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Review Article

Information and Communication Technology for Well-Informed Farmers in Pakistan: Current Status and Immediate Proposed Solution

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Abstract: Owing to geographical location, agriculture is a vital sector for Pakistan's economy. Agriculture contributes 18.9% to the Gross Domestic Product of Pakistan therefore constant augmentation of this sector needs attention. Over the past decade, no major growth in the agriculture sector has been observed and a recent notable decline in crops has raised several concerns. Apart from natural disasters, a major reason behind this drop is outdated farming practices. Majority of the farms are cultivated and harvested using decades old techniques involving huge manpower and very low mechanization or technology. In this paper, current practices adopted in various farming stages in Pakistan were discussed. Alongside, the status of Information and Communication Technology (ICT) interventions in those stages is described. Reasons behind abstinence of technology into various phases of farming were also enlisted. After detailed description and analysis of the issue, guidelines to an ICT related solution which will be easily accepted by local and small-scale farmers was proposed.

Keywords: Crops, ICT, Mechanization, Developing country, Smart farming, Portal

1. INTRODUCTION

Since independence of Pakistan in 1947, agriculture has been considered as the backbone of Pakistan's economy. Agriculture in Pakistan majorly constitutes of crops, livestock, fishery and forestry. This particular sector is highly popular in Pakistan because of its geographical location, thus presenting favorable climate, adequate water supply and sufficient land for agricultural practices. The people of Pakistan, of which 63.33% [1] reside in rural area, 70% are either un-educated or only primary educated, tend to adopt farming practices for livelihood as it is presumed to require least amount of training and investment [2].

Agriculture collectively is reported to contribute to 18.5% of Pakistan's Gross Domestic Product (GDP) and absorb 38.5% of the labor forces of 2018 [3]. Within the agriculture sector, major crops contribute to 5.4% of the GDP. Fig 1 summarizes the growth percentages of crops sector since 2010 considering year 2005-2006 as base. Crop growth percentage is calculated as increase in crop mass over a period of time. The trend observed is alarming and calls for emergency measures to revive the sector. Keeping in view the annual population growth rate of about 2%, the corresponding trends in farming sector are inadequate both for self-reliance and commercialization and hence leading the country into economic crisis. The Government of Pakistan along with its ministry of Agriculture is constantly finding ways to increase the crop yield. Several non-governmental organizations like UNFAO, LMKT and CABI are also providing consultancy on how to revive the farming sector of Pakistan, yet desired effects have not been depicted by the statistics. Another disturbing fact is the increasing gap between small scale and large-scale farming practices and farmers. Therefore, a collective approach needs to be followed to uplift the current farming status.

Over the years it has been established that there are three major market drivers, 1. Climatic Change, 2. Water conservation, 3. Farming Efficiency. In order

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to uplift crop yield the major concern is to minimize cost and effort by adjusting various agriculture resources like seed, fertilizers, pesticides and energy consumption hence paving way for smart farming. This concept goes back to late 1990's when the farmers used satellite information to plan their work which now includes optimizing farming practices to local area and designing their tasks to elevate current crop yield and maintain sustainability. Smart farming requires intervention by modern Information and Communication Technology (ICT) which includes sensing technologies, software applications, positioning technologies, hardware based IoT systems and effective data analysis to provide personalized assistance to individual farmers. Overall smart farming or precision farming strategies can be applied to four stages of a crop cycle as depicted in Fig 2.

The idea of connected farms emerged which included managing and analyzing farm activities and archiving results in a Farm Management Information System (FMIS) [4]. Leveraging Internet of Things (IoT) domain, the idea of FMIS was extended to involve sensors and monitors to capture on ground situation using wired or wireless technology. Resultantly, robotics, geo-mapping and autonomous machines paved way into all stages of crop lifecycle. Most research on smart farming is based in Europe and North America. Fourth Revolution in Farming or Farming 4.0 [5] is claiming to produce 'more from less'. The focus is on bringing digital revolution in the agriculture sector by using big data for intelligent decisions. However, even in developed continents like Europe, the uptake of smart farming is still very low. On the contrary, in Pakistan the concept of Smart Farming is completely new and impermeable due to economic and social factors. The aim of this paper is to present a survey of current ICT interventions adopted by small-scale Pakistani farmers and analyze the reasons behind non-welcome of ICT amongst the farmers. In the end we present a viable solution which will be widely adopted by the local farmers if implemented.

2. CURRENT FARMING PRACTICES IN PAKISTAN

In this section we will discuss the current farming practices followed in Pakistan and mention the extent of technology permeated in the fields. The discussion will be done according to crop stages.

2.1 Seeding and planting

A very crucial step in a crop lifecycle is it a suitable sowing time and method. If this step is mishandled, crop tonnage directly decreases. To have a healthy crop, it is must to consider soil condition at the time of seeding. Proper soil analysis should be performed to quantify the nutrients and soil constitutes. However, orthodox farmers in Pakistan have no knowledge about soil analysis method. The soil analysis process is considered to be expensive and lengthy, which includes isolation of a soil sample, taking it to a test center and waiting for results. As of now, a total of 130 soil testing centers for agriculture exist in Pakistan. In 2017, an initiative was taken up by the Punjab Agriculture Department under their Project Management Unit to develop a mobile application called 2-Dot through which farmers will be able to view their soil test results on the smart phones and devices. Equipping the famers with smart devices is to be handled by the department as well. This is part of a three year project, which has yet not been deployed. Therefore, the cultivators still believe that crop rotation is an adequate strategy to cater for nutrient depletion and land degradation.

After soil fertility testing, a major step is sowing of seeds which must be carried out with calculatedly. The distance between seeds and their depth in the soil are crucial for plant growth and survival. Yet, conventional farmers in Pakistan are still using the old manual seeding method due to availability of cheap, untrained labor while compromising on seeding accuracy and time consumed. Major concerns arise in terms of Rice sowing which requires sowing of 4-6 weeks old seedling in standing water of depth of 20-30cm. Puddling water has raised concerns in South Asia in terms of water losses as well as degradation of soil quality due to structural breakdown. Efforts are being made to employ Direct Rice Seeding (DRS) during which rice seeds will be planted directly into the soil. This method will control water usage and will require no tillage for the next crop. However, farmers are reluctant to use this method due to poor germination and high rate of seed mortality in case of adverse climatic conditions.

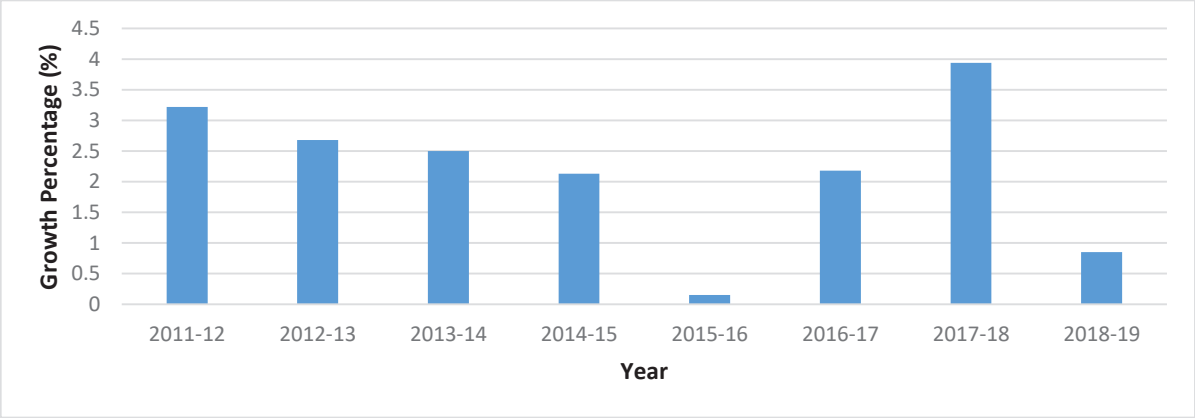

Fig. 1. Annual crop growth percentages in Pakistan form 2010- 2019 [3]

Fig. 2. Crop Stages

2.2 Watering and Irrigation

In the sub-continent, traditionally, irrigation water was taken out from wells using pulley system with the help of animals or humans. Tube wells were introduced in late 1970's which used electricity to pump out water from the wells. They were faster than manual wells but were expensive to install and maintain. Still in late 1990's, tube wells became a widespread technology for pulling out underground water for irrigation [6]. Of the 1.1million tube wells installed in Pakistan, 30% of then are operated by electricity. Due to electricity shortage and expenses, a shift towards solar powered tube wells was observed after 2010. However, two issues still exist. 1) The installation cost is very high and only high-income farmers can afford it, 2) Water wastage is a concern. The government promised subsidized rates and banks were asked to finance the small farmers but still not many solar powered tube wells are observed.

In 2005, the concept of micro irrigation erupted which uses low pressure water for direct irrigation to the root zone. A well-known application of this technology is the Drip Irrigation System (DIS). Its main principle is to apply water and other inputs slowly, regularly, and frequently as close to the plant roots as possible through emitters installed on plastic pipes laid out in the field. Regular and timely availability of nutrients throughout the plant growth period as per exact requirements and maintenance of favorable soil moisture conditions facilitate to maximize crop productivity. DIS has become the most valued innovation, which optimizes use of water and fertilizers by enhancing the irrigation efficiency as much as 95 percent. The government of Pakistan along with several service providers are advocating the use of drip irrigation system however only 0.1% of the cultivated land is irrigated by DIS. Sprinkler Irrigation System is a more widespread form of efficient irrigation system being used for sprinkling irrigation water like rain over the crops. However, its efficiency is much lower than the DIS.

2.3 Weeding and Crop Maintenance

Crops require constant and consistent care through all stages after sowing. The most critical stage for any crop is it growing season. It needs to be guaranteed that required soil nutrients, pH and moisture are available for the seed to sprout and grow. However,

this phase is highly affected by climatic changes, natural disasters and various pests and diseases. These factors directly impact the quality and quantity of the crop yield. Unfortunately, Pakistan's farmers are least informed and/or prepared to handle this phase.

A very small percentage of farmers use the climatic forecasts to plan their crop cycle. The local farmers are un-aware of rainy days, dry periods, or flood predictions mostly because they do not own smart phones or televisions and not enough firsthand information is delivered to them timely by the authorities. Even if they are informed about the weather conditions, they do not have the capability to handle the adversity.

Weed on the other hand accounts to 20-30% of the losses in different crops on average. The diverse climatic conditions of Pakistan are very favorable for various types of weed growth. Weed invades the farm land while consuming vital nutrients from the soil and providing shelter to pest and insects. In Pakistan, the main effort for eradication of weed is to perform tillage before cultivation. Conventionally it was done manually or with help of animals, but later with the advent of mechanization in 1970's, tractors were used for this purpose. Pakistan has achieved 95% localization in terms of tractor production and is producing lowest priced tractors in the world [7]. However, it must be noted here that tractors are by far the most common farm machines still penetration in Pakistan stands at 0.9hp per acre as compared to average international norm of 1.7hp per acre. This is mainly due to unaffordability of tractors for the local farmers but it must be documented that an average landholding size is approximately 12.5 acres which makes the use of tractors for weeding unfeasible [7] .

The other most critical reason for low crop yield is in adequate crop healthcare. Disease and pest detection is most commonly done by visual inspection of the farm which makes the process vulnerable to human error. Further alleviating the situation is the lack of training of the farmer, who is unaware of the disease identity, types or level; thus, most of the disease go undiagnosed or are wrongly treated. The wrong dosage of incorrect chemical agents has an adverse effect on the produce as well as the environment. In past years, Pakistan's cash crops have been hit by major pest invasions by the Whitefly, Locust, Corn Borer etc. These pests majorly migrate across borders and hence the farmers are unable to identify and tackle them while they are in larvae stage. Once fully grown, these pests require heavy pesticides to kill them otherwise they cause emergency situation all over the country. Several engineering research institutes of Pakistan are underway of designing autonomous land and aerial vehicles for timely detection of disease and pests. Several projects involve using aerial vehicles for pesticide spray, but all the projects are at initial level of maturity and experts are of the opinion that such advance and expensive technology will take much time for locals to adopt it.

Another alarming fact about Pakistan's agriculture is that soil analysis is almost never performed by local farmers. Resultantly, the farmer is indifferent to actual contents of nutrients in the soil and thus introduces redundant fertilizers. The three most essential nutrients for cultivatable soil are Nitrogen, Phosphorus and Potassium, commonly called as NPK. But because soil analysis is never considered, local farmers simply follow the guidebook and present the soil with redundant fertilizers. The most common choice of fertilizer is Urea which replenishes the soil's nitrogen while other nutrients are commonly ignored. Urea is chosen due to its lower cost as compared to phosphate and potash which are import dependent. Due to this imbalance of chemical fertilizers and aforementioned pesticides, the customers are now being inclined towards 'Organic foods', which might further effect the local farming market.

2.4 Harvesting

Crop harvesting time in Pakistan is greeted with joy as families, adults and kids all lend a hand to earn yearlong income. Due to a large population, Pakistan is awarded with cheaply available labor. Pakistan's hand-picked fruits and vegetables conquer the imports when it comes to Mangoes and Oranges. Therefore, mechanical harvesters are used in large wheat and rice farms only, while rest of the harvest is dominated by men, women and children of all ages. As this is the earning time for Pakistan's rural population, not much heed is given in terms of automatic or autonomous harvesting via machines. Still there is a nationwide concern when it comes to

manual picking of cotton due to high temperature, chemical laden crop and thorns.

3. MATERIALS AND METHODS

In Pakistan, the total area under cultivation is about 50 million acres and there are approximately eight million farm owners. An overall fact is that the yields are very low and the cost of inputs is very high; as a result, farmer economics are not very good. This repeating cycle has forced this country to depend on imports for food security. In fiscal year 2017-2018, average wheat yield in Pakistan was 2580 kg/ha while its neighbor India averaged to 3500 kg/ha. These numbers are minimal as compared to high end wheat producers Ireland and New Zealand with nearly 10,000 kg/ha. 'Doing the right thing at the right time' is the advice given by Eric, the highest wheat producer of the world in 2017 [8]. Hence there is a dire need to increase the yield per hectare according to the given advice.

Keeping in view the overall illiteracy rate (38%) and the number of people using internet (15.51%), very advance and internet enabled solutions might not be feasible. The start-up key is to have well informed farmers. In Pakistan information to farmers is delivered via television or paper-based notes. Many organizations like National Agriculture Department, Centre for Agriculture and Bioscience International (CABI) [9], LMKT [10] etc hold workshops and gathering to educate the farmers. However, this method of information delivery is outdated. Hence, introduction of e-farming is much needed. Many platforms like Pakissan.com [11], Agribusiness.com.pk, geo-solutions.it and AMIS.pk are available for the farmers who are willing to look for relevant information for their farms. Mobile applications like E-Kissan, AgriHunt, Jazz Bakhabar Kissan, are also available for those who have smart phones. However, the percentage of such people is very less, and the information provided on these websites are not localized or synchronized. Due to this, the local farmers are not confident about such electronic information. The success of e-farming in Pakistan will emerge once the cultivators are provided by personalized information about the climatic forecasts, soil condition, possible natural calamities, pest invasions etc. The necessary local information must be communicated to the farmers via the most used Global System for Mobile Communications (GSM) network. This provision of information must be free, accurate and user friendly for it to gain popularity. A complete e-farming portal must include the following features:

- Provide Interactive Voice Response (IVR) in local languages
- Suggest appropriate fertilizers according to soil conditions of that farm
- Provide a direct link between a farmer and chemical dealers to obtain fertilizers, fungicides and pesticides at subsidized rates
- Provide an expert system to suggest an optimized crop calendar to the farmer so they are prepared
- Support image exchange in case the farmer is unclear about plant health
- Intimate farmers about schemes and governmental policies regarding relief granted to cultivators
- Locate nearby soil testing service, tractor renting facility and overall improve local farmer networking
- Provide a web as well as mobile application

For success of such a portal, time will be needed. The providers must ensure accuracy of timely delivered information. Once the farmers' faith in technology has established, more advanced and far-fetched project will be feasible and demanded.

4. CONCLUSIONS

The statistics of country wise crop yields clearly indicate that despite adverse climatic conditions or insufficient water, some countries have been able to achieve record crop yields leveraging engineering and technology. Pakistan, on the other hand, is blessed with suitable climate, stable terrain and sufficient water from the Himalayas and Hindukush ranges can be promised immense gain in crop yields by taking up the challenge of accurate advising of the farmers via e-farming.

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