A Seminar Paper on

Artificial Intelligence-Based Climate-Smart Agriculture: Context of Bangladesh

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Artificial Intelligence-Based Climate-Smart Agriculture: Context of Bangladesh[1]

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ABSTRACT

Bangladesh is primarily an agricultural country, and the sector's contribution to rapid economic growth is crucial where about 50 percent of people are directly dependent on their livelihood. About 70 percent land of this country is dedicated to crop growing. Bangladesh is considered a highly climate-vulnerable country where natural calamities hit its agriculture frequently. AI-driven climate-smart agriculture has the potential to transform Bangladesh's agricultural industry by enhancing productivity, lowering risks, and boosting climate change resilience. This paper is a comprehensive review of artificial intelligence implementation on climate-smart agriculture in both Bangladesh and the global context is presented to mitigate its effects and assess the feasibility and obstacles of adopting AI in Bangladesh. This work also highlighted the use of AI in farming systems and policymakers to implement AI in a proper way. Opportunities and challenges of implementing artificial intelligence at the farmer level are also articulated. Moreover, possible solutions to overcome challenges to mitigate climate vulnerability with the help of artificial intelligence are recommended in this write-up.

Keywords: Climate change**,** Climate-smart agriculture, Artificial intelligence, Bangladesh

[1]Title of the seminar paper presented as a part of course AER 598 during Winter 2022

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CHAPTER I

INTRODUCTION

Bangladesh can be addressed as one of the most climate-vulnerable countries in the world. It is in seventh place in the world, but its contribution to global warming cannot be ignored. It contributes less than half of the 1% to the total greenhouse gas emissions which are 0.25% in the global aspect (Dhakatribune, 2022). Living in threatened climatic conditions, it is quite impossible to provide food for almost 165 million people. Food will be scarce by 2050 as the population will be reached almost 10 billion and it's quite impossible to feed more people through existing agricultural practices (Ranganathan et al., 2018). At the same time, greenhouse gas emission is rising through current production systems. In this scenario, it will be more important to focus on production by eliminating vulnerable factors and adapting to this changing climate situation.

Climate-Smart Agriculture (CSA) incorporates climate change into the planning and development of long-term sustainable agricultural Practices. CSA is defined by the Food and Agriculture Organization (FAO) of the United Nations as "agriculture that sustainably improves safe and nutritious food yield, increases production with climate change (adaptation), reduces greenhouse gas emission (mitigation) where possible, and improves achievement of national food security and sustainable development goals" (FAO, 2013).

Artificial Intelligence (AI) refers to the compilation of advanced technologies that simulate human decision-making capabilities in machines which enables machines to think and act, both humanly and rationally, through sensing, comprehending, acting, and learning depending by involving years of data and imagery rapidly and efficiently to find relationships that would be impossible for a human to detect (Moigne, 2018). Most people think of AI as a robot. Artificial intelligence can with a help of humans. But it helps to reduce costs by eliminating labor costing.

Bangladesh is a highly populated country with an enormous population growth rate and its near to 1.04 percent per year. Agriculture is the most dependent sector which contributes almost 11.63 percent to the 2021-22 GDP and secured food for above 165 million people (BBS, 2021-22). Cultivable land has decreased in the general run of 66 thousand acres every year quantify as 0.29 percent of the total agricultural land in Bangladesh (Hossain & Islam, 2022).

Climate-Smart Agriculture (CSA) can be achieved through the help of Artificial Intelligence. AI technology has the potential to offer farmers timely and valuable insights into their agricultural lands. Analyzing data can help them identify which areas require watering, fertilization, or pesticide treatment. Moreover, innovative farming techniques such as vertical agriculture can increase crop yield while minimizing resource usage. As a result, farmers can reduce their herbicide usage, improve crop quality, increase their profits, and achieve substantial cost savings with significant production (Islam, 2022). AI-based smart agriculture augments crop production by 22.46% more than conventional agriculture (Islam, 2022).

Objectives

Based on the above circumstances the present study was undertaken with the following specific objectives to:

i. review the existing challenges posed by climate change;
ii. explore the potential of artificial intelligence-driven climate-smart agriculture to alleviate the impact of climate change; and
iii. assess the feasibility and obstacles of adopting artificial intelligence in Bangladesh.

CHAPTER II
MATERIALS AND METHODS

This is entirely a review article and, therefore, relies on secondary sources of information. The review draws from various published reports and articles sourced from books, journals, proceedings, and online platforms. Through the synthesis and analysis of these sources, this review aims to present a comprehensive overview of the topic and identify key findings, trends, and gaps and how to implement them in our country effectively in the current knowledge base.

Constructive suggestions from my major professor and course instructors helped me to improve this paper. Personal communication with respective resource personnel assisted me to collect valuable information to develop the paper. After collecting all the related information, it was gathered and logically presented in its current form.

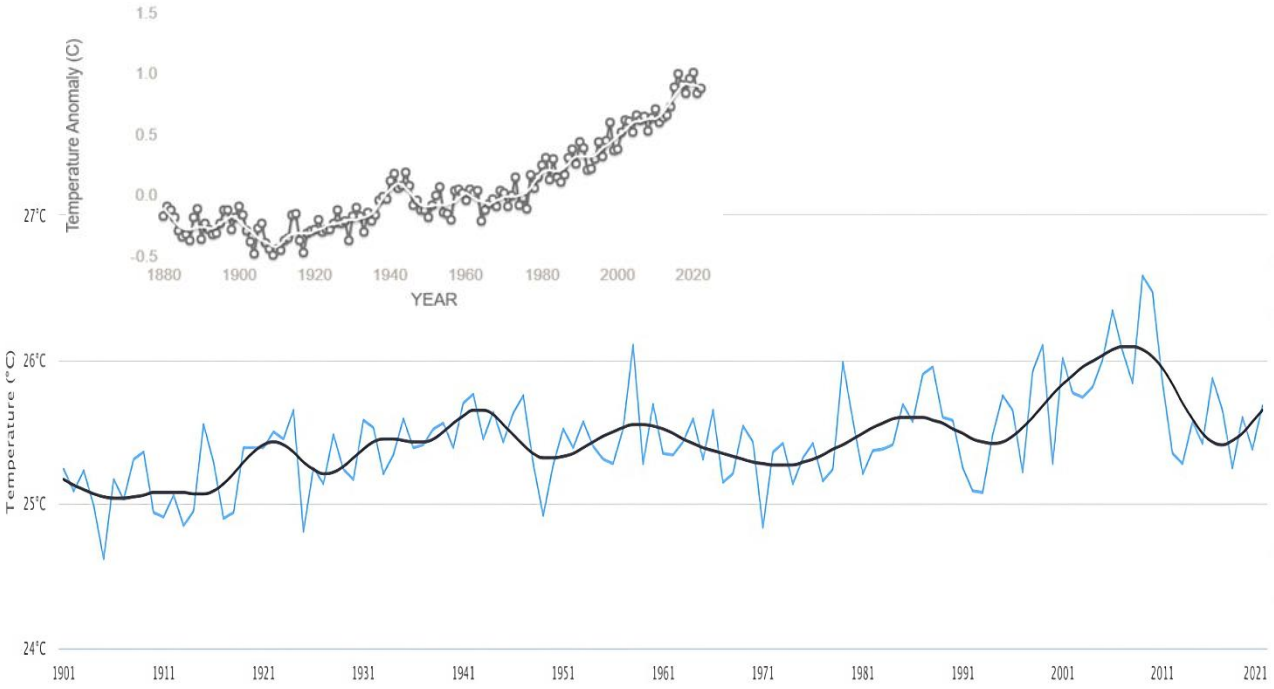
CHAPTER III

REVIEW OF FINDINGS

As this paper is entirely a review, the major findings found are presented here along with their appropriate discussions according to the objectives.

3.1.1 Evidence of climate change

World temperature is rising significantly in the last few decades. It is evinced from Figure 1 that there is a 1.1^{o}C temperature rise in the past few centuries. From 1880 to 1980 the temperature was almost tending to 0^{o}C, but in the last 20 years, there was a significant rise of almost 0.89^{o}C. The Earth's global average surface temperature in 2020 was statistically tied with 2016 as the highest ever recorded, proceeding a long-term temperature rise caused by human activity (NASA, 2022).

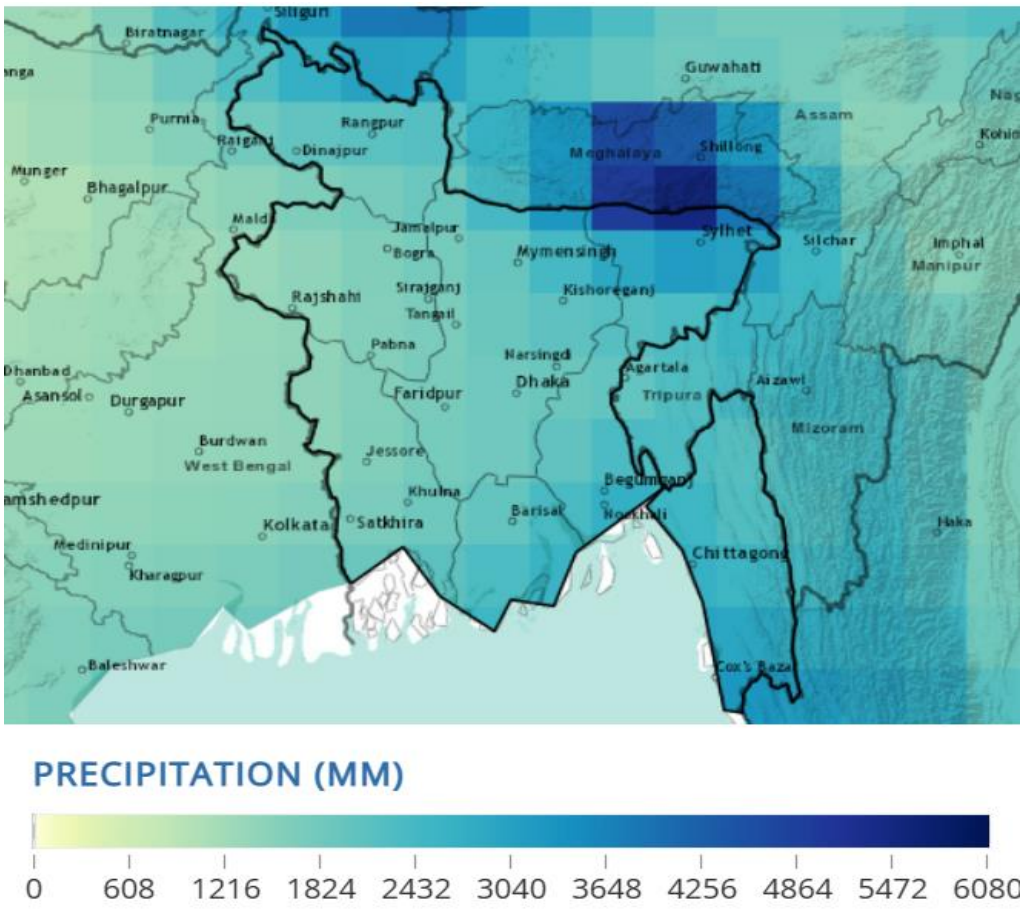


Source: World Bank, 2023

Figure 1. The monthly average temperature during 1901-2020

Bangladesh has an alarming change in temperature and rainfall. The chronological climatic condition of Bangladesh has seen average temperatures around 26°C, with temperatures ranging between 15°C and 34°C year-round (Figure 1).

The temperature has a huge effect on production. It influences production and creates vulnerability to food security. At the flowering stage of Boro rice varieties, exposure to high temperatures resulted in a significant decrease in both yield and yield attributes when the soil moisture was maintained at 80.0% of field capacity (Mahmood et al., 2021).



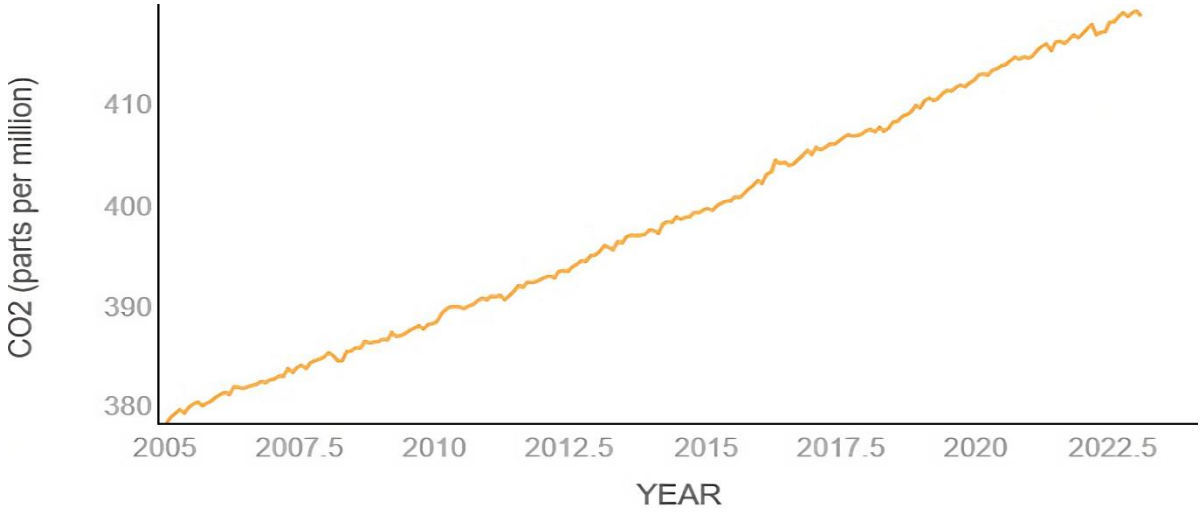
Source: World Bank, 2023

Figure 2. Monthly average rainfall in Bangladesh during 1901-2021

Rainfall amount has a significant role in agricultural production. Food production will be hampered by abrupt cyclones and floods in coastal regions, and the nation will suffer economic losses. The rainy season (April-September) coincides with the warmest months, whereas the winter (December-February) is chillier and drier. Bangladesh is an extremely moist country, with annual precipitation of about 2,200 millimeters (mm). Most areas have a minimum of 1,500 millimeters (mm) of rain annually, while other regions, like the northeastern border regions, receive up to 5,000 mm (World Bank, 2021).

Through Rainfall soil moisture levels will rise; lessening the need for irrigation and groundwater dependence; with a high production rate. Yet, there are drawbacks, including excessive rain and flash floods (Chakraborty et al., 2021). These climate-changing factors can reduce crop yields by up to 30% percent (Sikder & Xiaoying, 2014).

The climate is changing due to the increasing emission of greenhouse gases (GHG). From the above data, it can be seen that there is a huge climb in the last 17 years. In 2005, there were 378 ppm (parts per million) and now it goes up to 420 ppm.



Source: NASA, 2023

Figure 3. Annual CO_2 Emission in the world during 2005 to 2022

Because of human activity, atmospheric CO_2 has increased by 50%, making it 150% higher than it was in 1750. This is more significant than what naturally occurred around 20,000 years ago after the last major ice age (NASA, 2023).

Bangladesh only emits 0.21 percent of the world's CO_2 emissions, but the situation has changed dramatically in recent years. According to historical data, Bangladesh's CO_2 emissions rose at an average yearly rate of 7.52% from 3.3 million tons in 1971 to 108.5 million tons in 2020 (Haque, 2022). GHG emission is responsible for climate change and the increase in global temperature.

3.1.2 Water availability

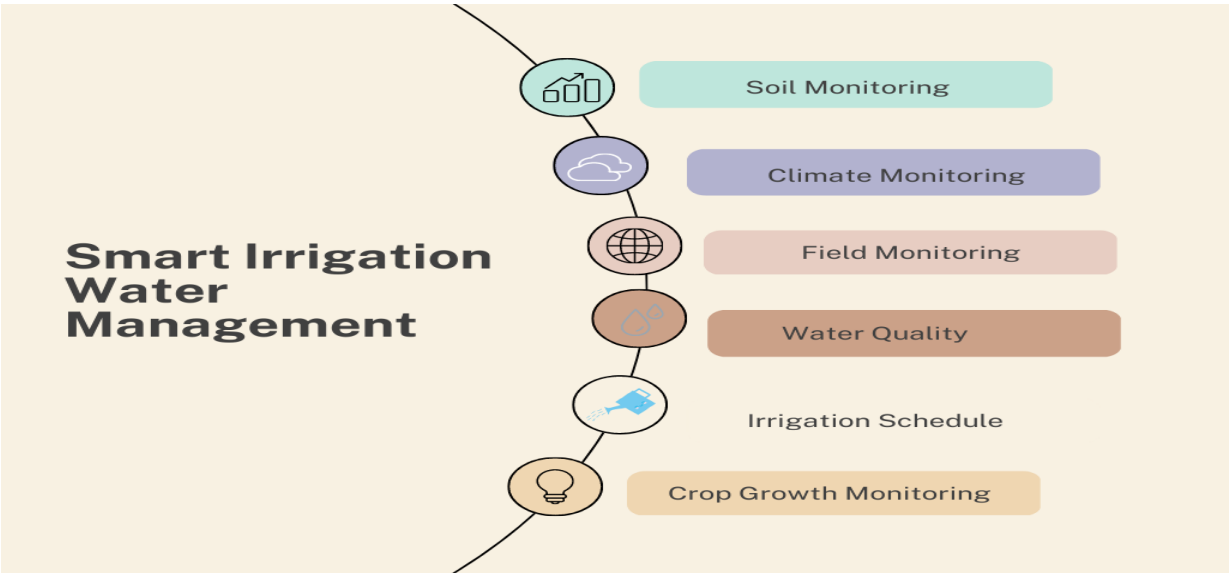
Groundwater has reached an alarming condition. Only 3% of water is drinkable, of which 70% of water is used for irrigation. Smart irrigation can save 40% of water which also enhances production (WWF, 2023). Water availability is in vulnerable conditions which affect the climate.

These are important climate change indicators that only can be solved by practicing climate-smart agriculture and Artificial Intelligence can be a facilitator to adapt to these climate-changing actors Our focus is to use AI to mitigate the climatic challenges. Artificial intelligence can fight these factors with minimum use of resources and maximum output.

3.2 Use of Artificial intelligence in different agricultural Process

3.2.1 Smart irrigation

Smart irrigation systems can analyze real-time data to determine the optimal watering schedule, reducing water usage while ensuring that the plants receive the appropriate amount of water and it has a significant role in production. Conventional irrigation needs a lot of work and wastewater to keep the soil moist for crop growth (Hossain & Islam, 2022).



(Modified from Saggi & Jain, 2022)

Figure 4. Smart water management

AI goes through some processes for smart Irrigation. It uses a smart sensor to monitor soil after monitoring soil it accumulates climatic conditions with a field survey. After surveying the field, it observes water quality and sets a schedule for spraying water, sensor also observes crop growth for its better growth and development as well as plants requirement (Figure 4). AI can detect soil moisture content through accumulating information AI synthesizes those data and provides water whenever needed. Which can save a lot of water wastage. AI can assist cut expenses, diminishing

environmental damage, and minimizing or eradicating waste. Water use will be decreased with the aid of AI-driven localized weather predictions (Gow, 2020).

Table 1. Findings on water saving in agriculture using Artificial intelligence

Country	Method	Strategy	Water saving (%)	Other remarks	Reference
Turkey	Drip Irrigation	Soil Moisture	23	60% decrease in the labor force	(Işik et al., 2017)
China	Drip Irrigation	Soil Moisture	3	Irrigation water use efficiency was higher compared with a conventional system.	(Liao et al., 2021)
India	Drip Irrigation	Rain sensor, Soil Moisture sensor	15-50		(Barkunan et al., 2019)
India	Drip Irrigation	Rain sensor, Soil Moisture sensor	13-41.5	The system uses a motor for 9.72% of the total time for watering	(Krishnan et al., 2020)
China	Drip Irrigation	Soil moisture sensor (Soil temperature, air humidity, and temperature)	20	Field soil condition improved	(Zhang et al., 2017)

From Table 1 it can be assumed that different researchers have found AI-based drip irrigation can save more than 20% of water than the conventional irrigation method. These irrigation methods are mainly based on AI. AI can detect water requirements using smart sensors and send signals about how much water is needed and irrigate that much water which was its requirement. Thus, it irrigates when a plant is actually in need and saves water to conserve climate.

3.2.2 Pest control

In Asia, 90% of rice is produced globally, and about 20% of yield loss is due to insect pest infestation. Among 232 species only rice hispa, leafroll, stem borer, brown planthopper (BPH) and gall midge are responsible for major yield loss. More specifically, rice hispa and BPH can up to 62% and 44% yield damage in rice crops (Khatun et al., 2021).

To overcome the outbreaks in odd years and to keep the loss up to 5%, it is necessary to take some preventive measures such as planting resistant or tolerant varieties, stopping insecticide spraying at the early establishment of rice, establishing an early warning and forecasting systems, avoid cultivation of susceptible variety and following crop rotation (Ali et al., 2021).

Table 2. Different artificial intelligence techniques to detect pest

Technique	Accuracy rate	Study
R-L1, LR-L2, MLP, RF, GBT, SVM	96.13%	(Khalili et al., 2020)
Deep learning, correlogram	99.4%	(Saleem et al., 2019)
CNN, CAE	93.38%	(Bedi & Gole, 2021)
ELM (Extreme Machine Learning	84.94%	(Pitts et al., 2021)
VGG-16	98.7%	(Sanga et al., 2020)

Different authors had tested smart pest management systems which use machine learning. There were many techniques to detect pests with a high accuracy rate and the mean accuracy rate is 93%. Among those tests, deep learning and correlogram have a high accuracy rate which is about 99.4% (Table 2). Artificial intelligence can detect pests more effectively with an overall accuracy rate of

95%. If pests can be detected at an earlier stage with help of AI, it will suggest an effective pesticide to remove pests. AI can help in the minimum use of pesticides and enhance production. It will also help to reduce CO_2. Weather conditions, especially the wind, have a significant impact on insect movement (Dwivedi et al., 2020).

3.2.3 Weed detection

By utilizing ai algorithms, robotics, and machine learning, AI manages weeds, enabling farmers to apply chemicals where only weeds are present and reducing the need to spray a whole field with chemicals. In the end, it effectively suppresses weed growth while also using fewer herbicides in the field than is typically applied (Thakur, 2021).

Weed is one of the crucial factors which can reduce farmers' profits. If weed cannot be controlled Maize and wheat has a significant loss in yield which quantifies almost 50 and 48%, respectively (Zha, 2020). Weed monitoring increases production increases efficiency, reduces cost, and better targets for spraying agrochemicals (Jagdish, 2022).

3.2.4 Yield forecasting

The number of precipitation events, temperature, degrees of water stress, accumulation of growing degree-days, and NDVI are all climatic and remote sensing variables that are used as part of the model's input (Normalized Difference Vegetation Index). The NDVI and other vegetation indices are computed using pictures captured by sensors that can be installed on a variety of platforms (e.g., satellites and drones). Because they include details regarding plant health, canopy coverage, and/or water status of canopies, NDVI values estimated during the cropping season aid in the yield forecasting process (Fraisse et al., 2022).

3.2.5 Intelligent spray

AI sensors can recognize and concentrate on weeds before determining which herbicide to use locally, lowering the need for herbicide use and maximizing cost savings. Numerous technical firms created weed-controlling robots that employ computer vision and artificial intelligence. These robots can reduce the number of pesticides typically sprayed on crops by 80% and the cost of herbicides by 90%. By significantly reducing the number of pesticides used in crop cultivation, these clever AI sprayers can increase cost-effectiveness while also enhancing the standard of agricultural output (Uddin, 2022). Herbicide dispersal is meant to be reduced via smart sprayer technology, which includes reducing risks. In comparison to conventional sprayers, smart sprayers use 70% fewer herbicides (Muts, 2022).

3.2.6 Climate forecast

One of the modern and promising technological developments in agriculture is the use of machine learning and AI to forecast weather.

Every AI solution for weather forecasting needs a lot of data to inform machine learning algorithms. Bangladesh's northwestern region is a drought-prone area. More drought episodes will result in a decrease in soil moisture content, a rise in agricultural water requirements, and damage to crop growth, yield, and productivity. Excessive rain may responsible for floods in the northeastern region of Bangladesh. Every year a lot of yields are destroyed due to floods. A total of 41,918 hectares of land were totally demolished, resulting in a BDT3.49 billion loss (bdnews24.com, 2020). Accurate weather forecasts can be generated using crowdsourcing from connected satellite sensors and local hardware weather stations. Large data sets must be processed in order to make these predictions, and there must be enough storage to keep the data for future use. The quality of the data is typically what deep learning algorithms rely on the most, and

labeling is crucial for making accurate predictions. After a deep learning model has been trained, extracting precise insights on evaluating climate conditions should be aided by recognizing weather patterns and classifying data. Farmers can make meaningful decisions if AI can reliably assess the amount and timing of rain (Radhika, 2020). Farmers can now comprehend potentially hazardous weather conditions as well as the existing health of their crops, including their water level, overall temperature, and humidity, which would otherwise be practically difficult to discover.

3.2.7 Reduction of carbon footprint

AI can revolutionize agriculture by improving the monitoring and management of agricultural yields and climate change. While increasing crop production, artificial intelligence can also reduce the use of water and fertilizer. Almost 4.8% of greenhouse gas emissions could reduce by 2030 with help of AI technologies with a minimum of 5.1% GDP growth in Asia (Briony Harris, 2019). Synthetic fertilizers and insecticides are responsible for GHG emissions. Synthetic nitrogen fertilizers emit 2.1% of the global greenhouse gases (University Exeter, 2022). AI helps to use a minimum quantity of fertilizer, pesticide, and water and the lowest contamination with planned farming which will help to reduce carbon footprints (Mor et al., 2021).

3.3 Challenges to Implement AI-based Climate Smart Agriculture: A context of Bangladesh

The concept of AI use in climate-smart farming systems is an emerging idea, though there are many challenges in implementing AI in agriculture. Though Bangladesh is an agricultural country, technological advancement in the farming system is not well-established instead of the remaining advantages of using technology.

There are some challenges in establishing AI and other advanced technology in agriculture are mentioned below:

Data lacking

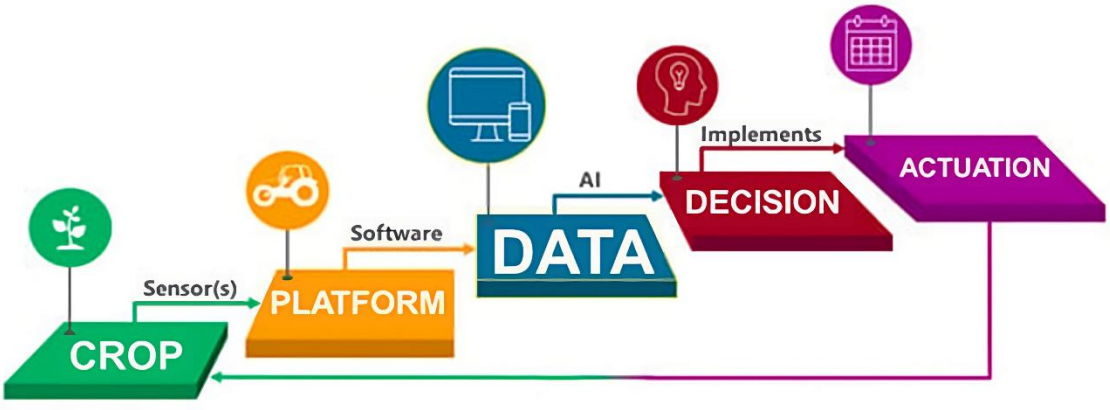
Big data can be helpful in transferring traditional agriculture into digital agriculture. To work with big data incorporated with AI, researchers need the following data to strengthen the digital farming system.

Metadata

This type of data keeps records about input (pesticides, herbicides, etc.) application dates. And by analyzing these data a crop cultivator can easily fix their crop harvesting date avoiding the residual effect of pesticides and herbicides.

Geospatial data

This type of data can help the researcher to create a map of the land use system and helps to forecast farming system change over time. In Bangladesh, many agricultural lands are transforming into aquaculture (Palash, 2022).



Source: (Saiz-Rubio & Rovira-Más, 2020)

Figure 5. Big data-based decision-making cycle for digital agriculture

Telematics data

These data are used to sense the amount of fuel (major cost-taking input) needed to cultivate alongside how much time is needed by a particular machine.

Unfortunately, Bangladesh agriculture could not make available these data yet. There are some more challenges,

1. Limited access to the technology

Though there is huge potential to increase crop productivity by using AI in agriculture, in Bangladesh, using AI is still overlooked. Illiterate farmers can not perceive the advantages of mechanization let alone AI use (Talaviya et al., 2020).

2. Small farm size

Small and fragmented land holdings that prevent the efficient use of technology have been identified as the main barrier to digitalizing agriculture by using AI. When these dispersed lands are used to grow a variety of crops, the issue is made worse.

3. Lack of area-based research station

Though Bangladesh is a small country, farming interests vary in area basis widely. Moreover, Bangladesh is a climate-vulnerable country where heat waves, drought, floods, and cyclones hit frequently. For example, the north-western region of Bangladesh is drought prone on the other hand 20% of Bangladesh's land area is coastal, and 53% of that is influenced by various salt levels, but there is no research center in this area to study on solving this problem (Haque, 2006).

CHAPTER IV
CONCLUSION AND RECCOMENDATIONS

4.1 Conclusion

Climate change is a significant threat to Bangladesh's food security and its growing population, but the country has the potential to overcome this situation through smart agriculture. The review will include an overview of changes in temperature, precipitation, and water scarcity, and their impact on agriculture. By identifying the specific challenges that farmers face due to climate change, this study aims to provide insights into how artificial intelligence can help improve agricultural practices.

Artificial intelligence-driven climate-smart agriculture to alleviate the impact of climate change can be achieved through the use of technologies such as smart irrigation, pest management, weed detection, yield forecasting, intelligent spray, and climate forecasting. These technologies can help enhance productivity while reducing carbon footprints by minimizing the use of fertilizers and synthetic pesticides. By leveraging the potential of artificial intelligence, this study aims to develop recommendations for sustainable agricultural practices in Bangladesh.

The successful implementation of AI in agriculture will require addressing certain challenges, including technical expertise, infrastructure development, and data availability. The study evaluates the current state of technical expertise and infrastructure in Bangladesh's agriculture sector and identifies potential obstacles to adoption. The findings of this study can provide guidance to the government, researchers, and other stakeholders on how to promote and invest in the use of AI in agriculture to achieve sustainable development and food security in Bangladesh.

4.2 Recommendation

Recommendations are suggested to overcome the challenges. Some suggestions are

1. Make available AI-based technology: Government should import state-of-the-art technology from abroad. To make it available in a farmer's field, first of all, technology should be implemented in research organizations like BRRI, and BARI along with affiliated universities.
2. Strengthen extension work: Extension workers may play a crucial role in this context. To bring technology to the farmer's field, extension workers can associate themselves with the researcher.
3. Providing adequate power supply in the rural area: though Bangladesh has developed its power supply in recent years, short-time power cutting is still problematic in a rural area where most of the farmland is available.
4. Rising awareness among farmers: A study conducted by Rashid et al. (2019) on 281 randomly selected farmers stated that 60% of farmers found the mobile phone very useful). But they are not aware of AI use in smart farming systems. Government and private organizations should pay attention to raising awareness among farmers to implement AI in the farming system.
5. Establishing a local community base research station: to meet the local farmers' needs, the country should pay attention to establishing a local community base research station.
6. Appropriate policy-making: Many opportunities exist for AI technologies to increase productivity and accelerate GDP development. Increasing consumer demand and changing products will account for 45% of all economic benefits by 2030 (PWC, 2016.). AI may make it possible for products to vary over time, becoming more beautiful, customizable,

and affordable. By increasing China's GDP by 26% in 2030 and North America's GDP by 14.5%, which accounts for over 70% of the global economic impact, China and North America are anticipating AI will lead to the biggest economic development (ICT Division, 2020).

From the concept of AI, Bangladesh has set eight AI-based industrial priorities among them AI use in Agriculture is the third priority. Further, making proper policy and outline to incorporate AI into the farming system.

So, incorporating AI with agricultural production by making proper policies, will bring long-term economic advantages.

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