

The Role of Technology in Environmental Conservation: A Critical Analysis

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Abstract

The rapid advancement of technology has deteriorating the environment at rapid pace and transformed the way we approach environmental conservation. This study provides a critical analysis of the role of technology in environmental conservation, examining its potential benefits and challenges. Technology has a dual impact on the ecosystem, encompassing both benefits and challenges for environmental conservation. In today's digital area, it's important to understand the role of technology in conservation process to raise awareness about the environmental issues. This can be done by educating the public, decision-makers, and industries about the significance of environmental stewardship and the potential of new innovative solutions and technologies to address the ecological issues. The role of technology in environmental conservation is a multifaceted and complex issue that needs critical examination. On one hand, technological innovations transformed the way we approach traditional conservational practices and enable us to monitor and track environmental issues, identify areas of degradation, and develop sustainable solutions for the same. Technologies such as remote sensing, sensor networks, renewable energy, green infrastructure, etc improved our understanding of ecosystems, facilitated data-driven decision-making, potential to reduce carbon footprint, and promote environmental sustainability. However, a critical analysis of this reveals various challenges and limitations. The production, usage, and disposal of technological devices have significant environmental costs, including generation of e-waste, depletion of resources, and pollution. This paper provides an understanding that technology's role in environmental conservation is essential for maximizing its benefits while minimizing its limitations. By examining the complex interplay between environment, technology, and society, we can identify opportunities for a better sustainable future.

Keywords :- environment, conservation, technology, ecological footprint, sustainability.

Introduction

In today's digital era of 21st century, technology plays a major role in everyone's life and transformed the various aspects of human life. The relationship between technology and environment is complex and interdependent. As the world tackles with the challenges of climate change, biodiversity loss, and environmental degradation, the technology has emerged as a major tool in pursuit of the sustainability. For monitoring and tracking the environmental

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issues and changes to develop innovative solutions for conservation, technology has potential to play a transformative role in protecting the planet.

Technology is designed to provide tools and machinery for environmental protection and conservation, mitigating the adverse effects of climate change and global warming. On the other hand, environment supplies the material necessary for technological advancement. This indicates the interdependency of technology and environment as a critical aspect of the relationship between the two. However, the introduction of harmful gases such as sulfur dioxide, carbon monoxide, methane, and nitric oxide releases from factories, burning of fossil fuels, and vehicles into the atmosphere due to technological activities leads to air pollution, highlighted the negative impact of technology on environment (Banger et al., 2017; Bala et al., 2021; Singh et al., 2015; Sharma et al., 2022).

One of the major contributions of technology in environmental conservation is its ability to monitor and track environmental changes. Technologies, such as, drones, satellites, sensors enable us to collect huge amount of data on various environmental parameters such as deforestation, ocean health, and climate patterns, etc. The data further helps us to identify the areas of degradation, track the impact of conservation efforts, and inform policy decisions.

In recent years, there has been a growing recognition of the need for sustainable technology, which prioritizes environmental sustainability and social responsibility. Sustainable technology includes a wide range of innovations, from renewable energy and energy-efficient appliances to sustainable agriculture and eco-friendly products.

Methodology

This study includes a thorough and critical examination of the role of technology in environmental conservation by employing a qualitative research approach. Through an extensive literature review, by exploring academic databases such as JSTOR, ResearchGate, and Scopus articles to find relevant articles and research papers. Key search terms for the same includes "technology and environmental conservation", "sustainable development", "green technologies", "information and communication technology", and "biotechnology", etc. By analyzing the data thematically, we identify patterns that throw light on the benefits and limitations of technology in environmental conservation. This critical analysis evaluates the effectiveness of technology to deal with pressing environmental issues, identify areas for development and potential solutions. The study aims to contribute the understanding of role of technology in environmental conservation, inform policy-decisions and future research.

Environmental Conservation

The term Environment has been derived from the French word “Environner” which means - ‘to surround’. Environment is everything that around us or affect us, which includes both biotic and abiotic components such as soil, water, plants, and animals, etc. As per the Environment Protection Act, 1986 - “*The environment is sum of total of water, air, and land, inter-relationships among themselves and also with the human beings, other living organisms and property.*” According to Douglas and Holland (1947), the environment is a word which

describes, “in the aggregate, all of the external forces influences and conditions, which affect the life, nature, behaviour, and the growth, development and maturation of living organisms.”

Environmental Conservation refers to the practice of protecting and managing the natural environment, including its ecosystems, biodiversity, and natural resources to ensure sustainability for present and future generations. The United Nations (UN) defines environmental conservation as “the practice of protecting natural resources and ecosystems from degradation and destruction, ensuring their availability for present and future generations.” The Environment Protection Agency (EPA) defines conservation as the, “wise use of natural resources to meet the needs of the present without compromising the ability of future generations to meet their own needs.” The definition of environmental conservation by EPA is supported by the concept of sustainable development, defined by the Brundtland Commission Report. According to environmental psychologist, Rachel Kaplan, defines environmental conservation as “actions taken to protect and preserve the natural environment, including the conservation of natural resources, reduction of pollution, and protection of biodiversity.”

Environmental conservation is necessary for maintaining the health and integrity of ecosystems, protecting biodiversity, and promoting sustainable development. Anthropogenic activities such as deforestation, pollution, and climate change have negative impacts on the environment, and conservation strategies are necessary to mitigate these impacts, which includes protecting and restoring habitats, managing natural resources sustainably, and reducing pollution.

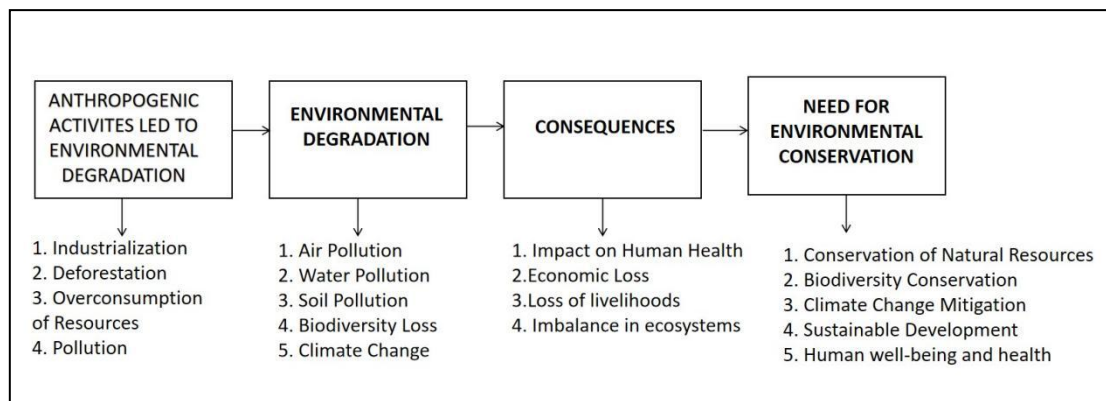


Fig.1 Need for Environmental Conservation

Environmental Conservation through Technology

The intricate relationship between technology and environment is complex and multifaceted. In view of some environmentalists, technology is a major contributor to the ecological degradation. On the other hand, some see it as a potential solution to solve the environmental issues. In recent years, many scientists and environmentalists acknowledge technology as a valuable tool in search of sustainability and conservation.

One of the prominent areas where technology makes a positive impact is in the field of renewable energy. As the shift of countries towards the cleaner and green energy resources,

technology played a significant role in developing and implementing these energy-efficient systems. Biotechnology is another area which have a significant impact on environmental conservation. It involves the use of living organisms or their byproducts to develop new products and technologies. Then, Geoengineering, is the field which involves technological intervention in Earth's system at a large scale to mitigate the effect of climate change. Artificial Intelligence (AI) is another area which can be used to support the conservation efforts. AI involves the use of machine learning algorithms and other techniques to analyze data on environmental trends and patterns, which further helps in decision-making process.

In this way, technology has immense potential to play a critical role in environmental conservation. From renewable energy to waste reduction, conservation and wildlife management, geoengineering, bioremediation, stream restoration, poverty reduction, biotechnology, information and communication technology, drones, satellites, sensors and artificial intelligence, etc. there are many ways in which technology can be used to promote sustainability and conserve the environment, which will be discussed further in detail.

Literature Review

A large number of research studies were conducted to study whether technology affects the environment in a more positive or a negative way. Previously, the majority of scholars investigated how technology can lead to pollution, resource depletion, and climate change; however, recent contemporary scholars focuses on how technology can also be used to assist in environmental protection.

For instance, Cetinndamar (2001) explored the effect of government regulations on the adoption of environmental technologies in the Turkish fertilizer industry. The biggest surprise was that for most companies, the action adopted 'green' by necessity because it was forced to comply with the rules of the government, not because concerned with the environment. This is proof that laws are needed but also that awareness and responsibility are key.

Daniels (2005) elaborated the notion of a green techno-economic model, a model where technology is used to serve both economic development and ecological equilibrium. He maintained that green technologies have contributed to the saving of energy and resources, particularly in low-income countries.

Zulkifli et al.(2009) too have conducted a study in Malaysia to examine the accountants knowledge about social and environmental accounting. However, the findings indicated that knowledge and awareness among a certain number of the professional were missing, but that new laws and training could pave into the way of improved company performance on environmental issues.

Setthasakko (2010) who identified that Environmental Management Accounting (EMA) is not being utilized by many enterprises due to knowledge and attention. His research indicated that organizational learning and training are significant facilitators of organizational responsibility to its environment.

Chang (2013) conducted a university in Taiwan' research and showed that the accounting method for monitoring environmental costs such as water, electricity and paper are not generally used. Even universities should enhance their green ranking and successful cases.

Ribeiro (2016) centered on Portuguese Local Authority. His research demonstrated that small municipalities frequently lack the resources or know-how required for appropriate environmental accounting. Size and budget and methods of management limited the extent to which they could monitor the environmental impact.

Zolfaghari et al. (2017) investigated the renewable energy sector in Spain. They talked about how companies can expand into global markets and yet be an eco-friendly company. Their research proves invaluable for startups to learn how to grow sustainably.

Miner and Ameer, 2018 also investigated the impacts of economic growth and urbanization on the environment in Asian countries. They concluded that technology abets development but that it also generates carbon emissions unless green technologies are embraced.

Kwakwa (2020) explored Tunisia and discovered that financial development as well as urban planning would contribute towards minimizing environmental degradation if they are directed towards renewable energy and eco-friendly activities.

To conclude, the literature indicates that while technology may cause damage to environment ,but it can also serve to protect it if used correctly. There is broad consensus across many studies that government polices, corporate responsibility, and public awareness are critical to ensuring that technology contributes to sustainable development and environmental protection.

Technology and Environment : A historical debate

In the early 1970s, a group of researchers, including Herbert Simon, Nathan Rosenberg, Vernon Ruttan, Chauncey Starr, and Richard Rudman, emphasized the significance of technology in addressing environmental issues (Ruttan et al., 1970s). They argued that relevant and possible solutions to environmental issues require a deeper understanding of technological change and the factors governing the dispersion of environmentally relevant technologies. This argument was largely neglected, and the predominant view considered technology as a major source of environmental degradation.

The debate "Limits to Growth", sparked by Forrester (1971) and Meadows et al. (1972), further consolidated the view that technology can led to environmental degradation. However, a group of researchers, including Simon and Kahn (1984), critiqued this view, arguing that technology could be a solution to environmental issues.

Until the late 1980s, a more nuanced view of technology was not emerged. The "paradox of technological development" highlights the dual nature of technology: that it has both negative and positive impact on the environment. There was mention of three mechanisms which contribute to the positive environmental influences of technology: (1) technological substitution, (2) "natural resource augmenting" technologies, and (3) long-term trends in materials and energy use.

However in 21st century, a new notion of technology as a research tool and instrument of observation has emerged, highlighting its potential role in understanding environmental issues and developing solutions to mitigate them.

Key Technologies in Environmental Conservation

There are various key technologies in environmental conservation which helps to reduce the emission of greenhouse gases, protect ecosystems, promote sustainability and a healthier environment. Some of them are :-

1. Role of Artificial Intelligence (AI)
2. Geoengineering
3. Biotechnology
4. Bioremediation
5. Use of Information and Communication Technology (ICT)
6. Use of Renewable Energy
7. Use of drones and satellites

1. Role of Artificial Intelligence (AI) in Environmental Conservation

It is a subfield of computer science which focuses on developing algorithms and computer programs that can perform tasks such as sensing, reasoning, learning, and decision-making that would typically require human intelligence (Rodgers, 2020; Sarker, 2021). AI plays a vital role in environmental monitoring which aims to enhance the objectivity of results and improve accessibility in regions with limited resources. One of the major benefits of AI is its ability to analyze large datasets, which has recognized useful for identifying patterns and making accurate predictions (Duan et al., 2019; UNEP.org,2022). In the context of environmental monitoring, AI has been exercised in several areas, such as, predicting natural disasters, monitoring the quality of air and water, and detecting pollutants (Subramaniam et al., 2022). Following are the names of some AI models used for environmental monitoring :-

Sno.	AI Models	Uses
1	Support Vector Machines (SVMs)	Predict harmful algal blooms in lakes and monitors air quality.
2	Decision Trees	Predict water quality in rivers.
3	Random Forests	Predict air quality index in urban areas and forest fire.
4	Convolutional Neural Networks (CUNs)	Monitor health of coral reef via underwater images and coastal erosion.

5	Recurrent Neural Networks (RNNs)	Predict floods based on historical rainfall data and level of river flows.
6	Hybrid Models	Predict level of air pollution.

Table 1 :- AI models used for environmental monitoring

Source : Reference no.12

In current scenarios, AI has gained attention for its ability to predict and mitigate the effects of natural disasters. It can help in provide real-time data, enabling authorities to create efficient response plans and reduce public safety risks (Pyayt et al., 2011; Zhang et al., 2021). By analyzing data from various sources, such as satellite imagery and seismic sensors, AI can predict natural disasters and provide early warnings to communities and emergency responders (Marcin, 2023). Then it can help in predicting air quality, providing real-time data and enabling authorities to create efficient policies and interventions (Duke University, 2021; Zheng et al., 2021). Machine learning algorithms can analyze data from air quality sensors, satellite imaging, and weather data to identify sources of pollution, estimate levels of pollution, and recommend actions to minimize the levels of air pollution. The application of AI in soil monitoring has transformed agricultural management, environmental conservation, and land-use planning (Abdulraheem et al., 2023). Machine learning algorithms, such as Random Forests and Decision Trees, can analyze large volumes of data from various sources to predict soil properties like moisture content, nutrient levels, and pH (Folorunso et al., 2023; John et al., 2020).

2. Geoengineering

Geoengineering, also called as climate engineering, is a technological approach which aims to resolve environmental issues by interference in the climatic system of Earth to mitigate global warming. The concept encompasses two primary categories of technologies: solar radiation management and carbon dioxide removal.

Solar radiation management reduces the amount of solar radiation that the Earth absorbs, so that it redeem the effects of greenhouse gases. This can be achieved through various techniques, which are:

1. Enhancing reflectivity of clouds by using fine sea water spray to whiten clouds.
2. Use of pale-colored roofing and paving materials to increase the reflectivity of Earth's surface.
3. Creating reflective aerosols, such as stratospheric sulfur aerosols, aluminum oxide particles, or specifically designed self-levitating aerosols (PNAS).
4. Use of space-based mirrors or asteroid dust to curb solar radiation (Berwick R.,2012).
5. Implementing reforestation efforts to prompt positive biophysical changes, such as cloud formation, which can reflect sunlight and contribute to mitigation of climate change (Canadell J., 2008).

On the other hand, removal of carbon dioxide technologies focus on reducing greenhouse gases from the atmosphere through methods like:

1. Producing biochar and incorporating it into soil to form terra preta.
2. Generating bio-energy with carbon capture and storage technology to sequester carbon while providing energy.
3. Use of carbon air capture technology to remove carbon dioxide from the air.
4. Planting trees to minimize carbon emissions.
5. Implementing ocean nourishment, including iron fertilization of the oceans

3. Biotechnology

Biotechnology plays an important role in environmental conservation by providing innovative solutions to mitigate pollution, conserve natural resources, and promote environmental sustainability. Environmental biotechnology is a vast field that includes a wide range of applications, including environmental monitoring and safety, waste treatment and recovery, restoration of environmental quality, and exchange of non-renewable resources with renewable ones. This field promotes the sustainable use of natural resources like plants, algae, and bacteria in industrial processes, generation of useful organic chemicals from bioconversion of biomass, and reduction of energy consumption.

Some applications of environmental biotechnology have indirect beneficial effects on environmental issues like global warming, acid rain, and climate change. However, the uncontrolled or accidental release of genetically engineered microorganisms (GEMs) or their hosts derived from recombinant DNA technology into the natural environment can pose hazards to natural ecosystems.

Therefore, it is necessary to consider environmental safety and legal aspects when applying biotechnology. This technology also offers solutions for pollution control, such as reducing phosphate excretion in animal manure by adding the enzyme phytase to their feed. This can lead to a significant reduction of over 30% in phosphate excretion.

Biotechnology tools can be used to conserve endangered plant species of economic and medicinal significance which also helps in mitigating environmental pollution, restoring environmental quality, and develop cleaner technologies. Tissue culture techniques have been established for endangered plants that are native to southern coastal ecosystems. Various initiatives have been supported under this, including ex-situ conservation, micro-propagation, and in vitro conservation of rare and endangered plants with medicinal importance, as well as ethnobotanical plants and microbial diversity in the North Eastern region.

All these efforts reflect the potential of biotechnology in biodiversity conservation, mitigating environmental pollution, mitigate the effects of climate change, agricultural management, and promote environmental sustainability.

4. Bioremediation

It's a type of technology which utilizes the power of microorganism metabolism to remove pollutants from the environment. This process modifies the metal contaminants as a direct result of microbial activity, with the aim of immobilizing, mobilizing, or decreasing the toxicity of metals in soil or water, depending on the goals of remediation.

Bioremediation can be attained through the introduction of new microorganisms to a contaminated site or by adjusting the environmental conditions to enhance the degradation rates of indigenous fauna. This technology has various applications, which includes, the recovery of brownfields for development, treatment of contaminated industrial sewerage prior to discharge into waterways, and remediation of contaminated wastewater, groundwater, surface water, soils, sediments, and air.

Various strains of bacteria and fungi has been experimented to treat pollutants like Vinyl Chloride and Polychlorinated Biphenyls (PCBs). Certain algae and bacteria can gather large quantities of metals, and mixtures of microbes and enzymes are used to clean up chemical wastes.

This technology can also be used for purification of drinking and process water, treatment of air and waste gas, and treatment of soil and land. In-situ and ex-situ treatments are used for soil and groundwater cleanup, encompassing the introduction of microorganisms, ventilation, and nutrient solutions.

5. Role of Information and Communication Technology (ICT)

Information and communication technology (ICT) has very important role to the environmental protection. In recent years, the environment has become increasingly degrading globally due to climate change, air pollution and deforestation, and in between the all of this, the information and communication technology (ICT) tools contributed to the finding of various new solutions to the environmental issues. One of the primary positive impacts of the ICT can be **Energy Efficiency**: ICT can be used for clean energy processes and can reduce green house gas emissions. For instance, we can decrease the use of physical travel and letters (as opposed to emails and video calls) to reduce the use of paper and fuel. Smart ICT tools can therefore also contribute to more efficient energy use in homes and offices. Intelligent lighting, and climate control systems minimise waste of energy. ICT also enables the development of "smart grids" that can more effectively manage energy supply and prevent energy loss. These enhancements contribute to minimising CO₂ emissions and decelerating global warming. ICT is also a valuable tool for **observing and predicting changes to our environment**. It could aid in monitoring changes in forests, weather patterns and pollution levels. That's useful if you want to crack down on illegal happenings such as deforestation or forest fires. Sensors and satellite data can report information in near- real time about the state of the environment, leading to quicker response at natural disasters such as floods, hurricanes and storms. **Agriculture** ,in the agriculture sector, ICT provides farmers with vital information such as weather, soil and crop health. This enables them to minimize chemical use and waste. Farmers receive market information through mobile phones and the internet to help them get better prices and reduce food wastage. This has allowed farmers to act more effectively in ways that are both economically profitable and environmentally sustainable. ICT can also be used for **waste**

management. Smart waste bins and GPS tracking are now used by many cities to enhance garbage pick-up efficiency. This cuts down on fuel usage and makes the city a cleaner place. Information and communication technology (ICT) can assist in the development of systems for reuse of e-waste and other toxic materials, however e-waste remains to be managed in many developing countries. Despite its advantages, however, ICT also has adverse effects on the environment. The production of ICT devices like computers, smartphones and servers involves the consumption of large amount of non-renewable resources including rare metals. They also consume power, something which needs to be plugged into, and are often made to be disposable, adding to the catastrophe of e-waste in this modern era. When this e-waste is not managed appropriately, the environment becomes contaminated and public health is negatively affected. In some developing countries, energy spent in manufacturing ICT equipment can surpass environmental benefits achieved through ICT use. In the end, ICT provides a great opportunity to contribute to the conservation of the environment if used wisely. It can help reduce pollution, enhance energy use, support sustainable agriculture and make waste management more efficient. But it also needs to be controlled for its harmful effects, like e-waste. And if governments and communities use ICT smartly and wisely, it can become a powerful tool to shape a cleaner and greener future.

6. Use of Renewable Energy

Sources of renewable energy refer to as clean source of energy or technology in environmental conservation. In the era of rapid pace of industrialization and digitalization, the world needs to prioritize environmentally sustainable energy sources to ensure a cleaner and more sustainable future. Sources of renewable energy like solar, wind, hydro, geothermal, and biomass are essential in reducing our dependence on fossil fuels and mitigating the effects of climate change.

Sno.	Type of Renewable Energy	Advantages	Disadvantages
1.	Solar Energy	• clean and renewable source of energy; • use sunlight as a source of fuel; • allow individuals and communities to generate their own energy by using solar panels; • low operating costs; and • reduce carbon emissions.	• require large space to operate; • initial cost to buy and install the panels is high; • total dependence on sunlight;and • energy storage solutions, such as batteries are expensive.
2.	Wind Energy	• use wind as a source of fuel;	• dependence on wind speeds which

		• no emission of greenhouse gases; • improve energy security; • helps in reducing carbon emissions	• can be vary and unpredictatble; • pose a significant risk to lives of birds; • create noise pollution;and • require regular and proper maintenance to ensure optimal performance.
3.	Hydro Energy	• use of water to generate energy; • high energy conversion efficiency; • long time of life span; and • low emissions of greenhouse gases	• construction of dams led to displacement of people and communities; • high upfront costs; • habitat destruction of aquatic ecosystem;and • affect quality of water.
4.	Geo-thermal energy	• use of heat from the Earth's core to produce energy; • no emission of greenhouse gases; • use for both small and large scale power generation; and • contribute to diversified energy mix.	• require suitable geology, making it location specific; • exploration, drilling are expensive; • led to noise pollution, land subsidence;and • require large amount of water for cooling;

5.	Biomass	• derive from organic material such as plant and animal waste; • led to waste reduction; • reliable source of energy; • eco-friendly source of energy; • low emission of sulfur dioxide; and • stimulate rural economy through localized production.	• require significant space of land; • led to air pollution and soil degradation;and • combustion of biomass led to emission of greenhouse gases
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Table 2 : Advantages and Disadvantages of Types of Renewable Energy Sources

7. Use of Drones and Satellites

In recent years, drones (Unmanned Aerial Vehicles /UAVs) and satellite technologies are widely being used in environmental conservation and protection. These technologies allows us to accurately collect and monitor real-time environmental data in a cost-efficient manner. Unlike traditional approaches like ground surveys or manned overflights, drones can easily reach to remote or dangerous terrain and provide real time and detailed images using high-resolution cameras and advanced sensors that are helpful for scientist in further studies.

Drones are increasingly being helpful for wildlife monitoring, for example we can track and monitor species like elephants, whales, birds, reptiles, and sea turtles without actually disturbing them and their natural habitat. Drones are equipped with thermal cameras help in finding animals at night. Drones also help in assisting habitat mapping and ecosystem health assesments. They are built with sensors like LiDAR, multispectral camera, and sometimes hyperspectral sensors, with AI based analysis system to calculate and measure vegetation cover, tree height, density, plant disease, biomass and finally to achieve health of an ecosystem.

In Romania, researches use drones to map the forest , measure size and height of trees, and take biomass measures in areas that were in real too difficult and unsafe to reach out and conduct research. In the case of disaster and emergency response drones are very useful and provide a rapid source of information during an event like floods, wildfires, landslides, and oil-spill. Drones deliver real time data for the rescue teams and environmental managers to be able to response as soon as possible without putting human lives at risk. Some regions utilize satellites such as Copernicus Sentinel-2 to detect early signs of droughts and floods.

In other regions drones are also being used to investigate anti-poaching and law enforcement activities such as monitoring protected areas for illegal activities associated with logging,

mining, and animal poaching. Night vision drones are specially used to track poachers and endangered species. Like in Africa, where drones have been used to assess local rhino populations to get an idea of where poachers are most frequently active in illegal hunting so that it can be timely monitor and proactive actions and measures can be taken against poaching activities.

In another example, drones even identified a biodiversity hot spot from area-level biodiversity surveys that shows biodiversity surveys had not been done enough research in these areas this also points to the potential of application of drone technology has in environmental studies and exploring areas of research.

Satellites also plays an important role in environmental monitoring, mainly over large broad areas. They measure long term changes in climate, glacier, ocean health and forest cover. While drones offer the close detail of a snapshot satellite offer the big picture. These two work simultaneously – satellite can indicate areas of concern and drones can go and examine those areas in detail.

While they have a lot of benefit there are some challenges also drones can be expensive, especially if you want drones with state-of-the-art features like LiDAR or hyperspectral cameras. In some areas, there are regulatory constraints on flying drones in protected areas. Also, there are concerns about animal disturbance if drones fly too closely or frequently. In addition, drones collect a large volume of data that is often best addressed by trained personnel with fast computers. Ethical guidelines, operators with training, and appropriate regulations can regulate these concerns.

According to researchers Jesús Jiménez López and Margarita Mulero-Pázmány (2019) if we use wisely responsibly, drones can help in advance conservation objectives and facilitate improved management of protected areas. Vasiloni and colleagues (2023) also confirm that drones lower human impact on fragile areas and show potential as economically viable methodology for conservation and to address research objectives in protected areas.

The future aspect and potential of drones in environmental protection and conservation are quite bright. As technology improves, the possible futures we will see more advance drones (UAVs), with creative possibilities such as planting seeds in degraded landscapes, following air pollution, controlling insects which carry disease, maybe even removal of marine litter. In agriculture, we will see (climate-smart) applications such as precision farming, using both drones and satellites, to optimize water, fertilizer, and pesticide use, minimize environmental impact. The EU already applies remote sensing technologies, such as Copernicus for agricultural monitoring as part of the Common Agricultural Policy (CAP). Future UAVs are expected to be able to fly longer durations, carry additional sensors, and provide more possibilities in extreme environmental conditions. At last, drones and satellites are changing environmental management practices forever, making them faster, safer, inexpensive, and accurate. UAVs provide scientists and conservationists to learn more about our ecosystem and species-at-risk, as well as respond to disasters and emergency situations, and provide smarter in preventing and reducing damage using their reports. As technology continues to improve,

UAVs and satellites will become even more appropriate for environmental management and protection, ensuring a sustainable future on our planet.



Fig.2 Precision Farming with help of Drone

Source: https://spao.shortpixel.ai/client/to_webp,q_lossy,ret_img,w_1920,h_750/https://iotechworld.com/wp-content/uploads/2024/01/Fertilizer-Spraying-Techniques_a5.jpg

Challenges and Limitations

While sustainable technologies have vast potential to address environmental problems, they suffer from various challenges and limitations that make them hard to deploy at practical scale. One of the main issue is overpricing of green technologies which makes them unaffordable for companies as well as ordinary citizens. There are also technological constraints as a number of eco-friendly alternatives are still at the level of research or its development and, therefore, not yet commercially available. That even more true in the sphere of renewable energy industry, where many industries (solar, wind, tidal, hydro energy) are not yet mature from a commercialization point of view to use .So while they may be solutions to lowering greenhouse gas emissions, the slow pace of progress means they're not helping the environment in the near real practical aspect.

Other problems include weak infrastructure, logistics, and regulatory backing. These issues are hindering the successful application of new technologies in practice. Challenges also exist in enhancing the efficiency and effectiveness of innovations for their usefulness in real life. On larger scales, for example, the establishment of renewable energy plants, the above type of environmental problems may be amplified, and the land use and ecological standings as well as natural habitats get some new challenges too. This demonstrates that also green solutions can have unintended consequences if not well thought through. Adequately measuring the sustainability performance of a new technology over its life cycle is a major challenge and, from a rigorous scientific perspective, no framework to model this exists yet. Without a transparent system to measure the environmental impact at every level, it would be hard to determine how environmentally friendly a technology really is. Additionally, research and development needs to be more advanced, funding needs to be better, and policy support needs to be stronger to drive down costs and increase innovation. We need financial assistance in the

form of low-interest loans and environmental incentives to promote green energy practices. In industries such as transportation, the transition to electric vehicles (EVs) and the smart grid confront challenges including high costs and absence of charging infrastructure. Managing resources such as water, air quality, and energy through the Internet of Things (IoT) in cities shows promise, but that approach will also require advance data systems and privacy safeguards. Lastly, incorporation of Artificial Intelligence (AI) and Machine Learning (ML) into environmental technology solutions have potential to sharpen solutions, but demand big amounts of financial capital and data. Thus, technology can save the environment, but we must face down these challenges with more planning, research, funding, collaboration, and make government, industry, and the public all part of the solution. So that is the only way sustainable technologies can bring profit to the planet and all of those future generations.

Conclusion

Thus, technology plays a major role in environmental conservation by developing innovative solutions to mitigate the pressing environmental issues. Sources of renewable energy helps in reducing emissions of greenhouse gases and offer a more sustainable alternative to fossil fuels. By using microorganisms to degrade pollutants, the process of bioremediation demonstrate an approach to restore contaminated ecosystems. The process of Geoengineering, holds potential for large-scale environmental interventions, such as carbon capture and management of solar radiation. Biotechnology, by harnessing advances in genetic engineering and synthetic biology, can enhance ecological stability and develop innovative solutions for pollution reduction. Then, the strategic application of Artificial Intelligence (AI) can develop energy systems, predict environmental trends and patterns, and improve resource management. The use of Information and Communication Technology (ICT) facilitates real-time monitoring, data analysis, and informed decision-making, while the use of drones and satellites provides unprecedented advancements for environmental surveillance, mapping, and monitoring. By utilizing the collective potential of these technologies, we can create a more sustainable, resilient, and environmentally conscious future, where economic growth and environmental stewardship go hand-in-hand. As we move forward, it is essential to prioritize responsible innovation, ensure equitable access to these technologies, and foster global collaboration to address the complex environmental issues that require a unified and collaborative effort. Thus, technology is an essential tool in pursuit for the environmental conservation, but its effectiveness rely on our abilities to use it wisely and sustainably.

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