

# Agro Informatics Vis-à-Vis Internet of Things (IoT) Integration & Potentialities—*An Analysis*

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## ABSTRACT

Agriculture is the most valuable term and becomes a necessity of human beings. Agriculture is a kind of producing that is responsible for farming or clearly on food and feed, fiber and other items with the help of cultivation of certain plants; however, in broader context agriculture also means as domestic animals. The cultivation and agricultural process in the recent past has changed rapidly and there are many tools, technologies being incorporated for a healthy agricultural process. The Applications of Information and Communication Technologies led the advanced agricultural systems. And these are called as Smart Agriculture. In general, the application of IT and Computing in Agriculture field is called Agro Informatics. With the development of Agro Informatics, the recent concept of Smart Agriculture or Farming has arrived. These various advanced and modern technologies are using for enhancing the quantity as well as the quality of agricultural systems, cultivation and ultimately the products. In the recent past, the cultivators of modern age are associated with modern technologies like GPS, soil scanning, websites, cloud based data management services, basic internet and also Internet of Things based technologies. Adapting modern strategy, now the farmers can increase the effectiveness huge manner as far as pesticides and fertilizers are concerned. On the other hand, Smart farming techniques also help in indirect operations in agriculture including the monitor of agricultural products and individual animals. In the recent past, the scenario of IT and Computing applications has radically changed and Agro Informatics has also become a field of study. Among the latest technologies, IoT or Internet of Things becomes popular and important in a different context. This paper is conceptual in nature and deals with various aspects of Smart Agriculture with special reference to the IoT applications in Agro field.

**Keywords:** Smart Agriculture, IoT, Agro Informatics, ICT in Agriculture, Cultivation, Agricultural Information Technology, Development

Agricultural Informatics is the combination of two subjects or branches i.e. 'Agriculture' and the other hand 'Informatics'. This branch is also called as Agricultural Information Science, Agricultural Information Technology, or Agricultural Computing. All these branches are closely related and responsible

for healthy agricultural development in different

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sorts [1], [5], [30]. The Agro Informatics provides many emerging concepts viz. Smart Farming, Tech Enable Agriculture, Smart Agriculture, etc. However, among these, Smart Agriculture term is mostly used which is actually the application of modern technologies viz. Computing, Information and Communication Technologies into agriculture and allied fields. This development of Agriculture is called Third Green Revolution [2], [3], [10],[30].

Smart Agriculture is also responsible for the plant breeding, genetics revolutions, field cultivations, etc using various components of Information Technologies and this combined application of ICT solutions with the support from the following but not limited to –

- ♦ Precision equipment and tools
- ♦ Networking and Communications
- ♦ Internet of Things
- ♦ Geo-positioning systems and Remote Sensing
- ♦ Big Data Analytics
- ♦ Cloud Computing
- ♦ Unmanned Aerial Vehicles
- ♦ Robotics, etc. [4], [9], [20].

Among these technologies, IoT i.e. Internet of Things most emerging and applicable in enhancing the agricultural efficiency, product quality including reduction of cost, reduction of resources, technologies incorporation in the automation of agriculture over traditional IT based agricultural processes. The involvement of agriculture and IoT as called Agro IoT which is considered as an important aspect and area within Agro Informatics [6], [7], [21].

## Objective

The current paper entitled ‘Smart Agriculture powered by Agro Informatics with reference to Internet of Things (IoT) Integration – *An Analysis*’ is conceptual and interdisciplinary in nature and deals with following aim and objective –

- ♦ To get knowledge about the Agro Informatics including its basic features and functions.
- ♦ To learn about the Stakeholders, technologies involved in Agro Informatics and also in building Smart Agriculture as well.

- ♦ To learn about the basic features, tools and emergence of Smart Agriculture in general.
- ♦ To get the knowledge in the Internet of Things with reference to its application in Agriculture and its allied fields.
- ♦ To learn about the challenges and opportunities in developing Smart Agriculture and allied fields.
- ♦ Smart Agriculture powered by technologies and IoT: Advancement of Agro Informatics.

Informatics is a field of study and a little different from Information Technology or conventional Computer Science. The branch Informatics is responsible for the information related activities viz. collection, selection, organization, processing, management and dissemination of the information [8], [14], [32]. Informatics is considered as both a practicing field and a field of study and research. The nomenclature in some context and countries are also called/ known as Information Science. Hence the applications of Informatics in Agriculture or a combination of both the field are called as Agro Informatics or Agricultural Informatics. In Agro Informatics, all the IT components technologies are employing for different activities of Agricultural Sciences and promotion viz. –

- ♦ Database Technologies.
- ♦ Networking Technologies
- ♦ Software Technologies.
- ♦ Web Technologies.
- ♦ Multimedia Technologies etc. [11], [13], [28].

The emerging areas within these subjects viz. Cloud, IoT, etc., have also become important and valuable for a different context. Advanced Technologies led the concept of Smart Agriculture and it has great potential to deliver advanced as well as more productive agriculture with more healthy resource-efficiency [22], [24], [39]. According to a study, it is noted that in the USA possibly about 80% of farmers are started to use technologies whereas in Europe it is about 24%. As far as cultivators point is concerned, it should be provided to the farmer for the development of healthy better decision making, efficient production including operations and their execution. The basic applications can be seen in Fig. 1. The following three major interconnected technology

and areas are important according to the Smart AKIS Network and these are –

### Management Information Systems

Management Information Systems (MIS) is a technique which is planned systems for information and data processing regarding cultivators activities, operations as well as functions.

### Precision Agriculture

Uses of Decision Support Systems (DSS) GPS, GNSS, aerial images by drones and the latest generation are the prime example of this category including creation of maps which can help in various activities viz. crop yield, topography, moisture levels, nitrogen levels, soil condition, the growth stage of the products,etc [15], [16], [33].

### Use of Intelligent Systems and Robotics in Agricultural

There are more process and way regarding the applications of robotics, artificial intelligence, deep learning, machine learning techniques in different activities of agriculture viz. agricultural production; which includes even the most modern farmbots and farmdrones [17], [19], [36].

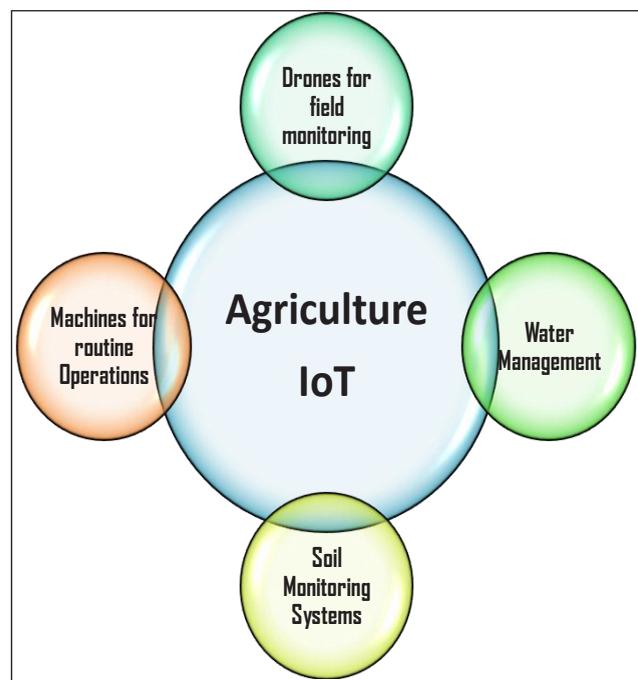


Fig. 1: Basic IoT Applications in Agriculture

Apart from the automated cultivation or agriculture in conventional farming as well tools and technologies are adopting and increasing day by day including in emerging organic farming. Moreover, Smart Agriculture also helps in environmental benefits viz. in water, or optimization of treatments and inputs, soil,etc [23], [25], [37].

Internet of Things in short popular as IoT which is run on internet systems and well connected digital and may be controlled from anywhere. The IoT also helps in rising the efficiency, safety, security of the products and services viz. manufacturing, education and training, health and medicine, transportation, agriculture, retail sectors etc.

The establishment of initial costly for IoT is little higher but later it has less organizational cost and importantly the IoT can be useful in following stakeholder in different way.

- ♦ The users of various products and services/ sectors.
- ♦ Commercial of various products and services/ sectors.
- ♦ Industrial or organizational(of various products and services/ sectors).
- ♦ Infrastructure spaces (of various sectors)

The application of IoT in Agriculture is also called as Agro IoT or AIoT. In building of smart agriculture IoT plays a leading role. There are many direct and indirect benefits that may happen viz. *Increased Efficiency* as it prepares for better monitoring of agricultural products in real-time. The prediction become easy regarding soil, agro products condition, decisions making and also in other process and components such as – Demand-based irrigation, Healthy Agro fertilizing, Robot based harvesting, Climate and weather prediction, etc; however, in process of healthy AIoT apart from IoT following technologies play a leading role viz. –

- ♦ Big Data Analytics
- ♦ Cloud Computing
- ♦ Robotics and AI
- ♦ Machine Learning and Deep Learning etc.

It is an important fact to note that in the world, 70% of the population stays in or urban areas and here IoT-based greenhouses may be helpful in enhancing

short food supply chain and as a result it helps in *Expansion* of Agricultural Systems. Moreover, the agricultural systems are enhancing rapidly and in all these areas IoT is applicable. *Resource Reducing* is another important feature in IoT based agriculture which ultimately helps in enhancing the uses of the water, energy, land and so on [29], [34], [40]. Such on the collected data from various sensors. As far as *Cleaning* IoT is also important including the managing of pesticides, fertilizers and ultimately helps in the following –

- ♦ IoT based agriculture helps in precision farming by adopting different sorts.
- ♦ Cleaning and sustainable strategy is very perfect with IoT based systems in eco-friendly cultivation.
- ♦ IoT based agriculture helps in reducing less use of pesticides as well as fertilizer and as a result, complete organic Agriculture is possible with the IoT applications in Agriculture and allied fields.

*Faster and Efficient Agricultural* is also possible with IoT applications in Agriculture with the remote and real-time systems using deep learning and AI based systems, etc and with this, the agricultural peoples may quickly be done and also needful in agriculture condition prediction the aspects on weather and humidity. With IoT support health condition of each crop can be monitored even about the weather changes by the Agro IoT tools and systems.

Hence in IoT based Agriculture and cultivation *Quality Production* become possible and here use of aerial drone become useful for analyzing and monitoring of the crop and fields using sensors. Even farm mapping become also possible with this. The quality of agricultural products and crops can be analyzed using IoT and it helps in better quality products. So, in farming, collection of the data on various aspects including temperature and weather viz. rainfall, humidity, the speed of wind, to find out and managing pest infestation, condition of soil, etc. Thus, automated farming including the techniques and technology is possible with Agro Informatics. However, based on categories following can be considered as an important area where IoT applications are positively possible to use and their applications are also increasing. However, apart from

these few other areas are also important in which IoT applications are applicable such as –

### *In Analyzing Weather and Climate*

Weather and climates are important aspects of agriculture and farming; thus, the information regarding climate results in the quantity and quality of crop production and post crop production activities. As real-time weather conditions are possible in IoT supported sensors so such are to collect data from various means. So here the right crops and right weather etc can be benefited by the Agro IoT systems importantly to grow the particular climatic conditions. The detection of real-time weather viz. humidity, rainfall, temperature is possible with sensor enable IoT Eco Systems more accurately. Monitoring the condition of crops, field, weather are be noted with intelligent IoT systems then an alerting systems can be used and farmers take take decision based on this. Hence there is no need of physical presence of the cultivators or peoples during the normal or bad climatic conditions; as a result, Agro IoT improved agriculture benefits in weather by different means [2], [7], [32].

### *In Precision Farming and Cultivation*

Precision Agriculture and cultivation become easy with the help of farming practice and different activities viz. livestock monitoring as well as field observation, inventory management and monitoring, vehicle management in agricultural zone, etc. The analysis of data is possible using sensors and thus cultivation becomes so easy in the units and organizations as an intelligent way. Moreover, using intelligent systems, the IoT can predict the soil conditions, as well as allied aspects for improved operational efficiency including the water and nutrient level and all these, can lead to healthy Precision Cultivation.

### *In making of Green House perfect*

Internet of Things can be helpful in making of intelligent weather stations with the control the climate according to the given set of instructions. The system will reduce human intervention thus it become cost-effective as well as more accurate. Even the Solar-power based IoT sensors improve

the greenhouses. As with this, the real time data collection as well as monitoring becomes possible with a proper greenhouse in real-time situations. With IoT water consumption is possible in an intelligent way and thus helps in making Green House Perfect; directly and indirectly.

### *Use of Drone and Agriculture using IoT*

Technological help in different way in agricultural and allied fields with multiple operations. Drones are very important tool which covers ground and aerial look and thus helps in analyzing healthcare of drone with crop monitoring, spraying, field work analysis, etc. This technology comes with real time data and ultimately these are helping in healthy agriculture systems and industrial output. As this may with the multispectral sensors so responsible for the emerging areas finding and improvement in the systems of irrigation. The growth of the agricultural product may be analyzed with the smart drones and responsible in reducing environmental impact. Huge reduction in chemical finding is also possible with drones [5], [18].

### *Data Management in Agriculture using IoT*

IoT sensors are very useful in various Cloud based data storage systems, and all these play leading role in agriculture system. In smart agricultural systems traditional database systems are not so worthy here Data Management plays a leading role thus Analytics plays a leading role and, in this context, sensors are responsible for various activities on data within the large scale. Data Analytics with core support from IoT thus can led with following roles viz. –

- ♦ Analyzing and assessing the weather as well as condition of climate of agro zone.
- ♦ Studying and analyzing the livestock as well as products.
- ♦ Find out the crop conditions including its management.
- ♦ Enhancing decision making systems and its inclusion in agro space.
- ♦ Find out the actual status of the crops and agro fields and so on.

Here in such activities predictive analytics helpful including harvesting and knowing the future weather conditions, fields, crops, product volume and quality, etc.

### *In Livestock Management & Development*

Internet of Things or IoT is a great name in livestock management as well as development. Wireless IoT perfectly useful in agricultural companies and industries. In this context data basically collected from different settings on location, well-being etc. Identification and location finding of the animals become also possible with IoT based systems. As far as minimizing of labor costs are concerned IoT can also be useful. Different pet animals and farm animals viz. cows, sheep, pig, etc., can be properly managed with IoT based systems.

### *In Environmental Monitoring*

As far as Energy management and environmental monitoring is concerned various electronic products viz. switches, power outlets, bulbs, televisions, etc. can get the benefits of IoT based systems. IoT is applicable and emerging over the traditional IT and IoT can help in healthy environmental protection for the betterment and practice such as –

- ♦ Monitoring air or water quality; by this environmental monitoring become possible.
- ♦ Movements of wildlife, animals including their habitats can be analyzed and helpful in may context.
- ♦ In any kind of natural disaster including disaster management IoT can be used and very useful in a different context [12], [33], [38].

According to a study, it is expected that about 30 billion devices within 2020 may be associated with the IoT with the potential value that may reach \$7.1 trillion by the end. Organizations and companies are moving in developing IoT systems and many companies are offering and expressing various services for the interest of AIoT in different stakeholders and among these organizations, the few flagship offering of Octal Systems are mentioned in Fig. 2 (Source: octalsoftware.com)



Fig. 2: Few Agro IoT areas for Smart Agriculture

### IoT in Agriculture: Requirement, Issues & Challenges

Internet of Things (IoT) is a leading tool in modern Agriculture Management as well as Cultivation Systems [30], [35], [40]. There are many concerns as well issues, challenges of introducing IoT in Agro field or introducing Smart Agriculture and among these few important include (but not limited to the following) –

- ♦ Sensors, cameras, database, AI based tools including robots, drones, etc are essential for accurate monitoring as well as operation.
- ♦ Internet of Things depends on various kinds of technologies and so skillful human resources or staff are very much important including the implementation, managing bots, etc., and here IoT is very important to note.
- ♦ Internet of Things (IoT) can lead the AIoT and here most of the devices are costly so initial implementation is important and valuable for building healthy agro based systems.
- ♦ Maintenance budget including evaluation of the existing IoT based system in agriculture is an important issue as here the aspects of various hardware and devices important.
- ♦ With the help of IoT here computer imaging is possible by the sensor cameras including the drones. But here manual operator is an important concern and issue.
- ♦ Smart Agriculture is helpful in healthy and scientific supply chain management in some cases.

- ♦ It is worthy to note that in Smart Agricultural Systems individual data in a specific farm difficult to manage sometimes as these are not possible to manage separately, so it is an important issue.
- ♦ Communications and connections of existing as well as new devices become an important challenge in IoT based Agro Systems.
- ♦ Good internet connections with robust speed are very important issues in the Internet of Things (AIoT) implementation in Agro and allied field.
- ♦ Proper research and scientific investigation are expected from the educational institutes, research centres, universities are very much important and expected; which is still not yet possible in many countries.
- ♦ Rules, regulation and proper budget are expected in the growth of healthy IoT based Agriculture.

### Suggestions

Implementing IoT and allied technologies are sometimes difficult due to numerous aspects, issues and challenges that already been discussed. For better IoT based Agriculture following suggestions need to incorporate –

- ♦ Good amount of initial investments in establishing the systems, devices are important to bring AIoT viz and for this governmental support are highly important.
- ♦ Qualified and trained manpower is required to produce from the universities and training institutes for the designing and operating IoT based Agro Management Systems.
- ♦ Connectivity is another important fact in Agro IoT, thus proper connectivity from different sources is highly welcome and important.
- ♦ Specializations or major or concentration in the educational programs at Bachelors, Masters and Doctoral systems are highly required and thus proper educational policies are important to grow IoT based Agriculture properly.
- ♦ Integration system is most important and,

in this context, a proper arrangement in this context better governmental support and industrial tie-ups are essential.

- ♦ Within the organizations' proper communications and collaboration are very much important and required to build healthy IoT systems in Agriculture. Here collaboration with the educational institutes with technological organizations and companies is also expected to create solid manpower.
- ♦ Connectivity among the allied and related technologies viz. Cloud Computing, Big Data, Data Analytics, etc., are important; thus, better organizational supports are also required in a different context.

## CONCLUSION

Smart farming with the support of IoT is called as "third green revolution," that combined with the application of IT and Computing in Agro and Allied fields with various equipment such as precision equipment, sensor, geo-positioning systems, GIS, UAVs, Robots and Intelligent Systems and so on. IoT based technology helps better control agricultural processes and helps the farmers for a better plan and also to identify crops; their quality including the harvesting and reducing labor cost, etc. As discussed for better IoT based Agriculture good IT and network infrastructure integrating different stakeholders are important. The applications of IoT in humidity, temperature, soil, etc., can be a great deal in modern Agro Management. Many challenges are existing in Agriculture IoT practice including the manpower development, proper planning, educational situation and policies, collaboration with various stakeholders etc. It is better if the full degree or specialization is offered in AIoT or simply Agriculture Informatics & IoT. However, the starting of Agro IoT based programs needs support from the Government, agricultural firms, and technological organizations, etc., for healthy real implementation smart agro based systems. In a developing country, initial challenges are very important but with proper solution a healthy deal can be possible.

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