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How Smartphones Can Bring About a Developmental Breakthrough in Agriculture

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Abstract

Modern smartphones come with high computing power, a variety of sensors and customization abilities that allow creation of a range of practical applications (apps). These features, coupled with the mobility and accessibility in terms of cost that smartphones offer, make them a potential game-changer for smallholder farmers in developing countries, particularly for these farmers' information needs. Smartphones can also make accessing government benefits, land records and crop survey requirements etc. more convenient for farmers. This paper explores how smartphones can be used in different ways, right from production planning to eventual sale of crop. Advanced applications like IoTs, drone use in conjunction with smartphones and design and willingness to pay aspects have also been covered. We believe that given the contemporary trends of robust low-cost devices (e.g., the JioPhone Next etc.) coupled with competitive data tariffs, smartphone use in agriculture will be beneficial for Indian farmers. In fact, the Indian experience can boost similar developments in the developing world, particularly in Africa.

1. Introduction

Smartphones can play a vital role in empowering the smallholder farmers with crucial information on a variety of aspects relating to agriculture whether relating to his soil health, nutrient content, what best to grow and when, prevailing wholesale and retail crop prices in various markets and the like. Additionally, smartphones can deliver online public services using mobile technology quite effectively. The opportunity to pole vault in agriculture, and other sectors, such as education and healthcare is very large, and the introduction of new low-cost devices (such as JioPhone Next and low-cost tablets) with sharply reduced prices for data, makes their widespread use very critical.

'Smartphones have become a useful tool in agriculture because their mobility matches the nature of farming, the cost of the device is highly accessible, and their computing power allows a variety of practical applications to be created'. (Pongnumkul S. et al., 2015)

We strongly believe in connecting the uptake of reasonably priced smartphones with a new array of digital public services in e-agriculture. Further, we believe that the bundling of more advanced public services along with the smartphones will be a huge developmental breakthrough for India, and one that can be an inspiring global role model for further introductions of digital connectivity in other regions, especially in sub-Saharan Africa.

The digital connectivity will of course not only provide crucial public services, but also an enormous flow of data for government agencies to improve their programmatic performance.

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2. Smartphones for Crop Planning and Cultivation

Meena R.L. et al. (2018) have reviewed various mobile applications for the agriculture and allied sectors in India. They find that smartphone based solutions help in different aspects of agriculture like farm management, leading to improvement in yields and boosting agricultural growth. They state that in contemporary agriculture, soft resources like knowledge and skill are as important as hard resources like inputs etc. But the issue that has been pointed out by them is that as per some estimates, 60% of farmers do not access any source of information for advanced agricultural technologies resulting in a huge adoption gap. This is more striking in view of the fact that against a requirement of field level extension personnel that is estimated to be about 1.3-1.5 million, the availability is only about 0.1 million personnel. The

conclusion of this study is that the wide spread network of mobile phones can tackle this problem.

Sharma S. et al., (2018) have conducted an overview of mobile Android based agriculture applications for India. According to their review, smartphones can play a vital role in transmitting information to farmers. Most of the smartphone applications under review in the paper cater to specific but different functions like cropping information, market rates, online shopping for farmers to weather forecast, and daily agriculture news for farmers. Yet, very few apps were able to capture all needs of a farmer comprehensively in a single app, in fact, an effective such type of application is missing. Thus they suggest that the different functionalities required by the farmers should be available in a unified app, one which is easy to access and in the local language that the farmer can comprehend.

Solutions are increasingly being designed around smartphones; for example, 'Plantix' app (plantix.net/en/) provides information about crop diseases based on just a phone image of the disease-affected crop/leaf. It is available in multiple Indian languages including Hindi, Bengali, Marathi, Gujarati and Punjabi etc.

Moreover, there are a lot of agriculture related channels/farmer groups etc. on social media (Facebook, YouTube, WhatsApp etc.) that farmers access through their smartphones. They share their experiences and most of the time, groups like these are very locally contextual and benefit the farmers. These are good channels for dissemination of relevant and useful information to the farmers.

Based on the above as well as our own understanding, smartphones can be helpful for farmers in the following aspects as far as crop planning and cultivation are concerned.

Smartphones can facilitate access to detailed and verified information about the agro-climatic zone of farm and crops supported in that geography, based on farm GPS. Specific as well as general properties of soils found in any particular agro-climatic zone can be covered. Advanced options to input soil test results of a particular farm can be provided to the farmer user so that the farmer can receive detailed crop choice options available for his field based on the inputted soil test parameters, agro climatic zone and weather forecast. This can help the farmer take an informed decision on planning his crops.

Based on sowing date and variety, a customized crop calendar and advisory of key farm operations like inter cultivation, irrigation, nutrient management etc. can also be generated and shared with farmer to enhance crop production efficiency/yields.

Salient aspects of weather related information of the farmer's location could be made available along with recent specific weather events, which may have triggered specific crop-related incidents (like better/low yield, pest infestation, disease infestation etc.) and also weather forecast for that geography. Again, this helps the production planning and irrigation management of the farmer.

Nearby agricultural advisory centres like Krishi Vigyan Kendras, extension centres of agricultural universities/institutes; agricultural research institutes and other such centres which farmers can approach for crop advisory can also be mapped and made available to the farmer users.

Agri land profiles can be prepared and yields can both be forecasted and also estimated using remote sensing helping in insurance and other financial operations leading to faster disbursements of loans and claims to farmers.

Remote sensing advancements have also made it possible to identify biotic and abiotic stress on the crop; thus, pest & disease forecast, can also be generated and shared with farmers to take preventive action.

3. Smartphones for Agriculture financing, Marketing and Supply Chain aspects

Marketing is an extremely important aspect of Agriculture. Given that millions of livelihoods depend on agriculture in India, accurate market information can go a long way in ensuring a fair deal to our farmers.

Smartphones can be used to deliver prevailing and past price information to farmers in their nearby markets (with customizable parameters like distance tec.) and options can also be provided for some triggers on specific price events. An advanced option may also provide price forecasts for crops.

Along with prices, all nearby markets/avenues (including eNAM availability, online channels servicing the area etc.) for crop sale as well as availability of agriculture inputs/seeds etc. can also be shown to the farmer.

Information of warehouses and other logistical information like transporters etc. can also be made available.

Digital quality assaying solutions that work via smartphones also being experimented with good results.

Smartphones also support digital Negotiable Warehouse Receipts (eNWRs) that can help the farmer avail finance against his harvest stored in the warehouse.

Agriculture based financial technology entities (Agri Fintechs) offer their services based on eKYC (know your customer), eNWRs and other digital channels as far as possible. This reduces both transaction costs and time. Smartphones facilitate these.

Direct exports of agricultural commodities like fruits, specific vegetables and other agricultural produce can fetch good returns for farmers. There are many regions in India where farmers still don’t have direct export linkages. In this context, an intervention that can

be tried is to provide a detailed step-by-step audio-visual module, which explains all the requirements from planning, grading, traceability norms and packing to eventual sale/export of the produce. Costs involved in production including risks, if any should also be covered. Not only this, this module should also be able to connect an individual farmer to the specific government personnel in the farmer's locality, an FPO (farmer producer organisation) or co-operative in the vicinity or even a private entity in his area carrying out similar export oriented trade of fruits etc. This way, a farmer growing conventional but lower value crops may be encouraged to diversify to a crop which may provide better returns. The module should be customizable so that an individual farmer based on some inputted parameters can understand his crop potential. This way, even a smallholder farmer can experiment with a high-value crop on a small portion of his land and generate better returns for himself.

4. Applications of IoTs, drones and smartphone sensors in Agriculture

Almalki, F.A et al. (2021), in their paper, present a low-cost platform for environmental smart farming monitoring system that is based on IoTs and UAVs (drones). The platform was tested and deployed in a real farm in Tunisia over a year from 2020 to 2021. The experimental results obtained suggest that due to the innovative integration between IoT sensors with drones it is possible to suggest automated and human-made sets of actions which can intensely boost crop productivity, saving natural resources. Thus, this low-cost platform can help farmers, governmental, or manufacturers to predict relevant environmental data over farms leading to enhanced productivity and cost-effective farm management. Further, the authors involved in the experiment suggest that implications of the results can lead to more elaborate future work that may include developing predictive machine learning algorithms, decision support systems that link the farm's smart devices together to achieve an autonomous system etc.

Gómez-Chabla et al (2019) have surveyed the literature around IoT Applications in Agriculture. Their major findings are that the main applications of IoT technologies in agriculture are found in precision agriculture, intelligent greenhouses (including hydroponic and small-scale aquaponic systems), vertical agriculture (which also allows controlling soil moisture by means of computers or mobile devices such as tablets and smartphones. Further, there are also IoT-based softwares available for agriculture. Major benefits of IoT in Agriculture as listed by the study include aspects like Agriculture can have better resource efficiency and enhanced quality of food by taking advantage of large amounts of data. Automatic irrigation and other agricultural processes that work according to temperature, humidity, and soil moisture values that are obtained through sensors can be implemented using IoTs. Direct to consumer business models, lower costs of production and Decision support systems that analyze large amounts of data to improve operational efficiency and productivity can be achieved/ operationalised by using IoTs.

According to Prasanna S. and Jebapriya J. (2020), a smart phone can be used to keep a farmer updated with the ongoing conditions of his agricultural land using IoT at any time and any part of the world. Use of smart phones or wireless PDA can easily monitor the soil moisture content and also control the irrigation requirements of the field.

Chandhini K. (2016) has conducted a literature study on agricultural production system using IoT as inclusive technology. The study states that IoT (in agriculture) is all about connecting systems so as to allow an integrated, multidimensional view of farming activities, enabling deeper understanding on how the whole ecosystem works. Nowadays, smartphones can also facilitate data gathering and synchronization in IoT systems. By using IoT, quality of agricultural products can be improved as farmers can observe the complete cycle from seeding to selling. The production system can be further improved to support more types of products and provide more services. Thus by using IoT technology, the efficiency of agricultural production can get a significant improvement.

Pongnumkul S. et al., (2015) have reviewed the literature around how smartphone sensors have been used in agriculture. They have categorised use cases of utilizing different sensors available in a smartphone like image sensor (camera), Global Positioning System (GPS), Ambient temperature sensor, Light sensor, Accelerometers, gyroscope etc. Some of these use cases have been categorised under the following areas of agriculture: Disease Detection and Diagnosis, Fertilizer Calculator, Soil Study, Water Study and Crop Water Needs Estimation, Crop Produce Readiness Analysis, HR Management and Farm Activity Journaling, Vehicle Monitoring, Agricultural Land Management, Information Localization, Pest and Disease Information, Market information, Extension Service Applications like Pest and Disease Inspections by Experts and Tools for Extension Workers etc. Thus there is an availability of a number of helpful smartphone applications for farmers via basic smartphones, because most of their reviewed applications use two sensors, cameras and GPS. The paper concludes that researchers and smartphone application developers, governments and agricultural agencies are able to identify and can respond to the agriculture needs that can be solved via smartphone sensors and apps.

5. Designing smartphone based interventions for farmers

Kenny U. and Regan ´A. (2021) led a very interesting study with Irish farmers on co-designing a smartphone app that empathises with farmers' values and needs. Their study

provides a greater understanding of the adoption and use of smartphones and smartphone apps by Irish farmers. The results reveal the following points about smartphone apps for farmers:

- Adoption is not uniform and usage varies across different farming sectors and farmers' ages
- Generally, apps that are simple and effortless to use, accessible to and easily understood by all and error free are attractive to farmers

The study also suggests that future research should focus on quantifying findings identified in their study. It also recommends, that on a general basis, for the design of new agricultural technologies, user needs, preferences, skills, and capabilities should be taken into account and focus should be on co-creation and co-development approaches. With specific reference to agricultural apps, the recommendation is that if these are designed in a user-oriented manner, farmers will perhaps use them more and benefit from them.

In India too, pilot projects are being undertaken under the India Digital ecosystem for Agriculture (IDEA) initiative by the federal Agriculture Ministry in collaboration with leading private sector technology companies as well as Agtech startups. In fact, most of the use cases that we have enumerated in this paper are being piloted by the different entities like Reliance Jio, ITC, ESRI, etc. We have covered these pilot projects in detail in a recent work (Beriya A., 2022).

6. Farmers' Willingness to pay for smartphone apps

Bonke V. et al. (2018) have explored different factors that may influence technologically experienced German farmers' willingness to pay (WTP) for agriculture smartphone apps (applications) and also assess different apps' usefulness from the farmers' perspective. Even though they found that 82.76% of the surveyed farmers indicated a willing to pay for a crop protection app but only 32.18% of the respondents had already used paid apps for any agricultural purpose. The study attributes this difference between WTP and payment in reality to the possibility that the available apps for agricultural purposes might not cover topics which farmers find worth paying for. Weather forecasts, identification of pests, diseases, and weeds related apps were considered to be useful apps by farmers. Very significantly, more than $3/4^{th}$ of the surveyed farmers deemed recommendations of manufacturers of crop protection products to be not useful. This result is interpreted by the authors as a perception that farmers view apps released by manufacturers as biased and thus emphasize that trust is a key factor in app acceptance. Other important results of this study are that the perceived potential of cost reduction, the perceived potential to reduce negative

environmental effects, the farmer's age, an agricultural university degree, knowledge of crop protection apps, as well as the farm size effect farmers' WTP.

7. Role of smartphones for citizen science in agriculture

A study (Dehnen-Schmutz et al., 2016) explores interest of European farmers in use of smartphones for citizen science in Agriculture and the study results indicate that there is a strong willingness amongst farmers to engage with citizen science for agricultural research. Farmers would want citizen science projects having an applied focus and where the project aims have been developed in a participatory manner, to ensure that research objectives have practical utility for farmers "on the ground"; at the same time, there is the potential need to support some of the work financially. Smartphone technologies, thus, offer great potential for participatory agricultural research and large scale data collection. In the quoted study context (European farmers), the farmers have sufficient access to and knowledge of smartphone technology, and they are also enthusiastic about citizen science participation, thus providing a basis for the wider application of smartphones in future participatory research projects in Agriculture.

8. Role of Smartphones in measuring the scope of agriculture as an economic agency/activity

a. Smartphones as interface to state policies and regulations (digital land records, crop survey, govt. schemes etc.): Information about government schemes, services and benefits; their eligibility criteria and steps to access these benefits for the farmers can be disseminated through digital channels. Applications for these schemes etc. can also be sourced using sms and smartphone applications etc. Land record and the processes involved with crop survey carried out by the respective state governments can also be digitized for faster and error-free completion and updation.

b. Accurate estimates of different aspects of agriculture: Smartphones can facilitate accurate data generation for individual level farm and farmer; this can be leveraged to define the precise extent of economic contribution of agricultural activities in the life and livelihood of farmer as well as extent to contribution to economy. Once an accurate estimate is generated, it can be used to focus on agricultural areas that need support for developmental breakthrough. In that sense, it will be also a real data driven process facilitated through the medium of the smartphone thus leading to enhanced economic prosperity of farmers.

9. Role of Smartphones as an agent of change driving sustainable agriculture

Smartphones can be used as a medium of awareness generation and nudges towards change. For instance, a farmer, Mr.F, is growing paddy and making Rs. X per acre; based on data available, targeted props on Mr.F's smartphone can be used to inform Mr.F that another farmer Mr. Y, around 15 kms away from Mr.F, cultivated marigold on his farm (similar to that of Mr.F's farm) and made 1.7X per acre. This is just to illustrate that a smartphone can be used for such 'nudges' to shift a farmer to diversify as well as hedge risks and other relevant, progressive and scientific agricultural practices. Such efforts can also lead to better environmental outcomes, thus enhancing sustainability.

10. Conclusion

We have listed a variety of scenarios covering smartphones use in agriculture and different use cases are possible. Implementation of such use cases over different crop seasons can generate data, which can be analysed to arrive at trends over a period of time. Using artificial intelligence, data modelling, and machine learning techniques, these insights can be used to fine-tune the offerings. As time advances and more and more data is generated, all the above can be better customized even upto the individual farmer/ his/her field. A very significant feature of using a digital approach is that extremely modular approach can be adopted and the customization can be drilled down to the very basic levels. As an example, in cultivation area above, if a farmer wants to view details of a very specific pest problem for a specific variety of a given crop, it is possible to design a digital solution in such a way that the farmer can directly browse to the specific point of his/her interest. Once these are tested and the efficacy of the interventions is established, business models can be set-up for the financial sustainability of these initiatives.

To summarise, smartphones could benefit the farmer in the following broad areas:

- Government interface like land records, crop survey etc. and in accessing government benefits for farmers
- Crop planning and cultivation (relevant advisories both macro and micro)
- Crop Financing and Markets
- Financial well-being of farmers and environmental sustainability

Smartphones provide good computing power and smart interfaces to do stuff; mobile apps can be used for most activities that can be done via interfaces. Moreover, smartphones have shown to be helpful in smart farm pilot projects with IoTs and drone technology and further development of these models on a commercial scale can be explored. The key, though, remains adoption by farmers; for the same, end user focus and factors that influence farmer willingness to pay (for paid apps) are the most important elements. This should be kept in mind while designing smartphone applications for farmers.

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