(REVIEW ARTICLE)

Check for updates

A review on sustainable biodiversity challenges and opportunities

Saranya K G *, Hema A and Joanish Muthu J

Department of CSE, PSG College of Technology, Coimbatore, Tamilnadu, India.

Abstract

Sustainable biodiversity is to make use of biodiversity in a sustainable manner which implies to use natural resources at a rate the nature can renew them. This is the way to ensure that we meet the needs of present and future generations. Conservation of biodiversity is the practice of protecting and preserving a variety of species, genetic resources, habitats, and ecosystem on the earth. It is essential for food security, economic growth, poverty reduction, and resolving effects of climate change. Deforestation, climate change, invasive species, poaching, carbon emissions, land use change, Flooding and hurricane, forest degradation, mining are the major issues in Biodiversity in forest area. This paper addresses the Sustainable biodiversity challenges and opportunities associated with it.

Keywords: Sustainable Biodiversity; Artificial Intelligence (AI); Internet of Things (IoT); Forest Management system; Surveillance

1. Introduction

Pollution is the introduction of harmful elements into the natural environment which in turn has adverse effects on land, water and air. Pollution directly injures plant tissues, impairs photosynthesis and respiration rate. Pollution affects animals by causing diseases, stress, organ injury and possible death. Bioremediation, phyto-remediation, sustainable agriculture, proper waste disposal, sustainable forest management, reducing use of non biodegradable materials can be done to resolve the effects of pollution.[1].

Deforestation or forest clearance is the removal of a forest or stand of trees from land that is then converted to non-forest use. Reforestation and afforestation, Community forest, Education, Awareness campaigns, Law and Regulations, Eco-forestry, Green business, Land use planning.[3].

Invasive species are the species that are not native to a specific area. It becomes overpopulated and causes problems in the local environment. Research on detection and control measures, Public education.[4].

Poaching is illegal trafficking and killing of wildlife. Creating sanctuaries, installing trackers and sensors can be done to avoid illegal poaching.[6].

Mining is the extraction of valuable and other geographical elements from earth. Mining causes erosion, contamination of soil, water, loss of biodiversity. Rehabilitating mining sites, shutting down illegal mining, using eco friendly equipment, reusing mining waste, soil treatment ,water treatment, Sustainable mining.[5].

Carbon emission causes temperature to rise on a global scale. This in turn causes sea level rise, decreases the available land area used by many plants and animal species. It also kills vulnerable species, causes species to migrate, invasion, extinction of native species. Afforestation , reforestation, reducing use of firewood.[8].

---

* Corresponding author: Saranya K G

Forest degradation is a process in which the biological wealth of a forest area is permanently diminished by some factor or by a combination of factors. Using sustainable wood products, reduce, reuse, recycle, reduce use of firewood, practice eco forestry, establishing organization to restore forest can be followed to reduce it.[2]

Climate change is the long-term shifts in temperatures and weather patterns. Forest ecosystems are sensitive to climate. Climate change affects forest ecosystem by altering the growth, mortality and reproduction of trees, affects rate of photosynthesis, carbon cycle, disease, invasions. Reducing use of fossil fuels, using renewable energy, switching to sustainable transport, reducing plastics, afforestation, enabling rights based land use.[7].

Forest Fire is the unplanned, uncontrolled and unpredictable burning of plants in forest, grasslands, brush land etc. Checking weather conditions, drought conditions, Monitoring forest can be done to prevent forest fire and its effect.[9].

2. Importance of sustainable development

Sustainable development is important because humans have responsibilities for future generations. Sustainable development is essential because it motivates us to preserve nature, respect the environment and protect biodiversity. Sustainable development makes us to protect and enhance our resources by modifying the ways in which we develop and use technologies. Sustainable development also implies environmentally sustainable economic growth. The main aim is to achieve harmony between environmental sustainability, economic sustainability, and socio political sustainability. The future generations should have access to natural resources, should live in peaceful society, and should have decent employment.

- Section 2 addresses the related works done in the areas of biodiversity.
- Section 3 gives an overview of challenges in Sustainable biodiversity and opportunities for improvement.
- Section 4 gives the details of the Forest Monitoring system and its technologies..

3. Related works

Technology plays key role in protecting biodiversity and contribute to sustainable development. Unmanned aerial vehicles called as Drones help to monitor species in places which are difficult to access. IoT is widely used to automate the tasks, track animals and prevent poaching. Camera, sensors along with other tools is used to collect data. These data are analyzed using techniques like Machine Learning, Artificial Intelligence to detect lifestyle of species, risks for their survival, conservation. Satellites are deployed to continuously monitor Earth to provide environmental data. LIDAR is used to collect information on vegetation structure.

Table 1 Pollution Monitoring

S.no	Title	Technology	Advantages	Limitation
1	Pollution monitoring system using IoT	IoT	The system has web server to measure air quality	Multi year lifetime requirement
2	IoT based pollution monitoring system for effective Industrial Pollution Monitoring and control	IoT, cloud computing	Reduces the involvement of human being in hazardous environment	Security problem

Table 2 Forest Degradation/Deforestation Detection

S.no	Title	Technology	Advantages	Limitation
1	Remote sensing of forest degradation: a review	Remote sensing	Helps in detecting forest degradation in areas which are difficult to reach	Model building is expensive
2	Current remote sensing approaches to monitoring forest degradation in support of countries measurement, reporting and verification (MRV) systems for REDD+	InSAR and LiDAR	Minimum human dependency	High operating cost
3	Deforestation detection using scattering power decomposition and optimal averaging of volume scattering power in tropical rainforest regions	Synthetic aperture radar (SAR) ,scattering power decomposition	Superior penetration capability	Very slow,more complex and expensive
4	Real time poaching detection: A design approach	Acoustic sensor, Transmitter	Gathers data efficiently	Installation and maintenance cost is high
5	Flood detection using sensor network and notification via sms and public network	sensor network	Reliable, message delivered quickly	User needs to check the news every moment

Table 3 Poaching Detection

S.no	Title	Technology	Advantages	Limitation
1	Real time poaching detection: A design approach	Acoustic sensor, Transmitter	Gathers data efficiently	Installation and maintenance cost is high
2	Animal borne anti-poaching system	Embedded system, Sensor network	Wearable device, helps to track animals	Multi year lifetime requirement, false positive rates
3	IoT based Anti poaching sensor system for trees in forest	IoT, Sensor technology	Tells the status of trees through dashboard	Modules can be damaged.
4	Design and Development of wireless sensor node for anti poaching	IoT	reliable	wireless sensors are costly
5	IoT based Anti poaching alarm system for trees in forest	IoT	It also detects forest fire	no rechargeable power system

Table 4 Invasive Species/Disease/Pest

S.no	Title	Technology	Advantages	Limitation
1	Automatic detection of Acacia longifolia invasive species based on UAV acquired aerial image	Neural Network, UAV	Accurate prediction	It does not detect other acacia species.
2	Plant disease detection using Image processing	Image Processing	Farmer gets the detail about type of disease	Detects only in few plants

Table 5 Forest Fire Detection

S.no	Title	Technology	Advantages	Limitation
1	Early Forest Fire Detection with Sensor Networks	Sensor network	flexible	Very sensitive to extreme environmental changes
2	Forest fire detection using co2 sensors	IoT, sensors technology,	Long distance data collection and transmission	Inefficiency, costly, power consumption.
3	Forest fire detection system	Wireless sensor network, IoT, GPS	reliable, gives location	Climate/Seasonal change affects, has many secondary antennas
4	IoT based Forest fire prediction and detection	IoT	detects and send alerts to officials	Wireless sensors are costlier than other sensors.
5	Forest fire detection for near real time monitoring using geostationary satellite	Satellite, data science	helps monitor large area	Clouds disturb remote sensing, lack of fire ground data.

4. Inference

All the above methods (mentioned in Table 2.1, 2.2, 2.3, 2.4, 2.5) effectively address the issues affecting forest and provide appropriate solutions.IOT based methods proved to be efficient but has some limitations like expensive model building, high maintenance cost, manual interference, damage, security issues. Satellite images are useful to cover large areas. Surveillance, Artificial Intelligence and neural networks have capability to address the problems effectively.

5. Opportunities to improve the sustainable biodiversity

5.1. Anti Poaching

An IOT based Anti-Poaching alarm system, the modules can be damaged by external factors like human interference ,external factors like human interference, extreme weather conditions ,Animals etC..The damage can be prevented by using rugged materials to cover the modules The IOT based Anti Poaching sensor system has no rechargeable power system. This project can be further extended by adding mini solar chips at the tree section so that the transmitter part can work on rechargeable power. Solar Panel can also be installed at the receiver part. Waterproof solar panel can be used to power audio monitors. In order to prevent shade of trees from disrupting solar panels ,multiple solar panels can be used to catch the sun at different times during the day.

5.2. Forest Degradation/Deforestation

Should investigate effective ways for extracting the volume scattering power with fewer independent parameters than quad-polarization data.

By installing an NGO-based anti poaching team and using various anti poaching technologies, the equipment can be maintained.

The automated alerts can be given using LED signals and buzzer sound. And SMS alerts can be sent when the water level reaches beyond the limit.

5.3. Pollution

Cloud Storage can be used in pollution monitoring to store data. Cloud storage solution is able to store huge amounts of heterogeneous data and provide them in a uniform way. This data can further be used for research and analysis of patterns in each place.

5.4. Security of Data

One of the most efficient measures for preventing cloud security risks is gaining complete control over data across all endpoints Using solution that scan, access and take action on the data sources ,before its transaction from its network, enables a robust defense against any data loss through the cloud provider

This also helps in avoiding attack

5.5. Invasive species / Disease

Other acacia species can be detected by allowing the aerial vehicle for inspection and recognition of other Acacia species. This detailed inspection would allow to distinguish the various species by using imagery of the leaf structure or other relevant plant characteristics. Plant disease detection system can be improved by training the system with many plant species, their details, area, type of diseases, characteristics from different places under various seasons, temperature, humidity, Rainfall pattern etc.

6. Enabled forest monitoring system

Forest Monitoring involves managing forest and preserving its wildlife and vegetation and also alerting in emergencies. The emergence of new technology in remote sensing, electronics and informatics offers the opportunities for monitoring at distant locations.

To address all these issues, developing a Forest Monitoring System is one solution. The surveillance technology can be used to monitor the levels of deforestation, poaching, illegal human activities, Pests and insects, forest fires, and invasive species.

Camera traps are inexpensive methodology for capturing high quality photos and videos of plants and animals in the forest. It has long battery life and it is capable of running AI models on the device.

- Network of camera traps can be used to monitor vegetation to analyze levels of deforestation with automated data collection.
- Many of the forest fires can be avoided by monitoring atmospheric variables like temperature, relative humidity, and wind speed. Forest fires can be detected by capturing infrared image of forest fire using camera, detect fire with RGB and YCbCr color model or Neural Networks.
- Imaging analytics can be applied to camera traps to help differentiate between humans and animals. Thermal imaging applications can be used to detect presence of the poachers or unauthorized persons in the forests which can be used to detect illegal logging and mining.
- IoT can be used to monitor soil condition, quality of water on rivers to check the level of pollutants which leads to deforestation.
- Invasive Plants can be detected by using deep learning methods on images obtained from cameras.

Object detection methods can be used to train the system and to make the system monitor forest and GPS and Geographic Information System (GIS) can be used to send alerts with location to officials in emergencies.
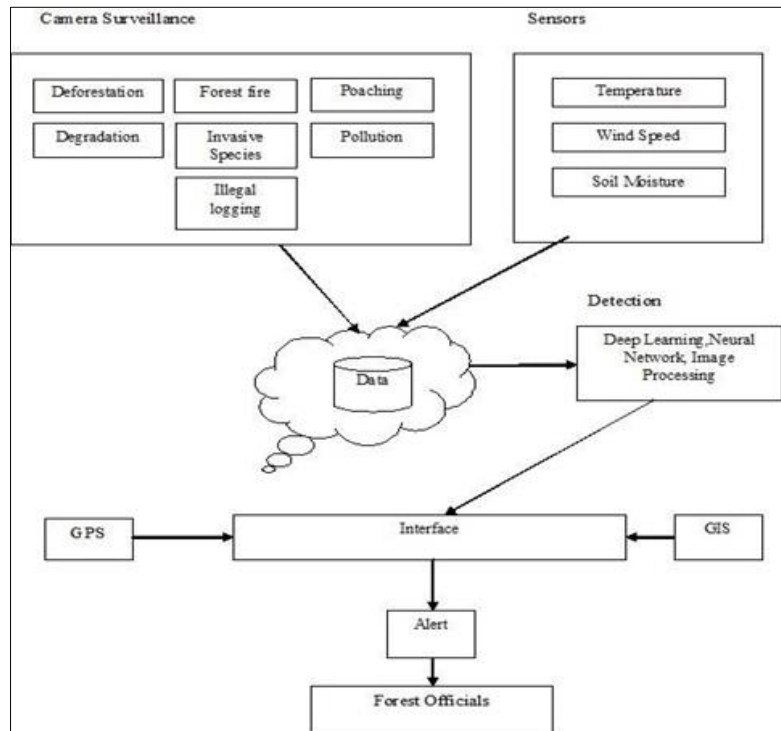
Figure 1 Forest Monitoring System

7. Conclusion

Wildlife management is an important key indicator used for Biodiversity Protection. The use of camera and surveillance technology has the potential to effectively manage Biodiversity. The interconnected network of remote cameras is suggested to monitor biodiversity at global scale to conserve biodiversity. The use of Artificial Intelligence makes the Forest Monitoring system more efficient. This system efficiently detects the issues and alerts the officials in case of emergencies. The future work involves identifying the disaster prone areas using data collected from the system in order prevent disaster in such areas.

Compliance with ethical standards

Acknowledgments

Authors: Saranya K G, Hema A, Joanish Muthu J contributed to the paper's development. We now express our thoughtful concerning our work.

Disclosure of conflict of interest

No conflict of interest.

Statement of informed consent

Everyone who participated in the study investigation gave his or her informed consent.

References

[1]   https://education.nationalgeographic.org/resource/pollution

[2]   https://www.iucn.org/resources/issues-brief/deforestation-and-forest-degradation

[3]   https://en.wikipedia.org/wiki/Deforestation

[4]   Amit Kumar & Santosh Prasad, Threats Of Invasive Alien Plant Species,January 2014 , International Research Journal of Management Science & Technology Volume 4 Issue 2 Online ISSN 2250 - 1959.

[5]   https://www.conserve-energy-future.com/causes-effects-solutions-mining-pollution.php

[6]   https://www.worldwildlife.org/threats/illegal-wildlife-trade.

[7]   https://www.fao.org/3/ac836e/AC836E03.htm#:~:text=The%20increase%20of%20CO2,crops%20(IPCC%2C%202001)-climate change.

[8]   https://www.fao.org/3/i1960e/i1960e00.pdf climate change .

[9]   Shailesh Tawade , Rinku R. Choudhary And Vaishnavi Santosh Chavan, Effects Of Forest Fire On Forest Ecosystem, Biodiversity And Loss Of Plant And Animal Species, 2022, International Journal of Advanced Research (IJAR),ISSN 2320-5407,pages=4.

[10]   Jukka Miettinen, Hans-Jurgen Stibig, Frederic Achard, Remote sensing of forest degradation in Southeast Asia—Aiming for a regional view through 5–30 m satellite data, Global Ecology and Conservation, Volume 2, December 2014.

[11]   Shreya Shivaji Gaikwad, Pranit Mohan Mhatre, Cyril Silvester DabrePranit Mohan Mhatre ,Poacher Detection using YOLO Algorithm, International Journal of Engineering Research & Technology (IJERT),ISSN: 2278-0181,2021.

[12]   E.Shalini, S.Subbulakshmi, P.Surya, R.Thirumurugan, Cooperative Flood Detection Using SMS Through IoT,,International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering,ISSN (Online): 2278 – 8875,2016.

[13]   https://en.wikipedia.org/wiki/Cloud_computing_security

[14]   Miss Aachal Ramteke, Prof. Rohini Pochhi, Prof Rahul Dhuture, IoT Based Forest Fire Detection System Using Raspberry PI and GSM,IJARSCT,,ISSN (Online) 2581-9429,2021,pages=4.

[15]   Jewel Simon, Suraj Kamat, Vijaykumar Gutala, Ahmer Usmani4Plant disease identification using image processing, (IOSR-JCE),p-ISSN: 2278-8727,2020,pages=5.