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Assessment of smart agriculture in developing countries: Principles, current trends, future directions

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Abstract
The approach of Internet of Things (IoT) has demonstrated another bearing of imaginative research in rural space. Being at incipient stage, IoT should be generally tested in order to get broadly applied in different rural applications. To concentrate on the particular prerequisites the gadgets, and wireless correspondence advancements related with IoT in horticultural and farming applications are dissected thoroughly. Examinations are made on those sensor empowered IoT systems that offer insightful and smart types of assistance towards smart agriculture. Different contextual investigations are introduced to explore the existing IoT based arrangements performed by different organizations and people and categories according to their sending parameters. This paper discusses smart agriculture principles and how they are currently used in many developing nations. This paper will act a readymade guide to researchers who want to initiate novel methods in smart agriculture as well as know the challenges present in this area.

Keywords: internet of things, smart, automated, agriculture

Introduction
Agriculture is consistently the foundation of many creating nations. It doesn't just fill the individuals midriff yet in addition it is the piece of economy. As indicated by study in, India's populace is practically equivalent to 1.30 billion, which is actually a colossal number. In worry of giving nourishment to such a major populace there must be another innovation giving more yield in brief period. In that way, nature is intricate which will have irregular characteristics which straightforwardly influences plants and crops and by implication creatures and human. Different variables which influence agriculture are lacks in large scale and smaller scale supplement content, populace blast, industrialization, exhaustion of water source, distinction in soil condition, and disintegration of top soil. In agriculture the principle motivation to utilize manure is to give undeniable large scale and miniaturized scale supplements which for the most part soil needs. 35-40% of the yield profitability relies on manure, yet a portion of the compost influences the plant development directly. To conquer every one of these downsides a more astute way i.e., nanotechnology can be one of the source. Since manures are the fundamental concern, creating nano based compost would be another innovation right now. Manures are showered from numerous points of view either to soil or through leaves, even to oceanic conditions; these inorganic manures are provided so as to give three primary segments, nitrogen, phosphorous and potassium in equivalent proportions. It expands the Nutrient use proficiency (NUE) by multiple times and it additionally gives pressure enduring capacity. Independent of the kind of yield it can be utilized, it will be the finished bio source expanding the eco benevolent nature, manufactures carbon take-up, improves soil collection. Since these nano manures contain supplements, development advertisers typified in nano scale polymers, they will likewise have a moderate and a directed effective discharge. Nanotechnology is gathering data of molecule in nano scale run, with considering the physical, synergist, attractive, optical properties. Be that as it may, the convergence of use constantly uncovered soil organisms and smaller scale fauna, as well as the plants themselves, to level of compound reactivity that might be poisonous. When contrasting with substance manures prerequisite and cost, nano manures are monetarily modest and are required in lesser sum. For quite a long time ranchers have discovered that nitrogen take-up is the fundamental explanation behind inappropriate yield. In past ongoing days advancement of detecting gadgets are in blast. At the point when it

comes to test a specific analyte from the dirt causing aggravation in the recorded there are measures which give precise outcome yet it has a disadvantage of utilization of time and furthermore the significant expense for performing. Sensors are those give better outcomes with the live pictures and states of the field. Sensors do screen changes or the impacts brought about by different pesticides, manures, and herbicide, additionally the physical states of soil like pH, dampness level, and development states of harvest, stem organic product or even root, harmfulness contemplates, it can continually screen the danger created in the field. Since it is a human inviting sensor begins distinguishing and alerts rancher in order to demonstrate any right measures to be taken before as opposed to representing a result after. With regards to wireless innovation certain hub establishment is done which causes the individual to screen the happenings in the field all the hubs to can be controlled simultaneously through distributed computing or even through air programming. With regards to wireless innovation certain hub establishment is completed which makes the individual to screen the happenings in the field all the hubs can be controlled. Atmosphere changes and precipitation has been flighty over the previous decade. Because of this in late time, atmosphere shrewd strategies called as savvy agriculture is embraced by numerous Indian ranchers. Savvy agriculture is a mechanized and coordinated data innovation actualized with the IOT (Internet of Things). IOT is growing quickly and generally applied in every single wireless condition. Right now, innovation and wireless systems mix of IOT innovation has been considered and checked on dependent on the genuine circumstance of rural system. A joined methodology with internet and wireless correspondences, Remote Monitoring System (RMS) is proposed. Significant goal is to gather ongoing information of agriculture creation condition that gives simple access to horticultural offices, for example, cautions through Short Messaging Service (SMS) and advices on climate design, crops and so on.

Smart Principles in Agriculture

Smart Farming is a paradigm of farming management utilising modern Information and Communication Technologies to enhance the quantity and quality of products.

Among the technologies available for present-day farmers there are

1. Sensing technologies, including soil scanning, water, light, humidity, temperature management;
2. Software applications — specialized software solutions that are used for specific farm types;
3. Communication technologies, such as cellular communication;
4. Positioning technologies, including GPS;
5. Hardware and software systems that enable IoT-based solutions, robotics and automation; a
6. Data analytics, that underlies the decision making and prediction processes.

Furnished with every single imaginable device, ranchers can screen the field conditions without setting off to the field and settle on vital choices for the entire homestead or for a solitary plant. The main impetus of the keen cultivating is the IoT — the idea of associated savvy machines and sensors coordinated on farms to make cultivating forms information driven and information empowered.

The IoT-Based Smart Farming Cycle

The idea of IoT is the information we can extract from things ("T") and send over the Internet ("I"). To enhance the farming procedure, IoT gadgets introduced on a ranch should gather and procedure information in a tedious cycle that empowers ranchers to respond rapidly to rising issues and changes in encompassing conditions. Smart farming follows a cycle like this one:

1. Perception

Sensors record observational information from the harvests, animals, soil, or environment.

2. Diagnostics

The sensor esteems are taken care of to a cloud-facilitated IoT platform with predefined choice standards and models—likewise called "business rationale"— that discover the state of the inspected question and distinguish any insufficiencies or necessities.

3. Choices

After issues are uncovered, the client, as well as AI driven segments of the IoT platform decide if area explicit treatment is vital and assuming this is the case, which.

4. Activity

After end-client assessment and activity, the cycle rehashes from the earliest starting point.

IoT Solutions to Agricultural Problems

Many accept that IoT can increase the value of all zones of farming, from developing harvests to forestry. Right now, talk around two major regions of agriculture that IoT can revolutionize:

1. Precision farming
2. Farming automation/robotization

1. Precision Farming

Precision farming, or precision agriculture, is an umbrella idea for IoT-based methodologies that make farming more controlled and exact. In basic words, plants and dairy cattle get accurately the treatment they need, dictated by machines with superhuman exactness. The greatest distinction from the traditional methodology is that precision farming permits choices to be made per square meter or even per plant/animal as opposed to for a field. By exactly estimating varieties inside a field, ranchers can support the adequacy of pesticides and manures, or use them specifically.

2. Precision Livestock Farming

As on account of precision agriculture, smart farming strategies empower ranchers better to monitor the necessities of individual animals and to change their nourishment accordingly, in this manner forestalling sickness and upgrading crowd wellbeing. Huge ranch proprietors can utilize wireless IoT applications to monitor the area, prosperity, and strength of their dairy cattle. With this information, they can recognize wiped out creatures, so they can be isolated from the group to forestall the spread of malady.

Automation in Smart Greenhouses

Conventional greenhouses control the natural parameters through manual intercession or a proportional control component, which often brings about creation misfortune, vitality misfortune, and expanded labor cost.

IoT-driven smart greenhouses can brilliantly monitor just as control the atmosphere, wiping out the requirement for manual intercession. Different sensors are sent to quantify the ecological parameters according to the particular necessities of the harvest. That information is stored in a cloud-based platform for additional preparing and control with negligible manual intercession.

Farming Drones

Agriculture is one of the major verticals to incorporate both ground-based and aerial drones for crop wellbeing appraisal, water system, crop monitoring, crop showering, planting, soil and field examination and different circles. Since drones gather multispectral, warm and visual symbolism while flying, the information they assemble furnish ranchers with bits of knowledge into an entire cluster of measurements: plant wellbeing records, plant tallying and yield forecast, plant stature estimation, shelter spread mapping, field water lake mapping, exploring reports, reserve estimating, chlorophyll estimation, nitrogen content in wheat, seepage mapping, weed pressure mapping, etc.

Importantly, IoT-based smart farming doesn't just objective enormous scope farming activities; it can increase the value of developing patterns in agriculture like organic farming, family farming, including rearing specific steers as well as developing explicit societies, protection of specific or top notch assortments and so forth., and improve profoundly straightforward farming to buyers, society and market awareness.

Internet of Food, or Farm 2020

On the off chance that we have the Internet of Things (IoT) and the Internet of Medical Things (IoMT), why not have one for nourishment? The European Commission venture Internet of Food and Farm 2020 (IoF2020), a piece of Horizon 2020 Industrial Leadership, explores through research and normal meetings the capability of IoT advancements for the European nourishment and farming industry.

IoT has cultivated the conviction that a smart network of sensors, actuators, cameras, robots, drones, and other associated gadgets will bring an exceptional degree of control and mechanized dynamic to agriculture, making conceivable a suffering ecosystem of advancement right now ventures.

Third Green Revolution

Smart Farming and IoT-driven agriculture are preparing for what can be known as a Third Green Revolution. Following the plant reproducing and hereditary qualities revolutions, the Third Green Revolution is assuming control over agriculture. That revolution draws upon the consolidated utilization of information driven examination advancements, for example, precision farming gear, IoT, "enormous information" investigation, Unmanned Aerial Vehicles (UAVs or drones), apply autonomy, and so on.

Later on this smart farming revolution delineates, pesticide and compost use will drop while generally effectiveness will rise. IoT advances will empower better nourishment detectability, which thus will prompt expanded sanitation. It will likewise be valuable for nature, through, for instance, more effective utilization of water, or enhancement of medicines and information sources. Therefore, smart farming has a genuine potential to convey a more gainful and maintainable form of agrarian creation, in light of a more exact and asset effective methodology. New farms will at long last understand the interminable dream of humankind. It'll take care of our populace, which may detonate to 9.6 billion by 2050.

Current Trends in Developing Countries:

This section presents the list of possible agricultural, farming and related applications that are currently being implemented using IoT.

- Irrigation management system: Nowadays day agriculture needs an improved irrigation management system to optimize the water utilised in farming and related works .Certain factors are popularly being used in smart irrigaton system such as, integration of real-time weather forecast data, control of farmer's system from anywhere in the world using home, enabling WiFi and Ethernet connection, adding synchronization with moisture sensors installed in farmer's yard, and reducing farmer's monthly bills while supporting to save limited water resources. IoT is constantly getting popularity in irrigation management related systems around the world.
- Pest and disease control: Controlled usage of pesticides and fertilizers supports increasing the crop quality as well as reducing the farming cost. Nevertheless, for controlling the usage of pesticides, we need to monitor the probability and occurrence of pests in crops. To predict this, we also need collecting disease and insect pest information using sensor nodes, data processing and mining, etc. with help of IoT infrastructure . A three layered IoT architecture is proposed that may identify the disease occurred and take necessary actions to point out the responsible pest which has caused the disease. Farmer can imply upon the required medicine to save the corp. − Cattle movement monitoring: A herd of cattle grazing a field can be monitored using IoT.
- Dairy monitoring: IoT based cloud solutions, such as, Connecterra are being currently popular to monitor dairy in smart way. It is able to provide multiple behavior detection and predictions including animal heat & estrus cycles, health analysis and also provide a forward looking prediction of the next cycle start dates. Further, individual activity assessment and location aware functionalities can be added on top of the services.
- Water quality monitoring: Placing sensor nodes empowered with wireless communication help in monitoring the water quality. A recent article develops a real time monitoring of the water quality using IoT. The system measures physical and chemical parameters of the water like, temperature, pH, turbidity, conductivity, dissolved oxygen. The sensor data can be observed on Internet using cloud based service aplications.
- Greenhouse condition monitoring: Greenhouse and agriculture are closely related to each other. Greenhouse gases are responsible for increasing the climate temperature, and thus has direct impact on

agriculture. On the other hand, greenhouse gas emission depends on pH, temperature, CO2, etc. HarvestGeek provides an IoT cloud based services to monitor the greenhouse condition remotely which can further be controlled by the user or by self autonomously.

- Soil monitoring: Soil property is crucial for agricultural domain. Knowledge of soil adds an advantage to the production of corps. Few companies have incorporated LoWPAN technology with IoT to remotely aggregate the condition of soil while implementing various sensor nodes. SNMP is used to monitor the network in real time.
- Precision Agricultural by UAV: Agricultural precision can be obtained by utilizing advanced technologies such as, UAV and Drone, for productive outcome of the farm. Precision Hawk (www.precisionhawk.com) enterprise leverages UAV, GIS and sensors enabled IoT cloud platform to deploy artificial intelligence through in the-air flight path calculations for detection of weather conditions in the air. Further, in-flight diagnostics and monitoring processes continually monitor its own status while in flight and counts on the operational weather/wind limitations, land mapping, and real time analytics supports.
- Agricultural means production supply chain management: Agricultural products need to be efficiently managed so that farmer can gain profit, hence the operating efficiency on it. Supply chain management on the argi-products can be monitored by IoT. It further provides a reference framework for the node enterprises of the product chain for necessary implications.

Future Directions

The current arrangements have incorporated IoT based smarter applications for fathoming various difficulties in the rural and farming space. We examine the different possibilities of these applications to improve the current arrangements as underneath, while the following segments will demonstrate the way to improve the current circumstance point-wise.

− **Cost-adequacy:** Researchers around the globe are primarily centering at the decrease of equipment and software costs in IoT organizations, while boosting the system yield. Creating nation men look for savvy types of gear so additional cost required because of the utilization of foreign imported gadgets to fabricate the systems get limited. However, global farms are creating bleeding edge innovations right now, the test despite everything exists how to cut down the cost further. Introduced works do need cost viability. Subsequently, such point is intentionally the need of the time.

− **Standardization:** Current works in don't conform to the institutionalized format of portrayal of information just as the procedure. Institutionalization is another coagulation which may exactly be worked for development of IoT. Institutionalization in IoT implies to let down the underlying obstructions for the service suppliers and dynamic clients, ad lobbing the interoperability issues between various applications or systems and to see better rivalry among the created items or services in the application level. Security models, correspondence benchmarks and ID guidelines should be developed with the spread of IoT advancements while planning rising advancements at a horizontal comparability. Also, individual scientists will record industry specific rules and indicate required models for effective usage of IoT. Agriculture related institutionalization while utilizing IoT ought to carefully be followed.

− **Heterogeneity:** IoT is a confused heterogeneous network platform. Be that as it may, the referenced works in agriculture can't cooperate with heterogeneous modules or correspondence innovations. This, in turn upgrades the intricacy among different sorts gadgets through different correspondence innovations demonstrating the inconsiderate behaviour of network to be deceitful, and postponed. Researchers have unmistakably referenced that the administration of associated protests by encouraging through collaborative work between various things (equipment segments or software services) and the controlling them in the wake of giving tending to, distinguishing proof, and advancement at the engineering and protocol levels is a genuine research issue. Be that as it may, to prevail at the agriculture space, IoT should be reconsidered to sort out the consumption of the normal platform.

− **Context mindfulness:** When billions of sensor empowered things are associated with the Internet, it might not be doable for the client gathering to deal with all the information gathered by the sensors. Setting mindfulness registering methods should be utilized in better manner to help choose what information should be prepared. Talked about agri-errands are drained of setting mindfulness. This appears to find out the nullification of information approval in form of ceaseless disturbed procedure. Encompassing natural parameters and self appraisal may move the confined setting to other people while making an all around associated mindful IoT ecosystem.

− **Middleware:** Most of the introduced works follow the vertical storehouses intended for sole purposes. A middleware could give a typical platform to accomplish the particular objectives incorporating multilocalized (topographically) modules inside an occupant. Middleware clears the horizontal progression of information among the gadgets, protocols, and applications regarding itself. Applications can be performed over the entire informational index and question be handled on the associated gadgets in an incorporated way.

− **IoT hub personality:** The IoT is visualized to incorporate an unbelievably high number of hubs. All the appended gadgets and information will be retrievable; here in such setting, the extraordinary personality is an absolute necessity for proficient point-to-point network con Figuration. IPv4 protocol recognizes every hub through a 4-byte address. As it is notable that the accessibility of IPv4 numbered addresses are diminishing quickly by arriving at zero in next a couple a long time, new tending to arrangements will be countered where IPv6 is a solid contender. Introduced systems do for the most part use IPv4 for correspondence. In any case cutting edge network may exceptionally be populated so that the interesting character would persuade hard to be forced upon the hubs. Improved procedures to be alloyed with the present methodology.

− **Energy the executives:** Energy the executives is the most important issue in IoT based systems. System parts, for example, IoT gadgets, network receiving wires, and other ward aloof modules alongside the core algorithms ought to appropriately be readdressed while revelling into the

gathering of vitality. Something else, non-traditional wellspring of vitality gathering arrangements, for example, sunlight based force, wind, biomass, and vibration cloud additionally be tried while planning IoT based smart agriculture systems. Starting at now, sun oriented controlled IoT systems are as of now being used. Consequently, scientists may get included to work on the other sources in future.

− **Fault resistance:** Fault resilience is for the most part missing in the above arrangements. To make an impeccable system, adaptation to internal failure level of the system ought to be kept extremely high so that in spite of specialized error, the system continue working. Equipment modules may flop because of exhausted battery or some other explanation. Additionally age of incorrect incentive by the sensor, flawed alignment, and disappointment in correspondence may build up a shortcoming circumstance. While looking for arrangement, sun powered force may give an option in contrast to the battery worked modules. Utilization of large number of correspondence protocol may build the force utilization yet consistently give consistent availability. Force utilization in such case, might be drop somewhere near authorizing one protocol to get enacted at any example. Legitimate adjustment should be done prior to conclusive establishment.

− **Need of continuous arrangement:** Most of the introduced arrangements don't include genuine practicality into the account. Be that as it may, to empower precision agriculture, climatic information, and soil parameters be smartly incorporated with the present improvements.

Conclusion

The consideration of IoT is imagined to be valuable for propelling the agrarian and farming ventures by presenting new measurements. In this paper a far reaching audit of IoT arrangement for cutting edge agrarian applications as been presented. IoT based agrarian framework is proposed to use undeniable blend among agriculture and IoT. Different wireless correspondence advances which are reasonable for agriculture applications are likewise introduced. A couple IoT cloud service suppliers are as of late being mainstream in horticultural fields. I have postponed a rundown of cloud service suppliers dynamic right now application dependent on a lot of key traits. It is trailed by a review of IoT based systems being by and by sent in different farms and zones of the globe. An a couple of contextual analyses have been outlined with arrangement subtleties in various applications, for example, honey bee keeping, vineyard monitoring, precision farming, and waterway water quality monitoring and so on. At last, the paper throws light on the challenges of the current applications. A rundown of a few bearings for future research what's more, applications are imagined. In particular, minimal effort, self-governing, vitality productive, interoperable, institutionalized, heterogeneous and hearty arrangements with highlights like man-made brainpower, and choice support system also, low upkeep is sought after. Overall, the underneath depictions of different parts of IoT ought to be developed so that agriculture be smart and omnipresent.

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