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What Is the Role of Agro-Met Information Services in Farmer Decision-Making? Uptake and Decision-Making Context among Farmers within Three Case Study Villages in Maharashtra, India

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Abstract: Scientific studies of climate and meteorology focusing on India show significant increase in the variability and frequency of extreme precipitation events. The increased variability of weather patterns places a huge constraint on farmer's ability to make strategic agricultural practice decisions. In response, public and private agro-met information services disseminate agro-met information to farmers. Yet, studies still show that there are constraints related to access and understanding of the information. An agro-met information service is based on scientific input from meteorology coupled with agricultural information and this information package is disseminated to farmers. Based on a study in three villages in Maharashtra, India, we show that the relevance of agro-met information differs depending on the decision-making situation. Several factors play an important role in farmer's agricultural decision-making. The usefulness of the agro-met information from farmer perspectives depends on the access, salience, and credibility of the information. Some subscribers complained about the credibility and the salience of services, while others painted a more positive picture of the service, arguing that there was value in receiving such information. The subscribers mainly valued agro-met information for the ability to undertake precautionary actions. We found that agricultural decision-making was discussed in different arenas; these arenas represented possibilities for farmers to contextualize agro-met information and thereby translate information to timely and appropriate actions suited to the specific local context.

Keywords: agro-met information; farmer decision-making; agro-met service providers; climate change

1. Introduction

Climate change and variability of weather conditions in India have increased in the last decades, causing reductions in agricultural yields and increased vulnerability, both locally and regionally [1,2]. Irrespective of production systems, climate-related events such as droughts, floods, hailstorms, frost, high winds, and extreme temperatures have negative impacts on local and national food security [3,4]. Scientific studies of climate and meteorology in India show significant increases in the variability and frequency of extreme precipitation events, and variability is projected to increase further [5]. This variability affects rainfall patterns of the monsoon in the semi-arid tropics, where approximately 80% of the total annual rainfall falls within three or four months of the year [6]. Hence, when the monsoon is delayed or comes earlier than usual, agriculture is adversely affected [2]. The increased variability of weather patterns places a huge constraint on farmer's ability to make tactical and strategic agricultural practice decisions. Currently, farmers in Maharashtra express frustration about the unpredictability of weather events and the traditional systems, which are no longer to be trusted in the changed and unpredictable environment [7,8].

As a response to this increased variability in weather and climate, public and private institutions have been developing skills in modeling ocean-atmosphere circulations [9,10]. Such modelling skills, combined with improved telecommunications, have enabled distribution of weather forecasts and climate variability worldwide [6]. In India, the government has worked to develop seasonal forecasts and weather service information for farmers in rural areas since 1988 [11]. The Agromet Division of India Meteorological Department (IMD, New Delhi, India) have, through the Gramin Krishi Mausam Seva (GKMS) program, generated weather forecasts and agro-met advisories, which are disseminated as SMSs through the portal "mKisan" for registered users. Under the Public Private Partnership mode, IMD in collaboration with private service providers like Reuter Market Light, IFFCO Kisan (IK), NOKIA-HCL, Handygo, Mahindra Samriddhi, and CAB International disseminate agro-met information. This is done through the use of channels such as SMSs, voice messages, and app-based portals to farmer communities. An agro-met information service is based on scientific input from meteorology coupled with agricultural information; this information package is disseminated to farmers with the purpose "to enable the farmers in planning of farming operations to minimize damage of crops under adverse weather conditions" [12]. It may refer to weather forecasts only, agro-met advisories, market information, or a combination. It can be distributed to farmers for free or it may be a paid service. The agro-met services reportedly reach more than ten million Indian farmers, which have enabled increased yields and reduced loss due to unexpected weather variability [12,13]. Yet, studies still show that there are constraints related to such issues as access, understanding, and capacity to respond to such information [14–16]. Analysis of data on subscription of agro-met services shows that user groups typically include "progressive farmers" (Progressive farmer: typically, wealthier, and better educated relative to the majority of farmers, and use newer farmer technologies and practices. They may provide advice and information on farming practices to other farmers, while use and awareness among marginal farmers, including women farmers, are low [11].

This study investigates the uptake of agro-met information services and addresses farmer agricultural decision-making context in three villages in Maharashtra, India. The Meteorological Department (IMD) informed in an interview that, in India farmers who subscribe to agro-met information services, receive weather forecasts, and agro-met advices, some also receive market information, while climate information and seasonal information are mainly provided by newspapers and television. We define uptake of agro-met information services as when a subscriber explains that agro-met information, referring to either weather forecast, agro-met advices, or market information, is considered in agricultural decision-making situations.

Decision-making ability is defined as the correct interpretation of accurate information at the right time [10], but the complexity of the different decision-making factors makes the task of "correct interpretation" difficult. This places a high demand on the capacity of agro-met service providers to present and communicate weather forecast and agro-met advices in a way which facilitates for access and uptake [17]. Access can be understood as the ability to interpret and translate agro-met information into doable actions suited to the local context. The usefulness of agro-met information from farmer perspectives, however, depends on the salience and the credibility of the information [11,18]. We understand salience as tailoring crop-specific, location-specific agro-met advisories in various stages of crop growth stage. Credibility refers to farmers' perception of agro-met information to be accurate, and that the information received is mostly correct. Regarding access to agro-met information, this may be limited by the teledensity situation in many rural areas. The mobile phone is the main channel for distributing agro-met information to farmers, however, usage in rural India is still rather low and Internet access varies. As of June 2016, the rural tele-density was 51% compared to a national tele-density level of 81% [19]. Farmer practices reflect community contextual factors, such as Internet availability and the presence or non-presence of different agro-met information services. Such factors influence access to agro-met information and the diversity of arenas, where discussion of agro-met information can occur. Learning through discussion and collective engagement with others is referred to as social learning [20]; an approach which has been presented as important to overcome challenges of access, translation, and interpretation. It has been argued that social learning facilitates for interpretation of information in the local context [14].

Decision-making never occurs in isolation and a decision is mostly taken considering a number of factors in combination. There is a range of factors having an impact on farmer agricultural decision-making, including agricultural subsidies, the market situation (local, national and or international), rainfall patterns, social relations, history, cultural traditions, and the adaptive capacity of individual farmers [21]. Furthermore, traditions and social relation context factors places a strong influence on people's decision-making [22,23]. Formerly in India, in the state of Maharashtra, agricultural practices were mostly influenced by the traditional Panchangam, the Hindu Almanac that has been in practice for 5000 years [24,25]. The Date's Almanac Pvt Ltd produces the annual calendar where information about meteorological predictions are provided. Meteorological predictions are generalized over a region, based on astrological phenomena like planet-star conjunctions, transits, etc. Although some of these understandings are loosely based on climate phenomena, scholars argue that agricultural producers' successful adaptation to future climate variability and change depend upon them increasing their use of climate and agro-met information services [15,26]. However, for the tailoring of both climate and agro-met information services, there is a need to have close understanding of farmer decision-making rationality [27–29], that is, focusing on which factors are seen as important in farmer agricultural decision-making, in which situation and why.

In this paper, we present empirical findings on the presence of agro-met information services, the subscription and uptake of such services by farmers in three rural villages within the state of Maharashtra, India. Agro-met information is one information factor among several, which farmers have available for consideration when making operational decisions such as sowing, spraying and irrigation scheduling, harvesting, and more. We present the main information sources for decision-making; the factors identified by farmers as relevant before making a decision regarding an agricultural practice, and the degree that farmers consider these factors. With reference to these decision-making factors, we discuss farmer decision-making rationality and their perception of salience and credibility of information sources. We show that uptake of agro-met information differs with reference to the different decision-making situations, and that access to arenas where discussion of best decision-making practices occurs are increasingly important.

2. Materials and Methods

2.1. Study Area

The study was undertaken in Maharashtra, the second most populous state in India, with over 112 million inhabitants and covering 307,713 km^2. Maharashtra includes the state capital Mumbai and is considered a relatively wealthy and developed state. Agriculture is the main occupation in the state, contributing to 14.3% of the country's national income [30]. Nearly 58% of the population live in rural areas, depending largely on agriculture for their livelihood. The climate is tropical monsoon with large variation in rainfall, between 400–6000 mm across the state. The western part of the state receives relatively more rainfall than the eastern part, as the eastern part is located in the rain-shadow of the Sahyadrian Mountainous. The monsoon starts with drizzling rains in June, and the maximum number of rainy days occurs in July. This period is usually followed by a dry spell in August. In September, the rains again occur in drizzles, but with occasional heavy rains. Thunderstorms with hail may occur in March and April. April and May are the hottest months in the district, and maximum temperature during these months often rises above 36 °C. Maharashtra has traditionally remained a drought-prone state, and almost 70% of the state lies in a semi-arid region, rendering it vulnerable to water scarcity. The state is prone to climate change and predictions are that monsoon rainfall will be more unpredictable, erratic, and have a later onset [4]. The main agricultural cropping seasons are the Kharif (July–October) and Rabi seasons (October–March). Rabi (winter) crops are typically irrigated cash crops such as onions, tomatoes, but also jowar, wheat, and gram (non-irrigated) are rabi crops. Kharif (monsoon) crops, paddy, and bari are not irrigated by many farmers, and are thus more sensitive to variations in rainfall. Families generally work together on farms. The typical division of labor refers to men being responsible for machinery work, while women are responsible for weeding. Some women informed in interviews that they had responsibility for detecting signs of disease on crops. The gender dimension of harvesting depended on the crop being harvested. Several informants explained that in the evenings, they talked to their wife about that day's experiences and work needed on the farm the following day. Women of medium to lower socio-economic status daily went to the field, and a general perception by both men and women was that women undertook a substantial part of the agricultural work in the fields (See also, [31,32]).

2.2. The Agro-Met Service Providers in the Study Area

The four main providers of agriculture-relevant information services present in the study area are IMD GKMS (public, New Delhi, India), IFFCO Kisan (public-private, New Delhi, India), RML Agtech Pvt Ltd (private, Mumbai, India), and Watershed Organization Trust (WOTR) (non-profit, Pune, India). These services providers disseminate weather forecast information and agro-met advices, and some providers, only RML and IFFCO KISAN also disseminate market information. The mandate is to support farmers, agriculturists, planners and other users in agricultural decision making and practices by providing advanced information. The services include agricultural relevant advisories on diverse areas like soil management, weather forecasts, weather based agro-advisory, crop management, market rates, dairy and animal husbandry. We use the term, agro-met information to refer to all the services provided. The various delivery mechanisms include SMS, push messages, voice messages and mobile apps, meetings and trainings, local knowledge centers, and microphone announcements in villages.

Among the services, the IMD GKMS (Indian Meteorological Department Gramin Krishi Mausam Seva) formerly known as AAS (Agrometeorological Advisory Service) is the largest public service actor. It is based on cooperation between the IMD (headquarter in New Delhi, with six regional and one in every state capital meteorological centers in India) and State Agricultural Universities (SAUs) which exist around the country. For disseminating forecasts and building forecast based agricultural advisories, GKMS works with 130 Agro-Meteorological Field Units (AMFUs), distributed across the agro-climatic zones of India. Based on forecasts provided by IMD, the AMFUs prepare weather-based agro-advisory bulletins in consultation with a team of agricultural scientists [13]. IMD launched a portal in 2013 called "mKisan" to disseminate SMSs for registered users. Its subscription is free, so the only cost is related to having a mobile phone. GKMS is, according to sources [33], providing agromet advisories to more than 18 million farmers in the country, of which 5 million are in Maharashtra alone.

IFFCO KISAN (IFFCO KISAN Sanchar Limited, New Delhi, India) is a private-public service launched in 2007 and developed and promoted by the Indian Farmers Fertilizer Cooperative Limited (IFFCO, New Delhi, India) as a joint venture with the telecom company Bharti Airtel and the non-banking finance company Star Global Resources Ltd., New Delhi, India). IFFCO KISAN offers a helpline, an agriculture mobile app for android and iOS users, and telecom products of Airtel, all of which are made available to villages through cooperative societies [34]. A green SIM card of Airtel provides regular network services and avoice message platform, though limited to prepaid users only. The voice messages cover diverse information areas, such as weather forecast, market rates, soil management, crop protection, horticulture, employment opportunities, and government schemes. IFFCO Kisan covers 19 states in India including Maharashtra and has reached over 3.6 million users in India, with 1.8 million users active to date [35].

RML (RML Agtech Pvt Ltd, Mumbai, India), formerly known as "Reuters Market Light", is a private provider delivering weather, agricultural, and market information to farmers. RML offers both a feature/simple phone version where farmers subscribe to information for a subscription fee. RML also has an app "myRML" launched in 2014 for android, which is currently free to download and use. The SMS-based service aims to provide farmers with personalized agricultural information in the local language. RML provides information and advice on weather forecasts, crop management, market data, health, and education. The service covers over 450 crops and crop varieties, and more than 1300 markets and 6200 weather locations across 50,000 villages and 18 states of India [36]. It was estimated that in 2015, RML had 1.5 million registered users [37].

WOTR (Watershed Organisation Trust, Pune, India), a non-profit organisation established in India in 1993, has developed a weather-based and crop-specific information system AGRIMATE that uses phone messages and awareness campaigns for helping farmers in Maharashtra. The approach has been piloted since 2012 in some regions of western and central Maharashtra by WOTR in collaboration with the India Meteorological Department (IMD, Pune, India), the Central Research Institute for Dryland Agriculture (CRIDA, Hyderabad, India), the State Agriculture University, Mahatma Phule Krishi Vidyapeeth (MPKV, in Rahuri, Maharashtra, India). Agro-advisories are broadcasted to farmers through SMS in the local language at least twice a week to farmers based on the local weather data and the particular crop growth stage [25]. Farmers pay a fee to subscribe to information through SMS relating to a specific crop or set of crops. Around 12,000 farmers in 70 villages in Maharashtra have received this service.

2.3. The Study Villages

The study was conducted in the three villages, Vadaj, Parinche, and Pargaon in Maharashtra during 2015–2016. Vadaj is located in the Junnar block in the north-western part of the Pune district, Parinche in the Purandar block in the southern part of Pune district, and Pargaon is located to the east in the Shrigonda block within the Ahmadnagar district (Figure 1). The villages are located at about the same altitude, 552–619 amsl [38]. Climate characteristics among the villages are similar and are characterized by intermediate rainfall, between 500 mm and 600 mm per year [39]. Access to irrigation is important in the three villages and although most farmers irrigate their fields, levels of access varies extensively among villages and with economic wealth (Table 1). Some farmers use drip irrigation and some irrigate from wells. In general, the poor are landless and typically marginal workers. According to the Agricultural Census Database (NIC, 2011), Vadaj had 6.6%, Pargaon 0.8%, and Parinche, 8.4% marginal workers. Literacy rates in all the three villages were around 80%.

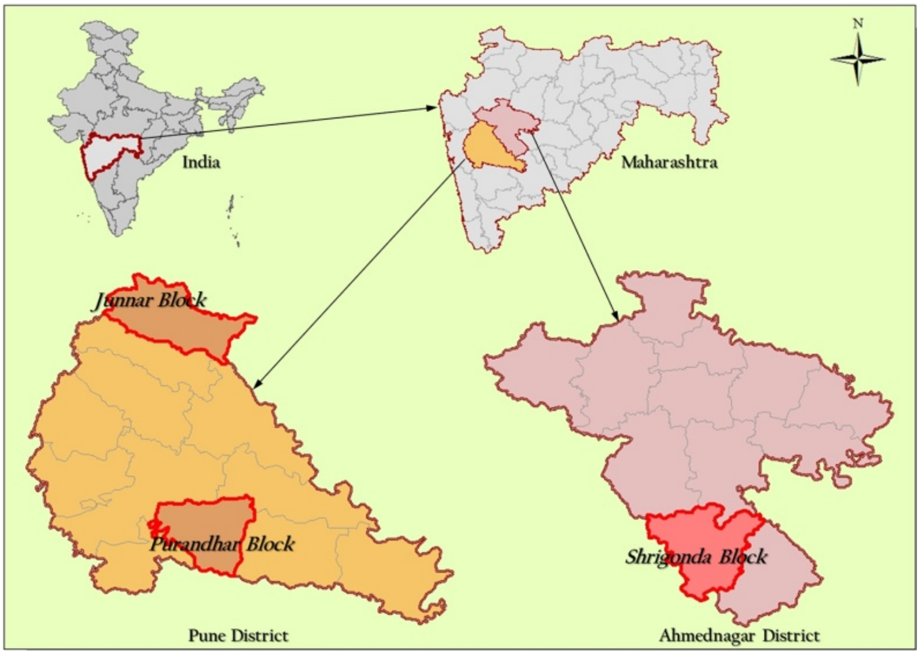

Figure 1. Map showing the location of the study villages in the state of Maharashtra, in India.

Table 1. Characteristics of the three study villages, Vadaj, Parinche, and Pargaon [40].

District, Block	Village	Area (ha)	Altitude	No Inhabit	No. Households	Literacy Rate	Employment %	Area Irrigated by Source (ha)	Type of Irrigation	Main Cash Crops	Presence of Agro-Met Service
Junnar block in Pune district	Vadaj	789.3	619 masl	2753	566	94	Main 93 Marginal 7 Cultivators 54 Agri-labourers 29 Household industry 2 Others 16	147.1	Drip irrigation, well, river	pomogranates, onion	Mkisan, WOTR, RML
Purandhar block in Pune district	Parinche	3265	585 masl	3093	721	75	Main 92 Marginal 8 Cultivators 65 Agri-labourers 16 Household industry 2 Others 17	1085.8	Drip irrigation, well, river	onion, tomato	Mkisan, RML
Shrigonda block in Ahmadnagar district	Pargaon	1116.5	552 masl	4419	889	69	Main 99 Marginal 0.8 Cultivators 57 Agri-labourers 32 Household industry 0 Others 11	338.6	Drip irrigation, well, river	pomegranates, grapes	Mkisan, IFFCO KISAN

2.4. Approach

The districts of Pune and Ahmednagar in Maharashtra, India were selected for this study as the area is subject to major climate and extreme weather risks and related agricultural challenges, e.g., drought, hail storms, floods, heat, and pests. Furthermore, Maharashtra has a long history of developing advanced drought and climate risk response systems, reflecting an important farm sector which is mainly rainfed. Key public and private agro-met service providers are present in the state and provide services there.

2.4.1. Data

The study involved combining several different methods in order to study uptake of agro-met information and the decision-making context. This study did not aim to be representative for all farmers, but rather to provide an exploratory insight into uptake of agro-met information in different decision-making situations. Some bias may have been introduced in our study, as the participants in the survey were in parts based on the service providers' overview of subscribers.

Data triangulation, i.e., use of multiple methods or data sources to develop a comprehensive understanding [41], was completed by gathering data from semi-structured interviews, focus group discussions, observations, and a survey of farmers regarding the uptake of agro-met information services. The villages Vadaj, Parinche, and Pargaon, in the two districts Ahmednagar and Pune, were selected using a purposive sampling method, considering villages where farming is a major activity, and where agro-met information services were available. Since agro-met information services are still in the early stages, it was decided to focus on villages where presence was "secured", rather than including low-subscription villages. These locations were identified by informal discussions with the service provider staff. Nevertheless, despite the purposive sampling strategy, several of the local people approached in the villages were still unaware of the existence of the services.

2.4.2. The Research Process and Sampling Strategy

The study involved four stages, where each was characterized by specific set of methods, carried out in the period of May 2015–July 2016. Most of the data collection occurred within three dedicated field visits to the case villages.

Stage 1: Collection of baseline data in the overall study area, its population, and land use patterns, including also a review of agro-met service providers present in Pune and Ahmednagar districts, were undertaken in this initial stage. Desk-top studies, discussions with key stakeholders (including representatives of government agencies, non-government organizations, and climate service providers), and a visit to one of the villages in June 2015 were carried out. The study design specified selection of case villages, which represented a mixed presence of public and private agro-met public providers. Stage 1 provided for the final selection of case study villages, and an understanding of the overall context in which farmers in the three villages operate and make agricultural decisions.

Stage 2: Key informant interviews, focus groups among the farmers, and observational visits in the three villages were conducted during November 2015. Informants were both men and women, subscribers and non-subscribers. It was ensured to include both genders in interviews and focus group discussions to get a picture of the context in which the farmers make decisions and manage their agricultural resources. In total, 30 interviews and 9 focus group discussions were conducted. The qualitative data formed the basis for developing the survey and further analysis.

Stage 3: A targeted and confined farmer survey was conducted during May–June 2016, with 17 questions to subscribing farmers in the three villages. It was decided in the survey to include only farmers who subscribed to agro-met services to investigate how much such information formed the basis of their farming decisions. Quantitative data was collected from 89 respondents using a structured questionnaire that was coded. The survey also allowed for some key narratives to be captured. After a quality check, 86 of the responses were used; some responses were left out of the analysis, as the affiliated respondents belonged to other villages. Identification of subscribers of agro-met services was facilitated for by the panchayat in the study villages and by the service providers. Each of the three villages was visited three times during the survey and data collection was done with help of four research assistants fluent in the local language. Each farmer was asked the survey questions and the investigators filled in the form. Each session lasted around 1 h. The investigators verbally obtained informed consent prior to the start of the survey. The investigators also made photo documentation, with consent, of relevant aspects, e.g., SMS messages. The filling of the form started with an open question related to each of the farming situations, e.g., what are the main factors having an impact on when to sow? On what information do you base your decision? The informant would first answer freely; then, the investigator inquired more into the different factors. The survey was done for the main cash crop of the farmer.

Stage 4: Data analysis was carried out on the collected material and results, including qualitative and simple quantitative analysis on the survey data. In terms of decision-making and uptake level of information, it was noted how much farmers relied on or based their decisions on certain information, or knowledge—both in terms of types and sources in the specific farming decision-making situations.

3. Results and Discussion

3.1. Presence of Agro-Met Service Providers in the Study Villages

Information from focus group discussions and semi-structured interviews revealed that agro-met services had been available for subscription in the three villages for the last four to five years, since around 2011. However, the private and public-private agro-met service providers, WOTR, IFFCO KISAN, and RML, started to offer agro-met information in only the last two to four years. It was quite common among the respondents to subscribe to more than one service, and often to both a public and a private service, while in no household did more than one member subscribe. The historic availability of private agro-met services differed among villages, and some agro-met service agents explained in interviews that the service was still in a startup phase. Based on data for each case village provided by the agro-met services providers and supplied by members in the village panchayat (referring to a decentralized administration system), only about four percent of the households subscribed to agro-met information services. There is, however, some uncertainty around this number, as the number of individuals who download apps to receive agro-met information was not available. However, apps are available only for smart phones—hence, for a considerable number of rural farmers, this was not a possibility [42]. Only the agro-met service providers, IFFCO KISAN and RML had developed apps for presenting agro-met information. There was also less account of subscribers of the public service, mKisan. Yet, there are reasons for supporting the conclusion that relatively few farmers in these villages subscribed to agro-met information services. Information about subscription of private and the public private information services was provided by the agents of the service providers working in the villages. The agents were responsible for the number of subscribers in their respective villages, and for gaining new subscribers and for ensuring that farmers continue to subscribe. Information about subscribers to the public portal, Mkisan, was provided for by the Panchayat, as the leader of the "Savings group" (a "aving group" is a type of self-help group typical in India) were perceived to have the responsibility for encouraging farmers to subscribe. Regarding subscribers to this public service, several subscribers informed that they were enlisted through membership in the Savings group. Some subscribers of the public service informed that they did not know how they became enlisted; these respondents explained that agro-met information suddenly appeared on their phone. In focus group discussions, it was informed that one could get enlisted by visiting the local Agricultural Department Office, running under the Government of Maharashtra. The public portal was not presented by any agents in the villages, though, irregularly, the KVK officer would visit the village. Some informants reported that KVK officers occasionally visited the village to inform about agro-met information and that they would visit as a response to an inquiry. However, others were not aware of such visits. A few respondents had learned about how to subscribe to agro-met information services from people outside the village.

Looking beyond those who subscribe to agro-met information services, non-subscriber informants revealed in interviews and focus group discussions that they knew little about agro-met information services. They had not been approached by agents of agro-met information services and they had not received invitation to attend meetings. Reasons for not subscribing, however, varied among informants. Some non-subscribing informants explained that they were not interested in subscribing. Others did not find it necessary, as they received this information already, e.g., "my cousin subscribes and I receive information from him every morning". Some farmers emphasized that in the case of extreme weather patterns, there are no actions to mitigate such extreme weather incidences in any case. (See, [43,44]). Others argued that agro-met advices with reference to pests was available only for certain crops, and not the crop in their fields, reducing their interest in subscribing.

3.2. The Subscribers in the Study Villages

The surveyed subscribers referred to 86 households in total. They were farmers dependent on horticulture and grain cultivation, all were land owners, and all were men. No women subscribed, though several explained that they discussed agro-met information sent to their husband's mobile. The subscribers were generally fairly well-educated with a mean number of 12 years of education reported. The survey indicated some difference regarding the presence of agro-met service providers and also characteristics of subscribers in the three villages. Except for in Parinche village, most of the respondents were relatively new subscribers. In Parinche, 67%, in Vadaj 46%, and in Pargaon, 25% of the respondents reported to having subscribed for more than a year. The presence of public and private service providers differed among the villages. In Parinche village, the respondents mainly subscribed to the public service mKisan; in Vadaj village, respondents subscribed to WOTR and some to mKisan; in Pargaon, the respondents subscribed to IFFCO KISAN and RML (Table 2). There was also a difference in the characteristics of the subscribers among the villages. Subscribers in Parinche had a higher mean age, 49 years, compared to the two other villages: 39 years in Vadaj and 28 years in Pargaon. For all villages, respondent's age varied between 18 and 71 years. The majority of the surveyed subscribers irrigated their land, but access differed among the villages. In Parinche village, 41% had drip and sprinkler irrigation, compared to 77 and 88% in Pargaon and Vadaj villages, respectively. Another difference referred to the possession of smart phones, in Parinche 40%, in Vadaj 74%, and in Pargaon, 88% had a smart phone (Table 2). Those who did not have a smart phone had a simple hand set (feature phone), including only a small window for viewing messages. Simple hand phones allowed, according to the informants, for the display of about 60 characters in the local language (Marathi).

Table 2. The table shows the number of subscribers and also presence of agro-met service providers in the three study villages. Some subscribers received services from more than one provider.

Village	No of Subscribing Respondents	Phone Types %		WhatsApp Users	No of Subscribers to Services			
		Simple	Smart		MKisan	IFFCO KISAN	WOTR	RML
Parinche	35	66	34	4	34	1		
Vadaj	24	29	71	11	12		15	4 (2 had app)
Pargaon	27	7	93	15	6	17 (3 had app)		6 (2 had app)
Total	86	37	63	30	52	18	15	10

Another source for receiving agro-met information was through membership in a "WhatsApp group". WhatsApp Messenger is a free Internet-based messaging app available for smartphones that is used by over 1 billion people in over 180 countries. The app is not an agro-met service, it is a channel for communication, for sending blessings and greetings, and it is used by farmers for sharing agro-met information and discussing agricultural practices and market information. Among the survey respondents (all men), the highest number of WhatsApp users lived in Pargaon, while the lowest number was found in Parinche (Table 2). Also, a few women in the villages were members of WhatsApp groups. The women informed in interviews and in focus group discussions that they did not post messages themselves, but that they read the agricultural discussions. It was informed that the number of WhatsApp group members varied between 15–100, and that "all" young people with smart phones were members. Some also stated that, "since I am in a WhatsApp group, I don't need to subscribe to a service as I receive all the agro-met information I need on this platform". Again, others said, "We check WhatsApp 100 times a day, such as when waiting for something". Among the survey respondents, 38% of those having a smart phone were members of a WhatsApp group. Those using WhatsApp would typically be in a group of farmers cultivating the same crop—to exemplify, there existed "pomegranate groups", "grape groups", and "tomato groups". Information sharing and discussions typically involved pictures of crops followed by questions on pests. Also, some regional experts were members of WhatsApp groups and groups often extended village borders. This arena for discussing agricultural practices was mentioned by several as an increasingly important channel for receiving information. Another app downloaded by some to access weather forecasts, was Accuweather, a free app which presents weather forecasts for many parts of the world (See, [44]).

3.3. Agricultural Decision-Making Situations and Rationality of the Different Decision-Making Factors

Eight decision-making situations related to agricultural practices were identified based on a literature review and interviews in the study villages; (1) when to till the fields, (2) when to sow, (3) when to add fertilizers, (4) when to provide pesticides, (5) when to irrigate, (6) when to harvest, (7) when to sell, and (8) choice of crops. The farmer informants did not agree that when to till the soil was a decision-making situation—hence, this decision-making situation was dropped from the survey. For each of these situations, farmers must decide what is the timely and appropriate action. According to the farmers, a decision was based on 15 situation-related factors (Table 3). The survey showed that in all the agricultural decision-making situations, the agro-met subscribers surveyed considered more than one factor. Some factors were considered by a higher number of farmers and in more situations than others. Table 3 shows the degree that farmers considered the identified factors in their farming decision-making. More farmers considered personal competence, hence, this factor ranked first with regard to relevant input for agricultural decision-making. The factor "interaction with others" ranked second, while information from agro-met service providers ranked third by farmers as relevant information for agricultural decision-making. The other factors, TV, radio, newspapers, agricultural extension officers, shop keepers, were less distinct with regard to farmer perception of relevance. With reference to these three decision-making factors, we discuss agricultural decision-making rationality and farmer's perception of salience and credibility of the information.

Table 3. The percentage of surveyed subscribers considering the identified factors when in a specified agricultural decision-making situation.

Situations/Factors	Sow	Provide Fertilizers	Provide Pesticides	Irrigation	Harvest	Sell	Choice of Crops
Personal competence	69%	65%	55%	56%	59%	36%	30%
Level of water in well	50%	2%	1%	41%	3%	0	16%
Interactions with others in village	33%	42%	47%	13%	20%	22%	19%
WhatsApp Group	12%	5%	5%	5%	7%	8%	1%
Information from agricultural officers	13%	27%	29%	6%	1%	1%	1%
Newspapers, TV, Radio	17%	23%	24%	10%	12%	23%	6%
Weather forecast services	48%	19%	29%	13%	29%	6%	5%
Agro-met advice services	12%	37%	50%	6%	8%	1%	2%
Market info from Agro-met service	3%	1%	1%	1%	17%	23%	9%
Market info from other sources	7%	2%	2%	0	30%	45%	12%

The factor "personal competence", which refers to each farmer's knowledge of agricultural practices and the agricultural calendar (learned through many years of own experience), was marked in the survey by a high number of respondents for all decision-making situations (Table 3). Sowing (69%), irrigating (56%), and providing fertilizer (65%) were decision-making situations where traditional practices had high impact. Farmers argued that the main decision factor for when to sow was personal competence used to assess availability of necessary irrigation water, in combination with knowledge of the crop calendar. Farmers would explain that, "if there is not enough water in the well, I delay sowing". After sowing, if the soil is dry, it was explained, "then we irrigate, we don't wait for rain according to forecast information". The survey results were supported by information from interviews and focus group discussions across the three villages, where farmers argued that personal competence was the most important factor guiding agricultural decision-making. Two types of arguments were put forward by the informants to explain their focus on own competence as the main guide in their decision-making. One argument referred to the self-confidence of the respondent as an expert; as exemplified by a quote from a farmer in one of the villages: "I have been farming for 40 years, I know the soil and the agricultural calendar very well, no need for anything else". The other argument referred to lack of trust in other types of information and in particular farmers referred to the uncertainty of weather forecasts provided by the agro-met service providers (See also, [44]). According to the informants, weather forecasts were 60–80% wrong generally. The uncertainty in particular referred to rainfall and the amount of rainfall. The farmers explained that: "When forecasts are correct, we all know that it will rain, while when there is uncertainty, forecasts are mostly wrong".

The unpredictability of climate and weather makes the farmer unprepared for the upcoming growing season challenging long-term planning. Hence, farmers make decisions based on their understanding of local climatic patterns, finding their own understanding more credible and also specifically tailored to their farm rather than other sources of information. This situation which is typical for many farmer societies leads to conservative farming strategies, as farmers perceive their own insights to be the most rational strategy [10,45]. However, it is also a strategy which may sacrifice productivity in order to reduce the risk of loss [46].

Farmers across villages considered the factor "interactions with others in the village" as important for most decision-making situations. Farmers explained that they discussed agricultural practices with other farmers in various arenas. The most informal type of interaction referred to the discussion of agricultural practices before/after prayers at the village temple, as has been a custom for centuries in India. A more formal interaction referred to meetings at the village center for discussions of agricultural practices. This was particularly common in the Pargaon village. These meetings can be characterized by the discussion of information presented by members with access to connections at agricultural centers and agricultural experts. Frequently, information from agro-met service providers was also discussed at these village meetings. Typical discussion topics referred to "new" pests and the use of pesticides. Consensus in decision-making could be reached within such community groups, but apparently this was not an objective. It was argued that the main objective was to receive and share information. It may be hypothesized that these groups served as arenas for translating agro-met information to localized adapted actions. The regularity of meetings varied, but informants referred to these as relevant inputs for their own decision-making. The degree that agro-met information or other sources of external information was discussed depended on access; where agro-met information was available, this was discussed in meetings. An emerging type of interaction practiced in parallel to those described above refers to the discussion of agricultural practices on the Internet-based messaging app WhatsApp. The app enabled farmers to discuss agricultural practices with other farmers outside of the village, and it was appreciated for its possibility to share pictures of crops with farmers from other places. Another advantage of being member of a WhatsApp Group was the possibility for two-way interactions with other farmers. The discussion in WhatsApp-groups, however, was limited to certain crops, it primarily referred to discussions of pests, and was only applicable to people with smart phones.

With reference to uptake of agro-met information, it may be argued that involvement in farmer groups and social networks can be crucial for access, as well as translation and interpretation and hence, for uptake of agro-met information [47,48]. It may also be speculated that as such, farmer perception of salient and credible information increased as part of this translation process (See also, [45]). These discussion arenas provided for, and increased access to, agro-met information and other information sources to those who were included in the circle, and also for non-subscribers. This study does not allow for a thorough analysis of the degree that villagers of different socio-economic groups attend such discussion meetings, however, interviews and observations indicated that participants of these meetings belonged to the same circle of family and friends (See also [45]).

Agro-met information was considered relevant in some decision-making situations and was ranked as the third relevant factor to be considered in farmers agricultural decision-making. All the studied service providers disseminated both weather forecasts for three to four days in a week and agro-met advices to the farmers. In the case of sudden change of weather, SMSs to inform about "afternoon" changes would also be disseminated. Examples referred to by the agro-met service providers, and also being observed on farmers phones, were, for example; "heavy rain is expected in the afternoon, there is a need to protect crops and harvest" and, "humid weather is expected, crops may need spraying". The subscribers valued weather forecast information to some extent with reference to sowing (48%). Despite complaints over the credibility of weather forecasts with regard to sowing, subscribing farmers were very much aware of the forecasts presented. It was explained that the accuracy of weather forecasts varied—some years it was more accurate than others, and a general trend was that it was quite accurate "off season", while it was mostly inaccurate in the rainy season. Yet, some informants explained that they "liked to see the forecast information", as it was an affirmation of their own decision-making. It was mentioned that forecasts which would predict non-season irregular weather patterns would be appreciated. While agro-met advices rarely triggered actions related to sowing practices, it did seem to trigger actions related to harvest situations. Stories were told to explain how the whole family rushed to the field with carpets and towels to protect the piled-up harvest against rain as a response to a weather forecast SMS. Further, if the crop was ready or almost ready for harvest, a forecast predicting rain allowed for harvest of the crop to avoid damage. The need to harvest the onion in the case of rain was mentioned, and it was explained that if not harvested, water would drain into the onion and the onion would rot. The subscribers (50%) valued agro-met advices in the case of pests on crops, or as a precautionary action to avoid pests (Table 3). Both crops and pests represented situations of uncertainty, hence, the need for advice was higher. However, for all three villages, a general increase in the application of pesticides was mentioned as problematic, and it was argued that currently, three times more pesticides were applied, compared to five years ago. With regard to market information from agro-met service providers, information was considered with reference to harvest (17%) and the selling situation (23%). The percentage considering this information was low, but this may be explained by the situation that few respondents received such information. Apart from this, it was also common to call the regional "market agent" to get market information. To get information about the local market, farmers had to travel or call someone to get this information.

A number of subscribers complained about the credibility and salience of the provided agro-met information. Further, it was argued by those having a simple handset (feature phone) that the limitation of about 60 characters on the mobile screen represented a major constraint for comprehension. However, overall, the subscribers stated that they valued agro-met information for the ability to undertake precautionary actions; this also involved low-risk actions in the case of imprecise advice. The result is also in line with other studies which show that farmers generally tend to be risk averse, yet that context factors such as the size of the farm, income levels, and other socio-economic factors influence farmer's perceptions of risk and their ability to act in a risky situation [49]. Some informants painted a positive picture of the service, arguing that there was value in receiving agro-met information, and that "SMS and agro-advisories are the future of agriculture". Typically, according to interviews, those who were positive seemed to consider agro-met information in a number of agricultural decision-making situations. These informants also frequently referred to the discussion of agro-met information alongside other types of information in different arenas; both women and men referred to sharing agro-met information with family and friends. These discussion arenas, which were mostly to be initiated by the farmers themselves, seemed to represent important platforms for discussion of information factors and agricultural practices. Several studies have shown that social norms have significant influence on farmer's decision-making [50–52]. Hence, it can be hypothesized that social interactions in villages impact or perhaps even determine information flow and, therefore, farming practices within villages. It may be hypothesized that agents of the private and public-private agro-met information providers, represented a social influence, a driver for discussion, and, therefore, for the interpretation of agro-met information. As Pargaon and Vadaj were the only villages with agro-met information agents, this could represent a bias with reference to access to agro-met information among the study villages.

4. Conclusions

Considering the time of subscription and the number of subscribers to agro-met climate services in the study villages in India, the case villages can be characterized as being in a startup phase regarding agro-met information services. Based on this study's fieldwork, the villages' uptake of agro-met information appeared to be rather low and subscribers have most likely not reached its potential. However, it is important to realize that a number of factors play an important role in farmer's agricultural decision-making, and that the relevance of agro-met information differs depending on the different decision-making situations. The subscribers valued agro-met information in situations where it allowed for precautionary actions. In particular, this referred to agro-met advice to avoid pest attacks, but weather forecast information that allowed for protection of the harvest were also valued. Understanding perceptions of risk and the probabilities that are assigned to future events is key to understand patterns of uptake of agro-met information by farmers. Agricultural decision-making was discussed in a number of arenas, formally and informally, and hence, non-subscriber farmers received access to agro-met information indirectly via these arenas. These platforms represented possibilities to contextualize agro-met information, and therefore translate information to timely and appropriate action suited to the specific local context. This study indicates that group interaction within villages, and also with other farmers outside the village, is an increasing trend. It has been enabled or accelerated by the availability of Internet-based services, such as agro-met information services and other app based services (like WhatsApp); yet, the study indicated that the availability of discussion arenas differed among and within villages. Knowledge of agro-met information services is still quite low, and subscription does not automatically translate to uptake of information. It may be concluded that platforms for interactions and social learning of agro-met information should, to a larger extent, be facilitated for by agro-met service providers—as such, platforms will not only increase access to information for a wider circle of farmers, but also contribute to better interpretation and translation of agro-met information in local contexts.

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