
AI for Good
Capgemini
PROTECT
OUR FORESTS
Quest towards sustainability
with the help of AI

*“First and foremost,
we must triple the speed of
the shift to renewable energy…
It means protecting forests
and ecosystems as powerful
climate solutions.”*

GENERAL ANTÓNIO GUTERRES
UN Secretary[1]

Forests are at the heart of our fight for sustainability

Accounting for a little over one-third (38%) of habitable land area in the world, the importance of forests to earth's diversity of life is hard to overstate.[2]

Forests play a crucial role in carbon sequestration, the ability to capture and store carbon, removing it from the atmosphere. As the globe warms – and 2021 was the seventh consecutive year when the global average temperature has been more than 1.1°C above pre-industrial levels[3], inching closer to the 2°C limit of the 2015 Paris Agreement – this purpose is increasingly necessary. "The climate is not on track, so we really need to predict, mitigate, and respond to these forest disturbances in order to have more effective and sustainable forest management solutions," reported Inge Jonckheere, Forest and Climate Officer at the Food and Agriculture Organization of the UN (FAO) at Capgemini's 2022 AI for Good webinar.

In addition to absorbing and storing carbon, forests are home to earth's most diverse species, and they provide a natural barrier between natural disasters and urban zones – all of which contributes to the quality of human life on earth.

Unfortunately, the degradation of forests and deforestation altogether continues to take place at alarming rates. Since the 1990s, the area of primary forest worldwide has decreased by over 80 million hectares, with significant consequences for biodiversity and global warming.[4] In a cruel cycle, climate change (combined with land-use changes by humans) is projected to cause a global increase of extreme fires, 14% by 2030, 30% by 2050, and 50% by the end of the century, further reducing the size of old-wood, diverse forests.[5]

Forests are integral for human development

Adopted in 2015, the **UN's Sustainable Development Goals** provide a call to action in all areas of life. While forests are most evidently linked to SDG 13 and 15, they also have direct and indirect impacts on various others.

Important to note is the secondary ways in which forests touch the SDGs – for instance, forests contribute to ending poverty (Goal 1) by reducing vulnerability to natural disasters. They contribute to achieving food security (Goal 2) and water and sanitation (Goal 6) by regulating rainfall and hydrology – thus also providing clean water which reduces disease and contributes to healthy lives (Goal 3)[6]. The impacts of trees on human development, and thus on the SDGs, is extensive.

Many **people's livelihoods, especially in developing countries, depend on intact forest resources** such as firewood, forest-based plant food and medicines. An abnormally large wildfire can be disastrous! (target 1.5, 2.1, 2.4)

Smoke from wildfires causes air pollution and adversely affects health (target 3.4.1, 3.9.1, 3.d). **Wildfires release harmful pollutants** including particulate matter and toxic gases such as carbon monoxide, nitrogen oxides, and non-methane organic compounds into the atmosphere.

When they spread to urban or semi-urban areas, **wildfires can damage infrastructure** (target 9.1, 9.4, 9.a, 9.c.1) such as power lines, mobile phone masts and homes. Rebuilding may be costly or time consuming.

Wildfires **contribute significant greenhouse gases** to the atmosphere and thus exacerbate climate change (target 13.1, 13.2.2, 13.3). Forest- and land-based climate action has the potential to contribute to upto 20% of the needed emission reductions to meet the 2°C goal (Paris Agreement)

Air pollution caused by wildfires causes or contributes to acidification of lakes,eutrophication of estuaries and coastal waters, and mercury bioaccumulation in aquatic food webs. Forest management action has the potential to minimize ocean acidification (target 14.1,14.3).

While humans have used fire to manage landscapes for thousands of years, current wildfires, exacerbated by global heating and drought, are growing in scale and impact, **destroying houses, infrastructure and wildlife—affecting biodiversity** (15.1.1, 15.2, 15.4, 15.5,15.7,15.b).

Observe, Defend, Enhance – the time is now

While deforestation – the removal of forests to be replaced with mines or urban development – typically commands the most attention from policy makers, forest degradation is just as detrimental. A gradual process defined by the slow decline of a forest's biomass, soil quality, and species composition, a lack of ability to monitor changes and poor understanding of its causes results in less attention from those who could fight its effects.[7]

More land mass is affected by forest degradation than deforestation, and forest degradation usually leads to deforestation, thus it is a larger challenge overall. Solutions built to support forests must fully understand, monitor, and visualize the catalyst of forest degradation in addition to the second stage, deforestation.

Tackling these challenges

The urgency to tackle the quest of preserving our forests is not new, and Ms. Jonckheere stated it clearly: "The climate crisis is here, it's now, so monitoring and forecasting forest land use is more crucial than ever. 11% of [carbon] emissions are due to deforestation and forest degradation, so we really need to focus on reforestation. It's one thing to know about the data and what's going on, and another thing is to act."

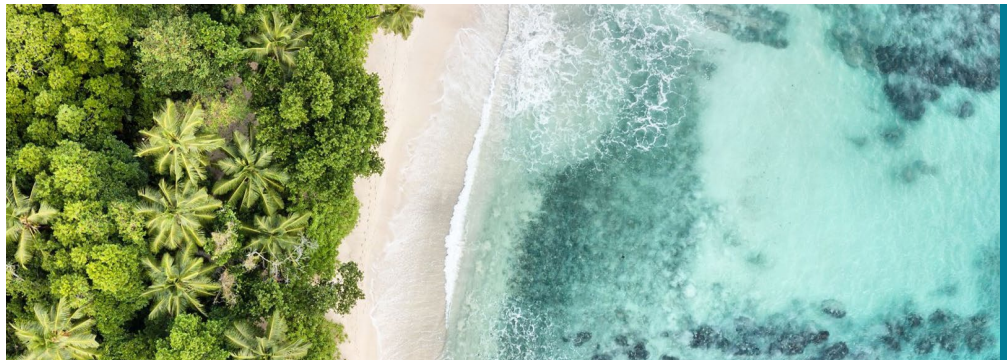
Consolidated efforts are required to tackle this global problem – with the human leading and technologies helping. We need effective governance, integrated policies, and monitoring of resources through advanced technologies such as Data and AI, which have the potential to better manage forest resources through critical insights & analysis – to better observe, defend, and enhance our forests.

Observing

The indicator for measuring progress toward halting deforestation should be based on independent analysis of satellite imagery. Progress in remote sensing technology now allows accurate measurement of annual changes in forest cover from space, including the ability to model the quality and type of the forest. This allows innovations such as observational technologies taking note and informing the relevant authorities when invasive species appear and target one species of vegetation. As a result of these innovations, the international community's previous system for monitoring forest cover change – in which the FAO compiled self-reported data from member countries every five years – is now completed by annual, monthly and near real-time data that help to observe what happens, and to understand scaled leitmotivs and dynamics.[8]

By using AI in combination with satellite imagery, the physical labor that goes into this tedious process can be reduced tremendously, while benefits such as data precision and quality are derived.[9] Using pre-existing data available from governments together with high-resolution satellite images, the comprehensive tree-level maps (inventorying forests by predicting the sizes & species of trees) can be used to ***determine the effects climate change has on sustainable land practices***, support or improve species habitat, and provide a more sustainable harvest.

Advances in remote sensing technology make it possible to track and respond to events threatening forests in near real time and to measure forest-based emissions annually with a high degree of accuracy. These will enable preventative measures and timely responses.



"We need to know and monitor before we can really act."

Ms. Jonckheere

Across geographies, several actors already started to leverage Data & AI to better observe forests:

1. The World Resources Institute (WRI), which has used spatial modeling software and an artificial neural network architecture to map the links between past forest loss and its drivers in these landscapes, whether tied to biophysical factors (elevation, slope, and precipitation), accessibility (distance from roads, settlements, rivers, conflict, and shifting cultivation), or land management (forest concession and protected areas).[10]

2. Global Forest Observations Initiative (GFOI – hosted by FAO), an informal partnership to coordinate international support, is using remote-sensing and ground-based observations in developing countries on forest monitoring and greenhouse gas (GHG) accounting.

3. SilviaTerra (now NCX), as part of the Microsoft AI for Earth grant program, established a system that builds a list of the trees standing in each 0.02 hectare (smaller than the footprint of an average U.S. home). The list includes the species of each tree and their diameters as measured 1.4 meters off the ground and other key metrics, such as tree height and total carbon storage, can be derived from these values.

4. Capgemini, in partnership with the European Space Agency and NASA, is using satellite data from the Biomass satellite mission to map forests. This data is collected in a cloud native network and shared, allowing analysts to measure forest resources, the carbon cycle, and reduce uncertainties about carbon emission from deforestation. The different satellite missions offer various data like amount of biomass above the ground, degradation data, and tomographic cube data (which shares the vegetation cover in 3 dimensions on different vertical layers).

Geosatellite imagery is not the only technology revolutionizing the observation of forests -- observing soil moisture levels, which can then be used for wildfire prevention and drought prediction is being innovated by the University of Maine's wireless sensor networks laboratory. By using an AI system that learns from the environment, predicting incoming solar energy and the quality of a sensor's wireless link, networks of soil sensors can be used efficiently at lower cost. Adjusting the data collection and transmission frequency rather than sampling and sending every data point allows for a greater adoption of these systems by smaller, public sector or non-for-profit organizations focused on **conservation.**[11]

Observing forests is an important step, but these initiatives must be paired with a tangible response if they are to address any of the many challenges. "The pressures on forests are compounding, so it's not enough for us to just watch and report on the changes that are happening," said Kait Creamer from Overstory, a startup using geosatellite imagery to create real-time vegetation intelligence, during the AI for Good webinar. A wholistic response for management and forest defense requires observations via satellite or remote sensing technologies to be combined with in-situ observations and data to be validated. With this systematized coordination of new technologies and in-situ data, observational initiatives must be supported via interconnected datasets, especially of datasets that include cross-border forests. Only then can observations be used to their full potential to defend the forest.

Defending

One of the greatest threats to forests, and to the human and animal lives that depend on it, are wildfires. Causing billions of dollars a year in damage, climate change is increasing these once-rare events from natural and expected experiences into massive and forest-altering catastrophes. In recent years, wildfires also started to appear at high scale in geographies for the first time such as this summer in London, leading to the London Fire Department's "busiest day since **WWII".**[12]

With the advance of machine learning techniques, such measures as fuels characterization, fire detection, and mapping; fire weather and climate change; fire occurrence, susceptibility, and risk; fire behavior prediction; fire effects; and fire management have been defending forests and their inhabitants from **catastrophic effects.**[13] For example, monitoring tree health and combustible biomass on the ground, provides data that can be used in algorithms to predict the size, spread, and probability of a **fire outbreak.**[14] "We need to know the past in order to predict the future," argues Ms. Jonckheere, "and for this, machine learning and AI can really help." Not only can this type of analysis protect forests themselves, but it can prevent loss of life by accurately predicting which inhabited areas should be evacuated at which point in a wildfire.

One company already using data and AI to defend against wildfires **is Salo Sciences**, based in San Francisco, California. With AI-driven digital monitoring, reporting, and verification tools, they can see the vegetation layer below a tree canopy, and determine wildfire risk. This information allows them to forecast how potential fires will spread, and other variants of the wildfire threat such as burn probability and potential flame length.

Fires are not the only threat to defend forests against -- focusing on health and biodiversity of a forest can mitigate degradation that results in deforestation.

Palm oil, derived from palm trees grown in large plantations, is a highly profitable agricultural input covers 27 million hectares of **land**[15] and has driven the deforestation of 2.3% of global forests (5% when only **considering tropical hectares).**[16] To defend against this, over 97% of globally traded oil palm is under a zero-deforestation commitment – but that commitment must be **verified.**[17] Using satellite imagery combined with deep learning algorithms, images of palm oil plantations and the forests that surround them can be scanned and the trees identified based on the color, size, shape and pattern of the pixels – verifying that the area planted with palm has not **expanded.**[18]

Defending against invasive species, **Sogeti Sweden's AI solution** produces maps that visualize the progression of spruce bark beetles, which destroyed 3-4 million cubic meters of forest in Sweden in 2018. By combining geo-satellite imagery with advanced algorithms that identify which trees are effected, the progression of spruce bark beetles can be visualized and quickly managed by on-the-ground foresters. In the Waikamoi preserve of Hawaii, a similar AI initiative is helping to defend against an invasive weed that destroys the environment for native plants, Himalayan ginger. After training algorithms to recognize the plant from drone, helicopter, or satellite images, environmentalists can quickly see where the weed has sported, and remove the weed before it forms a dense mat on the **forest floor.**[19]

Stéphane Mermoz, CEO and Research Scientist at **GlobEO**, a company that provides services based on Earth observation and remote sensing data, shared as part of the AI for Good webinar that another use case for predictive algorithms is illegal mining – data show that illicit mining operations on Indigenous lands and in other areas formally protected by law have hit a record high in the past **few years**[20] - so we can use analysis through AI and machine learning to build correlations for predicting deforestation.

Defending forests successfully requires international cooperation and transnational partnerships, especially as technology and data-driven knowledge is playing a growing role in defensive innovations. Making forest data available and sharable across countries so that it can be used in algorithmic prediction models and in new, innovative AI applications, is imperative to defending forests from cross-border threats.

Enhancing

Responding to threats, however, will never rebuild the forest lost in the past – using data coming from earth observation programs, combine to in-situ data and indigenous knowledge can help proactively support global forests ecosystems.

Via reforestation, first:

The **trillion Trees initiative**, launched at Davos 2020, is shaped to directly address the **UN Decade on Ecosystem Restoration** and SDGs, and aims to support reforestation efforts by planting **at least 1 trillion new trees by 2030**. The number of organizations planting trees in the tropics has increased 288% since the 1990's, and these organizations report planting nearly 1.4 billion trees since 1961. With the newest AI and Data technologies however, reaching that 1 trillion goal, and doing it efficiently and effectively, is within reach.

Drones, combined with AI, can be used as an enhanced measure to reforest, especially in difficult to reach areas. The Canadian company **Flash Forest** is one example of the many companies leading such approaches, first using a mapping drone to map the area to be planted. Then, an algorithm identifies zones where seeds are unlikely to take root (rocks, streams, etc.) and the company's software calculates the optimal density of seeds and drone paths for planting. Mechanical "guns" on the drones can then plant (firing them at 165 km/hr into the ground, buried 2.5 cms into the soil) five seed pods per second, far faster than human-driven planting efforts.

However reforestation, even when enabled with the use of drones, is not going to solve the deforestation problem today. It takes several decades to regrow trees to see the same level of carbon sequestration attained by those lost to deforestation, some of which have existed for several millennia, so the sooner we can plant and incubate new life, the better off we will be in the future.

With data-driven insights into the type of forest and compatibility of soil, reforestation efforts will have more success – currently, ***the emphasis on tree planting fails to account for how many trees survive infancy***, or how many organizations diversify the type of trees they plant, accounting for necessary forest diversity. More information about the specific type of tree needed in each reforestation location will support real change, rather than well-meaning but ill-informed reforestation efforts. This is an opportunity for data and AI.

Via Urban Forestry, second:

As the populations of cities grow and their temperatures rise, trees become ever more important as carbon sinks and as leaf cover to shade the homes and inhabitants below. Urban heat islands occur when hot air is trapped between closely situated buildings and dark-colored roads that seal the earth from absorbing the heat and cooling temperatures during the night. Both dense areas of trees within the city limits, and sparce tree cover dispersed throughout city streets provide relief, but must be maintained amidst harsh city growing conditions. “Urban forests” can mitigate stormwater, cool air temperatures, improve air quality, and enhance the livability of communities.

An example of AI empowering urban forestry is the **Google Tree Canopy Lab in Los Angeles**, which uses satellite imagery and a tree-detection AI to map the density of tree cover in the city. Policy makers can then identify neighborhoods outside of the typical public spaces that could benefit from an increase in trees – to lower street temperatures, increase shade, and establish carbon sinks outside of the traditional public parks.

A startup doing similar work in this field is PlanIT Geo, an Arvada-based tech company that developed a **suite of software applications** to simplify and improve urban forest management. The company uses algorithms trained on satellite imagery and geographic data to map the distribution of trees in a defined area, allowing foresters and city officials with a big-picture view of the quantity and location of trees, and helps guide where new trees should be planted. Traditionally, staff would have been required to create this guide by hand, however with AI, the task is now less expensive, automated and thus less time-intensive, and easier to quantify positions with data points.

Data & AI help, the human commits and act:

AI & Data are tools with great potential to change the landscape of forest management. However, technology needs to be digested within policy activities and vice versa – and this includes work on "data availability, interoperability and room for action", emphasized Ms. Jonckheere.

Panelists at the 2022 AI for Good webinar heavily emphasized that initiatives with AI and data need to be linked to effective policies and better law enforcement. "Policy is the thing which holds us all accountable," Ms. Creamer remarked, "in a way that maybe an individual couldn't."

According to Ms. Jonckheere, we have two things – global data, like the IPCC global report, that serves the needs for policy makers, and the other is action that needs to be done on a national and local scale. Globally we do have the UNFCCC network, but then it's up to different nations to come up with policy and measures and follow up with their implementation. Linking these two is crucial because these are global data products which are very useful in the case that there is no national data which can be used by national government or local end users.

On the global policy front, more than 25 countries at the COP 27 climate talks (Egypt, 2022) have announced the creation of a group to hold each other accountable towards a pledge to end deforestation by 2030 (that was launched in 2021). The group of countries represents 35% of the world's forests. The group has pledged to coordinate the dispersal of $12 billion in funds pledged towards ending deforestation by 2025, of which so far, only 22% has been allocated.[21]

The group also plans to lead the dispersal of $1.7 billion promised to indigenous communities to promote land rights and forest protection, people for whom the forest ecosystem is their backyard. By funding community-led groups, international organizations empower people to lead the changes that will make the most difference in their own lives. As Ms. Creamer remarked in the AI for Good webinar, ""When we're conscious of making policy that serves our communities and businesses—with climate in mind—we create inherent motivation to follow through."

Data and AI are game-changing tools when supporting and counteracting the degradation of our world's forests, but rather than relying upon the existence of new innovations, it is a commitment to action that will be decisive in this sphere.

To reach the SDG's, humans need to make critical decisions about how to best leverage technology as to enable our commitment and ambitions, and to better understand, protect, and enhance forests.

More information on Capgemini's Assets

Supporting the European Space Agency with the Exploration of Forest Biomass

Sogeti Sweden Leveraging AI to Hunt Spruce Bark Beetles

Sustainability Data Hub

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