Asia-Pacific
Economic Cooperation

Best Practices on Tools for Combating and Preventing Illegal Logging Activities and Associated Trade

EGILAT Workshop to share experience, knowledge and challenges on implementation of tools for combating and preventing illegal logging activities and associated trade

Santiago, Chile, 23 – 25 February 2019

APEC Experts Group on Illegal Logging and Associated Trade

APEC PROJECT EGILAT 01 2018A

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Chapter 01.

OVERVIEW

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1. OVERVIEW

According to INTERPOL estimations, around 15 to 30 percent of the timber traded around the world is obtained through illegal logging activities, generating illegitimate revenues of between USD 50 to 150 billion annually. These actions lead to forest loss and degradation, as well as habitat destruction and consequent species extinction.

Some of the main challenges in preventing and combating illegal logging and its associated trade relate to the difficulties in monitoring large areas of forest cover. This is often exacerbated by the geographical remoteness of these areas and the limited human resources available to forestry enforcement agencies to monitor such areas. In this context, remote sensing technology, such as satellites and UAV, have proved to be a valuable tool for identifying illegal activities and focusing enforcement actions on the territory where illegal logging may be occurring. Traceability systems have also provided improved certainty and control on different stages of the supply chain of timber products

However, the significant differences in operating environments, climates, and forest product formats, can be constraining factors in successfully replicating those tools. The knowledge, experience, and challenges on the implementation of these tools could provide a valuable resource for their potential replication in other contexts and realities across all APEC economies.

This document aims to summarize best practices identified by the “Workshop to Share Experience, Knowledge and Challenges on Implementation of Tools for Combating and Preventing Illegal Logging Activities and Associated Trade.” The workshop was held on 23 and 24 February 2019 alongside the 15th APEC Expert Group on Illegal Logging and Associated Trade (EGILAT) meeting in Santiago, Chile.

It is intended to provide an overview of forest monitoring and supply chain traceability tools developed and used by APEC member economies and multilateral organizations to prevent and combat illegal logging and its associated trade (ILAT). Where possible, it seeks to also outline some of the practical considerations in applying such tools.

Chapter 02.

SOURCES OF INFORMATION

02

2. Sources of Information

As an option for discovering and updating knowledge and information about combating and preventing ILAT activities, Chile proposed in 2018 an initiative called "Workshop to Share Experience, Knowledge and Challenges on Implementation of Tools for Combating and Preventing Illegal Logging Activities and Associated Trade".

Chile sponsored the workshop, with Australia, Canada, Papua New Guinea, Peru, and the United States all supporting the project as co-sponsors. The implementation was accomplished through APEC funding support, as a two-stage project.

In the first stage of the project, relevant information was collected through a survey circulated to all APEC economies; with inputs received from 14 of them. The information collated through the survey was then used to identify key theoretical aspects, implementation challenges, and case studies to be further explored in the workshop.

The topics defined for the workshop, in consensus with co-sponsor economies and EGILAT members, were tools that are used along the supply chain or at different stages of the timber supply chain, from monitoring logging in the forest to sawmills and customs at points of imports, including:

- Remote sensing tools
- On-field tools
- Traceability and Timber origin tracking tools
- Wood identification tools

For the second stage, in February 2019 during the First Senior Officials' Meeting and Related Meetings of APEC Chile 2019, a two days workshop and a field trip were held in Santiago and Valparaiso Region, respectively.

In this instance, 14 APEC economies, as well as seven other organizations: University of Adelaide (Australia), Elements Software & University of Chile (Chile), Chinese Academy of Forestry (China), World Resources Institute, INTERPOL, and Forest Trends; were engaged in the event.

Diverse challenges and limitations for ILAT tools were covered during the presentations, including information such as cloud coverage and connectivity (for remote sensing), autonomy and performance (for UAV), industry and government interaction (for traceability) lack of reference databases (for wood identification) and tools usability and users engagement for most of them. This information, complemented with the survey's findings[1], were analyzed and later summarized to create this document.

Figure 1. *Participants of EGILAT 01 2018A "Workshop to Share Experience, Knowledge and Challenges on Implementation of Tools for Combating and Preventing Illegal Logging Activities and Associated Trade."*

[1] Only those tools presented in the workshop were included in this document.

Chapter 03.

WORKSHOP EXPERT SPEAKERS

03

3. Workshop Expert Speakers

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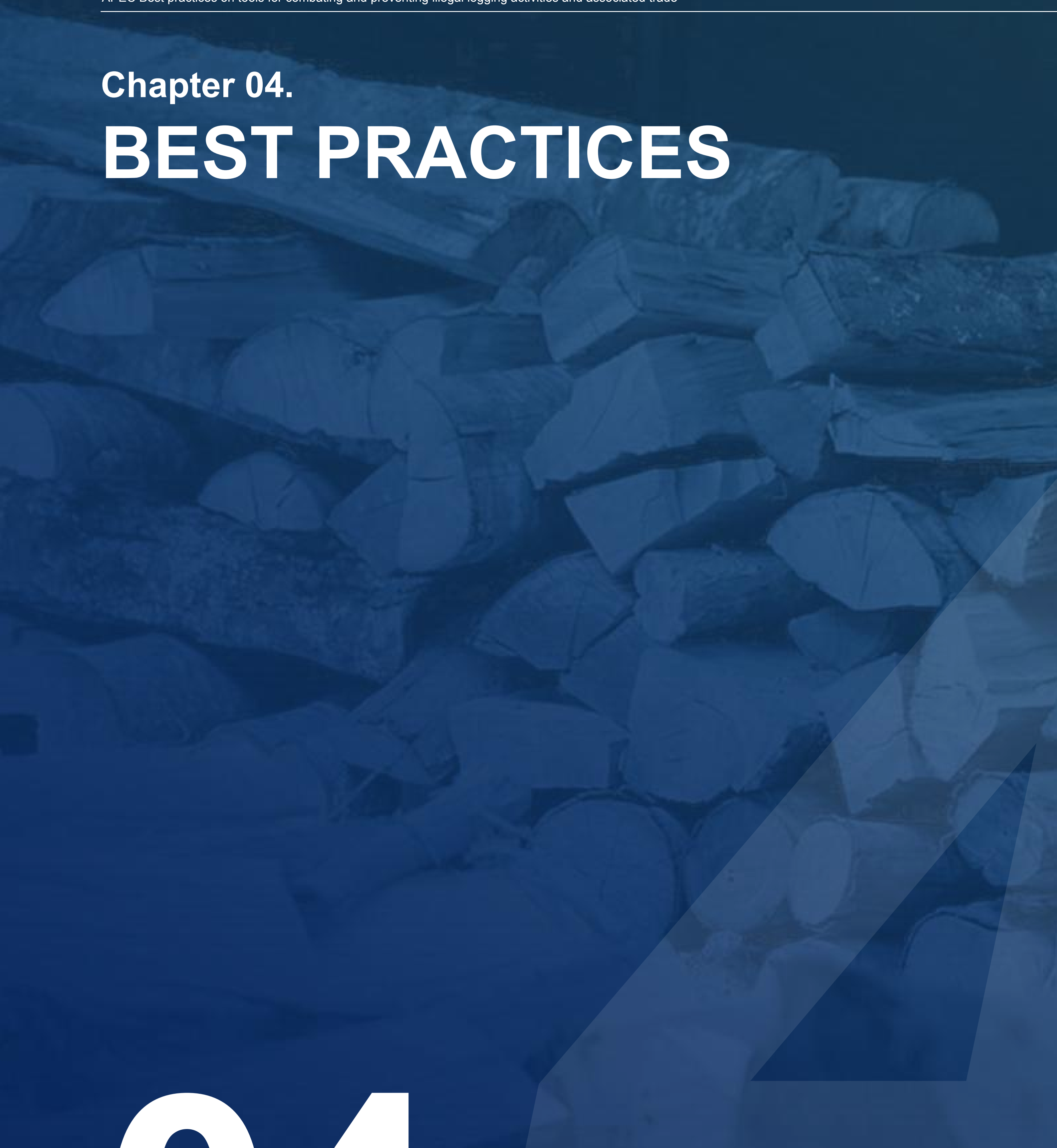
Figure 2. *Speakers of EGILAT 01 2018A "Workshop to Share Experience, Knowledge and Challenges on Implementation of Tools for Combating and Preventing Illegal Logging Activities and Associated Trade". From left to right: Ruth Nogueron, Chun-Lin Lin, Wan Abdul Hamid Shukri W A Rahman, Gonzalo Tapia, Andrew Lowe, David Kennan, Neil Garbutt, Shelley Gardner, Anna Tyler, Yafang Yin, Virginie-Mai Hô.*



Chapter 04.

BEST PRACTICES

04

4. BEST PRACTICES

4.1 Remote Sensing Tools

Remote sensing involves the acquisition of information through electronic devices without making contact with the studied object. This acquisition can be passive when electromagnetic energy coming from the Earth is retrieved (e.g., Landsat, Sentinel or MODIS satellites), or active when the device produces and captures its signal (e.g., SAR, LIDAR).

These resources are useful for monitoring extensive areas and identifying changes that can not be easily detected by human eyes (e.g., water stress, plague infestation); due to its capacity of retrieving information associated with the photosynthetic activity of the vegetation.

The main constraints of using them as a mechanism for preventing and combating illegal logging and associated trade are related mostly with spatial resolution (i.e., level of detail and minimum area of analysis), temporal resolution (i.e., availability and periodicity), atmospheric interference (i.e., cloud cover and reflectance source) and processing infrastructure (i.e., software and hardware).

4.1.1 Detect potential forest cover loss using satellite imagery

A reduced revisit time (higher temporal resolution) can promote an effective monitoring scheme and increases the probability of getting cloud-free images, whereas the use of specific bands designed for vegetation analysis (Red Edge, NIR and SWIR bands) improves the detection rate of forest cover changes. In compliment, higher detail (higher spatial resolution) could facilitate the identification of low scale illegal logging activities.

Employing photosynthetic activity variations which are estimated from satellite imagery using scientifically designed indexes, early warning systems can be created, providing systematic alerts about potential forest cover changes.

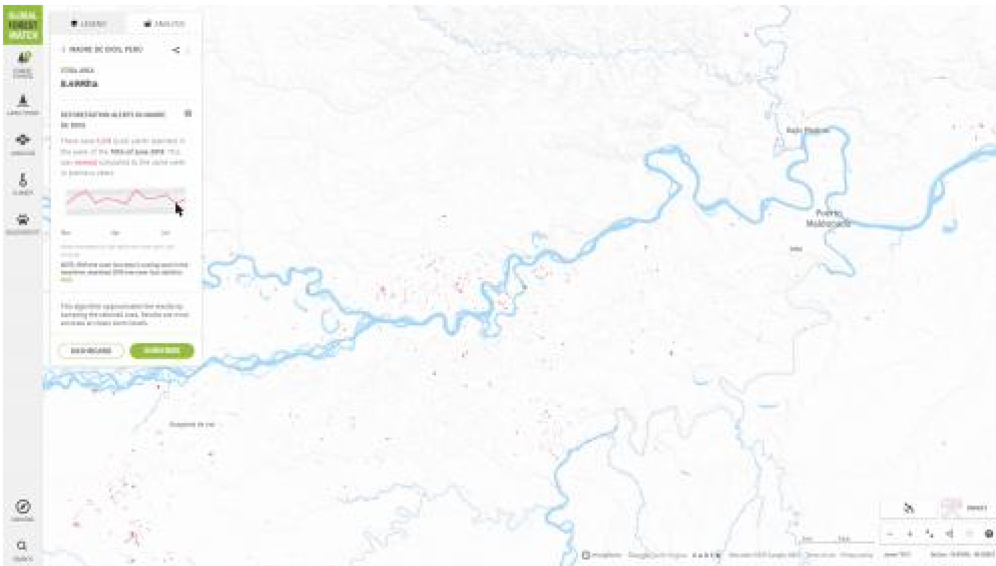


Figure 3. *Example of GLADS deforestation alerts (pink polygons) near Puerto Maldonado (Madre de Dios Department, Perú) from 01 Jan 2019 to 05 Jul 2019. Source: https://www.globalforestwatch.org*

It is worth to mention that image analysis can detect forest cover changes but cannot give potential causes of them directly; hence, they must always be supported by field work and relevant available historical GIS layers of the particular Area of Interest (AOI) for further validation.

Resources:

Global Land Analysis & Discovery (GLAD) Alerts (United States)
https://glad.umd.edu/projects/global-forest-watch
Geobosques, Platform for monitoring changes in forest cover (Peru)
http://geobosques.minam.gob.pe/geobosque/view/index.php

4.1.2 Explore cloud computing as alternative for processing

The primary constraint when using satellite imagery is the hardware and software resources required for processing such data. The problem exponentially scales when areas to be covered are extensive or when a historical analysis is needed. Although the open source software alternatives for image processing (e.g., QGIS, Grass) allow avoiding licensing costs, often dedicated equipment, including servers, must be used to support the previously indicated requirements.

Platforms such as Collect Earth and Google Earth Engine provide a valuable choice for monitoring large areas, due to their extensive data catalog, high-end processing capacity, and free of charge usage. Although they may require programming and user interface development, the final result could be user-friendly tools that can produce quick results and could be integrated into the planning stage of monitoring workflow.

Planet.com, although commercially based, currently provides free viewing access to monthly high-resolution images of the world from several satellite providers where it is possible for member economies to conduct an analysis of their own AOI.

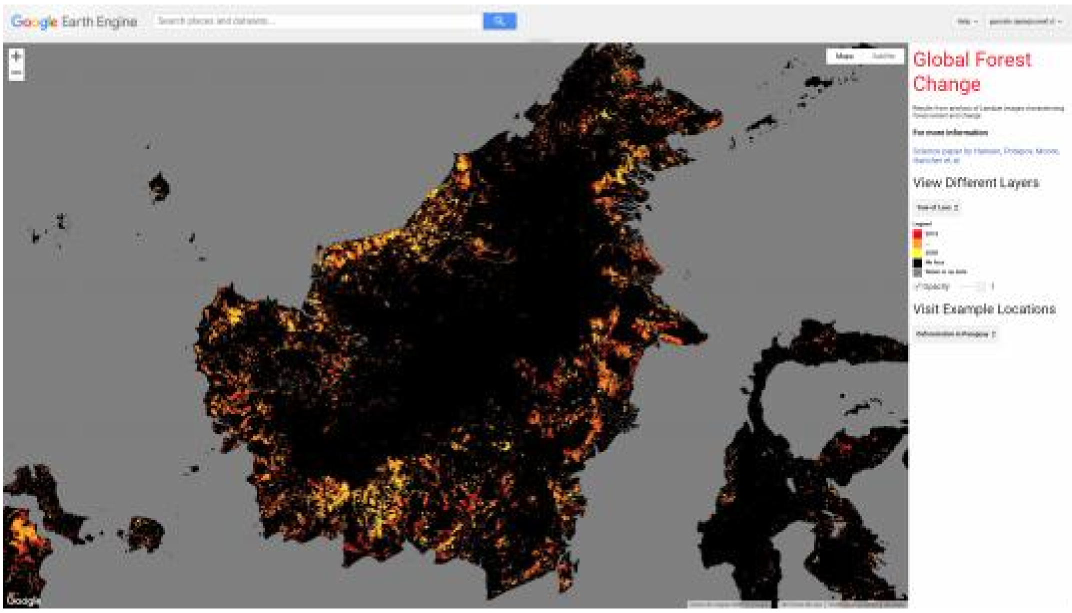


Figure 4. Forest change between 2000 and 2016 in Borneo Island, calculated using Landsat Imagery in Google Earth Engine. Source: Forest Change example on https://code.earthengine.google.com/

Resources:

Google Earth Engine, A planetary-scale platform for Earth science data & analysis
https://earthengine.google.com/

Collect Earth, Augmented Visual Interpretation for Land Monitoring
http://www.openforis.org/tools/collect-earth.html

4.1.3 Engage local communities and integrate GIS and mobile devices

A GIS platform containing both approved and current harvesting permits, as well as, information related to historical reports of illegal logging activities, is one of the optimal approaches for starting a forest monitoring tool. Long-term records may allow to discover spatial patterns, calculate the probability of new events occurrence and the identification of hot spot areas.

The increasing availability of mobile devices embedded with Global Navigation Satellite Systems (GNSS), to determine location, tracks and navigation plus real-time reporting , in addition to the participation of local communities with their vast knowledge on their forests and what is happening with them, has proved to be an enormous source of information that could be used for proper evaluation and feedback of detected forest cover loss.

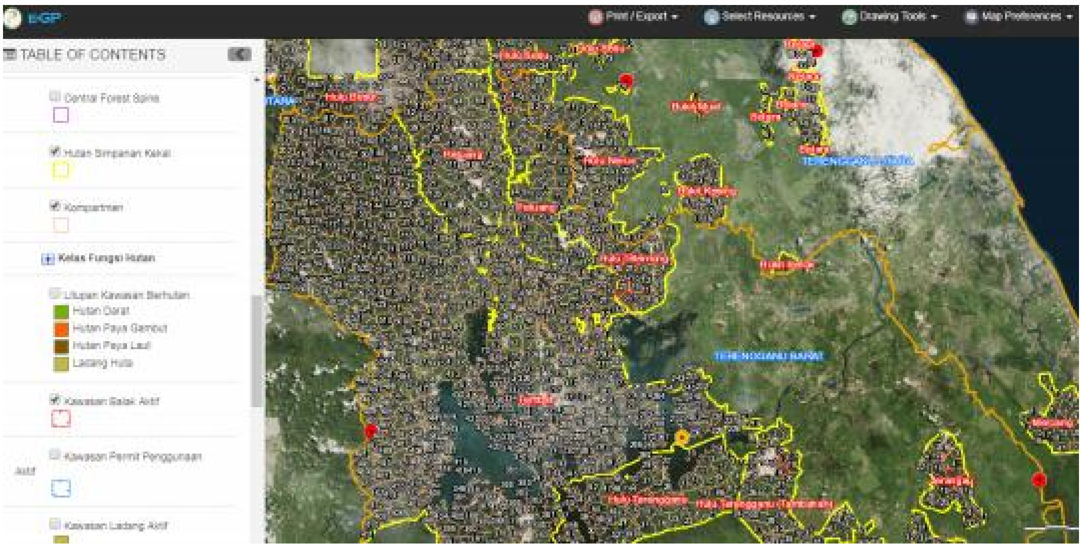


Figure 5. *Interface of a customized forestry GIS web-based application developed by Malaysia, with pertinent layers inserted for visual change detection analysis. Source: Malaysia FRMS.*

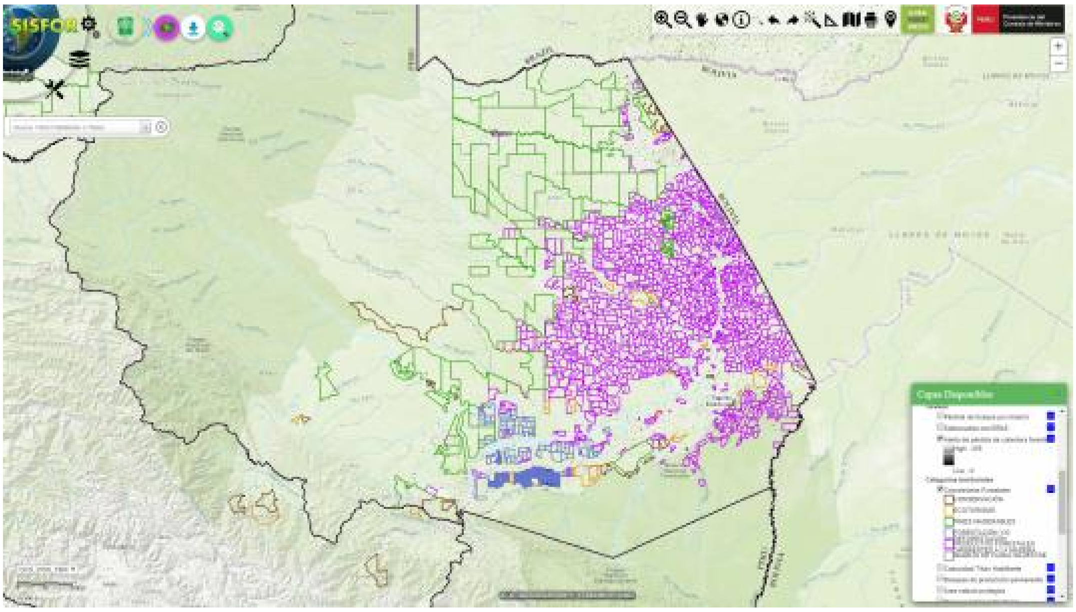


Figure 6. *SISFOR platform combines information about forest concessions and forest loss alerts. Source: https://sisfor.osinfor.gob.pe/visor/*

A 'win-win' approach with the local communities where their participation will partly reap benefits to them are critical in ensuring its success and sustainability. Successful examples of this are the projects conducted by indigenous people and NGOs using the platform Global Forest Watch for detecting and monitoring forest cover loss in Mexico, Peru, Uganda, and Indonesia, among others economies.

Figure 7. *Peruvian indigenous communities participating in field activities for deforestation alerts checking. Source: Ruth Nogueron (WRI).*

Even though Internet connection could be a limiting factor in remote areas, hybrid solutions employing local storage and later connection with a centralized database are a feasible option for those conditions.

Resources:

SISFOR, Geographic Information System of Forest and Wildlife Supervisions (Peru)
https://sisfor.osinfor.gob.pe/visor/
Global Forest Watch, Forest Monitoring Designed for Action
https://blog.globalforestwatch.org/
Forest Watcher, Mobile app to track and reduce tree cover loss
https://forestwatcher.globalforestwatch.org/
Forest Monitoring Using Remote Sensing (FMRS) (Malaysia)
http://www.remotesensing.gov.my/portal/index.php

4.1.4 Minimize error sources and false positive detection

Image mosaicing technique (i.e., create a scene based on a set of small parts) could be the most appropriate option for near cloud-free image generation, depending on imagery frequency and time frame. Filtering and masking options must also be applied to obtain the ''cleanest'' products for the mosaic creation.

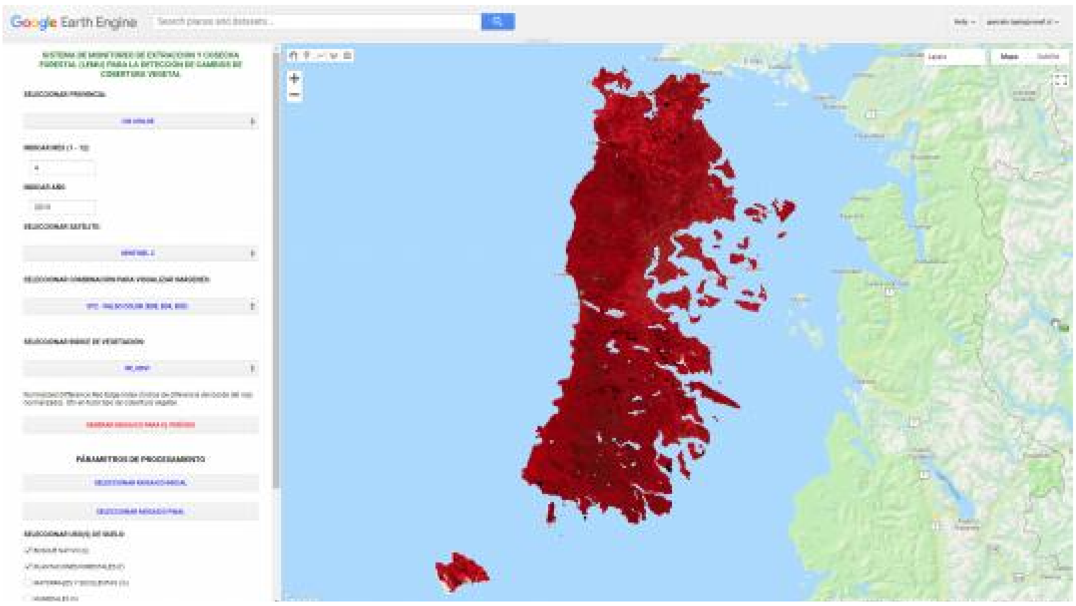


Figure 8. Cloud-free mosaic of Chiloé Island (Chile, April 2019), created using the Logging and Extraction Monitoring Unit (LEMU) and Sentinel-2 images. Source: CONAF (Chile).

In another hand, due to its wavelength properties, SAR sensors (e.g., ALOS, Radarsat, Sentinel 1) can penetrate through clouds and avoid the "image contamination" produced by them or their shadows. However, changes in soil moisture or snowfalls that affect ''surface roughness'' may contaminate the analysis; hence their influence must always be taken into consideration.

Integration or fusion of radar with optical images of the area of interest using the remote sensing method is among the better options to enhance image clarity for visual interpretation and analysis.

Resources:

Global Forest Watch, Forest Monitoring Designed for Action
https://www.globalforestwatch.org/
JICA-JAXA, Forest Early Warning System in the Tropics (Japan)
https://www.eorc.jaxa.jp/jjfast/system.html

4.2 On-Field Tools

In the context of this document, on-field tools refer to any option that allows preventing or combating illegal logging activities directly in the forest, employing technology or human resources.

The availability of multipurpose mobile devices (e.g., smartphones, UAV, trap cameras, etc.) and the spread of internet connection toward rural areas have benefited the use of these tools, providing interconnection with centralized databases for retrieving real-time information and perform in-situ validations.

On another hand, their main difficulties are associated with accessibility, weather conditions, and extension of the object to be protected.

4.2.1 UAV are cost efficient for pre-assessments and inspection

A low-cost UAV aircraft provides a practical and straightforward solution for inspection on areas where pedestrian movement is restricted due to thick vegetation, rough topography, or safety conditions. It can also offer, in a single operation, real-time images and video, elevation data, and cloud-points for 3D modeling of the resources. The cost of the newest options for consumer level equipment could be around USD 1,500 to USD 2,000 per aircraft.

Figure 9. *DJI Phantom 4, a low-cost UAV option for forest surveillance and evaluation. Source: CONAF (Chile).*

In manual flight mode, these aircraft could review around 300 hectares per battery (20 - 25 minutes), whereas, in grid mode (i.e., using predefined paths for a later generation of orthomosaics) and depending on the overlay between flying routes, they could survey around 50 hectares per mission.

However, their use is restricted due to weather, and are not safer of using with strong winds or gusts, rain, high humidity, or fog conditions. Extreme temperatures and low atmospheric pressure may also affect their battery performance, reducing their flight time drastically. In addition, maximum flight height and distance from the operator are also constrained by aircraft regulations in some economies (to 400ft and 500m respectively).

Despite their limitations, they provide an excellent option for the inspections due to their ease of usage, range of vision, and portability. Therefore a proper planning stage, pre-defined routes, and battery replacements are good practices for improving the efficiency of these tools.

Each UAV vendor includes a proprietary software for capturing images and video, and in compliment, there is an extensive catalog of free applications available on Android and IOS for performing such tasks (e.g., Pix4D Capture, Drone Deploy, Precision Flight, etc.).

Although most of the alternatives for drone image processing (i.e., mosaic creation, digital terrain models or 3D representations) are commercial and subscription-based software, there is an option called “OpenDroneMap’’ which is an open-source project; hence it could be an inexpensive alternative for government agencies.

Figure 10. 3D representation of a recently harvested stand using UAV imagery and OpenDroneMap. Source: CONAF (Chile).

Besides, the imagery retrieved by UAVs could be used to estimate forest height and volume, and furthermore, combined with neural networks and artificial intelligence algorithms could be used to identifying individual trees and therefore perform a census.

Resources:

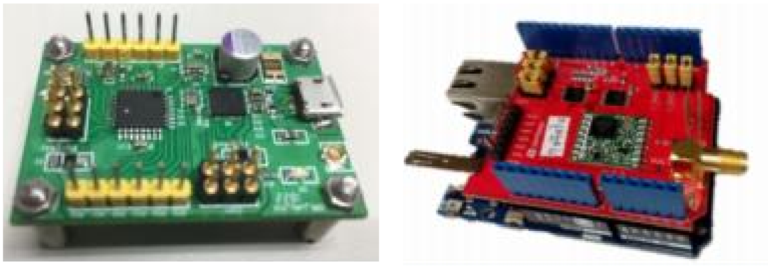
OpenDroneMap, Drone Mapping Software
https://www.opendronemap.org/

4.2.2 Take advantage of affordable solutions through IoT

Internet of Things (i.e., the interconnection of electronic devices through the Internet) can be used as an information transmission method, employing affordable and broadly available equipment (transmission modules cost between USD 50 to USD 100). This could be particularly useful in remote or mountainous regions, where accessibility, vegetation, and topography may interfere with the flow of information.

Solution & Plan-Equipment Spec.

Internet of Things for Alarm



- Operation Frequency : 868 MHz ~ 925 MHz
- Long Distance (12 Km@63mW ; LOS)
- Relay Mode : Re-Transmitting Forwarding
- Low Power Consumption (> 30 days Lifetime[1])
- Wake up Function
- Data Rate: 0.3~20 kbps
- Sensitivity ≦ -140 dBm

[1]In the condition for a full-charged (6400 mAh) mobile power and transmit signals per 10 sec.

Figure 11. *The specification of IoT wireless transmission and receiving modules. Source: Chinese Taipei Forestry Bureau.*

Devices such as people motion detector, as well as trap cameras and microphones -as information producers-, and IoT and transmission modules -as carriers-, can be combined to make use of this technology efficiently.

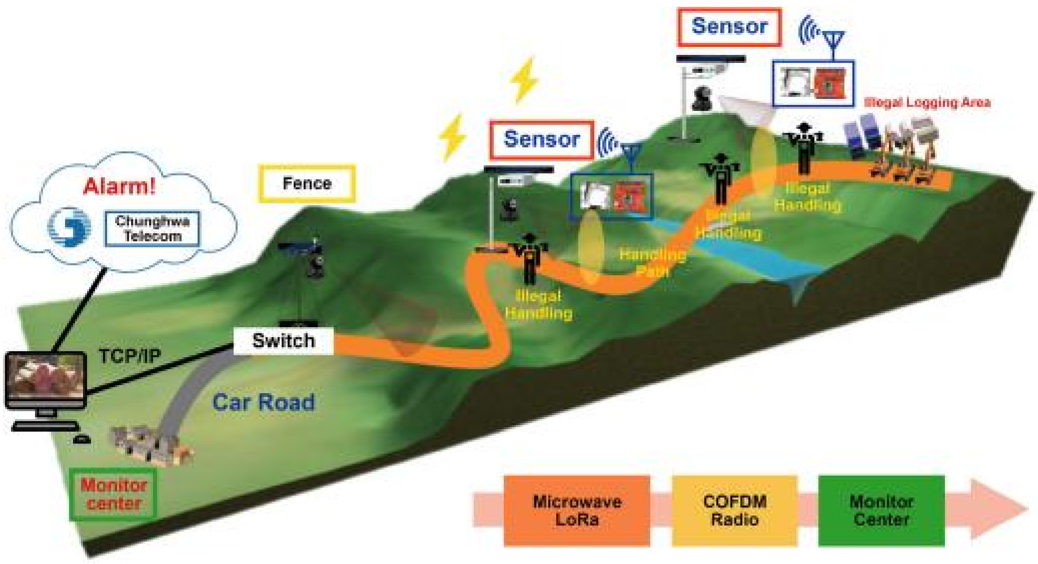


Figure 12. *The scenario for monitoring illegal logging IoT platform. Source: Chinese Taipei Forestry Bureau.*

Resources:

Forestry Bureau - Forest Land Management and Forest Protection (Chinese Taipei)
https://www.forest.gov.tw/EN/0002670

4.2.3 Empowering and properly training enforcement officers

Fieldwork performed by enforcement officers is the final, and perhaps, the most crucial resource for evaluating legality on timber harvesting and trade activities. However, to provide effectiveness and above all safety, their actions on the field must be supported by proper means of planning and deployment. Besides, their duties and authority must be granted and ensured by law, giving them an adequate legal framework for the proper performance of their jobs.

In compliment, training sessions related to legislation, species and wood identification, GPS and cartography, among others; must be periodically performed to build capacity and provide new knowledge for new and senior enforcement officers, respectively.

Resources:

LEI, Law Enforcement and Investigation (United States)
https://www.fs.fed.us/lei/index.php

4.3 Traceability and Timber Origin Tools

As defined by ISO, traceability is ‘’the ability to trace the history, application or location of an entity by means of recorded identifications.’’ When related to timber production, involves the harvest, storage, and transport of the products for ensuring their legal origin[2].

Within this context, the complexity of the process is mostly associated with product types, stages of production, internal regulations, and final destination (domestic or international).

4.3.1 Tracking timber movements

Transporting timber in most supply chains requires a paper-based waybill describing the species, volume, destination and origin of the timber being transported. Falsifying waybills has become regular practice to legitimize the legal origin of timber.

Typically, there are three or four transport movements: from the concession to the point of export with two main points of transformation: from the log to the sawn wood, and from the sawn wood to the product.

An online timber-tracking tool using a mobile app to create electronic waybills allows authorities to visualize timber movements online in real time. The movement data can be used to reconcile actual volumes harvested versus authorized volumes in harvest permits. Conversion factors at each transformation point and the use of mass balance calculations provide authorities with expected stock levels that can be verified during physical site or road checks.

[2] Source: Laporte, J.; Vandenhaute, M. Traceability A Management Tool for Enterprises and Governments. Programme FAO FLEGT, Technical Paper N°1. 2016. Food and Agriculture Organization (FAO), Rome, Italy.

Figure 13. Truck loaded with firewood being audited for ensuring timber legality with the support of mobile devices. Source: CONAF (Chile).

Any system tracking timber movements should only focus on the collection of data. Analysis of the data will then provide an indication of illegal activity. Attempting to incorporate legality restrictions over complicates the development of such a system increasing costs and timeframes for implementation dramatically.

4.3.2 Understanding who the end user is

Each actor in a timber supply chain plays their own unique role from concession owners, to sawmills and exporters alike. Exporters however have the responsibility to demonstrate the legality of the timber they are shipping to international markets. The exporters have the influence on their suppliers to ensure the supply chain records of the timbers legal origin are in order.

The end user of the traceability system is therefore the exporter, all other supply chain actors are data collectors. Data collection is a task already performed using pen and paper, through the introduction of simple mobile applications data collection becomes easier, more reliable and auditable.

Resources:

Elements Software Chile SpA, timber traceability systems
https://www.elementssoftware.cl/

4.4 Wood Identification Tools

Wood identification by enforcement officials is crucial in the national and international efforts to combat illegal logging and associated trade. Hence, the collaboration between enforcement and wood identification experts is key

It is a global challenge to have access to reference databases, encouraging the sharing of existing databases, and developing new ones.

4.4.1 Options and scope

There are four main approaches for identifying wood: computer-vision, anatomical, chemical, and DNA tools. Many experts recognize that these methods are complementary and can be used in an integrated way.

Computer-vision based wood species identification uses artificial intelligence to classify the wood species with visible light digital images of wood pieces/specimens. As with other technologies, the machine-vision system is trained and validated using scientifically vetted reference wood collections. Digital images of specimens from the wood collection are obtained, the deep-learning model is trained with wood images and then validated. The advantages of machine-vision based wood species identification are portability, low operational and equipment cost, and accurate classification to the species level.

As an example, the XyloTron machine-vision based system costs around USD 2,300 to produce with almost negligible operating costs. With a image proper database, species differentiation can be reached, providing law enforcement officers a practical option for their field work. Currently, the developer of XyloTron has a database that yields robust identification of 39 species with a validation accuracy of 98% to the species level and is currently working with several economies for increasing the number of species. Additionally, the XyloTron will be linked to Arbor Harbor.

Figure 14. *Example of the Xylotron machine-vision based system usage, scanning a transversal section of a piece of timber for its identification. Source: https://www.xylotron.org/index.html*

The anatomy tools involve macroscopic (hand lens) or microscopic (microscope) level, being the first the simplest but also lesser effective due the human interpretation. With the second option, a sample must be priorly obtained, processed, sectioned, and later stored, which involves proper maintenance. This method at best allows certainty to the genus level.

Figure 15. Wood specimens for wood identification training course. Source: Wood Collection, Chinese Academy of Forestry.

The chemical analysis based on mass spectrometry uses a machine that provides the biochemical profile of a piece of wood, wood powder or wood extractive and later compares it with reference data to estimate species and geographic region of the sample. The success rate reached with this method is higher than previous but requires expensive equipment and a comprehensive reference library.

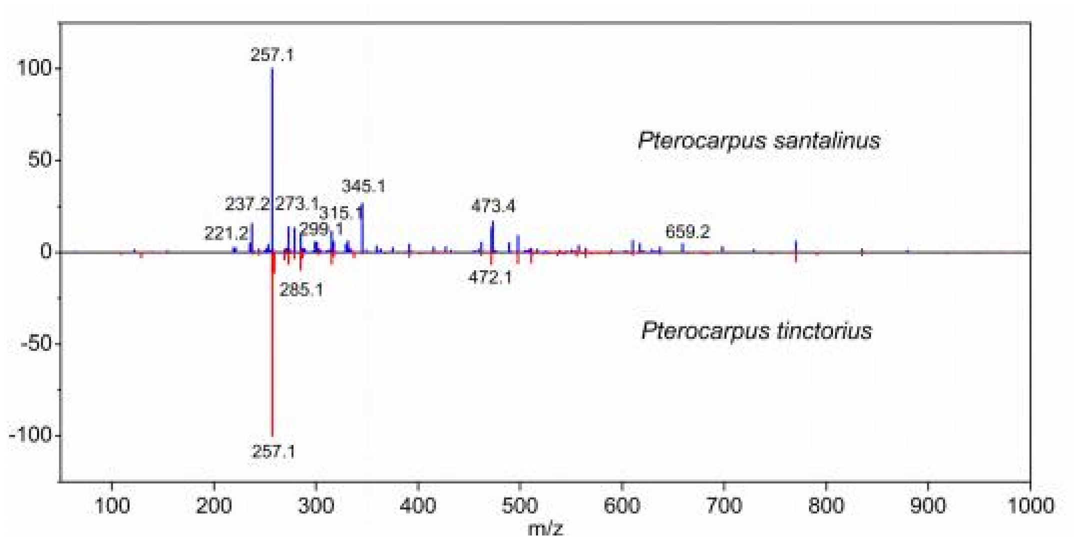


Figure 16. Wood discrimination analyses of heartwood from Pterocarpus species, using chemical analysis based on the mass spectrometry method[3].

[3] Source: Maomao Zhang, Guangjie Zhao, Bo Liu, Tuo He, Juan Guo, Xiaomei Jiang, Yafang Yin. Wood discrimination analyses of Pterocarpus tinctorius and endangered Pterocarpus santalinus using DART-FTICR-MS coupled with multivariate statistics. IAWA Journal, 2019, 40(1): 58-74.

Finally, when using DNA, three main challenges arise: extract genetic material from the sample, find suitable locus for the comparison and, as equal to the previous methods, the availability of a proper reference library. DNA identification can be performed through two techniques: barcoding, which allows distinguishing between species, has been successfully applied for law enforcement on CITES-listed Pterocarpus and Guibourtia species in China; and fingerprint, which lets individual-level discrimination. The accuracy of this method is the highest, but also may be expensive because it relies on specialized laboratories.

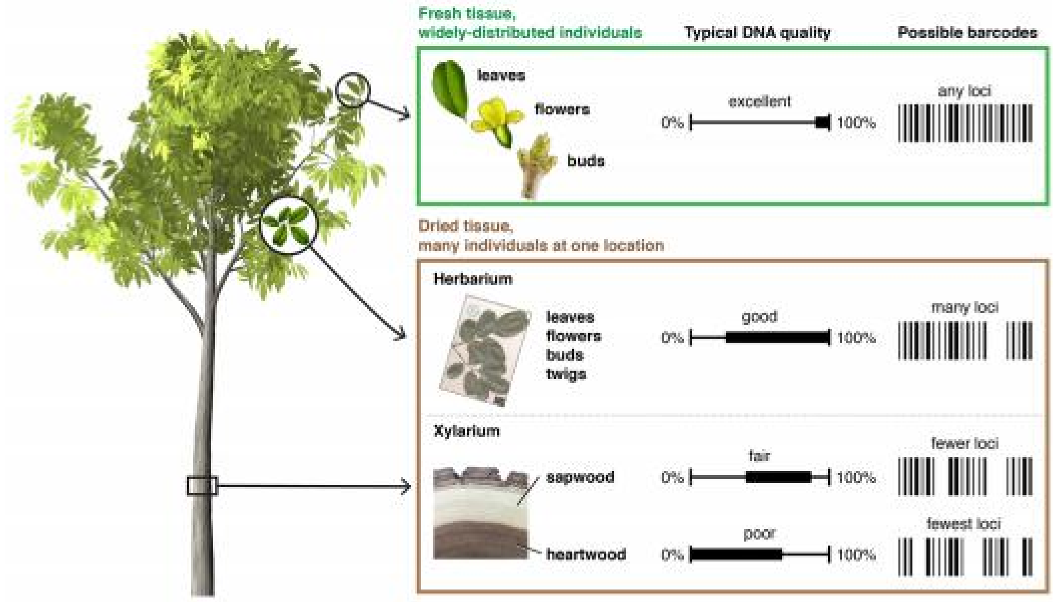


Figure 17. A schematic representation of the potential strengths and weaknesses of source tissue (fresh, herbarium, xylarium) for developing DNA barcoding reference libraries[4].

Resources:

XyloTron, Field-deployable wood species identification (United States)
http://xylotron.org/
Arbor Harbor, A trees to trade reference system (United States)
http://woodid.info/
Best Practice Guide for Forensic Timber Identification
https://www.unodc.org/documents/Wildlife/Guide_Timber.pdf

4.4.2 Collaboration is key

Creating and maintaining wood databases for anatomical, chemical, or DNA identification is cost- and time-consuming. Encouraging collaboration and sharing of available information could benefit all the economies involved in the timber products exchange process.

When proper means of communication and collaboration are reached, duplication of efforts can be almost eliminated, allowing economies to allocate funding for common interests and new researches.

Resources:

Global Timber Tracking Network (GTTN),
https://globaltimbertrackingnetwork.org/
International Association of Wood Anatomists (IAWA)
http://www.iawa-website.org/

[4] Source: Lichao Jiao, Min Yu, Alex Wiedenhoeft, Tuo He, Jianing Li, Bo Liu, Xiaomei Jiang, Yafang Yin. DNA barcode authentication and library development for the wood of six commercial Pterocarpus species: the critical role of xylarium specimens. Scientific Reports. 2018, 8:1945, DOI: 10.1038/s41598-018-20381-6.

Chapter 05.
ACRONYMS

05

5. ACRONYMS

ALOS	Advanced Land Observing Satellite
APEC	Asia-Pacific Economic Cooperation
CONAF	National Forestry Service
DNA	Deoxyribonucleic Acid
GIS	Geographic Information System
GLAD	Global Land Analysis & Discovery
ILAT	Illegal Logging and Associated Trade
INTERPOL	International Criminal Police Organization
JICA	Japan International Cooperation Agency
JAXA	Japan Aerospace Exploration Agency
LIDAR	Light Detection and Ranging
MODIS	Moderate Resolution Imaging Spectroradiometer
NGO	Non-governmental organization
NIR	Near Infrared
SAR	Synthetic Aperture Radar
SWIR	Short Wave Infrared
UAV	Unmanned Aerial Vehicle
USDA	United States Department of Agriculture

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