

# A Comparative Study on How AI is Partnering with Nature for a Sustainable Future.

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## Abstract

Mounting ecological and socio-economic challenges demand a paradigm shift to sustainability. Artificial intelligence (AI) becomes a powerful means to pursue this objective; it establishes a “Symbiotic Synergy” with nature’s complex networks. This study attempts to investigate the SDGs using AI as a transformative tool, the sustainability of AI and its socio-economic impact. The research applies a multimethod approach, using surveys, case studies and categorizations to determine how AI is helping achieve the SDGs in harmony with nature.

Key applications of AI in important domains are covered including agriculture and sanitation, renewable energy sector, hydrogen energy sector and the impact that AI is having leading to the future sustainable cities. Case studies and real-world examples demonstrate the effectiveness of AI technologies in forecasting energy demand, improving power dispatchment, and boosting performance within renewable resources. This study is a guide to the harnessing of AI potential for meeting SDGs, which leads us into an era where humans will attain great heights with cooperation between technology and nature.

**Keywords:** Sustainable AI, Symbiotic Synergy, AI for SDGs, Sector Applications

## 1. Introduction

Artificial Intelligence (AI) is leading the way in technological development aimed at providing transformative solutions to solve some of the world’s most significant issues as identified by the SDGs set out by the United Nations. The integration of AI and sustainability has led to the emergence of Sustainable AI, which includes the creation, implementation, and use of AI technologies that foster long-term sustainable environmental, social and economic outcomes. Belonging to the class of sustainable AI, this term does not solve only immediate issues of AI use but also applies a broad approach to each stage from design and training through implementation and usage which does everything possible to minimise negative impacts ones increase positive outcomes for the development with sustainability. This paper discusses how Sustainable AI plays an imperative role in developing the SDGs through numerous domains, agriculture, sanitation and also to mention a few of them, renewable energy. It includes environmental monitoring and Sustainable AI as well. Through analysis of research findings and case studies, this paper aims to shed light on the crucial role that AI plays in advancing towards a more sustainable and equitable future while also taking into account the ethical dimensions associated with developing and deploying such technologies.

## 2. Sustainable AI

'Sustainable AI' as the term interprets is a domain of investigation encompassing computer-aided knowledge (AI) technology, which can incorporate both hardware that are supporting the framework and strategies to prepare this innovation, and digital touchable processing by AI, in any case figuring out how to manage issues identified with thoughtfulness of computerised intelligence. Sustainable AI deals not exclusively with the implementation or use of AI but ought to address the entire life cycle of AI, the sustainability of the: development, optimization, verification and validation of AI design, training of AI sets, establishing the norms for using it, implementing AI systems in practical activities and use of artificial intelligence.

## 3. Potential of Sustainable AI

Sustainable AI has the potential to make a significant contribution to the achievement of the SDGs. For example, AI can be used to:

- Develop renewable energy sources and improve energy efficiency
- Monitor and protect ecosystems
- Improve food security and agricultural productivity
- Provide access to education and healthcare
- Create more efficient and sustainable cities

## 4. Sustainable Development Goals (SDGs)

The Sustainable Development Goals (SDGs) are 17 goals focused on by the United Nations in 2015 as an agenda for development to have a better and fruitful future by building up till 2030. The goals aim to tackle social, economic and environmental issues such as poverty, hunger inequality, climate change and degradation of the environment.

The SDGs are significant because they build a global framework through which governments, business entities and other bodies are connected to fight for a fairer world. Moreover, they offer a blueprint for investing in eco-friendly progress that generates new jobs, leads to the increase of economic growth rates and improves life quality overall.

By their nature, SDGs refer to 17 interdependent goals that aim at solving the most pressing issues in Social, Economic and Environmental spheres worldwide.

## 5. Applications of AI in SDGs

### Society

#### 1. No Poverty

Applied in focused solutions that are concerned with such issues, AI would enable concocting solutions to these problems. For instance, AI is able to fight poverty by providing access to resources like education and actions. Financial inclusion: The use of AI in fintech solutions helps to make available microloans to the poor as well as other financial services such as mobile banking for those who have no access. This encourages financial independence and opportunism.

#### 2. Zero Hunger

Food supply chains could be enhanced with the help of algorithms featuring AI that inform us about demand, transportation and build some food waste reduction options. AI algorithms parse huge data sets on soil, weather patterns and plant health to determine the adjustments needed in planning, resource

allocation, and pesticide application. In the end, it results in higher yields and reduced waste, making crops surviving on long years hence giving people more food.

### **3. Good Health and Well-being**

AI algorithms have the potential to help doctors and other health care providers save time as well as improve the accuracy of diagnosis for instances of diseases. Harnessing the power of predictive analytics employs AI techniques to parse through health data in large volumes that include medical records, genetic information, and environmental influences to determine those who are predisposed to developing specific diseases.

### **4. Quality Education**

Quality Education can be achieved by using a range of AI technologies that provide Adaptive Learning Platforms, Intelligent Virtual Tutors, Language Learning and Translation, Automated Assessment and Feedback among other solutions.

### **5. Gender Equality**

Some of the biases that can be identified and worked around by the use of AI algorithms are gender bias as among other forms of inequality in fields such as hiring, jobs or promotions while others consciously build themselves up through education or finding fair opportunities. AI impacts the surroundings to make it in a fair and nice manner for women as well as girls because of helping organizations to come up with decision-making procedures that are just.

### **Environment**

### **6. Clean Water and Sanitation**

AI technology enables the monitoring of water quality by trying to identify bacteria, chemicals and pollutants from sensors and data analysis techniques, ensuring immediate response measures. The AI algorithms can use the data on infrastructure health and environmental aspects, which will help to predict leaks or failing parts of water supply systems in advance, making possible prophylactic replacement techniques that decrease failures' influence. As AI is able to look at patterns of water consumption and the weather, it could reduce and regulate the distribution of wasted water in a manner that would not normally be possible while using such little resources.

### **7. Ensure access to affordable, reliable, sustainable and modern energy for all.**

These solar panels and wind turbines that are created with the help of AI became more effective. AI is leading the way in the creation of smart grids, which have been designed to serve a more thorough distribution of energy. The invention and application of AI is being used to create methods for storing energy in the form of renewable power by the energy that is not utilised.

### **8. Sustainable Cities and Communities**

In transportation systems, utilising the power of AI assists in improving flow or optimising it, reducing congestion and enhancing the public transit system efficiency. Impact of AI in Energy is monitoring energy consumption patterns and minimising the use of resources while giving renewable energies a focus to help cities minimise power costs, reduce carbon emissions, and achieve its climate change objectives.

### **9. Responsible Consumption and Production**

AI-based LCA tools would be able to assess the level of impact on environment and society that products render during its three stages of life; namely production, use and waste disposal. With the help of AI it is possible to quantify environmental footprints, analyse product sustainability, find out growth points and improve company's products using statistics data.

### **10. Climate Action**

AI gives climate projections which help policymakers, planners and the communities to prepare for or adjust accordingly before implementing practices against such future occurrences. Through AI algorithms, the introduction and utilisation of renewable energy sources will be able to be modified; some examples include solar power, wind farms, and hydroelectric dams. Using AI to forecast the amount of renewable energy generation, controlling grid stability and managing electrical systems fast switching from fossil fuel will help transform towards a low carbon energy future.

### **11. Life Below Water**

By using image recognition and machine learning as part of the AI technologies, it is possible to interpret satellite imaging and footage taken underwater in order to distinguish the polluters – from marine trash litter, oil spills, plastic debris. Also, other technologies are developed for annually aimed under-water cleaning robots.

### **12. Life on Land**

AI algorithms can analyse ecological data, species distribution maps and habitat suitability models to locate biodiversity hotspots, evaluate the extinction threats of some kind and provide potential conservation priorities. Through AI used in the navigation of conservation planning and decision-making, artificial intelligence supports attempts at saving endangered species, protecting biodiversity and restoring destroyed habitats.

### **Economy**

### **13. Decent Work and Economic Growth**

Likewise, AI-based platforms can create a viable connection between productive applicants and jobs based on skills, qualifications, and personal choices. AI can thus make workers' lives easier by freeing them from performing any repetitive, dull activities leaving more space for creative and strategic jobs that are so much needed to develop the economy of a country as well as to increase the overall level of production therein.

### **14. Industry, Innovation and Infrastructure**

Intelligent sensors and the devices supported by IoT technology make it possible to track the current state of infrastructural assets like roads, bridges, or buildings instantly. AI is able to link and govern city systems such as traffic lights, water supply, community power lines; with this, it would contribute to more resource utilisation economy. The level of pollution in cities might drop down while urban resistance will only increase.

### **15. Reduced Inequalities**

AI can examine huge datasets to identify areas and communities with poverty, as they take into account demographic characteristics, such as income levels, access to natural and manmade resources in the environment. This extends as a guide allowing for informed target interventions and resource allocation.

### **16. Peace, Justice and Strong Institutions**

The AI algorithms study the data collected from social media, news reports, and satellite images to answer predictive questions about an uprising and conflict potentials that provide proactive interventions and peacebuilding activities. AI-enabled legal systems can help disadvantaged people gain access to the necessary level of information, advice and support in cases where they do not have sufficient material means for obtaining classical formulations of legal aid.

## **17. Strengthen The Means Of Implementation And Revitalise The Global Partnership For Sustainable Development.**

With data analytics, AI can process huge datasets with socio-economic indicators as well as environmental and progress measures for a great number of developing countries and make its findings public as the basis to inform decision-making processes. This can be achieved through data analysis tools that are driven by artificial intelligence; such sensors can track performance in real-time towards the SDGs and provide timely information for course corrections and informed decision making.

### **6. AI as a Sustainability Gained in accordance with SDGs**

A new study from Nature has demonstrated that about 82 percent of the society's outcomes our metrics in the SDG can be potentially improved by AI-based technologies, such as the poverty reduction goal under SDG 1 and quality education (SDG4), clean water and sanitation (SDG6), affordable/clean energy (SD7).

The SDGs have been of special interest to AI researchers due to the fact that the same Nature study has unearthed the insights that an adoption of any doable artificial intelligence technologies contributes positively to 70 percent of outcomes which are economic.

AI is an instrument that would assist the governments, businesses and NGOs in achieving targets they have in their mind speedily and at a cost lower than those applying outdated methods. In actuality, AI could enable us to fulfil up to 93% of the environment-related SDG Outcomes.

Another Study reports that AI may act as an enabler on 134 targets (79%) across all SDGs, generally through a technological improvement, which may allow it to overcome certain present limitations. However, 59 targets (35%, also across all SDGs) may experience a negative impact from the development of AI.

## **7. AI and Various Development Domains**

### **1. Agriculture**

#### **Automated Precision Irrigation System**

With the help of AI-driven tools, the software could point out soil moisture levels and determine when there will be rainfall, which would consequently allow it to adjust irrigation in order to give the crops what they need. It will conserve water and ensure that plants are not overwatered, nor under-watered which usually leads to better growth making a decent harvest. Advanced watering technologies such as Hilar Irrigation Systems significantly enhance water use efficiency, which is an important part of sustaining environmentally friendly agriculture.

Imagine, for example, a vineyard using a smart irrigation system powered by AI. It perpetually checks soil moisture while forecasting weather conditions. This system will then automatically have to adjust the percent being delivered water per each vine and so on. Each plant receives precisely enough water to promote diverse height, spatial form and yield.

### **2. Sanitation**

Clean water and sanitation are part of the Sustainable Development Goals (SDGs) established by the United Nations (Goralski & Tan 2020). Researchers have harnessed the power of AI to create a testing system specifically designed for monitoring water quality in time. This advanced system can swiftly identify contaminants at a cost. It's worth noting that the entire setup only requires an investment of around \$500 making it accessible to organisations seeking alternatives to costly traditional methods. The ongoing development of this program aims to encompass all types of bacteria and even viruses that are much



smaller than bacteria. The visionary behind this technology Peter Ma envisions its expansion for use not by offices for monitoring water contamination but also, by individual consumers (Goralski & Tan 2020; Lant, 2018).

### 3. Renewable Energy Sector

Artificial intelligence (AI) and deep learning (DL) have shown their effectiveness in detecting faults in energy systems well. An example of this is a system proposed by Pierdicca et al. (2020) which uses learning to identify anomalies in images demonstrating how AI can help maintain the health of renewable energy systems. Moreover the development of datasets for analyzing defects, in cells using deep convolutional generative adversarial networks (DCGANs) has significantly advanced the field.

### 4. Hydrogen Energy Sector

AI is now playing a crucial role in the- world of hydrogen energy, with a particular e-mphasis on fuel cell technologie-s. It helps in fine-tuning strategie-s for managing energy in hydrogen fue-l cell vehicles. For e-xample, Wang and his coworkers (2023) create-d an energy strategy for hydroge-n fuel cell buses, significantly improving the-ir efficiency and fuel saving capabilitie-s. Also, Fayyazi and team (2023) pointed out how AI and machine le-arning could help manage, control, and optimise hydroge-n fuel cell vehicle-s. This suggests exciting possibilities for improve-ments in predicting, controlling, and vehicle--to-everything (V2X) applications. Plus, AI has proven handy in cre-ating models that predict ene-rgy and hydrogen production from solar thermochemical plants.

### 5. Smart Grids

Smart grids are advanced electricity networks that utilise digital technologies, sensors, and software to efficiently balance the supply and demand of electricity in real-time, all while keeping costs low and ensuring the stability and reliability of the grid. As we make the shift to clean energy, there will be a significant rise in electricity usage and the widespread implementation of renewable sources such as wind and solar, which will place a greater strain on power grids. In order to manage this transition and minimise the need for expensive new grid infrastructure, smart grid technologies are crucial. Additionally, they can also improve the resilience and reliability of grids. Despite some signs of economic recovery from the Covid-19 pandemic, there needs to be a considerable increase in investment in smart grids to stay on track.

### 8. Case Studies

The World Environment Situation Room (WESR), by UNEP, started in 2022. It's a digital platform. It uses artificial intelligence. This AI examines difficult and various data. WESR manages and shows the best Earth observation data and sensor data. It uses this data for fast analysis and predictions. This includes things like carbon dioxide in the atmosphere, changes in glacier size, and sea level rising. The aim is for the WESR to be like a command centre for the Earth. Here, every important environmental signal can be watched smoothly to direct actions.

1. The UNEP is leading an important project in the WESR digital environment: the International Methane Emission Observatory (IMEO). This tool works as a worldwide free-to-access database that holds proven methane emission facts. The tech used by IMEO lets us gather and merge all kinds of data on methane emissions. This gives us a free, publicly available record of methane emissions, all proven and very accurate. One of the quickest, easiest, and cost-friendly ways to slow down global warming is to cut down on methane emissions coming from the energy industry.
2. UNEP and IQ Air joined forces to create GEMS, a powerful air pollution monitoring system. With data collected from over 25,000 air quality stations in 140+ countries, this technology provides

instantaneous information on the impact of air quality on individuals. This valuable tool aids in the development of public health strategies.

3. Artificial intelligence has the potential to revolutionise the way we assess a product's environmental and climate impact. By diligently calculating its footprint throughout its entire life cycle and supply chain, businesses and consumers can make informed and impactful decisions. This innovation holds immense potential for positive change.
4. The pressing issue of e-waste cannot be ignored, as only 17.4 percent of it is currently being recycled and disposed of in an environmentally-friendly manner. According to the latest UN Global E-waste Monitor report, this number is expected to skyrocket to a staggering 75 million tons by 2030. In light of these concerning projections, UNEP research urges consumers to take a proactive stance by reducing consumption, ensuring responsible recycling of electronics, and fixing any salvageable items.
5. In the current era, agricultural enterprises have the ability to leverage artificial intelligence for analysing critical farming data, yielding invaluable revelations for crop forecasting and climate management. This technological advancement is especially advantageous for Singapore, a country facing limited space and resources in the agriculture sector. Fueled by a partnership between A\*STAR and locally-based Agri-tech firm Archisen, AI has seamlessly integrated into their on-site facilities, propelling the agricultural industry towards efficient and sustainable growth.
6. Get ready for a game-changing revolution in energy usage through the use of artificial intelligence. A prime target for this advancement is the creation of "Microgrids" - a revolutionary system fueled by AI. This cutting-edge technology has the capability to identify and harness emerging energy sources, unaffected by weather conditions. Say hello to a more resourceful and efficient use of energy.
7. While AI's prevalence carries a significant ecological toll, it also offers valuable contributions to sustainability. Notably, Singapore has ingeniously employed AI to combat its carbon footprint by implementing a cutting-edge technology that efficiently tracks and curtails emissions throughout the metropolis.
8. The forceful winds of Hurricane Maria caused extensive damage to acres upon acres of lush rainforest, leaving many pondering how to differentiate between the fallen trees and those which managed to withstand the storm's fury. While a NASA flight in 2017 captured extraordinary aerial shots of the treetops in Puerto Rico, the daunting task of identifying individual species in such an expansive green landscape seemed impossible. Although the human eye may have been able to tackle this challenge, the sheer volume of images made the prospect excruciatingly slow. However, the ingenious team decided to employ the assistance of artificial intelligence to analyze the high-resolution photos and merge them with data collected by Uriarte, who meticulously plotted and identified each tree in specific areas. By focusing on these designated plots, the AI has the ability to accurately determine the impact of Hurricane Maria on each species.
9. At the renowned SLAC National Accelerator Laboratory, the Department of Energy harnesses the power of machine learning and artificial intelligence to detect and address grid vulnerabilities, proactively preventing power outages and minimizing downtime in the event of failures. Their ultimate goal is to design a grid that can seamlessly manage the integration of renewable energy sources and autonomously recover from any system malfunctions, reducing the need for human intervention. Through the use of satellite imagery, the lab also identifies potential hazards, such as trees encroaching on power lines, that could pose a threat during storms. Artificial intelligence is also utilised by wind energy companies to optimise the production of each turbine by analysing real-time weather and

operational data. With the assistance of AI, individual turbines are able to adjust their propeller speed and direction based on the wind patterns from surrounding turbines.

10. Colombia is home to remarkable technologies that have the potential to revolutionise our efforts against air pollution and extreme heat. Among them is an advanced artificial intelligence system that isn't just capable of predicting pollution levels, but also identifies its sources and devises effective strategies to combat it. On top of that, IBM has developed a cutting-edge tool to enable cities to plan for heat waves in the future. This intelligent system simulates the local climate and experiments with various solutions to measure their effectiveness in mitigating extreme heat. For instance, if a city plans to increase its greenery by planting more trees, the AI makes use of machine learning models to determine the best spots for planting, ensuring maximum coverage and reduced sidewalk heat.
11. With the backing of advanced detectors continuously covering humidity, soil conditions, and temperature. AI has the implicit to revise the agrarian assiduity. Through assaying this critical data, AI is suitable to determine the optimal timing for planting, scattering, and harvesting crops with point delicacy. also, it can effectively combat conditions and proactively address any implicit problems. This will also lead to increased productivity and yields in the agrarian sector. while also reduce the reliance on inordinate water, diseases, and fungicides.

## 9. Evaluation from case studies

Based on these Case Studies however, it can be concluded that artificial intelligence has the potential to determine the future of our cities in a number of ways. Short-term solutions like AI augmented agriculture with robotics can be able to detect crop diseases and problems at early stages. There are several other cases of agriculture based applications technology, which has yielded high yields like that in Singapore's farms and 30 percent more peanut farmers have utilised AI to achieve efficiencies on farm productivity. AI SIS can interpret satellite images and see changes reflecting change in vegetation, use of land, forest cover or the effects of natural disasters. Automated agriculture by way of robotics working with AI is a futuristic development that makes early plant disease and problem detection possible. Besides, AI gives a more efficient and precise satellite image analysis that highlights calamity areas and foreign species of rare trees which need help or the destruction of rainforests. Currently, not only cells with preinstalled artificial intelligence or their analogs that allow recording the key air and environmental qualities in real time but also adjusting the filtering efficiency are emerging. The ability to track pockets of areas where air quality can be poor, methane emissions and IOT (electronic waste) emissions will eventually contribute to the environment's health.

## 10. Conclusion

In essence, AI has been proven to enhance the implementation of the United Nations sustainable development goals and can thus be integrated in various sectors to strengthen its progress. The extant literature from research studies and case studies indicates the ability of AI to transform how societies grapple with societal, economic, and environmental dilemmas.

Moreover, AI's ability to analyse vast amounts of data in real-time enables proactive decision-making and targeted interventions, thereby contributing to the attainment of SDGs. By harnessing AI technologies, governments, businesses, and organisations can optimise their efforts towards sustainable development while minimising costs and maximising outcomes. By conducting a broad overview of artificial intelligence applications within various disciplines including the agricultural sector, sanitation, renewable



energy and environmental monitoring it becomes increasingly clear that AI can transform our approach to the attainment of sustainability. AI plays the role of an innovative device that can solve disparate problems and help in optimization of resource allocation in agriculture to water quality monitoring, as well as climate change mitigation.

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