Climate Change and Indian Agriculture: Challenges and Adaptation Strategies

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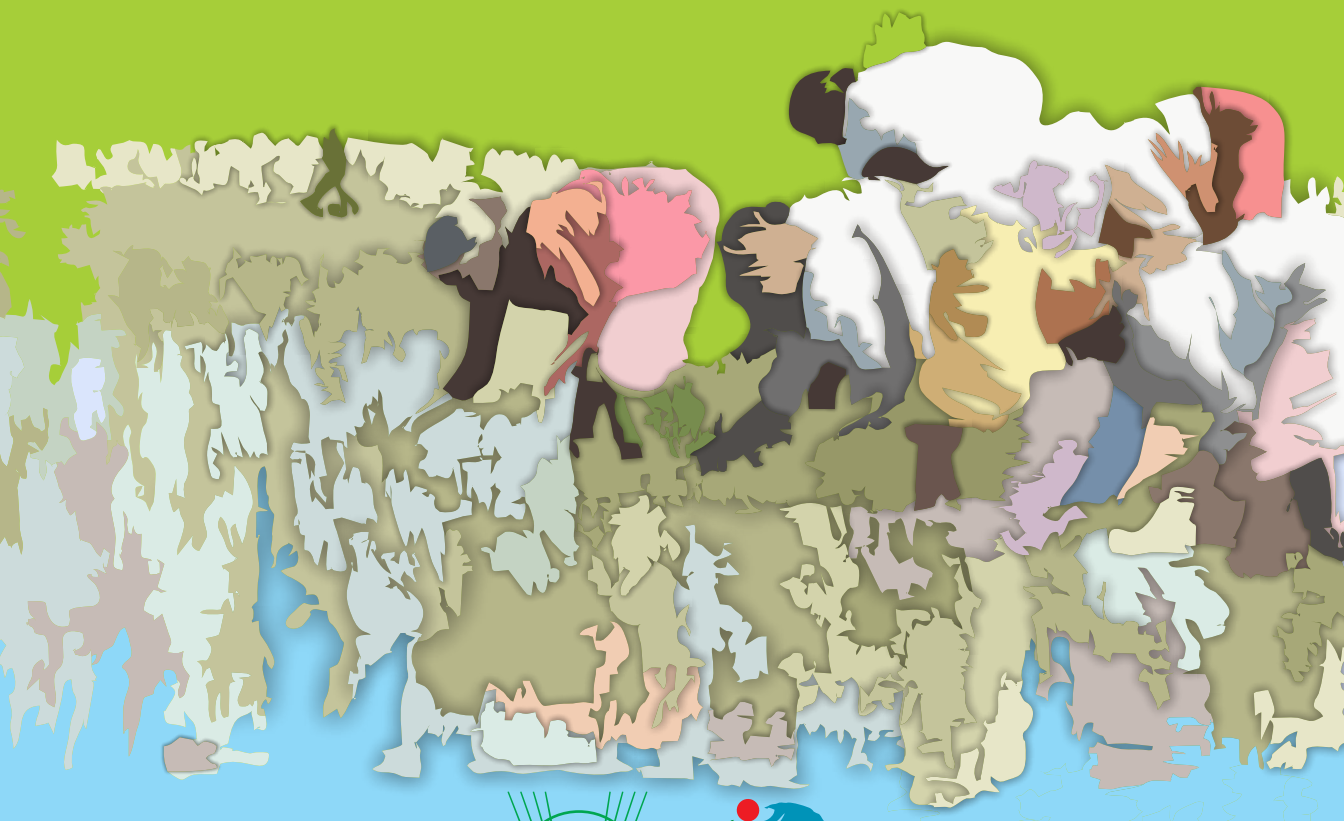

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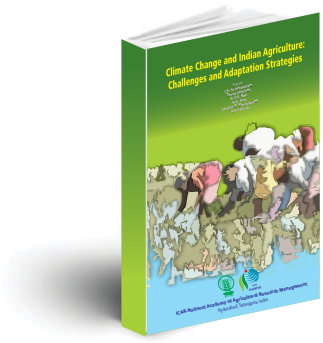

Preferred Citation of Book
Srinivasarao, Ch., Srinivas, T., Rao, R.V.S., Rao, N.S. and Vinayagam, S.S., Krishnan, P. (2020). Climate Change and Indian Agriculture: Challenges and Adaptation Strategies, ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India. p-584.

Preferred Citation of Chapters
Kumar, K., Bhattacharjee, S., Vaikuntapu, PR., Sharma, CL., Jayaswal, D., Sharma, R., Sundaram, R.M. 2020. Climate Change Mitigation and Adaptation Through Biotechnological Interventions. In: Ch. Srinivasarao *et al.,* (Eds). Climate Change and Indian Agriculture: Challenges and Adaptation Strategies, ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India. pp-1-22.

ISBN No. : 978-81-943090-7-9

Published by
Director
ICAR-NAARM
Hyderabad - 500 030

July 2020

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Role of Artificial Intelligence (AI) and Internet of Things (IoT) in Mitigating Climate Change

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Abstract

Artificial Intelligence (AI) and Internet of Things (IoT) have a huge potential to effectively address the issues of climate change. The aim of this study is to present the role of AI and IoT based technologies in making environment friendly smarter and higher performing systems. These technologies aid in managing the climate change impacts by utilizing limited resources and less human interference. Integrating IoT and AI technologies, data is collected from sensors in the field about soil moisture, weather conditions, fertilization levels, irrigation system, soil composition and temperature. This helps in increasing the crop production which eventually lead to higher income for farmers.

Keywords: Agriculture, Artificial Intelligence, Climate Change, Internet of Things

I. Introduction

In recent years, with the rising population, Indian farmers need to produce more food with lesser resources for sustainable agriculture. Agriculture has always been accorded an important position within the Indian society. It provides employment to the maximum number of Indians and plays a big role in the overall socio-economic development of India. The changing weather conditions play a sensitive role in food production and thus crop yield is directly affected by the climate change. Agriculture and climate change are inextricably linked and has a direct biophysical effect on the agricultural production in general and specifically deteriorating the soil health. Unfortunately, current farming practices and climate changes result in soil degradation. Soil is linked to the atmospheric system through the different cycles such as carbon, nitrogen and hydrological cycles. Due to this, change in climate can have impact on soil processes and properties. It affects the agricultural productivity, in terms of both quantity and quality of crops. Moreover, natural disasters like droughts, cyclones, floods, heavy precipitation and heat waves are known to have negative impact on agricultural production and farmers' livelihoods.

In this new era of technologies, Internet of Things (IoT) and Artificial Intelligence (AI), have the potential to address the climate change. IoT technologies, such as sensors, collect data about soil moisture, weather and fertilization levels, and these can help farmers optimize irrigation and crop production. Farm machinery equipment such as automated tractors are used in drilling, seeding and spraying fertilizers/herbicides at the right place and the right time to reduce human labour.

On the other hand, Artificial Intelligence is a game-changer in mitigating the climate change. AI helps scientists in building robust systems to learn from weather conditions, sense all the data and analyse them to propose effective solutions for the farmers (Bannerjee *et al.,* 2018). AI solutions such as robotics, computer vision, machine learning and deep learning algorithms are used for processing the data to predict environmental impacts on crop yield.

The combination of IoT and AI will be the key drivers for a successful, risk-minimized shift to agriculture economy (Alreshidi, 2019). IoT is a system of computing devices, mechanical and digital machines, objects with distinctive identifiers (UIDs). IoT also has the calibre to transfer knowledge over a network without human-to-human or human-to-machine interaction (Grieve *et al.,* 2019). IoT enabled farming can effectively enhance farm production by automatic monitoring of the crop and other factors like fertilizer application, irrigation system, controlling disease infestation, etc. IoT devices allow farmers to detect illegal deforestation and report activities. It can be used in designing an early warning system and predicting flood. The sensors play a vital role in collecting real-time data on flood related parameters such as river flow, water level, rainfall, wind-direction, temperature and so on

when placed on the river basin. The AI based technologies also play a critical role in providing the information to farmers about the weather conditions such as temperature, precipitation, wind speed and radiation. It is also used in many applications such as automated machine adjustments which are used for weather forecasting, disease or pest identification. AI can also be used directly for reducing emissions of harmful gases in the air or indirectly it helps to increase the energy efficiency of industrial machinery. In this chapter, several benefits and challenges of IoT and AI will be identified and how it may help to analyse the soil condition and climate changes are discussed.

II. Recent Technologies in Mitigating Climate Changes

In recent years, effect of extreme weather, deteriorating soil health and drying lands, collapsing ecosystems make food production difficult for farmers (Lakhiar *et al.,* 2018*)*. AI and IoT support different sectors including agricultural sector and its main purpose is to increase productivity, efficiency and to solve the traditional challenges faced in major agricultural activities. In agriculture sector, AI plays a vital role for the farmers in improving efficiency by reducing the hostile impacts on the environment. Moreover, the agriculture sector emphatically and transparently adopts AI and IoT technology into practice to change the general result.

Machine learning is a sub-domain of Artificial intelligence which can play a significant role in fighting against climate change and reducing greenhouse gas emissions (Liakos *et al.,* 2018). It helps in building better electric systems, agricultural emissions and deforestation monitoring creating new low-carbon materials, predicting extreme weather events and stubble management. All these are elaborated in the following subsections.

II.1 Blue River Technology

Blue river technology, a California-based start-up founded in 2011 (Chostner, 2017), combines artificial intelligence, robotics and computer vision to generate agriculture equipment for chemical spraying and cost reduction. The detection of each plant in smart farming can be done by computer vision where the machine learning algorithm is used to treat plant individually and robotics spring into action. This technology brings crop protection into the digital era by developing "See & Spray" machine that utilizes artificial intelligence to differentiate crops and weeds. It also helps in spraying herbicides only in infected areas.

The main purpose of "See & Spray" is to distinguish the harmful weeds among crops and make decision to apply herbicide or not. The advanced and complex hardware used in See & Spray machine to view plants consists of front and rear facing sensors, NVIDIA Graphical Processing Units for each individual to provide computer vision along with deep learning power. See & Spray uses computer vision to analyse digital images, object identification, etc. Further,

computer vision uses deep learning algorithm to identify distinctive parts of an image, stitches all of the parts together and performs comparison with the newly formed picture to the images that have already seen. Therefore, the new technology is going to contribute to the global climate as well as economy by reducing herbicide consumption.

II.2 Sensors Driven AI-based Agriculture Recommendation Model for Assessing Land Suitability

One of the essential tools for the development of smart and efficient farming techniques in agriculture is land suitability assessment. Various technologies have been implemented in agriculture to collect the farm information and then they are processed. The implementation of wireless sensor networks (WSN) have prompted the low-cost design of small sensor devices that are useful for automating and decision-making in the agriculture domain. An expert system known as Sensors Driven Artificial Intelligence (AI) - Based Agriculture Recommendation Model was developed by incorporating sensor networks with Artificial Intelligence systems. It includes neural network and MLP (Multi-Layer Perceptron) for the assessment of agricultural land suitability in terms of four different decision classes namely more suitable, suitable, moderately suitable, and unsuitable. The assessment of agricultural land suitability is determined according to the input collected from the different sensor devices that are used for training the system. This artificial intelligence model can be used for the evaluation of future assessment and to classify land after cultivation (Vincent *et al.,* 2019).

II.3 Monitoring of Agriculture Emission Using Remote Sensing and AI

AI is being used to analyse data from IoT sensors and remote sensing data automatically to identify pollutants such as particle pollution, ground-level ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide and others. It is very useful for analysing the climate change remote locations where it is difficult to determine the source and volume of mentioned pollutants. Most of the satellites have coarse spatial resolution with large temporal and spatial gaps that makes them unsuitable for precise tracking of emissions. Remote sensing is one of the effective technique used to recognize biomass burning explicitly in the forest. The burnt area installed with remote sensors provide emission analysis with high temporal resolution at the global scale. Burned area products consist of errors and other uncertainties due to several factors (Rolnick *et al.,* 2019).

II.4 Deforestation Management

In cases where deforestation is conducted illegally, deforestation tracking tools assist policy makers and law enforcement agencies by providing valuable data. Machine learning (ML) can be used with remote sensing imagery to differentiate selective cutting from

clear cutting. Other approach is installation of old smartphones powered with solar panels in the forest. ML can be used in detection and report chainsaw sounds within a range of one-kilometre radius (Rolnick *et al.,* 2019).

In the case of artificial intelligence, the drones are used in forests to monitor fires. Drone can be classified based on the range of criteria, which include size, payload, flight range, control systems, altitude and endurance. At high survey frequencies, the ability of drones to acquire extremely high spatial resolution imagery can be utilized to collect data from tropical forests. The forest management and decentralization of forest data acquisition can be effectively achieved by drone-assisted Community-Based Forest Monitoring programs (Paneque *et al.,* 2014). The tropical deforestation prevention and forest degradation reduction are climate mitigation option, that has an immediate and large impact globally. Thus making it a relevant and typical subject necessary for global biodiversity conservation (Sakr *et al.,* 2010).

II.5 Stubble Management Using AI and IoT

An AI based tool was developed by a Gurgaon based start-up to monitor and measure the farm fires and stubble burning in India. In recent years, stubble burning has become a major issue in different parts of India. An AI-enabled application developed by "Blue Sky Analytics" named "Zuri" uses satellite data to improve and monitor supply chain, perform price analysis and allocation of crop waste as raw material for use in other industries. The app "Zuri" refers to the history of farm fires that happen in every district and state. With the help of this historical data it predicts high-risk zones along with the expected volume and calorific value of crop waste. It helps farmers to sell stubble to marketplaces by providing them with relevant information thus providing an alternate to stubble burning. Such innovations have the potential to solve carbon challenge, create cleaner energy and also provide income to farmers (Sharma, 2019).

II.6 Predict Extreme Weather Events

Events such as tornadoes, hurricanes and severe thunderstorms are categorized as high impact weather events, causing significant disruptions to property, infrastructure and even cause fatalities. With the assistance of wireless communication technology, the data is transmitted to data centres which is further processed and measured on the cloud service. Finally, the information alerts are delivered to users via smart phones. The early warning message in terms of location, time and other flood related parameters is thus received by the people (Maspo *et al.,* 2018).

The gap between prediction using numerical model and the real time guidance can be bridged by Artificial intelligence techniques especially machine learning through improving accuracy. Also, additional decision support is provided to forecasters and users by AI techniques through

extracting unavailable information from forecast model output with observations (McGovern *et al.,* 2017).

II.7 Renewable Energy Management

Due to the increased global energy demands, fossil fuels will not be adequate to fulfil our energy needs in the future. On the other hand, a reliable alternative to fossil fuels is renewable energy, which is safer and cleaner than traditional sources of energy. Smart, Centralized Control Centres collect a large amount of data. The energy grid is interconnected with devices and sensors. AI-powered control system analyses the energy collection data and provides insights on energy consumption and addresses the quality and congestion issues. AI based Smart Grid integrated with Intelligent storage can provide a sustainable and reliable solution to the renewable energy management (Bose, 2017).

III. AI and IoT based Agricultural Start-ups in India

In India, various AI and IoT based platforms are being developed that uses the farm level data and predicts the ideal growth conditions, resource requirements including irrigation, fertigation and other measures. A select list of companies that provide the IoT based platform for smart agriculture are given below:

- **Intello Labs**: It is an Indian startup that provides image-based solutions powered by deep learning algorithms for agricultural products, crop infestation and soil conditions. It helps in determining the quality at real-timeproduct by using the crop images, to recognise the diseases, pest infestation in the plot (https://www.intellolabs.com).
- **CropIn**: A smart system that provides future-ready farming solutions to the farmers quickly. It provides the information to various companies with real time data and insights of all farms operations in the entire growing season (https://www.cropin.com/about).
- **Aibono**: It brings several small farms on a cloud platform to create smart farming collectives. It aggregates the soil data and weather conditions to build an imagery of the region and gives the advisory on right fertilizer dosage to the farmers (https://www.aibono.com).
- **Fasal**: It provides microclimate forecasts to farmers about day –to-day operations at the farm. It is powered by AI based microclimate forecasting algorithm incorporating real-time field information relating it to publicly available weather forecast (https://fasal.co).
- **Gobasco**: A startup that developed AI optimized automated pipeline to enhance the efficiency of supply chain(https://www.crunchbase.com/organization/gobasco#section-overview).

Besides the above mentioned start-ups, some AI and IoT based

solutions have been registered as patents in India. Among them a few salient ones are discussed below:

- Integrated IoT (Internet of Things) system solution for smart agriculture management: The utility model relates to the technical field of wireless sensing, specifically an agricultural IoT monitoring device based on optical fibre sensing, wherein the device can monitor the temperature, humidity, vibration and other parameters of an agricultural cultivation base.
- Smart control/IoT system for agriculture environment control: In this system, plurality of sensor hubs is placed in predetermined locations in a farm, each hub including a meteorological data acquisition system and an environment data collection system; and monitoring key elements in the growing of plants from a number of sensor hubs including lighting, humidity, temp, Soil moisture, and elements that influence plant growth.

IV. Conclusion

Climate change can be described as any detrimental alteration of the natural properties of resources like soil, water and air. All these resources are extremely useful in conducting successful farming. Not only natural resources affect agriculture but faulty farming practices also have detrimental effects on the climate. This chapter enlists several AI and IoT techniques that can help continue to practice sustainable agriculture and can also alleviate the harmful effects of climate change. Several benefits of using IoT based system in efficient farm management have been identified and their challenges have also been mentioned. Advanced IoT technologies have been described in ensuring sustainable land transport for generating lesser carbon emission. How AI can help in quality production of renewable energy sources and their roles in expanding the concerned market have been mentioned here. Role of remote sensing has also been explained in identifying the areas burning biomass and in controlling agriculture emission. Many start-ups which are agriculture based have been enlisted that uses IoT based system or provides real time weather forecast data using several AI techniques.

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