ORF ISSUE BRIEF

JULY 2020
ISSUE NO. 382

Modern Technology for Sustainable Forest Management in India

ANUSHKA SHAH

ABSTRACT India's Intended Nationally Determined Contributions for climate action emphasises the creation of an additional carbon sink of 2.5 to three billion tonnes by 2030 by increasing the country's green cover. At the same time, however, harmful human activities such as legal and illegal logging, as well as deforestation for development purposes seem poised to negate the impact of these climate-action plans. While steps are being taken to prevent the further decline of India's forest cover, the question remains: Is enough being done? This brief explores the potential of the Internet of Things (IoT)—in particular, the use of smart sensors or 'green bots'—in helping meet India's challenges in sustainable forest management.

Attribution: Anushka Shah, "Modern Technology for Sustainable Forest Management in India," *ORF Issue Brief No. 382*, July 2020, Observer Research Foundation.

ISBN 978-93-90159-53-6

INTRODUCTION

Even as India has taken positive steps to mitigate carbon emissions through the promotion of renewable energy, [1] climate change continues to pose massive challenges to the country' growth. One of the primary reasons is that forest restoration and conservation have been largely ignored in the fight against climate change.[2] The government itself, through its Intended Nationally Determined Contributions (INDCs) submitted to the United Nations (UN) in 2015, recognises that forestation will provide more than 33 percent of the country's potential carbon emissions solutions.[3] India's INDCs emphasise creating an additional carbon sink of 2.5 to 3 billion tonnes between 2021 and 2030 by increasing the country's green cover.[4] Yet, at the same time, activities such as legal and illegal logging, deforestation for development purposes, and people-induced forest fires continue unabated, contradicting the goals set by official climate-action declarations.

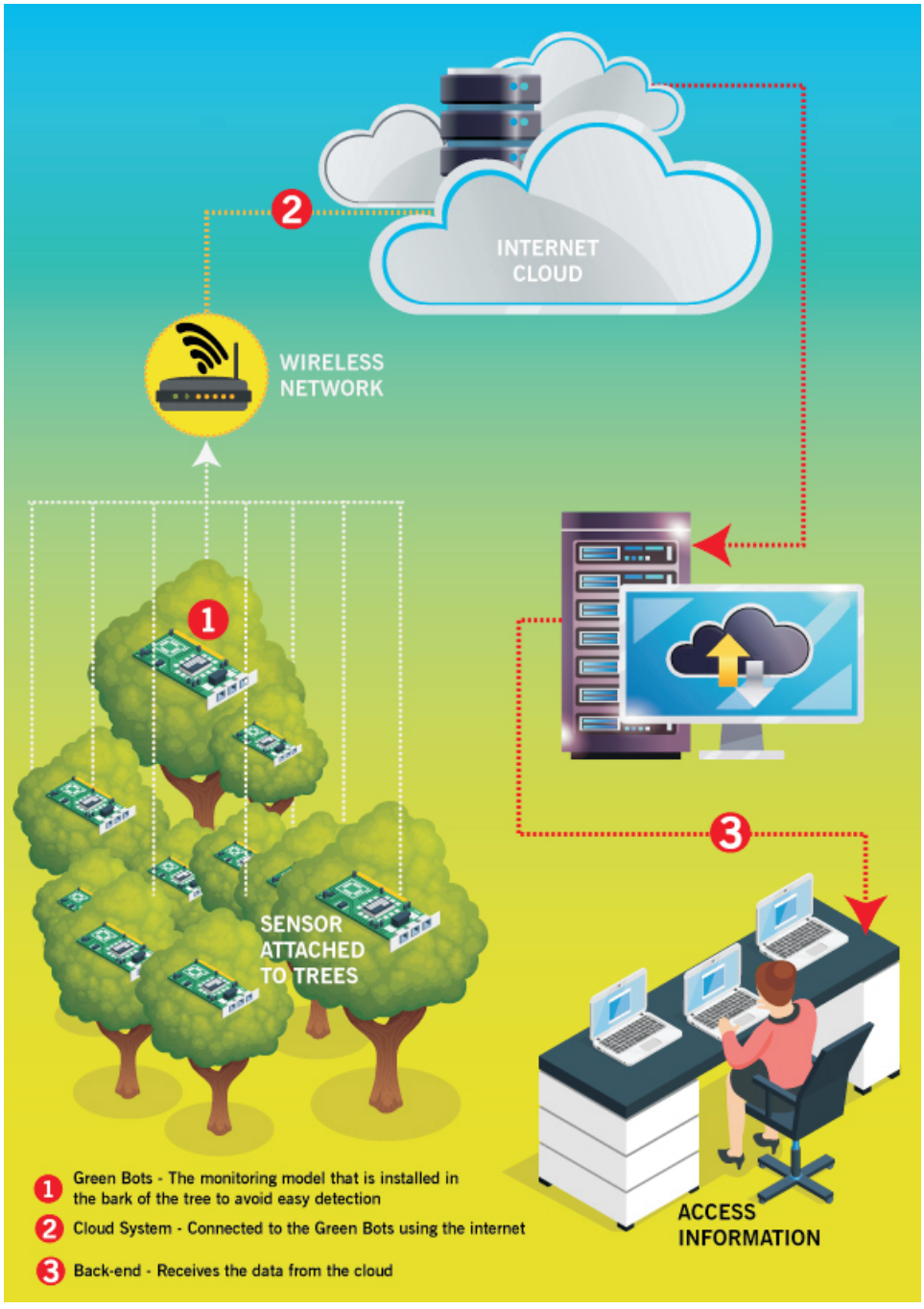
It is imperative to control the use, exploitation and management of existing green cover through sustainable planning, which can only be resolved by bringing about a radical change in the country's forest management and conservation practices. Integrating technological innovation with the current sustainable practices can be an effective tool. Modern economists emphasise the catalytic role that technological changes play in a country's development,[5] especially for developing nations such as India, which are lagging in developing such technologies.

The Internet of Things (IoT)[a] is amongst the modern technological innovations that have received a significant amount of consideration in the Indian markets.[6] While IoT in India is still in its nascent stage, the government has recognised its potential by introducing, for example, smart wearable devices for women to promote safety, smart waste-management practices, and portable water-monitoring mechanisms.[7] The Ministry of Electronics and Information Technology, in its draft IoT policy, has also encouraged Smart Agriculture, which includes the monitoring of soil moisture, vibrations, earth density and pests, to detect potentially problematic patterns in land conditions and create a real-time monitoring system for Indian farmers.[8] There exists in India a mechanism to avail real-time updates on farm's soil conditions including soil moisture, P^H levels and nutrients, which then advises the farmers on pesticides and fertilisers; it has already been adopted by some large-scale farmers.[9] Indian start-ups are also working towards the adoption of drones for crop monitoring and spraying pesticides and fertilisers on crops, as well as web-based crop modelling, in an effort to promote agri-tech in the country.[10,11]

Forest management is another sector that could benefit from these technological applications. Based on the concept of IoT, an intelligent and interoperable network of devices interconnected through a dynamic, global infrastructure network can be created to connect and exchange data across locations at any time. These technology-driven smart

a Internet of Things (IoT): A system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Figure 1: How green bots work



Author's own

sensors (called '*green bots*') can be key to preserving India's forests, while also providing data that can serve as a catalyst towards more sustainable forest management. By using data on soil and weather conditions, these smart sensors can employ predictive analytics to help in sustainable forest management and conservation practices.

SMART SENSORS: RESPONSE TO KEY CHALLENGES IN INDIA'S FORESTS

Conversations around the use of "forest-smart interventions" to monitor forest action plans have been taking place at the international level for some years now. Various countries have proven to be trailblazers in this regard. In

Brazil, for instance—whose forest cover is approximately 64 percent[12] of its total land area—the start-up Treevia developed a remote forest-monitoring system called *SmartForest* in 2014.[13] Treevia has developed wireless electronic sensors to monitor the real-time growth of Brazil's forest. The data collected by these sensors is then analysed and used to inform policymaking. The solutions offered by SmartForest include digital asset registration systems, forest research using high-precision data, hazard assessment, and specialised forestry consultation. The project is awaiting accreditation by two of Brazil's largest forest companies, where proof-of-concept tests have yielded promising results. The preliminary results covering only a few months indicates that SmartForest is more successful in data gathering than traditional sources.

Brazil is only one country where forest management is being aided by technologies such as smart sensors.[b] In India, too, these technologies have the potential to help address some of the most fundamental challenges in forest management.

Illegal Logging: Clearing Forests for 'Development'

In the pre-Independence era, India's forest policies focused on generating revenue by selling timber and other forest produce (Forest Act, 1865), and facilitating the conversion of forest lands for agriculture and timber-logging (Forest Act, 1894). A shift occurred following Independence, as forest policies began to be framed towards management (National Forest Policy, 1952). The goal was to achieve ecological balance and maintain India's forest area as 33 percent of the country's total land cover. The Forest Conservation Act, 1980 emphasised on governing the diversion of forests for non-forest purposes. The industrial production of round-wood timber dropped, but the demand remained high, and illegal logging of timber grew large-scale. From 2002 to 2011, the imports of illegally sourced timber increased from one million to 3.5 million cubic metres.[14] After China and Vietnam, India is now third in this illegal trade, accounting for 9.4 percent of the total illegal trade of timber.[15] Additionally, given the nutrient-rich property of Indian forest soil, a market has evolved for high-value trees such as Sandalwood, Red Sanders, Rosewood and Oaks. The Sandalwood market alone is expected to be worth over INR 100 billion (approximately US$ 144,70,62,800) annually, and the high price it commands has led to the Indian sandalwood slowly becoming endangered.[16] As the Indian market for high-value trees grows, a stringent regulatory framework towards its sustainability has become both an economic and ecological priority for India to meet its national forest-cover goals. Using satellite information for the period October–December 2015, the Forest Survey of India (FSI) surveyed the extent of forest cover of each state and the various reasons for its increase or decrease.[17] Smart sensors (or 'green bots') can detect any disturbance in forest areas that might indicate logging activities: the activity triggers a signal on the green bot, which then gets reflected to the cloud, allowing the authorities to take appropriate action. This helps in the timely

b Countries such as United States and Brazil are using green bots for forest management.

detection and prevention of illegal logging. Each sensor can be programmed to detect events occurring within a set grid (for instance, 5x5 km). Parameters such as daily relative humidity, daily temperature, and forest-cover density can be used to detect occurrences in the forests. The data gathered can then be assessed over time. The data can also help understand the evolution of forest dynamics more comprehensively. As the Government of India launches various programmes and introduces policy regulations to achieve the targets set in the country's INDCs, the use of green bots can be vital in providing real-time feedback on the impact of different policy and management regimes.[18]

India's geography comprises many small and large sacred groves. In India, the total number of sacred groves could range from 100,000–150,000; there are 5,000 sacred groves in Himachal Pradesh alone.[19] The maintenance process for these differs from place to place. For instance, while some are managed by the gram panchayats, others are managed by the local communities. Currently, there are several threats to sacred groves. Among them—the degradation of forests due to urbanisation, livestock grazing and invasion by exotic weeds, increasing demand for fuelwood, invasion for agriculture, and natural calamities. It is crucial to encourage the recognition of conservation and community reserves under an amended Wildlife Protection Act, which will facilitate the conservation of groves by making them eligible for government funding and technical support. Green bots can provide a complete inventory of sacred groves and landscapes in all bio-geographic zones with details of the biological, ecological and sociocultural values associated with each. This can be a strategic tool to conduct site-specific conservation and restoration plans through the participation of local people or the guardians of the groves.

Legal Logging

In India, the logging of certain trees is permissible under the law. However, it is important to correctly identify these trees. For instance, if an ageing or diseased tree is not cut, it can spread parasitic infections or compete for more nutrients, harming the growth of healthy trees in its vicinity. Green bots can help formulate a smart cutting plan that will allow people to examine the data to ascertain which tree in a forest is worth felling based on its health. Green bots can also help in detecting decayed trunks; assessing a tree's vulnerability to being affected by natural gas leaks at the root level; and checking for methane leaks, which can deplete root level oxygen and result in the death of a tree, enabling the timely relocation of improperly located trees.

Preventing Forest Fires

The 2019 FSI report states that MODIS[c] had detected 37,059 forest fires in India in 2018, which indicates a 1.5 times increase in the number of forest fires over a period of six years.[20] Despite the surge in the number of forest fires from 2015 (15,937) to 2017 (35,888), the government has reduced funding to states and union territories

c MODIS: Moderate Resolution Imaging Spectro-radiometer

towards forest protection measures by 21 percent.[21] At the same time, forest fires were responsible for approximately INR 4.95 billion worth of economic loss in 2018 alone.[22] Moreover, forest fires directly affect forest regeneration, severely impacting the lives and livelihoods of the communities dependent on these forests.[23]

In 2004, the FSI (with assistance from the National Remote Sensing Centre, ISRO, Hyderabad) launched a mission to alert the state forest departments regarding forest fire locations with the help of the MODIS data from the Aqua and Terra satellites of the US National Aeronautics and Space Agency (NASA). Each satellite passes over India twice, and alerts are sent to users, i.e. citizens who have registered with the FSI website to receive alerts via SMS for their chosen state/districts. However, this does not prevent forest fires, as evident by the increase in their occurrence across the country. In 2012, the GoI also launched the "Forest Fire 2.0" initiative, designed to send alerts on the occurrences of forest fire via email using Google Earth along with compatible KML[d] files, to the officers of the state forest departments. This policy, too, did not aim to prevent forest fires. Thus, satellites have so far not been useful in minimising the risks of forest fires.

Green bots offer a solution to this problem by allowing for the monitoring of real-time activities in areas that are more prone to forest fires. As soon as the sensors detect a hazardous situation, such as a sudden increase in the surrounding temperature or the detection of smoke, management tools can be deployed to contain and minimise the impact of the forest fire. According to a World Bank Press Release in 2018, the creation of a national forest fire information database, bringing together satellite-based remote-sensing data and field-reported data, can prove instrumental in assessing long-term trends across states and regions.[24] Green bots will be key to creating this database, providing relevant information to the authorities to allow for predictive analysis.

The frequency of forest fires and the reasons behind their occurrence are grossly under-reported in our country. Consequently, the long-term impact of deforestation and the loss of biodiversity is poorly understood. For best results, biodiversity monitoring using green bots should be tied into the biennial national forest cover-mapping carried out by the FSI. Over time, every FSI report could include these monitoring results, for which the FSI may have to coordinate with organisations such as the Botanical Survey of India, the Zoological Survey of India, universities located in forest areas, the National Bureau of Plant Genetic Resources, think tanks, and other institutions with a similar mandate. Along with the State of Forest Report, the FSI could also include the state of "forest types," following regional ecosystem boundaries.

Improving the Lives of Tribal Communities

Many tribal communities in India suffer from severe discrimination and destitution, despite

d Keyhole Markup Language (KML) is an XML notation for expressing geographic annotation and visualisation within internet-based, two-dimensional maps and three-dimensional earth browsers.

living in areas rich in natural resources. The modernisation of the Indian society and industries has resulted in the exploitation of these resources, such as forests, relegating the local communities to the margins. At the same time, such modernisation has become an important source of revenue for the states. Large forests have been designated as "reserved" and put under the control of the state department, for the regulated extraction of timber and other produce. Consequently, tribal communities have been denied access to these resources, leading to conflicts between the community and the state's claim to the entire forest wealth. It is crucial for governments to formulate effective strategies to address these conflicts through developmental activities. In its Draft Policy 2018, the GoI proposed to launch the Community Forest Management Mission to improve the management of community forest resources through a participatory forest-management approach.[25] The Draft Policy also includes specific provisions to ensure that the interests of local communities are protected and that they are viewed as partners in the management of forests. In this regard, West Bengal has been a pioneer by developing the Joint Forest Management Programme (JFMP), which has now been adopted by various states such as Himachal Pradesh, Andhra Pradesh and Madhya Pradesh.[26] As a part of the JFMP, communities living in the vicinity of forests in West Bengal are now responsible for protecting the forests, plantation and wildlife; and preventing trespassing, forest fires, and any other activity not mentioned in the Indian Forest Act, 1972. In return, a share of the harvest is distributed amongst the community.

To improve this collaborative effort between the state and local communities, the latter must be increasingly integrated into modern society. One step in this direction is to introduce green bots in the areas where the tribal communities reside, involving them in the installation process and teaching them how to use them. The green bots will aid the communities in developing and better applying their indigenous knowledge and skills, without external interference. In states where a JFMP is already in place, green bots can improve the mechanism as well as the revenue generation for the tribal communities. In its preamble, the Paris Agreement on Climate Change notes the importance of recognising the relationship between indigenous people and their environment to improve the conservation, protection and preservation of forests.[27]

FOREST RESTORATION

India is a largely tropical to subtropical country, with the temperature being the most important factor in the growth and development of vegetation. It is home to diverse terrains and climates, which pose several policy challenges.

Building a Primary Database

Based on the Indian terrain complexity,[e] green bots can allow for the remote monitoring of

e According to the FAO 2011 report, the Indian forests based on the terrain complexity are (i) tropical rainforest; (ii) tropical moist deciduous forest; (iii) tropical dry forest; (iv) tropical shrubland; (v) tropical desert; (vi) tropical mountain (vii) subtropical mountain; and (viii) temperate mountain.

climatic conditions, such as humidity, rainfall and sunlight. If green bots are embedded into the soil, the sensors can likewise monitor the moisture, ground-water level and nutrients, enabling necessary measures to be taken.[28] Since the areas monitored by green bots are often remote, they can act as early warning systems for issues other than forest fires as well, such as droughts, floods and storms, which can be overlooked by satellites. The alerts naturally generated by the sensors can accordingly allow for preventive measures to be taken through active coordination amongst the agencies concerned.

The utility of green bots as a tool extends beyond simply providing soil or weather data. The technology can recognise and identify individual trees with a tracker called the Universal Resource Indicator (URI). The URI maps and labels each tree with its location coordinates (latitude and longitude), type, age, width, height, fruit and seeds, thereby creating an inventory. This digital inventory helps document the roots, types of soil, and climatic conditions for each significant Indian territory.

Identifying Areas for Afforestation

Given the shifts in Indian forestry from manicured landscapes to purpose-based plantations to enhance air quality, conserve water and counter global warming, a database of soil types by geographical area is of utmost importance. Approaches such as the "Miyawaki Method"[f] to grow urban forests are centred on the idea of cultivating native trees. For this, it is essential to analyse the soil type to recognise and subsequently ensure that the correct forest tree species for each region is easily determined. Such a database allows for the streamlining of the whole process of growing forests.

KEY CHALLENGES IN IMPLEMENTATION

The fundamental mechanism involved in using IoT in forest management is the capture of data through sensors, which are connected to the cloud and use the internet to disseminate real-time information. If India wants to harness the power of IoT in forest management, specifically green bots, the primary issue that needs to be addressed is the lack of internet connectivity in highly dense forests.

To ensure the use of green bots and IoT systems in forests, expanding the evidence base is a prerequisite. Since cities in India have their own jurisdictional and functional responsibility for planning, a "bottom-up approach" must be adopted. One way is to encourage implementation through Urban Local Bodies (ULBs). The 12th Five-Year Plan (2012–17) proposed reinforcing the ULBs and providing a financing framework to promote urban development. A comprehensive procedure involving ULBs, as well as communities, must be formulated and implemented.

Each forest in India poses unique challenges, which can only be resolved on a

f Miyawaki Method: The Miyawaki Method is a method for regenerating tropical forests using indigenous species of trees and plants.

case-by-case basis. There must be a joint, coordinated effort between people working across various fields—including climate change, land, and forestry—to provide sufficient viable data and use it to frame supportive policies. Further, departments and units responsible for forest management must be involved in the decision-making process to guarantee inclusive governance. To ensure a smooth and wide adoption of green bots, partnerships must be encouraged and facilitated between state governments and private organisations, ecologists and environmentalists, environmental non-government organisations (NGOs), and relevant academics.

The Question of Cost

The large-scale adoption of green bot mechanisms in Indian forests will entail a significant expenditure, since one small green bot can cost INR 1,000–1,500. The Central government's Compensatory Afforestation Fund (CAMPA)[g] is aimed at addressing the issue of deforestation in the context of India's development and industrial transition, and can be used as a source of funding. As of March 2018, an amount of INR 50 million has been accumulated and remains unutilised under the Ad-hoc CAMPA Act.[29] As a part of this Bill, the unutilised funds can be used to subsidise the cost of green bots, or fund them entirely, in the country's endangered forest areas.

Currently, India is working towards creating an additional carbon sink of 2.5 to three billion tonnes by 2030, by undertaking afforestation activities, e.g. the Miyawaki Method. The unutilised CAMPA funds can be redirected towards the development of a database to record information in an efficient and streamlined manner—such as the climatic conditions in a given region, type of soil, as well as the native trees of that region—while deploying green bots at the beginning of the planting process, marking each tree with a URI. A part of the fund can also be used for the maintenance of the green bots post installation and for research and development in the area of identifying new ways for the green bots to preserve and conserve the indigenous forests of India. Once green bots are widely accepted, subsequent research can focus on cutting down costs, reducing the size of the sensors, and enhancing their battery life. Already, the conceptualisation for 3-D printed green bots is underway, which can provide these sensors to remote and rural regions of India efficiently and at a lower cost.

Financing for ecological conservation can also be obtained through the private sector's Corporate Social Responsibility (CSR) funds, usually earmarked for long-term investments in sustainable development.[h] According to Section 135 of the Companies Act, 2013, companies are to set aside CSR funds

g Compensatory Afforestation Fund (CAMPA): The legal framework is designed to compensate for the loss of forests by mandating that new forest areas equivalent to the size of the forest diverted should be planted through afforestation. It is important to note that afforested land cannot become a forest as easily as it is thought, and a newly planted area will take around 50 years to mature. To compensate for the losses suffered in the interim, the Net Present Value (NPV) of the diverted forest is calculated by the expert committee for 50 years and recouped from the developers that cut down the forest.

h CSR in India is a result of the Companies Act, 2013. CSR in India is legislated with the hope that it will bring about a change in the attitude of corporate institutions, by giving back to the society in a big way as it is the society whose needs helped them prosper in the first place.

equivalent to no less than two percent of their net profit. These funds have non-profit-driven obligations, since they are utilised for the welfare of society. However, the current lack of adequate knowledge in terms of existing societal issues and policy measures hinders the channelling of CSR into appropriate projects. Often, companies may choose their CSR activities based on vested interests, often aligning them to their area of business, instead of serving the greater needs of society. Between FY2014–15 and FY2018–19, approximately INR 48.42 billion have been spent towards "environmental sustainability" through CSR funds.[30] Diverting even a small portion of this corpus towards leveraging technological solutions for effective forest management will help solve many existing critical issues.

Green Bot Projects in India

In India, the implementation of a pilot project between the Institute of Wood Science and Technology (IWST) and Hitachi India is currently underway.[31] The latter has undertaken this project as a CSR activity. Under this project, IoT technology is being used to develop a solution for the monitoring and protection of high-value forest species, such as sandalwood and rosewood, at the Rural Bangalore/IWST campus in Malleshwaram Bengaluru.

According to Hitachi, a small sensor is worth INR 1,000–1,500, but Hitachi India is actively working to reduce this cost.[32] Moreover, as a part of its Smart Cities Initiative, the Ministry of Housing and Urban Affairs has allocated INR 70.6 billion for the quick expansion of IoT across the country, aiming to transform India into a digitally empowered economy and society.

CONCLUSION

Globally, technological innovations such as IoT, blockchain, artificial intelligence and Big Data analytics are being increasingly adopted in various sectors including healthcare, banking and environmental management. Using smart sensors (or green bots) as a tool in forest management can prove to be a game-changer in monitoring forest activities and ensuring the sustainable use of resources. For activities such as poaching and illegal logging, which cannot be easily detected with remote sensing, green bots can be utilised to gather data and inform policymaking. To this end, they can also improve transparency and accountability.

Green bots can help monitor the health and growth of trees, contributing to the conservation and preservation of forests and flora and fauna; provide information that can help prevent forest fires and other catastrophes; and create databases that can aid in rapid reforestation. Once green bots start yielding results, they can even be utilised for increasing the green cover outside forests, since the existing forest cover cannot meet the country's current carbon sequestration targets.

The data captured by green bots can help create a real-time forest inventory, which can then inform all afforestation activities taking place in the country. Indian forests possess certain unique internal threats, and green bots can be vital in mapping them. By developing a more robust mechanism, the green bots can

also be programmed to alert the officials about man vs. animal conflicts in the forests, which have become more frequent in the recent years. Another potential function of the green bot could be saving the agriculture produce close to or within the forests from animals. This will help India meet and measure the national and international targets, such as the INDCs, as well as ensure the sustainable management of natural resources.

Green bots can be fundamental to the formulation of a well-informed local and national policy and planning. Developing countries face many challenges in obtaining and using basic information about the forests. Thus, information on daily forest area, burnt area assessment, and forest encroachment monitoring can enable greater responsiveness and decision-making for those responsible for the management of the forests and natural resources. While remote-sensing, too, can map the overall forest cover and the areas of deforestation, green bots have shown to yield better results. Finally, by identifying key areas of afforestation and promoting afforestation activities, green bots can eventually improve the connectivity of forests, improving biodiversity and expanding habitats for indigenous species. ORF

ABOUT THE AUTHOR

Anushka Shah is a Research Assistant at ORF.

ENDNOTES

1. "Annual Report 2017–2018," Ministry of New and Renewable Energy, 2017, https://mnre.gov.in/file-manager/annual-report/2017-2018/EN/index.html.

2. "Press Release," Ministry of Environment, Forest and Climate Change, 2019, http://envfor.nic.in/sites/default/files/press-releases/revised%20PPT%20Press%20Conference%20INDC%20v5.pdf.

3. "Press Statement," Ministry of Environment, Forest and Climate Change, 2015, http://www.moef.gov.in/sites/default/files/Press_Statement__INDC_English.pdf.

4. "India's Intended Nationally Determined Contribution: Working towards Climate Justice," UNFCC, 2015, https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf.

5. Cheryl Martin and Helena Leurent, "Technology and Innovation for the Future of Production: Accelerating Value Creation," World Economic Forum, 2017, http://www3.weforum.org/docs/WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf.

6. "India IoT Report – Emergence of a New Civic," Tata Communications, 2018, https://www.tatacommunications.com/wp-content/uploads/2018/02/IoT-Report.pdf.

7. "Draft Policy in Internet of Things," Ministry of Electronics and Information Technology, 2015, https://meity.gov.in/writereaddata/files/Revised-Draft-IoT-Policy_0.pdf.

8. Ibid.

9. Rama Krushna Das, Manisha Panda and Sweta Shree Dash, "Smart Agriculture System in India Using Internet of Things," 2018, https://link.springer.com/chapter/10.1007%2F978-981-13-0514-6_25.

10. Fasal, https://fasal.co/.

11. Anushruti Singh, "Agricultural Drones: The Shape of Indian Agriculture to come," SME Futures, 10 January 2019, https://smefutures.com/agricultural-drones-shape-indian-agriculture-come/.

12. "Forests and Forestry Sector," Food and Agriculture Organization of the United Nations, 2016, http://www.fao.org/forestry/country/57478/en/bra/.

13. Treevia, https://treevia.com.br/?lang=en#solucoes.

14. "Wood is Good," Centre for Science and Environment, 2017, http://admin.indiaenvironmentportal.org.in/files/file/wood-is-good.pdf.

15. Ibid.

16. Staff Reporter, "33 Sandalwood Trees Stolen from BU Campus in Five Days," *The Hindu*, 21 April 2018, https://www.thehindu.com/news/cities/bangalore/33-sandalwood-trees-stolen-from-bu-campus-in-five-days/article23622221.ece.

17. "India State of Forest Report 2019," Forest Survey of India, http://fsi.nic.in/isfr19/vol1/chapter2.pdf.

18. PIB, "India's Intended Nationally Determined Contribution is Balanced and Comprehensive: Environment Minister," Ministry of Environment, Forest and Climate Change, 2 October 2015, https://pib.gov.in/newsite/PrintRelease.aspx?relid=128403&utm_source=twitterfeed&utm_medium=twitter.

19. CPR Environment Education Center, Sacred Groves of India, http://ecoheritage.cpreec.org/innerpageof.php?$mFJyBfKPkE6.

20. "India State of Forest Report 2017," Forest Survey of India, 2017, http://fsi.nic.in/isfr2017/isfr-forest-fire-2017.pdf.

21. Shreehari Paliath, "Forest Fires Increased 158% In 6 Years; Warming A Factor," India Spend, 2018, https://www.indiaspend.com/forest-fires-increased-158-in-6-years-warming-a-factor-experts-53125/.

22. "Details of Economic Loss due to Forest Fire from 2016 to 2018," Ministry of Environment, Forest and Climate Change, https://data.gov.in/resources/details-economic-loss-due-forest-fire-2016-2018-ministry-environment-forest-and-climate.

23. "Strengthening Forest Fire Management in India," Ministry of Environment, Forest and Climate Change and the World Bank, 2018, http://documents.worldbank.org/curated/en/333281529301442991/pdf/127284-Forest-Fire-Prevention-Management-8Oct2018.pdf.

24. "Strengthened Forest Fire Management to Help India Meet Climate Change Goals," 2018, http://www.worldbank.org/en/news/press-release/2018/10/09/strengthened-forest-fire-management-to-help-india-meet-its-climate-change-goals.

25. "Draft National Forest Policy, 2018," Ministry of Environment, Forest and Climate Change Forest Division, 2018, http://www.indiaenvironmentportal.org.in/files/file/Draft%20National%20Forest%20Policy,%202018.pdf.

26. "Resolution of JFM Committees in the districts of South West Bengal," Government of West Bengal, 2008, http://www.westbengalforest.gov.in/upload/actrules/jfm8.pdf.

27. "Paris Agreement," United Nations, 2015, https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

28. Phytosense, http://www.phytosense.net/forgrowers.html.

29. "Guidelines for Investment Policy and Procedure for Investment of Funds Lying with Ad-Hoc Campa," Ministry of Environment, Forest and Climate Change, 2018, http://envfor.nic.in/sites/default/files/Anexxure%20I%20Campa.pdf.

30. "CSR In India," 2019, CSR Box, https://csrbox.org/CSR-in-India.

31. "Press Release: Institute of Wood Science and Technology and Hitachi India collaborate on

SMART Forests," 2017, https://hitachi.co.in/press/2017/20171011.html?WT.ac=in_press_2017_171011.

32. Ibid.

ORF OBSERVER RESEARCH FOUNDATION
Ideas • Forums • Leadership • Impact

20, Rouse Avenue Institutional Area, New Delhi - 110 002, INDIA
Ph. : +91-11-35332000 Fax : +91-11-35332005
E-mail: contactus@orfonline.org
Website: www.orfonline.org