# IoTization and Cloudification of Agriculture in Rural India

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**Abstract—***We know a vast population of rural India is dependent on agriculture today. As per the land use statistics 2011-12 the net irrigated area is 65.3 million hectares and the Agriculture and Allied Sector contributed approximately 13.9% of India's GDP during 2013-14 which is substantial [as per Annual Report 2014-2015 by Hon. Ministry of agriculture [1]]. We have wide variety of new smart technologies available today, to address different problems in various industries. A more practicable use of these smart technologies plays a vital role in order to address the agriculture field level problems, maximize predictability and minimizing costs. New stack of technologies like electronics, sensors, drones, software and their connectivity, which in a nutshell called Internet-of-Things (IoT) along with cloud computing, are recently proving to be a boon to major industries like retail, manufacturing etc., to improve their large and complex workflows. These technologies are also proven to be lowering their operational costs, automating their management and thereby increasing their productivity/profits [2]. This paper will analyze how to apply these patterns and some of the current technology barriers rural India is are facing today like low internet connectivity, no regional language readiness of technology services, cost of maintenance etc., that are hindering rural population's technology usage and how IoT, devices and cloud computing technologies can be promising alternatives to overcome these problems. Over the course of paper, we will also design a better practical framework combing existing software tools, IoT and cloud computing technologies on any given public cloud platforms (in this paper we consider Microsoft Azure [3] as cloud platform) today.*

## 1. INTRODUCTION

Vast population of rural India is dependent on agriculture today. As per the land use statistics 2011-12 the net irrigated area is 65.3 million hectares and the Agriculture and Allied Sector contributed approximately 13.9% of India's GDP during 2013-14 which is a huge contribution. The world's population is going to be more than 9 billion in the coming years, with nearly all of the growth occurring in less developed parts of the world where agricultural productivity is relatively low, such as Sub-Saharan Africa and Asia. According to the Global Harvest Initiative (GHI), 49 percent and 41 percent of our growth is expected to occur in Sub-Saharan Africa and Asia, respectively [4]. To meet this demand food production should also increase by an estimated 70 percent, and almost double in developing countries [5].

Based on the facts, it is important to realize improving agriculture process is paramount for Indian economy. For this below are the growth drivers of Indian Agriculture.

i. Government & policies

ii. Genetic Engineering

iii. Use of technology

Given below are the It is considered that sole use of technology cannot help Indian agriculture totally.

Use of latest and greatest technologies like Internet-of-Things (IoT) and cloud computing, are helping various industries to simplify their processes and supply chain; thereby increasing their overall productivity. Realizing this, major players like Intel, Microsoft, IBM, Google and Amazon had heavily invested in their cloud computing platforms and are providing best in class services readily available to end users. Unfortunately, agriculture in India is one discipline which is mostly ignored and lacking this momentum to use these technologies

## 2. OBJECTIVE

The objective of this paper is, on a high level, decode agriculture process in rural India and provide a blueprint of how to practicably use new stack of technologies like electronics, sensors, drones, software and their connectivity, which in a nutshell called Internet-of-Things (IoT) along with cloud computing to address the agriculture field level problems, maximize predictability and minimizing costs. Though out this paper for practical approach, we consider Microsoft Cloud computing offering called 'Microsoft Azure' to describe cloud computing.

## 3. PROBLEM

A more practicable use of smart technologies like IoT and cloud computing in order to address the agriculture field level problems, maximize predictability and minimizing costs.

## 4. KEY BARRIERS

### 4.1 Growth drivers of Indian Agriculture

It is considered that sole use of technology cannot help Indian agriculture totally. Below are the growth drivers of Indian Agriculture.

i. Government & policies

ii. Genetic Engineering

iii. Use of technology

### 4.2. Challenges for IoTization and Cloudification of Rural Agriculture

Before discussion about feasibility of implementing technologies like IoT and cloud technologies in general, let us discuss problems in rural India in adopting technology in general. Below are some of the operational and technical challenges today to use any kind of technology in rural India.

#### 4.2.1. Penetration of Smart phones in rural India

The major challenge to use technology in rural India is lack of connectivity and use of smart phones. Yet India is expected to have 236 million mobile Internet users by 2016, says a new IAMAI-KPMG report. It further projects that mobile internet user base will reach 314 million by 2017. With these trends evident it can be safely assumed that mobile device penetration in rural India is happening. It is just matter of time every home will have a smart phone with minimum capabilities all over India.

#### 4.2.2. Connectivity in rural India

As per The Indian Telecom Services Performance Indicators report by TRAI the number of telephone subscribers in India increased from 957.61 million at the end of Sep-14 to 970.97 million at the end of Dec-14, registering a growth of 1.40% over the previous quarter. This reflects year-on-year (Y-O-Y) growth of 6.09% over the same quarter of last year. The overall Tele-density in India increased from 76.75 as on 30th Sep-14 to 77.58 as on 31st Dec-14 [6]. As per report the share of the Rural areas increased from 40.52% at the end of Sep-14 to 41.06% at the end of Dec-14 making nearly half of Indian rural population access to internet.

The question is on how to provide internet access to rest of rural population? Innovative ideas like Google's Project Loon, Facebook's Internet.org and Microsoft's White Spaces are looking to solve this issue on a global scale but not yet available in India as of today. Also minmum bandwidth available for rural india is also a challenge. Initiatives like AirJaldi, Bharat Broadband, Satellite Internet etc., are also playing their role to reduce the gap, but still the gap is significant and to be addressed with a combination of technology advances with Government initiatives.

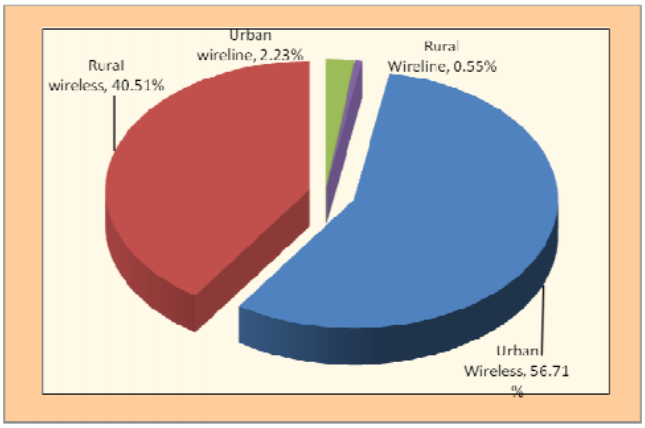


**Fig. 1: Composition of Telephone Subscribers [6]**

#### 4.2.3. Use of technology in regional language

India is a huge diversified country. According to Census of India of 2001 [7], India has 122 major languages and 1599 other languages. This pose a huge challenge in terms of technology usage since the primary medium of any technology device today is English. Even though some of new initiatives like Skype translator [8] etc. and Cortana service are trying to solve this problem globally, it takes considerable time and effort to make them a reality in India.

#### 4.2.4. Cost of implementing new technologies

As per ruralpovertyportal.org by 2014, out of 857 million rural populations, approximately 220 million are poor. This is a major challenge unless the technology provided for this population is cheap (if not free), there will be very less chance of adopting it. Cloud computing is one technology that can solve this problem to some extent.

## 5. KEY DEFINITIONS

### 5.1 Cloud computing

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models. The emerging cloud abstracts infrastructure complexities of servers, applications, data, and heterogeneous platforms.

Service providers like Microsoft Azure, have their offerings ranging from infrastructure to ready to use software for specific needs. For instance, as per Microsoft Azure [3] is Microsoft's cloud computing platform, a growing collection of integrated services—analytics, computing, database, mobile, networking, storage and web—for moving faster, achieving more and saving money. This means that all the services are ready for end user for consume and pay as they use.

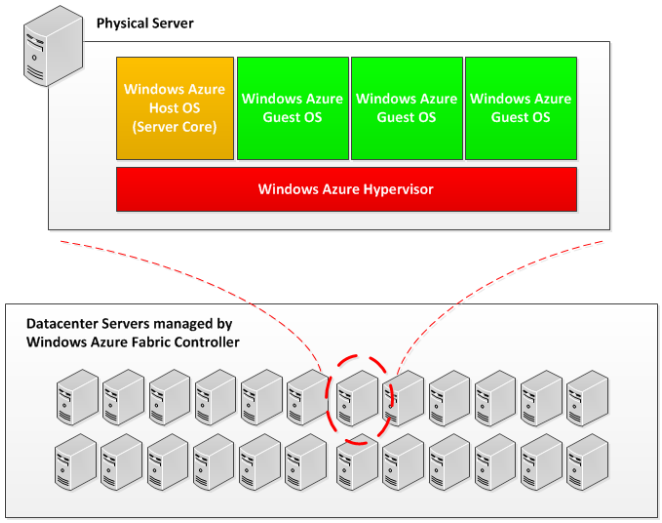


**Fig. 2: High level diagram of Microsoft cloud platform that shows the model how the services are managed and shared for public access**

What this means in a nutshell, Cloud computing is a model that provides you virtually multiple data centers with all their capabilities like hardware (Infrastructure-as-a-Service), services (Platform-as-a-Service) and software(Software-as-a-Service); at disposal, as long as consumer pay for it. Once an end user register for any public cloud platform they are free to use any services and can build custom applications using any services available with no initial hardware or software costs and which are powered by services provider's data centers. In case of some public cloud platforms like Microsoft Azure, cost of using these services is calculated per minute. This strategy of using public platforms provide huge benefits like.

#### 5.1.1. Low cost of implementation

Since the infrastructure is not procured, rather it is rented in case of a public cloud, the cost of implementation can be controlled to the extent of the capital investment to be almost zero. All the investment made should be on the basis of usage. Moreover, wherever possible, if existing software available on cloud is used, following Software-as-a-Service model, the cost and time of developing a custom application can also be reduced.

#### 5.1.2. High pace of innovation

Cloud computing can help to increase the pace of innovation. The low cost of entry to new markets helps to level the playing field, allowing any company or individual to use processing capabilities more effectively. This can help to increase the pace of innovation and with many innovations being realized.

#### 5.1.3. Unlimited capacity

Cloud computing virtually provides unlimited capacity at disposal. If application architecture demands, all the services in entire datacenter can be used seamlessly.

#### 5.1.4. Zero maintenance costs

In cloud computing world all the data centers are maintained by external services providers who take care of managing them on day to day basis securely.

### 5.2 Internet of Things

Internet of Things or IoT refers to an environment where every object, living or non-living are identified by a unique indentifier and transmits data over network without any interaction of any form. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) and the Internet. A 'thing' in Internet of Things can be any person or a farm animal that can be assigned an Internet Protocol (IP) address and can transmit required data over internet. Normally this data is crucial in analyzing and making decisions.

## 6. EXPLAINING AGRICULTURE PROCESS BY PDCA CYCLE

**PDCA** (**plan–do–check–act** or **plan–do–check–adjust**) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. It is also known as the **Deming circle**/**cycle**/**wheel**, **Shewhart cycle**, **control circle**/**cycle**, or **plan–do–study–act** (**PDSA**) [9]. PDCA cycle can be applied to agriculture like any other businesses to improve overall productivity.

In general, PDCA steps are explained as follows:

- **Plan:** Establish the objectives and processes necessary to deliver results in accordance with the expected target or goals.
- **Do:** Implement the plan, execute the process, make the product. Collect data for charting and analysis in the following "CHECK" and "ACT" steps.
- **Check:** Study the actual results (measured and collected in "DO" above) and compare against the expected results (targets or goals from the "PLAN") to ascertain any differences.
- **Act or Adjust:** If the CHECK shows that the PLAN that was implemented in DO is an improvement to the prior standard (baseline), then that becomes the new standard (baseline) for how the organization should ACT going forward (new standards are enACTed).


**Fig. 3: Applying PDCA to agriculture**

## 7. PROPOSED SOLUTION–USING IOT AND CLOUD COMPUTING

Plan phase of agriculture broadly contains field management, crop water management and knowledge management. Proposed solution tries to apply IoT and cloud computing technologies to plan phase to ensure rest of the phases are improved to large extent.

Application of new technologies like electronics, sensors, drones, software and their connectivity via Internet-of-Things (IoT) along with cloud computing to agriculture is a new dimension of our solution.

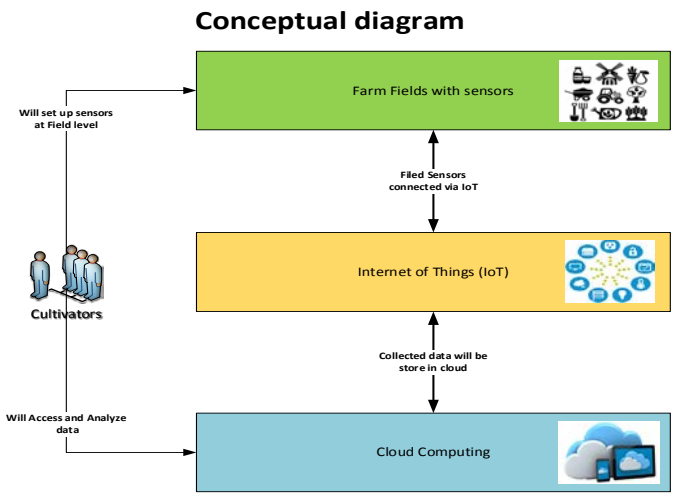


**Fig. 4: Conceptual diagram of our proposed solution**

## 8. DETAILED SOLUTION

Our proposed solution consists of major data flow between solution components Filed sensors, IOT and Cloud computing

**IOT** is applicable in major attribute of Agriculture like Observation, Inspection, and Identification.

**Cloud computing** is applicable in Decision making, Record Tracking and Data Management / Learning

- Proposed solution contains a IoT layer where data is collected from field sensors and other Intelligent Systems via a service called Intelligent Systems Service (ISS) agent. These IoT devices are mostly sensors ranging from smart sensors or even satellites that can take aerial images. Problem here is most IoT solutions today have been fragmented — either custom and unrepeatable or incompatible with existing infrastructure, with incomplete and unprotected data access and insights. To overcome this problem, a practical solution is to have different SDKs built in to the devices in farms ranging from sensors and field vehicles that can supply or transfer data to a public endpoint of a service on internet. This is ISS as a whole takes care of device registration and their management; and acts as a single point of collection unit and transfers data to cloud.
- This data collected from various device sources will be ingested to a high performance pipe (here it is called Event Hubs) to avoid any data loss. This data is transformed according to needs. For example, not all the data from a soil sensor is used as it is. It should be cleaned by applying some conditions to make it more accurate.

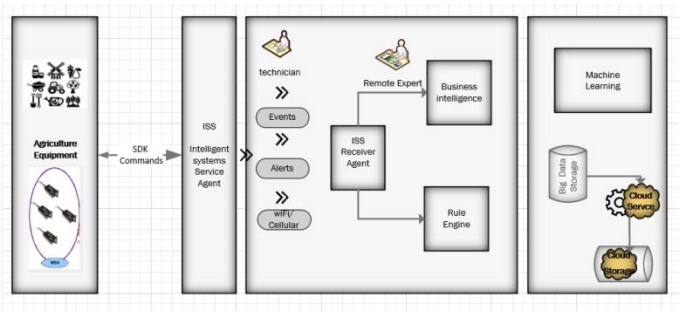


**Fig. 5: Proposed solution**

- All the clean data which is result of cleaning process can be used for reporting as is. This can be consumed by agriculture scientists / experts to provide better solutions. This data can also be provided to local agriculture technicians in their day to day business. For example, a report that can provide number of faults in an agriculture equipment can help a technician to either repair or refresh the equipment.
- One step further is harnessing the data for predictive analysis using Machine Learning. Imagine a system that can predict the effect to weather condition of the farm fields; or a system that can predict the water scarcity in the soil coming future; or system that can alert a technician for a possible equipment failure in near future. All these can be made possible by

running various machine learning models applied on the data collected from soil and equipment sensors; and weather prediction data from public data sources available.

Cloud computing platforms like Microsoft Azure can provide end to end services that are readily available to integrate our solution. More services like a learning management service and a collaboration service like SharePoint Online can be easily deployed on cloud infrastructure with in no time, that can provide necessary tools for farmers to collaborate with each other and with experts if necessary.

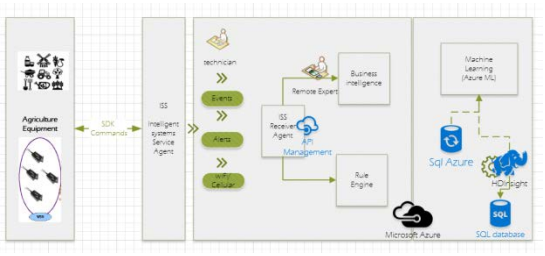


**Fig. 6: Proposed solution - practical with Microsoft Azure components**

## 9. BENEFITS OF PROPOSED SOLUTION

Proposed solution intends to provide huge benefits of following areas of agriculture which are

1. Water management
2. Field management
3. Knowledge management

### 9.1. Water management

Water supply is an important aspect of agriculture. Crops can be damaged in either of situation of excess of water supply or in shortage of water supply. With proposed solution we can predict the amount of water levels given time and provide water precisely for crop needs. Service built on top of machine learning models can provide farmers with information needed to plan agriculture based on weather and ground water availability. A simple service like Sensor Observation Service (SOS) can be deployed on cloud to observe sensors and predict water requirement of crop smartly and utilizes the scarce water resource available to reduce wastage of water.

Smart sensors like Trimble's Green Seeker, Topcon's CropSpec, and Ag Leader's Opt-Rx uses optical sensing technology; Veris Technologies, Geonics that can measure soil features can be used to read everything from plant health and water needs in the crop to nitrogen levels in the soil.

Another type of sensing system is called remote sensing, which uses satellite or aerial imaging techniques. In this technique satellites will take images of defined agricultural areas for a time period regularly to note differences in crop health. Farmers can take necessary action a prescription from the satellite images.

### 9.2. Field management

The accuracy of weather forecasts affects the crop productivity to a great extent. Proposed solution provides accurate and timely communication of real time data or information related to dynamic agricultural processes like plantation, harvesting etc. and weather forecasts, soil quality, availability and cost of labor required to the farmers before-hand. Farmer's with availability of such important real time information in advance are able to plan their course of activities pre-hand and take corrective/preventive measures for future contingency.

### 9.3. Knowledge management

Knowledge sharing plays a key role in any process evolution. Expert advice along with peer experience can provide much needed help for improving ones' process. The information generated from our proposed solution along with a platform built on cloud to interact with each other can provide an excellent solution for knowledge sharing. Market information can also be shared in proposed solution. This can help farmers to market their products as per standards.

## 10. SUMMARY

IoT and cloud computing are two key technologies evolving rapidly. Prosed solution is practical and when implemented can provide much needed automation and precision to rural agriculture process. These technologies not only help farmers but also can help tech savvy youth in rural India with an employment option. Maintenance of technology is minimum with cloud infrastructure being used predominantly. With proper Government initiatives in terms of internet coverage and expert support proposed solution can definitely change the landscape of our rural India, as it has already proved in various developed nations.

## 11. ACKNOWLEDGEMENTS

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