing trend in Pithora which is very crucial in rainfed agriculture. Total spells < critical value is another critical parameter as its increasing or decreasing trend is indicating whether that spell frequency is in increasing or decreasing trend. It has been found that Bagbahara block has shown significant decreasing trend which will be advantageous for rainfed agriculture. It means that there will be fewer dry spells in this block now and farmers should take advantage of this situation for practising sustainable and profitable agriculture.

Table 3.2: Trend of dry spells at different blocks in Mahasamund District

Blocks	Longest dry Spell (< Critical Value)	Total dry Spells (<Critical Value)	Total dry Days (< Critical Value)	Longest dry Spell (>=Critical Value)	Total dry Spells (>=Critical Value)	Total dry Days (>=Critical Value)	Highest Value
Bagbhara	S** (0.05) Dec	S** (0.05) Dec	NS	NS	NS	NS	NS
Basna	NS	NS	NS	S** (0.05) Dec	S*** (0.1) Dec	NS	NS
Mahasamund	NS	NS	NS	NS	NS	NS	S*** (0.01) Inc
Pithora	NS	NS	S** (0.05) Inc	S*** (0.1) Dec	NS	S** (0.05) Dec	NS
Sarailpali	NS	NS	NS	NS	NS	NS	NS

*Significant at 90% level ** Significant at 95% level *** Significant at 99% level

Annual rainfall and rainy-days

The number of rainy days was found to be in decreasing trend (non-significant) in Bagbhara, Basna, Pithora and Sarailpali blocks and increasing in Mahasamund block. However, the annual rainfall was found to have an increasing trend (5.9 mm/year) at Basna and decreasing trend of 3.9 mm/year and 23.3 mm/year at Bagbhara and Pithora blocks, respectively.

Table 3.3: Trend analysis of annual rainfall and rainy days at different blocks of Mahasamund district

Blocks	Annual rainfall (Trend)	Rainy days (Trend)
Bagbhara	Decreasing @ 3.9mm/year	Decreasing @ 0.06 days/year (NS)
Basna	Increasing @ 5.9mm/year	Decreasing @ 0.20 days/year (NS)
Mahasamund	-	Increasing @ 0.15 days / year (NS)
Pithora	Decreasing @ 23.3mm/year	Decreasing @ 0.76 days/year (NS)
Sarailpali	-	Decreasing @ 0.33 days/year (NS)

3.3 Agricultural drought at Malappuram district, Kerala

Farmers of Malappuram district grow paddy during *kharif* season for fodder as well as grain purpose with a long duration variety *'Vellakkoli'*. The sowing of the long duration paddy variety was done during 22 standard meteorological week (SMW) and the harvesting of crop was done during the 51 SMW. They used to cut the leaves for fodder purpose during the 34, 37 and 39 SMW and maintain the paddy crop for the grain purpose. The panicle initiation occurs during 44 SMW and the harvesting of crop was done during the 51 SMW. If any drought occurs during the early stages, it will affect the fodder as well as the grain yield. From the drought analysis, it was seen that, agricultural drought was experienced in Malappuram district during 36-38 standard meteorological weeks. This agricultural drought situation may lead to the reduction of fodder as well as grain yield. Hence, irrigation during 36-38 SMW is very much essential for the long duration paddy variety like *'Vellakkoli'* which was grown for fodder as well as grain purpose at Malappuram district of Kerala.

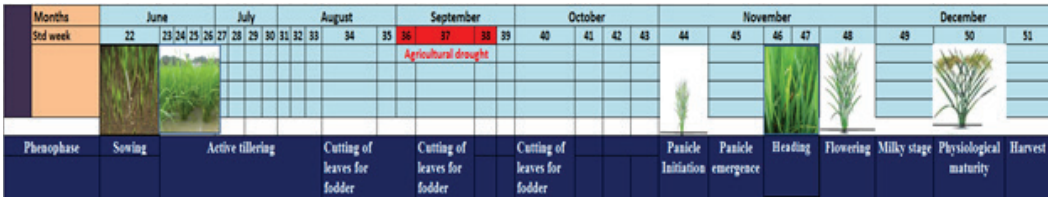


Fig 3.2: Phenological stages for the rice variety 'Vellakkoli' during kharif season at Malappuram district of Kerala

In Malappuram district, during *rabi* season, farmers grow short duration rice variety '*Ponmani*'. The sowing of the short duration variety is done on 36 SMW and it extends up to 52 SMW. The transplanting is done during 37-38 SMW and panicle initiation occurs during 43 SMW and the grains are harvested during 52 week. In Malappuram, after analyzing the agricultural drought, it was seen that, agricultural drought occurs during 36-38 SMW. This drought situation coincides with the sowing/transplanting of the rice variety '*Ponmani*' in the *rabi* season. This drought situation may lead to grain yield reduction in the *rabi* crop. Hence, irrigation during 36-38 SMW is very much essential for short duration varieties during *rabi* season at Malappuram district.

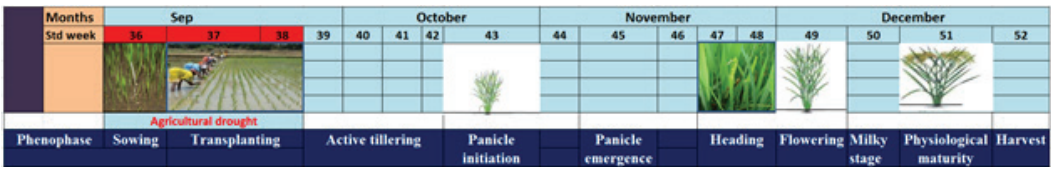


Fig 3.3: Phenological stages for the rice variety 'Ponmani' during rabi season at Malappuram district of Kerala

3.4 Dry-spell analysis in different blocks of AICRPAM-NICRA districts of Odisha

Dry-spell analysis of durations 7 and 14-days in AICRPAM-NICRA, AICRPDA-NICRA and TDC-NICRA districts (Table 3.4) showed that Kandhamal district (average over all blocks) experiences 3 dry-spells and Kendrapara district received one dry spell during the last 31 years (1988-2018). Only Phiringia and Tumudibandh block of Kandhamal district and Dharakote block of Ganjam district received dry spells of > 7-days 4 times and Dharakote, Sheragada and Sorada blocks received dry-spell of >14-days once in last 31 years.

Table 3.4: Dry-spell duration in various blocks of Kandhamaal, Kendrapara and Ganjam districts

	> 7-days	Duration	> 14-days	Duration
Kandhamal District				
Baliguda	3	18.06 - 26.06, 09.09 - 17.09 & 22.09 - 29.09	NIL	
Chakapad	3	14.06 - 26.06, 29.06 - 06.07 & 23.07 - 30.07	NIL	
Daringibadi	NIL		NIL	
G.Udayagiri	1	29.06 - 06.07	NIL	

	> 7-days	Duration	> 14-days	Duration
Khajuripada	2	18.06 - 26.06 & 08.09 - 16.09	NIL	
Kotagarh	3	14.06 - 21.06, 08.09 - 16.09 & 23.09 - 30.09	NIL	
Nuagaon	2	17.06 - 26.06 & 09.09 - 16.09	NIL	
Phiringia	4	14.06 - 26.06, 29.06 - 6.07, 08.09 - 16.09 & 23.09 - 30.09	NIL	
Phulbani	3	14.06 - 26.06, 08.09 - 16.09 & 22.09 - 30.09	NIL	
Raikia	1	15.06 - 23.06	NIL	
Tikabali	3	14.06 - 21.06, 29.06 - 06.07 & 08.09 - 16.09	NIL	
Tumudibandh	4	04.06 - 11.6, 14.06 - 21.06, 08.09 - 16.09 & 22.09 - 30.09	NIL	
Kendrapara District				
Kendrapara	1	14.06 - 21.06	NIL	
Derabis	1	14.06 - 21.06	NIL	
Marshaghai	1	14.06 - 21.06	NIL	
Mohakalpara	1	14.06 - 21.06	NIL	
Garadapur	3	04.06 - 12.06, 14.06 - 21.06 & 23.08 - 31.08	NIL	
Pattamundai	1	14.06 - 21.06	NIL	
Aul	1	14.06 - 21.06	NIL	
Rajnagar	2	14.06 - 21.06 & 08.09 - 16.09	NIL	
Rajkanika	2	14.06 - 21.06 & 08.09 - 19.09	NIL	
Ganjam District				
Bhanjanagar	3	06.10 - 20.10 & 23.07 - 30.07	NIL	
Belaguntha	2	01.06 - 08.06 & 12.06. - 20.06	NIL	
Jagannathprasad	1	10.06 - 19.06	NIL	
Buguda	3	12.06. - 21.06, 23.07. - 30.07 & 08.09 - 16.09	NIL	
Aska	1	01.06 - 08.06	1	12.06 to 27.06
Dharakote	4	01.06 - 08.06, 29.06 - 06.07, 23.07 - 02.08 & 08.09 - 17.09	1	10.06 to 26.06
Sheragada	2	01.06 - 08.06 & 08.09 - 16.09	1	11.06 to 30.06
Sorada	1	10.06 - 20.06		

3.5 Agro-climatic onset of season in NICRA districts of southern Karnataka

The agro climatic onset date can be defined as the first wet day of a 3-day wet spell receiving at least 20 mm without any 10-day dry spell (<1 mm) in the following 20 days (from 15 April). Sowing date is defined as the day when plant available water in soil is greater than 10 mm at the end of the day, followed by a 20-day period during which crop establishment is monitored. The juvenile stage of the crop is considered failed, triggering automatic re-sowing, if the simulated daily total biomass decreases during 11 out of 20 days. Simulated sowings are possible from 15 April to 31 August. However, the ideal sowing date may not be 'ideal' from an agro-ecological, agronomic, socio-economic point of view, since it does not take into account nutrient dynamics, pests and diseases, or labor availability.

Taking into consideration of the above pre-requisites for estimating the agro climatic onset of season, a MatLab code was run to estimate the Agro-climatic onset of monsoon in 3 NICRA districts (Tumkuru, Ramanagara and Chikkballapura) by using 30 years rainfall data.

Table 3.5: Simulation results of running MatLab expressed in terms of days after start date and agro-climatic onset dates of NICRA districts

District	Taluk	Agro-climatic onset date
Tumkur	Tumkur	15th May
	Gubbi	14th May
	Koratagere	15th May
Ramnagara	Ramanagara	10th May
	Chanapattana	30th May
	Kanakapura	23th May
	Magadi	20th May
Chikkaballapur	Chikkaballapur	04th June
	Chintamani	16th June
	Siddalaghatta	10th June
	Gouribidanur	03th June
	Gudibande	06th June
	Bagepalli	14th June

Among three NICRA districts, earliest onset date was simulated in Magadi taluk of Ramanagara district (20 May). In Tumkur district, earliest Agro-climatic onset can be observed in Gubbi taluk (14 May). But, in Chikkaballapur district, earliest Agro-climatic onset can be observed at Siddalaghatta taluk (10 June). Variations in Agro-climatic onset were observed among the different taluks of the three districts due to spatial and temporal variations in the rainfall. Keeping this in mind of early onset of rain, in the month of May in Tumakuru and Ramanagara districts, the double cropping systems are being advised to the NICRA farmers and impact analysis of double cropping system against the traditional systems are made. On the contrary, the double cropping system is not recommended in Chikkaballapur district due to the late Agro-climatic onset and less LGP.

4. Validation of block level weather Forecast

District level weather forecast is used for preparation of bi-weekly agromet advisory services (AAS) in India, since last two decades. But it did not account for the large spatial variation in weather parameters, especially rainfall, which may vary between a few kilometers. Hence, the validity of AAS prepared based on district level weather forecast is a problem to be solved. India Meteorological Department has started issuing block-level weather forecast since 2014. AICRPAM has been using this block-level forecast for preparation of micro-level AAS under this project. AICRPAM centres have compared block and district level rainfall forecasts with the observed rainfall at the AICRPAM-NICRA adopted villages and the results are presented in this chapter.

Thrissur

The block level and district level rainfall forecast for Malappuram district during the southwest (SWM) and northeast monsoon (NEM) season is verified with the observed rainfall data as per the guidelines laid down by IMD. The observed rainfall data has been collected from the Agricultural Research Station, Anakkayam, KAU of Malappuram district.

Table 4.1: Verification of forecast for Thavanur village, Malappuram distrct, Kerala

Forecast resolution / Period of forecast	Block level - SWM period	District level - SWM period	Block level-NEM period	District level-NEM period
Total number of days	122	122	90	90
Number of days when rain was forecasted and also observed	101	65	50	12
Number of days when rain was not observed but forecasted	0	50	0	35
Number of days when rain was observed but not forecasted	21	1	36	0
Number of days when rain was not observed and also not forecasted	0	6	4	43
Number of matching cases	101	71	54	55
Skill Score or Ratio Score of rainfall	82.79	58.2	60	61.11
Probability of detection (POD)	0.83	0.98	0.58	1
False Alarm Ratio (FAR)	0	0.43	0	0.74
Root Mean Square Error (RMSE)	24.47	21.95	9.95	15.77
Correct forecast (%)	10.66	15.57	13.33	50
Usable (%)	13.11	8.2	5.56	1.11
Unusable (%)	76.23	76.23	81.11	48.89

At Thavanur, for block level, during SWM period the total usable forecast (Correct forecast (10.66) + Usable (13.11)) is 23.77%, whereas unusable was 76.23%. Whereas for the district as such, during SWM period the total usable forecast (Correct forecast (15.57) + Usable (8.2)) is 23.77% and unusable was 76.23%.

At Thavanur, for block level, during NEM period the total usable forecast (Correct forecast (13.33) + Usable (5.56)) is 18.89% and unusable was 81.11%. Whereas for the district as such, during NEM period the total usable forecast (Correct forecast (50) + Usable (1.11)) is 51.11% and unusable was 48.89%. This shows that there is a need for improvement in the forecast, especially for SWM period.

Table 4.2: Verification of forecast for Valavannur village, Malappuram distrct, Kerala

Forecast resolution / Period of forecast	Block level - SWM period	District level - SWM period	Block level-NEM period	District level-NEM period
Total number of days	122	122	90	90
Number of days when rain was forecasted and also observed	95	65	58	12
Number of days when rain was not observed but forecasted	0	50	0	35
Number of days when rain was observed but not forecasted	27	1	28	0
Number of days when rain was not observed and also not forecasted	0	6	4	43
Number of matching cases	95	71	62	55
Skill Score or Ratio Score of rainfall	77.87	58.2	68.89	61.11
Probability of detection (POD)	0.78	0.98	0.67	1
False Alarm Ratio (FAR)	0	0.43	0	0.74
Root mean square Error (RMSE)	30.1	21.95	9.62	15.77
Correct forecast (%)	13.93	15.57	10	50
Usable (%)	9.02	8.2	14.44	1.11
Unusable (%)	77.05	76.23	75.56	48.89

At Valavannur for block level, during SWM period the total usable forecast (Correct forecast (13.93) + Usable (9.02)) is 22.95% and unusable was 77.05%. Whereas for the district as such, during SWM period the total usable forecast (Correct forecast (15.57) + Usable (8.2)) is 23.77% and unusable was 76.23%.

At Valavannur, for block level, during NEM period the total usable forecast (Correct forecast (10) + Usable (14.44)) is 24.44%, unusable was 75.56% and for the district as such, during NEM period the total usable forecast (Correct forecast (50) + Usable (1.11)) is 51.11% and unusable was 48.89%. This shows the need for improvement in the forecast, especially for SWM period.

Raipur

Comparison of rainfall data actually observed through ordinary rain gauge (ORG) installed at Kapsi and Jhalkhamharia villages with district level weather forecast (GKMS) and block level weather forecast (NICRA-AICRPAM) has been shown in Fig. 4.1 and Fig. 4.2.

One ORG was installed during monsoon season of 2018 at village Kapsi in NICRA-AICRPDA domain district, Kanker. It can be very well observed that whenever the rainfall of moderate to heavy quantity is occuring, either of the weather forecasts (district level or block level) will be detecting it, but with some variation. However, on 3-4 occasions it is the block level forecast which

is coming close to the actual rainfall recorded. It can be very well seen from RMSE values which are somewhat higher at Kapsi village of Kanker district. These values have crossed the numerical value of about 20 which are on higher side (Table 4.3). Moreover, district-level and block-level RMSE values are almost in the same range. This indicates that there is a difference between observed and predicted values of rainfall. Therefore, it requires effort on the part of IMD to improve both block level and district level forecast in Kanker district.

Comparison of observed rainfall at Jhalkhamharia village and district level/ block level forecast of rainfall is shown in Fig. 4.2. A close observation has also been made for this village by drawing observed rainfall versus district level forecast and block level forecast. One positive observation is that at Jhalkhamharia village there is less value of RMSE as compared to Kapsi village. It can be very well seen that whenever any rainfall in moderate to heavy quantity is occurring, it is block level forecast which is performing better (forecast issued by IMD for NICRA-AICRPAM district Mahasamund). That's why RMSE value is less for block level forecast than district level forecast.

Table 4.3: Root Mean Square Error (RMSE) values have been calculated for Kapsi and Jhalkhamharia

S.No.	NICRA Village	Forecast	RMSE Values
1.	Kapsi (Kanker)	Block level	24.0
		District level	24.4
2.	Jhalkhamharia (Mahasamund)	Block level	18.9
		District level	20.6

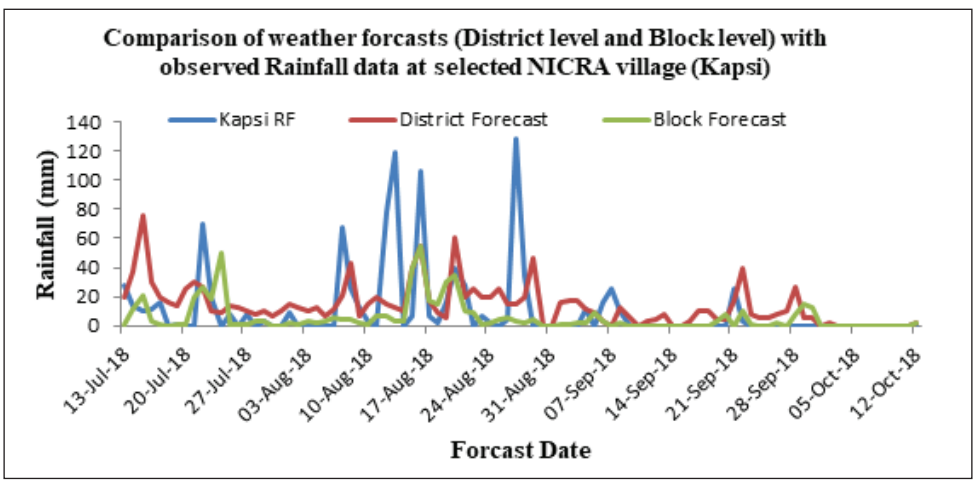


Fig. 4.1: Variation of meteorological parameters (Rainfall) during 2018 at Kapsi

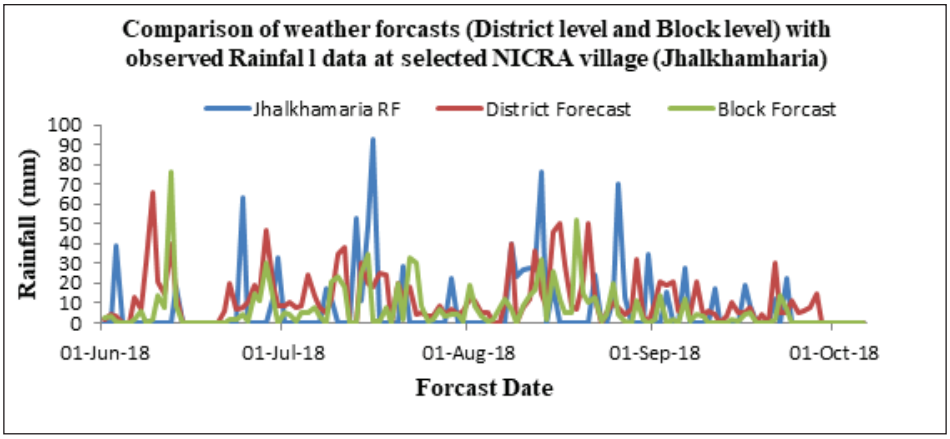


Fig. 4.2: Variation of meteorological parameters (rainfall) during 2018 at Jhalkhamharia

Udaipur

During monsoon season, out of total 122 days of rainfall forecast (Table 4.4), per cent of success of rainfall (yes/no) in village Jorawar Singh Ji Ka Kheda (Rajsamand), Kundeli (Deogarh), Bagatpura (Relmangra) and Chomakot (Sangod) were 61.5%, 63.11%, 68% and 68.8%, respectively. The per cent success of forecast for no rainfall, light rainfall and moderate rainfall was 88.7, 14.6 and 23.5%, respectively at Jorawar Singh ka Kheda, 93.6, 5.7 and 31.2% at Kundeli, 91.1, 10.5 and 11.1% at Bagatpura, and 80.39, 24.4 and 30.4%, respectively at Chomakot (Table 4.5). The per cent success of forecast for heavy rainfall during the season was 20.0% in Bagatpura, 12.5% at Kundeli and 0% at Jorawar Singh Ji ka Kheda and Chomakot.

Table 4.4: Success and Failure of weather forecast for rainfall (yes/no)

Village/Tehsil (Udaipur)	Number of events		No. of observations
	Success events	Failure	
Jorawar Singh Ji Kheda (Rajsamand)	75 (61.5 %)	47 (38.5%)	122
Kundeli (Deogarh)	77 (63.11%)	45 (36.89 %)	122
Bagatpura (Relmangra)	83 (68.03%)	39 (31.96 %)	122
Chomakot (Kota)	84 (68.85%)	38 (31.15 %)	122

Table 4.5: Success and failure of rainfall forecast during 1 June 2018 to 30 September, 2018

Rainfall Range (mm/day	0 mm (No rain)			Trace- 10 mm (Light)			11-30 mm (Moderate)			>30 mm (Heavy)			Total	
	No. of Obs	Suc.	Fail.	No. of Obs	Suc.	Fail.	No. of Obs	Suc.	Fail.	No. of Obs	Suc.	Fail.	Suc.	Fail.
Jorawar Singh Ji Kheda (Rajsamand)	53	47 (88.7)	6 (11.3)	48	7 (14.6)	41 (85.4)	17	4 (23.5)	13 (76.5)	4	0 (0.0)	4 (100.0)	75 (61.5)	47 (38.5)
Kundeli (Deogarh)	63	59 (93.6)	4 (6.4)	35	2 (5.7)	33 (94.3)	16	5 (31.2)	11 (68.8)	8	1 (12.5)	7 (87.5)	77 (63.1)	45 (36.9)
Bagatpura (Relmangra)	56	51 (91.1)	5 (8.9)	38	4 (10.5)	34 (89.5)	18	2 (11.1)	8 (88.9)	10	2 (20.0)	8 (80.0)	83 (68.0)	39 (32.0)
Chomakot (Kota)	51	41 (80.4)	10 (19.6)	41	10 (24.4)	31 (75.6)	23	7 (30.4)	16 (69.6)	7	0 (0.0)	7 (100.0)	84 (68.8)	38 (31.2)

Hisar

The season-wise quantitative verification analysis of the forecast of rainfall at Sirsa during 2018 was carried out using various error structures (Table 4.6) and the rainfall forecast was perfect i.e. 100% correct during post monsoon and winter seasons and in case of pre monsoon it is almost perfect i.e. 98.8%. The accuracy is comparatively lower during monsoon season (82.4%). In case of annual rainfall forecast, the forecast accuracy was 95.3%.

Table 4.6: Quantitative analysis (%) of predicted rainfall events at Sirsa using error structures

Error structure	Season				
	Pre Monsoon	Monsoon	Post Monsoon	Winter	Annual
Correct	98.8	82.4	100.0	100.0	95.3
Usable	0.0	4.1	0.0	0.0	1.0
Unusable	1.2	13.5	0.0	0.0	3.7

The quantitative analysis of predicted maximum temperature presented in Table 4.7 showed that the highest correct forecast events were during post monsoon season (65.2%) followed by monsoon (50.8%) and winter (39%). The pre monsoon season recorded the least correct events i.e. 37%. In case of annual values, the correct events were 49% with 21.1% usable and 29.9% unusable events. The highest unusable events were recorded during pre-monsoon season.

Table 4.7: Quantitative analysis (%) of predicted maximum temperature events at Sirsa using error structures

Error structure	Season				
	Pre Monsoon	Monsoon	Post Monsoon	Winter	Annual
Correct	37.0	50.8	65.2	39.0	49.0
Usable	14.1	22.1	22.8	27.1	21.1
Unusable	48.9	27.1	12.0	33.9	29.9

The season-wise minimum temperature forecast verification results (Table 4.8) revealed that the highest (54.1%) correct event forecast was observed during monsoon season followed by winter (49.2%) and post monsoon (47.8%) and lowest accuracy was observed during pre-monsoon season (46.7%). Annual forecast verification of minimum temperature events showed that 49.9% of values were correct. The annual usable forecast events were 24.9% and 25.2% were unusable. The usable percentage was relatively low during monsoon season (19.7%). The diffrence between predicted and observed maximum and minimum temperatures is presented in Fig 4.3.

Table 4.8: Quantitative analysis (%) of predicted minimum temperature events at Sirsa using error structures

Error structure	Season				
	Pre Monsoon	Monsoon	Post Monsoon	Winter	Annual
Correct	46.7	54.1	47.8	49.2	49.9
Usable	28.3	19.7	28.3	25.4	24.9
Unusable	25.0	26.2	23.9	25.4	25.2

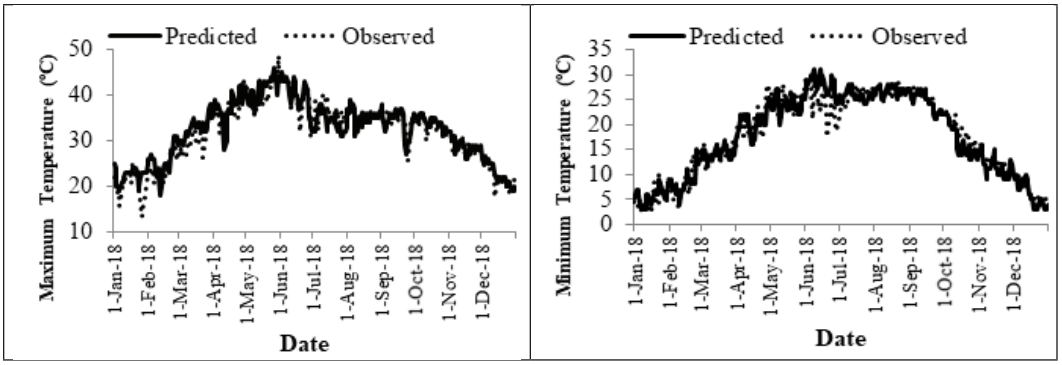


Fig 4.3: Comparison of predicted and observed daily maximum and minimum temperature at Sirsa

Jammu

The events of monthly rainfall were analyzed and presented in Table 4.9. The rainfall analysis shows that the accuracy of forecast events of rainfall was found to be 60 to 100% in all months except for the months of March, October, November and December with ratio score ranging from 76.29 to 90.9%. The error structure (correct + usable) showed more than 90 percent accuracy in all the months except April, June and September. The H.K. Score and RMSE were -0.79 to 0.63 and 0.96 to 43.46%, respectively for all the months. The ratio score was found to be higher in the month of November and December and lowest in the months of June and July.

Table 4.9. Verification of block level rainfall forecast during the year 2018 at Sherpur village

Month	Day of Forecasting	Total no. of days forecast received	Error Structure			RMSE	Ratio score	H.K. score
			Correct	Usable	Not usable			
March	Tuesday	23	100	0	0	3.28	78.26	-0.14
	Friday	22	100	0	0	1.25	81.82	-0.05
April	Tuesday	20	100	0	0	5.64	65.00	-0.28
	Friday	21	93.3	0	6.67	5.63	71.43	0.16
May	Tuesday	22	94.12	5.88	0	1.11	77.27	0.18
	Friday	22	100	0	0	0.96	68.18	-0.21
June	Tuesday	20	66.67	0	33.33	14.59	26.09	-0.29
	Friday	20	92.31	0	7.69	4.09	65.00	0.63
July	Tuesday	20	100	0	0	18.53	20.00	-0.79
	Friday	23	66.67	0	33.33	14.59	26.09	-0.29
August	Tuesday	23	28.57	7.14	64.29	28.43	60.87	0.31
	Friday	20	11.11	11.11	77.78	43.46	45.00	-0.02
September	Tuesday	20	92.86	0	7.14	19.02	70.00	-0.06
	Friday	22	63.64	0	36.36	19.69	50.00	0.1
October	Tuesday	21	100	0	0	1.53	76.19	-0.11
	Friday	23	100	0	0	1.37	82.61	-0.14

Month	Day of Forecasting	Total no. of days forecast received	Error Structure			RMSE	Ratio score	H.K. score
			Correct	Usable	Not usable			
November	Tuesday	22	100	0	0	1.87	81.82	-0.14
	Friday	20	100	0	0	0.71	90.00	-0.05
December	Tuesday	20	100	0	0	3.44	85.00	-0.11
	Friday	22	100	0	0	3.21	90.91	0.0
January	Tuesday	22	100	0	0	9.78	50.00	-0.35
	Friday	22	85.71	7.14	7.14	14.87	63.64	0.11

Jorhat

In Thengalgaon, the actual total rainfall received per month was somewhat higher than the forecasted total rainfall except for October and December. It was observed that the actual maximum temperature was comparatively lower than the forecasted maximum temperature in the month of January, February, March, April and July. However, the actual minimum temperature was substantially higher than the forecasted minimum temperature round the year. Similar analysis was also done for Kochupathar and Nagharia (Fig. 4.4, 4.5, 4.6).

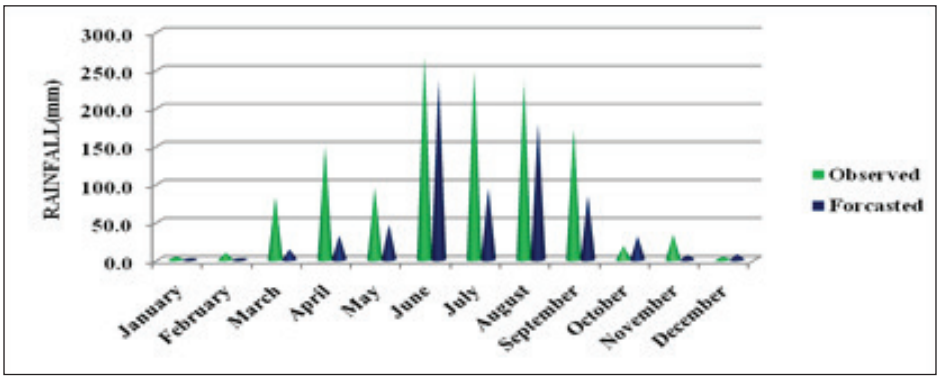


Fig. 4.4: Comparison between Forecasted Rainfall and Actual Rainfall at Thengalgaon.

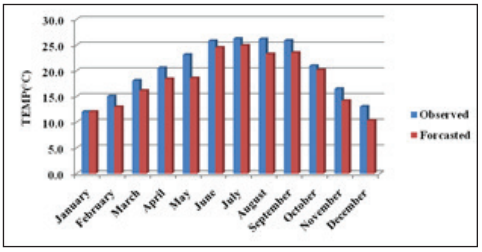


Fig 4.5: Comparison between Forecasted Minimum Temperature and Actual Minimum Temperature at Thengalgaon

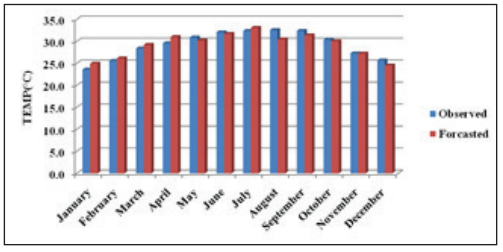


Fig 4.6: Comparison between Forecasted Maximum Temperature and Actual Maximum Temperature at Thengalgaon.

Mohanpur

The rainfall data from Gopalganj and Bongheri Villages was collected and compared with the forecasted data. It was observed that during monsoon season (June, July and August), there were few deviations between actual and predicted data. The September and October rainfall forecast was slightly better, although the daily rainfall was under-predicted (Fig. 4.7).

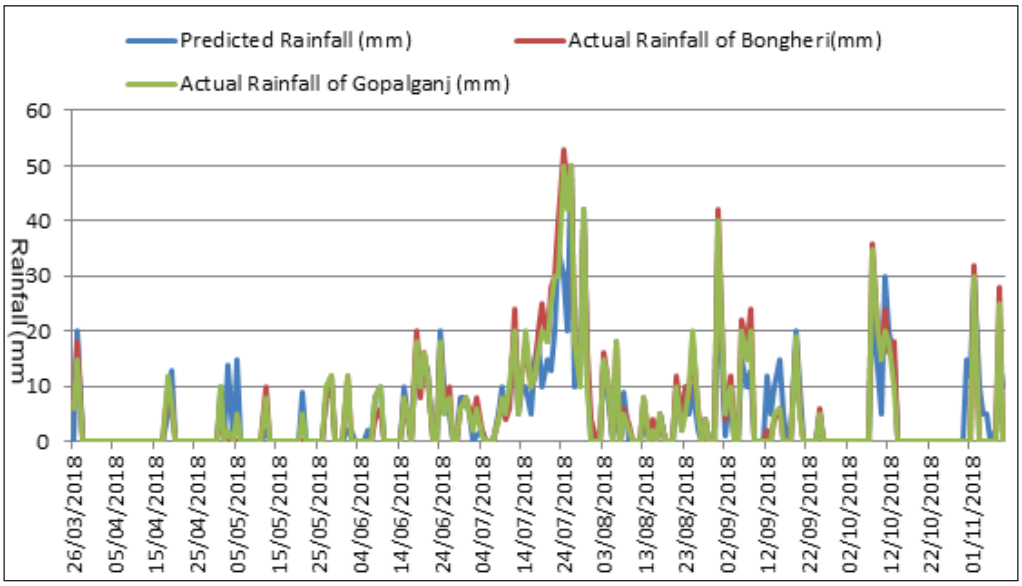


Fig. 4.7: Forecast and actual daily rainfall at Bongheri and Gopalganj villages, South 24 Parganas

5. Micro-level Agromet Advisory Services

Agromet Advisory Services (AAS) have been issued at district-level since 2008 by India Meteorological Department (IMD) and continued even now. The district-level AAS is provided to farmers making use of medium range weather forecast of National Center for Medium Range Weather Forecast (NCMRWF) and IMD. However, the validity of blanket advisories disseminated at district-level has limitations, particularly in view of the large variability in terms of crops, varieties and spatial weather anomalies at this level.

Under this project, AICRPAM initiated block-level AAS in Belgaum district of Karnataka through its Vijayapura center. However, the same district-level forecasts were used. After three years of experimentation it was concluded that the district-level forecasts were indeed not sufficient to answer the demands of the block-level crop and weather variability within the district. To overcome this constraint, on request, block-level weather forecasts for identified districts were provided by IMD since 2014. This has now enabled AICRPAM to ingeniously develop and disseminate AAS at block-level through all its 25 cooperating centers and Krishi Vigyan Kendras (KVK) of the respective districts. The conceptual process diagram of block-level AAS developed by AICRPAM is presented in Fig. 5.1

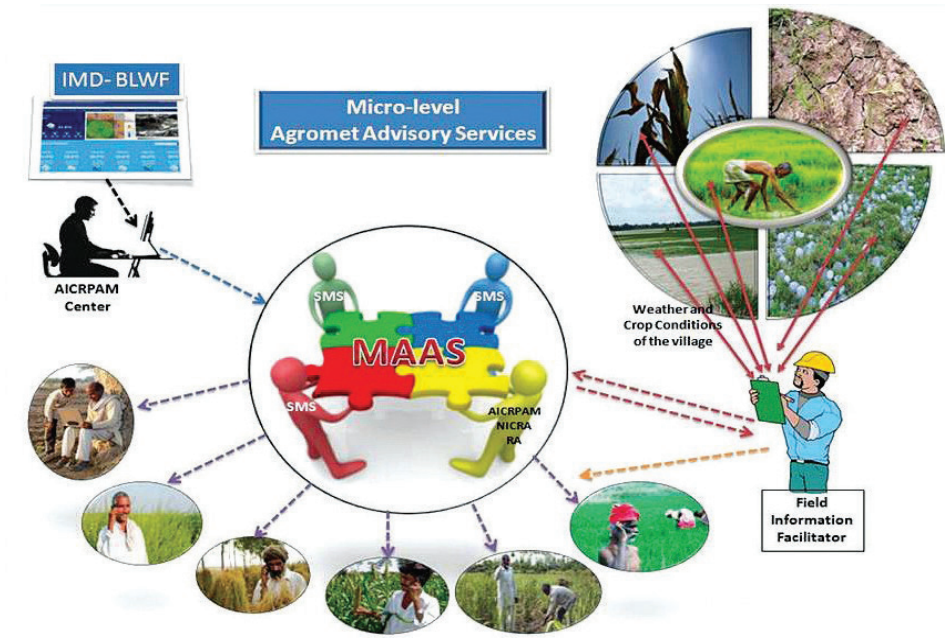


Fig. 5.1: Conceptual diagram of block-level AAS

Such advisories are now designated as micro-level AAS. AICRPAM centers have initiated micro-level AAS on pilot basis at 50 villages across India under this project in the past three years. The scientific staff receives block-level weather forecast from IMD website, and advisories are developed in consultation with Subject Matter Specialists of respective KVKs. Another important

and useful concept has been introduced in micro-level AAS in the form of appointing "Field Information Facilitator (FIF)" to serve as the interface among the farmers, AICRPAM and KVK. Further, FIF collects weather and crop information (prevailing local weather conditions, crops and their growth stage, vigour, incidence of pests and diseases etc.) and disseminates advisories to the farmers. Generally, a young and progressive farmer in the selected village is identified for this purpose. Feedback from FIF provides real situation at village level based on which and the block-level forecast, micro-level advisories are prepared. Thus, the Agrometeorologist of the AICRPAM center develops the Agromet advisory bulletins with the help of SMS at KVK using the field level crop information blended with weather forecasts and communicated to the FIFs by email who pass on the bulletins to farmers. The micro-level AAS is generated in the name of Program Coordinator, KVK and is disseminated by multiple communication modes, viz., mobile text as well as voice SMS, display at public places, personal contact etc. The feedback obtained from the farmers is being evaluated for improving as well as expanding services for the benefit of farming community.

5.0.1 Selection of AICRPAM-NICRA villages

The selection procedure for district/ villages was defined clearly. A district has been selected under AICRPAM-NICRA program should not be a IMD- GKMS operating district. After selection of the district, two villages were selected by each AICRPAM centers from a district for implementation of micro-level AAS in AICRPAM- NICRA project. A pictorial representation of site selection is given in Fig. 5.2.

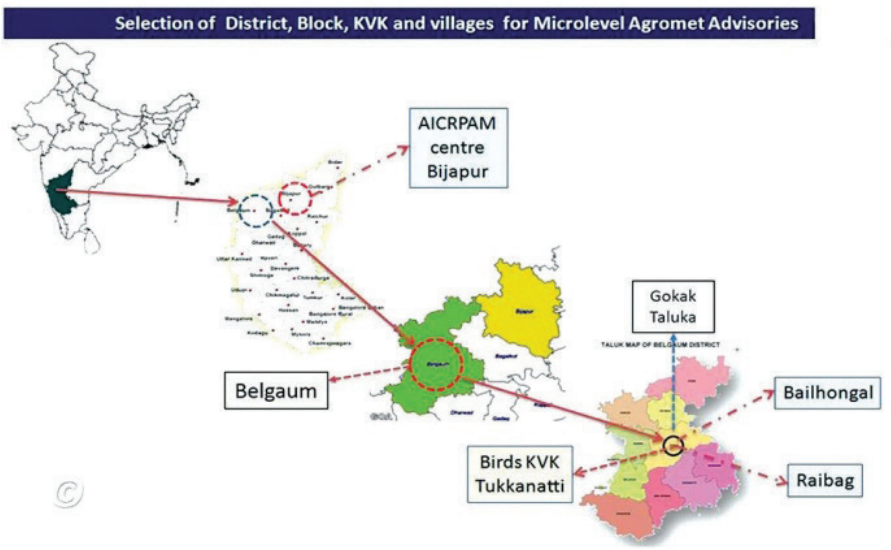


Fig. 5.2 Selection of district, block, KVK and villages for micro-level AAS

5.1 Modes of AAS Dissemination

The success of any AAS depends on timely dissemination of them to farmers. In this era of Information-Communication Technology, plenty of options are available to ensure dissemination of AAS to farmers on time. Under AICRPAM-NICRA project, both conventional and latest ICT tools are used for dissemination of micro-level AAS. A pictorial representation of various methods of dissemination used in AICRPAM- NICRA project is given in Fig. 5.3

Fig. 5.3 Various methods of micro-level AAS dissemination adopted by AICRPAM cooperating centers

A brief description of the methods adopted for AAS dissemination is given below:

- Displaying AAS bulletins on common places like milk booth, PDS shops, Panchayat office etc, where farmers will visit frequently.
- Text SMS: AAS is send to farmers as text SMS through mobile phones. mobile apps like Havamaana Krishi
- Nowadays, many government and private agencies allow bulk SMS facilities (mostly free of cost).
- Voice SMS: AAS is send to farmers in the form of voice SMS, which will be helpful for illiterate farmers.
- Personal contact: Field Information Facilitator (FIF) distributes micro- level AAS developed to individual farmers through personal contact.
- Whatsapp: AAS information is provided through Whatsapp group for tech-savvy farmers.
- Dandora method: It is followed by Anantapur center in the event of extreme weather event forecast. A person with a drum will travel through the adopted village to inform the farmers about forecast of heavy rainfall, hail storm etc so that livestock, harvest-ready crops etc can be saved.

5.2 Economic impact of block-level Agromet Advisory Services

The crucial objective of weather based AAS is to help the farmers in decision making in their day to day activity as well as in the judicious input use. Regulating the erratic weather on a large scale is beyond the human control. However, it is possible to adapt or mitigate the ill effects of weather through appropriate Agromet advisory. Further it will increase the economic benefit of the farmers by suggesting management practices suiting the anticipated weather conditions. Impact assessment is an essential tool for assessing the viability of any activity. Economic impact assessments of AAS issued to farmers of NICRA adopted villages were carried out by various centers. Economic impact of individual advisories is discussed here and the cumulative impact of block-level AAS issued throughout provided to the farmer in the season is detailed in the case study section. There were mixed impacts, some farmers gained from the agromet advisories while others suffered losses. Some of the examples from different NICRA villages collected and compiled by the individual centers is discussed below.

Table 5.1. Microlevel agromet advisories and their economic benefits on different crops at various locations

Akola

Crop: Cotton

Date of issuing AAS	Weather forecasted	AAS issued	Observed weather	Action taken by Farmer	Remarks
28/07/ 2018	Forecast of cloudy weather and 19 mm rainfall in next 5 days.	Keep the crop weed free during critical period of crop weed competition.	24 mm rainfall received	Advisory was followed and weeding undertaken	Weeding efficiently Eliminated weed Competition and facilitated better crop vigour and subsequent growth
06/08/ 2018	Forecast of cloudy weather and 15 mm rainfall in next 5 days.	Furrow opening between rows to be carried out at the time of hoeing	No rainfall received	Advisory was followed and hoeing with furrow opening followed	Hoeing and furrow opening ensured better soil aeration and in situ rain water conservation
13/08/ 2018	Forecast of 15 mm rainfall in next 5 days.	With incidence of sap sucking pest undertake spraying of acetamaprid	Rainfall received 182 mm	Spraying of acetamaprid 20% SP @ 4 g /10 litres of Water undertaken	Notably reduced the infestation and Improved crop condition
21/08/ 2018	Forecast of cloudy weather with 159 mm rain fall in next 5 days.	Do not undertake any plant protection /foliar spray. Real time advisory to drain out excess water due to water logging	79 mm rainfall received	Drained out waterlogged areas immediately	Adequate drainage of water logged areas improved field/ crop condition.
28/08/ 2018	Cloudy weather and forecast of 13 mm rainfall	Do not undertake any plant protection /foliar spray. Drain out excess water in the event of water logging	No rainfall received	No other operations undertaken. Drained out water logged patches.	Better field condition prevailed for further crop growth and development
04/09/ 2018	Cloudy weather and light rainfall (31 mm) in next 5 days.	Recommended foliar spray of 2% urea (200g/10 litres of water)	No rains occurred next 7-days.	Foliar spray of urea was done on 3 September.	Foliar spray would benefit in terms of crop nutrition during pod formation stage.
10/09/ 2018	Forecast of scattered light to moderate rainfall (13 mm) next 5 days.	Real time advisory to apply protective irrigation in view of continued subdued rainfall activity period causing moisture deficit like situation.	No rainfall received	With insufficient rainfall and with dry weather expected further, protective irrigation was given on September 12	Timely protective Irrigation improving the readily available Moisture benefited subsequent crop growth and development

Date of issuing AAS	Weather forecasted	AAS issued	Observed weather	Action taken by Farmer	Remarks
17/09/ 2018	Forecast of light to moderate rainfall (37 mm) next 5 days.	In view of the weed growth in crop field, advisory to under- take weeding to prevent weed competition during subsequent crop growing period.	One rainy day (21 mm) occurred	Advisory was followed and weeding undertaken	Weeding facilitated better crop vigour and further growth/development.
24/09/ 2018 and 01/10/ 2018	Cloudy weather & light to moderate rainfall (8 mm) expected	With incidence of sap sucking pest- white fly, undertake spraying of Triazophos 40% EC @30 ml OR Diafenthiuron 50 % WP 12.0 g /10 litres of water on a clear day, avoiding rainy weather.	No rainfall occurred	Plant protection undertaken on 28 September.	White fly infestation reduced improving crop vigour
09/10/ 2018	No rainfall expected	Recommended foliar spray of 2% (200g DAP/10 litres of water) judging a clear weather.	Dry weather prevailed with no rains next 6 days.	Foliar spray of 2% DAP was done on 08 October	Foliar spray would benefit in terms of crop nutrition during boll formation phase, reflecting in final yield output.
15/10/ 2018	No rainfall expected	Advisory to under- take spraying of Triazophos 40% EC @30 ml OR Diafen- thiuron 50 % WP 12.0 g /10 litres of water on a clear day avoiding rainy weather.	No rainfall received during the week	No other operations undertaken.	White fly infestation reduced improving crop vigour
23/10/ 2018	No rainfall expected	Recommended foliar spray of 2% (200g DAP/10 litres of water) judging a clear weather.	No rainfall received during the week	No other operations undertaken.	--
29/10/2018	No rainfall expected	Real time advisory during cotton harvest to ensure clean collection of fully opened burst bolls for better market grade of the produce	No rainfall received during the week	No other operations undertaken.	---

Date of issuing AAS	Weather forecasted	AAS issued	Observed weather	Action taken by Farmer	Remarks
06/11/ 2018	Forecast of dry weather	Real time advisory during cotton harvest to ensure clean collection of fully opened burst bolls for better market grade of the produce	No rainfall received during the week	First picking undertaken	--
12/11/ 2018	Forecast of dry weather	Advisory to undertake spraying of Quinolphos 25% EC @ 25 ml OR Deltamethrin *2.8%* EC @ 9.0 ml /10 litres of water.	Dry weather prevailed	Plant protection by Quinalphos spray undertaken	Incidence reduced improving development of bolls
22/11/ 2018 - 14-01- 2019	Forecast of dry sunny weather	Undertake harvesting of cotton. Ensure clean collection of fully opened burst bolls and storage at dry place for better market grade of the produce	Dry weather prevailed	Picking wise harvest undertaken	Obtained total seed cotton yield of 14.8 q ha^{-1}

Bhubaneswar

Crop: Rice

Date of Issue during 2018	Crop	Rainfall Forecast	Advisory Given	Observed Rainfall	Action taken by the Farmer	Profit/ Loss
14 - 26 July	Rice	149.0	Go for puddling and transplanting of Rice	227.0	Transplanting was done	Timely planting could be made
11 - 15 Aug.	Rice	67.0	Withhold spraying for controlling pest like leaf folder	52.0	Spraying withheld	Rs. 550/- (Could save the cost of pesticide and Labour cost)
25 - 29 Aug.	Rice	55.0	Withhold spraying for controlling pest like leaf folder	66.4	Spraying withheld	Rs. 550/- Could save the cost of pesticide and Labour cost)

Date of Issue during 2018	Crop	Rainfall Forecast	Advisory Given	Observed Rainfall	Action taken by the Farmer	Profit/ Loss
7 - 11 Oct.	Vegetable Cole crops	0.0	Normal advisory for vegetable crops	91.8	Sowing was done	Rs. 800/- (Washing of vegetable seedlings)
7 - 11 Oct.	Rice	0.0	Normal advisory	91.8	Harvesting of short duration paddy could not be made due to heavy rain because of Cyclone "PHETA"	Rs. 5100/- (Reduced rice yield due to heavy rain at maturity.
16 -20 Dec.	Rice	16.0	Go for harvesting of late planted rice	57.0	Harvesting was carried out	Rs. 6800/- Saved the grain damage.

Dapoli

Horticultural crops: Mango and Cashew

Date of Issue of AAS during 2018	Crop	Forecasted Weather/ Reason	Advisory given	Observed Weather	Action taken by farmer	Benefit or Loss
11/12/2018	Mango Stage: Vegetative flush & flower bud Initiation	• The continuous cloudy weather i.e. 3 to 8 Octa cloud cover was forecasted during forecasting period from 12/12/2018 to 19/12/2018. • Maximum temperature was also forecasted to increase up to 33°c	There is possibility for incidence of mango hoppers at the time of flower bud initiation on Mango, spray Lambda cyhaothrin 5%EC @ 6 ml per 10 liter of water Hexaconazole 5% @ 5 ml or wettable Sulphur 80% @ 20 gm per 10 liter in water. for control of powdery mildew disease spray	According to weather condition recorded by AMFU Dapoli Centre, the weather parameter recorded max temp.: 30.5-34°C, Min. temp: 9.4-17°C., RHI: 80-90% and RHII:60-71% cloudy weather i.e. 2 to 4 Octa cloud cover	Sprayed lambda cyhaothrin 5% EC @ 6 ml per 10 litre of water.	• The advice was helpful for protection of flowering flush from Mango hoppers. • This will ultimately increase yield of mango up to 30-40 % by saving flowering flush from mango hopper incidence.

Date of Issue of AAS during 2018	Crop	Forecasted Weather/ Reason	Advisory given	Observed Weather	Action taken by farmer	Benefit or Loss
14/12/2018	Cashew nut Stage : Flowering	These warm and cloudy weather conditions are congenial for causing incidence of Mango hoppers and Power mildew and tea mosquito bug and thrips.	There is possibility of incidence tea mosquito bug and thrips on the inflorescence of cashewnut, if incidence is noticed spray Profenophos 50% EC @10 ml per 10 litre of water. (insecticide is not under label claim)	-Do-	Sprayed Profenophos 50% EC @10 ml per 10 liter of water.	• The advice was helpful for protection of flowering flush of cashew from Tea mosquito bug and thrip. • This will ultimately increase Cashew yield up to 20-60 % by saving flowering flush of cashew. • Economic Benefit: (No. of Trees of mango :- 35) (No. of Trees of Cashew nut :- 55)

Jammu

Crop: Rice (Sherpur village)

Date	Crop and Stage	Forecast	Advisory given	Observed	Action taken	Benefit/Loss
03/07/18	Normal Transplanted Rice (at Transplanting)	30.0 mm	Bund the rice fields for in situ storage of rain water and utilize the same for puddling	50.4 mm	Followed the advisory	Farmer saved fuel and labour charges of Rs 1200-1400/ha at the time of transplanting
12/07/18 13/07/18 14/07/18	Normal Transplanted Rice (at Transplanting)	50.0 mm	Go for transplanting of rice	59.2 mm	Transplanted the rice and saved the irrigation	Farmer saved fuel and labour charges of Rs 1200-1400/ha at the time of transplanting
21/07/18	Normal Transplanted Rice (Seedling establishment stage)	30.0 mm	Bund the rice fields for in situ storage of rain water	51.2 mm	Followed the advisory	Saved the irrigation amounting Rs 1200-1400/ha

Date	Crop and Stage	Forecast	Advisory given	Observed	Action taken	Benefit/Loss
21/07/18	Late Transplanted Basmati Rice (Transplanting stage)	30.0 mm	Transplant the Basmati rice after receipt of the rain	51.2 mm	Transplanted the Basmati rice and saved the irrigation	Saved the irrigation amounting of Rs 1200-1400/ha
23/07/18	Normal Transplanted Rice (Seedling establishment stage)	20.0 mm	Bund the rice fields for in situ storage of rain water	22.0 mm	Followed the advisory	Saved the irrigation amounting of Rs 1200-1400/ha
05/08/18 06/08/18	Normal Transplanted Rice (Tillering stage)	20.0 mm	Do not irrigate and postpone the plant protection, weedicide & fertilizer application	113.1 mm	Postponed all the operations and saved the irrigation	Saved the chemicals, fertilizer and labour charges
11/08/18 12/08/18	Normal Transplanted Rice (Tillering stage)	80.0 mm	Drain out the excess water and do not apply weedicide	114.0 mm	Followed the advisory	Saved the weedicide and labour charges
15/08/18 17/08/18	Early Transplanted Rice (Vegetative stage)	60.0 mm	Do not irrigate and postpone the plant protection, weedicide & fertilizer application	96.7 mm	Postponed all the operations and saved the irrigation	Saved the chemicals, fertilizer and labour charges
20/08/18 21/08/18 22/08/18	Normal Transplanted Rice (Vegetative stage)	110.0 mm	Drain out the excess water and do not apply weedicide	125.5 mm	Followed the advisory	Saved the weedicide and labour charges
29/08/18	Late Transplanted Rice (Tillering stage)	25.0 mm	Do not irrigate and postpone the plant protection, weedicide and fertilizer application	86.0 mm	Followed the advisory	Saved the chemical fertilizer and labour charges of Rs 800-900/ha
06/09/18	Early/Normal Transplanted Rice (Milking/Panicle initiation stage)	5.0 mm	Postpone the chemical spray to crop suffering from Stem borer/ plant hopper	32.4 mm	Followed the advisory	Saved the chemicals and labour charges of Rs 800-900/ha

Date	Crop and Stage	Forecast	Advisory given	Observed	Action taken	Benefit/Loss
22/09/18 23/09/18	Early/Normal Transplanted Rice (Reproductive/ Flowering stage)	0 mm	Go for the chemical spray to crop suffering from blast	185.0 mm	Followed the advisory	Wastage of the chemicals and labour charges was saved
11/12/18	Normal/late sown wheat (CRI/sowing stage)	5.0 mm	Postpone the irrigation and fertilizer application Go for sowing of the wheat after receipt of rain	10.2 mm	Postponed the sowing	Saved the irrigation, fertilizer and labour charges of Rs 800-900/ha Good germination and saved labour charges
21/01/19 22/01/19	Late/Normal sown wheat (CRI/vegetative stg.)	21 mm	Postpone the irrigation and fertilizer application	77.3 mm	Postponed the irrigation and fertilizer application	Saved the irrigation, fertilizer and labour charges of Rs 800-900/ha

Jorhat

Crop: Potato (Thengalgaon)

Date	Forecast	Actual	Advisories	Farmers Response	Result
12.10.2018	The weather will remain clear in the coming 5 days. and no rainfall is predicted. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 16 to 17°C and 29 to 30°C respectively. The expected morning and evening RH will be in between 87-93% & 15-17% respectively. Wind will blow mainly from north-east direction at a speed of 3.6kmph.	The weather was remained clear. 4.8 rainfall was observed on 13th Oct. The daily actual minimum and maximum temperature for the ensuing 5 days is ranged from 27.2°C - 27.4°C and 31.7-31.9, respectively.	Farmers are advised to prepare land for sowing of potato crop. Field should be thoroughly ploughed to obtain a good tilth. It should be leveled for uniform distribution of irrigation water or to maintain soil moisture uniformly under rainfed situation. The furrows should be prepared at 50 cm apart.	Followed by few farmers	Certified seeds were obtained and field was ready for good establishment of seedling.

Date	Forecast	Actual	Advisories	Farmers Response	Result
23/10/2018	The sky will remain partly cloudy. 4mm rainfall is predicted on 25th October, 2018. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 19 to 20°C and 29 to 30°C, respectively. The expected morning and evening RH will be in between 93-100% & 50-57%, respectively. Wind will blow mainly from North -east direction at a speed of 2.4 kmph.	The sky remained partly cloudy. 15.2 mm rainfall was received on 25th October, 2018. The daily actual minimum and maximum temperature for the ensuing 5 days is ranged between 25.8 to 27.1°C and 29.7to31.2°C respectively.	The farmers were advised to go for sowing of potato.	Followed by some farmers.	Receipt of 15.2 mm rainfall after sowing ensured better and uniform emergence of crop.
23/11/2018	The sky will remain clear. No rainfall is predicted in coming 5 days. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 16 to 17°C and 29 to 30°C, respectively. The expected morning and evening RH will be in between 87-93% & 38-45%, respectively. Wind will blow mainly from North-east direction at a speed of 3.6 kmph.	The sky remained generally cloudy. The daily actual minimum and maximum temperature for the ensuing 5 days ranged between 21.9 to 22.9°C and 26.1 to26.7°C, respectively.	Farmers are advised to go for earthing up operation for proper anchorage of the roots and to obtain quality tubers.	Followed	The crop is in good condition and no competitive stress or environmental stress is found.
27/11/2018	The sky will remain cloudy. No rainfall is predicted in coming 5 days. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 11.2 to 17.5°C and 26.4 to 28.1°C, respectively. The expected morning and evening RH will be in between 77-100% & 37-50%, respectively. Wind will blow mainly from North-east direction at a speed of 3.8 kmph.	The sky was partly cloudy. The daily actual minimum and maximum temperature for the ensuing 5 days is ranged between 17.4 to 18.1°C and 24.2 to 24.8°C, respectively.	Farmers were advised to go for a irrigation just after earthing up for better growth and development, since no rainfall is predicted for coming 5 days.	Followed by few farmers	No water stress symptoms *i.e.* dull and droop leaves is seen by those who followed the advisory.

Date	Forecast	Actual	Advisories	Farmers Response	Result
11/12/2018	The sky will remain clear. No rainfall is predicted in coming 5 days. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 10 to 13°C and 23 to 26°C, respectively. The expected morning and evening RH will be in between 93-95% & 33-38%, respectively. Wind will blow mainly from South-east direction at a speed of 2 kmph.	The sky remained clear. The daily actual minimum and maximum temperature for ensuing 5 days ranged to be 12.1 to 16.4°C and 23.6 to 24.2 °C, respectively.	Present conditions is favourable for occurrence of late blight disease, so farmers were advised to take prophylactic measure against late blight disease by spraying the potato crop with Mancozeb @ 2.5gm/lit of water. Alternatively, Zineb @ 25 gm per 10 litre of water may also be used. While spraying ensures wetting of lower sides of the leaves.	Followed by maximum farmers.	It was observed that spraying of Mancozeb reduced the disease occurrence to a greater extent.

Enterprise: Fishery (Thengal gaon)

Date	Forecast	Actual	Advisories	Farmers Response	Result
6/02/2018	The sky will remain partly cloudy in the coming 5 days. No rainfall is predicted for coming 5 days. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 11.8-15.1°C and 23.9-25.3°C, respectively. The expected morning and evening RH will be in between 62-88 % & 19-27 %, respectively. Wind will blow mainly from North-east direction with an average wind speed of 4.4 kmph.	The sky was generally cloudy. The daily actual minimum and maximum temperature for the ensuing 5 days is ranged to be 13.8 to 14.5°C and 21.1 to 21.4°C, respectively.	As the water level of ponds are going down, the fishery owners may arrange for partial harvesting of marketable sized fish (>700gm). To control the EUS diseases, dip treatment in 500 ppm potassium permanganate solution may be practiced	Followed	Harvesting is generally carried out after a period of 7-8 month, when the fishes attain average weight of 800 gm to 1.25 kg.

Date	Forecast	Actual	Advisories	Farmers Response	Result
					
27/02/2018	The sky will remain clear in the coming 5 days. No rainfall is predicted for coming 5 days. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 14.8-17.2°C and 27.7-29.7°C, respectively. The expected morning and evening RH will be in between 65-81 % & 22-25 %, respectively. Wind will blow mainly from North-east direction with an average wind speed of 4.6 kmph.	The sky remained clear. The daily actual minimum and maximum temperature for the ensuing 5 days is ranged between 16.7 to 17.1°C and 22.8 to23.3°C, respectively.	Farmers are advised to drain the pond, if fish from the pond is already harvested. Remove silt from the pond bottom and apply lime to condition the soil. .	Followed	Quick lime (Cao) is widely used as it has higher neutralizing value, when it is applied in water combined with Co2 it will transform into carbonate and further to bi carbonate.
					

Date	Forecast	Actual	Advisories	Farmers Response	Result
27/04/2018	The sky will remain partly cloudy in the coming 5 days with possibilities of getting light rainfall on coming 5 days. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 18.5-20.0°C and 27.9-33.9°C, respectively. The expected morning and evening RH will be in between 73-94% & 20-34%, respectively. Wind will blow mainly from North -east direction with an average wind speed of 5.4 kmph.	The sky was partly cloudy. The daily actual minimum and maximum temperature for the ensuing 5 days ranged between 22.7 to 22.7°C and 26.2 to 26.7°C, respectively.14.1, 37.3, 9.7 and 19.8mm of rainfall received on subsequent week.	As water started to accumulate in the fish pond, farmers are advised to apply 26 kg lime per bigha of water area, if the unwanted fishes, weeds are removed from the fish pond. It is required to apply 266 kg of fresh cow dung7-10 days after application of lime.	Followed	Decomposition of organic manure in pond leads to slow and continuous release of nutrients to the water and help in long term maintenance of rich plankton population

Date	Forecast	Actual	Advisories	Farmers Response	Result
28/06/2018	The sky will remain mainly cloudy with possibilities of getting light rainfall on 9th and 12th June and moderate rainfall on 10th, 11th and 13th June. The daily minimum and maximum temperature for the ensuing 5 days is predicted to be 25.3 -26.7°C and 26.9 -35.4°C, respectively. The expected morning and evening RH will be in between 87-98% & 34-62%, respectively. Wind will blow mainly from South west direction with an average wind speed of 4 kmph.	The sky was partly cloudy. The daily actual minimum and maximum temperature for the ensuing 5 days ranged between 26.2 to 26.9°C and 33.5 to 33.9°C, respectively.17.2, and 21.7mm of rainfall received on 29th and 30th June.	As water has already started to accumulate in the ponds, stocking with fingerlings or carried over seeds of 15 cm size @ 5000 per hectare of water surface area may be advocated. For composite fish farming stocking density for different species per ha area are: Rahu 750 nos, Silver carp 1000 nos, Catla 750, Grass carp 500 nos, Mrigal 1000 nos, and Common carp 1000 nos.	Followed	Depending on availability of seed and market condition, stocking is done with 3, 4 or 6 species combination.

Samastipur

Crop: Paddy

Date	Crop stage	Weather forecast	Advisory given in NICRA bulletin	Actual rainfall happened	Action taken by the farmer	Loss/profit	Remarks
12 June, 2018	Nursery sowing	Chances of light rainfall during 12-14 June	Nursery sowing of short duration paddy crop was advised	About 29.3 mm rainfall occurred	The farmer waited for rain and acted as as per our advisory	He saved labour charge and cost of irrigation Rs.500/ha	
3 July, 2018	Transplanting	Chances of light rainfall during 3-6 July	In view of rainfall forecast, transplanting of paddy was advised.	About 15 mm rainfall occurred	With receipt of 15 mm rainfall, the farmer went for transplanting with light irrigation	Light rainfall helped him to use less irrigation, thus got economic benefits by saving diesel	
13 July, 2018	Early transplanting	Chances of mainly dry weather in next 3-4 days	Farmers were advised to give life saving irrigation in paddy crop.	No rainfall occurred during this period	Farmer applied life saving irrigation in paddy crop.	Saved his paddy crop from ill effects of water stress condition.	Rice crop of other farmers who transplanted in upland condition was severely damaged due to dry spell.
27 July, 2018	Tillering stage	Chances of rainfall during 28-30 July	In view of rainfall forecast, farmers were advised to postpone irrigation in paddy crop	About 87.8 mm rainfall occurred	Waited for rain and acted as per our NICRA advisory	He saved irrigation cost of Rs. 2000/ha	
25 Aug, 2018	Booting stage	Chances of rainfall during 26-31 August	In view of rainfall forecast, Postpone irrigation in paddy crop	About 91.6 mm rainfall occurred	waited for rain and acted as per our advisory	He saved irrigation cost of Rs. 2000/ha	
18 Sep., 2018	Late reproductive stage	Chances of rainfall during 20-21 September	In view of rainfall forecast, Postponement of irrigation in paddy crop was suggested	About 40.0 mm rainfall occurred	Waited for rain and acted as our advisory	He saved irrigation cost of Rs. 2000/ha	

Udaipur

Crop: Maize (Kundeli)

Date	Crop Stage (Maize)	Forecast	Advisory Issued	Actual Condition	Action taken by farmer	Profit/Loss
6.07.2018	Sowing	Medium rainfall in next 2 days	Start sowing, Use improved varieties Aravali Makka-1, Pratap Makka-3, and Bio- 9637	42 mm rain received on 10 July 2018 and next 2 days dry weather	Sowing was done on 12 July	Got good germination & healthy seedlings
10.07.2018	Before emergence	No rainfall in next day	Apply atrazine 1-1.5 kg/ha in maize before emergence	No rainfall on 13 & 14 July	Atrazine spray was done	Control weed at initial stage
17.07.2018	3rd Leaf stage	Medium to heavy rainfall in next 5 days	Drain out excess water from field to prevent water logging conditions.	Heavy rainfall (67 mm) in next 3 days	Excess water was drained out from field	Crop was saved from water logging
10.08.2018	Knee height	Light rainfall on 14 & 15.8.2018	Top dressing of remaining 1/4 dose of urea	Medium rain was received on 14.8.2018	Top dressed 1/4 dose of urea (55 kg/ha) on 15.08.2018	Proper nutrient management done by farmer
21.08.2018	Vegetative stage	light rainfall on 22 & 23.08.2018	Spray carbaryl 2g/litre for control of maize stem borer	14.0 mm rain was received on 25 & 26.08.2018	Spray of carbaryl was done	Loss: Wash out of insecticide with rain water, Loss of 550 /ha and labour charge
31.08.2018	Tasselling	Medium rainfall on 3 & 4.09.2018	Top dressing of remaining 1/4 dose of urea at tasselling stage	Light rainfall received 03.09.2018	Based on available moisture in field farmer applied 1/4 dose of urea (55 kg/ha)	Proper nutrient management done by farmer

Date	Crop Stage (Maize)	Forecast	Advisory Issued	Actual Condition	Action taken by farmer	Profit/Loss
07.09.2018	Silking - Milking	Medium rainfall in next 3 days	Postpone plant protection measures in maize	7.0 mm rain was received on 11 & 12.09.2018	Plant protection measures was postponed	Profit: Saved insecticide and labour cost
14.09.2018	Milking	No rainfall in next 5 days	Give irrigation in crop at critical stage	0nly 9 mm rain was received in next 5 days	Applied irrigation in maize at milking stage on 17.09.2018	Saved crop from drought condition
25.09.2018	Maturity	No rainfall	Harvest the crop and store at safe place	27 mm rain was received on 28.09.2018	Crop harvested timely	Crop & quality of produce were saved from rain

6. Case Studies of Economic Impact of Micro-level AAS

6.1 Case Study- Cotton, Kanshivani, Akola

Shri Punjaji Waghmare, who is from Kanshivani (Akola taluka) NICRA Village of Akola Centre has 8.0 acres of rainfed land under cotton cultivation. Bt cotton Ajeet 155 was grown during *kharif* 2018. Crop was sown on during 26 SMW (24 June). During the crop growing period, a series of AAS bulletins/real time advisories were issued which were followed as such by the farmer. The following table includes B:C ratio obtained in case of the cotton farmer Shri. Punjaji Waghmare, in response to the AAS issued and accordingly timely action taken by the farmer. The expenditure on different operations and returns received on sale of produce and other details were collected from farmer's feedback. It also includes the B:C ratio obtained in case of other four AAS farmers also who have followed more or less similar agro-met advisories as aforementioned for their respective soybean cultivation.

Table 6.1: Analysis of B:C ratio in Cotton of AAS farmers and non AAS farmers at Kanshiwani NICRA village

Input Details (Rs. ha^{-1})	AAS farmers			Non AAS farmers		
	Punjaji Waghmare	Pramod Shelke	Chandu Waghmare	Ramdas Pathak	Manik Waghmare	Avdhutrao Kale
Land preparation	4350	3950	3600	4850	3800	4350
Fertilizer	5280	5260	5260	5380	5160	5160
Seed cost	4620	4720	4820	4815	4915	4715
Planting	2700	2800	2800	2800	3240	2800
Gap filling	1420	1420	1420	1420	1200	1420
Weeding	3650	4010	4370	4730	4250	3830
Hoeing (*with furrow opening)	*1900	*1900	*1900	1700	1700	1700
Plant protection	4270	4025	4325	4860	4860	3910
Irrigation	900	900	900	0	0	0
Spraying of 2% Urea and 2% DAP	1000	1000	1000	0	0	0
Miscellaneous	1300	1200	1400	1800	1600	1700
Harvesting cost	6500	6050	6500	5750	5750	5000
Cost of cultivation	37890	37235	38295	38105	36475	34585
Seed cotton yield	14.8	13.9	14.8	13.1	13.1	11.8
Price	71040	66720	71040	62880	62880	56640
Net Profit	33150	29485	32745	24775	26405	22055
Benefit cost (B:C ratio)	1.87	1.79	1.86	1.65	1.72	1.64

Higher profit obtained by Mr. Punjaji Waghmare is attributed to

- Timely implemented advisories and farm operations accordingly.
- Timely weeding and hoeing
- Postponement of insecticidal/foliar spraying due to rainfall forecast.
- Foliar spray of 2% urea at pod formation stage.
- Timely application of irrigation coinciding with soil moisture stress period.
- Immediate drainage of excess water logged areas in crop field
- Timely harvest of the crop during rain free weather for its safe drying and storage.

6.2 Case Study- Soybean, Warkhed

Shri Prakash Avhade, hailing from Warkhed (Barshitakli) NICRA Village of Akola distric has 5.5 acres of rainfed land under soy bean cultivation. JS-335 variety was grown during *kharif* 2018. Crop was sown on during 21 SMW (26 June). During the crop growing period, a series of AAS bulletins/real time advisories were issued which were followed as such by the farmer.

B:C ratio obtained in case of the soy bean farmer Shri Prakash Avhade and other selected farmers of Warkhed village, in response to the AAS issued and action taken by them. The expenditure on different operations and returns received on sale of produce and other details were collected from farmers feedback on soy bean cultivation.

Table 6.1: Analysis of B:C ratio of soy bean of AAS farmers in Warkhed NICRA village

Input Details (Rs. ha^{-1})	Narayan Avhade	Prakash Avhade	Sahadev Tople	Mahadev Kondankar	Shivdas Rathod
Land preparation	3810	4260	2960	3810	3430
Fertilizer cost	5255	4565	4565	5255	5255
Seed cost	4839	4935	4305	4906	4705
Planting cost	1350	2700	2500	1350	1350
Weeding	1300	1600	1900	1300	1900
*Hoeing	940	900	900	940	940
Plant protection	1855	2400	2000	1920	1855
Irrigation	600	800	800	600	800
Foliar spray of 2% urea	450	450	450	450	450
Miscellaneous	0	1100	1100	0	0
Harvesting cost	2000	2700	2700	2000	2000
Threshing cost	2272	2600	2585	2183	1591
Cost of cultivation	24671	29010	26765	24714	24276

Input Details (Rs. ha^{-1})	Narayan Avhade	Prakash Avhade	Sahadev Tople	Mahadev Kondankar	Shivdas Rathod
Seed yield	16.9	19.2	19.1	17.43	14.05
Price of soy bean	47320	53760	53480	48804	39340
Net Profit	**22649**	**24750**	**26715**	**24090**	**15064**
Benefit cost ratio	**1.92**	**1.85**	**2.00**	**1.97**	**1.62**

**Hoeing with furrow opening*

Table 6.2: Analysis of B:C ratio of soy bean of Non-AAS farmers in Warkhed NICRA village

Input Details (Rs. ha^{-1})	Mahadev Dange	Anil Avhade	Omkar Waghmare	Madhukar Shinde	Sunil Avhade
Land preparation	3660	4810	3810	3810	4760
Fertilizer cost	4665	5255	5405	4805	5330
Seed cost	4415	5676	5040	4839	5375
Planting cost	2320	1350	1350	1350	1350
Weeding	1900	1150	1750	1450	1150
Hoeing	800	940	940	900	940
Plant protection	2100	1855	1855	2395	1775
Miscellaneous	1200	0	0	1100	0
Harvesting cost	3200	1700	2300	2000	2000
Threshing cost	2000	1364	1527	1746	1355
Cost of cultivation	26260	24100	23977	24395	24035
Seed yield	15.2	12.7	11.75	14.2	12.2
Price of soy bean	42560	35560	32900	39760	34160
Net Profit	**16300**	**11460**	**8923**	**15365**	**10125**
Benefit cost ratio	**1.62**	**1.48**	**1.37**	**1.63**	**1.42**

From the above tables, higher profit obtained by Shri Prakash Avhade is mainly due to

- Adoption of issued advisories and carrying out timely farm operations accordingly.
- Timely weeding and hoeing with furrow opening facilitated better crop growth.
- Timely application of irrigation coinciding with soil moisture stress period.
- Immediate drainage of excess water logged areas in crop field.
- Timely plant protection and postponement of spraying due to rainfall forecast.
- Foliar spray of 2% urea at pod formation.

Fig 6.2: Display and dissemination of agromet-advisory

6.3 Case Study - redgram, Yagantipalli, Kurnool (Andhra Pradesh)

Sri B. Prathapa Reddy, a farmer from Yagantipalli village is one of the active farmer adopting AICRPAM – NICRA Agromet advisory. During *Kharif* 2018, he cultivated redgram crop (variety – PRG 176) in his 5 acre land.

By adopting NICRA AAS from sowing to harvest, he earned net returns of Rs. 18600 acre^{-1} (Rs.50,625 ha^{-1}), with a benefit cost ration of 2.21:1.(Table 6.3)

Table 6.3: Benefit cost ratio of red gram farming adopting AAS at Yagantipalli village, Andhra Pradesh

S.No.	Name of the operation	Cost of Cultivation (Rs Ha^{-1})
1	Land preparation, Harrowing and levelling	2500
2	Sowing and basal application of fertilizers	2250
3	Cost of seed	750
4	Cost of fertilizers/foliar spray chemical	2500
5	Intercultivation and formation of dead furrows	1750
6	Cost of protective irrigation – Twice	5000
7	Spraying	1250
8	Harvesting, threshing and cleaning	5000
9	Total Cost of Cultivation	21000
	Yield of redgram	**1500 kg ha^{-1}**
	Price of the produce (Rs./kg)	**Rs.45 kg^{-1}**
	Gross returns due to adoption of NICRA AAS	**Rs.67500 ha^{-1}**
	Net returns	**Rs.46500 ha^{-1}**
	B:C ratio	**2.21:1**
	Saving in cost of cultivation due to adoption of protective irrigation	**2500**
	Benefit from yield advantage	**Rs.50,625 ha^{-1}**

6.4 Case Study - different crops, Nayanahalli, Bangalore

Benefit:Cost (B:C) ratio was worked out by pooling the total cost of cultivation and gross returns of 25 Non-AAS-farmers and 25 AAS-farmers from Nayanahalli, a NICRA adopted village. Here, B:C ratio was worked by categorizing the major crops into vegetable crops, fruit crops, flower crops and field crops, which are grown in the study villages. Comparison of B:C ratio between AAS farmers and Non-AAS farmers has shown (Flow chart-1) that, farmers who have followed Agromet Advisories (AAS) had obtained higher B:C ratio when compared to those who have not followed.

Among the different crops of NICRA adapted village, fruit crops recorded considerable higher gain in terms of B:C ratio (3.00) followed by vegetable crops (1.98), field crops (1.89) and flower crops (1.72) against the B:C ratio of 'Non-AAS farmers' in fruit crops (2.16), vegetable crops (1.86), flower crops (1.47), and field crops (1.38). These values clearly indicated that, Agromet Advisories have played greater role in deciding farm activities like pesticide sprays, fertilizer application, irrigation schedules, weeding, harvesting and many other activities.

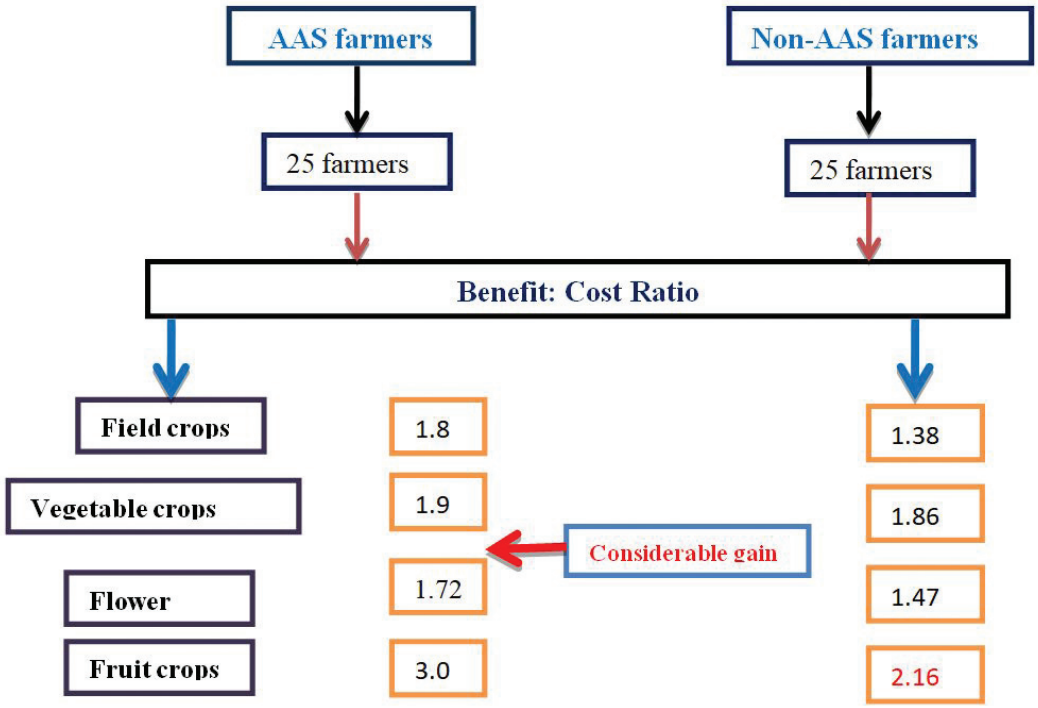


Fig 6.3: Economic Impact of Agromet Advisory Services in terms of Benefit:Cost ratio of 25 farmers at AICRPAM-NICRA adopted village

Economic Impact of Block Level AAS in Odisha

A study was conducted among the farmers of NICRA villages to assess the economic impact of weather forecast-based advisories issued during 2018 from AICRPAM-NICRA, OUAT, Bhubaneswar. The major crops chosen for the study included food grains & pulses. The sample set consisted of 10 farmers, comprising 5 responding AAS and 5 non-responding (Non-AAS) farmers. The main aim was to study the percentage increase/ decrease in the yield and net return due to AAS. Results obtained suggest that the AAS farmers accrued a net benefit of 10-15% in the overall yield and a reduction in the cost of cultivation by 2-5% over the non-AAS farmers.

6.5 Case Study - paddy crop, Ekalpur, Sorada block, Ganjam

Particulars	Details	
Village: Ekalpur, Block: Sorada, Sub. Divn: Bhanjanagar, Dist: Ganjam	**Pratap Nayak (NICRA)**	**Lachman Malika (Non-NICRA)**
		
Total Agricultural area (in acres)	4	4
Major Crop Grown in *Kharif* 2018	Paddy (4 acres)	Paddy (4 acres)
Amount (Rs) invested in *Kharif* 2018		
I. Land preparation cost	15,000	15,000
II. Seed Cost	2,400	2,400
III. Fertilizer cost	5,000	6,500
IV. Pesticides Cost	3,500	5,000
V. Labour Cost	15,000	15,000
VI. Harvest Cost	14,000	14,000
VII. Total Cost	**54,900**	**57,900**
Total Yield (q) and value (Rs)	105,000 (60 q)	87,500 (50 q)
Price	Rs. 1,750/-/q	Rs. 1,750/-/q
Net Benefit/ Loss (Rs.)	**50,100**	**29,600**
Major Crop Grown in *Rabi* 2018-19	Green Gram (1acre)	Green Gram (1acre)
Amount (Rs) invested in *Rabi* 2018-19		
I. Land preparation cost	2,000	2,000
II. Seed Cost	300	300
III. Fertilizer cost	1200	1500
IV. Pesticides Cost	1200	1800
V. Labour Cost	5,000	5,000
VI. Harvest Cost	2,000	1,900
VII. Total Cost	**11,700**	**12,500**
Total crop Yield (q) and value (Rs)	24,000 (4 q)	19200 (3.2 q)
Price	Rs. 60/kg	Rs. 60/kg
Net Benefit/ Loss (Rs.)	**12,300**	**6,700**

6.6 Case Study - paddy crop, Padmapur, Sorada block, Ganjam

Particulars	**Details**	
Name	**Muralidhar Badatya (NICRA)**	**Santosh Gouda (Non-NICRA)**
Village-Padmapur,Block – Sorada,Sub-Divn-Bhanjanagar,Dist-Ganjam		
Total Agricultural Area (in acre)	3 acres	2.5 acres
Major Crop grown in *Kharif* 2018	**Paddy (3 acres)**	**Paddy (3 acres)**
Amount invested (Rs) in *Kharif* 2018		
1.Land preparation cost	10000	9000
2. Seed cost	2600	2200
3.Fertilizer cost	4000	2800
4.Pesticide cost	3200	2800
5. Labour cost	12000	11000
6.Harvest Cost	10000	9400
TOTAL COST	41800	37200
Total yield (q) and value (Rs.)	**Rs. 80,000/- (50 q)**	**Rs. 67,200/- (42q)**
Price	Rs. 1,600/ q	Rs. 1,600/q
Net Benefit (Rs.)	**38200/-**	**30000**
Major Crop Grown In *Rabi* 2018-19	**Cauliflower (1 acre)**	**Cauliflower (1 acre)**
Amount (RS) Invested In *Rabi* 2018		
1.Land preparation cost	4000	4000
2. Seed cost	1100	1000
3.Fertilizer cost	7000	6900
4.Pesticide cost	3000	3300
5. Labour cost	10500	10200
6.Harvest Cost	2500	2200
TOTAL COST	RS-28,100/-	Rs. 27,600/-
Total Seed Yield (q) and value (Rs)	**Rs. 1,12,000/- (80q)**	**Rs. 1,05,000/- (75q)**
Sale Price of Seed	Rs. 14/kg	Rs. 14/kg
Benefit (Rs.)	**Rs. 83,900/-**	**Rs. 77,400/-**

6.7 Case Study in wheat crop, Banpurwa, Bahraich, Uttar Pradesh

Faizabad center has selected Banpurwa village of Bahraich district, in which wheat crop grows predominantly. All the selected farmers were categorized into large, medium and small and provided with Agromet advisories during the season. The farmers are mostly growing Rice, Wheat, Sugarcane and Maize etc. Selected farmers received agromet advisory for wheat crop through personal contact/ SMS/Newspaper/ Gosthi /awareness. The average wheat yield harvested by AAS and non AAS farmers is given below;

Table 6.4: Comparative wheat yield harvested by AAS and Non-AAS farmers at Banpurwa village

S.No.	Farmers category	Average yield (kg/ha)		Increased yield (%)
		AAS	Non-AAS	
1.	Large Farmers	4079.0	3648.0	11.8
2.	Small Farmers	3811.0	3454.0	10.3
3.	Marginal Farmers	3563.4	3328.0	7.0
	Average	**3833.3**	**3476.6**	**9.7**

From the above table, it is clearly observed that per hectare yield of wheat achieved by AAS farmers showed an average increase of 9.7% over Non-AAS farmers. It is proved that better quality seed and timely cultural practices based on weather Agromet advisory were responsible for increased wheat yields achieved by AAS farmers during the year of study. Benefit-cost ratio (B:C) has been calculated and presented in the tables for AAS and non- AAS farmers, separately.

Table 6.5: Cost of cultivation of wheat (AAS farmers) under Banpurwa village of dist. Bahraich

Field Preparation		Cost (Rs)
i. Ploughing /Harrowing (1) ii. Cultivator with planking (2)	1 hr @800/hr 3 hr @700/hr	800 2100
Compost (FYM)	5 tonnes /ha @ Rs. 500/tonne	2500
Fertilizer (150:60:40) NPK		
(i) DAP	130 kg/ha @ Rs. 29.0/kg	3770
(ii) N	275 kg/ha @Rs.6.0/kg	1650
(iii) MOP	66 kg/ha @Rs .18.0/kg	1188
(iv) Zn	5.0 kg/ha @Rs .50.0/kg	250
Seed Rate	100 kg/ha @ 35.0/kg	3500
Sowing/Fertilizer/weeding/Thinning / irrigation	30 labour /ha @174/ labour	5220
Plant Protection measures		
(i) Trichoderma virdy (WP)	5.0 kg/ha (soil treatment)@Rs. 65.00/kg	325
(ii) Weedicide (Sulfosulfuran)	33 g/ha @ Rs.6.00/g	198
(iii) 2, 4-D	625 g/ha@0.35/g	218
3 Irrigation (8.0 hr/ha /irrigation)	Irrigation @ Rs. 150/hr	3600
Harvesting	15 labour @174/ labour	2610

Field Preparation		**Cost (Rs)**
2 hr threshing of tractor / winnowing	Tractor Rs. 600/hr & 10 labour @174/ labour	2940
Land Rent	Rs. 6000/year/ha.	3000
Cost		**30929**
Seed yield	40 q/ha @1600/q	64000
Straw yield	74 q/ha @ 500/q	37000
Gross Income		**101000**
Net Profit		**70071**

Table 6.6: Cost of cultivation of wheat (Non-AAS farmers) at Banpurwa village of Bahraich District

Field Preparation		**Cost (Rs)**
(i) Ploughing /Harrowing (1) (ii) Cultivator with planking (2)	1 hr @800/hr 3 hr @700/hr	800 2100
Compost FYM	5 tonnes /ha @ Rs. 500/tonne	2500
Fertilizer (150:60:40) NPK		
(i) DAP	130 kg/ha @ Rs. 29.0/kg	3770
(ii) N	275kg/ha @ Rs.6/kg	1650
(iii) MOP	66 kg/ha @ Rs 18.0/kg	1188
Seed Rate	125 kg/ha @ 35/kg	4735
Sowing/Fertilizer/weeding /irrigation	35 labour/ha @174/ labour	6090
Plant Protection Weeding by		
(i) Weedicide (Sulfosulfuran)	33 g/ha @ Rs.6/g	222
(ii) 2, 4-D	625 g/ha @ 0.35/g	218
4 Irrigation (8 hr/ha/irrigation)	Irrigation @ 150/hr	3600
Harvesting	15 labour @ 174/ labour	2610
2 hr threshing of tractor / winnowing	Tractor Rs. 600/hr & 10 labour @ 174/Labour	2940
Land Rent	Rs. 6000/year/ha	3000
Cost		35423
Seed yield	34 q/ha @ 1600/q	54400
Straw yield	67 q/ha @ 500/q	33500
Gross Income		87900
Net Profit		52477

Table 6.7: Comparative wheat yield and B:C ratio between AAS and Non-AAS farmers at Banpurwa village of dist. Bahraich

S.No.	Status of farmer	Cost of cultivation (Rs)	Gross Return (Rs)	Net return (Rs)	B:C ratio
1	AAS	30929	101000	70071	1:2.26
2	Non-AAS	35423	87900	52477	1:1.48

This higher B:C ratio achieved by AAS farmers over the non AAS farmers was made possible by conserving moisture in upper layer of the soil and also due to saving the cost of seed, labour, irrigation, insecticide /pesticides which resulted in better performance of the crop and reduction in cost of cultivation, as compared to Non-AAS farmers.

6.8 Case Study in soy bean crop, Jorawar Singh Ji Ka Kheda village of Rajsamand

Mr. Narayan Lal Gayri from Jorawar Singh Ji Ka Kheda village of Rajsamand district is selected by Udaipur center for distributing AAS to manage the soy bean crop during the *Kharif* season *2019*. He has 5.0 hectare of land. Earlier he cultivated traditional crop maize but after advisory he adopted soy bean. In this season he sowed soy bean in 1.0 ha. He sowed soy bean variety JS-9560 on 12 July 2018. He got 2-3 times more income as compared to other farmers. Main reasons for higher yield were use of long duration variety & adoption of ASS. During the crop growing period a series of AAS bulletins were issued. Farmer response to AAS and the impact on the yields of AAS farmer and Non- AAS farmer are assessed through cost benefit ratio analysis and given in table below;

Table 6.8: Comparison of B:C ratio analysis between AAS and non-AAS farmers in soy bean at Jorawar Singh Ji Ka Kheda

Input details	AAS Farmers	Non-AAS Farmers
Field preparation and sowing cost (ha^{-1})	Rs. 9375	Rs.9375
Seed cost (ha^{-1}) @50/ per kg for AAS and @30 kg for non-AAS	Rs. 3750	Rs.2250
Seed treatment	-	-
Fertilizer cost (ha^{-1}) N:P (40:40 kg/ha)	Rs.2400	Rs.2160
Herbicide + labour cost (ha^{-1})	Rs.1800	Rs.1800
Labour cost (Drainages and application of fertilizer, & irrigation) (ha^{-1}) 5 men days	Rs. 1500	Rs.1500
Harvesting (Cutting, Threshing and Transport) (ha^{-1}) 36 man days	Rs.10800	Rs.10800
Cost of cultivation (ha^{-1})	Rs.29625	Rs.27885
Soy bean grain yield (q ha^{-1})	20	10

Input details	AAS Farmers	Non-AAS Farmers
Soybean stover yield (q ha^{-1})	20	24
Total income (ha^{-1})	Rs.64000	Rs.34800
Net profit (ha^{-1})	Rs.34375	Rs.6915
Benefit cost ratio	1.16	0.25
Cost of grain and stover = Rs 3000 and Rs 200		

Higher profit obtained by Mr. Narayan Lal Gayri was attributed to:

- Followed all the AAS issued and carried out all farm operations in time
- Use of high yielding varieties
- Maintained proper drainage system in field
- Provided timely life saving irrigation at critical stage
- Undertook proper nutrient and plant protection measures

7. Farmer's Awareness Programs on Climate Change

The details of awareness program on climate change conducted for farmers of different states under the project are presented in Table 7.1

Table 7.1: Details of farmer's awareness programs conducted at different locations during 2018-19

Center	Name of Village/Location	Date on which Conducted	Total No. of farmers	Men	Women
Akola	Dr. PDKV, Akola	19-Aug-18	97	90	07
Bengaluru	Rajakallahalli, Kolar	07-Sep-18	35	23	12
	Vanarasi, Kolar	14-Sep-18	56	40	16
	Shettihalli, Chikkaballapur	17-Sep-18	34	22	12
Hisar	CCS HAU, Hisar	04-05 Oct-18	4300	4000	300
	CCS HAU, Hisar	23-Dec-18	150	120	30
Dapoli	Bandhtivare, Dapoli	27-Nov-18	75	43	32
Jorhat	Thengalgaon, Golaghat	01-Aug-18	95	60	35
Kovilpatti	Malangudi, Tiruppullani, Ramnad	18-Dec-18	100	75	25
Ludhiana	Rampurfasse, Roopnagar	10-Oct-18	65	56	09
Raipur	Jhal, Bemetara	19-Sep-18	72	69	3
	Bihajhar, Mahasamund	31-Dec-18	64	54	10
	Sureli, Kanker	21-July-19	54	53	01
Ranichauri	Hitanu, Dunda block	02-Sep-18	65	31	34
Solapur	Narotewadi Village	04-Aug-18	35	20	15
	Narotewadi Village	23-Aug-18	60	45	15
	ZARS, Solapur Farmers rally	06-Sep-18	400	280	120
	ZARS, Solapur on world soil day	05-Dec-18	100	71	29
	ZARS, Solapur on world safflower day	10-Dec-18	80	66	14
	Kisan Diwas KVK, Solapur	23-Jan-19	150	110	40
	Chick mahud	23-Jan-19	50	35	15
Udaipur	Bagatpura, Rajsamand	11-Jan-18	65	45	15

Annexure - I

Location of NICRA adopted villages

AICRPAM Center	Name of NICRA-KVK	District	Block/Tehsil/ Mandal	Name of NICRA Village(s)
Akola	AICRPAM village Akola	Akola	Akola	1. Kanshivani
	AICRPDA village Akola	Akola	Akola	2. Warkhed
	KVK, (Dr. PDKV), Buldhana	Buldhana	Buldhana	3. Chautha
Anand	KVK, Mangalbharti	Chhotaudepur	Sankheda	4. Manjrol
	KVK, Targhadia	Rajkot	Rajkot	1. Magharvada
				2. Rafala
				3. Targhadia
Anantapur	KVK, Yagantipalle	Kurnool	Banaganapalle	1. Yagantipalle
	KVK, Reddipalli	Ananthapuramu	Singanamala	2. Peravali
	AICRPDA NICRA	Ananthapuramu	Gooty	3. Vannedoddi
Bengaluru	KVK, Chintamani	Chikkaballapur	Chikkaballapur	1. Nayanahalli
	KVK, Magadi	Ramanagara	Magadi	2. Kuthanagere
	KVK, Herehalli	Tumkur	Koratagere	3. Durgada Nagenahalli
Bhubaneswar	Ganjam	Ganjam	Ganjam	1.Ekalpur, Padampur
	Kandhamal	Kandhamal	Kandhamal	2. Budhadani, Phulbani
	Kendrapada	Kendrapada	Kendrapada	3. Krushnadaspur
Chatha	KVK, Kathua	Kathua	Hiranagar	1. Chhapaki Khurd 2. Sherpur Bala
Dapoli	College of Agriculture, Dapoli	Ratnagiri	Dapoli Khed	1. Bandhtivare 2. Natunagar 3. Udhale-Kalambani
Faizabad	KVK, Bahraich	Bahraich	Huzurpur (Kaiserganj)	1. Banpurwa (AICRPAM)
	KVK, Gonda	Gonda	Paraspur, (Colonelgan)	2. Bambampurwa (TDC - NICRA)
	AICRPDA-NICRA	Faizabad	Amaniganj (Milkipur)	3. Amawachhitan
Hisar	KVK, Sirsa	Sirsa Hisar	Sirsa	1. Farwain Kalan
			Sirsa	2. Rupana Khurd
			Hisar	3. Balawas

AICRPAM Center	Name of NICRA-KVK	District	Block/Tehsil/ Mandal	Name of NICRA Village(s)
Jabalpur	KVK, Rewa	Rewa	Raipur Karchuliyan	1. Padiya 2. Rithi
Jorhat	KVK, Khumtai	Golaghat	Kothalguri	1. Thengalgaon (AICRPM) 2. Kochupathar (AICRPAM)
	KVK, Napam	Sonitpur	Balipara	3. Nagharia (NICRA-TDC)
	KVK, Bilasipara	Dhubri	Agomani	4. Udmari III (Additional TDC)
Kanpur	KVK, Daleepnagar	Kanpur Dehat	Maitha Hamirpur	1. Baghpur 2. Ludhaura 3. Barua
Kovilpatti	KVK, Madurai KVK, Ramanathapuram	Madurai Ramanathapu-ram	Madurai Ramanathapu-ram	1. Allikundam 2. Buchampatti 3. Malangudi
Ludhiana	KVK, Fatehgarh Sahib	Fatehgarh Sahib	Fatehgarh Sahib	1. Badhoshe Kalan 2. Bauranga Zer
Mohanpur	KVK, Ram Krishna Ashram	South 24 Paraganas	Kultoli	1. Bongheri 2. Gopalganj
Palampur	KVK, Bara	Hamirpur	Sujanpur Bhoranj	1. Bagehrah Buhla 2. Palahi 3. Karot Khas 4. Dhamrol
Parbhani	VNMKV, Parbhani	Parbhani	Parbhani	1. Babulgaon 2. Ujalamba 3. Mandakali
Raipur	KVK, Mahasamund KVK, Kanker KVK, Bemetara	Mahasamund Kanker Koriya	Mahasamund Kanker Bemetara	1. Jhalkhamaria, Lafin khurd 2. Kapsi, Sureli 3. Jhal
Ranchi	ZRS, Chianki KVK, Bishunpur	Gumla (KVK, Bishunpur) Palamu (ZRS, Chianki)	Gumla Palamu	1. Belagarha (Gumla) TDC 2. Rajderwa (Palamu) 3. Jorkat (Palamu) Dry land
Ranichauri	KVK, Chinyalisaur	Uttarkashi	Dunda	1. Badethi, AICRPAM-NICRA 2. Hitanu, AICRPAM-NICRA 3. Dunda, TDC-NICRA 4. Asthal, TDC-NICRA
			Chinyalisaur	1. Bharkot, TDC-NICRA

AICRPAM Center	Name of NICRA-KVK	District	Block/Tehsil/ Mandal	Name of NICRA Village(s)
Samastipur	KVK, Saraiya	Muzaffarpur	Saraiya	1. Ballisaraiya
			Marwan	2. Bhagwatpur
		Saran	Dariyapur	3.Darihara
Solapur	Solapur	Solapur	Solapur	1. Narotewadi
			Sangola	2. Chik mahud
Thrissur	KVK, Malappuram	Malappuram	Malappuram	1. Thavanur 2. Valavannur
Udaipur	KVK, Rajsamand	Rajsamand	Rajsamand	1.Bagatpura 2. Jorawar Singh ji Ka Kheda 3. Kundeli
	KVK, Kota	Kota	Kota	4. Chomakot
Vijayapura	ICAR-KVK, Tukkanatti	Belagavi	Gokak	1. Arabhavi
	ICAR-KVK, Hulkoti	Gadag	Gadag	2. Kurthkoti
	AICRPDA, Vijayapura	Vijayapura	Vijayapura	3. Kavalagi

Annexure - II

Staff position of NICRA during 2018-19 (Upto 31st March 2019)

Centre	Agrometeorologist / Jr. Agronomist	Young Professional - I / II
Akola	Dr. Arvind R Tupe	Sri. Vijay M. Bodade
Anand	Dr. M. Lunagaria Dr. N.J. Chaudhary	Sri. Vikram Parmar
Anantapur	Dr. S.N. Malleswari Dr. G. Narayana Swamy	Ms. L. Mounika
Bengaluru	Dr. H.S. Shivaramu Dr. M.H. Manjunatha	Mrs. C. M. Munirathnamma
Bhubaneswar	Dr. Anupama Baliar Singh	Sri. Gourisankar Panigrahi
Chatha	Dr. Mahender Singh	Dr. Charu Sharma
Dapoli	Dr. V.G. More	Sri. Onkar Arvind Lad
Faizabad	Dr. A.K. Singh	Dr. Manoj Kumar
Hisar	Dr. Chander Shekhar	Dr. Divesh Chaudhary
Jabalpur	Dr. Manish Bhan	Sri. Bhirendra Kumar
Jorhat	Dr. Bondita Goswami	Sri. Sri Pranjal Dutta
Kanpur	Dr. Naushad Khan	Sri. Ajay Kumar
Kovilpatti	Dr. G. Sudhakar Dr. S. Subbulakshmi	Sri. K. Sappanimuthu
Ludhiana	Dr. Prabhjyot K. Sidhu Dr. SS Sandhu	Dr. Rupinder Kaur
Mohanpur	Dr. Saon Banerjee Dr. Asis Mukherjee	Sri. Mrinal Kanti Das
Palampur	Dr. Rajendra Prasad	Sri. Manoj Kumar Negi
Parbhani	Dr. K.K. Dakhore	Sri. A.D. Nirwal
Raipur	Dr. J.L. Chaudhary	Ms. Surbhi Jain
Ranchi	Dr. Pragyan Kumari	Dr. Bably
Ranichauri	Mr. Sumit Chaudhary	Sri. Ashutosh Negi
Samastipur	Dr. A. Sattar	Sri. Shanta Kumar Choudhary
Solapur	Dr. H.L. Ghadage Dr. Vikas Londhe	Ms. Kiran Kundlik Chavan
Thrissur	Dr. B. Ajith Kumar	-
Udaipur	Dr. N.S. Solanki	Sri. Jitendra Kumar Tak
Vijayapura	Dr. H. Venkatesh	Mr. Jagdeesh R. Hiremath

Annexure - III

Budget allocated for AICRPAM-NICRA 2018-19

(in Rupees)

S.No.	Centre	RE 2018-19			
		TA	RC	SCSP	Total
1	Akola	9000	475000	-	484000
2	Anand	12000	220000	-	232000
3	Anantapur	9000	480000	170000	659000
4	Bangalore	11000	390000	-	401000
5	Bhubaneswar	7500	440000	-	447500
6	Bijapur	9000	375000	-	384000
7	Chatha	12000	420000	170000	602000
8	Dapoli	9000	200000	-	209000
9	Faizabad	6000	270000	-	276000
10	Hisar	8500	250000	170000	428500
11	Jabalpur	8000	250000	-	258000
12	Jorhat	9000	400000	-	409000
13	Kanpur	11000	487584	170000	668584
14	Kovilpatti	12000	270000	170000	452000
15	Ludhiana	9000	409000	170000	588000
16	Mohanpur	10000	247000	170000	427000
17	Palampur	10000	300000	170000	480000
18	Parbhani	13500	210000	-	223500
19	Raipur	13500	380000	-	393500
20	Ranchi	13500	475000	170000	658500
21	Ranichauri	7000	200000	-	207000
22	Samastipur	12000	325000	-	337000
23	Solapur	11000	400000	-	411000
24	Thrissur	9000	150000	170000	329000
25	Udaipur	13500	450000	-	463500
	Total	**255000**	**8473584**	**1700000**	**10428584**

Annexure - IV

AICRPAM-NICRA
Publications 2018-19

Coordinating Unit

Books / book chapters/ technical bulletins

- Bal, S.K., Mukherjee, J., Choudhary, B.U. and Dhawan A.K. eds. (2018). Advances in Crop Environment Interaction. Springer Nature Singapore Pte Ltd. p.450. https://doi.org/10.1007/978-981-13-1861-0
- Bal, S.K., Dhakar, R., Sarath Chandran, M.A., Subba Rao, A.V.M. and Vijaya Kumar, P. (2018). Rainfall based crop planning in drought prone rainfed regions. pp.419-430. In: Rainwater Management for Climate Resilient Agriculture in Drylands. (eds. Krishna Rao et al.) ICAR-CRIDA, Hyderabad. ISBN: 978-93-80883-49-6
- Subba Rao, A.V.M., Sarath Chandran, M.A., Dhakar, R., Bal, S.K. and Vijaya Kumar, P. (2018). Agromet Advisory Services and their Role in Drought Management. pp.379-389. In: Rainwater Management for Climate Resilient Agriculture in Drylands. (eds. Krishna Rao et al.) ICAR-CRIDA, Hyderabad. ISBN: 978-93-80883-49-6
- Vijaya Kumar, P., Sarath Chandran, M.A., Bal, S.K., SubbaRao, A.V.M., Dhakar, R. (2018). Annual Report 2017-18. NICRA-AICRPAM component, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad 500059 India, p.64.
- Vijaya Kumar, P., Subba Rao, A.V.M., Sarath Chandran, M.A., Sandeep, V.M., Pramod, V.P., Dhakar, R., Bal, S.K., Rao, V.U.M. and Sammi Reddy, K. (2018). Network of Automatic Weather Stations: An AICRPAM-NICRA Initiative. ICAR - Central Research Institute for Dryland Agriculture, Hyderabad 500059, p.40.

Anand

Papers in Peer Reviewed Journals

- Lunagaria, M.M. and Patel, H.R. (2018). Evaluation of PROSAIL inversion for retrieval of chlorophyll, leaf dry matter, leaf angle, and leaf area index of wheat using spectrodirectional measurements. *Int. J. Rem. Sens.,* DOI: 10.1080/01431161.2018.1524608

Bangalore

Papers in Peer Reviewed Journals

- Shivaramu, H.S., Ventatesh, H. and Padmashri, H.S. (2018). Trends in rainfall - Length of growing period and drought occurrence in Karnataka. *India. J. Dry Zone Agric.,* 4(2): 65-69.
- Sharanappa Kuri., Shivaramu, H.S., Thimme Gowda, M.N., Yogananda, S.B., Prakash S.S. and Murukannappa. (2018). Effect of row spacing, varieties and sowing dates on growth and yield of Pigeonpea. *Int. J. Curr. Microbiol. App. Sci.*, 7 (08): 1125-112.

- Shivaramu, H.S., Padmashri, H.S., Singh, K.K., Nagesha L., Manjunatha, M.H., Jayashree H.T. and Munirathna C.M. (2018). Forecasts and agromet advisory evaluation. *Int. J. Curr. Microbial App. Sci.,* 7(04): 2863-2871.

Books/ Book Chapter

- Shivaramu, H.S., Rajegowda, M.B., Padmashri, H.S., Govindaraju, C., Soumya, D.V., Narendra Babu., Vijayakumar. P., Singh. K.K., Nagesha, L. and Manjunatha, M. H. (2018). "Agroclimatic Characterization of Southern Dry Zone of Karnataka (NARP Agroclimatic Zone-VI)". 2nd Eds. (Director of Research, UAS, Bengaluru) pp.179.
- Shivaramu, H.S. (2018). Watershed approach for rainwater management. In: "Swachh Bharat: From Sanitation to Cleaning up the Financial Systems". pp. 80-88. (Archers and Elevators Publishing House, Bangalore).

Popular Articles/ Leaflets

- Shivaramu, H.S. (2018). Impact of north east monsoon deficiency on yield. Indian Express, 28.6.2018.
- Shivaramu, H.S., Shadakshari, Y.G., Manjunatha, M.H., Nagesha, L., Padmashri, H.S., Munirathnamma, C.M. and Jayashree, H.T. (2018). "Nakshthra - Krushi Gadegalu".

TV/ Radio programs

- Shivaramu, H.S. has given TV Programme on "Current Year Monsoon Situation and Recommended Crops and Cropping Systems for the Situation" at D.D. Chanadana on 07.08.2018.
- Shivaramu, H.S. has given TV Programme on "Monsoon Crop Plan" at D.D. Chanadana on 19.06.2018.
- Manjunatha, M.H. has given a Radio Talk on "Crop Planning in Different Agricultural Zones (South Interior Karnataka)", at All India Radio on 21.05.18.

Faizabad

Papers in Peer Reviewed Journals

- Kumar, A., Kumar, S., Singh, A.K., Kumar, D., Harikesh Gopal, T., Pandey, D. and Pandey, V.K. (2018). Effect of moisture regime and nutrient management system on yield and economics of wheat (*Triticum aestivum L.*). *Int. J. Curr. Microbiol. App. Sci.,* 7 (2): 59-66.
- Yadav, A., Singh, A.K., Chaudhari, R. and Mishra, S.R. (2018). Effect of planting geometry on growth and yield of mustard (*Brassica Juncea L.*) varieties. *J. Pharmacogn. Phytochem.,* 2624-2627.

Popular Articles/ Leaflets

- Kumar, M., Singh, A.P., Singh, A.K. and Mishra, A.N. (2018). "Badlte Parvesh Me Parveesh Me Kheti Ka Adhunikikaran", Krishak Nidan, Hindi Patrika, Page 26-28.

Hisar

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- Choudhary, D., Singh, R., Singh, S., Dagar, C.S. and Kumar, A. (2018). Influence of prevailing weather conditions on Indian mustard under Hisar Conditions. *J. Agrometeorol.,* 20 (Sp.Issue): 49-54.
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- Thorve, S.B., Jadhav, J.D., Pawar, P.B., Amrutsagar, V.M., Bhanavase, D.B. and Upadhye, S.K. (2018). Agromet advisories a guide for sustainability: A case study in water scarcity zone of Maharashtra. *J. Agrometeorol.,* 20 (1): 212-216.

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Recognitions

- Mr Shekharayaa Basayya from Shanwad village, Dharwad, Karnataka and Mr Vimal Kumar Dhruw from Labharakhurd, Chhattisgarh were given best farmers' award on the occasion of Foundation Day of ICAR-CRIDA held on 12-04-2019.

Mr Shekharayaa Basayya adopted the technology "Use of weather forecast and agromet advisory services for management of crop and reducing loss due to risks". He also popularized agromet advisory services among fellow farmers in his village.

Mr Vimal Kumar Dhruw adopted the technology "Adopting Micro-level Agromet Advisories (MAAS) issued by AICRIPAM-NICRA project and making use of weather forecast in all agricultural activities".