# Artificial Intelligence and Sustainability

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*Abstract –* Sustainability is one of our most important global goals. To achieve this goal, many areas such as environmental awareness, efficient use of resources, and waste management need to be addressed. Artificial intelligence has become an important tool to achieve this goal by offering various applications in different sectors of sustainability. For example, artificial intelligence technologies can be used to produce sustainable solutions in areas such as energy and resource efficiency, agriculture, water management, waste management, and transportation. Additionally, artificial intelligence can also be used for monitoring and preventing environmental damage. However, there are potential risks of artificial intelligence technologies in sustainability. Therefore, in order to use artificial intelligence technologies in line with sustainability goals, ethical and legal regulations should be increased, as well as user awareness. This study presents a perspective on the importance and applications of artificial intelligence technologies in sustainability, and how these technologies can contribute to sustainability goals.

*Keywords – Artificial Intelligence, Sustainability, Energy Efficiency, Renewable Energy, Agriculture*

## I. INTRODUCTION

Sustainability is the principle of using natural resources carefully and effectively to meet current needs while maintaining the ability to conserve and use natural resources in a way that meets the needs of future generations. The topic of artificial intelligence (AI) and sustainability is becoming increasingly important today. Environmental problems, economic inequalities, and social issues resulting from human activities are increasing the need for sustainability [1].

AI is a technology with the potential to develop applications that make human life easier in many areas. AI is the general name for computer systems designed to mimic human intelligence or perform better than human intelligence [2]. These systems attempt to mimic human intelligence characteristics such as learning, problem solving, perception, decision-making, and language understanding. AI can be used to increase sustainability in areas such as energy efficiency, water management, agriculture and food security, environmental pollution, and smart cities.

AI can provide information about environmental issues by analyzing large data sets, monitor environmental pollution, save energy, and help natural resources to be used more effectively. AI applications in agriculture and food security can increase productivity, increase food supply, and reduce food waste. In smart cities, AI can be effectively used in areas such as traffic management, environmental monitoring, and energy management to increase sustainability.

For these reasons, the topic of AI and sustainability is extremely important, and it is of great importance to conduct research, develop applications, and carry out work in this field. The purpose of this article is to introduce and explain the use of AI technology to achieve sustainability goals. This study will discuss how AI technologies can be used in sustainability, what advantages these technologies offer, examples of applications, and potential future uses. The goal of the article is to provide readers with a broad perspective on how AI technology can be used in sustainability and to

explain the contribution of these technologies to sustainability.

## II. The Relationship Between Artificial Intelligence and Sustainability

The topics of artificial intelligence and sustainability have become increasingly important in recent years. Sustainability can be defined as the ability to meet the needs of future generations by meeting the needs of today [3]. Artificial intelligence, on the other hand, is a technology with the potential to develop applications that make human life easier in many fields.

Artificial intelligence can be used in many areas related to sustainability. This technology can support sustainability goals such as environmental issues, economic inequalities, and social problems. Artificial intelligence can provide information about environmental issues by analyzing large data sets, monitor environmental pollution, provide energy savings, and help to use natural resources more efficiently.

For example, in smart cities, artificial intelligence technology can increase sustainability by being used in areas such as traffic management, environmental monitoring, and energy management. This technology can reduce energy consumption by reducing traffic congestion and reducing environmental pollution. Additionally, artificial intelligence can be used to increase sustainability in areas such as water management, agriculture, and food security. Artificial intelligence applications in agriculture and food security can increase efficiency, increase food supply, and reduce food waste.

While the contribution of artificial intelligence technologies to sustainability goals is significant, there are also potential risks and ethical issues associated with these technologies. For example, artificial intelligence applications can create problems in areas such as data privacy and security, human rights, and equality.

However, artificial intelligence technologies can support many aspects of sustainability. These technologies can support people in data analysis, predictability, planning, and implementation processes, and help to take the necessary steps for a more efficient and sustainable future.

Artificial intelligence technologies can be an important tool for supporting sustainability [4]. The potential of this technology to increase sustainability is quite high. However, it is necessary to use artificial intelligence technologies carefully, taking into account the ethical issues, data privacy, and security risks associated with these technologies. Nevertheless, it is clear that artificial intelligence technologies are an important tool for supporting sustainability. Therefore, in order to move towards a sustainable future, artificial intelligence technologies must be used in an ethical and human-centered manner.

## III. Artificial Intelligence Applications in Sustainability

To achieve sustainability goals, artificial intelligence (AI) technologies offer various applications in many sectors. Sustainable solutions can be generated by using AI technologies in areas such as energy and resource efficiency, agriculture, water management, waste management, and transportation. These applications can be achieved thanks to the capabilities of AI algorithms such as more accurate predictions, data analysis, optimization, and forecasting. Some of the developed applications will be detailed in this section.

**Smart Home Systems and Energy Efficiency:** Smart home systems provide homeowners with a smarter way of managing their homes by connecting household devices and systems (Figure 1). These systems can be equipped with artificial intelligence technologies to control and optimize the home's energy consumption. These technologies have the ability to collect, analyze, and predict data to provide homeowners with better energy efficiency [5].



Fig. 1. Smart home systems [6]

For example, a smart home system continuously measures parameters such as temperature, humidity,

and light levels in the home, collecting and analyzing data. Based on this analysis, homeowners can receive suggestions on how to reduce energy consumption and costs in their homes. Additionally, the system can measure temperature and humidity levels to recommend optimal settings. By monitoring the light levels in the home, the system can suggest optimal lighting conditions.

Artificial intelligence-supported smart home devices interact and communicate with each other to learn user habits. Data collected by artificial intelligence smart home technologies can predict user behavior and even develop situational awareness. For example, an artificial intelligence device on a smart cooktop can monitor the temperature of the food being cooked and adjust the temperature to optimize cooking.

**Electric Vehicles:** Vehicles themselves are equipped with various devices such as sensors, cameras, radars, LiDARs, GPS receivers, and other data collection devices. These devices collect data about the vehicle's surroundings and transfer this data to artificial intelligence algorithms (Figure 2), enabling the vehicle to move more safely and efficiently during the journey [7].



Fig. 2. Intelligent Autonomous Systems [8]

Electric vehicles offer a more environmentally sustainable transportation option by reducing the use of fossil fuels. However, charging electric vehicles and managing batteries still face many challenges. Artificial intelligence (AI) technologies can be used to overcome these challenges. Intelligent Autonomous Systems (IAS) are the next generation computer systems that can think and learn like humans. They can store and use large amounts of data, understand natural language, and make instant decisions. IAS will be implemented in vehicles for many reasons, such as safety, driving experience, and cost savings.

AI can address charging issues related to electric vehicles. For example, charging an electric vehicle depends on many factors, such as battery capacity, travel distance, temperature, and usage patterns. AI can analyze these factors and predict the vehicle's charging needs, ensuring that the battery stays at an optimal level. This reduces the charging time and cost for the vehicle owner while extending the battery life.

Moreover, AI technologies can optimize the battery life of electric vehicles. Factors such as usage patterns, temperature, and charging status can affect the battery's life. AI can analyze these factors and determine the best usage strategies to maximize the battery's lifespan.

AI can also manage the charging infrastructure of electric vehicles. Factors such as the location of charging stations, power management, and charging time can affect the use of electric vehicles. AI can analyze these factors and design the best charging infrastructure, which can make charging operations more efficient and economical.

It is expected that AI will significantly increase the efficiency of vehicle operations. For instance, Tesla uses AI to charge its cars, using only 10% of the energy used for driving. With thousands of electric vehicles on our roads, emissions and fuel consumption will decrease further. Tesla is not the only company using AI in their cars. Volvo has been using it for years, and BMW will soon follow. AI offers many advantages for electric vehicles as it can learn from mistakes and even improve over time.

**Renewable Energy Sources:** Artificial intelligence (AI) technologies are an important tool for ensuring the efficient use of renewable energy sources [4]. These technologies can enable more effective use of renewable energy sources such as solar, wind, and hydraulic power, and can help manage energy production processes (Figure 3).



Fig. 3. Artificial intelligence in renewable energy sources [9]

For example, in solar energy systems, artificial intelligence technologies can optimize solar energy production by analyzing the position and angle of solar panels, cloudiness levels, and other weather conditions. In addition, artificial intelligence technologies can also optimize the maintenance and repair of solar energy systems, increasing system efficiency.

Similarly, in wind energy systems, artificial intelligence technologies can optimize wind energy production by analyzing the position and angle of wind turbines, wind speed, and direction. Artificial intelligence technologies can also optimize the maintenance and repair processes of wind turbines, increasing system efficiency.

In hydraulic energy systems, artificial intelligence technologies can optimize hydraulic energy production by analyzing water flow, water levels, and other weather conditions. These technologies can also optimize the maintenance and repair processes of hydraulic energy systems, increasing system efficiency.

Artificial intelligence technologies can enhance the efficiency of renewable energy sources by enabling their more efficient use in energy production. This can encourage wider use of renewable energy sources, which are environmentally friendly sources of energy.

**Air Quality Monitoring:** Air pollution is a significant environmental problem that can cause serious harm to human health. Artificial intelligence technologies can be used to monitor air quality and identify the causes of pollution. Artificial intelligence can help predict air quality by analyzing air quality data collected from sensors. AI algorithms can consider measured components of air quality (such as $PM_{2.5}$, $SO_2$, $NO_2$) and other factors that affect air quality (such as temperature, humidity, wind speed) to make air quality predictions [10]. This data can be used by individual users, city authorities, or environmental protection agencies.

Artificial intelligence can also be used to identify the sources of air pollution. Using data collected from sensors, this technology can determine the sources of air pollution. For example, an AI system can detect changes in the data from a sensor near a pollution source and make estimates about the source of those changes. This can help identify

sources of air pollution more quickly and efficiently, leading to more effective interventions.

In conclusion, artificial intelligence technologies are an important tool for air pollution monitoring and management. These technologies can assist people in identifying sources of air pollution, making air quality predictions, and managing air quality, ultimately contributing to the creation of a cleaner and healthier environment.

**Waste Management:** Waste management is of great importance in terms of environmental sustainability. The increasing amount of waste and depletion of natural resources require innovative solutions in waste management. At this point, artificial intelligence (AI) technologies can play an important role in waste management processes.

To provide smart solutions for waste management, government agencies, system integrators, network operators, and technology providers can utilize these technologies by using an IoT prototype with sensors that collect data over the internet to provide intelligence to trash cans (Figure 4).



Fig. 4. Smart waste management using AI and machine learning [11]

AI technologies can help manage waste management processes more effectively and efficiently. Firstly, automatic recognition of waste types is required. In this respect, AI can recognize waste types using image processing and learning algorithms. For example, the types of waste can be identified using cameras placed on garbage cans. This allows for more effective separation of recyclable materials.

Additionally, AI technologies can assist in predicting the amount of waste. The filling rates of waste bins can be monitored with sensors, and this data can be analyzed by AI algorithms to predict the amount of waste. This enables more efficient

planning of waste bin emptying and more effective use of waste collection vehicles.

In conclusion, AI technologies can play a significant role in waste management processes. AI can assist in waste type recognition, waste amount prediction, and separation of recyclable materials, enabling waste management processes to be managed more efficiently and sustainably.

**Water Pollution:** Water pollution is the contamination of water sources with toxic substances, chemicals, and other pollutants that can harm human health and ecosystems [12]. Artificial intelligence technologies can play an important role in monitoring and controlling water pollution. AI can collect and analyze data from sensors in water sources to monitor water pollution (Figure 5). These sensors measure important characteristics such as water quality, temperature, pH level, dissolved oxygen level, and others. AI can collect and analyze this data to create a broader picture of water quality.
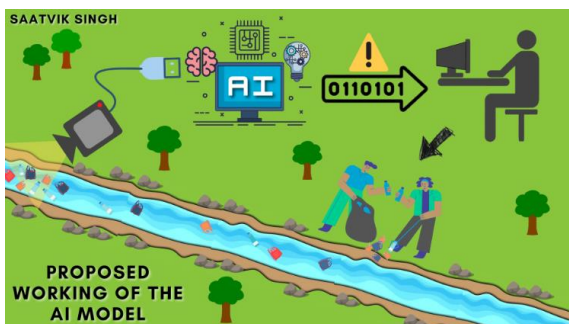


Fig. 5. Real-time detection of water pollution using AI [13]

Especially when combined with camera systems and technologies integrated with sensors, artificial intelligence systems make water pollution monitoring more accurate. These technologies can capture images or videos of the water and detect signs of water pollution. They can also make observations at specific times or intervals to monitor water quality.

Artificial intelligence can also help determine the source of pollutants in water sources. Water pollution can originate from agricultural activities, industrial activities, domestic wastewater, and other factors. By analyzing water quality data, artificial intelligence can identify pollution sources and help take the appropriate measures to prevent water pollution.

In conclusion, artificial intelligence technologies can be a valuable tool for monitoring and controlling water pollution. These technologies can help prevent water pollution and contribute to the sustainability of water resources.

**Agricultural Chemicals:** Agricultural chemicals are often used to control plant diseases and pests and to achieve efficient crop yields. Artificial intelligence sensors in agricultural chemicals can be connected to devices such as agricultural robots and drones (Figure 6). However, the use of agricultural chemicals can have negative impacts on natural ecosystems and groundwater resources [14]. Artificial intelligence technologies can monitor and control the use of agricultural chemicals to reduce these negative effects.



Fig. 6. Artificial intelligence in agricultural chemicals [15]

Using sensors and satellite data, for example, they can monitor the extent of agricultural areas and plant growth. This data can be used to detect plant diseases or pests. Artificial intelligence systems can analyze data that can be used to detect plant diseases and pests, enabling more accurate measures to minimize chemical usage.

Artificial intelligence can also be used to control the use of agricultural chemicals. For instance, sensors can be placed on farming equipment to monitor chemical usage and limit it in agricultural areas. These sensors can track the amount of chemical substances used and send alerts when predefined limits are exceeded. This can help to control the use of agricultural chemicals and enable environmentally-friendly farming practices.

**Water Resources Management:** Water resources management has become an increasingly important issue for the future. Artificial intelligence can be a useful tool for water resources management. AI can be applied in many different areas to save water (Figure 7). By analyzing water

usage data, AI can provide recommendations for more efficient use of water resources. These recommendations may be based on reducing water consumption or using methods that require less water [16].
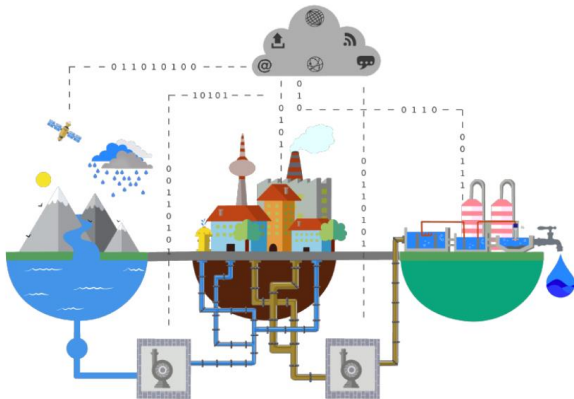


Fig. 7. Data Science and Artificial Intelligence for Urban Water Management [17]

For example, an AI system can monitor a home's water usage and detect increases in consumption. This information can provide homeowners with suggestions for areas where they can save water by using less. Additionally, AI can monitor water usage in a particular region and propose water management strategies that will lead to more effective use of water resources.

AI can analyze farmers' irrigation needs for more efficient use of water resources. Using data collected through sensors, AI can predict irrigation requirements and optimize timing. This could be a significant step in increasing agricultural productivity and promoting more efficient water use.

Furthermore, AI can monitor a city's water consumption and detect periods of increased or decreased water usage. This information can assist city officials in developing strategies for better management of water resources. Additionally, AI can monitor water quality in wastewater treatment plants and offer suggestions to make these facilities operate more efficiently.

In conclusion, AI can be employed in various fields to promote more efficient use of water resources and offer suggestions for water conservation. This represents a significant step towards sustainable water management.

**Increasing Agricultural Productivity:** The structure of the agriculture and food sector poses a great risk for farmers, who are often the weakest link in the chain [18]. Artificial intelligence (AI) not only enables farmers to achieve better results with less effort, but also brings high-quality, nutritious, and safe food to every person on the planet. AI in agriculture can be linked to many devices, such as farming robots, drones, sensors, and cameras, which make the use of AI technologies in the industry possible (Figure 8). The use of innovative AI in this field will also lead to many other environmental and economic benefits.

AI technologies used in agriculture can assist farmers in optimizing plant growth conditions, detecting plant diseases, automating agricultural machinery, and increasing soil fertility, among other things.



Fig. 8. Artificial intelligence in agriculture and food industry [19]

With the help of artificial intelligence (AI) technologies, the detection of plant diseases can become easier and faster. AI algorithms can be combined with image processing techniques used in the diagnosis of plant diseases to obtain detailed information about plant health. This allows farmers to intervene early in the case of diseases and prevent crop losses.

AI can also be used to optimize plant growth conditions. For example, monitoring and controlling parameters that affect plant growth, such as soil moisture level, sunlight intensity, temperature, and other factors, can become easier through AI technologies. This leads to higher productivity and less loss.

Automating agricultural machinery is another area of application for AI technologies. AI can enable more efficient use of machinery, such as tractors, harvesters, and other agricultural equipment used by farmers. For instance, AI-based agricultural machines can sow seeds at varying rates based on weather conditions while moving in a specific path

in the field. This results in more efficient seeding and higher yield.

Finally, AI can also be used to improve soil fertility [20]. Soil fertility is critical for the productivity of agricultural lands. By analyzing the quality of agricultural soils, AI can provide farmers with recommendations on soil analysis and agricultural management. These recommendations can help farmers achieve higher productivity with less input.

## IV. ROLE OF ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY IN THE FUTURE

The role of artificial intelligence technology in future sustainability projects will be significant. This is because AI technology offers many different applications to enhance sustainability in areas such as environment, energy, water resources, agriculture, waste management, and others. Examples include:

Climate Change: AI has great potential in combating climate change, particularly in predicting and preventing natural disasters, reducing greenhouse gas emissions, and increasing energy efficiency.

Energy Efficiency: AI can be integrated with many technologies used to increase energy efficiency. For instance, smart home systems, smart grids, and energy storage systems can be made more efficient through AI technologies.

Water Resources: AI technology can be used for monitoring and managing water resources. This includes water quality monitoring, water resource prediction and management, and analysis of water consumption data.

Waste Management: AI has significant potential in waste management. AI technologies can automatically recognize waste types, estimate waste amounts, and separate recyclable materials.

Agriculture: AI can increase productivity in agriculture through the detection of plant diseases, optimization of plant growth conditions, and improvement of soil fertility.

In addition to these examples, AI technology can be used in many other areas for sustainability. New applications are expected to emerge in the coming years along with AI technology.

## V. CONCLUSION

Sustainability is a critical goal for the future of humanity. To achieve this goal, significant steps need to be taken in many areas such as sustainable use of natural resources, waste management, energy and resource efficiency. At this point, artificial intelligence (AI) technologies have significant potential in the field of sustainability. AI technologies can contribute to solving environmental problems and can be used to produce nature-friendly solutions. For example, AI technologies used in the agricultural sector enable the development of smart agriculture, which is a more sustainable and efficient farming method. Smart agriculture contributes to the more sustainable use of natural resources by saving water and energy while increasing productivity. Additionally, AI technologies can assist in developing environmentally friendly products from a sustainability standpoint. AI-supported product design can provide environmental benefits such as prolonging product lifespan and increasing recycling rates. In this way, it becomes possible to develop products that contribute to sustainability. In conclusion, AI technologies can play a significant role in achieving sustainability goals by providing nature-friendly solutions and contributing to the development of environmentally friendly products.

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