**Abstract— Rural areas in our country face a number of similar issues in the domains of agriculture, connectivity, water, irrigation, transport, health and education etc., This time we have a solution for these kinds of problems using the current technology that we have; which calls for potentially similar solutions to be directed towards solving these issues. The intention of this research is to investigate the potential contributions of internet of things technologies (IoT) towards poverty reduction and high crop yield in these rural areas, in line with the needs identified in these communities and with emphasis on agriculture. The paper identifies examples of IoTs to mitigate the agricultural needs of these communities for the domains of crop farming, weather forecasting, wildlife management, forestry, livestock farming, and market identification.**

*Keywords- agriculture, Internet of Things, agro tech.*

I.INTRODUCTION

Today, advancement in technology have shaped a society where data, whether wanted or unwanted, is collected and disseminated in droves. And the world of agriculture is no exception.  “Agro-Informatics: applications of Big Data in delivering Food Security.” Agricultural informatics, also referred to as e-agriculture, is a field which combines the advances in agricultural information, agricultural development and entrepreneurship to provide agricultural-services-enhanced-technology, dissemination and information delivery through information and communications technologies (ICTs) and the internet. E-agriculture focuses on enhancing agricultural and rural development through improved information and communication processes. More specifically e-agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use ICTs in the rural domain with a focus on agriculture. ICT is an umbrella term which includes anything from radio to satellite technology to mobile phones or electronic money transfers. The interest in potential of the Internet of Things (IoT) is growing at a rapid rate largely due to recent developments in the technical fields and increase in availability of mobile data at cheaper than ever rate with speeds faster than ever. This will lead to the upliftment of living standards in the rural areas of the country. The contribution of this research is the investigation of the potential contributions of IoTs to the domain of agriculture for rural environments of India.

*IoT on the other hand is the connecting of physical things to the internet which makes it possible to access remote sensor data and control the physical world from a distance.* The IoT has the purpose of providing an ICT-infrastructure facilitating the exchange of ‘things’ in a secure and reliable manner, i.e., its function is to overcome the gap between objects in the physical world and their representation in information systems.

The increase in ICT affordability, accessibility and adaptability has resulted in their use even within rural homesteads relying on agriculture. The drivers of ICT in agriculture are: 1) low-cost and pervasive connectivity; 2) adaptable and more affordable tools; 3) advances in data storage and exchange; 4) innovative business models and partnerships; 5) demand for agricultural information services [26]. Any ICT intervention that improves the livelihoods of poor rural farmers will have significant direct and indirect impacts on enhancing agricultural production, marketing and post-harvest activities, which in turn can contribute to poverty reduction.

For all rural areas, the barriers that need to be addressed by broadband ICTs are: 1) distance barriers, i.e., access to administrative and government services and structures, 2) economic barriers, i.e., access to wider business and labor markets, 3) social barriers of rural inhabitants’ access to information, education and training, health, social services, etc., 4) traceability of production, products and services throughout the value chain including logistics.

II. PROBLEM STATEMENT

In the villages of our country people face a vast amount of issues in domains such as of agriculture, tourism, environmental management, finance, communications infrastructure, connectivity, water resources management, sanitation, roads and transport, access to markets, health and education, which calls for similar but locally relevant solutions to be directed towards solving issues related to these similarities. In order to respond to the needs of the rural communities, alleviate poverty and narrow the digital divide between urban and rural areas, this research recommends the adoption of information and communication technologies (ICTs), namely internet of things technologies (IoT), in the delivery of services to rural communities of India. The intention of this research is to identify needs and recommend IoTs in response to these needs that will contribute to lessening the impact of poverty in the rural areas of India, with emphasis on the agricultural sector.

Agriculture contributes about 17.32% of the total GDP of India. It has fallen from >50% in 1950 with increasing demands due to the increase in the population of India and the rise of industries. The land for agriculture is not going to increase so and after the green revolution in 1960’s we need to have another major change to meet the growing demands of the Indian population increasing with as many as 34 births are registered every minute.

The questions asked are:

--What are the agricultural needs of the rural communities that, when addressed, will lead to the upliftment of their lives and poverty alleviation

--What IoT technologies are in existence and what IoTs can in the future be designed and developed to meet these needs

The research objectives therefore will be:

--Review existing literature on the agricultural challenges in India

--Identify the IoT technologies that can address these needs through use cases

In order to effectively address the research problem, an interpretive approach is used. The interpretive approach is based on qualitative methods to obtain and analyze data. It is critical in enhancing the researcher’s understanding of human behavior and action as it relates to the phenomenon under investigation. It is based on the notion that knowledge of reality can be best obtained through social construction which includes documents, shared meanings, etc.. A literature review was conducted on both the agricultural needs/challenges of the rural communities, and IoT technologies that can be adopted to meet the needs/challenges. The final product is recommendations on IoT technologies for the domain of agriculture, looking specifically at solutions to the identified needs.

III. THE STATE OF AGRICULTURE IN INDIA

Agricultural productivity depends on several factors. These include the availability and quality of agricultural inputs such as land, water, seeds and fertilizers, access to agricultural credit and crop insurance, assurance of remunerative prices for agricultural produce, and storage and marketing infrastructure, among others. This provides an overview of the state of agriculture in India. IoTs would enable access to agricultural services, identification and access to markets for produce; management of rural transport for farmers, communication with extension services for information on agricultural practice and for information of weather forecasts to mitigate agricultural risks.

The country’s requirement for food grains in order to provide for its population is projected to be 300 million tonnes by 2025.6 The estimate of food grains production in 2015-16 is 252 million. This implies that the crop output needs to grow at an annual average of 2%, which is close to the current growth trend.

Despite high levels of production, agricultural yield in India is lower than other large producing countries. Agricultural yield is the quantity of a crop produced on one unit of land. Agricultural yield of food grains has increased by more than four times since 1950-51, and was 2,070 kg/hectare in 2014-15. IoT can be adopted in the management of agriculture, keeping track of animals in communal grazing lands, managing agro- processing factories, controlling irrigation systems and transport logistics management.

Indian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about 14 million people in different activities. With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species since independence, the country has shown continuous and sustained increments in fish production. Constituting about 6.3% of the global fish production, the sector contributes to 1.1% of the Gross Domestic Product (GDP) and 5.15% of the agricultural GDP. This creates immense opportunities in cold storage and haulage of fresh fish using refrigerated trucks and related logistics using IoT. IoT can be adopted in the management of aquaculture ventures.

Livestock plays an important role in Indian economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households. Livestock provides livelihood to two-third of rural community. It also provides employment to about 8.8 % of the population in India. India has vast livestock resources. Livestock sector contributes 4.11% GDP and 25.6% of total Agriculture GDP. IoT can be adopted to keep track of livestock especially in rural areas where there is communal grazing and animals are likely to get lost.

IV. POTENTIAL IoT SYSTEMS IN AGRICULTURE

The following sections give a few examples of potential applications of IoT in agriculture. For agricultural purposes and in an environment where the advent of climate change results in unpredictable rainfall patterns, automated drip irrigation can be adopted. Drip irrigation is the crop watering technique that waters only the soil closest to the plant’s roots. Linking data on temperature, radiation, humidity and soil water content collected by various sensors, controls not only where water is released but how much is needed. Since the rural areas are endowed with renewable energy and there is little or no access to the electricity grid, these renewable energy technologies such as solar and wind can feed energy into water pumps which in turn pump water from underground into tanks. This water is used to irrigate crops.

Weather forecasting can be done through analysis of weather data over long periods to reduce agricultural risk. This is referred to as big data analysis. In weather forecasts for pest management, humidity, precipitation, crop type, soil fertility, leaf wetness, temperature, winds and soil moisture are collected at local level through sensors. The life cycle of pests is monitored along with the climate data, allowing researchers to predict pest outbreaks more accurately because pest maturation depends on environmental conditions.

To prevent stock theft, animals are fitted with radio frequency identifiers (RFIDs) that enable tracking of the animal. The position of the animal can be visualized on a map in a control center through data remitted wirelessly. In rural areas where there is communal grazing, animals tend to get lost. Livestock are fitted with radio-frequency identifiers (RFID) chips and RFID readers are placed at various monitoring spots to transmit information to an agricultural extension services centre. The position of the animal can be queried.

The IoT can also enable branchless banking services. Farmers can deposit, withdraw and transfer money, and pay bills from a network of agents that include retail outlets, to the benefit of rural communities, who have no access to banks within a reasonable distance. A regional price information system could collect data from the main national markets and filter it out to local level through small information centres that have internet access. In more isolated communities, two-way or rural radio can be used to broadcast market prices to wider audiences.

Satellite light radiation can detect water pollution in the massive bodies of water. It uses the wavelength of pollutants to identify the class of pollutant. This technology would become handy in aquaculture. Flooding is a problem in river basins. A web site can be set up with real time presentation of a river basin. The ability to see what is happening throughout a river basin and react promptly to changing hydraulic and

weather patterns can save a lot of lives in agricultural communities. Sensors monitor the environment in the river basin and wirelessly feed information into the website.

Fires in uncultivated land are also a problem in rural areas. Satellite technology can be used to detect the fires through heat intensity sensors and photos which are transmitted wirelessly to the relevant stations. Trees can have plastic barcodes hammered into them, to prevent illegal logging of the coveted hardwoods. The tag on the tree is scanned as soon as the tree is cut, uploading the information via satellite to a secure database. The database tracks tree inventory, and provides reports. Trees can be tracked from the forest all the way through the supply chain to the consumer.

Organic greenhouses use technologies such as sensors to monitor and control temperature, humidity, soil aeration, soil moisture and drainage, fertility levels and light. The linking of these technologies with systems to control them can lead to smart systems that not only help farmers effectively utilize their resources but also lead to diversification where a wide range of crops can be grown. These organic greenhouses also require electrical energy to operate as expected. The form of energy will come from solar and wind energy, thus a system that integrates solar panels and wind turbines to sensors.

The IoT technologies can support precision agriculture, a form of agriculture whose goal is to maximize return on investment in agriculture. Irrigation / water detection / soil detection sensors give alerts to help protect a farmer’s crop and relay information wirelessly to water reserve points on when to irrigate. Furthermore, farmers can adopt automated drip irrigation in areas where water is scarce. This can be achieved by linking data from various sensors which controls not only where water is released but how much is needed.

In order to minimize crop damage by plant eating pests, animals and veld fires among others, better in-field monitoring is required. This can be accomplished by building sensors that monitor the fields. These will be able to inform farmers of any attack on their crops or fires detected before they spread.

Various decision support systems that run on smartphones assist farmers plan for the following farming season. In addition, these applications help farmers diagnose crop and livestock diseases and prescribe medications to the identified diseases. Alternatively, in cases where a farmer visits several veterinary officers, villagers can carry smart health cards. These cards can store all their animals’ information and is updated at every visit to the veterinary officer. For telemedicine to rural farmers, smartphones can be used to photograph and transmit images of affected livestock or crops to experts who prescribe remedies to the problems identified.

Public agriculture surveillance programmes enable decision makers guide agricultural interventions such as preventing the spread of plant eating pests or other plant diseases. Systems

that use IoT technologies, track and monitor farm animals and detect potential signs of diseases. These technologies can be integrated with a central system and help disseminate relevant advice to farmers. This can be used to identify outbreaks and trends. In addition, since livestock can be stolen, a system that monitors them using GPS technology can be put in place to detect their movement and alert the owners in case there are no detected animal movements for a certain period.

In order to facilitate the delivery of farm products to their destination, sensors that use IoT technologies such as GPS and RFID track and monitor farm products during transportation and storage. Since rural communities are sparsely populated, finding suitable transport to deliver products to their intended destination is a challenge. IoT systems can track farmers requiring transport to carry their farm products to intended destinations.

Satellite transmission can be made available in deep rural areas. This can connect to other areas via mesh technology. With this connectivity, rural farmers can have access to information on markets for their products and prices, government services and their rights.

To facilitate the purchasing of farm inputs and selling of farm products, buyers’ and sellers’ smartphones are equipped with IoT technologies such as Near-Field Communications (NFC) that facilitates the purchasing of products without using cash. Electronic transactions that debit or credit bank accounts for buyers and sellers instead replace exchange of cash. Such technologies also enable branchless banking services which is beneficial to rural farmers who have no access to banks within a reasonable distance. Mobile internet and low-cost sensors could enable farmers to interact directly with the consumers, cutting off the middleman. Implementation of Mobile Banking and m-wallets will make the mobile money transfer an easy task for rural communities.

V. RELATED LITERATURE

Although developed countries have led the world in ICT use for over two decades, the past decade has seen unprecedented growth in ICT usage by developing countries. The latter now boast the fastest growth in ICT penetration and related productivity growth has surpassed that of developed and transition countries. Today, public information and services that were difficult to access a decade ago are readily available especially to rural and marginalized communities India. In remote rural locations in india where communication would normally take several weeks to complete, the advent of mobile phones, instant short messaging system (SMS) and multimedia message system (MMS) has eliminated waiting periods to relay important decisions. Modern ICT such as Internet, email, 3G and 4G

mobile phones, personal digital assistants (PDAs) and social networking via YouTube, Twitter, Myspace, Facebook, etc. have extended the communication frontiers in the 21st century reaching previously excluded communities. These modern ICTs have enabled developing countries to “leap-frog” agriculture and rural development. As a result, increasing attention is being focused on the role ICT could play in promoting access to markets that is critical to the achievement of agricultural commercialization, food security, and poverty alleviation in India [14]. Mobile phones may help to increase income, improving the efficiency of markets, reduce transaction costs, and provide an opportunity for interventions in service delivery [8].

Internet of things (IoT) is a technology occurrence that is influencing the current context and will influence the future context. The idea of IoT relates to creating a network of objects that communicates with one another, via the internet, integrating embedded sensors, RFID, GPRS, computers, actuators, mobile phones, etc. These objects have unique addresses that enable them to address and verify their identities. The objects exchange and process information according to defined tasks and send reports to users [2]. IoT capabilities of interlinking objects through the internet can possibly be used in agriculture in several scenarios.

Several researchers addressed the use of IoT in agriculture to enhance the different agricultural processes. Xiaojing and Yuangua (2012) [25] emphasise mostly the use of cloud- enabled systems to show the relationship between the information cloud and IoT from the viewpoint of agricultural data and its use cases. They argue that the intelligent agriculture is one of the applications of Internet of Things (IoT), which has an extensive application and bright future.

ZigBee is a low-cost, low-power, wireless mesh networking standard [24]. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range. As a brand-new information acquisition and the processing technology, the ZigBee has seeped gradually into the agricultural environmental monitoring domain. The ZigBee technologies allow the identification of pests in the crops, drought or increased moisture. Having such information at a real-time interval, automated actuation devices can be used to control irrigation, fertilization and pest control in order to offset the adverse conditions. This technology can be applied for wireless applications in agriculture. The ZigBee nodes can obtain the temperature, humidity and illumination information in real time, and then transfer to a remote monitoring center.

A study made by Joe-Air Jiang (2014) [12] shows that precision agriculture (PA) has become an important issue. Wireless sensor networks (WSNs) and IoT might be great tools to monitor environmental parameters and plant growth in agricultural applications, because these two technologies can provide high-resolution spatiotemporal sensing data extracted from real world physical/analog signals. Precision agriculture is concerned with whole farm management aided by the information and communication technology (ICT) to optimize returns on inputs while preserving resources with regards to crop science, environmental protection, and economics aspects [16]. Thus, vital information can be provided in terms of farm record keeping, improve the decision making, foster a greater traceability process, and enhance the inherent quality and marketing of farm products.

DroneDeploy Software from the San Francisco–based startup DroneDeploy makes it possible for anyone to operate a small drone and analyze the captured mapping images using a computer or smartphone. The company focuses on industries such as agriculture, construction, inspection, and insurance. With one click, users can launch almost any commercially available drone on an automated path to get same-day aerial maps and 3-D field models. The technology can help them see where their crops need attention, estimate yields, and store accurate data for comparison over time.

Sensors connected to combine harvesters, tractors, and other equipment will allow farmers to collect a new level of information about their crops and soil. Flex President of Industrial and Emerging Industries Doug Britt suggests smart farming technologies will play an increasing role in efficient agriculture. "Sensing technology makes farms more intelligent and more connected through precision agriculture," Britt says. "This is just one way to increase the quality and quantity of agricultural production.” The information collected from sensors not only directly helps the farmers but also the agriculture business overall.

Onboard telematics software that monitors farm machinery's hours of use and maintenance needs also helps improve farming productivity. Farmers can gather data that are analyzed by software and provide feedback that will suggest exactly what should be planted and where, how much fertilizer to add, and when harvesting should begin.The author argues that ICT use in agriculture and rural development is a powerful instrument for improving agricultural and rural development and standards of living throughout Indian subcontinent. However, success in greater application of ICT in agriculture will require addressing impediments to adoption and diffusion. Such impediments include the lack of awareness, low literacy, infrastructure deficiencies (e.g. lack of electricity to charge electronic gadgets), language and cultural barriers in ICT usage, the low e-inclusivity and the need to cater for the special needs of some users. The work reviews successful applications of ICT in agriculture and urges greater use of ICT-based interventions in agriculture as a vehicle for spurring rural development in India.

VI. BENEFITS OF IOT IN AGRICULTURE

The purpose of this research is to identify and gain an understanding of the needs of Indian subcontinent’s rural areas and what interventions can be provided in terms of internet of things technologies (IoT). IoT technologies have the potential to alleviate poverty and uplift the standard of living of the rural farmers. For example, organic greenhouses make it possible to grow a wide range of crops that can not only be consumed locally but also for export to other countries. This enables farmers to generate extra income that help uplift their standard of living and also to contribute to the gross domestic product (GDP). The rural farmers can also leverage the investments in the IoT technologies that support agriculture to improve the standard of living. For example the tapped solar and wind energy can be also be used not only to light houses but also to stay in touch with current affairs through radios and television sets.

With IoTs it is possible to run public agriculture surveillance programmes which enable decision-makers to guide agriculture interventions, e.g., to prevent the spread of plant eating pests, other plant diseases or alerting farmers of veld fires approaching their fields. This helps the farmers to take

preventive measures before the situation gets out of hand. Without such interventions, the governments of both countries can spend lots of money in helping the affected farmers.

Precision agriculture can lead to bumper harvests even during times of drought. The governments of both countries will not spend a lot of money importing agricultural products from other countries since the farmers will produce enough farm products to feed the nations.

Since IoT technologies facilitate the tracking of farm products all the way to their destination, this is ideal for farm products that require further processing since the buyers can know in advance when the farm products will arrive and plan for the next processing steps in time. Since rural communities are sparsely populated, transportation of farm products can be a problem. IoT technologies can empower the transporters by providing them with information of farmers who require transport. Therefore, transporters do not need to wait until they have a full truck load of farm products to start off, they can leave any time provided they are aware that there are farmers waiting for transport ahead.

Through the use of Near-Field Communications (NFC), the farmers and buyers can benefit from paperless transactions and this helps minimize on theft and fraud. Similarly, this is beneficial to rural farmers who have no access to banks within a reasonable distance to deposit cash from purchases or withdraw cash to buy farming inputs.

The use of livestock or crop smart health cards which store information related to affected livestock or crops can be beneficial to both the veterinary or agriculture officer and the farmer. This can lead to efficient and effective diagnosis and prescription of medicine since the officer has access to all the historic information of the affected livestock or crop.

If satellite transmission is made available in the deep rural area, this has the potential to create jobs for local businesses who could offer low-cost solutions, access and wireless network services cheaper to the communities. Satellite transmission can also enable farmers in rural areas obtain information on markets for their products and prices, government services that they can access, and their rights. The systems can also connect to government departments and local and international markets. With the introduction of the mobile internet and low-cost sensors, farmers could interact directly with consumers and cutting off middlemen who usually exploit them. This is beneficial to farmers because they can make better profits on their products.

VII. CONCLUSION

This research has identified potential applications of IoT in agriculture for sustainable rural development in India. It has shown the business benefits of that can be derived from IoT by various domains of agriculture. These Domains include water management, weather forecasting,wildlife management, finance, forestry, plant and animal disease management, transport and storage of agricultural produce,extension services, etc. The study id meant to influence policy on adaptation of IoT in rural development and agriculture.This implementation of IoT based services has already been done successfully in countries such as America and Europe. The study can also be utilized by developers of new IoT technologies to build country-specific technologies based on the identified problems. The main aim of the research was to use the current available technologies at hand and build a futuristic farming method and bring on a revolution in automated farming in India by supporting poverty alleviation and uplifting the standards of the people.

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