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Use of artificial intelligence for precision agriculture in Bangladesh

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ABSTRACT
The world's most densely populated country is Bangladesh, and the population growth rate is 1.04 percent per annum. In this regard, crop production must increase by 2-3% per year for 238 million people by 2050 to address Bangladesh's continuously declining (0.29 percent per year) agricultural land. Drastic climate change, decreasing arable land, soil-water degradation due to heavy use of fertilizers, pesticides, industrial wastes, reduction of soil fertility and water table, etc., are the reasons for decreasing food production rates. The conventional method of crop husbandry is not sufficient to meet the food demand, despite the intensifying of input resources for crop production in Bangladesh. In this regard, IoT, ML, and AI technologies are effective tools for successful artificial intelligence-based precision agriculture. Precision agriculture increases crop yield by 22.46% more than imprecision agriculture. The AI-based technologies, viz., robotics, drones, GPS, remote sensing technologies, and computer imaging, are being used to predict the incidence of diseases and insect pests, weather forecasts, time of application and optimum dose of fertilizers and pesticides, irrigation scheduling, time of produce harvest, and predictive agricultural analytics, markets, and supply chain efficiency for economic, social, and environmental prosperity. AI-based technologies are alternative ways of traditional practice to ensure food security and a quality environment in Bangladesh by overcoming AI drawbacks.

1. Introduction

1. Why artificial intelligence is needed for Bangladesh's agriculture?

The world's most densely populated country is Bangladesh, and the population growth rate is 1.04 percent per annum. Economic development is dependent on agriculture because agriculture sectors contribute 12.92% of the country's domestic product (GDP) and ensure food security for 164.7 million people. Nowadays, the agriculture sector is in a critical situation for sustainable crop production, which is as follows: *Firstly, the* agricultural land of

Bangladesh has decreased by an average of sixty-six thousand acres each year, which is 0.29 percent of the total agricultural land in Bangladesh. Arable land area increased from 1964 to 1990, and then it decreased from 2010 to 2018 (Figure 1).

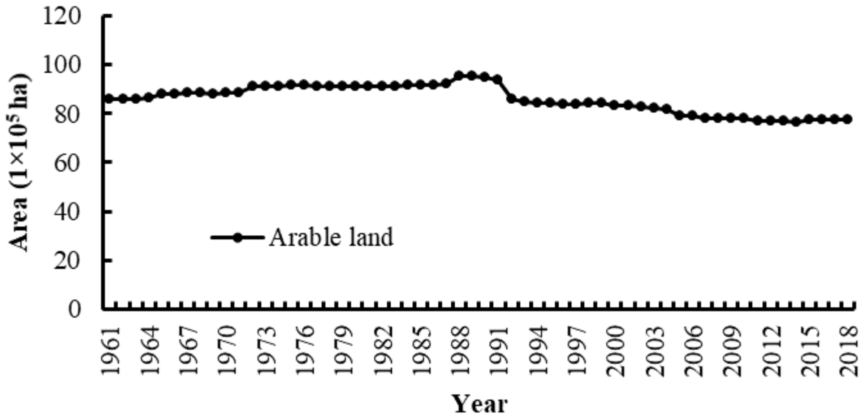


Figure 1. Total arable land status from 1961 – 2018 in Bangladesh

Secondly, food production rates are not up to the mark in Bangladesh when compared to other developed countries in the world (Figure 2). Food production rates slightly increased from 1959 to 1969 due to the Green Revolution, and thereafter decreased from 1970 to 1980, except from 1977 to 1978.

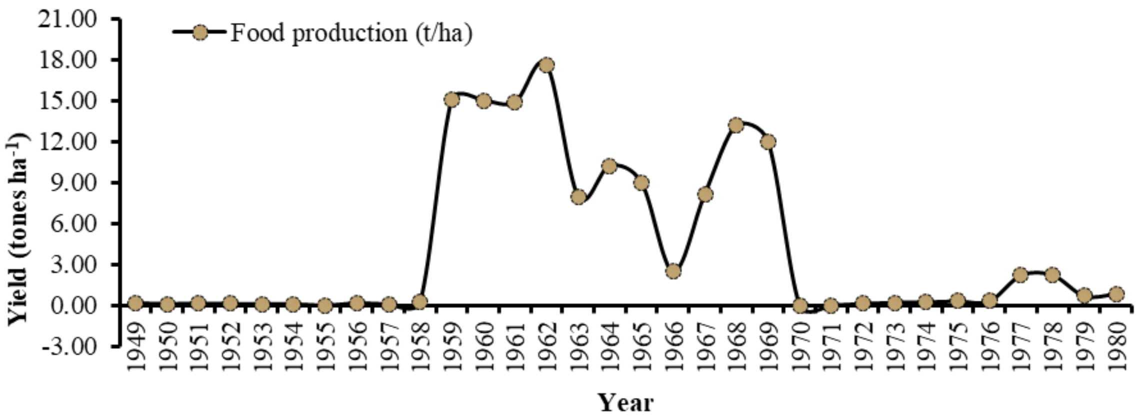


Figure 2. Bangladesh food production trend from 1949-1980 (adapted from Alauddin and Tisdell, 1987)

From these results, it may be concluded that traditional crop production systems cannot fulfill the food demand of the ever-growing population in Bangladesh. *Thirdly*, the Bangladesh rural labor market has undergone major structural changes over the past two decades, reflecting, in part, the rapid growth both in the urban and rural economies. Thus, Bangladesh Labor Force Survey data indicate that agriculture's share of total rural employment dropped by 6 percentage points, from 62 percent to 56 percent, in the 13 years between 2000 and 2013 (Figure 3).

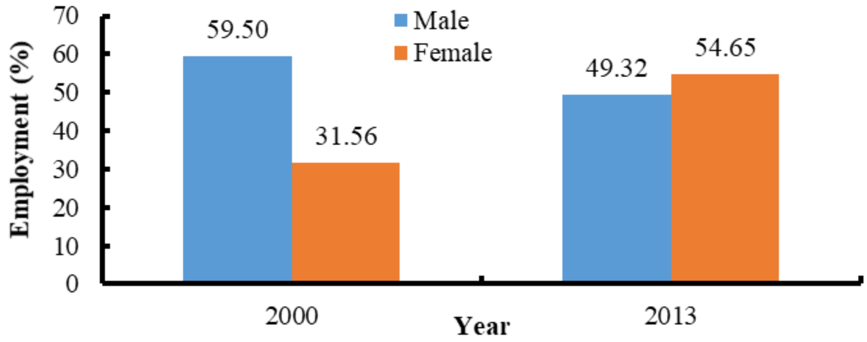


Figure 3. Distribution trend of rural workers in crop sector from 2000-2013

Fourth, the horizontal and vertical expansion of agricultural land is narrowing in Bangladesh. Fifth, soil productivity degradation is a serious problem due to imbalanced fertilization, inappropriate industrialization, and unwise use of underground water for irrigation purposes in Bangladesh. As a result, soil fertility in 10–12 and 39–52% of the areas in Bangladesh is very low and low, respectively. Medium and fertile soils cover 17–41% and 8% of the country, respectively. In Bangladesh, approximately 55% of soils have a medium to high SOC content, while the remainder is of low quality. In some areas, phosphorus (P) build-up has taken place (25% of areas), but K mining is widespread. In roughly 40% of areas, the sulfur and zinc status is low to very low. Soils in the major areas of the country have low pH (5.0–6.0) and CEC in the range of 15–25 $\text{cmol}_c\ \text{kg}^{-1}$ (Biswas *et al.*, 2019). *Sixth, being the backbone of the country, boosting the agriculture sector is an obvious huge concern for the Bangladesh government. Despite making remarkable progress (Chowhan and Ghosh, 2020) and getting government attention, the sector continues to face challenges due to its dependence on several unpredictable variables, viz., climate change, degradation of land, reduction in soil fertility, increased dependence on inorganic fertilizers for higher production, rapidly dropping water tables, emerging pest resistance, etc. Seventh*, climate variability and uncertainties (temperature rise and erratic rainfall), frequent floods and river erosion, cyclones and tidal surges, salinity, drought, heat waves, cold, fog, and water logging are common crop-damaging phenomena in Bangladesh. The conventional methods of crop husbandry are not sufficient to meet the food demand, despite intensifying the input resources for the crop production system in Bangladesh. It is therefore important to have a profitable, sustainable, and environmentally friendly agricultural system to ensure long-term food security for the people of Bangladesh. Usage of advanced technologies that include satellite imagery, and computer-assisted systems as well as AI technologies has enhanced the capabilities of weather forecasting systems to cope with these unusual circumstances in Bangladesh. AI can also solve problems in agriculture like overuse of chemical fertilizers and unwanted effects of pesticides, weeds, pollution, and plant diseases, and help with precision farming, soil monitoring, and weather predictions to boost the yield of crops and maintain a sustainable environment. Artificial intelligence (AI) is the potential to help Bangladeshi farmers overcome obstacles from seeding to end users.

2. Use of AI technologies in crop production system

High precision agriculture is an important role for artificial intelligence to play. Artificial intelligence (AI) is the science of design that exhibits similar characteristics associated with the intelligence found in human behavior (Bhar *et al.*, 2019). Knowledge-based computing, in particular in AI, is the most advanced and disruptive technology in agriculture services since it can understand, learn, and respond to different situations (based on learning) to increase efficiency. AI is a meaningful prospect in computer science that deals with system recognition learning, reasoning, understanding language, and taking actions to solve problems.

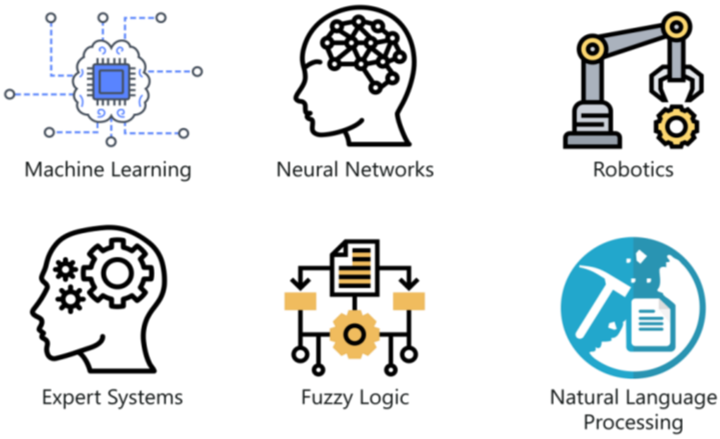


Figure 4. Branch of artificial intelligence (AI)

Expert systems, robotics, machine learning, neural networks, fuzzy logic, and natural language processing are the major branches of AI (Figure 4). An expert system is an AI-based system that learns and imitates a human being's decision-making ability. The Internet of

Things (IoT) creates a massive volume of data from millions of devices.

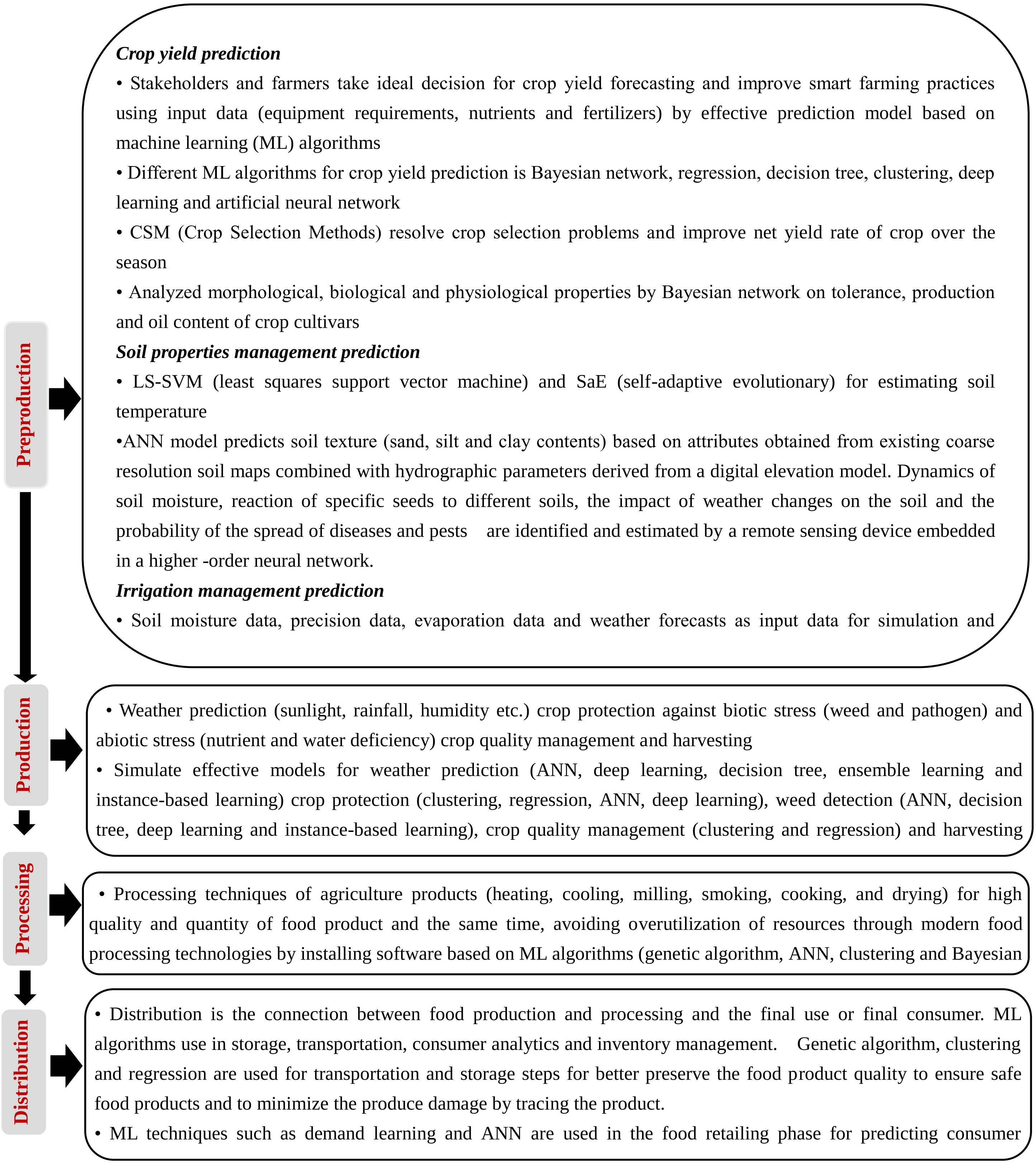


Figure 5. Use of artificial technologies for precision agriculture

Cognitive IoT solutions can analyze all this data and provide strong insights to improve crop productivity. Machine learning is powered by data and generates insight from it. These data can be correlated with data on historical weather patterns, soil reports, new research results, rainfall patterns, weeds, pest infestations, images from drones and cameras, etc. Machine learning is the central theme of AI and helps stakeholders work more creatively and efficiently. The use of machine learning (ML) algorithms is the main way for the agriculture supply chain to become more important. Machine learning conducts past behavior to identify patterns and build models that help predict future behavior and events. Both AI and ML play a massive role in how we use and monitor IoT devices. Its relation compares to the human brain and body. The body uses sight, touch, and sound as sensory input to gain situational awareness of its surroundings, and the brain uses the data to make informed intelligent decisions. A neural network is a branch of artificial intelligence associated with the use of neurology to incorporate cognitive science into helping computer systems and machines execute tasks. It is known as d*eep Learning* because it involves making use of artificial brain neurons to solve complex problems. A neural network helps machines process how the human brain operates. Fuzzy logic is the technique of modifying and representing uncertain information by analyzing the degree to which the hypothesis is true. Preproduction, production, processing, and distribution are the four clusters of AI algorithms (Figure 5).

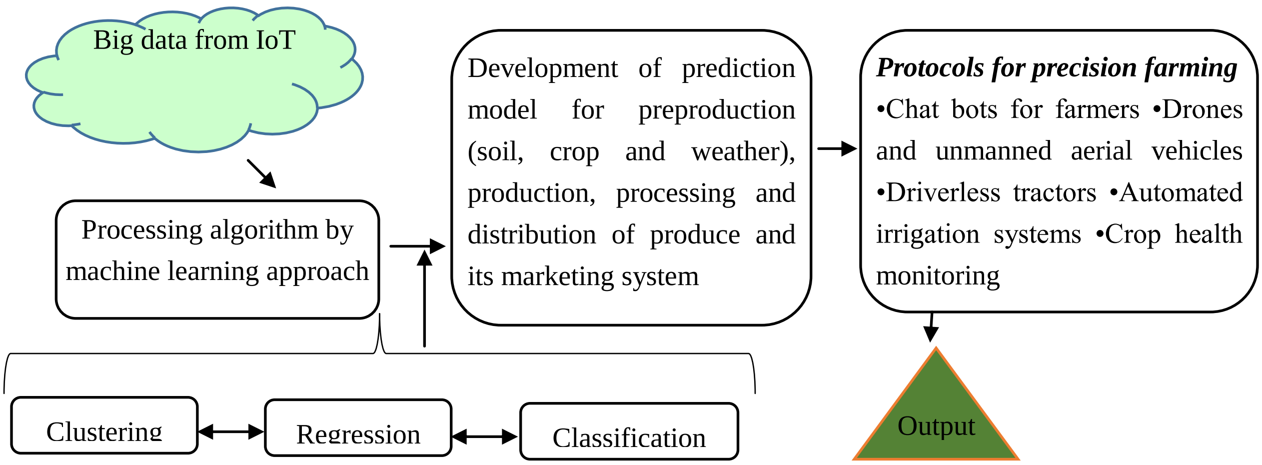


Figure 6. Use of IoT, ML and AI technologies for precision agriculture

The activities of AI based agriculture system can achieve the significant outputs for the end users in Bangladesh (Figure 6). AI-based technologies ensure the quality of agricultural products from preproduction, production, processing, and distribution for better service to end users. Four main clusters such as preproduction, production, processing, and distribution are discussed in brief which are as follows:

2.1 Preproduction

The preproduction is the initial step of AI based agriculture system. Monitoring soil and crop health and smart irrigation are included in the preproduction step.

2.1.1 Monitoring crop and soil health

Proximity sensing and remote sensing are effective soil management tools for crop production. The sensor based high-resolution data can be utilized for soil testing. Remote sensing requires sensors to build into airborne or satellite systems, while proximity sensing requires sensors to contact with soil or at a very close range. This helps in soil characterization based on the soil below the surface in a particular place (Sennaar and Baruah, 2019). An artificial neural network (ANN) model predicts soil texture (sand, clay, and silt content) based on attributes obtained from existing coarse-resolution soil maps combined with hydrographic parameters derived from a digital elevation model (Zhao et al., 2009). Soil moisture dynamics are characterized and estimated by a remote sensing device embedded in a higher-order neural network (Elshorbagy and Parasuraman, 2008). This also helps in understanding the reaction of specific seeds to different soils, the impact of weather changes on the soil, and the probability of the spread of diseases and pests (Irimia, 2016). On the other hand, conventional crop health monitoring cannot guarantee better crop production. These techniques are extremely time-consuming and mostly categorical. Environmental conditions are continuously changing due to climate change. Under changing climatic conditions, the crop cannot compete if an effective control measure is not initiated in the right way and at the right time. For example, the late blight of potatoes is very dangerous for potatoes. If control measures are delayed, the crop will be destroyed within a few days. So, a machine learning system with an agro cloud module can help to control this disease. Companies in the field of hyper spectral imaging and 3D laser scanning are predominantly increasing their precision and accuracy with the volume of data that gets collected. According to Priyanka et al. (2018), crop protection can be improved by providing an alert-based system that utilizes the deep learning technique of machine learning. Remote sensing artifices, along with hyperspectral imaging and 3D laser scanning, are essential to creating crop metrics across thousands of acres in a particular area or state. It could helper in an innovative and radical change in the management of cropland and monitoring by farmers in terms of available resources, time, and energy. This technology can help in a great way to manage crop health in terms of biotic and abiotic stresses. This will monitor crops from end to end of their entire life-cycle and generate reports to detect incongruities if any. Drone-based images can be utilized for in-depth field analysis, crop monitoring, scanning of fields, and so on. They can be coupled with computer vision technology and IoT to ensure rapid actions by farmers and better crop management. These feeds can generate real-time weather and pest alerts for farmers.

2.1.2 Smart irrigation

Traditional irrigation is a laborious and water-wasting system to maintain soil moisture for crop production. Automated irrigation systems, in combination with a heavy reliance on historical weather conditions, can predict required resources. Automated irrigation systems are designed to utilize real-time machine learning to constantly maintain desired soil moisture conditions to increase crop yields. This system not only reduces labor significantly but also provides the potential drive to reduce production costs. In the world, agriculture utilizes about 70% of the world‘s total fresh water for irrigation purposes.

2.2 Production

The production is the second step of AI based agriculture system. Detecting crop diseases and pests and decrease pesticide usage are included in the production step. Images of various crops in different areas are captured using computer vision technology under white/UV-A light. Beyyala and Beyyala (2012) reviewed a few techniques for the detection of plant traits or diseases using image processing. Chaudhary et al. (2012) have implemented an algorithm for disease spot segmentation using image processing techniques on plant leaves. According to the authors, farmers face great difficulties in changing from one disease control method to another. Naked-eye detection and classification of diseases are very expensive, various plant diseases pose a great threat to the agricultural sector by reducing the life of the plants. Using Internet of Things (IoT) technologies, Infosys has built a precision crop management practice for optimum use of pesticides. It recognizes faces, flora and fauna, and other objects and tags them in images.

2.3 Processing

Farmers can arrange the products into separate stacks for better quality categorization before sending them to the market. This technique would identify pests more specifically. Cognitive computing makes analysis and recommendations to farmers on the simplest choice of crops, seeds, and management based on multiple parameters, viz. soil condition, weather position, type of seeds, infestation around a certain area, etc. The recommendations are further custom-made based on the farm's requirements, local conditions, past crop management strategies, failures, and successes. Market trends, demands, prices, and consumer needs, can also be taken into consideration through artificial intelligence for better understanding and decision-making.

2.4 Distribution

Policymakers have not been able to tackle the agricultural supply chain challenge successfully yet. As a result, on the one hand, farmers either do not receive a suitable price for their produce that continues to rot in the marketplace and food consumers either end up paying exorbitant prices or are malnourished. So the application delivers a data-driven online marketplace for agriculture that offers better prices to farmers as well as buyers. Application of AI based agricultural supply chain management informs applications in supply chain planning and optimization, including demand forecasting and logistics, can lead to huge cost savings for farmers and solve the information asymmetry problem for buyers.

3. Risks of AI in Bangladesh agriculture

AI is a wishful concept for agriculture, but it has some drawbacks which are as follows:

» Bangladesh is the world's least developed country. The high cost of developing and maintaining intelligent machines and computers could be considered a technological limit.

» Land fragmentation is a major issue in Bangladesh. As a result, farmers grow multiple crops at the same time in small areas where AI-based agricultural technologies are difficult to manage in Bangladesh.

» AI creates unemployment, which is the most important social challenge. AI technologies such as smart machines, robots, and driverless tractors can do a huge amount of work in a short time. This is the cause of major employment standards.

» There is no skilled manpower available for using AI technologies.

» Machines can do only those tasks that they are programmed or developed to do, and anything outside of that tends to crash or give irrelevant outputs, which could be a major backdrop.

» AI software and hardware need to be updated every day for their latest requirements.

» Repairing and maintaining AI machines is expensive.

» Any creation of an agricultural production system requires an expensive, complex machine. As a result, the price of AI-based agricultural products is increased compared to traditional agricultural production systems due to the use of high-cost equipment.

» Last of all, some risks and apprehensions could be posed to sustainability, such as massive energy consumption, e-waste problems, market concentration, job displacement, and even the ethical framework due to the use of AI technologies.

4. Benefits of AI in Bangladesh agriculture

AI technologies are a wishful concept for a world where traditional agriculture practices cannot meet the social, economic, and environmental requirements. It is the ability of algorithms to imitate human behavior in applying knowledge. AI shares many aspects of intelligence allowing it to take over many tasks that are primarily done by human beings. Not only AI is creating solutions to common everyday problems but it is also making life simpler for everyone. Holistic approach among the biologists, agronomists, nutritionists, and policy analysts working with data scientists is using Big Data as source to create AI based technologies that can predict the potential outcomes of future scenarios for farmers. The proposed conceptual model for smart agriculture has been shown in Figure 7. Smart agriculture is a key tool to handle and manage the threats, challenges, and risks in the context of climate change, diseases, and pest attacks and ensure sustainability (Hirafuji, 2014). Data source, technological involvement, processing unit, institutional setting, governing process, indicators and sustainable agriculture are the key points for successful crop production. Precision agriculture is possible with smart agriculture, and AI technologies can help with this. AI generally uses the most updated technological facilities to maximize yield per unit of land sustainably in terms of financial earnings, quality, and amount. Precision farming or precision agriculture with AI technologies refers to performing the right thing, in the right way, in the right place, at the right time (Liakos et al., 2018). Precision farming is meant to match agricultural practices as per agro-climatic conditions to increase the accuracy of application (Hossain, 2021). Figure 8 shows that technologies under precision agriculture increase the fruit yield of tomatoes and brinjal by 13.23%, whereas precision agriculture achieves 35.72% more output than imprecision agriculture. Precision agriculture also yields 22.46 percent more than traditional agriculture.

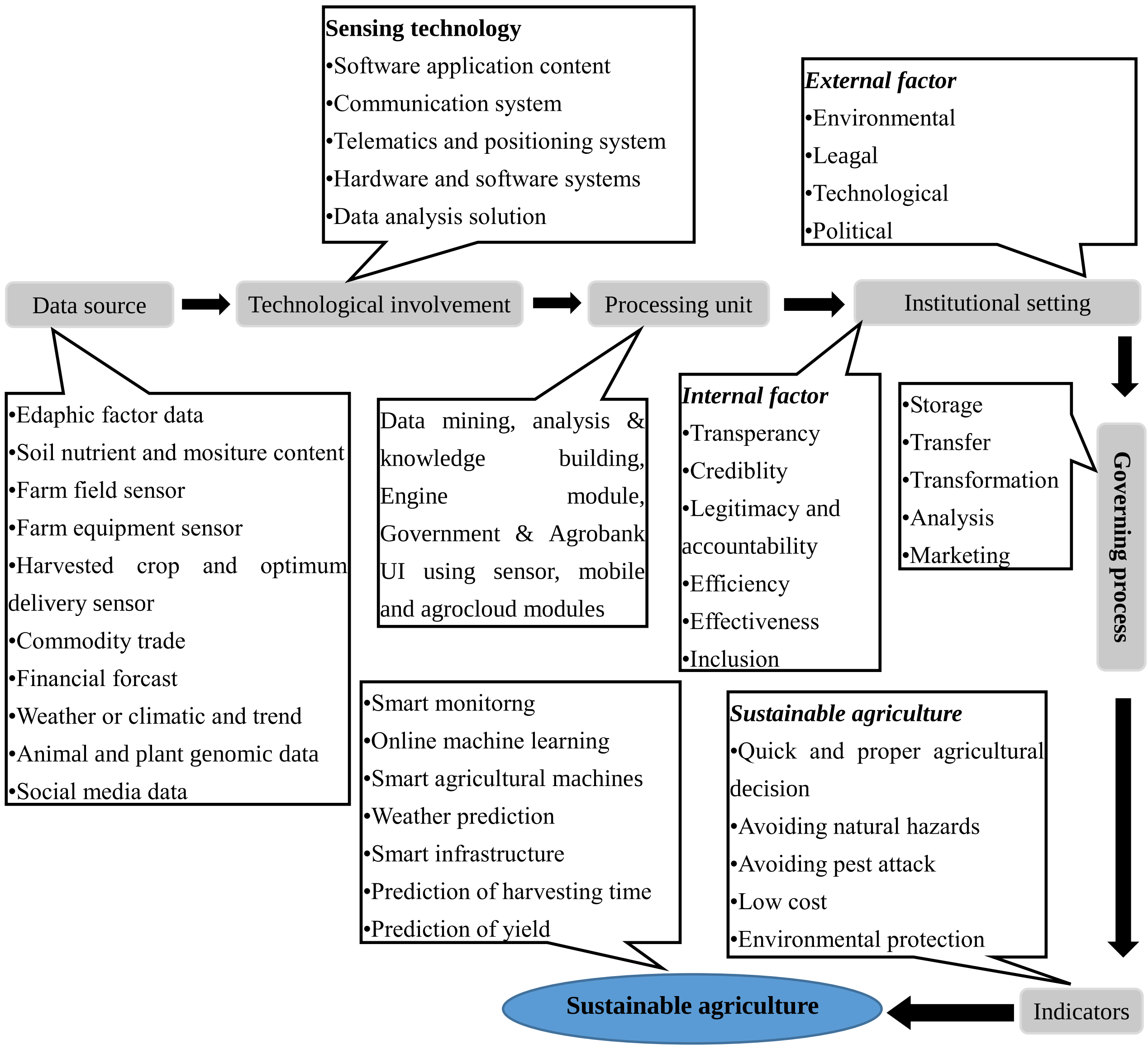


Figure 7. A conceptual model of big data driven smart agriculture for sustainable agriculture

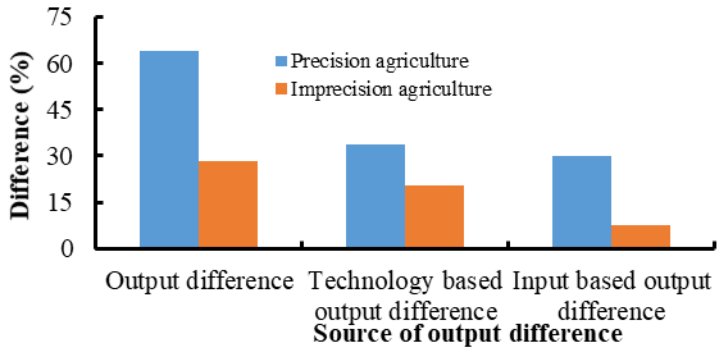


Figure 8. Effect of precision and imprecision agriculture farming on vegetables production (adapted from Mokaya, 2019).

Activities for successful use of AI technologies in Bangladesh agriculture

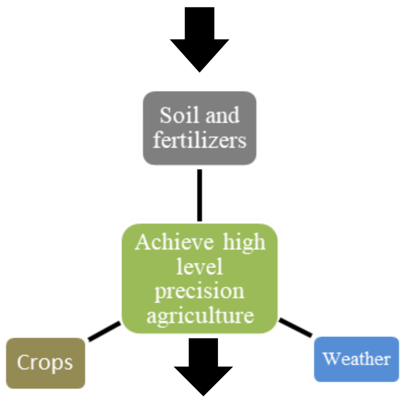
»Trained up extension, research, NGO's and farmers for using AI technologies

» Create facility of AI supporting tools and infrastructures

» Collaboration with CGIAR for satellite image and big data facilities

» Provide aids, reliefs, tax holidays, crop insurance and other incentives for farmers

» Develop community based farming system



Benefits from the AI based agriculture

» Reduce cost of production

» Improve soil fertility

» Control pests and diseases of crops

» Reduce environmental pollution

» Ensure climate smart agriculture

» Effectively use of fresh water for irrigation

» Help to divert workforce to other sectors

» Ensure quality and safe food

Figure 9. Effective AI system ensure food security and quality environment

Based on these results, it may be concluded that precision agriculture with modern technologies is needed to overcome the stagnation status of food production in Bangladesh. There is a big scope when precision agriculture can be applied to other vegetables and different crops. Skilled manpower, AI supporting tools, big data management, creating community and crop zoning based farming systems, and collaboration with national and international organizations can help to create a successful AI based agricultural system in Bangladesh (Figure 9). This AI-based agricultural system can help to improve soil fertility, reduce the cost of production and environmental pollution, control pests and diseases of crops, ensure climate-smart agriculture and quality and safe food, utilize fresh water for irrigation effectively and divert the workforce to other sectors. Ultimately, AI-technologies can ensure sustainable crop production and a quality environment in Bangladesh. Due to the Green Revolution, the agriculture system has completely changed in our country. Due to the use of fertilizer, irrigation, and developed crop varieties, Bangladesh is now achieving 3–4 times higher crop production than it was before (Maddikunta et al. 2021). At the beginning of the Green Revolution, farmers didn‘t accept chemical fertilizers for crop production in Bangladesh. Nowadays, farmers' perception is that without fertilizer, crops cannot establish themselves. So, in the near future, AI-based agriculture technologies will also be accepted for ensuring food security and quality environmental assurance by overcoming the drawbacks of this technology.

5. Conclusion and future scope

Precision agriculture remains a wishful concept for Bangladesh. It is possible to achieve the above vision in Bangladesh to improve the food security and per capita income of the farmers. As AI plays a major role in agriculture, traditional farming is slowly moving towards precision farming. The robots without humans can be used for planting, seeding, harvesting, etc., and the drones will send an alert to the farmer if there are any problems. The robots can do the work of 25–30 humans, reducing the amount of labor on the farm. By using automated machines to handle agriculture work, monitoring crop health and soil fertility, predicting weather conditions, and marketing channels, artificial intelligence can solve many problems in the agriculture sector. Technological advancements and government initiatives to foster and promote precision agriculture through aids, reliefs, tax holidays, and other farmer incentives attract a lot of investment. This move thus helps deliberate efforts to protect the growth and sustainability of future generations yet to come.

References

Alauddin, M. and C. Tisdell. 1987. Trends and projections for Bangladesh food production: an alternative view point. Food Policy. pp. 318-331.

Beyyala A.K and S.P. Beyyala. 2012. Application for Diagnosis of Diseases. *In* Crops Using Image Processing. ISSN 2250–3137.

Bhar, L.M., Ramasubramanian, V., Arora, A., Marwaha, S. and Parsad, R. 2019. Era of Artificial Intelligence: Prospects for IndianAgriculture. https://krishi. icar.gov.in/jspui/bitstream/123456789/19207/1/AI%20article%20for%20Indian%20 Farming %20_ IASRI.pdf

Biswas, J.C., Kalra, N., Maniruzzaman, M., Haque, M.M., Nahar, U.A., Ali, M.H., Kabir, W. and S. Rahnamayan. 2019. Soil fertility levels in Bangladesh for rice cultivation. 4(4): 1-11.

Chaudhary, P., Chaudhari, A.K., Cheeran, A.N. and Godara, S. 2012. Color Transform Based Approach for Disease Spot Detection on Plant Leaf. International Journal of Computer Science and Telecommunications 3 (6): 65-70.

Chowhan, S. and S.R. Ghosh. 2020. Role of ICT on agriculture and its future scope in Bangladesh. Journal of Scientific Research & Reports. 26(5): 20-35.

Elshorbagy, A. and Parasuraman, K. 2008. On the relevance of using artificial neural networks for estimating soil moisture content", Journal of Hydrology, Vol. 362, No. 1-2, pp. 1-18, 2008

Hirafuji, M. 2014. A strategy to create agricultural big data in Annual SRII Global Conference, SRII. pp. 249–250.

Hossain, M.B. 2021. Soil and crop management for sustainable agriculture. Advances in Agricultural and Life Sciences. Yessimbekov, Z. (edt.), Book Chapter, Weser Books, No. 79737, Zittau, Germany. pp. 29-52.

Irimia, M. 2016. 'Five ways agriculture could benefit from artificial intelligence.' AI for the Enterprise, IBM. ISSN: 0975–2927

Liakos, K.G., Busato, P., Moshou, D., Pearson, S. and D. Bochtis. 2018. Machine Learning in Agriculture : A review. Sensors. 18: 1-29.

Mokaya, V. 2019. Future of precision agriculture in India using machine learning and artificial intelligence. Intl. J. of Computer Sci. and Engineering. 7(3): 422-425.

Priyanka, R.R., Mahesh, M., Pallavi, S.S., Jayapala, G. and M.R. Pooja. 2018. Crop protection by an alert based system using deep learning concept. Int. J. of Sci. Res. in Computer Sci. and Engineering. 6(6): 47-49.

Zhao, Z., Chow, T.L., Rees, H.W., Yang, Q., Xing, Z. and F.U. Meng. 2009. Predict soil texture distributions using an artificial neural network model. Computers and Electronics in Agriculture 65(1):36-48.