Industry Revolution 4 (IR4) and Agriculture: 4.0Agriculture

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Abstract- *To increase the potential of crop and get higher yield, farmers need advance technologies. Green revolution modified the face of agriculture in the 20th century. Even as the purpose, this is, growing vegetation and maintaining livestock remained the equal, methodologies modified and that had a sizeable impact on consequences. Now, with cutting edge disruptive technology in IR4, agriculture is up for technical revolution. This is the want of the hour owning to growing demands of the developing population, that have led to the extra in-depth farming practices. Contemporary agriculture requires a sustainable yet greater green approach, that is termed as smart farming. The IR4 is starting to change how every agriculture player, from the circle of relative farmer to global conglomerate, produces meals and related products. The spread of vital IR4 technologies- together with AI, Cloud Computing, drones, machine gaining knowledge and the net of factors (IoT) – to agriculture is main to extended yields, lower charges, and the reduced environmental effect. Those gear are also empowering farms to liberate new plant totally based improvements and increasing their resilience to excessive climatic occasions and climatic modifications. However, this revolution in agriculture imposes new needs on producers and the business that serve them. To thrive in future, agricultural groups ought to carefully select some of the IR4 new technology, to keep away from wasting time and money or worse- lacking out on important opportunities.*

Keywords: **Industrial revolution IR4, Cloud computing, Agriculture, Data, AI, Machine learning**

1. INTRODUCTION

Agriculture is an essential practice for the survival of humankind for thousands of years. This relationship has resulted in the advancement of agricultural activities, initially through the time-consuming method of traditional agriculture. The current recent rapid increase in the global population (predicted to rise to approx. 10 million by 2050) has now led to an urgent need to balance demand and supply using new technologies to increase food production. This development places pressure on the natural resource, with agriculture now consuming 70% of the world's fresh water supply for the purpose of irrigation. Limited resources and the impact of the climate change will therefore lead to considerable challenges in producing sufficient high-quality food to support the population. Smart Agricultural using IR4 is a global initiative to preserve resources and maintain sustainable agriculture.

Recently, the new Industry Revolution (IR4) trend, and emphasis on the adoption and implementation of the viral technologies such as AI, ML, Cloud Computing, Data Science, Internet of Things (IoT) in agriculture, farming, and irrigation. Around the globe, many researchers are now focusing on the investigating new technologies to create a smarter agriculture environment keeping up the technological pace, involves economical, engineering, mechanical, food retailers and computing characteristics. However, agricultural processes are fragmented, resulting in several issues, that is, difficulties in operating and managing smart machines, data sharing and management, data analysis, storage, not having precise understanding of climatic conditions of an area which leads to low yield and poor-quality crops. Devasted crops results in higher prices for consumers in the market. So, for enhancing the yield of crops without worrying about climatic conditions in a place technology in IR4 could be used.

Now, this follows a profile of the methodology promoting this research, assisted by the history of smart agriculture, smart and advanced computing technologies, and examples of IoT/AI technologies related work in current agriculture practices. This is supported by an in-depth discussion on all the technologies such as Artificial Intelligence, Data Science, Machine Learning, Cloud Computing, and Internet of Things (IoT) along with the most significant outcomes from the study, this paper finishes with concluding remarks and plans for future work.

2. TECHNOLGIES DRIVING CHANGE IN AGRICULTURE

The Fourth Industrial Revolution and Agriculture can easily be understood by emphasising on the technologies that are driving it. These include the following:

2.1 Artificial Intelligence and Machine Learning (AI & ML)

AI refers to the potential of a computer program to execute tasks correlated with intelligent beings. AI solutions tried to dispense smart predictions or solution based on the input available. Talking of agriculture perspective, inputs can be in the form of time series data like rainfall patterns of an area, farmer's past yields, or relevant images. The output of AI solutions can be the predictions or proposal of many forms such as forecasts for next year's rainfall, yield projections, objects detected with an image.

AI is a sort of algorithm which learns to create logic from data. In terms of agriculture, previous rainfall pattern and other relevant meteorological data are used periodically to train models to forecast weather. Insect-pest images are used to direct models so that it can detect and classify the insect pests and stipulate their management. From this training, AI can translate new data into new insights. Data provided to AI should sustain suffice information to get anticipated output. To get better output, better data should be provided i.e., accurate, diverse available at required frequencies, and should have levels of granularity. Quality of data influences AI algorithms performance, agriculture is data rich field, but it is difficult to access and use data effectively. This data is usually siloed in private organizations or data sharing have limited access or data quality is incompatible.

AI developers often must develop new procedures for data collection which is tedious and time consuming to execute the AI models. Remote sensing and IoT technologies fulfilled this data requirement gap by dispensing regular soil-weather data. But still these IoT hardware not affordable by small farmers.

AI algorithms are of many types, but one of that is most significantly used which is called "Supervised learning". In this type of algorithm, data is labelled with descriptors which means it wants the machine to learn connotation about. In terms of agriculture, the image of a pest trap is labelled with the type of pest it contains, the algorithm then learns to relate that pest with hidden qualities of the image in a way that new images with similar qualities can be labelled automatically. AI algorithm output have the potential to be used to improve vision, analyses, forecast, predictions for better decision making. Practically, this algorithm output forms a function of a product such as an app, website, or tool which farmers and other stakeholders can use for smarter decision making. Creating an AI-based product which is beneficial and easily accessible is quite variable like many other technological innovations. Not even this, lots of farmers do not have smartphones, connectivity and network problem is also an issue certainly in remote rural areas. And even organising AI-based reference system in high-risks agriculture decision making put questions in trust, biases and vague, exceptionally if any predications vary from traditional practice.

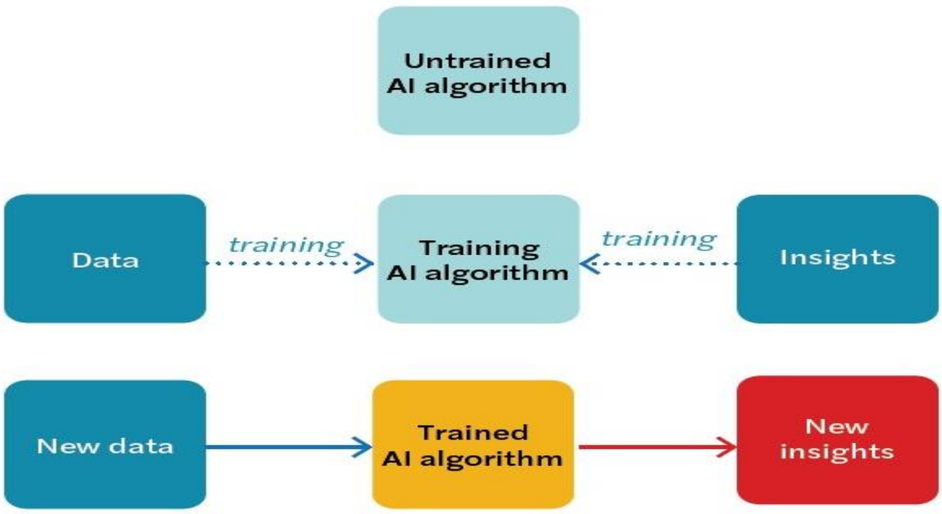

Fig 1. Flow diagram of data transfer

2.2 Internet of Things (IoT):

IoT is a technology which aimed to link all the intelligent objects in a single network i.e., the Internet. It includes all type of technologies such as intelligent boards and sensors hardware, advanced operating system, and AI algorithms software. The main target of IoT is establishment of applications for devices so that it can monitor and control any specific domain. It is widely adopted in different area such as health applications, smart homes and cities, industrial business processes, home appliances, etc. IoT connectivity incorporates people, tools, machines, and locations which aims to achieve unusual intelligent functions from data sharing and information exchange. Though in agriculture, IoT prime used is management of agricultural products within collected real-time data. Besides, searching, tracking, monitoring, control, managing, evaluating and operations inside a supply chain.

IoT in agriculture like Precision Farming refers to a technique of managing farms and conserving resources using IoT, information and communication technologies. It finds real-time data affecting the conditions of farm elements like crops, soil, nutrients etc. to protect the environment, ensure the profits and sustainability. Smart irrigation is a technique to improve the efficiency of irrigation process and reduction in water loss, at the same time conserving the existing water resources with the help of IoT based smart irrigation systems. Drones also play am major role in IoT related agriculture as it is employed in various agricultural applications which includes scanning large fields, monitoring the field crops and livestock. Meantime, sensors on the ground collect a huge range of information. Smart greenhouses indorse the crops cultivation with least amount of possible human interference and use the continuous monitored climatic conditions such as humidity, temperature, solar radiation, soil moisture, etc. which triggers the automated actions based on the evaluated changes and implements mitigation to maintain the most effective conditions for the growth of crop.

Category	Tool/Company	Description
Climate conditions monitoring	allMETEO	A portal to manage IoT micro weather stations, to gather real time data access and create weather map and provide an API for easy real time data transfer into developed or existing infrastructure.
	Smart elements	A collection of products that improve the efficiency by eliminating manual checking. They work by deploying a wide range of sensors generating a report back to an online dashboard, allowing rapid and informed decisions based on real-time conditions.
Greenhouse Automation	Farmapp	A process of monitoring pests and diseases, generating reports for mobile applications. It records the data quickly and more efficiently than traditional methods (i.e., paper) allowing a smooth implementation. The stored data is synchronized with the server, enabling the following metrics to be immediately observed: i. a satellite map with recorded points; ii. The current sanitary status of the farm; iii. Comparative heatmaps to easily compare previous measure with the current situation; and iv. Charts and reports concerning pests and diseases.
	GreenIQ	A system to control irrigation and lighting from all the locations and to connect IoT devices to automation platforms.
Crop Management	Arable	A device that combines weather and plant measurements, sending data to the Cloud for instant retrieval from all locations. It offers continuous indicators of stress, pests and diseases.
	Semios	A platform focused on yield improvement. It enables farmers to assess and respond to the insects, disease and health of the crop using real-time data, forming on-site sensing, big data and predictive analytics solutions for sustained agricultural products.
End to end farm management system	Farmlogs	This system monitors field conditions, facilitating the planning and managing the crop production. It also markets agricultural products.
Crop and Soil health monitoring	Plantix	A machine learning based tool to control and manage the agriculture process, disease control, and the cultivation of high-quality crops.
	Trace Genomics	A soil monitoring system performing complex tests (i.e., DNA) on soil samples. It uses a machine learning process known as "genome sequencing" that generates a heath report for a soil sample by reading its DNA and comparing it to a large soil DNA database

Table 1. List of IoT/AI applications in Smart Agriculture.

2.3 Cloud Computing:

Recently, Cloud Computing is growing rapidly inside the IT sector. The cloud is not bounded to a certain domain instead it has been executed to stimulate and support different applications and platforms. It offers simple entrance to the Cloud providers like AWS, Azure, GCP to delivers high-performance and storage infrastructure one the internet. Its main advantage is to conceal from users of the complexity of IT infrastructure management.

Cloud Computing defined as' ***"a model which enables convenient, on demand network access to a shared pool of configurable computing resources such as networks, servers, storage, applications services, etc. that can be speedily provisioned and released with minimal management effort or service provider interaction".*** The cloud seems to be high virtualization method for datacentric infrastructure allocated over an extensive geographical area connected by high bandwidth network cables which provides different kinds of virtualized service. It includes the whole infrastructure as well as software applications and services like high performance computing and large scalable storage services on a pay-per use model.

Cloud Computing has four main layers: a. Hardware, b. infrastructure, c. platform, d. application. Generally, delivery of Cloud services classified into three models:

i. Infrastructure-as-a-Service (IaaS)
ii. Platform-as-a-Service (PaaS)
iii. Software-as-a-Service (SaaS)

Cloud Computing considered as most efficient way of storing agricultural data including IoT and the Machine learning PaaS services offered by many cloud service providers.

2.3.1 Applications of Cloud Computing in Agriculture:

i. Establish a Global Integrated Agricultural Product Sales Platform through Cloud Computing Technology

Cloud computing technology is used in various countries for data mining and analysis of consumer information. This feature can further enlarge the agricultural e-commerce coverage. By combining cloud computing and data mining, it has strong information integration abilities. Once analysis and integration can be done, we are able to build globally combined agricultural product sales platform and able to sell agricultural product with excessive supply to many demanded regions and achieve maximum output.

ii. Building a high-quality Cloud Computing technology monitoring platform

Rural e-commerce logistics informatization must depend on accurate link control, intelligent decision support and real-time information distribution of rural electronic logistics public information platform. For all these, it requires use of cloud computing and big data technology to monitor data, build high quality monitoring platform, improve the efficiency of different logistics links and the environment, thereby generate an efficient logistics network. With the help of monitoring platform, we can track product logistics distribution, storage, and other relevant information. Agricultural product operators and consumers can grasp logistic information any time and lessens lagging logistics information problem. Monitoring platform establishment can allow rural e-commerce logistics distribution services to share information in time and decrease the stakes of information asymmetry.

iii. Cloud Computing Technology for data mining to determine market demand at any time

Due to impact of climate on agricultural products, demand by consumer cannot be able to meet in times. With cloud computing and big data global agricultural product integration can be achieved by their strong information integration capabilities and breaking seasonal restrictions on product production and sales. Agricultural e-commerce operators can find consumer information anytime by cloud computing data mining technology.

iv. Cloud Computing technology can reduce costs and improve efficiency

Cloud computing technology has the ability of powerful information integration which forms sequential and effective agricultural product classification with clear type, quantity, demand, and supply of agricultural products. It can display the harvest date of various agricultural products as well the quality inspection status in real time. It provides consumers a chance to purchase agricultural products online with assurance and producer to sell their products online, achieve high growth in e-commerce for agricultural products. Not only cloud computing technology uses extends the marketing channels for agriculture products but also recovers the marketing efficiency and decreases marketing costs.

Application of cloud computing technology in agricultural e-commerce will increasing complete the rural trade circulation, consequently increasing complete the circulation structure. With the help of this technology, we can mine information resources and quickly find the target customers and fulfil their requirement. Cloud computing technology fastens the interpretation of agricultural e-commerce platform and stable the growth of its e-commerce economy.

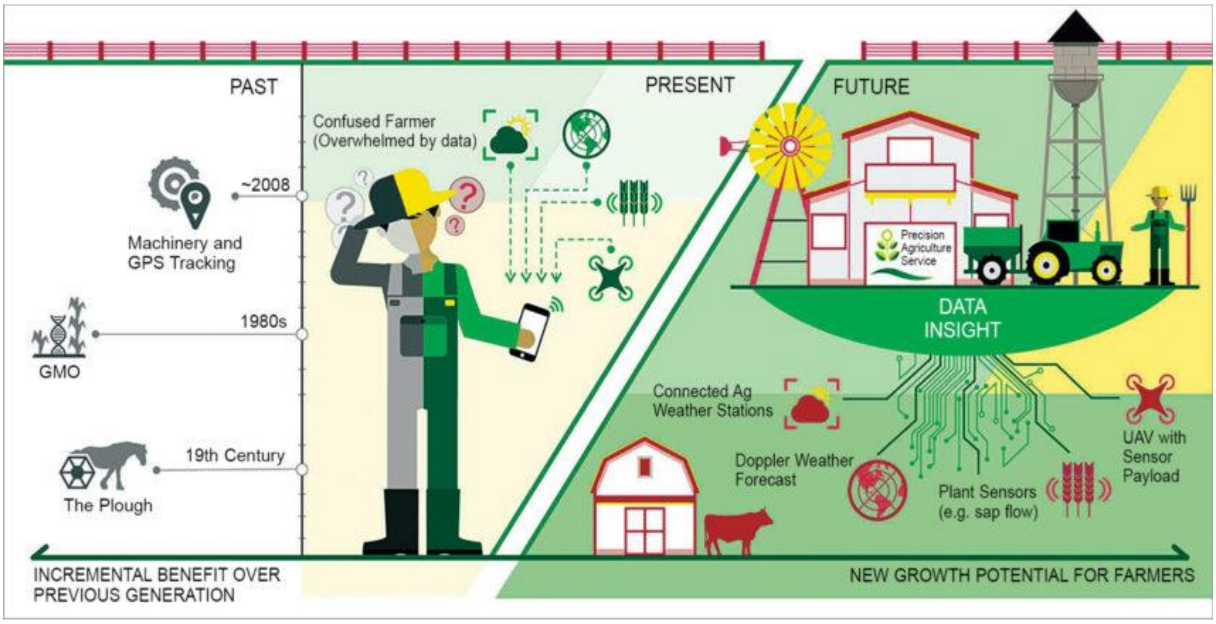

Fig 2. Transformation of agriculture from past to future

2.4 Data Science:

Here are some applications of data science agriculture sector which are as follows:

a. **Digital Soil and Crop mapping:** This application of data science is relevant to developing digital maps for types of soil and their properties. Large land holding farmers manages many acres of land and sometimes it is not possible to have update and alerts about the latent problems without the help of technology. There are many countries who depend on satellite-based soil and crop monitoring than traditional method so that they can rapidly inspect the areas. It helps farmers to decide of which type of crop should be grown on a certain area of land, therefore saves time and effort and leads to higher yield production.

b. **Weather prediction:** Crops vividly depends on physical factor. Weather plays a key role in agriculture production as it influences growth and development and yield of crops. Weather aberrations causes soil erosion as well as causes the severe physical injury to crop. Bad weather can affect the quality of crop. Experts in data science use tools to identify the potential patterns and relationship. They put up conclusions which drive agricultural science forward by examining specific factors results to change in weather conditions. Some of the feature of agricultural weather forecasts datasets are:
   - Amount and type of coverage of sky by clouds.
   - Rainfall and Snow
   - Maximum, minimum and dew point temperatures
   - Wind speed and direction
   - Relative humidity
   - Wind speed and direction
   - Low-pressure areas, cyclones, tornedoes, and depressions
   - Events like fog, first, hail, thunderstorm, and wind squalls

c. **Fertilizer recommendation:** Exact rate of fertilizer application is essential to agriculture, and it requires multiple factor analysis. Many dynamic parameters such as crop nutrient uptake rate, research data, soil chemical, physical and biological properties, weather, water composition, land type, soil testing methods, irrigation techniques, fertilizers characteristics, fertilizer interactions, etc must be considered. Due to difficulty in finding the "optimal fertilization range", fertilizer exploitation happens globally. Some farmers depend on trial-and-error method, guesswork, and estimation. These all leads to consequences; crop do not reach to expected yield potential and even induces environmental pollution. Data science experts are now accomplished to advise farmers with right amount of fertilizer recommendation dose.

d. **Disease detection and Pest Management:** Modern agriculture relies on advanced algorithm which is used to identify the behaviour and patterns of nature that is helpful in forecasting the spread of microscopic diseases and invasion of pests. With the help of advanced analytics in agriculture, farmers are getting information on how to manage pests. Digital tools ad data analysis in agriculture are now being applied to deal with non-beneficial harmful insects in a scientific manner. Agricultural pests are major problem, leads to exploitation of pesticides which can have adverse effects on human beings and environment. Some of companies recruited data science professionals so that they can develop user-facing platforms which analyses the situation of when to apply pesticide and which amount. It also detects which insect is beneficial to crop or which can be toxic and spread diseases. Detection of disease can be done by taking images of the fields with the help of drones and processing them to detect the disease infected field.

e. **Adaptation to Climate Change:** Climate change is the major issue which is affecting environment as well as agricultural sector. But data science experts are trying to figure the ways to mitigate the change. One project in Taiwan where Taiwanese farmers were given IoT sensor, so they can collect all the necessary information about their crops. It is helpful to farmers as they can optimize their production cycles without getting affect by any sort of climatic change. Farmers use the traditional calendar which is not effective because of extreme climate change but data analysis revolutionised the future of farming. Even soil data is analysed by data scientist to know how soil can manage and adapt climate change.

f. **Automated Irrigation System:** In automated irrigation, weather prediction is used. It is a system which tells farmer that soil is dry but there is no need of irrigation because it is going to rain after a few hours. Water scarcity is also a basic problem which farmers faces. To improve the water usage drip irrigation system is implemented as Automated irrigation system.

3. CONCLUSION

This paper displays the importance of employing Industrial Revolution 4.0 technologies in agriculture sector, such as AI, Machine Learning, IoT, Data Science. Agriculture is appraised essential to the survival of mankind. Supporting the current practices of traditional agriculture with IR4 technologies can enhance the performance, quality and quantity of production and profitability. This study classified the prime domains of smart, sustainable agriculture, i.e., human resources, crops, weather, soil, pests, fertilization, farming products, irrigation, livestock, farming machines and fields. The major contribution concerns with development of solution that involves IR4 technologies and constructing technical architecture on cloud as a proof of concept that all technologies combination can dispense better and the maximum output in AgTech. Major emphasis given on the research and development of a unified platform for agricultural resources to solve the situation which we get from the fragmentary nature of the agricultural processes. Future work will include investigation of the process of implementing IR4 technologies that will identify the relevant advantage and disadvantage for further enhancement.

4. POC CHALLENGES

Evolved technology environment: There is a requirement to ease up the access of collected data by building agriculture data stacks or hub and combine the data owned by government, private companies, and programs. There is a need to set new policies and framework for data ownership, privacy and protection and should create incentives and build infrastructure like private/public clouds with appropriate computational capacity for sharing information. For example, Ethopia's Agriculture Transformation Agency (ATA), Kenya's KARLO (Kenya Agricultural & Livestock Research Organization) are infusing in development of agricultural data hubs and combining their own data, global data sets and local data for improved support technology innovation across the ecosystem.

Building viable Solutions: For solutions to scale and secure the required financing, more efforts are required to demonstrate their value proposition, business case and commercial potential. Partnerships model such as PPPs, donor driven innovation support and market strategies such as product bundling should be employed across the AgTech.

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