Meghdoot—A Mobile App to Access Location-Specific Weather-Based Agro-Advisories Pan India

Working Paper No. 370

CGIAR Research Program on Climate Change,Agriculture and Food Security (CCAFS)

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Abstract

Timely agricultural advisories to farmers can enhance their decision-making and reduce production risk under challenging weather conditions. To enhance access to relevant climate information services in India, a mobile application called Meghdoot was designed to deliver weather information and crop-specific advisories, as a joint initiative of the India Meteorological Department (IMD), Indian Institution for Tropical Meteorology (IITM), Indian Council for Agricultural Research (ICAR) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Building on IMD's District Agrometeorological Advisory Service (DAAS) which issues crop-specific weather-based agro-advisories twice a week for all districts in India, the Meghdoot app makes available observed weather recordings, forecasts, and warnings generated by IMD and IITM. This working paper describes the concept design, the framework and a preliminary user analysis of the Meghdoot mobile application. Meghdoot mobile app is available on Google Play (Google Play Store) as well as Apple App Store. Since its inception more than two years ago, Meghdoot has received a good response with 200,000+ downloads/installs and an average rating of 3.3/5.0 by 863 app users (as of July 26, 2021) on Google Play(Google Play Store).

Keywords

Agrometeorological advisories; district-wise; climate services information; digital agriculture

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Contents

Acronyms

AAS	Agrometeorological Advisory Service
AMFU	Agro-Met Field Units
API	Application Programming Interface
AWS	Automatic Weather Station
DAAS	District-level Agrometeorological Advisory Service
DAMU	District Agro-Met Field Units
FTP	File Transfer Protocol
GFS	Global Forecast System
GUI	Graphic User Interface
ICAR	Indian Council for Agricultural Research
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
IVR	Interactive Voice Response
KVK	Krishi Vigyan Kendras
NCMRWF	National Centre for Medium-Range Weather Forecasting
SAU	State Agriculture Universities

Meghdoot – A Mobile App to Access Location Specific Weather Based Agro-Advisories

Introduction

Agricultural meteorology is an interdisciplinary science that offers application of meteorological information as a critical input in the management of agricultural activities (Ahmad et al. 2017). Accordingly, the India Meteorological Department (IMD) has been operating the District-level Agrometeorological Advisory Service (DAAS) since 2008. DAAS is now one of the largest integrated agrometeorological information programs in the world (Chaubey et al. 2018; Khobragade et al. 2014; Rathore et al. 2011). While dissemination of weather information in India goes back to 1945, it was in 1976 that IMD launched a more robust forecast-based agrometeorological advisory service (AAS) in collaboration with state governments. AAS enables the application of meteorological information to agriculture, thereby supporting farmers in making the best use of available natural resources (Ahmad et al. 2017) as well as facilitating technology transfer on climate change information (Ramachandrappa et al. 2018). In 1988, the National Centre for Medium-Range Weather Forecasting (NCMRWF) started a pilot project in which it issued agrometeorological advisories based on five-day, medium-range weather forecasts. IMD upgraded its AAS project to the current DAAS program in 2008 to provide district-level weather information and crop management advisories across India.

The aim of DAAS was to provide crop-specific advisories to serve farmers' needs at a district scale. To operationalize DAAS, IMD created an institutional framework drawing on expertise from the Indian Institute of Tropical Meteorology (IITM), the Indian Council for Agricultural Research (ICAR) and the State Agriculture Universities (SAUs) to constitute multidisciplinary teams called Agro-Met Field Units (AMFUs) in various agroclimatic zones. A total of 130 AMFUs were thus set up across India (Kumar 2020) with the responsibility of generating crop-specific agro-advisories customized to approximately 680 districts. The teams rely on local information and past and forecast weather data (obtained from IMD and its regional centers) to issue advisory bulletins for every district (Dheebakaran et al. 2020). The Agromet Advisory

Bulletin is a useful tool for enhancing production and farmer income and minimizing losses (Shivaramu et al. 2018; Vashisth et al. 2013). The advisories, based on the Medium Range Weather Forecast (MRWF) of the Global Forecast System (GFS) model T1534, are issued twice a week, Tuesday and Friday, with value addition by the IMD's Regional Meteorological Centres.

Currently, IMD and ICAR are jointly extending the network of AMFUs to the district level by setting up District Agro-Met Units (DAMUs) at Krishi Vigyan Kendras (KVKs) in 530 districts in addition to the existing 130 AMFUs. The DAMUs are mandated to issue advisories tailored to blocks (subdistricts) within their respective districts. Majumder et al. (2020) studied the reliability of block-level forecasts and the importance of agro-advisories issued by DAMUs in enhancing profitability. Regular farmer awareness programs, feedback to advisories and farmers' field visits are organized by DAMUs to spread awareness on important issues such as climate variability, extreme weather and coping mechanisms to manage risk.

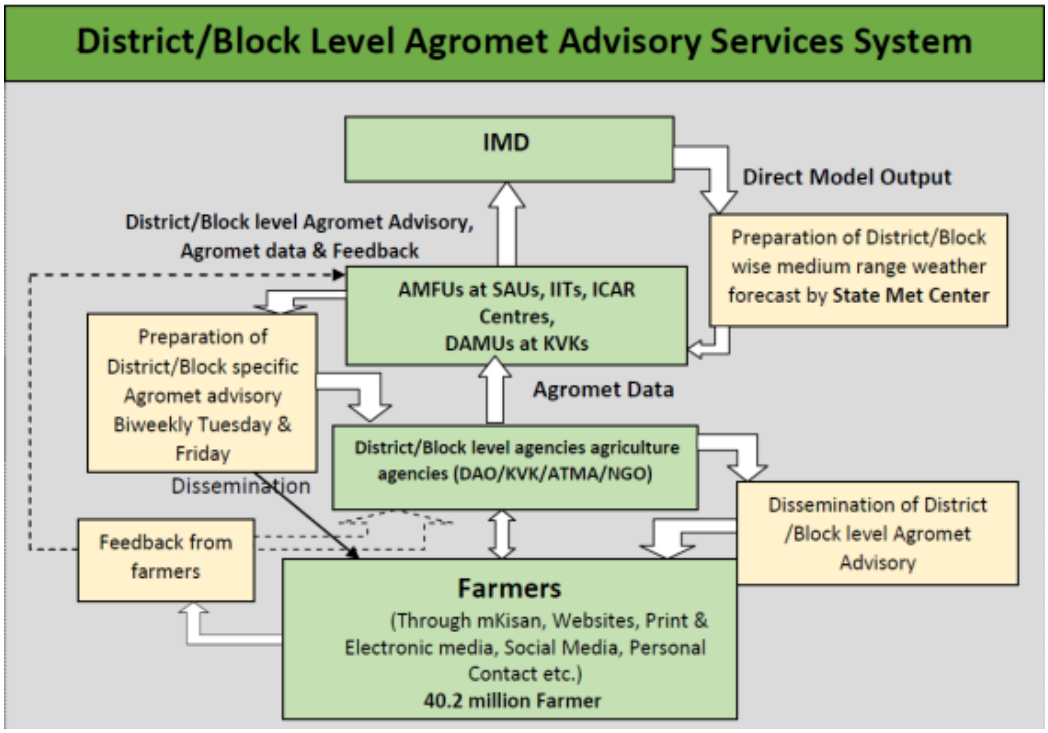

Figure 1. Workflow of IMD's agro-meteorology advisory bulletins (Source: IMD)

While the generation of agro-advisories is done by the AMFUs (Figure 1), their dissemination is done through various modes such as All India Radio, Doordarshan, private TV and radio channels, newspapers and internet and IVR (Interactive Voice Response) technology, etc. In addition, advisories are also disseminated through mobile phone short messaging services

(SMS) in regional languages as well as English and through the mKisan portal of the Government of India's Department of Agriculture, Cooperation and Farmers' Welfare, and by public and private sector partners. The advisories reach about 42 million farmers across the country.

Despite the impressive reach of the DAAS program, the efficacy of information dissemination from AMFUs to farmer users is variable and dependent upon the strength of farmer networks, the performance of local extension institutions, etc.

While dissemination pathways such as SMS and TV are an improvement over traditional extension channels, they have some limitations in terms of convenience, timeliness and other factors. For instance, SMS messages have a limitation on the length of the advisory, and a website advisory might have a lot of information but would require computers and human skills to be accessed and understood. Therefore, there has been limited success in translating the gains made in meteorology to agriculture through the provision of context-specific advisories, partly due to limitations in the existing channels of dissemination themselves but also due to the inadequate use in these advisories of available weather information (Gopalakrishnan and Subramanian 2020). Further, none of the existing channels used for dissemination has the means or the capacity to collect data about the uptake of the advisory, the quality of the information provided therein or any other kind of feedback from the intended users, who are predominantly farmers. Feedback loops coupled with a sustained engagement and dialogue between climate information producers, users and intermediaries is necessary to promote adaptation (Singh et al. 2016). Given this context, increasing smartphone penetration and mobile internet usage in rural communities presented an opportunity to use mobile phone applications to disseminate meteorological information and agro-advisories. Mobile phone-based advisories that disseminate weather and farming related information can lead to enhanced yields, reduced costs and knowledge of farmers (Baumüller 2018). Against this background, the Meghdoot mobile application and its backend information technology support were developed to overcome the challenges being encountered by the DAAS program. During the design and development of the Meghdoot app, the project teams benefitted from working on two previous applications developed by ICRISAT: The Sowing App (Rao and Dixit 2019) and the Intelligent Aagricultural Systems Advisory Tool (iSAT) (Rao et al. 2019). One of the objectives of this paper is to establish the invisible link between Meghdoot and the ICRISAT applications.

Rationale for developing the mobile app

The move to develop a mobile phone app to disseminate agro-advisories came from the realization of a need to provide farmers 24X7 access to location-specific weather and weather-based advisory information. It was supported by a grant awarded to ICRISAT under the Monsoon Mission II initiative launched by India's Ministry of Earth Sciences and coordinated by IITM, Pune. The grant to ICRISAT was entitled 'Climate services for better risk management and building the resilience of smallholder farmers in the highly vulnerable rainfed areas of India'. As part of this mandate, select AMFU personnel and agrometeorologists working with the DAAS program were trained on the use of techniques such as crop simulation modeling and data analytics to be able to draft context-specific agrometeorological advisories. One of the workshops organized as part of this effort—on Jan 22, 2019—was used to stimulate a multi-stakeholder consultation to explore the desirability of developing a mobile phone app—subsequently named Meghdoot—to disseminate advisories to farmers and the key information that such an application could provide. Insights from the workshop helped to articulate Meghdoot's overarching aim, which was to simplify access to crop- and district-specific agro-advisories developed by AMFUs/DAMUs and aggregate various weather information products including observed weather, weather forecasts, now-casts, weather warnings, etc. The workshop also distilled other important expectations from the Meghdoot app such simplified navigation, use of visual cues and symbols as well as pictures to aid farmer comprehension as well. The design of the graphic user interface (GUI) of Meghdoot was based on user-centered design principles and the inputs from the workshop. The guiding principles synthesized from the workshop and the several expert consultations that followed helped the project team in developing a blueprint for the Meghdoot application and coming up with a high-level solution design[1]. The design and architecture of Meghdoot benefited from the reference architecture[2] of two previous applications developed by ICRISAT: The Sowing App (Rao and Dixit 2019) and the Intelligent Agricultural Systems Advisory Tool (iSAT) (Rao et al. 2019). Both these applications demonstrated the effective use of software to support generation of agrometeorological advisories. Meghdoot interfaces with a cloud-based IT

[1]https://people.ok.ubc.ca/rlawrenc/research/Students/CJ_05_Design.pdf

[2]https://www.leanix.net/en/reference-architecture

backend application that compiles disparate information products generated at varied spatial and temporal scales and harmonizes them. The ICRISAT team that was closely involved in the development of the Sowing App and iSAT participated in the conceptualization and development of Meghdoot. This facilitated the spillover (Gandal et al. 2017) of key learnings and software design principles from the iSAT and Sowing apps to Meghdoot. Further, some of the tangible and intangible learnings will be embedded into the design of datahubs that are to be deployed as part of the world bank funded Accelerating Impact of CGIAR Climate Research for Africa (AICCRA) [3].

Technical details of Meghdoot

Meghdoot was developed on Xamarin, an open-source platform for developing mobile applications compatible with Android, iOS, tvOS, watchOS, macOS and Windows (Hermes 2015). The Xamarin framework uses Extensible Markup Language (XML), which is based on C# (C-Sharp) and .NET at the backend. It has platform-specific libraries which provide access to APIs (application programming interface) from Google, Apple, Facebook and other third-party APIs that provide specific services. The core programming language used is C# while the interface in Xamarin is Visual Studio 2019.

Figure 2 shows a schematic representation of the backend application that interfaces with Meghdoot. It shows the flow of data as the app calls for weather (past and forecast data) and agro-advisory information from the IITM and IMD websites using different APIs, which are indicated in Table 1.

[3]Development Projects: Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) - P173398 (worldbank.org)

Table 1. APIs used to access data from IMD and IITM websites.

API no.	Data type	Accessed from
1	Past weather	IMD website
2	Forecast weather	IITM website
3	Agro-advisory	IMD-Agrimet website
4	Weather warning	IMD website

IMD aggregates weather data recorded by its network of surface observatories, automatic weather stations (AWS), synoptic stations, automated rain gauges and agromet observatories, which are distributed across the country. It currently receives district-wise rainfall data recorded by 2,868 observatories and rain gauges installed all over the country under what is called the District Rainfall Monitoring Scheme (http://www.imdpune.gov.in/ndc_new/stations/DRMS_STN.html). In addition, 127 AWS stations installed in different agroclimatic zones of India provide hourly weather data to IMD. Powered by this huge network, IMD and its affiliate organizations manage one of the biggest agro-advisory systems in the world. The data recorded at various stations at different synoptic hours are point observations on maximum and minimum temperature (°C), precipitation (mm), relative humidity (%), cloud cover (okta), wind speed (km/hr) and wind direction. Meghdoot's backend application retrieves this data from IMD using API-1(Table 1) and displays it on the Meghdoot mobile app as observed weather data, which is refreshed once a day. Similarly, forecast data is sourced via API-2(Table 1) from the IMD website and updated three times a day. IMD and IITM also issue district-specific weather warnings for thunderstorms, lightning, cyclones, cloudbursts and heat /cold waves. The backend application of Meghdoot connects to this data through API-4 (Table 1) and checks for weather warnings on an hourly basis. Whenever such a warning is issued, Meghdoot triggers an alert notification on a user's smartphone. The app similarly accesses the district-wise agro-advisories issued by AMFUs through API-3 (Table 1), which is refreshed once every 24 hours.

Apart from accessing weather data and agro-advisories through the APIs, the backend application supporting Meghdoot has a database on an SQL server where old data is archived. However, only the currently active advisory is displayed on the app. The data flow/exchange from IMD and IITM APIs and the backend application is through Microsoft flows and any file

transfers are through standard protocol for file transfer known as FTP (File Transfer Protocol) (Fedak et al. 2009).

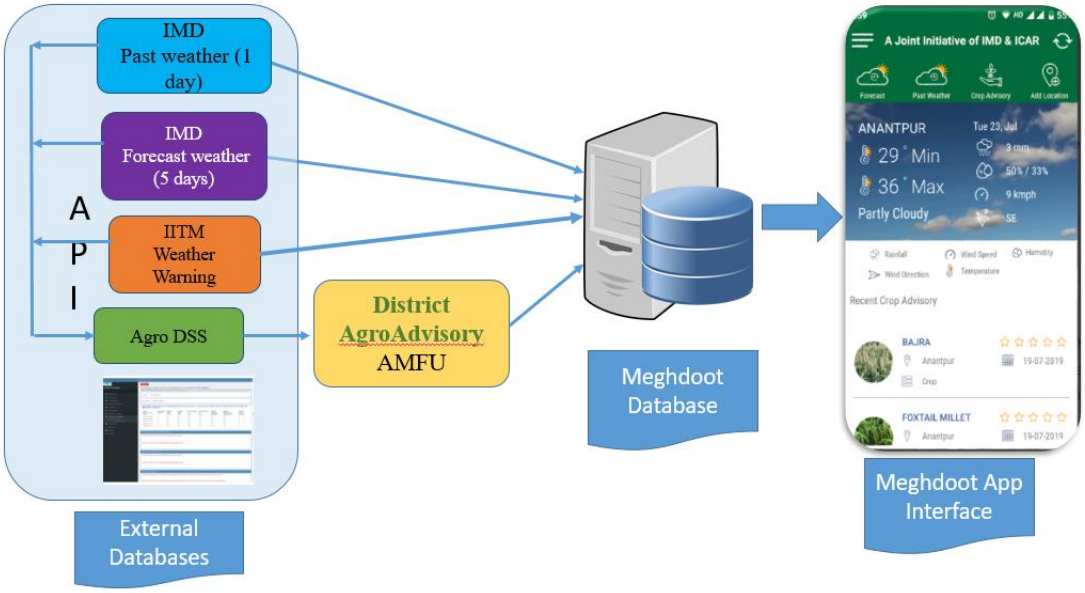

Figure 2. Flow of data in the framework of the Meghdoot application.

Meghdoot mobile interface

At the time of its launch, Meghdoot served agro-met advisories to nearly 150 districts of India. It now covers all 717 districts. The key features of the Meghdoot mobile application are:

Weather information and advisory

Meghdoot presents observed and forecast information on temperature, rainfall, wind direction and humidity downscaled to a specific location along with an agromet advisory issued by the local AMFU.

Language preference

The information is presented in English and 12 Indian languages (Hindi, Telugu, Assamese, Gujarati, Kannada, Malayalam, Marathi, Odia, Tamil, Mizo, Bengali and Punjabi).

User-friendly interface

The user-friendly interface was designed—with the help of inputs from experts who had worked closely with farmers—for easy navigation and querying by farmers.

Latest information

The app provides up-to-date location- and crop-specific, weather-based agro-advisories across India.

Pictorial representation

Complex weather data are presented pictorially and innovatively to aid easy comprehension.

Integration with other apps

The app is integrated with popular social media and messaging platforms such as WhatsApp and Facebook for easy sharing and discussion among farmer groups. The advisories from Meghdoot can be instantaneously shared via WhatsApp, thus widening the reach of the advisories.

Flexibility

The app is flexible for integration with YouTube and other media for better understanding and use.

Weather alerts

The app issues real-time notifications to alert users to a developing adverse weather event. This feature is not available in any other advisory system currently available.

Easy feedback

A novel feature of this app is the rating system by which users can provide feedback about the forecast and advisory. The app offers a simple way to link back feedback from farmers to the AMFUs. The lack of such a feature was a key shortcoming in the existing dissemination channels.

User guidelines

The Meghdoot (version 1.60) app can be downloaded from Google Play (Google Play Store) and Apple Appstore. It occupies 36 MB of phone memory and requires the 5.0 or later versions in the case of Android phones and iOS 10.0 or later in the case of iPhone. After installation, the user is required to provide some information such as mobile number, preferred language,

name, gender, state and district for user registration. This creates a user profile and retains the location and language preferences.

The advisory and weather information of a desired location can be retrieved using the Manage Location option. This interface provides the past and forecast weather, current agro-advisory and warning for a given location. Thus crop-specific advisory and weather data for several locations can be viewed using the Manage Location option.

User response

The Meghdoot app has been downloaded/installed more than 211,000 times (as of July 26, 2021) with at least one user in 671 districts of India. Cumulatively, as of July 26, 2021, Meghdoot has disseminated about 354,312 advisories since its launch. The state-wise number of users and number of advisories issued are presented in Figure 3. The highest number of Meghdoot users are in Karnataka (27,031) followed by Maharashtra (26,064) and Uttar Pradesh (22,504) (Figure 3a). The states where over 20,000 advisories have been disseminated through Meghdoot are: Uttar Pradesh (42,415), Maharashtra (30,938) and Gujarat (26,223) (Figure 3b). On an average, 12,218 agro-advisories per state have been issued through Meghdoot (as of July 26, 2021) since the inception of the app.

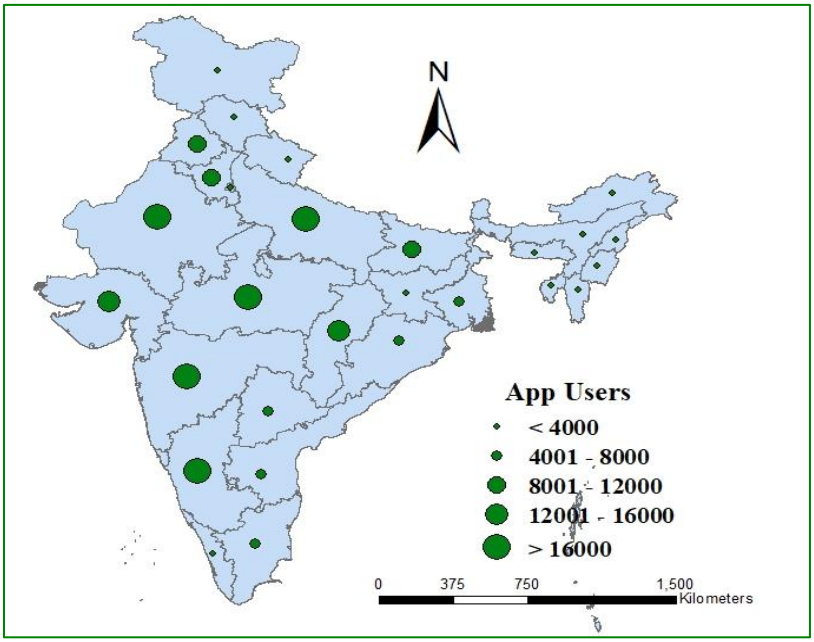

Figure 3a. State-wise number of users of Meghdoot app (as of July 26, 2021).

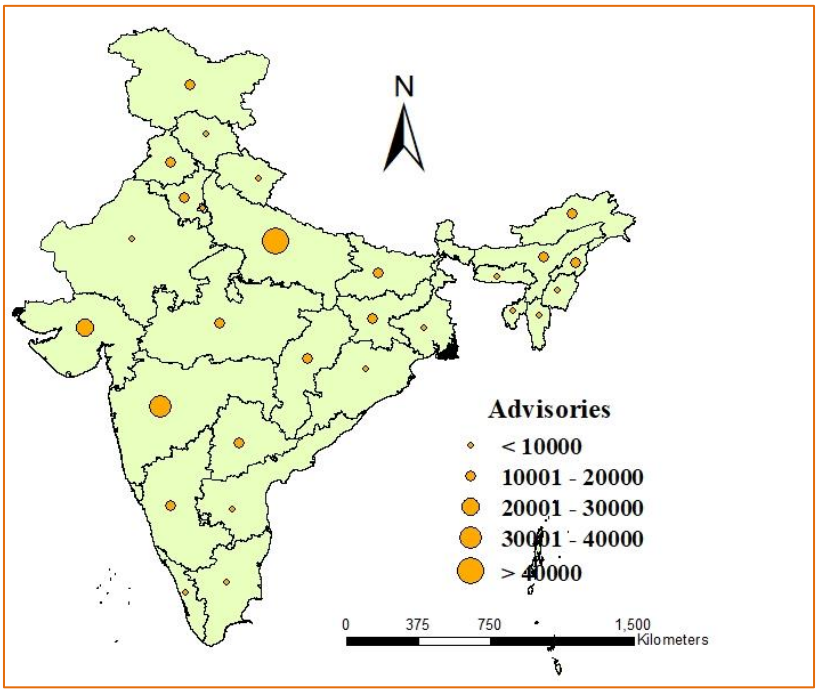

Figure 3b. Number of agro-advisories issued in each state of India through the Meghdoot app (as of July 26, 2021).

Meghdoot has received a favorable response in northern, western and central India with an average rating of 3.3/5.0 by 863 app users on Google Play (as of July 26, 2021). The comments provided by users on Google Play have been analyzed to summarize user feedback. There have been 168 mentions with a positive connotation compared to 62 negative mentions (Table 2). A slightly different analysis showing the percentage split for word pairs with opposite connotation (positive versus negative) is presented in Figure 4. In more than 68% of these cases, the application received a positive review while it was negative in 31% of cases. This indicates that the Meghdoot app has been found useful by most of the users. These comments are being used to inform continual improvement of the app.

Table 2. **The number of occurrences of positive and negative words in the Meghdoot comments section.**

Positive comments		**Negative comments**	
Text	**Occurrence**	**Text**	**Occurrence**
Good	66	Bad	19
Nice	29	Poor	5
Excellent	11	Slow	17

Useful	18	Useless	10
Helpful	10	Mess	1
Best	13	Worst	5
Awesome	5	Waste	6
Great	8	Crash	4
Easy	4	No access	2
Informative	2	Missing	5
Appreciate	2	Unable	2
Total	168	Total	76

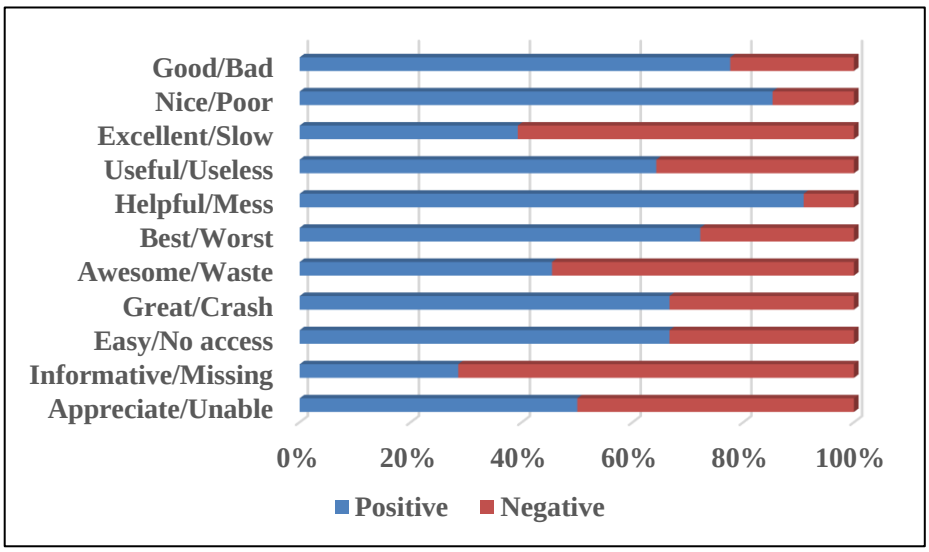

Figure 4. Percentage occurrence of positive vs negative comments.

Conclusion

The Meghdoot mobile phone app overcomes many of the shortcomings of existing channels in disseminating the agro-advisory services, weather data and forecasts provided by IMD, IITM and AMFUs/DAMUs to farmers. A unique collaboration of agencies made it possible to access sources of meteorological data and agro-advisory information which could be integrated into the app. Based on feedback provided by users, Meghdoot improves the accessibility and usability of the agro-advisories issued by AMFUs. The application has been receiving a good response from the northern, western and central parts of India. As of July 26, 2021, the app had notched up 200,000+ downloads/installs and received an average rating of 3.3/5.0 by 863 app users on Google Play. The Meghdoot app is being updated every month based on feedback from users. Further, innovative business models and opportunities with pvt sector and start-ups for bundling weather information and agro-advisories aggregated on Meghdoot could also be explored to improve the overall effectiveness and uptake of advisories.

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