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LEVERAGING AI AND SMARTPHONES FOR SUSTAINABLE AGRICULTURE IN SINDH, PAKISTAN: A CONTEXT AWARE FRAMEWORK

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Abstract

Agriculture sector contributes a large amount in the economy of Pakistan; agriculture land has contributed in the development of Pakistan in various ways; agriculture contributes about 24% of GDP Gross Domestic Product). Agriculture industry has been dealing with many problems in the recent years, for example, decrease in harvest yield, increment in information costs, lack of electricity. Major cause of these problems is lack of information sourcing systems. The available sources through which farmers are getting information are Mobile Phones, Television and Radio but not making use of Smart Phones. Agriculturists and government experts need to realize the effectiveness of the precision technologies in Pakistan through field investigations and land the board practices. Smart farms have already been introduced in the developed countries. This research bridges the gap between the farming in the Pakistan by adding an element of context-awareness.

INTRODUCTION

This research will provide a bridge between a technology and a traditional way of farming. Economic development of a country depends upon the agricultural so the important factor is to increase the cultivated areas for the good production, farmers must be fully informative. Technology will help them to gain the information as smart phones are easily available. Recent source of information the farmers are using are common communication methods or on the basis of their previous experiences. This research will provide the agriculturist the appropriate information in a short time with the context. This research can be implemented in the agricultural fields of Pakistan, especially in the Sindh zone. Smartphone-based systems can provide relevant, real-time information.

The available sources through which farmers are getting information are Mobile Phones, Television and Radio but not making use of Smart Phones [9]. Technology alone will not solve these problems but can aid to acquire, remember and process the data to turn it into the information, and achieve more optimal control of machines and processes [15]. Pervasive Computing promises to embed the devices into the real life, invisibly [6] as Ubiquitous computing is emerging in agriculture field is emerging rapidly, many applications of the system are growing in various fields of agriculture field. Smart farms have already been introduced in the developed countries and taking a great advantage by using the latest technologies, to connect physical world with pervasive networks there is a need to connect the things smartly

[12]. While developed countries benefit from smart farms, Pakistan lags due to lack of such systems [10,11].

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Challenges, Issues and Implications of Precision Agriculture in Pakistan:

Pakistan is a rural nation, yet the horticultural area can't deliver the potential dimension of creation from the current assets. This is credited to the absence of usage of present-day advances in farming, little landholding and high information costs. Absence of mindfulness is the most importantly purpose behind this poor start of accuracy agribusiness in Pakistan. The ranchers who know about these advances, the correct purposes behind their hesitance in execution of accuracy horticulture in Pakistan incorporate littler homestead measure (< 1 ha), arrive residency framework, surprising expense innovation, inaccessibility of innovation locally, heterogeneity of trimming frameworks or harvest assorted variety and absence of specialized ability and learning. Maybe the two noteworthy issues towards its execution are little landholdings and mind-boggling expense of this innovation. Different difficulties towards the appropriation of exactness rural innovations in agribusiness are as per the following:

• Introducing accuracy agrarian innovations in ordinary farming requires current advancements, for example, shrewd PCs, remote sensors, proximal sensors, yield screens, actuators and variable rate utensils together with capability to utilize present day GIS programming for joining GPS data in the yields of exactness horticultural advances. Right now, there is no such office in the nation and in this manner presentation of these advances will take a more drawn-out period.

• As 93 % of agriculturists have smallholding (Ghafoor et al., 2010) and utilization of these advancements may not give equivalent advantages, for example, factor rate use of sources of info constant. Be that as it may, the administration of zones can be effectively portrayed by utilizing remote and proximal sensors to describe soil and yield qualities.

• Heterogeneity of editing frameworks is likewise a test in the selection of exactness horticulture in the nation.

• The absence of enactment from the legislature towards utilizing ecological amicable generation rehearses in agribusiness is a major obstacle in such manner. Natural cultivating and controlled utilization of homestead inputs are the key methodologies in this regard, which can accomplish manageability in horticulture, enhance human wellbeing and essentially lessen the ecological defilement, for example, ground water and soil tainting with exorbitant synthetic substances and composts. The administration should step up with regards to deliver these issues to get supportability farming.

• In created nations, there are talented associations and organizations in private area that give consultancy administrations to ranchers to utilize accuracy advances and get potential advantages. Tragically in Pakistan, there are no such organizations in private segment that can give such consultancy administrations to ranchers. On the off chance that there is any office/association, it doesn't have such ability to persuade ranchers.

• Agricultural hardware producers are not all that talented and mindful about these advancements yet. They ought to be upheld to present the modernization in agrarian segment with the assistance of research and instructive foundations.

• The low fare volume of farming items is likewise a reason of ignorance of these advanced innovations in horticulture. In present day world, individuals are requesting more secure sustenance, which contain low or least measure of synthetic concoctions. The opposition in the worldwide market will drive neighborhood agriculturists to utilize these advanced advances for delivering more secure nourishments [8].

• Cheap and tremendous land can be developed with traditional kind of farming, yet accuracy advances may fit better in the nation on account of little landholding and high costs of land to get most extreme profit by the constrained land assets [13]. Reasons include small landholdings, high input costs, lack of modern technology, and limited awareness (Mahmood et al., 2013).

Additional barriers include absence of supportive legislation, weak consultancy services, and unskilled agricultural machinery manufacturers (Zakar & Zakar,

2009). Internationally, precision agriculture has demonstrated significant benefits (Singh et al., 2023).

The Missing Link in Pakistan's Agriculture Sector:

The more significant expense of creation has never-endingly been frequenting the agriculturist compose in Pakistan. This, together with natural change impact, has been acknowledging poor make and negative headway rates every so often. This article is an endeavor to look at the conceivable aftereffects of utilizing improvement to accomplish cost sensibility and to assist ranchers with upgrading results.

Agriculture area is the establishment of Pakistan's economy as it contributes around 20 percent in the general hard and fast national yield (GDP) – which addresses the all-out estimation of every single staggering and associations passed on inside the economy amidst a specific period-and is additionally a vital wellspring of work [14]. It helps meet the sustenance fundamental of routinely developing masses, giving foul materials to all the major mechanical zones including materials, calfskin, sugar, flour getting ready, and so forth., and has an immense movement in diminishing provincial urgency.

According to Economic Survey of Pakistan (ESP 2015-16), out of absolute obligation of developing to the GDP authentic things contribute 4.67 percent to the GDP, particular yields 2.25 percent, animal's 11.61 percent, fisheries 0.43 percent and officer advantage 0.41 percent each.

This segment besides gives 65 percent of the all- out sections of Pakistan. Further breakdown demonstrates 73.2 percent is cotton and cotton-based things while trademark thing, rice, subdued animals and others contribute 26.8 percent.

As shown by the ESP 2015-16, the agribusiness part offers work to 42.3 percent of the nation's complete work impel while in Punjab it offers work to 43.5 percent of the comprehensive network in the area, and to in excess of 61 percent in the country locales.

In like manner, when Pakistan is separated and the straggling remains of the world reliant on developing zone, the nation positions ninth in wheat age, eleventh in rice creation with an edge of having fragrant long grain basmati, fourth in cotton age, and fourteenth in sugarcane with close incredible position in mango, citrus and dates. Correspondingly, in prepared animals it is second in bison's masses, thirteenth in dairy bovines, and ninth in sheep and third in goat while in drain creation Pakistan's standing is at fourth spot on the planet. These figures depend upon the report 'Future Direction of Agricultural Diversification' by Dr. Azeem Khan, Director General of National Agricultural Research Center (NARC), Islamabad.

In spite of these amazing numbers, the development piece, which has by and large maintained an exquisite improvement to guarantee sustenance security for our making individuals, inevitably faces a basic preliminary of low comes back to agriculturists in light of progressively imperative expenses of age. The illuminations for, among many, are uncertified seeds, fake or unacceptable pesticides and herbicides accomplishing low yields of a few collects particularly cotton—which is the key money change and gives unpleasant material to the best entry region of the nation i.e., materials [16].

The year 2015-16 saw shocking execution of the developing part when it selected negative progression of 0.19 percent against 2.53 percent of a relative period in last monetary year. The last negative improvement in developing was seen by the nation in year 2000-01.

High production costs and climate change have reduced yields, with uncertified seeds and substandard pesticides compounding the problem (Economic Survey of Pakistan, 2015-16). Despite strong global rankings in wheat, rice, cotton, and dairy, Pakistan's agriculture growth remains volatile (Khan, 2016).

A Developed system according to the needs:

This system will be working with users, devices, database, severs and Google maps.

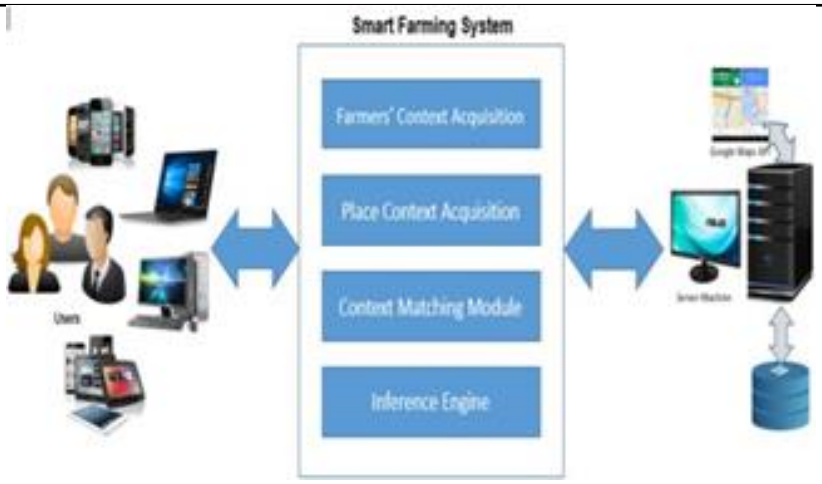


Figure 1. Farmers' Context Acquisition Mode

Farmer's Context Acquisition:
Context is the situation in which something is to be happen, Acquisition means the process of Getting something. In farmer's context acquisition system needs to take farmer's data and the context of the farmer, where actually farmer is working, what are the farmer's need that all will be set in database, which shows the matching results when a farmer needs the things at high time.

1. Farmers' Context Acquisition (Profile, Status, Affordance etc. of the Farmer)
2. Place context Acquisition (Location Vocabulary)
3. Context Matching Module (Knowledge Management, Mapping)
4. Inference Engine (Rule Engine to provide the results)

Place Context Acquisition:
In place context acquisition data of farmer's location will be collected.

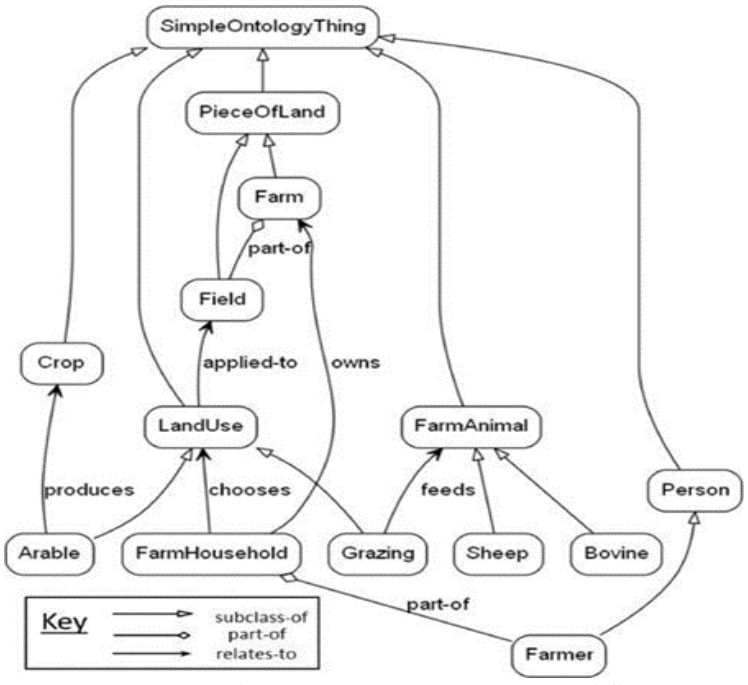


Figure 2. Place Context Acquisition Workflow

In place context acquisition data of farmer's location will be collected.
Where farmer will cultivate

Context Matching Module:
In this phase the farmer's data which was collected matches with the database and inference engine, to provide all the information to the farmer and facilitate him.

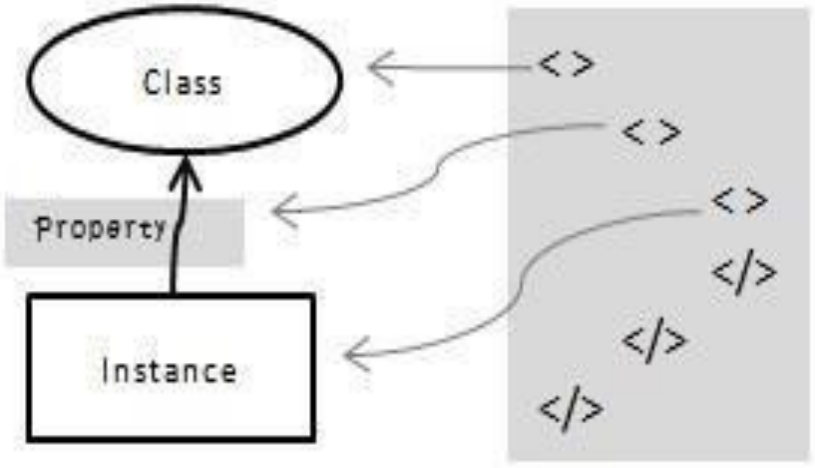


Figure 3. Context Matching Module Design (Xu, Wang, & Li, 2024)

Inference Engine:
It's a rule engine which applies all the algorithms to the rest of the system.
Some of the semantic rules for the context model are mentioned here:
$hasPlace(?\ fm, ?\ pl)$ Ù $(?\ t) \rightarrow$
$isCropping(?\ fm, ?\ wheat)$

Where fm is a farmer, pl is the name of a place, t is the time zone and wheat is the name of the sowing.

User Interface Design:
The front end design of the inference engine is shown in Figure 4 below:

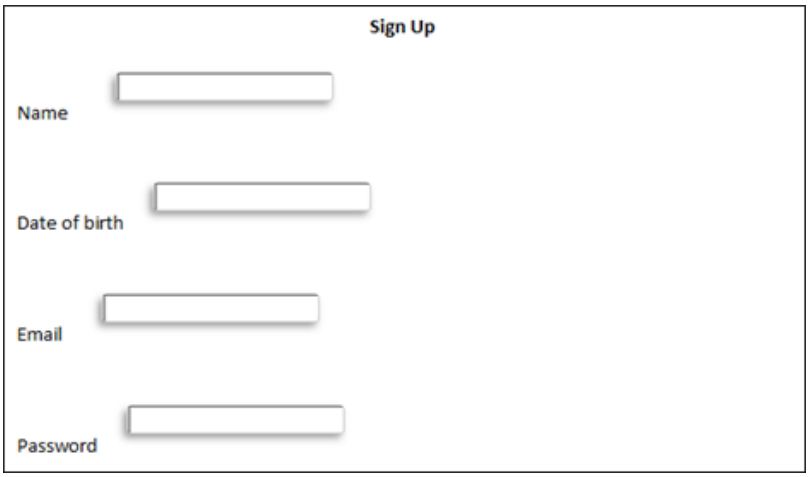


Figure 4. Inference Engine Rules (Zhang et al., 2022)

Conclusion and Future Work:
The usage of smart phone technology is in the farmer's life in specific and farming in general is enriched. The context of the user is acquired to provide the appropriate and relevant information to the farmer's aid in the decision-making process by

consuming less time and processes with the usage of smart phone technologies. To utilize the context-aware system smartly.

- Smart Farming (agriculture)
- Structured Data
- Vocabulary
- Knowledge Management
-

Research Gap and Open Areas:

Despite the conceptual framework proposed for a smartphone-based, context-aware information sourcing system for farmers in Sindh, several gaps remain that hinder a its transformation into a fully functional, scalable, and impactful solution. While the study addresses the need for timely, location-specific agricultural information, it does not implement or evaluate the system in real-world farming environments. Additionally, the model lacks integration with advanced technologies such as IoT-based sensors, AI-driven predictive analytics, and blockchain-enabled transparency, all of which have shown substantial potential in precision agriculture internationally.

Another major gap lies in the adoption and awareness barrier among smallholder farmers, where socio-economic, educational, and infrastructural limitations impede technology acceptance. The framework also does not address the long-term socio-economic impact of such systems or measure their contribution to productivity, income stability, and sustainability.

To bridge these gaps, the following open research areas are identified for future work:

Localized Context-Aware Mobile Applications:

Development of mobile applications in local languages (Sindhi, Urdu) with intuitive user interfaces and voice-based interaction for illiterate farmers. These applications should integrate the farmer's profile, crop type, and environmental conditions to deliver personalized recommendations [1].

Integration with IoT and Sensor Networks:

Linking smartphones with IoT-based sensors (soil moisture, pH, temperature, drones) for real-time monitoring and automated alerts. This integration can improve decision-making accuracy and reduce input wastage [1].

AI-Driven Predictive Analytics:

Using machine learning algorithms to forecast crop yields, detect pest outbreaks, and provide data-backed suggestions for crop management. Models can be trained on historical yield data, weather patterns, and soil parameters [2].

Block chain for Supply Chain Transparency:

Implementing block chain platforms to trace the origin of agricultural produce, ensure fair trade, and reduce middleman exploitation. Block chain-enabled traceability can also help meet export quality standards [3].

Farmer Training and Adoption Strategies:

Designing a training framework to improve digital literacy, increase awareness of precision agriculture benefits, and address socio-cultural barriers to technology adoption [5].

Location-Based Decision Support Systems (GIS-Enabled):

Enhancing the context-aware model into GIS-powered advisory systems to deliver location-specific alerts such as nearby crop disease outbreaks, pest migration, and government subsidy opportunities [4].

Socio-Economic Impact Evaluation:

Conducting longitudinal studies to assess how smartphone-based precision agriculture affects farmer income, crop productivity, environmental sustainability, and rural livelihoods. AI-driven predictive analytics, blockchain for supply chain transparency, and farmer training programs to increase adoption [2].

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