ICT Platform for Climate Change Adaptation in Agriculture

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***Abstract*—Climate change is now more visible in the form of frequent changes in the weather patterns leading to severe drought or floods. It endangers the food security, especially shrinking of cultivable land and increasing population. Agricultural Research Institutes are working on new cropping patterns, new heat and flood tolerant varieties and cultivation practices. However in the absence of sound knowledge extension system the results of such massive and costly research do not reach its end users, in this case farmers, on time. This research paper talks about the, National Agricultural Innovation Project (NAIP) pilot conducted to develop strategies to enhance Adaptive Capacity to Climate Change in vulnerable regions in India. As part of this research, extensive field demonstrations and data analysis were done to demonstrate how Information and Communication Technology (ICT) can play a crucial role in establishing a two way connect between the Research Lab and the end users of research. While Agricultural research can focus on identification of current and future risks to livelihoods due to climatic variability and development or identification of regional climate specific crop varieties and crop practices, the IT and ICT can work jointly to use the outcome of such research to spread awareness and promote the use of such varieties and practices in adaptation by farmers and other stakeholders through an ICT platform.**

Keywords—ICT; Agriculture; Climate Change Adaptation; mKRISHI; mobile; IVR;

I. INTRODUCTION

Climate change refers to change in "average weather" conditions over time [1]. Such variations adversely affect agriculture and call for adaptation measures to mitigate the climate change impact. The mitigation strategy will require use of modern agricultural technologies such as improved seed varieties and agro climatic zone specific cultivation practices. Agricultural research institutes across India have created new heat tolerant terminal and flood tolerant varieties suitable for drought and flood prone regions [2]. A knowledge extension framework is required to transfer these technologies from "Lab to Land". Information and Communication Technology (ICT) can play a decisive role in extending its reach beyond the research farms and universities. In July 2014 TRAI reported a rural wireless subscription of 376.22 million [3].

mKRISHI®[4] is a mobile, Interactive Voice Response (IVR) and web based rural service delivery platform offering multiple services in local language for farmers and its stakeholders. This platform has been used as knowledge dissemination platform for Climate Change Adaptation (CCA)

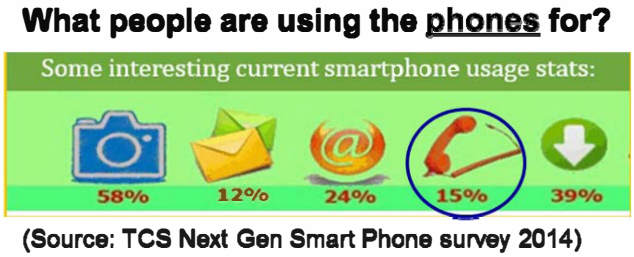

Fig. 1. Use of the modern day phone

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in National Agricultural Innovation Project (NAIP) pilots in four climatically sensitive districts in India viz., Mewat (Haryana), Dhar (MP), Raigad (Maharashtra) and Ganjam (Odisha). Out of these Mewat and Dhar are drought prone and Ganjam and Ragida are frequent flash flood prone areas. During the pilot, the agriculture experts from research institutes and universities used the platform to share information about the improved crop varieties and region specific crop cultivation practices with the farmers.

Farmers raised queries through a Marathi, Hindi and Oriya mobile app or IVR. The agricultural experts analyzed the queries in the context of the soil data, weather forecast for a week, climatic data calculated by Division of Environmental Science at Indian Agricultural Research Institute at Delhi. This led to a very personalized advice to farmer's query. This helped in reaching out to 9000 farmers across 360 villages in four districts. 19,000 queries were advised during the 18 months pilot. This paper highlights the observations from this pilot, query patterns in relation to the climatic data and strategy adopted to create knowledge based climate change adaptation measure.

II. Background

The frequency of occurrence of the extreme weather conditions have increased phenomenally in last 50 years. The weather data analysis of Mewat (Haryana) and Dhar (M.P.) between 1969 and 2005 indicated a 0.18 °C increase during Kharif season and 0.7°C during Rabi season, in every 10 years. Rainfall decreased by 1% and 19% in Mewat and Dhar districts, respectively [2]. Scientist at International Rice Research Institute (IRRI) Manila observed that yield of cereal crops like rice, wheat and maize will decrease by 10% for every 1°C increase in temperature over 30 degrees, during flowering stage [5].

Based on the climatic threats in the regions, interventions were made to reduce the crop loss due to temperature stress during rabi season. Scientist at various research institute are working towards creating new crop varieties or improve the crop cultivation practices

But the challenge lies in how to spread the awareness of such intervention to farmers and how to take this research from labs to the pilot farms. Mobile network can be used to offer region specific services in real-time at affordable cost, [6]. There are various agencies offering ICT based services in India [7]. But majority of them are based on generic information sharing using English SMS. Hence, there is a need to create a local language, farmer specific information delivery services, accessible by farmers anytime. mKRISHI® CCA enabled the agricultural research scientists to define the region specific recommendations for the varieties of crop and, their package of practices in a very crisp and actionable manner and upload it on the mKRISHI® Knowledge console. Farmers can access this information at any point of time using their GPRS enabled mobile phones. This established a real-time direct connect between the knowledge provider and knowledge consumer. Due to timely follow-up on the recommendations provided by the experts, farmers adopted seed replacement and controlled irrigation. This led to reduction in the cost as well as in losses.

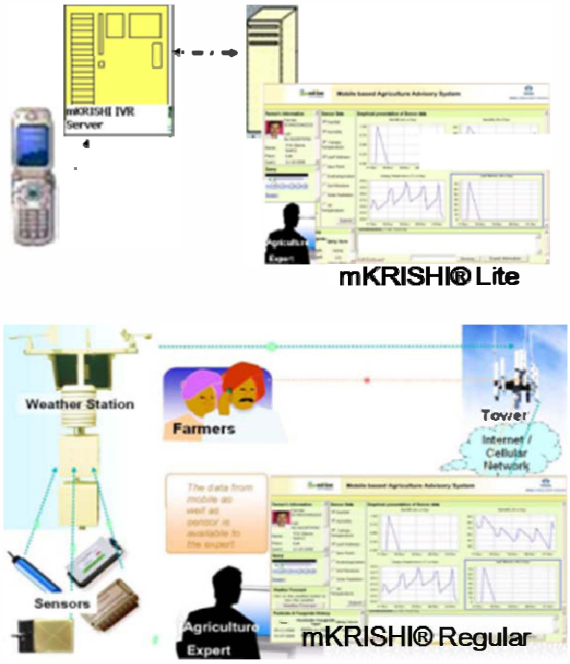


Fig. 2. mKRISHI Service

III. Proposed Solution

A. Service Design

Keeping in mind the different types of mobile handsets available in rural India, two flavors of mKRISHI® services were designed (Fig. 2):

- Plain Vanilla offering – mKRISHI® Lite.
- Value Added Service – mKRISHI® Regular.

1) mKRISHI Lite: is a local language IVR system. Farmer dials a toll free service number and records his query in local language. Agriculture Expert analyses these queries using web console and provides audio advice in the form of outbound call.

2) mKRISHI Regular : is a mobile application based service, where farmer is provided with mobile application for both Java and Android handsets. This application enables farmer to send queries, comprising of text, voice and images, specific to their land and crop to agricultural experts, using their mobile phones. Application also includes services like Weather, Best practices, Frequently Asked Questions, Agro Advisory, Farmer Profile, etc.

3) mKRISHI Expert Console : provides an integrated view of the farmers profile, farming history and the required farm parameters to an expert at remote location (Fig. 3). Using this data the experts analyse farmer's query and provide effective advices in local language.

Fig. 3. mKRISHI CCA Console components

B. *Service Flow*

There are two major data and information sources –

- From Farmer
- From agricultural domain partners

Farmer's personal information along with farm information is captured during the farmer registration process. Besides these, the farmer also provides other information such as crop - varieties, sowing date, and other farm operation data. Agricultural Expert develops region specific crop package of practices in local language, for the different crop stages. This information is fed in the system in text, image and audio format.

1) Farmer Registration : From each state a progressive farmer group is identified and registered in the system using mobile application or IVR system. Registration details include:

- Farmer personal data - Name, age, Location, etc.
- Farm data – Crop Data, Irrigation Source, Farm Operation data (sowing, harvesting, etc.)
- Soil Report, etc.

2) Information from Agro Domain : mKRISHI CCA was developed in collaboration with Indian Agricultural Research Institute(IARI) New Delhi and Indore, Central Rice Research Institute (CRRI), Cuttack, Odisha University of Agricultural Technology (OUAT) and Central Marine Fisheries Research Institute(CMFRI), Mumbai. These partners provided the region specific climate based information on seed and practices. Some examples are given below:

- In Mewat (Haryana) district, heat stress impacts the productivity of wheat and mustard crops. Hence, IARI introduced wheat varieties having terminal heat tolerance which were suitable for late sown conditions (WR 544). The yield improved by12% to 18% on pilot farms. Similarly, mustard yield increased from 5 to 7% by growing Pusa Mehak in place of local variety.
- In Dhar (MP) district, initial results indicate that aestivum varieties of wheat viz., HI 8627 and HI 8638 were potential replacements, as this area faces initial and late heat stress, therefore varieties with early and terminal heat tolerance are suitable. In case of gram, replacing local variety with JG varieties can improve the yields in the range of 25-50%.
- In Ganjam (Odisha) Flood tolerant varieties of rice i.e. Swarna Sub-1 and Gayatri produced about 31% and 48 % higher yield over Swarna in intermediate and semi-deep low lands whereas Varshadhan recorded 33 % yield advantage over farmers' variety, Patri Jagannath in deep low lands.

With the help of these research institutes, such information on the recommended local varieties, their yield, the cropping duration, the sowing precautions; were populated in the mKRISHI® CCA system. Division of Environmental Science, IARI prepared the climatic data for pilot location based on the 50 years of weather data. This included day wise averages of rain, minimum and maximum temperature, relative humidity, wind speed etc. The info and Weather data were received and fed into mKRISHI Server, which is further used for data analysis and providing effective advice to farmer.

3) Data Mapping : System intelligently maps both registration data and climatic data to provide integrated view to Agricultural Experts, helping them to provide farmer

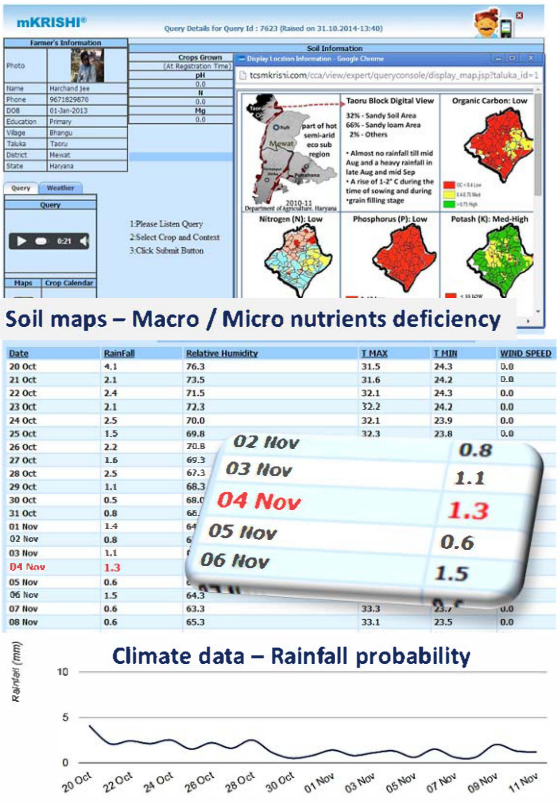


Fig. 4. mKRISHI CCA Console with Soil and Climate View

specific advice. Before providing advice, the expert looks into the farmer's location, soil report, farm activity and then sends advice to the individual farmer(Fig. 4). As system incorporates all data in one console, it has become easy to derive location based Best Practices, Frequently Asked Questions, etc. and provides it to farmer on their mobile handset.

4) Climatic and Weather Forecast Data: Average of the climatic data for 50 years for each location was added in the console. This data was plotted in a +/- 7 to 15 days interval w.r.t. the date when the query was asked. This provided a view of how the climate may behave in the upcoming days. This information was coupled by a "weather forecast" on temperature, rain and cloud coverage. Such diversified but crucial information helped expert to alter his advice based on this input. If the query was related to a pest attack and if there was a probability of rain, the expert mentioned this in the advice. Hence, farmer will know about the solution as well as the right time to implement the solutions. This personalization instilled tremendous belief for the farmers in the system.

C. *Baseline survey*

Detailed baseline survey was conducted of the pilot regions before and after the pilot period. It was observed that the mobile handsets were in the price range of 1500-3500 Rs. Expenditure on the mobile phones was not more than Rs. 50 to Rs. 100 and mainly used for talking to relatives. It is used occasionally to connect with the local artya to get the market price of the produce too. They relied on the past experience and suggestion from friends to decide what to grow.

D. *Training*

Service was deployed and more than 180 farmer awareness camps were organized across 250 villages. Mobile applications were downloaded on farmer's mobile, and IVR demonstration was given. Expert farm visits were conducted which helped farmer to solve their issues and also helped to increase their

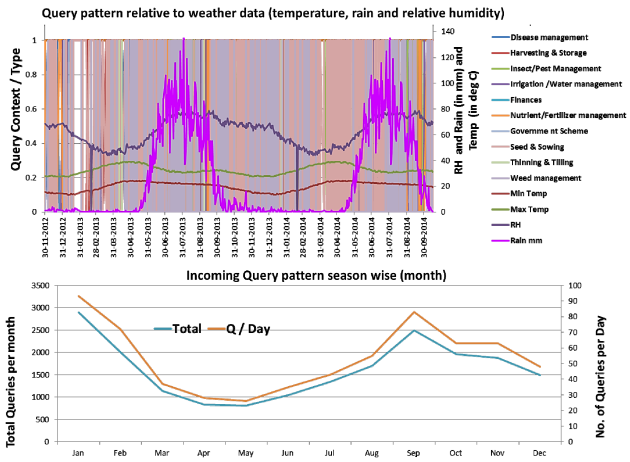


Fig. 6. Query Type and Incoming pattern

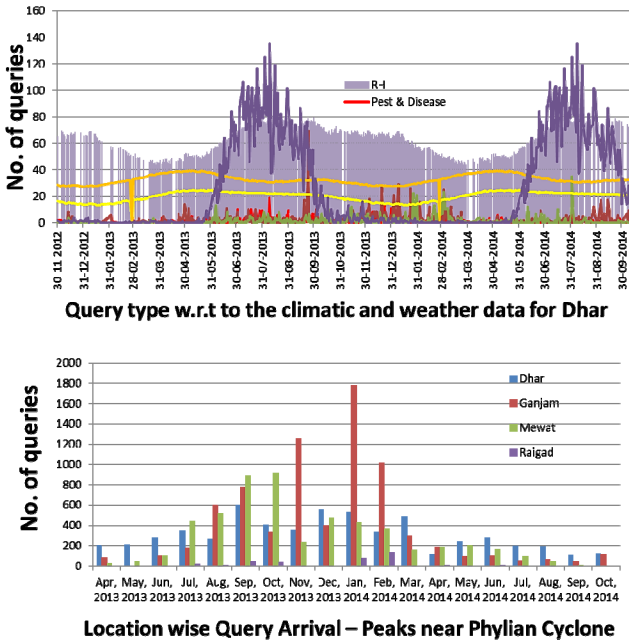


Fig. 5. Relevance to Climate Change Adaptation

confidence in the service. Periodic feedback was taken from farmer and expert which helped to simplify service design.

IV. Results

During 18 months of the pilot service, more than 9000 farmers registered for the service from 360 villages across four pilot districts. During this period 19,000 queries were raised, 88,000 voice and 59,000 text alerts were sent in local language. Based on the query analysis following interesting patterns and results were observed:

A. *Query type*

This varied with the month, season and the crop. But it was observed that the farmers were more worried about selecting the right crop and right variety before the sowing seasons. Their major questions were related to finding the crop variety suitable for farmer's region and which can give good yield. This was observed during onset of both the seasons – Kharip and Rabi (Fig 5). This was followed by major queries related to Pest and Disease management and Nutrient management. This was an interesting observation and quite opposite to earlier understanding that farmers were more worried about pest and disease. The advisory helped in encouraging "seed replacement" and experts recommended better yielding and pest resistant varieties which were in line with the Climate Change adaptation strategy.

B. *Query Arrival Rate and Response time*

On an average 55 queries were advised on daily basis. On an average, 77 queries were received every day in Sep 2013 (Fig. 5). This reached to 90 queries per day across pilot location in Jan 2014. This surge in queries was due to the questions on the pest management and market price (Dhar),

and Rabi sowing (Ganjam) in late Sep and probability of the disease attack due to low temperature and prolonged humidity.

93% queries were asked between 8AM to 11PM, which included 49% queries asked between 1pm to 6pm. Rest of the queries were asked during early hours. This highlighted that farmers need Any Time Query (ATQ) Resolution service. On an average each query was of duration 20-30 seconds only, which was in quite contrast to the queries raised on Kissan Call Centers which ranged from 5 minutes to 10 minutes. This provided an opportunity to increase the efficiency of the agricultural experts to handle more queries in a day.

80% of the queries were replied in less than 24 hours. Expert took on an average 3 to 5 minutes to listen to queries, check the photographs and the weather data and type or record the advice. The time reduced further if the queries were of similar nature and from the same region. Expert could maintain a "Answer Knowledge Bank" from which (s)he can reuse the advice.

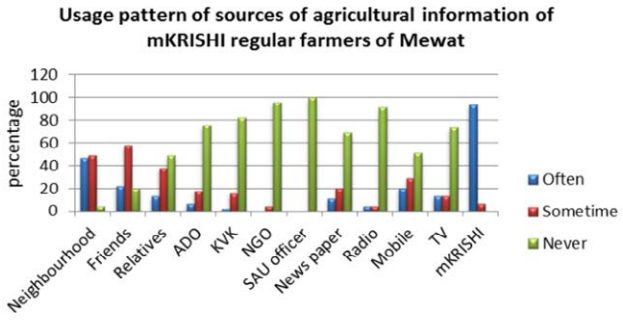
C. *Relevance to weather and climate change*

On analysis of the queries w.r.t. the climatic and weather data on a continuous time series, it was observed that the query pattern was in sync with the changing weather.

- A correlation between the climatic data (moisture and temperature) and the no. of queries was observed. When the moisture was very high and minimum day temperature was low for continuous 5-7 days, a surge in the pest and disease queries were seen. This helped the expert in alerting the farmers in advance to take the required precautions (Fig 6). Thus timely pest and disease management lead to saving the crop.
- During the period when the climatic data indicated probability of rain but the weather forecast predicted a delay, the expert stressed on controlled irrigation to save the plants. The expert also alerted the farmers to withhold the pesticide spray when the chances of rain were high and within couple of days of the recommended/scheduled pest control.
- During Phailin and Hudhud cyclone (Ganjam district), the farmers were alerted in advance to move to the safe places along with their cattle, drinking water, etc.
- Farmers also raised queries related to government schemes, subsidy – especially post phalin period. This reflected how farmers trusted the service to be a sole point of reaching out to all agricultural advisory (fig 6).

D. *Other observations*

The progressive farmers such as those growing vegetables and short duration cash crops asked more questions (32%) very frequently as they have multiple plots with small land areas and were growing different types of vegetables. Farmers raised queries for 26 crops out of which 11 were related



User Feedback

User %	Advice Followed	Remarks
50%	Yes	Highly competent user,. Young, Needs information
20%	Yes	Medium competent, Reserved / late starter, needs push
12%	Yes	High competency, Shares info with fellow farmers
5%	Yes	Low competency, Still learning the application

Fig. 7. Baseline survey

vegetables followed by pulses, cereals and oilseeds (four crops of each). This meant that the knowledge based climate change adaptation strategy must include the multi-crop information of varying duration for different soil and land characteristics.

E. *Final Baseline survey*

Farmers felt that there is a need for ICT service like mKRISHI®, as it reduces the time to seek information as well as the authenticity of the source helps in reducing their concerns. Post baseline survey indicated a good use of the mKRISHI service along with the traditional methods. Farmer case studies captured how the farmers and stakeholders found that "such direct need based communication" was very helpful in managing the situation.

F. *Farmer Impact*

- Reduction in the time to connect to the experts. Reduction in travel time and the hassles to take the specimen along with them to visit the experts. Farmers needed to travel 10-50 KM to the nearest KVKs to get an advice on the problem faced. Besides spending of Rs. 30-50 on the travel and food cost, it also consumed the entire day's human effort. As an alternative they tried calling the farmer helpline no. 1551, but as the number would be usually busy, they would give up after some time. With the mKRISHI CCA approach, they could raise the question in less than 2-3 minutes which were analyzed and answered by the experts in 24 hrs.

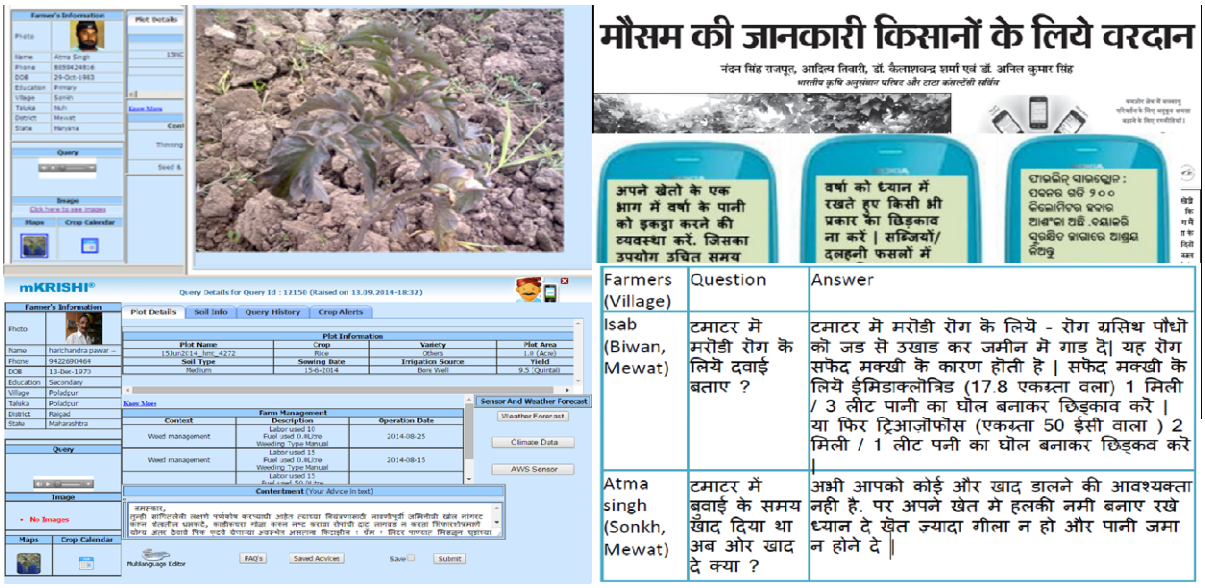


Fig. 8. mKRISHI(R) CCA – Relevance to Climate Change Adaptation using Knowledge

- Availability of all the researched crop protocols, variety details and Dos/Don'ts in a crisp manner to the farmers(Fig 8). The content shared by the experts to the farmers is small and specific (say 120 to 240 characters or so). This helped in easy understanding and using the information.
- Availability of best practices and FAQ helped in understanding climatically correct crop management, practices. Photo gallery helped in visual identification of pest at an early stage and take corrective action.
- Establishing a two way interactive system in a way that there is no additional load on the existing agro-extension system but still giving "Any Time Query (ATQ)" support. Since this is an offline query raising service, it enables the farmers to ask questions at any time of the day/night. Hence, it removes the dependency on the availability of an expert to pick up the phone to talk and ask.

G. *Farmer's Feedback*

- Ramesh jee, farmer from Dhar saves 20 % of the crop damage using mKRISHI® Weather forecast service.
- Atma Singh from Mewat was able to save approx. 4tonnes/ha and Rs 70,000 compared to last year by using mKRISHI service.

V. Conclusion

As discussed in the paper, the rural areas are not connected with the research outcome and hence various adoption mechanisms do not reach them in time. Availability of the information at the right time in the right format will help them take corrective steps to adopt to the climate change. They can also contribute in reducing the impact.

As climate change is imminent, the pilot result presented a model of public-private partnership based knowledge driven "digital extension". This brings together Agricultural Science and Computer Science not only to expedite the model based research to predict the climatic events, but also to create a fast, transparent and scalable delivery channel. This also provides a feedback loop which will help improve the research.

Acknowledgment

We would like to thank our partners NAIP, IARI, CRRI, OUAT and CMFRI for extending their support. We are grateful to our user for their support and feedback provided to develop a better solution.

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