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The Impact of Cloud Computing & ICT in Agricultural Productivity

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***Abstract*— In order to end hunger in the country, agriculture is essential. This article is about cloud computing, which aims to improve smart agriculture by maximizing the use of limited resources. It raises the standards of farmers and agricultural crops. To build a sustainable way of life, intelligent farmers need to be familiar with Information and Communication Technology. The data generated by cloud database will aid in gaining understanding and revealing fresh information for increasing the usefulness and efficiency of smart agriculture. Despite the availability of numerous intelligent technologies, farmers remain unaware about cloud computing. This study will help close this knowledge gap by educating agronomists about potential future prospects and ways to simplify the use of cloud storage in smart farming.**

***Keywords*— *Cloud computing, E-agriculture, Smart Agriculture, Smart Agronomist, Modern Agriculture, ICT Agriculture*.**

I. INTRODUCTION

Agriculture is crucial to the world economy. Online shared resources, software, applications, and services are made available to meet the customer's elastic demand with the least amount of effort or engagement from the service provider. India is a leading global food and grain exporter, but the country's agriculture is still largely conducted using outmoded, traditional methods. Farmers also impose many restrictions on their operations, so modernization is moving at a glacial pace. The result is a severe mismatch between the channels of supply and demand for agricultural products.

That's bad news for the farmer's bottom line and for the country's GDP. • Crop Related Information can catch data pretty much all crops grown in the recent past, allowing farmers to make decisions about what to grow next, has been the subject of much discussion over the past thirty years. The role that ICT (Information and Communication Technologies) may play in facilitating the successful adoption of novel approaches and methods in agriculture and related fields is an area ripe for investigation. It's possible that advancements in ICT could greatly improve the quality of life for people in rural and far-flung areas, boost agricultural output and income for farmers, and ultimately make it more appealing for them to settle there. The introduction of Cloud Computing has facilitated the widespread adoption of recent advances in information and communications technology.[1]

II. DIFFERENT COMPUTING MODELS

A. Cluster computing, defined as "a group of interconnected computers acting as a single system," is method A. The capacity is used to distribute the load among multiple servers. The primary advantage of this computer technology is that the workload can be spread across multiple servers. [2]

The centralized location has to be set up to store all the relevant data. It can include various, Separate databases Soil-related, weather-related, Research, Crop and Farmers-related data can all be stored at a single location, and data availability can be achieved. This data can be accessed by the end-users such as farmers, experts, consultants, researchers etc easily any time from any location through the devices that are connected to the cloud system.

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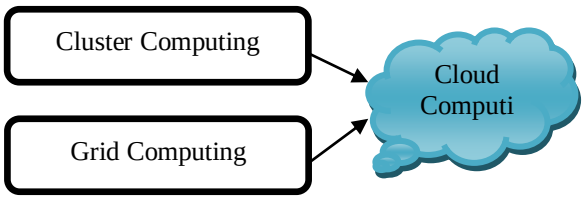
B. Grid Computing This term refers to the use of a network of interconnected computers to perform a single task. Grid computing has many advantages, such as facilitating greater data accessibility and collaboration, consolidating and disseminating data on a global scale, facilitating large-scale multidisciplinary efforts, promoting work-life balance, enhancing data security, and so on.

The term "cloud computing," also known as "demand computing," refers to the on-demand provisioning of computing resources and related IT infrastructure over the Internet. Everything must be prepared to be saved in one central location, like the cloud or a large hard drive. It could involve a large number of separate data stores. Storing information about soil, weather, research, crops, and farmers in a single location increases data accessibility. Farmers, specialists, consultants, researchers, and anyone else who needs access to this information can do so from anywhere with a device that is connected to the cloud system..

Fig 1. Various Computing



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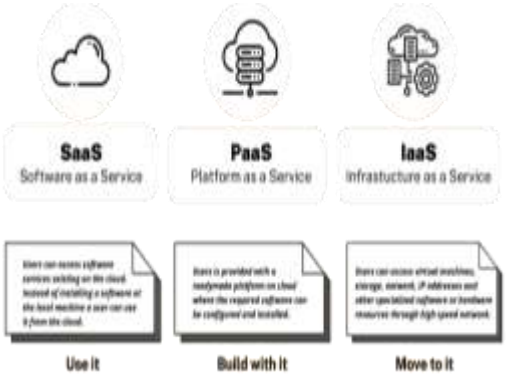
III. CLOUD COMPUTING AND ITS DEPLOYMENT

Public clouds, private clouds, and hybrid clouds are the three main types of cloud computing. We can evaluate the relative merits of public, private, and hybrid clouds in terms of data security and management needs by comparing them with one another and also with one another's respective strengths and weaknesses..

A. As a whole, the internet can be thought of as a giant public cloud. Services like software as a service (SaaS) and cloud storage are examples of what service providers use the internet for to offer their customers. Businesses can use public clouds like Amazon Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, Google AppEngine, and Microsoft's Windows Azure Services Platform.

Because the service provider foots the bill for hardware, software, and data transfer, this type of cloud has a low entry price for customers. It's a capacity-based pricing model, so you only pay for what you use. As can be seen in the figure, there is a wide variety of Public Cloud options.

Fig 2. Various Public Cloud services



Private clouds are scalable, adaptable, automated, and easily monitored cloud infrastructures that are owned and operated by a single organisation. The point of a private cloud isn't to make money off of "as-a-service" offerings for third-party clients; rather, it's to take advantage of cloud computing without giving up operational control of an internal data centre.

B. Hybrid clouds are useful for hybrid E-commerce. The actual work of processing orders can benefit from the elasticity of public cloud resources because e-commerce sites must react to daily and seasonal fluctuations in traffic. Personal and financial data, on the other hand, must be handled in accordance with stringent legal regulations, and this information is safer "on-premise" in the Private Cloud. This hybrid approach takes advantage of the benefits of both approaches by moving the store's transactional front end and order processing to a more scalable environment, while keeping sensitive information like customer payment details and account management in-house. Two examples of businesses that use a hybrid cloud are Adobe Creative Cloud and Sales Force [3]. The figure below depicts the most prominent Cloud service providers.

Fig 3. Public Cloud services

IV. KEY CHARACTERISTICS OF CLOUD COMPUTING

The characteristics of cloud computing are important from the standpoint of the cloud. The following characteristics are listed as per NIST [4]:

- On-Demand Self-Service – a consumer can get the a service independently, without involving the Cloud Service Provider in any way (CSP).
- The cloud can be accessed from any device with an internet connection, including smart phones, tablets, computers, and even TVs.
- The cloud allows for the sharing of both physical and virtual resources, which can then be allocated and reallocated amongst a number of users based on their individual needs.
- Rapid elasticity allows you to expand your facilities both horizontally and vertically in response to demand.
- • Metered Service, in which consumption is tracked and reported for full visibility by both the service provider and the pay-per-use customer..

V. USER EXPERIENCE OF CLOUD COMPUTING IN AGRICULTURE

Without worrying about the specifics of the underlying hardware or software, users of cloud computing services can take advantage of these features in real time.

- Particular applications include the following:
- To help farmers decide what to grow next, Crop Related Information can record details about all crops harvested in recent years.
- • Cloud-based meteorological archives can save both local and long-range forecasts, depending on the context. Once again, these are useful for farmers when deciding what to plant.
- • Soil Data Soil data plays a significant role in crop management decisions. In addition to the soil profile, it can reveal the soil's historical trend, which in turn can be used to foretell the soil's future behaviour. Is there a shift in the soil's acidity or alkalinity, or are there other changes to the soil's nature and composition?
- The expansion of crops can be tracked at regular intervals and in various locations. This enables analysis of current growth rates in relation to those of the past.
- Data from farmers or local farmers can be tracked and analysed at the national or even global scale. Policymakers can use this information to better target their efforts by focusing on the most crucial agricultural regions.
- Consultation with knowledgeable individuals is crucial. There are readily available answers to the most common issues that farmers face. Additionally, experts offer timely responses and tailored answers to problems.
- Disease alerts, crop damage from those diseases, and updates on agricultural practises are just some of the things that farmers can expect to receive from the FMS.
- • Agricultural data is monitored in general with Cloud Agro System. The cloud agro system can present the data stored there in the farmer's first language. It helps farmers plan crop production in response to fluctuating food prices and market demand.

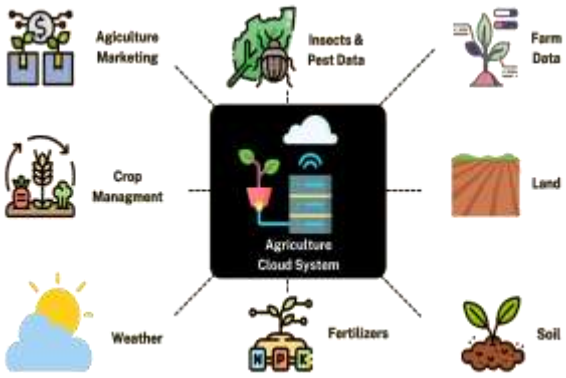


Fig4 . Cloud based Applications

VI. ICT IN PRECISION AGRICULTURE

Communication networks and computing devices are brought together to facilitate data retrieval, storage, and manipulation; this is known as information and communication technology (ICT). E-Agriculture, or the application of information and communication technology in farming, can help with a variety of socioeconomic issues. Cloud Computing is the newest and most exciting part of ICT (Information and Communication Technology). Precision farming relies on technology to analyse and improve machinery, fertiliser, water, and soil. Collecting, analysing, and storing agribusiness data is a common use case for distributed computing. Through the use of cloud-connected remote sensors that constantly gather data from the field and artificial intelligence calculations that analyse that data, ranchers can gain a deeper understanding of harvest conditions. Soil conditions such as moisture, pH, protein content, supplements, and temperature can be continuously monitored by sensors. [5]

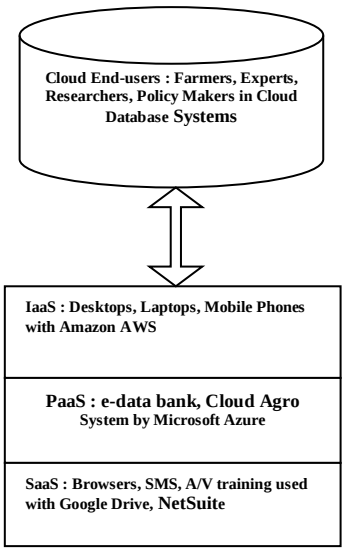


Fig 5. Cloud Environment in Agriculture Fig 6. IOT & Cloud Computing in ICT

VII. AREA COVERAGE OF ICT IN AGRICULTURE

- ICT services to block and district-level developmental officials, allowing for greater efficiency in delivering services for overall agricultural development; question-and-answer services, in which experts respond to questions on specialised subjects.
- Information such as practise packages, market data, weather forecasts, input supplies, credit availability, and so on should be updated as soon as possible and sent to farmers.

- Site-specific information systems and expert systems, as well as databases containing information about local villages and villagers' resources, are developed.
- Postharvest technology, rural development programmes, crop insurance, and early warning systems for diseases and pests are all provided.
- Providers of business and management advice for farmers;
- Extension (knowledge) workers have access to the most up-to-date information and are actively sought-after for their input, thanks to tele-education for farmers and websites set up by agricultural research institutes.
- The use of advanced database management systems and a widespread network of computers has increased the effectiveness and productivity of today's cooperative societies.
- Many different forms of information and communication technology (ICT) are put to use in the farming industry. Using ICT, farmers are better able to comprehend the gap between output and market demand.

VIII. CONCEPT OF IOT IN ICT

The term "Internet of Things" (IoT) is used to describe the systemic management of various everyday physical devices through information and communications technology (ICT), with automatic control and remote operation in mind. The concept of the Internet of Things (IoT) has actively spread to construction hardware, vehicles, aircraft, and other fields at the research level, and it is normal to prompt the development of a variety of new value- added services.

- The Internet's accessibility via increasingly compact devices is a direct result of the development of cutting-edge ICT strategies and solutions [6]. (Majeed & Ali, 2018). By creating a space where old and new practises can coexist, share resources, and work together, the Internet of Things has transformed agriculture. Through the use of I&C strategies and tools available online, we have created a culture of openness and collaboration. [7]

IX. METHODOLOGY OF SMART FARMING

- Though still in its infancy, cloud-based technology is already helping farmers with crop care in much the same way that it helps doctors with patient care. Farmers will be viewed as unique people, not clones.
- Experts recommend automated driving technologies such as cloud-based mobile applications, machine learning, artificial intelligence, computer vision, and so on. Certainly, information plays a pivotal role in this setting, as it is intended to help farmers increase their productivity by a factor of two.
- Market, crop planting, weather, composting, and many other types of information are all readily available to farmers thanks to this online database. In a similar vein, experts and researchers at the farming exploration station can now open up and discuss the methods used in conventional farming.

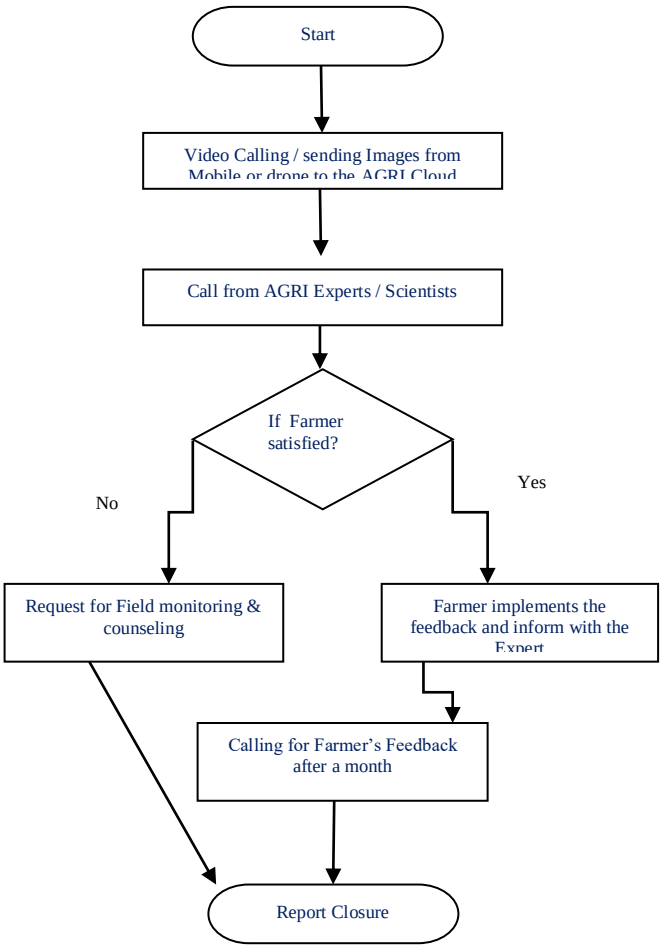


Fig 7. Framework for ICT based Farmer Management Systems

X. ICT AND MOBILE APPS DRIVE GLOBAL AGRICULTURE

As a result of advancements in cloud computing, integrated IT frameworks, online education, and mobile phone penetration, it is now much easier to disseminate agricultural information to ranchers in economically disadvantaged areas. Better land management decisions can be made with the help of increased connectivity and sharing of data among farmers. Soil monitoring in conjunction with weather information, for instance, can help farmers better schedule their planting and harvesting times. Similarly, GIS can be used to provide farmers with forecasts about pests and diseases, allowing them to take appropriate action in response to the degree of risk. The use of fertiliser, seeds, and water can all be optimised with the help of mobile and cloud computing technologies. The financial benefits to farmers are clear.[8,9,10]

Advantages of ICT in Agriculture:

- Enhances additional and advanced knowledge and income.
- Increases production efficiency through ICT techniques
- Increases sales and profitability
- Increases sales by market and supply and demand

My Agri Guru	Machinery guide
Iffco Kisan	Uzhavan (Tamil App)
Agriplex	Kisan Suvidha
Market yard	Agrowon
Indian Satellite Weather	Shetkari
Zero Budget Natural Farming	Kisan Yojana
Kisan Space	Krishi Network
Crop Insurance	MSAMB
e-Gram	Fasal Salah
Farm Bee	KVSMT
Coconut expert (Tamil)	Napanta
CCMobile	Bijak
Agromedix	Bajar Bhav
Agriculture Business	Agri Live
Agri App	
e-Gram	Fasal Salah
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CCMobile	Bijak
Agromedix	Bajar Bhav
Agriculture Business	Agri Live
Agri App	Tumaini

Table 1. Top Mobile Applications to increase the productivity.

XI. MODERN TECHNOLOGIES

- Information gathering and processing can be facilitated by employing cutting-edge technologies such as the Blockchain, the Internet of Things, machine learning, and deep learning. Computer vision, machine learning, and the Internet of Things applications will help farmers and related industries boost output, enhance quality, and boost earnings. In order to increase crop yields, the agricultural sector would benefit greatly from the application of precision learning techniques.

Fig 8. Machine Learning and Deep Learning Algorithm usage in Agro-Computing

The many uses of machine learning and the internet of things are discussed [12]. With the help of deep learning algorithms, machine learning is becoming more effective and reliable. The need for ML specialists can be reduced and the ML pipeline can be automated with greater precision using automated machine learning (AutoML). The newest method for rapidly creating high-quality ML models with improved efficiency and accuracy is called automated machine learning (AutoML) [13].

Unmanned aerial vehicles (UAVs) are increasingly being put to use in a wide variety of fields, including agriculture, where they are primarily put to use to maximise crop yields and keep tabs on how their products are developing. Drones are being used more and more in the agricultural industry to collect data on things like crop health, soil types, and the stages of crop growth. Multispectral sensors are used on agricultural robots to capture electromagnetic radiation beyond the visible range, including near infrared and short-wave infrared. The ubiquitous nature of cell phones, even in rural areas, has resulted in a proliferation of ICT services beyond the realm of mere voice calls and instant messages. There aren't that many apps out there that are specifically designed for farming or gardening on a smartphone. [14]

Steps in Machine Learning and Deep Learning:

1. Gather photos/videos - using a mobile camera or a drone to take photos/videos that will later be uploaded to a cloud service
2. Noise must be removed from data stored in the cloud before it can be used for training, testing, or validation using the appropriate algorithms.
3. Feature Extraction is the process of isolating and identifying key patterns.
4. Transfer Learning – Reduces the amount of time needed to run ML algorithms like Decision Making, Support Vector Machine, and K-Nearest Neighbors. Transfer learning in computer vision is associated with deep learning algorithms such as convolutional neural networks (CNNs) and their corresponding architectures (Alexnet, VGGNet, Inceptionnet, Resnet, SSD, YOLO, etc.). Common problems encountered during model construction include over-fitting and under-fitting..
5. Classification – The predicted result is shown with the help of ML or DL algorithms.
6. When it comes to solving difficult problems in farming and assisting farmers in cutting costs, the cutting edge technology is machine learning. From the results of this analysis, it is clear that machine learning algorithms have achieved remarkable success in resolving agricultural issues. [15].

XII. CHALLENGES IN CLOUD COMPUTING

- **Cyber law issue** Despite the many benefits of Cloud Computing, its widespread adoption has hit a wall for a number of reasons. It's possible, for example, that the industry will face difficulties due to the fact that cyber laws in various countries have different requirements, despite the fact that the industry itself has almost no borders.
- **Security Issue** is an issue to consider the security of data and services. The solution is to choose the most reputable service provider for the job.
- **If you want your distributed computing setup to function properly, you'll need a very fast internet connection.** On the off chance that the cloud servers are being upheld at that point, or on the other hand assuming the Internet is slow, we will be unable to get to applications right away.
- **High Cloud Storage** - Related data are stored in the cloud storage will slow down the process, during the process of computing.
- **High Cost** - Equipment used is expensive for implementing the IoT technology.
- **Understanding the Business model** - is to identify the problem
- **User Friendly design –** designing the user friendly application is not easy
- **Time Complexity** is to use "Transfer Learning" methods to shorten the time spent training a model..
- **Computer illiteracy** - It's the last thing stopping farmers in rural areas from using cloud computing.

xIII. CHALLENGES IN ICT

- Low access of technology in rural farmer society.
- Low service quality by the service providers
- Lack of money and resources for getting trained and to develop content
- Lack of community collaboration

- Lack of technical skills to access the technologies

In table 2 below, you'll find a few examples of cutting-edge ICT initiatives aimed at boosting output in service of an enhanced sustainable environment [16].

ICT Projects in Agriculture	
e-Velanmai	NCMRF
Video Volunteers	ICRISAT
NASSCOM	NIRD
SRISTI	yPARD
NDRI	e-Sagu
DRISHTEE FOUNDATION	MANAGE
Other ICT Projects	NCMSL
Trainers Manual	ANGRAU
IMD	INCOIS
ICT4Ag	ICT-AGRI: era-net
e-governance plan in Agriculture	e-Arik centre

Table 2. ICT Projects in Agriculture

RECOMMENDATIONS

This study recommends the following:

i. Government should provide at least one ICT centre in every local government headquarter. This ICT centre should have computers equipped with IT such as email and the World Wide Web, for ready access to farmers.

ii. Government should provide training and support staff in each of these ICT centres.

iii. Government should educate farmers on the role/benefits of ICT in agriculture so as to boost user's trust on ICT

option is to enable your business process with IT. With legal framework in place, e-commerce provides for better security than normal business transactions. Procurement, recruitment, disposal, communication and marketing are the important areas where e-business can be tried and adopted in agriculture.

CONCLUSION

Food, shelter and clothing are one of the three basic needs of life. Among the three, only one is needed to stay alive, food. Food security has become a global issue especially in recent times. Hence, the importance of agriculture cannot be overemphasised. As in every other sector, constant research in the agriculture sector is needed if it must stay in tune with advances in technology so as to meet the ever growing demand for its produce more so with the new trend of eco-friendly green world campaign. This has put more pressure on agriculture produce which are the most eco-friendly resources available (e.g. use of grains in fuel production). ICT has impacted positively every sector of the economy. Agriculture being a part of the economy is yet to witness any meaningful widespread impact by ICT. It is in this light that this paper presents a guideline as to what challenges and prospects ICT holds for Agriculture, if adopted.

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XIV. RECOMMENDATIONS

This study recommends the following:

i. GPU based Cloud environment can be arranged by the Government to ease the computing models.
ii. Data Compression can be done to reduce the execution time during data used from cloud storage.
iii. Rural farmers should understand the user friendly GUI application to use without any hurdle in their regional language.
iv. A High speed internet connection can be provided to the Smart Farmer Community.
v. Each county seat should have access to at least one centralised information and communication technology hub funded by the federal government. This ICT hub should provide farmers with ready access to the Internet and other forms of information technology via computers with such programmes installed.
vi. Each of these ICT hubs needs government-funded training and support staff.
vii. To increase farmers' confidence in ICT and its usefulness, the government should provide education on its role and benefits in the sector.

XV. CONCLUSION

Education and alternative methods of farmer training will almost certainly resolve the issue. The farmer's income and the viability of his farm will both increase if he adopts a more businesslike attitude through the help of well-thought-out training programmes. Cloud-based innovation is still in its beginning phases, yet it is as of now helping farmers in sustaining their yields similarly that specialists treat their patients. Rather than seeing farmers as a homogeneous field of yields, they will see an individual plant. Specialists advise utilizing cloud-based portable applications, AI, Machine Learning, Computer vision, and other robotized driving advances. The goal is to help farmers increase their yields by 100% by using the available data to inform better farming practises. It is also possible to improve cloud computing by using compression techniques. In the study is to demonstrate how Information and Communication Technologies & Cloud Computing can help to reduce information irregularity in the agricultural sector, thereby increasing farmer profitability and productivity. Inasmuch as the vast majority of farmers are technologically illiterate, it is unlikely that they will ever be able to use a computer effectively on their own. Therefore, there is a need for training centres that can instruct people on how to use computers and cloud services.

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