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Impact Assessment of Weather and Climate Services of the India Meteorological Department (Phase-I: Agrometeorological Advisory Services)

National Institute of Advanced Studies
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Impact Assessment of Weather and Climate Services of the India Meteorological Department (Phase-I: Agrometeorological Advisory Services)

Interim Report

Submitted to
Monsoon Mission Phase III

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Cover photo: Front Cover: Project team conducting household surveys
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Summary

The National Institute of Advanced Studies (NIAS) is implementing the project titled *"Impact Assessment of Weather and Climate Services of the Indian Meteorological Department (Phase-I: Agrometeorological Advisory Services)."* This project was awarded by the Monsoon Mission to NIAS on 27th June 2025 under Monsoon Mission–III.

The agricultural sector in semi-arid regions of India is susceptible to increasing rainfall fluctuations and extreme temperature events (Srinidhi et al., 2024). Agro-Meteorological Advisory Services (AAS) provide localized, weather-based recommendations which aids timely decision making on farm practices such as sowing, input use, irrigation, pest management, among others. This study evaluates the impact of AAS on the yields of major crops cultivated in three Agroclimatic Zones (Southern hills and plateau, Western hills and plateau & Gujarat plains and Hills). The study reports findings from household surveys in 21 villages across these 3 Agroclimatic zones. Data was collected for the agricultural years of 2023–24 and 2024-25.

Preliminary analysis indicates that access to Agrometeorological Advisory Services (AAS) is relatively high, with nearly 84% of households having access; however, utilisation remains moderate (around 45%), highlighting a significant access–utilisation gap. Despite this, farmers with access are substantially more likely to use advisory services. As shown in the following table, AAS has a significant positive impact on crop productivity across regions, with stronger effects observed during the Kharif season. This confirms that the utilisation of AAS contributes to improved agricultural productivity and decision-making in specific crops & regions. However, enhancing the reach, awareness, accuracy, and effective dissemination of AAS is critical to maximising its impact. These interventions will play a critical role in increasing the incomes of farmers who utilise the AAS effectively besides ensuring food security at a time when climate change impacts are becoming more pronounced.

Agroclimatic Zone	Crop	Yield gain (Kg/acre)	Yield gain (%)
Western Plateau and Hills	Cotton	341.82	49.4%
Southern Hills and Plateau	Groundnut	91.68	11.8%
	Paddy	337.79	11.6%
Gujarat Plains and Hills & Western Dry Region	Groundnut	146.52	19.2%
	Wheat	260.72	34.5%

Introduction

Agriculture is highly vulnerable to weather and climate variability, with rainfall and temperature extremes directly affecting crop production, particularly in rain-fed systems(Sathyan et al., 2018). The increased frequency of extreme climate events has further intensified risks for farmers (N. P. Singh et al., 2020). Recent analysis of the distribution of yields for cereal in the southern region of India indicates that seasonal weather risks affect production, emphasizing the vulnerability of smallholder farmers and the critical need for localized climate information services (Mohapatra et al., 2025).

In order to address this challenge, the India Meteorological Department (IMD) has established Agro-Meteorological Advisory Services (AAS), which integrate weather forecast and agricultural practices and provide location and crop-specific guidance to farmers. These advisories provide information on stage specific crop management practices, of which the key components include weather-based planning on sowing, irrigation, harvesting, and other stages of crop production, early warning and management practices for pest and disease attacks, irrigation scheduling for efficient water use, input optimization through recommendation on seed rate, fertilizer and manure application, and other advisories (livestock management, etc).

The Gramin Krishi Mausam Seva (GKMS) launched in 2015 by IMD acts as the foundation of Agrometeorological Advisory services in India. Agro-Meteorological Fields Units (AMFU), generate agrometeorological advisories twice a week by integrating district level forecasts for rainfall, temperature, wind, humidity and cloud cover with information relevant for crop cultivation such as fertilizer application, pest management etc. These bi-weekly Agromet Advisory Bulletins(AABs) are issued on every Tuesday and Friday and are disseminated through multiple channels, including SMS, WhatsApp groups, mobile applications such as *Meghdoot and Mausum,* and traditional mass media platforms such as television, radio, state and district level agricultural extension networks etc. reaching over 4.3 crore farmers (SOP for Preparation of Agromet Advisory Service Bulletins, 2020). The services have been extended to village level by the recently launched Panchayat Mausum Seva initiative which directly links weather alerts to local governance structures to enhance last mile connectivity (IMD VISION 2047, 2025). These advisories provide guidance on sowing windows, irrigation scheduling, fertilizer use, and pest and disease control, aiming to optimize input use and reduce weather-induced risks.

Despite the significant expansion of AAS dissemination, over the past decade, through multichannel delivery systems, there have also been challenges. In early 2024, IMD decided to shutdown District AgroMet units (DAMU), which had been functioning under the GKMS scheme, raising concerns about continuity of advisory services (Rout, 2024; Standard, 2024). The DAMUs provided localized advisories and tailored crop guidance, through Krishi Vigyan Kendra's (KVK) which are extension centres of agricultural departments, village level WhatsApp Groups, local newspapers, co-operative societies etc. Following the shutting down of DAMUs farmers have had to rely on more generic forecasts provided by AMFU's, which provide services to multiple districts at a lower level of granularity. This in turn has affected significant number of small and marginal farmers as they had lost access to precise ground level forecasts and advisory services (Nannewar et al., 2024). Recognizing the short comings of shutting down DAMU the government had planned to revive DAMU's under a permanent framework and more robust way which aims to ensure consistent block level advisories and better disaster preparedness (Choubey, 2025; Standard, 2025).

The adoption of AAS had improved crop performance and reduced yield losses in many cases as pointed out by many studies. A village level study in Madhya Pradesh showed that those accessing and using AAS reported higher crop production and net returns (Dubey et al., 2025). Similarly,, a recent study from Ladakh, found that climate risk management and utilization of weather-based information were enhanced by combining local advisories and farmer awareness programs (Kumar et al., 2023). In Karnataka, Agrometeorological Advisory Services (AAS) have been shown to improve yields of major rainfed crops such as pigeon pea, pearl millet, jowar, and maize (Nannewar et al., 2023, 2025) where small holdings and rain-fed agriculture are predominant, knowledge inputs become even more critical. The India Meteorological Department has provided integrated agrometeorological advisory services. Apart from yield outcomes, the awareness and utilization of advisories are strongly mediated by education and accessibility to extension services and media, as indicated in studies from Telangana and Tamil Nadu (Harshini et al., 2023; Kumar et al., 2023)

Notwithstanding these developments, there are still gaps in robust quantitative evaluations of AAS efficacy in various crop systems and agroclimatic zones. Few studies have separated the ways in which input adoption, crop management, and dissemination pathways interact to affect yield outcomes. Much of existing research has focused on farmer perceptions and economic benefits ((Mittal & Hariharan, 2018). By assessing the effects of AAS on the major crops—in three Agroclimatic zones (Southern Hills and Plateau ,Western Hills and Plateau, and Gujarat Hills and Plains) the current study fills this knowledge gap. We estimate yield differences between *AAS users* and *non-users* and determine the mechanisms through which advisories have an impact.

1. Study Area

The current research was carried out in three large agro-climatic areas of India, which included: Southern Hills and Plateau, Western Hills and Plateau, and Gujarat Plains and Hills and Western Dry Region. These areas were chosen to represent the different climatic conditions, farming activities, and exposure to different degrees of agro-meteorological advisories. The Southern Hills and Plateau region has a semi-arid to sub-humid climate with rainfall of approximately 600-900 mm/annum which is highly unpredictable and is often hit by dry seasons; the major crops grown there are millets (ragi and jowar), pulses, groundnut and cotton. The climate in the Western Hills and Plateau region is sub-humid to semi-arid with rainfall of between 700-1500 mm with a declining gradient west to east; the common crops in the irrigated lands are cotton, sorghum, pulses, oilseeds and sugarcane. The Gujarat Plains and Hills (Western Dry Region) is mainly arid to semi-arid with 300-800 mm of very erratic rainfall and subject to droughty conditions; the main crops that are cultivated in this area include groundnut, cotton, bajra (pearl millet) and pulses.

1.1. Data Sources

A combination of complementary data collection tools was employed to understand both the quantitative and qualitative aspects of the impact of AAS. The close ended questionnaire survey that was conducted provided representative data on farm level characteristics, crop production, and utilization of advisories. Additional sections in the survey questionnaire on the farmers' experience with extreme weather events and mitigation strategies adopted were also included in the survey. Focus group discussions offered insights into perceptions and barriers in the accessibility and adoption of AAS. A better understanding of the AAS generation, dissemination mechanisms and operational challenges were obtained from stake holder interviews with officials in charge of implementing AAS at the district and village levels.

a. Sampling Strategy

❖ **Village selection:**

For block-level analysis, the average number of households was calculated for each block within the selected districts. In districts with more than five blocks or taluks, only the top five blocks with the highest average number of households were considered. Additionally, at least one block with a Krishi Vigyan Kendra (KVK) or a Agrometeorological Field Unit (AMFU) or a District Agromet Unit (DAMU) was compulsorily included for village selection. One village per selected block was then chosen based on having a household count roughly matching the district average.

❖ **Household Sampling within Villages:**

The official village cultivator list was obtained from the government office (Gram panchayat/agricultural office), and the households were stratified based on landholding size categories such as marginal, small, medium, and large farmers. From each village, up to 100 households were selected using stratified random sampling to ensure proportional representation from each landholding category. This methodology ensures statistical validity and enhances the potential for generalizing the findings across the study area.

❖ **Sampling Formula:**

For each landholding stratum *h* in a village:

$$Number\ of\ sampled\ households\ in\ stratum\ h\ (n_h) = \frac{N_h}{N} * 100$$

Where:

- n_h = number of sampled households in stratum h
- N_h = total households in stratum h
- N = total number of households in the village

❖ **Questionnaire**

The agricultural survey questionnaire was developed, which aims to assess the impact of AAS. It includes sections covering household demographics, land ownership, crop-wise production, input use, sale and revenue, access to and use of irrigation, livestock-related information, and AAS access & utilisation. The questionnaire is designed for comprehensive, multi-scale data collection, accounting for seasonal variations and ensuring standardised, comparable data. It enables robust analysis of how farmers access and use AAS and provides the foundation for evidence-based policy recommendations and suggestions on service improvements.

The sources from which the farmers receive agrometeorological information were broadly classified into three categories:

1. **Public-sector agricultural extension services**, including agricultural officers, extension workers, Krishi Vigyan Kendras (KVKs), and training programs organized by the agricultural department.
2. **Technical instruments of extension**, such as mobile applications (e.g., IMD's Meghdoot app, Mausum app), text messages sent directly from mKisan Portal, WhatsApp groups maintained by AMFUs and KVKs, regular programs on radio and television, and newspaper reports.
3. **Social networks**, which include information on AAS received from input dealers, non-governmental organizations (NGOs), other farmers, and cooperative societies.

The surveyed households were classified into two groups, AAS User and Non- User of AAS for the purpose of analysis. Those farmers who had reported using agrometeorological advisories from at least one of the three sources mentioned above in their farming practices are *AAS Users*, those who were reported not using agrometeorological information, from any source, were classified as *non-users*.

We then estimate differences in crop yields between AAS User and Non-User households. Numerous biophysical and socioeconomic factors, including weather, soil fertility, water availability, input use, and farm management techniques, affect crop productivity. In rain-fed regions, rainfall distribution and soil moisture are the primary determinants of yield, while temperature and radiation are important drivers in irrigated systems (Lobell & Burke, 2010; Rockström et al., 2010). Increasing weather variability under climate change further amplifies the role of farmer decision-making, resource access, and adaptive capacity in determining outcomes (Howden et al., 2007). Our study accounts for these, determinants, along with access to ensure that any observed yield differences are appropriately attributed.

❖ **No:of Households Surveyed:**

The agroclimatic regions covered and the villages covered during the last 21 months of this project are shown in Figure 1. As shown in Figure 2, 762 households in nine villages (three per district) were surveyed in the southern region during Phase I (up to June 2025), covering Chitradurga (267 households), Nandyal (247 households), and Anantapur (248 households).

Data collection was completed in three villages in the Amaravati (275 households) and Buldhana (284 households) districts as shown in Figure 3. Further, in the Gujarat and adjoining dry regions, surveys were completed in Bikaner (270 households) and Junagadh (305 households) districts. Surveys in the Banaskantha district in Gujarat and the Sikar district in Rajasthan are in progress (Figure 4).

Table 1.1 Number of Households Surveyed

Agroclimatic zones	Districts (Villages)	Number of Households surveyed
Western Plateau and hills	Amaravati (3)	275
	Buldhana (3)	284
Gujarat plains and hills, and the western dry region	Bikaner (3)	270
	Junagadh (3)	305
Southern Plateau and hills	Chitradurga (3)	267
	Nandyal (3)	247
	Anantapuramu (3)	248
		1896

2. Socio-economic profile of the households:

This section presents the socio-economic characteristics of the sampled households, including gender composition, literacy status, landholding patterns, access to communication devices, religion, and participation in agricultural activities.

Table 2.1 Gender Distribution of the Head of Households (HoH)

Gender	Number of HoH (%)
Male	1748 (92%)
Female	148 (8%)
Total	**1896**

The sample is predominantly male, indicating that survey responses are largely representative of those of the male members of the farming

Figure 1.1 Agroclimatic Regions covered in the Project and Surveyed Locations

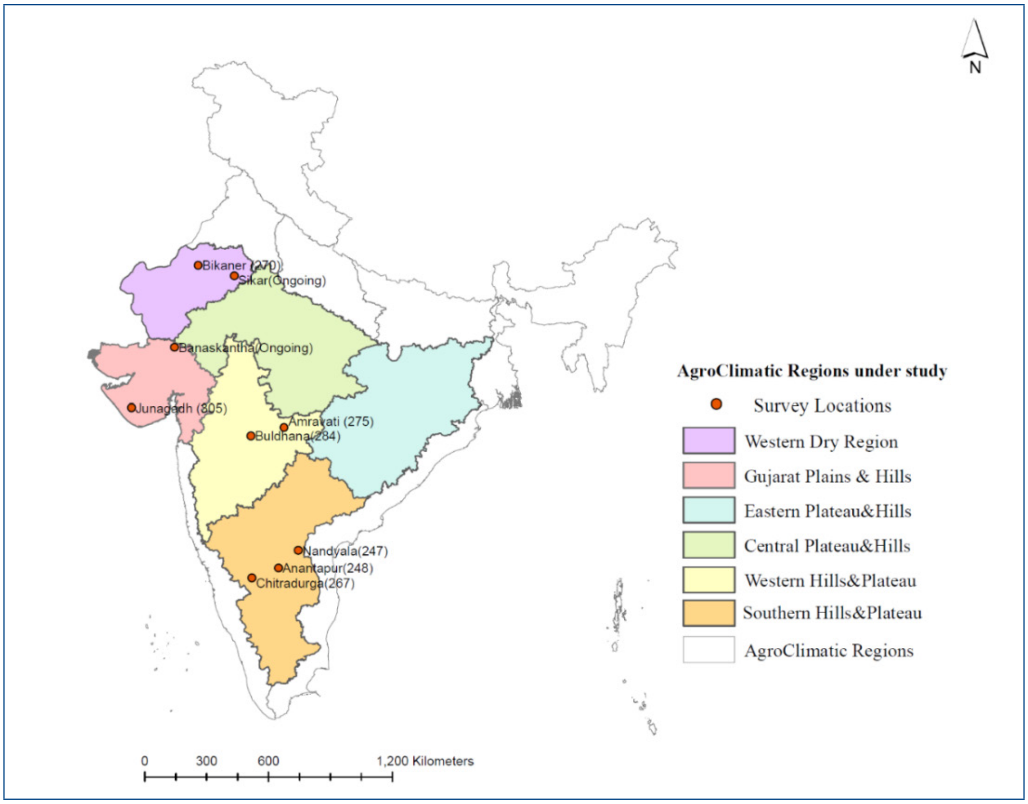


Figure 1.2 Villages Surveyed in Karnataka & Andhra Pradesh (Southern Plateau and Hills Region)

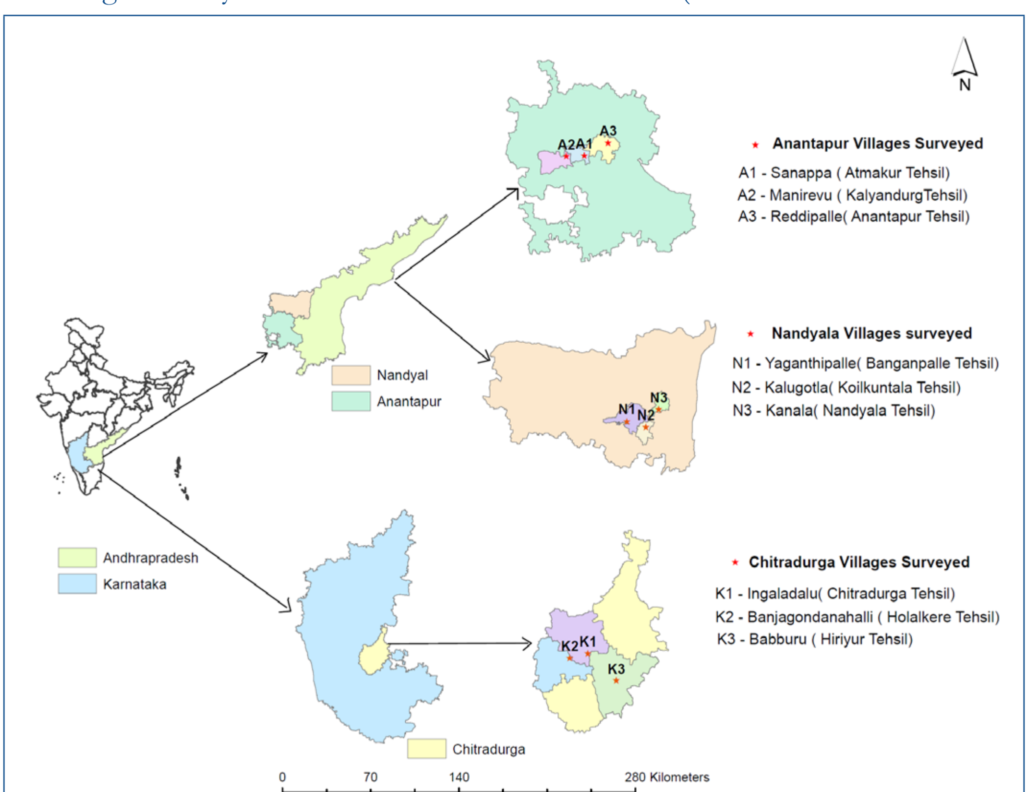


Figure 1.3 Villages Surveyed in Maharashtra (Western Plateau and Hills Region)

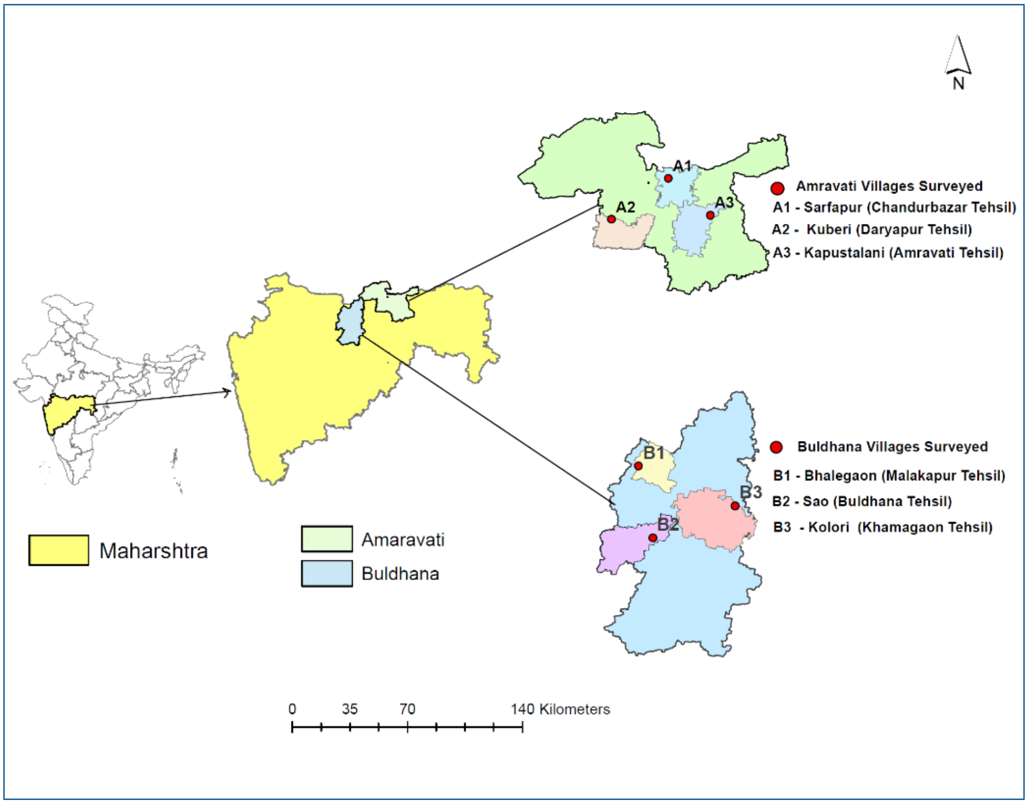
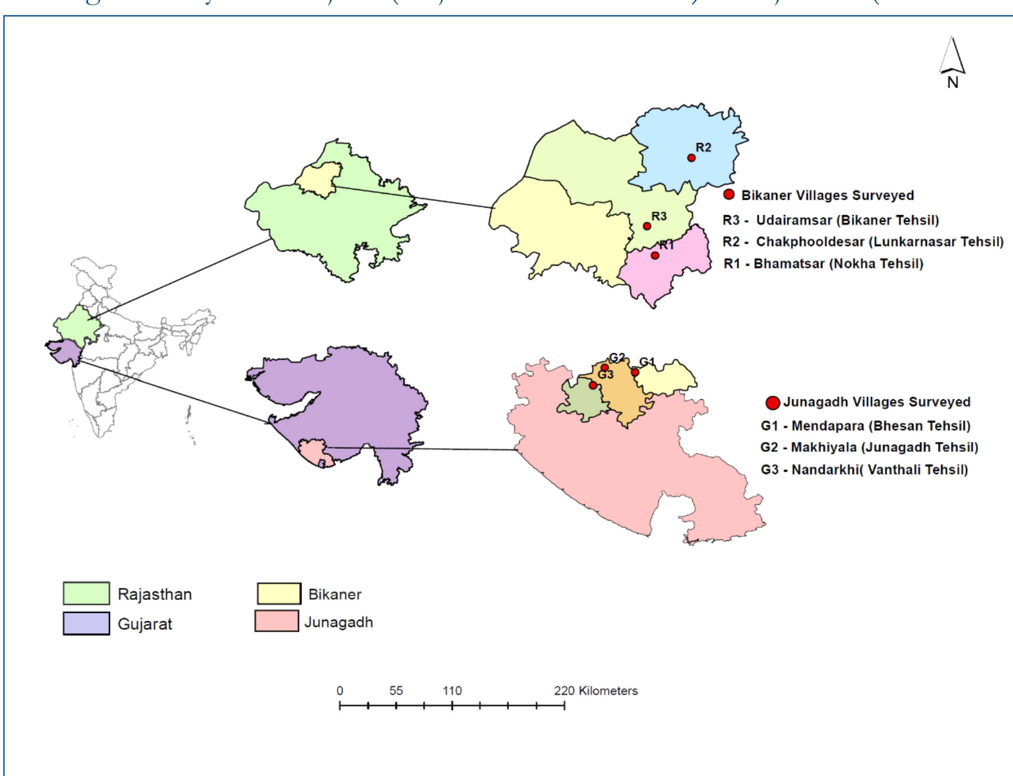


Figure 1.4 Villages Surveyed in Gujarat (Gujarat Plains and Hills) & Rajasthan (Western Dry Region)



community. The high proportion of male respondents (Table 2.1) suggests that access to and use of agricultural information, including AAS, is mainly concentrated among men.

Table 2.2 Type of Phone Used by Respondents (HoH)

Phone Type	Number of HoH (%)
Smart Phone	1193 (63%)
Keypad Phone	609 (32%)
Do not have a mobile	89 (5%)
Land Line	5
Total	**1896**

Mobile phone ownership plays an important role in accessing digital advisory services. Table 2.1. shows that 63 per cent of HoH own smartphones, which shows strong potential for delivering AAS through mobile-based platforms. However, 32 per cent still use keypad phones, indicating that SMS-based advisories remain important. A small percentage of respondents do not have access to a phone, which may limit their use of such services.

Table 2.3 Distribution of Households by Land Class

Land Class	Number of Households (%)
Small	589 (31%)
Semi-Medium	553 (29%)
Marginal	509 (27%)
Medium	211 (11%)
Large	34 (2%)
Total	**1896**

Landholding size is an important factor influencing agricultural practices and adoption of advisory services. Table 2.3 shows that most respondents belong to small and semi-medium landholding categories, together accounting for more than 60 percent of the sample. Marginal farmers also form a significant share (27%). This indicates that the study largely represents small landholding farmers, who are a key target group for AAS.

Table 2.4 Literacy Level of HoH

Literacy Level	Number of HoH (%)
Can read and write	1222 (64%)
Can only sign	374 (20%)
Cannot read and write	250 (13%)
Can read but not write	50 (3%)
Total	**1896**

Literacy plays a key role in understanding and using advisory information. A majority of respondents (64%) can read and write, which supports the use of text-based advisories. However, nearly one-third of respondents have limited or no literacy. This suggests the need for alternative communication methods, such as voice messages or visual formats, to ensure wider accessibility.

On average, about one to two members per household are involved in agricultural activities. This indicates that farming is typically managed by a small number of household members, which may affect labour availability and decision-making. The sample is predominantly Hindu (93%), with smaller representations from Muslim, Buddhist, and other religious groups. This reflects the general demographic composition of the study area.

Table 2.5 Distribution of Households by Primary Irrigation Source

Irrigation Source	Number of Households (%)
Groundwater	1219 (64%)
Only Rainfed	498 (26%)
Surface Water	179 (10%)
Total	**1896**

As shown in Table 2.5, the distribution of households by primary irrigation source shows that the majority (64%) of farmers depend on groundwater sources, such as borewells and open wells. Rainfed agriculture accounts for 26 per cent of households, indicating a significant proportion is still reliant on rainfall. Surface water sources, including canals and tanks, are used by only ten per cent of households. This pattern suggests a strong reliance on groundwater irrigation in the study area, with important implications for water resource sustainability and agricultural decision-making.

3. Access to Agrometeorological Advisory Services (AAS)

To capture farmers' engagement with AAS sources, an exposure index was constructed for both cultivation and weather advisories. The index is based on the number of advisory sources accessed by each household, including institutional, technical instruments (mass media), and informal channels. Extension sources, including institutional, mass media, and informal channels, refer to the capture of all major sources through which farmers receive agrometeorological advisory information. Institutional channels comprise formal sources such as agricultural officers, Krishi Vigyan Kendras (KVKs), agricultural research stations, and organized training programs. Mass media channels include broad communication platforms such as radio, television, newspapers, mobile text messages, and digital applications that disseminate information at scale. Informal channels encompass local social networks, including fellow farmers, input dealers, cooperative societies, and non-governmental organizations (NGOs). Together, these channels represent the complete information ecosystem that shapes farmers' access to and engagement with advisory services.

An exposure score was computed by summing binary indicators (1 = access, 0 = no access) across all relevant sources. Based on the total score, households were classified into an ordered categorical variable representing different levels of exposure:

- No Exposure (0 sources)
- Low Exposure (1-3 sources)
- Medium Exposure (4-7 sources)
- High Exposure (more than 7 sources)

3.1 Distribution of Exposure to AAS:

The distribution of households across exposure levels indicates that the majority of farmers fall within the medium exposure category for both cultivation and weather advisories. Specifically, 1,075 households are moderately exposed to cultivation advisories, while 1,131 households fall in the medium exposure category for weather advisories. Therefore, a significant proportion of farmers have access to multiple advisory sources, though not at the highest level of intensity.

A smaller proportion of households is categorised under low exposure (409 for cultivation and 379 for weather), indicating limited interaction with advisory sources. Notably, a non-negligible number of households remain in the no-exposure category, highlighting persistent gaps in access to advisory information. The no-exposure category is comprised of farmers who are older and prefer the traditional agricultural practices due to their unwillingness or inability (distance, illiteracy) to access the advisories. The high-exposure group remains relatively small, particularly for cultivation advisories, suggesting that comprehensive engagement across multiple advisory channels remains limited.

Overall, the pattern reflects a moderately developed information ecosystem, where basic access is widespread but deeper, multi-channel engagement is less common. This distribution is critical for understanding variations in advisory utilisation, in which higher exposure levels may lead to greater adoption of advisory services.

Table 3.1 Exposure Level of Advisories

Exposure Level	Cultivation Advisory (N)	Weather Advisory (N)
No Exposure	254	159
Low	409	379
Medium	1075	1131
High	158	227
Total	1896	1896

3.2 Direct access to AAS:

We have used a parameter, "direct access to AAS" to capture the meaningful and complete access to advisory services, rather than partial or fragmented exposure. Direct access to AAS is operationalised as a binary indicator capturing comprehensive and reliable access to advisory information. A household is classified as having *direct access* (value = 1) only if it receives both cultivation-related and weather-related advisories through at least one of the formal channels, namely public extension systems or technical institutions/mass media. Specifically, a household must report access to cultivation advisories via either public or technical sources *and* access to weather advisories via either public or technical sources. Households that do not satisfy both conditions are categorised as having no access (value = 0). In the context of agrometeorological decision-making, both weather forecasts and cultivation advisories are complementary inputs; access to only one type may not be sufficient to influence farmer behaviour effectively.

Furthermore, restricting access to formal channels (public and technical sources) ensures that the information considered is credible, standardised, and actionable, as opposed to informal or inconsistent sources. This approach minimises measurement error and strengthens the validity of the analysis by distinguishing between exposure to various sources and substantive advisory access.

The distribution of the direct access to AAS variable indicates that 84 per cent of households (1,591 out of 1,896) have access to AAS under the defined criteria, while 16 per cent (305 households) lack such access. This suggests that formal advisory systems, comprising public and technical sources, have achieved considerable reach among the sampled population.

3.3 Utilisation of AAS and Its Association with Access

The distribution of AAS utilisation indicates that among households with direct access to AAS, 45.5 per cent (724 out of 1,591 households) reported using AAS, while 54.5 per cent (867 households) did not utilise the available advisories (As shown in Table 3.2). This shows that, despite the availability of advisory services, actual utilisation remains limited, with more than half of the farmers not engaging with AAS in their decision-making. This clearly points to an access–utilisation gap, where the presence of advisory services does not necessarily translate into their effective use. Such a gap may arise due to factors such as a lack of awareness, limited trust in information sources, timing and relevance issues with advisories, or broader socio-economic constraints faced by farmers.

While it may appear intuitive that farmers who have access are more likely to use AAS, statistical testing is essential to formally establish whether this relationship is systematic and not due to random variation in the sample. To examine whether access to AAS significantly influences utilisation, a cross-tabulation analysis was conducted, followed by a Chi-square test of independence. The Chi-square test helps verify whether the observed differences in utilisation between households with and without access are statistically significant and generalisable beyond the sample.

Table 3.2 Cross-Tabulation of AAS Access and Utilisation with Chi-Square Test Statistics

Direct AAS Access	Not Utilised (0)	Utilised (1)	Total	Utilisation Rate (%)
No Access (0)	291	14	305	5%
Access (1)	867	724	1591	45%
Total	**1158**	**738**	**1896**	—
Statistical Test • Chi-square value (χ^2) = 178.51 • Degrees of freedom (df) = 1 • p-value < 0.001				

The Chi-square test results show a highly significant association between access to AAS and their utilisation ($\chi^2(1) = 178.51$, $p < 0.001$). The null hypothesis of independence between access and utilisation is therefore rejected, confirming that access plays a critical role in influencing farmers' adoption of advisory information.

A clear disparity in utilisation rates is observed across access categories. Among households without access to AAS, only 5% reported utilising advisory services (received through informal sources). In contrast, households with direct access to AAS exhibited a substantially higher utilisation rate of 45% (Table 3.2). This indicates that farmers with access to both cultivation and weather advisories through formal channels are nearly 10 times more likely to utilise advisory information than those without access.

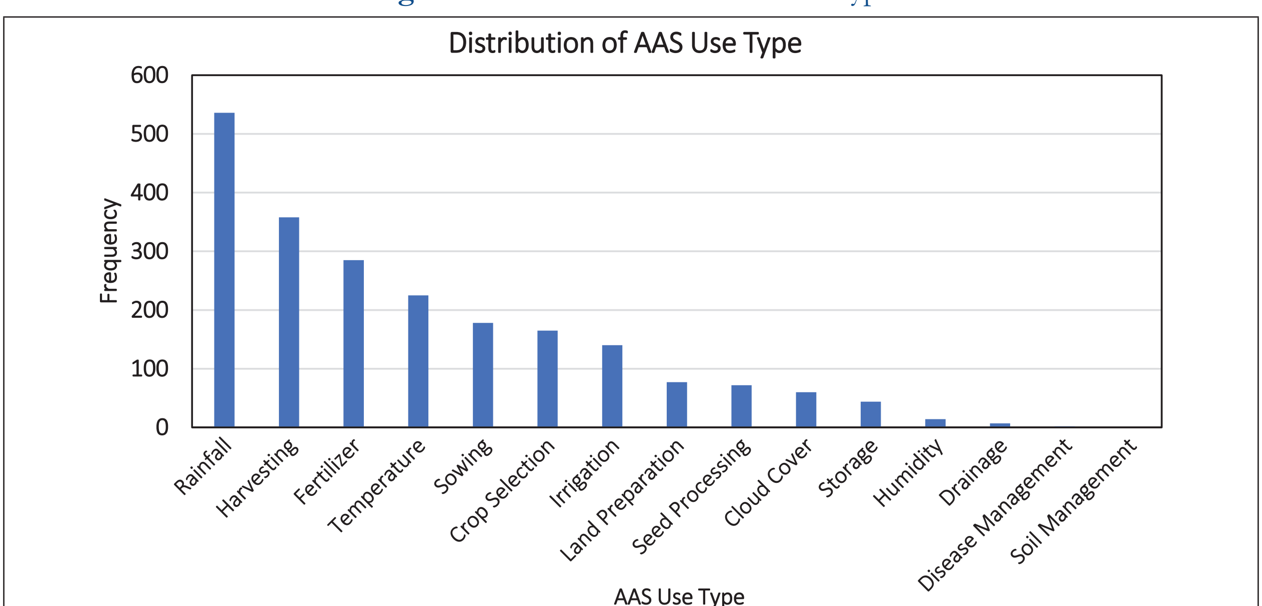
The findings highlight two important aspects:

1. Direct access to AAS significantly enhances the likelihood of utilisation, confirming the central role of institutional advisory systems in influencing farmer behaviour.
2. Existence of an Access-Utilisation Gap despite having access: More than half of the farmers (55%) still do not utilise advisory services. This suggests that access alone is insufficient, and other factors, such as trust, relevance, timing, and socio-economic conditions, may constrain adoption.

3.4 Advisory type-wise utilisation of AAS

Building on the earlier finding that access does not necessarily translate into utilisation, it is important to examine the types of advisories that farmers actually use. As shown in Figure 3.1, the distribution of AAS use indicates that rainfall-related advisories are the most frequently utilised,

Figure 3.1 Distribution of AAS Use Type



followed by harvesting, fertiliser application, and temperature-related information. This highlights the strong reliance of farmers on weather-related and immediate operational advisories. Advisories related to crop selection and sowing are used less frequently, suggesting possible gaps in early-stage decision support. Similarly, advisories on land preparation, irrigation, and seed processing show moderate levels of use, indicating partial integration of AAS into farm practices. In contrast, advisories related to long-term risk management, such as soil management, disease management, and drainage, are used very minimally. This suggests that farmers tend to prioritise short-term and weather-sensitive decisions over preventive and sustainability-oriented practices.

3.5 Advisory Timings among AAS users:

Table 3.3 Advisory Timing

Advice Timing	No of HH (%)
Before Planting	252 (34%)
Not Aware	183 (25%)
Pre-Harvest	160 (22%)
During Planting	108 (15%)
Post-Harvest	34 (4%)
Total	738

The distribution of advisory timing among households utilising advisory services indicates that a substantial proportion of farmers receive advisories at early stages of the crop cycle. Approximately 34% of users reported receiving advisories before planting, followed by 22% during the pre-harvest stage and 15% during planting. This suggests that advisory dissemination is relatively concentrated around critical decision-making periods in the agricultural cycle. However, a notable share of farmers (25%) reported being unaware of the timing of advisory receipt, pointing to potential gaps in communication clarity and information delivery mechanisms. Additionally, only a small proportion (4%) reported receiving advisories at the post-harvest stage, indicating limited emphasis on post-production decision support.

This suggests that while advisory services are reaching farmers during important production stages, there remains a significant need to improve awareness and clarity regarding the timing of advisory dissemination to enhance their effectiveness.

3.6 Challenges in accessing AAS:

This section presents the challenges households face in accessing AAS. Since respondents were allowed to report more than one challenge, the analysis is presented in two ways: (i) the type of challenges faced, and (ii) the number of challenges faced by each household.

Table 3.4 Challenges Faced in Accessing AAS (Multiple Response)

Challenge	Number of Households (%)
Lack of awareness	812 (43%)
Timing issue	621 (33%)
Poor communication	506 (27%)
Language barrier	295 (16%)

Note: Multiple responses were allowed; therefore, the total percentage exceeds 100 percent.

As shown in Table 3.4, the most common challenge households face is a lack of awareness of advisory services (43%). This indicates that many farmers are not fully informed about the availability of AAS. Timing issues (33%) are the second most reported challenge, suggesting that advisories may not be received at the right time for decision-making. Poor communication (27%) also affects access, indicating gaps in the delivery channels. In addition, 16 per cent of households reported language barriers, which may limit their understanding of the advisories. This highlights that both informational and communication-related constraints play an important role in limiting access to AAS.

Table 3.5 Distribution of Households by Number of Challenges Faced

Challenge Category	Percentage of HH (%)
No challenge	41%
One challenge	26%
Two challenges	16%
Multiple challenges	17%
Total	**100.00**

To better understand the severity of the challenges faced (as shown in Table 3.5), households were classified by the number of challenges they face. Table 3.5 shows that 41 per cent of households do not face any challenges in accessing AAS. However, the remaining households experience at least one difficulty. About 26 per cent of households face only one challenge, while 16 per cent face two challenges. A notable proportion (17%) of households experience multiple challenges simultaneously. This indicates that a significant number of farmers face combined barriers, which may reduce their ability to access and use advisory services effectively.

These findings suggest that improving awareness, ensuring timely delivery of advisories, and strengthening communication channels can significantly enhance the effectiveness and reach of AAS.

3.7 Preferred Sources of AAS

This section presents the primary preferred source of AAS among the sampled households. Respondents were asked to indicate their first preference, and the analysis focuses on identifying the most important source of advisory information as reported by farmers.

To identify the most important source of information, the primary preferred source was analysed. As shown in Table 3.6, agriculture officers (42%) are the most preferred source of advisory information. This highlights the strong role of extension services and direct institutional contact in providing reliable agricultural guidance. Television (22%) is the second-most-preferred source, indicating its wide reach and importance as a communication medium. Text messages (8%) and radio (4%) are also important channels for disseminating advisory information. Digital platforms such as mobile applications and social media are less preferred as primary sources, suggesting that their role is still emerging. The survey results show that farmers use multiple sources of information, but their most trusted and preferred sources differ. While television and interpersonal communication are widely used, agriculture officers are the most important primary source of information.

Table 3.6 Primary Preferred Source of AAS (First Preference)

Primary Source	Frequency	Percentage (%)
Agriculture Officer$	894	47
Television	422	22
Text Messages (SMS)	151	8
Radio	82	4
Input Dealer	58	3
Mobile Applications	25	1
Other farmers/Friends	31	2
Newspaper	16	0.84
NDMA	11	0.58
Social media	7	0.37
Training Programs	6	0.32
WhatsApp	2	0.11

Note: $*Agriculture Officers include Agriculture Officer/RSKs, KVK, AMFU/DAMU, and Agriculture Department sources. Across different states, grassroots agricultural extension personnel are referred to by different names such as RSK (Raitha Samparka Kendra), RBK (Rythu Bharosa Kendra), Krishi Mitra, ATMA staff, etc.*

This indicates that strengthening extension services and improving coordination between institutional and mass media channels can enhance the effectiveness of AAS. At the same time, there is potential to expand the use of digital platforms, especially given the increasing access to mobile phones among farmers.

4. Determinants of Utilisation of AAS

4.1 Methodology

To identify the factors influencing the utilization of AAS, a binary logistic regression model was employed. This method is appropriate as the dependent variable is dichotomous in nature, indicating whether a household uses AAS or not. The logistic regression model estimates the probability that a household utilizes AAS as a function of selected socio-economic, technological, and constraint-related variables. The model is specified as follows:

$$P(Y = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}}$$

where Y represents AAS utilization (1 = use, 0 = non-use), and $X_1, X_2, \ldots, X_n$ represent the independent variables.

Model Specification

$$\text{AAS Use} = f(\text{Socio-economic factors, Primary IR, Awareness, Constraints})$$

The dependent variable in the model is AAS use, a binary outcome coded 1 for household use and 0 for non-use. The independent variables are grouped into three categories: socio-economic variables, including gender, literacy level, landholding class, and the number of household members involved in agriculture; technological and awareness variables, including the type of phone used and awareness of mobile applications; and a constraint variable, namely the total number of challenges faced in accessing AAS. All categorical variables were converted into dummy variables, with one category treated as the reference group. The model was estimated using maximum likelihood estimation.

4.2 Logistic Regression Results:

Table 4.2 Model Summary

Statistic	Value
Number of observations	1896
Pseudo R^2	0.059
Log-likelihood	-1191.9
LR test p-value	< 0.001

As shown in Tables 4.1 and 4.2, the results of the logistic regression analysis indicate that several socio-economic, technological, and irrigation-related factors significantly influence the utilisation of AAS.

Awareness of mobile applications is the most important factor affecting AAS utilisation. The coefficient is positive and highly significant ($p < 0.001$), and the odds ratio indicates that households aware of mobile applications are about 11 times more likely to use AAS compared to those who are not aware. This highlights the crucial role of digital awareness in improving the adoption of advisory services. The number of household members involved in agriculture has a negative and significant effect on AAS use. This suggests that households with more members engaged in farming are less likely to depend on advisory services. One possible explanation is that such households rely more on internal experience and traditional knowledge.

Gender also has a significant effect. Male-headed households are less likely to use AAS compared to the reference category. This indicates differences in information access or decision-making behaviour across gender.

Table 4.1 Logistic Regression Estimates for AAS Utilisation

Variable	Coefficient	Odds Ratio	P-value
Constant	0.490	1.633	0.304
No of HH members involved in agriculture	-0.242	0.785	0.001 ***
Awareness of mobile applications	2.469	11.815	0.000 ***
Total challenges	0.085	1.088	0.028 **
Gender (Male)	-0.529	0.589	0.004 ***
Phone type (Keypad)	-0.488	0.614	0.040 **
Phone type (Smartphone)	-0.199	0.819	0.392
Social category (ST)	-0.488	0.614	0.056
Social Category (OBC, SC)	Not Significant		
Literacy (Read & Write)	0.304	1.356	0.023 **
Literacy (Read only)	1.127	3.086	0.000 ***
Literacy (Cannot read/write)	0.384	1.468	0.030 **
Land class variables	Not Significant		
Irrigation (Rainfed)	-0.544	0.581	0.000***
Irrigation (Surface Water)	0.575	1.778	0.001***

Phone type plays an important role in AAS utilization. Households using keypad phones are significantly less likely to use AAS, indicating limited access to digital information channels. Smartphone use shows a positive tendency but is only weakly significant, suggesting that access alone may not be sufficient without awareness and usage skills. Literacy level is an important determinant of AAS utilization. Farmers who can read and write are more likely to use advisory services, and those who can read but not write show even higher likelihood. This suggests that the ability to understand information plays a key role in adopting AAS.

Irrigation sources have a strong influence on AAS use. Households relying only on rainfed agriculture are significantly less likely to use AAS, indicating higher vulnerability and limited engagement with advisory systems. In contrast, households using surface water irrigation are more likely to use AAS, possibly due to better access to resources and information networks. The total number of challenges faced shows a positive and significant relationship with AAS utilisation, indicating that households experiencing more constraints are more likely to seek advisory support.

Social category shows some variation, with Scheduled Tribe (ST) households being less likely to use AAS, although the effect is only weakly significant. Landholding size does not show a significant effect on AAS utilisation, indicating that farm size is not a key factor influencing the adoption of advisory services in the study area.

5. AAS Impact on Crop Yield

5.1 Major Crops Grown

5.1.1 Western Plateau and Hill Region

Figure 5.1 shows the distribution of crops grown in the Western Hills and Plateau region during 2024–2025. Cotton (265 households) is the most dominant crop, followed by pigeon pea (176 households), wheat (168 households), and chickpea (154 households). Soyabean (64 households) has moderate representation, while other crops such as maize, green gram, black gram, jowar, sugarcane, and corn are grown by very few households.

This pattern indicates a strong dominance of cotton-based cropping systems supported by pulse and rabi crops. It suggests that agrometeorological advisories are likely to have the greatest impact on major crops such as cotton, pigeon pea, wheat, and chickpea, which constitute the primary crops in the region.

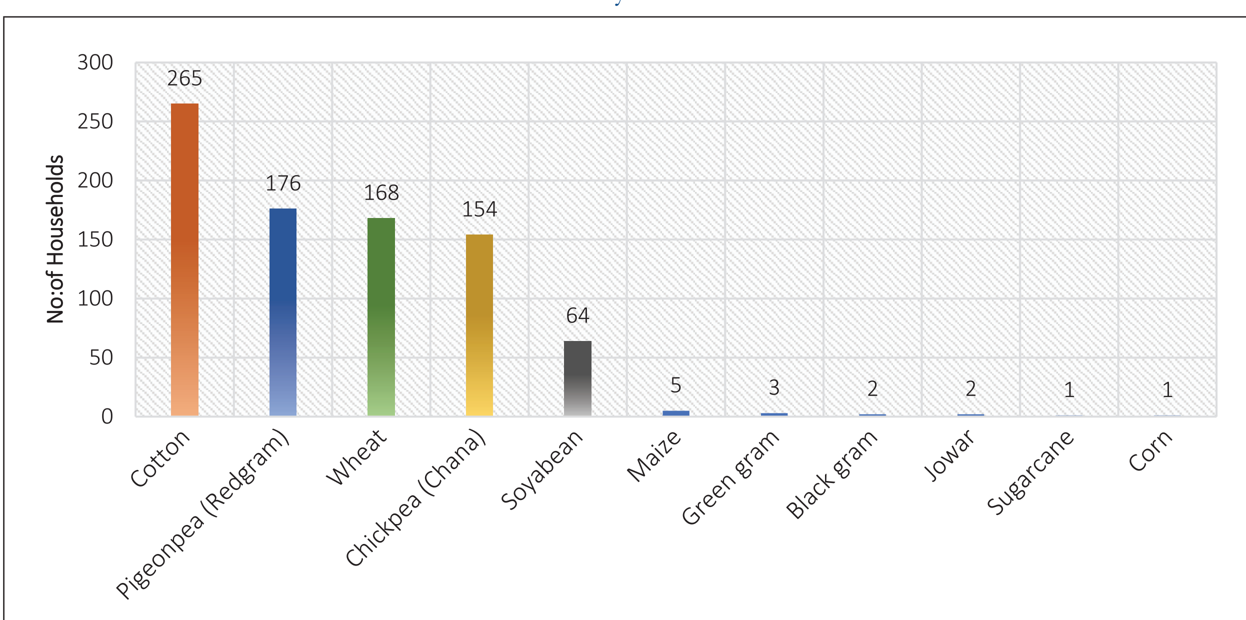
5.1.2 Southern Plateau and Hills Region

Figure 5.2 presents the overall crop distribution in the Southern Hills and Plateau region for the year 2023–2024. Maize (255 farmers) is the most dominant crop, followed by paddy (181 farmers) and groundnut (150 farmers). Redgram (101 farmers) also contributes significantly to the cropping system, while Mustard (75) and Bengal gram (71) are moderately cultivated.

Other crops such as, Black gram, Jowar, and Ragi, are grown by relatively fewer farmers. Minor crops like Castor, Sunflower, Cotton, Green gram, Horse gram, Flaxseed, and Foxtail millet have very limited presence.

This distribution indicates a concentration of cultivation in a few major crops, suggesting that agrometeorological advisories are likely to have the greatest impact on Maize, Paddy, Groundnut, and Redgram-based farming systems in the region.

Figure 5.1 Major Crops Grown in the Western Hills and Plateau Agroclimatic Zone in the year 2024-2025



5.1.3 Gujarat Plains & Hill and Western Dry Region

Figure 5.3 shows the distribution of major crops grown in the Gujarat plains and hills in the agroclimatic zone during 2024–2025. Groundnut (222 farmers) and Wheat (148 farmers) dominate the cropping pattern, followed by Cotton and Pigeon pea (76 farmers each), while Chickpea, Soyabean, and Cumin are cultivated by relatively fewer farmers.

This crop distribution indicates a concentration of farmers in a few major crops, suggesting that agrometeorological advisories are likely to have the greatest impact on Groundnut and Wheat-based farming systems in the study area.

Figure 5.4 presents the distribution of crops grown in the Bikaner region during 2024–2025. Moth bean (148 farmers) and Cluster bean (117 farmers) are the dominant crops, followed by

Figure 5.2 Major Crops Grown in Southern Hills and Plateau agroclimatic Zone in the year 2023-2024

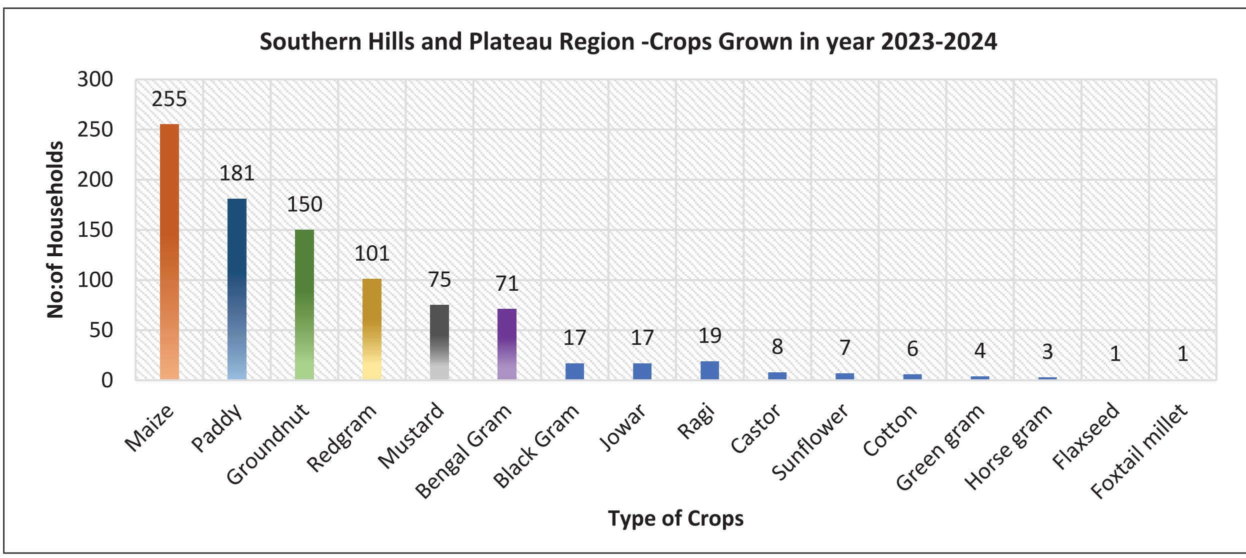


Figure 5.3 Major Crops Grown in Junagadh (Gujarat Plains and Hills) in the year 2024-2025

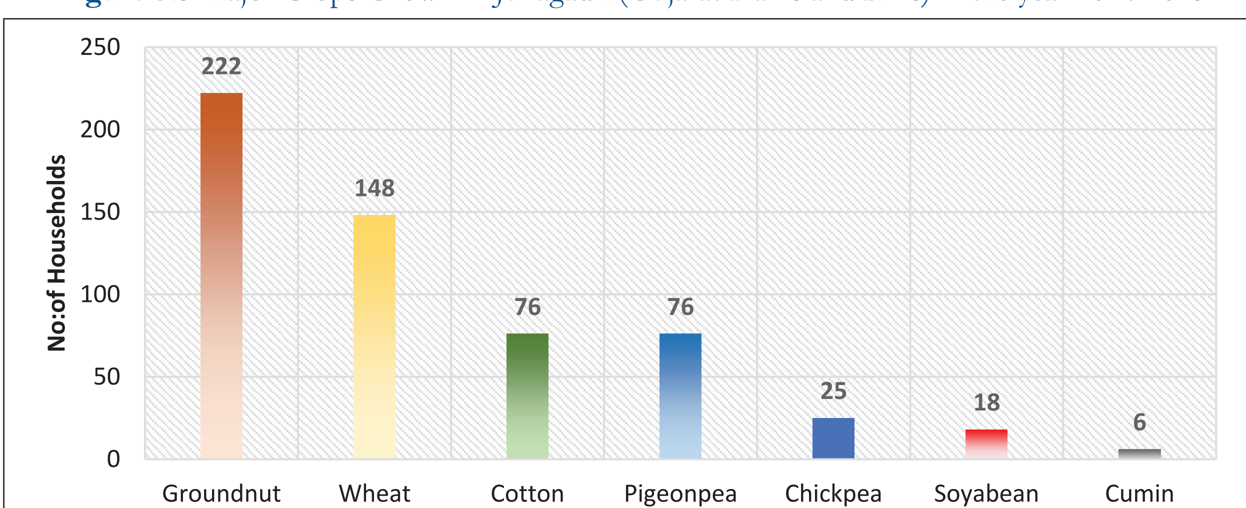
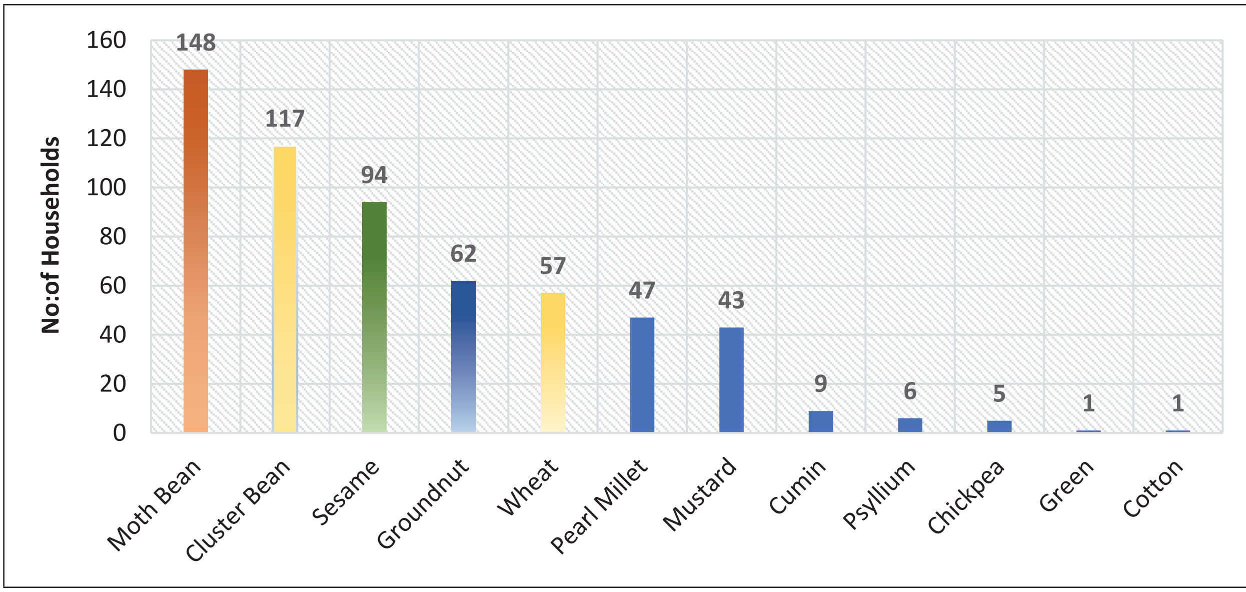


Figure 5.4 Major Crops Grown in Bikaner (Western Dry Region) in the year 2024-2025



sesame (94 farmers) and groundnut (62 farmers). Wheat, Pearl millet, and Mustard are moderately cultivated, while crops like Cumin, Psyllium, Chickpea, Green gram, and Cotton are grown by very few farmers.

This pattern indicates a predominance of drought-tolerant crops in the region, suggesting that agrometeorological advisories can play a crucial role in improving productivity and risk management for these climate-sensitive cropping systems.

5.2 Analytical Methods

5.2.1 Analysis of Variance (ANOVA)

To examine whether significant differences exist in input use between AAS users and non-users across major crops, a one-way Analysis of Variance (ANOVA) was applied. The ANOVA framework tests the null hypothesis that mean input use is equal across groups, against the alternative that at least one group mean differs. The general ANOVA model can be expressed as:

$$Y_{ij} = \mu + \tau_i + \epsilon_{ij}$$

Where Y_{ij} denotes the observation of j^{th} household in the i^{th} group (user or non-user), μ is the overall mean, τ_i is the treatment effect of group i and ϵ_{ij} is the random error term. The F test statistic is used to determine whether the between-group variance significantly exceeds the within-group variance.

5.2.2 Step Wise Multiple Linear Regression (SMLRM)

To assess the confounding factors that can impact crop yields, stepwise multiple linear regression was employed. This approach systematically adds or removes confounding variables based on their statistical contribution to the model fit. The model integrates both continuous and categorical predictors to capture variation in yield outcomes. The continuous predictor variables in the model developed here include the amount of chemical fertilizer applied, manure use, value of plant protection inputs, seed rate, and the extent of crop area. The categorical variables are shown in Table 5.1.

The step-wise procedure was applied to identify the most relevant predictors by iteratively including or excluding variables based on their statistical significance and contribution to

Table 5.1 Independent Categorical variables used in the analysis

Independent categorical variables	Levels	Values	Reference level
Social category	4	General, Other Backward Categories, Scheduled Caste, Scheduled Tribe	OBC
AAS Use	2	User, Non-User	User
Literacy status	4	Can Read and Write, Cannot Read and Write, Can Sign, Can read not Write	Can Read and Write
Gender	2	Male, Female	Male
Irrigation Status	2	Irrigated, Non-Irrigated	Irrigated

model fit. This process ensured a parsimonious specification while avoiding multicollinearity and overfitting. This adjusted regression framework enables the isolation of the independent effect of AAS use on yields, while controlling for socio-economic, demographic, and farm management factors. The final adjusted model was constructed using the subset of variables identified through the stepwise selection process. The general form of the regression model is expressed as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots \ldots \ldots \ldots \ldots \ldots + \beta_k X_{ki} + \varepsilon_i$$

Y_i denotes the crop yield for crop i,

which depends on the k explanatory variables,

X_{1i} ,X_{2i},………X_{ki} and ε_i are the error terms

β_0 is the intercept and β_1 ,β_2……..β_k are the co-efficients

5.2.3 Propensity Score Matching (PSM)

Propensity score matching (PSM) was used to mitigate any selection bias that might result from non-random use of AAS. The propensity score is defined as the conditional probability of assignment to the treatment group given observed covariates (Rosenbaum & Rubin, 1983).

$$p(X_i) = P(T_i = 1|X_i) = \frac{e^{\propto+\beta X_i}}{1+ e^{\propto+\beta X_i}}$$

In the PSM framework, the treatment indicator (T_i) was coded as 1 for Users and 0 for non-users. In this study, the effect of *using* AAS was estimated by comparing users with a matched counterfactual group of non-users who shared similar household and agricultural practices.

A 1:3 nearest-neighbour matching algorithm was used, matching each treated unit (user) with up to three closest control units (non-users) based on propensity scores, in light of the unequal group sizes (more non users than non-users). The Mahalanobis distance metric was added to the matching procedure in order to further improve similarity. By taking into consideration scale differences and correlations between covariates, this multivariate distance measure is used to enhance match quality beyond reliance on propensity scores alone. After matching, balance diagnostics are used to evaluate the reduction in bias. For every covariate, standardized mean differences (SMDs) are computed both before and after matching. A threshold of |SMD| < 0.2 was deemed indicative of an acceptable balance. SMDs below 0.2 suggest that the remaining differences between the treatment and control groups are minimal, indicating that covariates are sufficiently balanced for causal inference, while SMDs below 0.1 are considered optimal (Austin, 2009; Stuart, 2010a).

The causal effect of AAS access was then estimated through the Average Treatment Effect on the Treated (ATT):

$$ATT = E[Y(1) - Y(0)|T = 1]$$

Where Y(1) and Y(0) denote potential yields under treatment (user) and control (non-user) status respectively conditional on T=1.This estimator quantifies the mean yield difference attributable to the use of AAS, relative to the counterfactual outcomes of comparable non-users. The ATT is computed separately for each crop, providing crop-specific estimates of AAS impact.

5.3 Results

5.3.1 Western Plateau and Hills Region

1. Use of AAS

Across all crops, non-users are higher than users, indicating lower adoption of AAS. This trend is especially prominent in Rabi crops like wheat and chickpea, where non-users significantly dominate. Table 5.2 presents the distribution of cultivators by crops grown and AAS use. The table shows that cotton (Kharif) has the highest number of cultivators (265), followed by wheat (174), chickpea (141), and pigeon pea (126). .

Table 5.2 Cultivators distributed by crops grown and usage of AAS

Crop	User	Non-User	Total
Cotton (Kharif)	100	165	265
Pigeon pea (Kharif)	57	69	126
Wheat (Rabi)	37	137	174
Chickpea (Rabi)	34	107	141

2. ANOVA

The results of the ANOVA (Table 5.3) show that different crops experience different effects from advisory services on input use. Cotton showed no discernible variations in the amounts of inputs used. The use of Chemical Fertilizers (CF) and manure exhibit significant to marginal differences in pigeon pea, suggesting a partial impact.

Table 5.3 ANOVA Results for Cotton, Pigeon pea, Wheat, Chickpea

Variable	F	P value
Cotton (Kharif)		
CF	0.27	0.60
Manure	2.76	0.19
Seed Rate	0.14	0.71
PP	0.12	0.72
Pigeon pea(kharif)		
CF	5.93	0.02
Manure	3.81	0.05
Seed Rate	0.24	0.62
PP	0.02	0.90
Wheat (Rabi)		
CF	2.53	0.11
Manure	24.80	<0.001
Seed Rate	0.09	0.76
PP	1.65	0.20
Chickpea (Rabi)		
CF	5.34	0.02
Manure	0.56	0.45
Seed Rate	4.33	0.04
PP	1.43	0.23

As shown in Table 5.3. organic inputs (manure) have a significant impact on the yield of wheat. Fertilizer use and seed rate differ considerably in chickpeas compared to pigeon pea and cotton, indicating better crop management techniques. Overall, the findings demonstrate that advisory services have a crop-specific and selective influence, with greater effects on nutrient management than on other inputs.

3. Stepwise Multiple Linear Regression (SMLRM)

To determine the conditional determinants of yield for the four main crops while taking farm-level covariates and AAS access into consideration, stepwise multiple linear regression was used. AAS use was found to be a statistically significant positive predictor of yield across all models. Tables 5.4 and 5.5 summarize the results of the regression analysis examining the effects of AAS use and key management practices on the yields of major Kharif crops (Cotton, Pigeon pea) and Rabi crops (Wheat and Chickpea). Table 5.4 presents the estimated coefficients and their significance levels, while Table 5.5 provides the corresponding model statistics, including standard errors, R-squared, and adjusted R-squared values.

Table 5.4 Significant Predictors of Crop Yield for Cotton, Pigeon pea, Wheat, Chickpea

Predictors	Coefficient	P Value
Cotton (Kharif)		
AAS User	345.96	<0.0001
CF	0.34	<0.01
Seed Rate	-10.21	<0.05
Crop Area	-7.56	<0.05
Cannot Read and Write	-85.5	<0.05
Pigeon Pea (Kharif)		
AAS User	340.79	<0.0001
Non-Irrigated	-58.21	<0.01
Wheat (Rabi)		
AAS User	94.59	**<0.001**
Crop Area	-4.517	<0.05
CF	-0.020	<0.05
Chickpea (Rabi)		
Non-Irrigated	-311.84	**<0.0001**
Crop Area	-45.20	<0.001
AAS User	162.62	<0.05
CF	1.91	<0.05

Table 5.5 Summary statistics of SMLRM for Cotton, Pigeon pea, Wheat and Chickpea

Statistic	Cotton	Pigeon pea	Wheat	Chickpea
Standard Error	144.43	112.53	72.83	336.5
R- Squared	59.56%	68.84%	28.77%	26.13%
R-Squared (adjusted)	58.45%	67.81%	27.94%	23.39%

The regression results clearly demonstrate seasonal variations in the effects of irrigation and AAS advisory services. AAS use has a significant and steady positive impact on yield in kharif crops (Cotton and Pigeon pea), with large coefficients, suggesting that advisory services are important during the monsoon season when weather variability is high. While irrigation is less common in cotton, it is still crucial for pigeon pea, whose yield is greatly decreased by unirrigated conditions.

Conversely, the positive impact of AAS is evident for rabi crops (wheat and chickpea), but it is comparatively less than for kharif, indicating that advisory benefits are more noticeable in situations with uncertain rainfall. While wheat is grown only in irrigated conditions, chickpeas are grown in non-irrigated conditions also. However, growing chickpeas in unirrigated conditions during the rabi season results in a significant yield decline (Table 5.4). Overall, the findings show that although AAS increases productivity during both seasons, it has a greater effect during kharif, while irrigation is more important for rabi crops.

Significant variations between crops are shown by the model fit statistics. With higher R^2 values (59.56% and 68.84%), the models for kharif crops (cotton and pigeon pea) demonstrate comparatively stronger explanatory power, indicating that a significant amount of yield variability can be explained by the chosen predictors. On the other hand, rabi crops (wheat and chickpea) have lower R^2 values (28.77% and 26.13%), which suggests that the model performance is moderate and that there may be other factors that affect yields during the rabi season. Wheat exhibits comparatively lower error, while chickpeas have the highest standard error, suggesting higher variability and lower prediction accuracy. The models' overall performance for kharif crops is superior to that of rabi crops, suggesting that more complicated or unobserved factors may be responsible for the yield variability in rabi season.

4. **Propensity Score Matching (PSM)**

AAS users apply slightly lower chemical fertilizer and seed rate compared to non-users, while manure application is considerably higher among AAS users. Figure 5.5 shows input use comparison for cotton between AAS users and non-users. Plant protection expenditure is marginally higher for non-users. Overall, the differences in input use between the users and non-users of AAS are small except for manure. This is because the AAS users rely on the advisories to understand the importance (timing & quantity) of manure use while non-users of AAS lack the knowledge required to use the right amount of manure for the crop.

Propensity score matching was carried out using nearest-neighbor matching with Mahalanobis distance at a 1:3 ratio in order to mitigate potential selection bias in AAS adoption and to ensure comparability between treatment (users) and control (non-user) groups. Standard Mean Differences (SMDs) for most covariates were reduced to acceptable thresholds, as indicated by the balance diagnostics, which showed a significant improvement in covariate balance after matching. Table 5.6 presents the SMDs for key covariates before and after PSM for the major Kharif crop, cotton, in the Amaravati-Buldhana region. Table 5.7 compares the means of treated (users) and control (non-users) groups for each

Figure 5.5 Input use across AAs users and Non-Users for Cotton

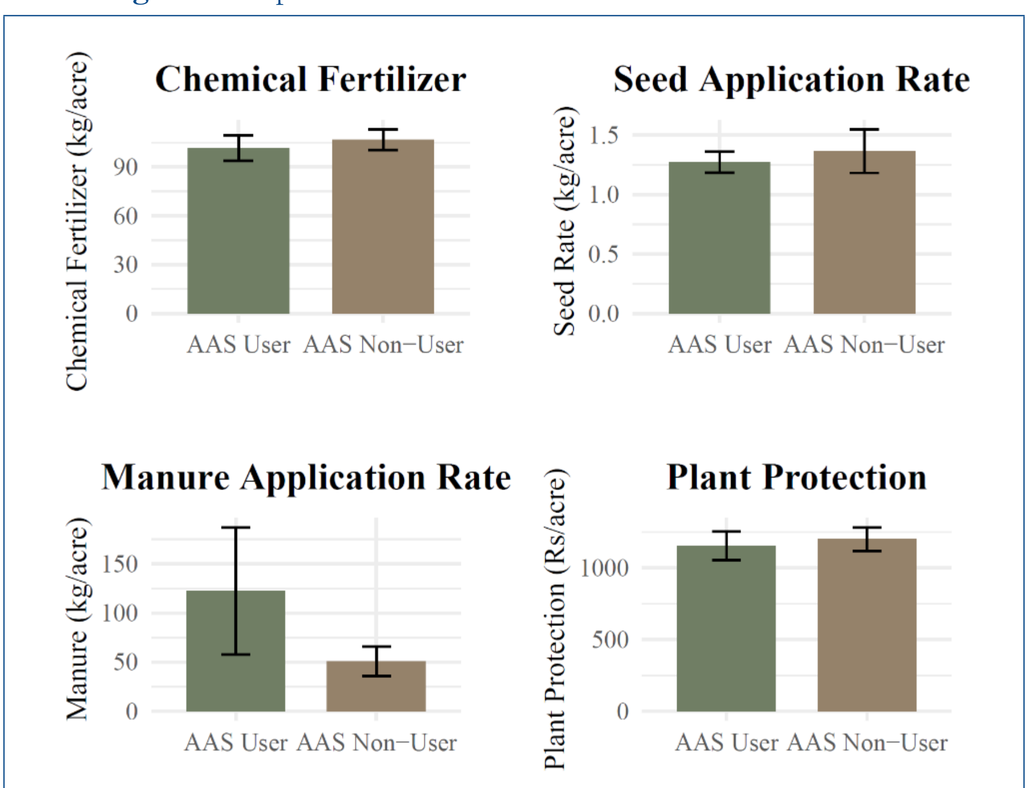


Table 5.6 PSM Summary Table for Cotton

Covariate	Before			After		
	Means Treated	Means Control	Std. Mean Diff.	Means Treated	Means Control	Std. Mean Diff.
Cotton						
CF	101.49	106.77	-0.07	101.49	106.21	-0.06
PP	1153.78	1200.19	-0.05	1153.78	1185.61	-0.03
Seed Rate	1.27	1.37	-0.10	1.27	1.36	-0.10
Crop Area	5.71	5.38	-0.13	5.71	5.31	-0.10

Table 5.7 Results of Yield Analysis for Cotton

No. of Matches	Mean (Treated-User)	Mean (Control-Non-users)	Gap (kg/acre)	Std. Error (kg/acre)	P-value
Cotton					
265	1033.92	692.1	341.824	17.6	<0.001

covariate, illustrating how matching reduced differences and improved balance.

The results suggest that the impact of AAS on cotton yield can be interpreted with high confidence because the treated (AAS users) and control groups were already well balanced in terms of key input variables such as CF, PP, Seed Rate, and Crop Area. Since the standardized mean differences are low both before and after matching, there is minimal selection bias between the groups. This means that any observed differences in yield are less likely to be driven by differences in input use and more likely attributable to the effect of AAS itself. Therefore, the estimated positive impact of AAS on cotton can be considered reliable, indicating that advisory services contribute to improved productivity rather than simply reflecting pre-existing differences between farmers.

The yield analysis results for cotton (Table 5.7) shows that AAS have a substantial and statistically significant effect on yield. There is a significant yield gap of 341.82 kg/acre because the mean yield of AAS users (treated group) is higher than that of non-users (control group). The p-value (<0.001) indicates that the difference is highly statistically significant, and the low standard error (17.6) suggests that this estimate is accurate. This yield advantage can be attributed to the effect of AAS rather than variations in input use or farm characteristics because the matching process ensured good balance between the groups. Overall, the findings demonstrate that AAS advisory services significantly enhance cotton productivity

5.3.2 Southern Plateau and Hills

1. Usage of AAS

Table 5.8 presents the distribution of cultivators based on crops grown and their usage of AAS. The results indicate that AAS adoption is moderate across all the crops, with a relatively balanced distribution between users and non-users, though non-users slightly outnumber users in all cases.

Table 5.8 Cultivators distributed by crops grown and usage of AAS

Crop	User	Non-User	Total
Groundnut (Kharif)	63	76	139
Paddy (Kharif)	61	88	149
Redgram (Kharif)	40	60	100
Maize (Kharif)	47	72	119

2. ANOVA

The impact of advisory services on input use varies among crops, according to the ANOVA results for kharif crops as shown in Table 5.9.

Table 5.9 ANOVA Results for Groundnut, Paddy, Redgram, Maize

Variable	F	P value
Groundnut (Kharif)		
CF	0.01	0.91
Manure	0.01	0.94
Seed Rate	1.26	0.26
PP	0.39	0.53
Paddy (Kharif)		
CF	0.21	0.65
Manure	0.70	0.40
Seed Rate	0.24	0.63
PP	1.04	0.31
Redgram (Kharif)		
CF	15.93	<0.001
Manure	0.28	0.60
Seed Rate	3.13	0.08
PP	2.43	0.12
Maize (Karif)		
CF	22.07	<0.0001
Manure	20.11	<0.001
Seed Rate	0.12	0.73
PP	0.49	0.49

There is no discernible difference in input use between the users and non-users of AAS in the case of groundnut and paddy, as none of the variables (CF, manure, seed rate, and PP) are statistically significant. Redgram shows some influence on planting and nutrient practices, with CF being highly significant and seed rate being marginally significant. While seed rate and PP are unaffected, CF and manure both have a significant impact on nutrient management in maize. Overall, the findings indicate that advisory services have little effect on input usage of farmers cultivating groundnut and paddy, while they have a significant and focused impact on the use of fertilizer and manure in maize cultivation, and their impact is limited to the use of fertilizer only in red gram cultivation.

3. Stepwise Multiple Linear Regression

The kharif crop regression results clearly and consistently demonstrate that AAS advisory services have a positive effect on yield for all crops. Tables 5.10 and 5.11 summarize the results of the regression analysis examining the effects of AAS use and management practices on the yields of four major kharif crops (Groundnut, Paddy, Redgram, and Maize). Table 5.10 presents the estimated coefficients and their significance levels. The corresponding model statistics, including standard errors, R-squared, and adjusted R-squared values are shown in Table 5.11.

The regression results indicate that AAS advisory services lead to a measurable increase in yield across all kharif crops, though the magnitude varies by crop. As shown in Table 5.10, advisory services have a significant (and positive) impact on yields of all four kharif crops with the effect being greatest in paddy, followed by maize, red gram, and groundnut. In paddy, AAS users gain the highest benefit, with an increase of about 334.73 kg/acre, followed by maize (100.53 kg/acre) and red gram (101.47 kg/acre), showing moderate improvements. Groundnut exhibits a relatively smaller but still significant gain of

Table 5.10 Significant Predictors of Crop Yield for Groundnut, Paddy, Redgram, Maize

Predictors	Coefficient	P Value
Groundnut (Kharif)		
AAS User	85.5	<0.0001
Non-Irrigated	-89.57	<0.001
Paddy (Kharif)		
AAS User	334.73	<0.0001
Non-Irrigated	-68.21	<0.001
PP	-0.27	<0.05
Redgram (Kharif)		
AAS User	101.47	<0.001
CF	2.49	<0.05
Manure	0.047	<0.05
Maize (Kharif)		
AAS User	100.53	<0.0001
Manure	0.14	<0.01
Seed Rate	28.77	<0.01

85.5 kg/acre. These results suggest that AAS contributes to improved productivity across crops, with the largest impact observed in paddy. AAS users consistently achieve higher yields compared to non-users, indicating the effectiveness of advisory services in enhancing farm performance. On the other hand, non-irrigated conditions significantly reduce paddy and groundnut yields, underscoring the significance of water availability even during the kharif season.

4. Propensity Score Matching

In paddy, input use is nearly similar between both groups, with non-users slightly higher in seed rate, manure, and plant protection, while fertilizer use is almost equal. Figure 5.6 compares input use between AAS users and non-users for Paddy and Groundnut. In groundnut, AAS users apply slightly higher plant protection and manure, whereas non-users use marginally more fertilizer and seed rate. Overall, differences between AAS users and non-users are minimal in both crops, indicating comparable input use patterns.

The covariate balance results (Table 5.12) indicate that the impact of AAS on yield can be interpreted with reasonable confidence, as matching has improved the comparability between AAS users and non-users. In groundnut, good balance across most variables after matching suggests that the observed yield differences can be largely attributed to AAS rather than pre-existing differences. In paddy, although balance improves, some moderate imbalance remains (especially in PP and manure), implying that while AAS has a positive impact, part of the yield difference may still be influenced by these factors. Overall, the results suggest that the estimated impact of AAS is more reliable in groundnut and moderately reliable in paddy.

The findings (Table 5.13) show that the yields of both crops are positively and statistically significantly affected by AAS advisory services. AAS use increase groundnut productivity by roughly 91.68 kg/acre, indicating a moderate improvement. While the yield gain of 337.79 kg/acre suggests that the impact of AAS usage is

Table 5.11 Summary statistics of SMLRM for Groundnut, Paddy, Redgram, Maize

Statistic	Groundnut	Paddy	Redgram	Maize
Standard Error	81.11	262.34	67.68	149.72
R- Squared	45.36%	35.63%	67.25%	34.33%
R-Squared (adjusted)	43.73%	34.29%	65.87%	31.42%

Figure 5.6 Input use across AAs users and non-users for Groundnut and Paddy

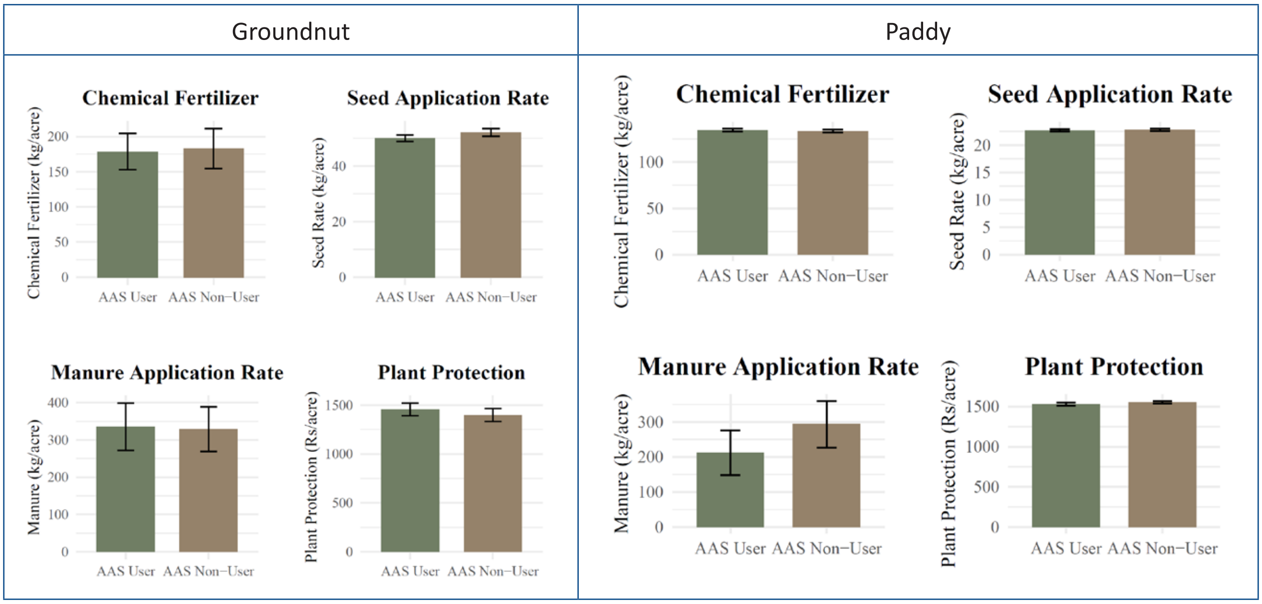


Table 5.12 PSM Summary Table for Groundnut and Paddy

	Before			After		
Covariate	**Means Treated**	**Means Control**	**Std. Mean Diff.**	**Means Treated**	**Means Control**	**Std. Mean Diff.**
Groundnut						
CF	178.61	182.91	-0.021	178.61	176.79	0.009
PP	1457.65	1398.94	0.113	1457.65	1379.43	0.151
Seed Rate	50.00	52.10	-0.226	50.00	51.02	-0.110
Crop Area	4.40	3.95	0.157	4.40	3.76	0.103
Manure	335.17	328.94	0.012	335.17	310.44	0.011
Paddy						
CF	134.50	133.42	0.076	134.50	132.45	0.046
PP	1530.67	1556.40	-0.157	1530.67	1575.12	-0.122
Seed Rate	22.68	22.83	-0.088	22.68	22.89	-0.067
Crop Area	3.26	3.21	0.066	3.26	3.18	0.043
Manure	212.55	293.46	-0.161	212.55	307.64	-0.140

Table 5.13 Results of Yield Analysis for Groundnut & Paddy

No. of Matches	Mean (Treated-User)	Mean (Control-Non-User)	Gap (kg/acre)	Std. Error (kg/acre)	P-value
Groundnut					
139	866.86	775.18	91.68	17.6	<0.001
Paddy					
149	3241.79	2904.79	337.79	42.76	<0.001

much higher in paddy compared to groundnut, the percentage increase in yields in both cases are in the range of 11.5% – 11.8%, suggesting that advisory services are useful in both crops. The reliability of these differences is confirmed by the low standard errors and highly significant p-values (<0.001).

5.3.3. Gujarat Plateau & Western Dry Region

1. Usage of AAS

The results show that AAS adoption is moderate across both crops, with a relatively balanced distribution between users and non-users, though non-users slightly outnumber users in both cases. Table 5.14 presents the distribution of cultivators based on crops grown and their usage of AAS.

Table 5.14 Cultivators distributed by crops grown and usage of AAS

Crop	User	Non-User	Total
Groundnut (Kharif)	96	109	205
Wheat (Rabi)	70	77	147

2. ANOVA

The ANOVA results (Table 5.15) for both the Kharif and Rabi seasons show that the influence of advisory services on input use appears to be limited across crops. Since none of the variables, chemical fertilizers (CF), manure, seed rate, and plant protection (PP), are statistically significant, there is no appreciable difference in input use between AAS users and non-users for groundnut (Kharif).

Table 5.15 Anova Results for Groundnut and Wheat

Variable	F	P value
Groundnut (Kharif)		
CF	0.17	0.68
Manure	0.34	0.56
Seed Rate	0.35	0.56
PP	0.14	0.71
Wheat (Rabi)		
CF	0.44	0.51
Manure	0.01	0.94
Seed Rate	0.38	0.54
PP	0.66	0.42

Similarly, all input variables in wheat (Rabi) continue to be non-significant, indicating that advisory services do not result in quantifiable variations in the individual use of these inputs among farmer groups. The ANOVA results show that advisory services have little direct impact on how much input is used in wheat and groundnuts. This implies that AAS may not be involved in changing input levels in these crops.

3. Stepwise Multiple Linear Regression

Advisory services have a strong and significant positive impact on crop productivity, according to the SMLRM results. Tables 5.16 and 5.17 summarize the results of the regression analysis examining the effects of AAS use and key management practices on the yields of major Kharif crops (groundnut) and Rabi crop(wheat). Table 5.16 presents the estimated coefficients and their significance levels, while Table 5.17 provides the corresponding model statistics, including standard errors, R-squared, and adjusted R-squared values.

Table 5.16 Significant Predictors of Crop Yield for Groundnut and Wheat

Predictors	Coefficient	P Value
Groundnut (Kharif)		
AAS User	143.24	<0.0001
Wheat (Rabi)		
AAS User	273.09	<0.0001
Crop Area	-16.43	<0.001
Manure	-0.01	<0.05
PP	0.01	<0.05

Table 5.17 Summary statistics of SMLRM for Groundnut and Wheat

Statistic	Groundnut	Wheat
Standard Error	2121.053	145.88
R- Squared	26.53	49.55
R-Squared (adjusted)	25.80	47.76%

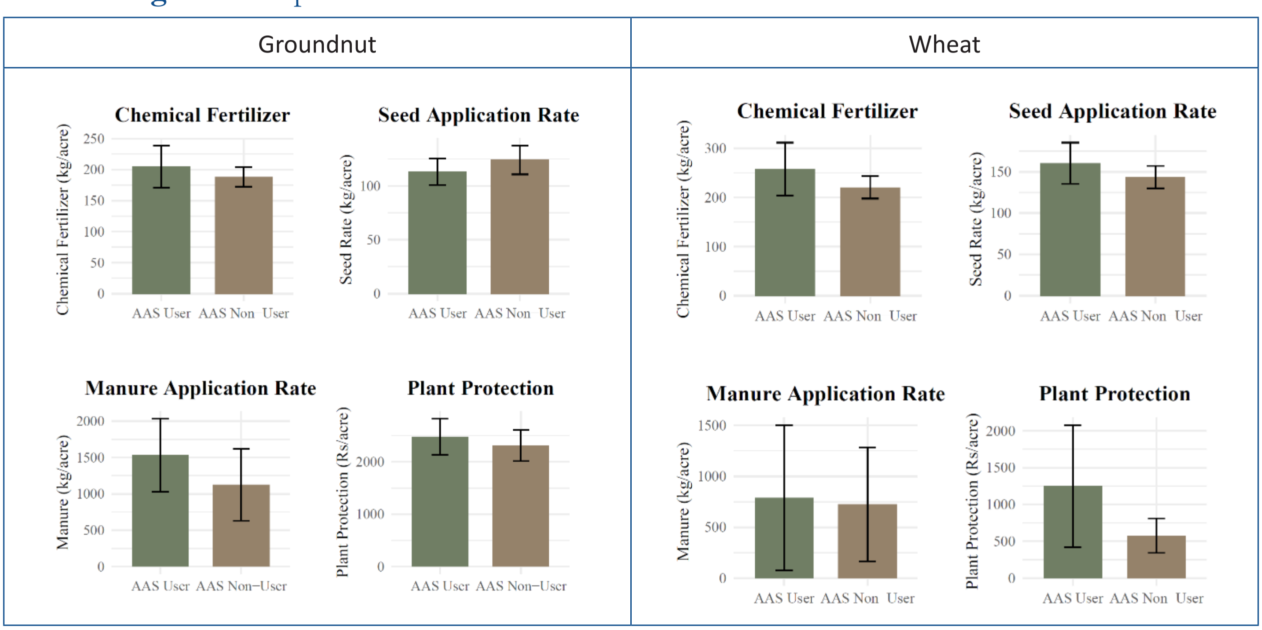
Groundnut (Kharif) and wheat (Rabi) yields increased by 143.24 and 273.09 units, respectively, for AAS users, both of which are highly significant.

4.Propensity Score Matching

In wheat, AAS users apply higher levels of all inputs, especially plant protection. The input use between AAS users and non-users for wheat and groundnut are compared in Figure 5.7. In groundnut, AAS users use more fertilizer, manure, and plant protection, while non-users apply slightly higher seed rates. AAS users show greater input intensity in both crops.

The PSM results (Table 5.18) indicate that

Figure 5.7 Input use across AAS users and Non-Users for Groundnut and Wheat



covariate balance between AAS users and non-users is largely acceptable, with most Standardized Mean Differences below 0.2. This suggests that the two groups are sufficiently comparable, and the observed differences in crop yield can be reliably attributed to the impact of AAS. Although crop area in wheat shows a slight residual imbalance (SMD ≈ 0.21), it remains close to the acceptable threshold and does not substantially affect the overall validity of the results.

According to the PSM results (Table 5.18), AAS use significantly increases crop yields. There was a significant yield gain (Table 5.19) of 146.52 kg/acre ($p < 0.001$) for groundnut (Kharif), with AAS users achieving a higher mean yield (909.44 kg/acre) compared to non-users (762.92 kg/acre).

Similarly, in wheat (Rabi), AAS users recorded a mean yield of 1016.36 kg/acre, a significant gain of 260.72 kg/acre ($p < 0.001$) compared with non-users' yield of 755.63 kg/acre. This shows that AAS significantly increases crop productivity.

Table 5.18 PSM Summary for Groundnut and Wheat

	Before			After		
Covariate	Means Treated	Means Control	Std. Mean Diff.	Means Treated	Means Control	Std. Mean Diff.
Groundnut (Kharif)						
CF	204.78	189.89	0.044	204.78	181.23	0.040
PP	2,481.41	2,325.068	0.045	2,481.41	2,127.78	0.103
Seed Rate	113.22	124.80	-0.095	113.22	124.37	-0.092
Crop Area	3.28	3.10	0.054	3.28	2.87	0.12
Manure	1,533.61	1,010.98	0.105	1,533.61	966.74	0.11
Wheat (Rabi)						
CF	258.01	220.41	0.085	258.01	219.58	0.083
PP	1,248.47	574.75	0.107	1,248.47	503.65	0.097
Seed Rate	160.57	143.61	0.084	160.57	143.70	0.081
Crop Area	3.61	2.64	0.233	3.61	2.57	0.208
Manure	789.28	724.57	0.015	789.28	455.19	0.010

Table 5.19 Results of Yield Analysis for Groundnut and Wheat

No. of Matches	Mean (Treated-User)	Mean (Control-Non-User)	Gap (kg/acre)	Std. Error (kg/acre)	P-value
Groundnut (Kharif)					
204	909.44	762.92	146.52	17.12	<0.001
Wheat (Rabi)					
145	1016.36	755.63	260.72	25.25	<0.001

Conclusions

The study highlights that while access to AAS is relatively high, their actual utilisation remains limited, indicating a significant access–utilisation gap. Farmers with direct access to AAS are substantially more likely to use advisory information; however, more than half of the farmers surveyed still do not integrate AAS into their decision-making. Our study indicates that, socio-economic and technological factors, particularly awareness of mobile applications, literacy, and phone type, play a crucial role in influencing utilisation.

The findings also show that farmers tend to prioritise short-term, weather-related advisories over long-term risk management practices. Key challenges, such as a lack of awareness, timing issues, and communication barriers, further constrain effective use. The survey results show that the advisory ecosystem is moderately developed, and improving awareness, communication, and relevance of advisories is essential to enhance their adoption and impact among farmers.

The study also examined the effects of AAS across three agroclimatic regions using survey data, regression analysis, ANOVA, and PSM. The results indicate moderate adoption levels, with non-users slightly exceeding users across the three regions studied till date. Despite variations in farming systems, key crops such as cotton, groundnut, maize, and paddy remain predominant.

The positive effects of AAS on crop yields are substantial in all regions, even though its strongest effects are observed in the Kharif season because weather variability is higher. The combined evidence from ANOVA, regression, and propensity score matching indicates that AAS positively influence crop yields, even though the pathways of that influence may differ across crops. The similarity between the results from two different statistical approaches indicates the robustness of the results (Challinor et al., 2014; Sultan et al., 2019)

Specifically, farmers cultivating cotton, paddy, maize, and wheat (which are the major crops cultivated in the regions studied) achieve higher yields in all these crops by using the AAS. Analysis of the PSM results confirm that these yield gains can be attributed to AAS usage rather than differences in the socio-economic conditions of the farmers or input use practices. The AAS effect is crop specific - meaning that AAS are more effective in crops that are sensitive to climate such as cotton, paddy and maize, and therefore more effective in the kharif season.

Further, the results of ANOVA indicate the minimal changes in the input utilization between users and non-users of AAS. However, the results of regression analysis and PSM analysis prove that AAS is more efficient in terms of input usage and farm management, which contribute to higher productivity. Irrigation is a supplementary factor since it is essential to Rabi crops, but not as significant in Kharif. This implies that the benefit of AAS in these crops may arise less from applied input quantities and more from improved timing and management — for instance, optimal sowing dates, irrigation scheduling, and pest/disease management as suggested in earlier work (Naseeruddin et al., 2025; C. Singh et al., 2018). The results highlight the importance of precision and timing of advisories rather than input intensity in irrigated and traditionally input-intensive systems such as paddy. Earlier studies also emphasized that climate services reinforce farmers' willingness to invest in inputs with more reliable weather forecasts that contribute to reduced production risks (Mittal & Hariharan, 2018; Partey et al., 2018). Altogether, AAS helps to improve the productivity of agriculture by enabling better decision-making and increase the resilience of farmers in the context of climatic uncertainty. Nevertheless, it is important to enhance its adoption and dissemination mechanisms in order to maximize its potential.

From a policy perspective, these results highlight the benefits of institutionalized multi-channel AAS delivery mechanisms through various schemes such as GKMS and the recently launched PMS in supporting climate resilience. Yet, the heterogeneity that is observed in the impact suggests that advisories should be tailored by crop type and production systems. Strengthening the timely delivery, accuracy, and accessibility of AAS has significant potential to further improve its contribution to climate adaptation and food security (Aggarwal et al., 2018; Ray et al., 2019).

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Appendix 1: Agromet Advisory Weather Bulletin issued jointly by S.D. Agricultural University & India Meteorological Department

GRAMIN KRISHI MAUSAM SEWA
AGROMET ADVISORY WEATHER BULLETIN

DEPARTMENT OF AGRIL. METEOROLOGY
C.P. COLLEGE OF AGRICULTURE
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(Issued jointly by S. D. Agricultural University & India Meteorological Department)

Bulletin No. 63 **Date** 30-12-2025

BANASKANTHA DISTRICT

Past weather summary for the preceding week

Sr. No.	Weather Parameter	Value
1	Rainfall (mm)	--
2	Highest Temperature (°C)	28.8
3	Lowest Temperature (°C)	12.8
4	Range of Relative Humidity (%)	31 - 84
5	Range of Wind Speed (kmph)	00 - 4
6	Range of Cloud Cover (okta)	0 - 2

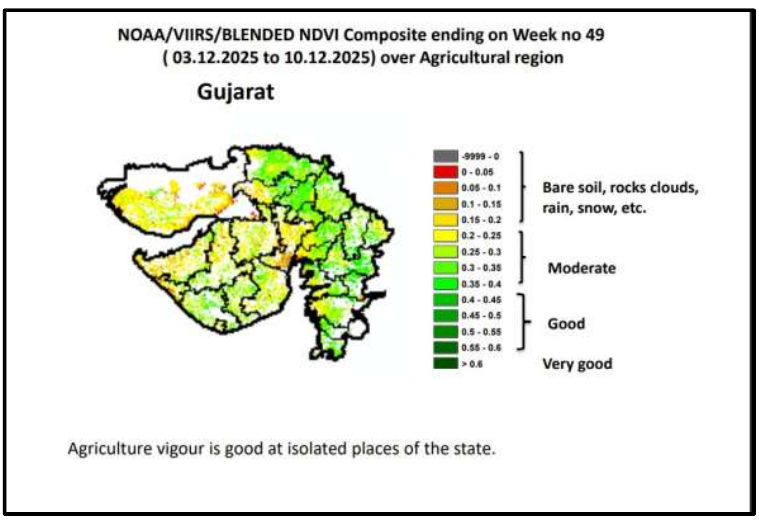
Weather Forecast (31-12-2025 to 04-01-2026)

Weather Parameters	Day-1 (31-12-2025)	Day-2 (01-01-2026)	Day-3 (02-01-2026)	Day-4 (03-01-2026)	Day-5 (04-01-2026)
Rainfall (mm)	0	5	0	0	0
Max. Temperature (°C)	29	28	28	28	28
Min Temperature (°C)	14	14	12	12	13
Max. Relative humidity (%)	85	85	90	85	80
Min. Relative humidity (%)	40	60	35	40	40
Wind Speed (Kmph)	6	5	6	13	14
Wind direction (Degree)	76	326	340	33	33
Cloud cover (Okta)	3	5	3	3	3

Weather Summary	As per the Indian Meteorological Department (IMD) weather forecast for the next five days, • The weather forecast for the upcoming five days indicates that the weather in the district is expected to be mostly dry, with partly cloudy sky. And, there is chance of light rain on date 1^{st} January 2026 within the isolated places of district. • Maximum and minimum temperatures will be in between 28-29°C and 12-14°C respectively. • Relative humidity will be in between 40-90 % during the period. • North-easterly wind will be blow with the speed of 05-14 km/hr.
General advice	➢ If an infestation of sucking-type (Aphid) pests is observed, control measures can be taken by mixing any one of the following pesticides in 10 liters of water and spraying thoroughly to ensure proper coverage of the plants: 15 ml of Dimethoate, 10 ml of Imidacloprid, 4 grams of Thiamethoxam, or 10 grams of Diafenthiuron. ➢ Apply irrigation to the standing crop as per the crop requirement. ➢ Carryout weeding and inter-culturing operations in different crops. ➢ Take the appropriate precautions for controlling the pest and disease during cloudy weather condition. ➢ Apply recommended split dose of nitrogen after irrigation. Irrigate the crops during evening hours under cold and dry weather condition to minimize cold effect. ➢ Farmers are advised to download different weather-based application *viz;* Meghdoot, Damini, Mausam from IOS and google store for acquiring weather-based information.

Agricultural Advisory			
Major Crops	**Stage**	**Disease/Pest Management**	**Advisory**
Mustard	Flowering	-	➢ Apply recommended split dose of 25 kg Nitrogen/ha. (For this apply 54 kg Urea/ha or Ammonium sulphate 125 kg/ha.) at 35 days. ➢ Apply light irrigation during evening hours to minimize cold effect.
Chickpea/Gram	Vegetative	-	➢ Carry out interculturing, hoeing and weeding in sown crop at vapsa condition. ➢ If white fungus is found at 15-20 DAS in crop, apply trichoderma powder 2.5 kg/ha. ➢ Apply light irrigation during evening hours to minimize cold effect.
Wheat	Crown root initiation	-	➢ Apply 130 kg urea/ha at crown root initiation stage (21 DAS). Irrigate crop at CRI stage without stress.
Cumin	Vegetative	-	➢ Keep crop weed free by doing weedng at 25 to 30 and 50 to 60 days after sowing. ➢ Application of mencozeb (35 gm/10 lit) and 25 ml concentrated desi soap solution at 10 days interval for effective control of blight disease.
Fennel	Growth & Flowering	-	➢ Farmers are advised to carry out weeding, interculturing, earthing up operations in kharif crop. ➢ Apply split dose of Nitrogen @ 22.5 kg/h after 30 DAS or transplanting.
Potato	Vegetative	-	➢ Carry out hand weeding operation and apply irrigation as per need. ➢ There are chances of blight in the crop. To control this disease spray Mencozeb 0.2% @ 30 gram plus 25 ml of concentrated desi soap solution in 10 litre of water. Spray next doses at the interval of 10 days.
Lucerne	Vegetative	-	➢ Lucerne crop required more water so, apply irrigation at short interval.
Castor	**Spike initiation**	White fly/ Semi-looper and Castor hairy caterpillar	➢ At 110 to 115 days after sowing, main spike turns yellow which get ready for harvest. For faster growth of sider spikes it is necessary to timely harvesting of main spike. ➢ Apply light irrigation during evening hours to minimize cold effect.
Hybrid/ B.T. cotton	**Flowering and ball formation, maturity**	Pinkball worm/ Leaf Spot/Root rot	➢ Apply irrigation to the standing crop as per the crop requirement. ➢ Picking should be made of mature boll regularly. ➢ For the control of pink bollworm, spray 10ml deltamethrin OR trizophos in 10 litres of water OR spray 100 gm Beauveria bassiana powder and 20 ml prophenophos mix in 10 liters of water. ➢ Install pink bollworm pheromone traps. ➢ At the initiation of the root rot disease drench copper Oxychloride (50% WP) 0.2 % solution (40g/ 10 litre water) around stem of the plants in rainless period.
Custard apple/Pomegranate	**Fruit maturity**	-	➢ Mature fruit should be harvest followed by cleaning and grading. ➢ Mechanical support to young fruit plants and vegetables to prevent the crops from lodging due to winds. ➢ Apply light irrigation during evening hours.
Vegetable crops		White fly	➢ Commence the harvesting of vegetables once the

	Fruits/ Vegetative stage/ Maturity		crop reaches maturity. ➢ Ensure weed-free cultivation of vegetable crops, maintain consistent irrigation, and regularly send graded produce to the market. ➢ Spray Diafenthiuron 10 ml in 10 liter of water three times at 15 days interval for control ➢ of white fly. ➢ To prevent soil borne disease drenching of nursery bed should be done with Mencozeb 75 % WP @ 2.5 gm/ litre of water after 15 DAS. ➢ Spray Quinalphos 20 ml in 10 liters of water for control of leaf miner.
			➢ For control of thrips, spray Profenofos 20 ml with 500 m of 5 % neem seed extract or neem seed oil 50 mlin 10 litres of water. In case of severe attack, spray Spinosad or Spinetoram 3 ml per 10 liters of water.
Cattle	➢ Feed animals with a mixture of green grass + hay + minerals + dry feed. ➢ Newly borne calves should protect from cold condition. ➢ All milch animals should be kept in cattle sheds during night. ➢ Udder of milking animals must be properly clean with zinc oxide or boric powder. ➢ **Vaccination:** It is recommended to vaccinate cattle against **Haemorrhagic Septicaemia**.		



Nodal Officer (GKMS)
AMFU, Dantiwada (Gujarat)

Appendix 2: Field Work Photographs

Sarfapur Village, Chandurbazar Tehsil, Amravati, Maharashtra

Kolori Village, Khamgaon Tehsil, Buldhana Maharashtra

Kapustalani Village, Amravati Tehsil, Amravati Maharashtra

Bhalegaon Village, Malkapur Tehsil, Maharashtra

Makhiyala Village, Junagadh Tehsil, Junagadh, Gujarat

Mendapara Village, Beshan Tehsil, Junagadh, Gujarat

Nandarkhi Village, Vanthali Tehsil, Junagadh, Gujarat

Juna Deesa Village, Deesa Tehsil, Banaskantha, Gujarat

Chakphooldesar Village, Lunkarnasar Tehsil, Bikaner, Rajasthan

Bhamstar Village, Nokha Tehsil & Udairamsar Village, Bikaner Tehsil, Bikaner, Rajasthan

Chakphooldesar Village, Lunkarnasar Tehsil, Bikaner, Rajasthan

Sewad bari, Sikar Tehsil, Sikar, Rajasthan

Redipalli Village, Anantapuramu Tehsil, Anantapuramu, Andhra Pradesh

Yaganthipalli Village, Banaganpally Tehsil, Nandyala, Andhra Pradesh

Kalugotla Village, Koilkuntala Tehsil, Nandyala, Andhra Pradesh

Babburu Village, Hiriyur Tehsil & Ingaladalu Village, Chitradurga Tehsil, Chitradurga, Karnataka

Document Control Sheet

1	**Document No. and Date**	:	NIAS/NSE/EECP/U/RR/02/2026 dt. 22 April 2026
2	**Title**	:	Impact Assessment of Weather and Climate Services of the India Meteorological Department (Agrometeorological Advisory Services)
3	**Type of Document**	:	Research Report
4	**No. of Pages and Figures**	:	vi + 45 Pages, 12 Figures & 33 Tables
5	**No. of References**	:	29 References
6	**Authors**	:	Rakesh Nannewar, Anjaly Unnikrishnan, Charumathi Kasiraju, Kruthika, S., Tejal Kanitkar, and R. Srikanth
7	**Originating School**	:	Natural Sciences and Engineering
8	**Programme**	:	Energy, Environment, and Climate Change Programme
9	**Collaboration**	:	NA
10	**Sponsoring Agency**	:	Ministry of Earth Sciences, Government of India

11 **Abstract** :

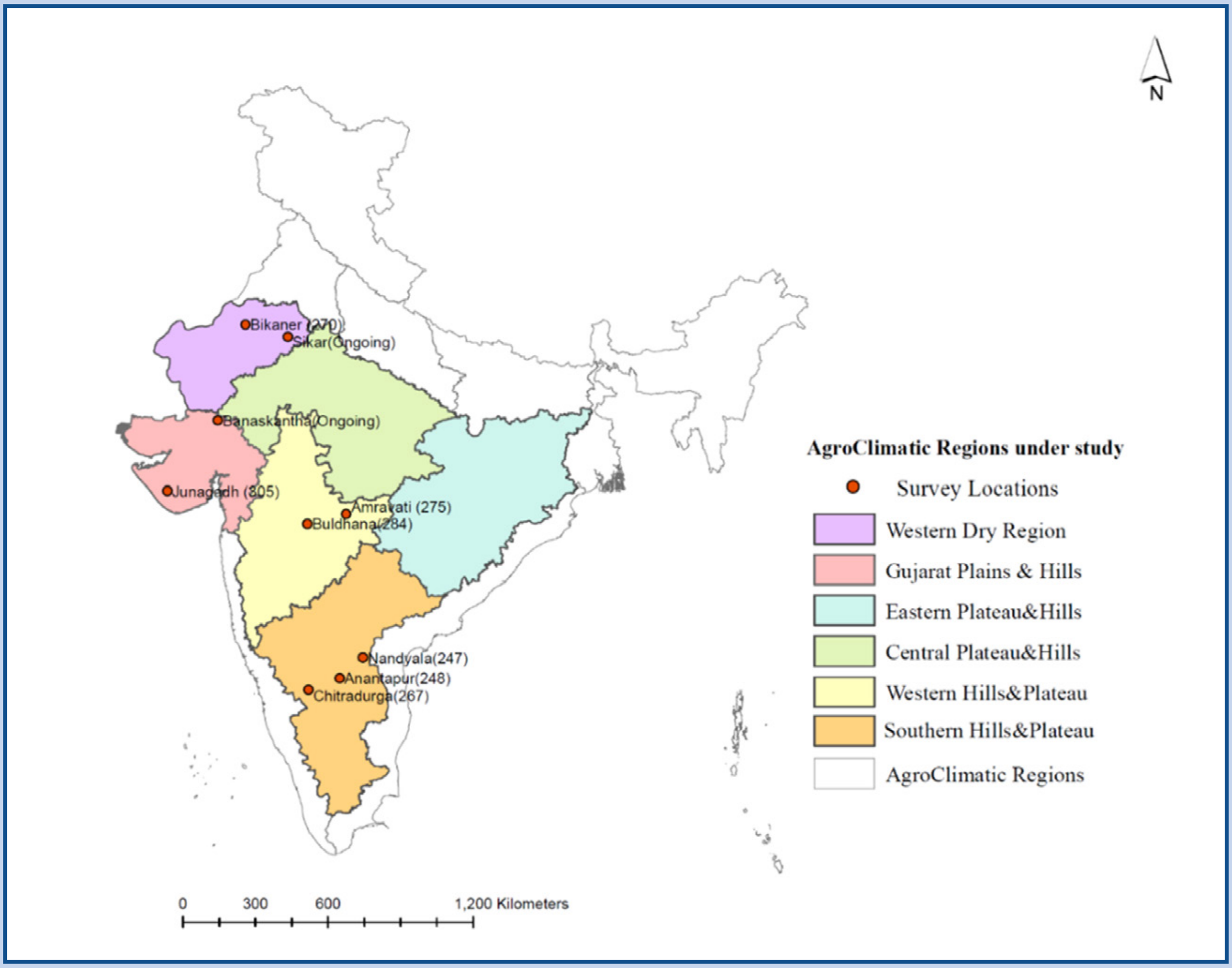
The agricultural sector in the semi-arid regions of India is susceptible to increasing rainfall fluctuations and extreme temperature events. Agro-Meteorological Advisory Services (AAS) provide localized, weather-based recommendations which aid timely decision making related to farm practices such as sowing, input use, irrigation, pest management, among others. This study evaluates the impact of AAS on the yields of major crops cultivated in three Agroclimatic Zones (Southern hills & plateau, Western hills & plateau and Gujarat plains & hills). The study reports findings from 1896 household surveys in 21 villages across these three Agroclimatic zones. Data was collected for the agricultural years, 2023–24 and 2024-25.

Our analysis indicates that access to Agrometeorological Advisory Services (AAS) is relatively high, with nearly 84% of households having access; however, utilization remains moderate (around 45%), highlighting a significant access–utilization gap. Despite this, farmers with access are substantially more likely to use advisory services. AAS utilization has a significant positive impact on crop yields across regions, ranging from 11.6% in the case of paddy to 49.4% in cotton cultivation. This confirms earlier findings that the utilization of AAS contributes to improved agricultural productivity and decision-making in specific crops and regions, with stronger effects observed during the Kharif season. However, enhancing the effective dissemination of AAS is critical to maximizing its impact.

12 **Keywords** :

AAS Utilization, Agroclimatic zones, Agriculture productivity, Crop Yield, Household Survey

13 **Security Classification** : Unrestricted



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