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Role of Artificial Intelligence and Information & Communication Technology for Efficient Nutrient Management in Agriculture

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Introduction

Out of the global population of 7.75 billion, around 67% people use mobile phones. About 87% of the mobile phone users have access to internet. These huge numbers indicate the access to and spread of technology around the globe. India has total internet users of 634 million, more than 50% (336 million) of which are from rural areas (Digital2021: India), and agriculture being the major occupation of rural people needs to be digitized and technology oriented to harness the benefits of this spread of technology and digitalization. The decreasing per capita land availability and small size of land holdings pose major threat to Indian agriculture. In the past 40 years, the number of farmers in the country has doubled from 70 million to 140 million and the per capita land availability has reduced only to 0.12 ha per person from 0.34 ha per person in the pre-green revolution era. Eighty-six per cent of the farmers own less than 2 ha of land. With such meagre resources in hand, it has become imperative to increase productivity and profitability per unit of available land. To achieve higher production levels, increased inputs have been used. This has resulted in over application of fertilizers which not only increases the cost of cultivation but also has severe environmental implications. Due to the low nutrient use efficiencies, India is facing an excess of 75-100 kg of N and 10-25 kg of P per hectare of cropland (Richie, 2021) which is though applied but not being utilized by the crop. The fertilizers consumption has increased from 1.70 million tonnes in 1961 to 31.27 million tonnes in 2019 (USDA, 2019) while the corresponding increase in yield was from 0.97 t ha^{-1} to 3.25 t ha^{-1}(FAO, 2020). Therefore, the use of novel technologies like Artificial Intelligence and Internet of Things has become vitally important in the present scenario to sustain agricultural productivity and profitability.

Artificial Intelligence and Internet of Things

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Artificial Intelligence (AI) refers to the techniques that allow machines to mimic human behaviour while Internet of Things (IoT) is considered to be a network of physical objects network connectivity. The IoT devices are used to collect real time unstructured data which is then fed to AI algorithms to process and generate information. IoT basically serves as user interface of the AI. Earlier, IoT was believed to be a separate discipline because the data collected was comparatively less and these devices were used to send simple SMS alerts but now, when huge real time data is being generated, AI is required to process the data. Nowadays, AI and IoTare considered to be two side of the same coin.

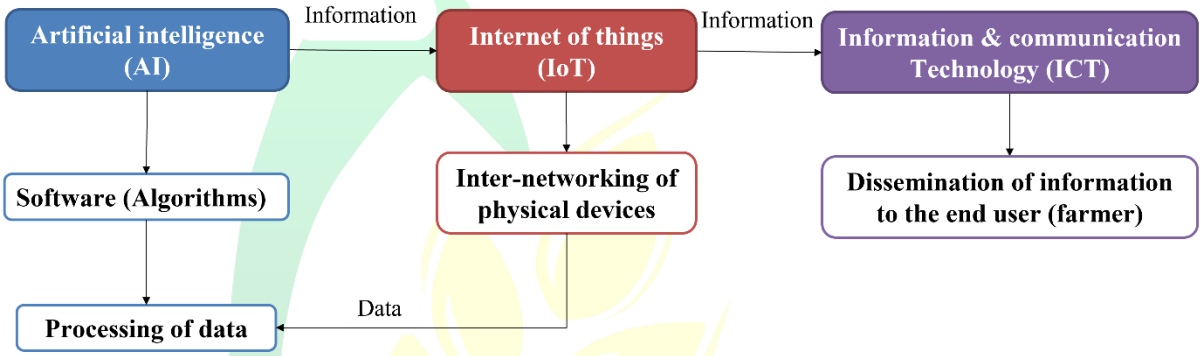

Fig. 1: Working of AI, IoT and ICT

Applications of AI and IoT

The IoT and AI have already started capitalizing across all the industries including agriculture. Advancement in these digital technologies has made revolutionary changes in agriculture by providing smart systems that can monitor, control, and visualize various farm operations in real-time and with comparable intelligence of human experts (Subeesh and Mehta, 2021). The potential applications of IoT and AI are in the collection of real time farming data, connecting livestock, development of smart farm machinery, agribots, drones, weather stations, *etc*.

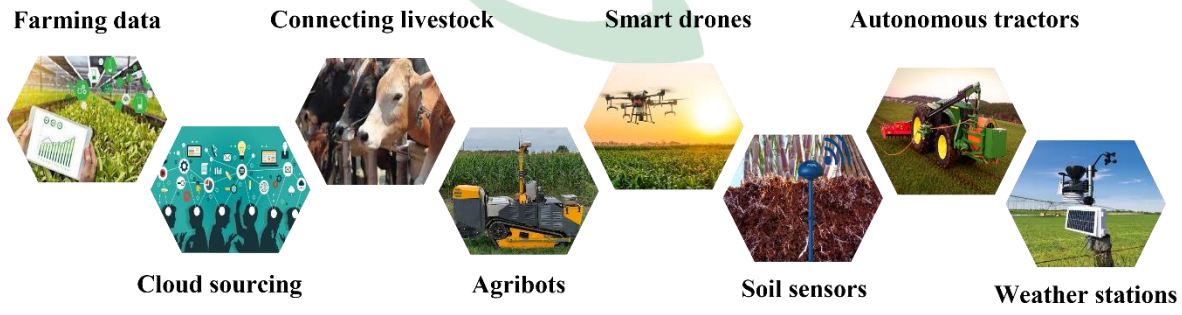

Fig. 2: Applications of AI and IoT in agriculture

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Development of real time nutrient sensors like Teralytic Probe, Agrocares Scanner, Agropad, *etc*. has led to early recognition of nutrient deficiencies to avoid yield losses. Technology oriented platforms like Trace Genomics and Becrop digitizes and decodes the living soil using genomics, advanced science, and machine learning.Aleksandrov (2022) conducted an experiment to identify nutrient deficiencies in plants using artificial intelligence by measuring the fluorescence of chlorophyll *a* in leaves. He developed photosynthetic fluorescence curves for N, P, K, Ca and Fe. Nutrient deficiencies in plant can also be identified by artificial vision techniques (Romualdo *et al.*, 2014). Sindhu and Indirani (2018) demonstrated IoT enabled soil testing and subsequent recommendations to the farmers in Tamil Nadu. The use of sensors such as Green Seeker and SPAD chlorophyll meter significantly increased the grain yield as well as the nitrogen use efficiency in riceand wheat, respectively (Singh *et al.*, 2015; Ghosh *et al.*, 2020). Ishola *et al.* (2013) depicted the successful application of fertilizers in oil palm orchard by RFID based Variable Rate Fertilizer Applicator.

Information & Communication Technology

Information and Communication Technology (ICT) is defined by the World Bank as "any device, tool, or application that permits the exchange or collection of data through interaction or transmission".The timely availability of right information and its proper utilization is indispensable for agriculture. ICT based initiatives should be taken for propagation of information, transfer of technology, procurement of inputs and selling of produce in a way so that farmers can be benefitted. ICTs help the farmers to adopt good agricultural practices, make better choices of inputs and to plan the cultivation of crops properly.

ICT serves as an important and efficient channel for popularization and dissemination of AI generated information to the farmers. Government initiatives in ICTs like kisan call centres, farmers' portal, mKisan, soil health card, *etc*. have contributed significantly in improving nutrient management besides agricultural productivity and sustainability. IFFCO Kisan and Green Sim initiatives by IFFCO have improved the timely flow of information and guidance to the stakeholders. IRRI has developed a web-based platform, Crop Manager, for field-specific information on crop and nutrient management to increase yields and income of rice farmers.

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Conclusion

With the introduction of artificial intelligence and information & communication technologies, the traditional agriculture has been reformed, eventually contributing towards the significant improvements in agricultural productivity and sustainability. Empowering farmers with the right information at the right time and place is essential for improving the efficiency and viability of small and marginal holdings.

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