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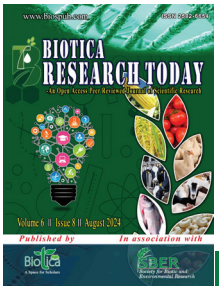

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Role of Artificial Intelligence in Natural Resource Management

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Abstract

Artificial intelligence (AI) in agriculture helps farmers by providing them with real-time information into their crops. This helps them identify areas that need irrigation, plant fertilizers and deal with problems like crop insect infestations and weather occurrences. It is the need of the hour to enhance the crop yield for feeding the future generation without adverse effect on soil health and environmental health. Numerous research initiatives aim to increase crop yields and resource usage efficiency in response to shifting climate situations. Effective resource management lowers cultivation costs, improves crop quality, maximizes input efficiency, *etc*. AI systems can analyze soil composition and also offering precise assessments of nutrient deficiencies. It also helps with disease detection, weed identification and management, pest control strategies & recommendations and plant health monitoring. These AI-driven capabilities encompass learning, problem-solving, thinking, perception, comprehension of spoken language and interaction with the surroundings.

Keywords: Artificial intelligence, Crop prediction, Data collection and analysis, Soil health

Introduction

The science and technology both are creating new horizons for human development. It enhanced the mechanization over a period to improve the work efficiency, cost saving, reducing time and less labour effort. The Tata Institute of Fundamental Research (TIFR) housed India's first computer. Shri Jawaharlal Nehru, the former prime minister, gave it the acronym TIFRAC (Tata Institute of Fundamental Research Automatic Calculator). Vikram Sarabhai turned on the first electronic digital computer ever developed in India on January 21, 1969 at the Bhabha Atomic Research Centre (BARC). Initially, computer started in precious observations and data analysis. Nowadays, it is an important part of every sector and its important growing over a period. Globally, artificial intelligence (AI) is one of the burgeoning fields. Artificial intelligence is the development of computer systems that are able to do tasks that typically require human intelligence. These abilities include learning, reasoning, problem-solving, perception, understanding spoken language and even engaging with the environment (Pandey *et al.*, 2023). Building devices that can replicate or duplicate human cognitive processes is the aim of artificial intelligence.

AI is used in many different fields, such as healthcare, banking, education, entertainment and transportation. Artificial Intelligence will continue to have a big impact on how many sectors and ordinary parts of life develop as technology develops. Managing soil, water, plants and

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animals with an eye toward how these actions impact the standard of living for both current and future generations is known as natural resource management. Among the natural resources, soil and water are important for crop production to feed the future generation. It is well known that plants need 17 essential nutrients for the healthy growth of the crop plants. Sustainable crop production systems promote soil health and improve the crop yield potential without any adverse effect on the environment. The ability of the soil to support life-people, animals and plants-as a living ecosystem is referred to as soil health. Use of AI is the important tool for efficient management of natural resources particularly soil health, water and crop management practices.

Types of AI

Classification of AI based on complexity:

1. Weak or Narrow AI: It is employed in a certain field. This class requires specialist knowledge. It is excellent at carrying out certain tasks, but its capabilities are constrained by the predetermined parameters. Virtual personal assistants (like Siri or Alexa), speech and picture recognition software and recommendation algorithms are a few examples.

2. Strong AI: Known by another name, general artificial intelligence is a more advanced form of AI that can learn, understand and apply information to a range of activities at a level comparable to human intellect. Research and conjecture on general artificial intelligence are still underway and the field is still mostly theoretical.

AI can be categorized into two main approaches based on its functionality:

✓ Symbolic AI, often known as Good Old-Fashioned AI or GOFAI, is a method of programming computers that uses explicit knowledge representations and reasoning procedures. It uses a rule-based or symbolic system to manipulate symbols and make judgment calls.

✓ Making algorithms that enable computers to learn from data is the aim of the machine learning (ML) branch of artificial intelligence. Rather than being explicitly coded, these systems use the incoming data to identify patterns and generate predictions. Deep learning, a sub-field of machine learning that has gained prominence for simulating human-like learning processes, heavily relies on neural networks. Most of the cases neutral network is playing an important role in AI. In which, computers can utilize this adaptive approach to learn from their errors and keep getting better. As a result, artificial neural networks make an effort to more accurately answer challenging problems, such as document summarization and facial recognition (Figure 1).

Significance of AI in NRM Activities

Managing natural resources entails keeping an eye on how people and the environment interact. This includes the long-term viability of numerous industries like agriculture, mining, tourism, fisheries and forestry as well as the coordination of land use planning, water management, biodiversity conservation and the preservation of natural heritage (Xiang *et al.*, 2021). Artificial intelligence presents innovative solutions for various environmental issues, which

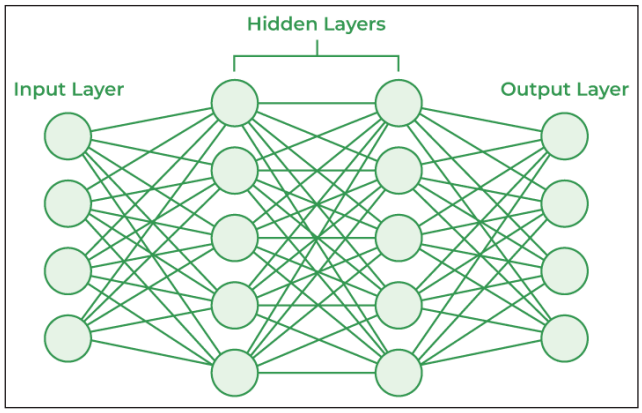

Figure 1: Artificial Neural Networks (Anonymous, 2024)

considerably aids in natural resource management. The following are some ways that artificial intelligence supports the management of natural resources (Chen *et al.*, 2023).

1. Data Analysis and Monitoring

• *Remote Sensing*: AI systems are able to monitor changes in ecosystems, deforestation, land use and environmental conditions by analyzing satellite pictures and remote sensing data. It is based on the long- term data available in different sources.

• *Data Integration*: To obtain a through understanding of the dynamics of natural resources, AI assists in the integration and analysis of sizable datasets from many sources, including databases on biodiversity, climate change and geographic information systems (GIS). In which different types of data analysis model are using for accurate analysis of the variables (Figure 2).

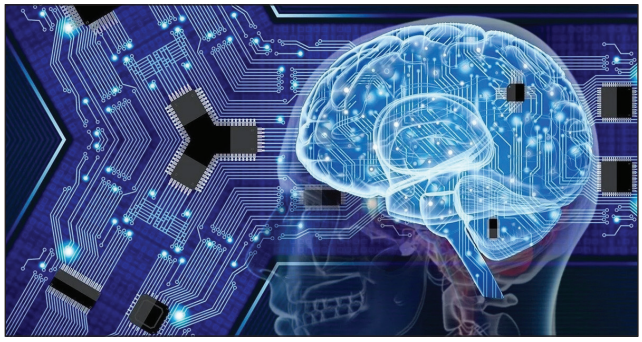

Figure 2: Classical data analysis model (LaFee, 2022)

2. Forecasting using Modeling

Climate Modeling: Artificial intelligence aids decision-makers in their thinking by making it easier to create intricate climate models that can imitate how climate change affects natural resources. AI is used to predict the distribution of plant and animal species, which helps with biodiversity management and conservation efforts. These models are known as species distribution models.

3. Precision Agriculture

• *Crop Monitoring*: AI-powered systems evaluate input from sensors, drones and satellite images to give farmers up-to-date knowledge on the condition of their crops so they can optimize fertilization, irrigation and pest management. AI-enabled systems utilize data such as temperature,

precipitation, wind speed and sun radiation, alongside imagery captured by satellites and drones, to make weather predictions, monitor agricultural sustainability and evaluate farms for the presence of diseases, pests, or diseased plants.

• *Automated Decision Support*: AI algorithms are essential in helping farmers make data-driven decisions since they analyze past data, weather patterns, soil conditions and a host of other variables. Large volumes of data are processed and interpreted by these algorithms to produce insights that can be put to use, helping farmers improve their agricultural techniques. Artificial Intelligence assists farmers in making more educated decisions that can result in improved crop management, higher efficiency and increased agricultural output. This includes forecasting crop yields, identifying potential dangers like disease or drought and deciding when to plant.

4. Wildlife Conservation

• *Anti-Poaching*: Artificial intelligence technology, which encompasses gadgets like drones and smart cameras, is essential for tracking and safeguarding species. These sophisticated algorithms are able to follow and identify animals in their natural environments, identify anomalous activity and even discover patterns linked to illicit operations like poaching. Smart cameras can automatically notify authorities of potential dangers through AI-driven image and video analysis, facilitating a prompt reaction to safeguard endangered animals. AI-equipped drones are capable of covering wide regions, offering real-time surveillance and assisting in the prevention of illegal acts before they have a negative impact. By making it simpler to protect fragile species from human dangers, this creative use of AI not only aids biodiversity preservation but also improves wildlife conservation efforts.

• *Behavior Analysis*: AI aids in the analysis of animal behavior patterns, which supports conservation initiatives and clarifies the ecological requirements of different species.

5. Water Management

• *Water Quality Monitoring*: To identify pollution and guarantee the sustainable management of water resources, AI algorithms examine sensor data on water quality. In order to ensure that treated wastewater satisfies safety requirements for reuse in a variety of applications, including irrigation, industrial processes and even potable water supply, artificial intelligence plays a critical role in precisely predicting the quality of treated wastewater. Artificial intelligence systems are able to predict the quality of treated water with high accuracy by evaluating complicated data from several sources, such as chemical composition, treatment procedures and environmental conditions. Because of its predictive power, water quality can be consistently monitored and adjusted in real time, reducing the danger to public health. AI therefore supports the safe and effective reuse of treated wastewater across several sectors, aiding in the sustainable management of water resources. This not only conserves water resources, but also mitigates the environmental impact associated with wastewater discharge.

• *Flood Prediction*: AI models help in disaster management by predicting and reducing the effects of floods through the analysis of real-time and historical data. Furthermore, AI-driven data analytics facilitate real-time monitoring and adaptive forecasting, allowing proactive responses to evolving flood conditions.

6. Energy Efficiency

• *Smart Networks*: AI optimizes how energy resources are distributed and used in smart networks, cutting waste and advancing sustainable energy practices.

• *Resource Optimization*: By maximizing their use, reducing their negative effects on the environment and encouraging the use of renewable energy sources, AI helps with the efficient management of energy resources. Artificial intelligence can forecast energy consumption, optimize energy distribution efficiency and boost system performance through sophisticated algorithms and real-time data analysis. Making better decisions about the production and use of energy is made possible by its assistance in spotting trends and abnormalities in energy use. Artificial intelligence facilitates the shift to cleaner energy sources, including solar and wind and lessens dependency on fossil fuels by integrating with smart grids and renewable energy systems. This not only aids in reducing greenhouse gas emissions but also promotes the creation of a greener, more resilient energy infrastructure and more sustainable energy practices.

7. Natural Disaster Response

• *Early Warning Systems*: The development of early warning systems for natural disasters, such as hurricanes, earthquakes and wildfires, is aided by artificial intelligence and allows for faster evacuation and disaster response.

8. Land Use Planning

• *Urban Planning*: Artificial intelligence supports the optimization of urban development by taking into account elements such as infrastructure, green areas and transportation to build resilient and sustainable cities. AI makes it possible to take a data-driven approach to urban planning, which helps to create cities that are more resilient to future challenges as well as more efficient and sustainable.

• *Assessment of Ecosystem Services*: It describes how ecosystems both directly and indirectly support human well-being, having a major impact on our ability to survive and lead generally satisfying lives. The four sorts of services that these can be divided into are supplying, regulatory, cultural and sustaining services. By analyzing massive information and simulating intricate ecological interactions, AI plays a critical role in maintaining and assessing these ecosystem services. Decision-makers can utilize this information to better understand the importance and state of ecosystem services, which will help them, develop more intelligent plans for conservation and land use. AI supports decision-makers in the process of land use and conservation by evaluating ecosystem benefits.

Conclusion

In the current years, the challenges in natural resource

managements are increasing in many folds. However, the scientific tool and techniques are also improved as need base. Growing population and its load for food grain production without adverse effect on natural resources are also a major challenge for policy maker and researchers. In this regards, AI is a hope for efficient management of natural resources in a sustainable manner. In nutshell, artificial intelligence improves natural resource management's efficiency by offering data-driven insights, predictive models and automated decision-making tools in a variety of fields. Its uses support the preservation, responsible use and safeguarding of natural resources.

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