Joint Submission to the First Global Stocktake
A satellite-based deforestation monitoring system for tropical forests, "JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST)"

The Japan Aerospace Exploration Agency (JAXA), Japan International Cooperation Agency (JICA), Institute for Global Environmental Strategies (IGES) and Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) are pleased to submit this paper to the Global Stocktake of the Paris Agreement in response to the mandate of Decision 19/CMA.1, paragraph 19, 36 and 37. This submission provides information to a crosscutting guiding question 23[1].

Summary

- A satellite-based deforestation monitoring system has been developed through enhanced international cooperation among JICA, JAXA, and countries with tropical forests: the JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST). This system can help countries to locate illegal deforestation, so that it can be combatted more efficiently. Reduced deforestation contributes to reduction of greenhouse gas emissions.
- JJ-FAST uses PALSAR-2, a synthetic aperture radar onboard JAXA's ALOS-2 satellite, to provide periodic deforestation information even for frequently cloud-covered areas and during the rainy season.
- JJ-FAST has detected about 3 million potential deforested plots in 78 tropical-forest countries between 2016 and 2021 (Figure 1), including more than 1 million deforested plots in Brazil. IBAMA uses JJ-FAST and other optical satellite systems to monitor and control illegal deforestation throughout the year, including rainy and cloudy periods. Practices of JJ-FAST application in Brazil should provide useful information on how tropical countries can enhance climate action by using JJ-FAST to detect and control illegal deforestation.
- To promote JJ-FAST to combat illegal deforestation, JICA and JAXA provide technical training to a number of countries and held an international conference in Tokyo and regional/country seminars in seven countries.

[1] What are good practices, experience and potential opportunities to enhance climate action, including international cooperation, on mitigation and adaptation and to increase support under Article 13.5 of the Paris Agreement (para36(g)? Which of these can be transferable or replicated by others? How effective was sharing good practices and experiences on climate action and support, including on enhancing the implementation of adaptation action (Article 7.14(b))?

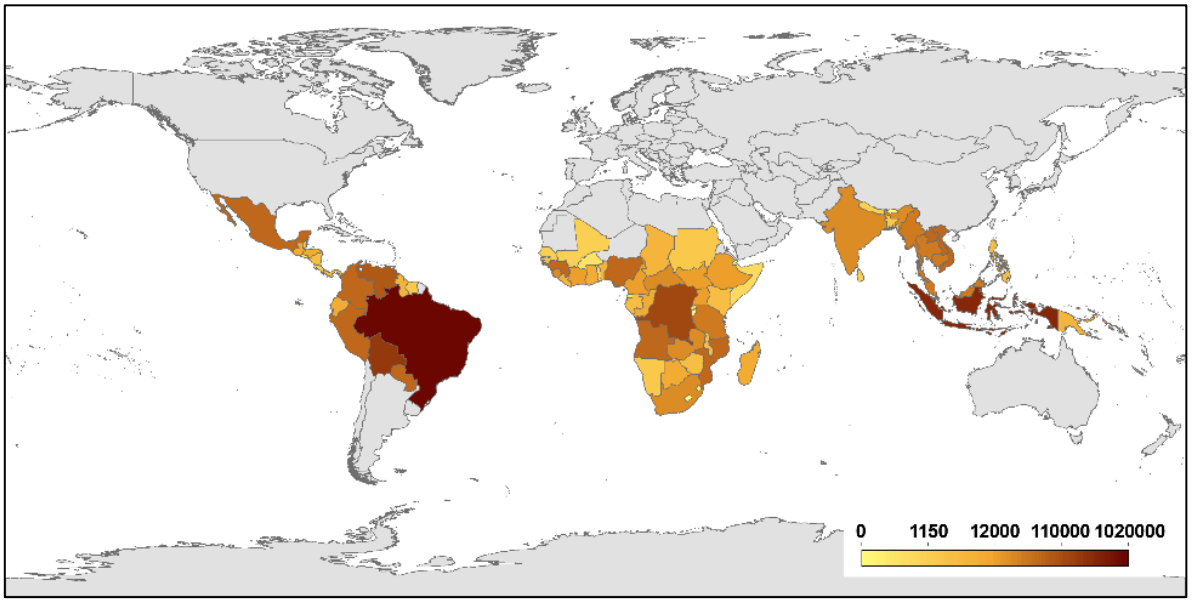

Figure 1. Number of deforested plots detected by JJ-FAST per country (as of November 2021).

Table 1. Key points about the JJ-FAST system.

System name	JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST)
Objectives	To provide information for detecting deforestation in the tropics to combat illegal activities and promote sustainable forest management
Period	Since November 2016 (still in operation)
Data	Synthetic Aperture Radar PALSAR-2 onboard ALOS-2 (resolution: 50m)
Target	Deforested areas of more than 2 ha (at present) in 78 tropical countries
Frequency	Every 1.5 months
Features	Reliable monitoring not affected by cloud cover
Results	Provided information on about 3 million deforested areas in 5.5 years

1. Method

1.1 Overview

JJ-FAST is a system that can detect deforestation of areas of more than two hectares in tropical forests. It relies on PALSAR-2, a synthetic aperture radar mounted on JAXA's ALOS-2 satellite, to provide deforestation information. JJ-FAST aims to make the information available to the public every 1.5 months. It is expected that the system will be utilized for forest monitoring by countries with tropical forests and will act as a deterrent against illegal deforestation. Governmental forest administrators are the primary target users. Since this system provides data on deforested areas that can be downloaded as a polygon shapefile, criminal activity can be identified by GIS analysis of superimposed land-use and concession maps available to users. Optical sensors cannot observe cloud-covered areas effectively, but the microwave sensors of the PALSAR-2 can acquire images of the ground surface through clouds, allowing deforestation information to be transmitted regularly for all regions.

1.2 Data used

The ALOS/2/PALSAR-2 used for JJ-FAST is the successor to the ALOS/PALSAR (2006–2011) sensor and has been operated by JAXA since 2014. PALSAR-2 is a synthetic aperture radar that transmits and receives microwaves reflected from the ground to acquire forest information. The microwave band was chosen because these wavelengths are less affected by clouds and rain than visible light. This all-weather observing capability is suitable for monitoring forest cover without clouds also. PALSAR-2 has three observation modes (Figure 2), of which JJ-FAST uses the ScanSAR mode for wide-area observations. The observation swath is 350 km wide and has a resolution of 50 m. It observes the targeted tropical regions nine times a year.

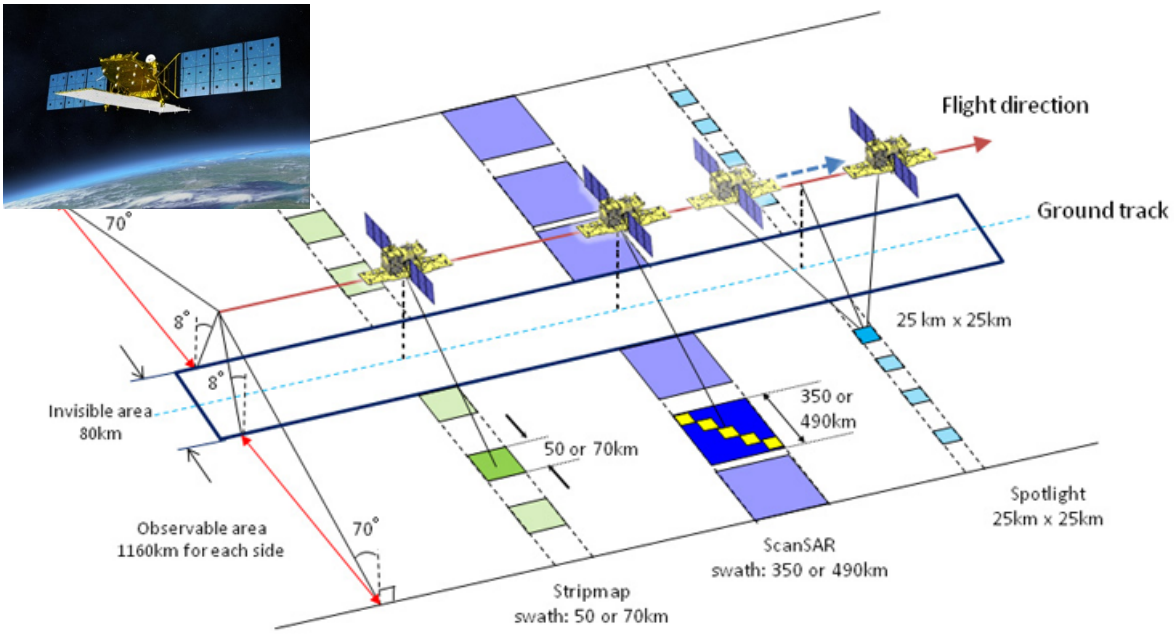

Figure 2. PALSAR-2 observation mode.

The target regions of JJ-FAST are 78 countries shown in Table 2, covering almost all the tropical forests globally.

Table 2. Seventy-eight countries covered by JJ-FAST.

Area		Country
Latin America	**South America**	Bolivia, Brazil, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, and Venezuela
	Central America and the Caribbean	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, and Trinidad and Tobago
Africa	**West Africa**	Benin, Burkina Faso, Cote d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo
	East Africa	Burundi, Djibouti, Ethiopia, Kenya, Madagascar, Rwanda, Seychelles, Somalia, Sudan, South Sudan, Tanzania, and Uganda

	Central Africa	Cameroon, Central African Republic, Chad, Republic of Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, and Sao Tome and Principe
	South Africa	Angola, Botswana, Eswatini, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Republic of South Africa, Zambia, and Zimbabwe
Asia		Bangladesh, Bhutan, Brunei, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Timor-Leste, and Viet Nam
Oceania		Papua New Guinea, and Solomon Islands

1.3 Algorithm

Six versions of the detection algorithm have been developed (Table 3). Because the PALSAR-2 image can distinguish between forest and non-forest cover, deforested areas can be detected by image analysis (Figure 3). Versions 0.0 and 1.0 detected changes in images between only two time periods. As mentioned above, the resolution of the PALSAR-2 image is 50 m, but the PALSAR-2 image contains noise called speckle, so it cannot detect changes of a size near the sensor resolution. Therefore, these early algorithms could detect deforestation of areas of 5 hectares or more. Since then, the JJ-FAST development team has improved the algorithms to use multiple polarimetric images provided by PLASRA-2 and time-series images of up to 21 time periods instead of just two. This now allows us to detect deforestation areas as small as 2 hectares.

In addition, satellite image-based deforestation information usually contains errors. Therefore, the JJ-FAST development team compares and interprets the automatically processed information with optical satellite images and releases information that is recognized as valid. This is called the Quality Check product. However, there were requests to release the information after automatic processing without the quality check, so from Ver. 2.1, the team has also released a Quick Look product to share the automatic processing results as quickly as possible.

Table 3. Revision history of the deforestation detection algorithm.

Version	Period	Algorithm
0.0	2016.11–2017.07	Changed detection between two images of PALSAR-2 HV
1.0	2017.07–2018.04	Changed detection between two images of PALSAR-2 HV
2.0	2018.04–2018.07	Analysis using a reference from ten scenes of PALSAR-2 HV, HH
	2018.07–2019.06	Analysis using a reference from 15 scenes of PALSAR-2 HV, HH
2.1	2019.07–2020.05	Analysis using a reference from 20 scenes of PALSAR-2 HV, HH with updated thresholds
3.0	2020.06–	Data processing changed from polygon- to pixel-based. Applied temporal normalization and introduced threshold level depending on the site

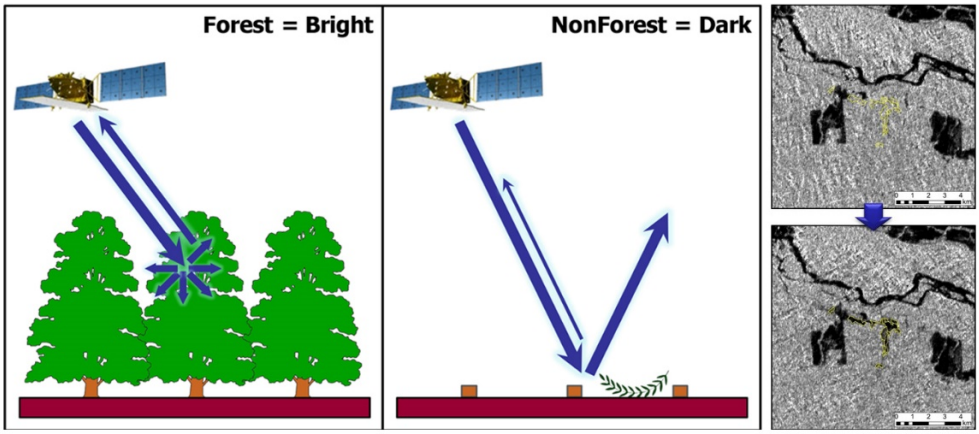

Figure 3. PALSAR-2 image changes between two periods in a deforested plot.

1.4 Webpage

JJ-FAST deforestation information is available to the public through a web page (https://www.eorc.jaxa.jp/jjfast/jj_index.html). As shown in Figure 4(a), the top page of JJ-FAST has drop-down menus. When the Map menu is selected, the distribution of deforestation is shown in a 1° grid of latitude and longitude (Figure 4(b)). By clicking on the grid, the user can display an enlarged map and its deforestation information (Figure 4(c)). Users can download the data as a polygon shapefile to their forest management system for analysis.

(a) (b)

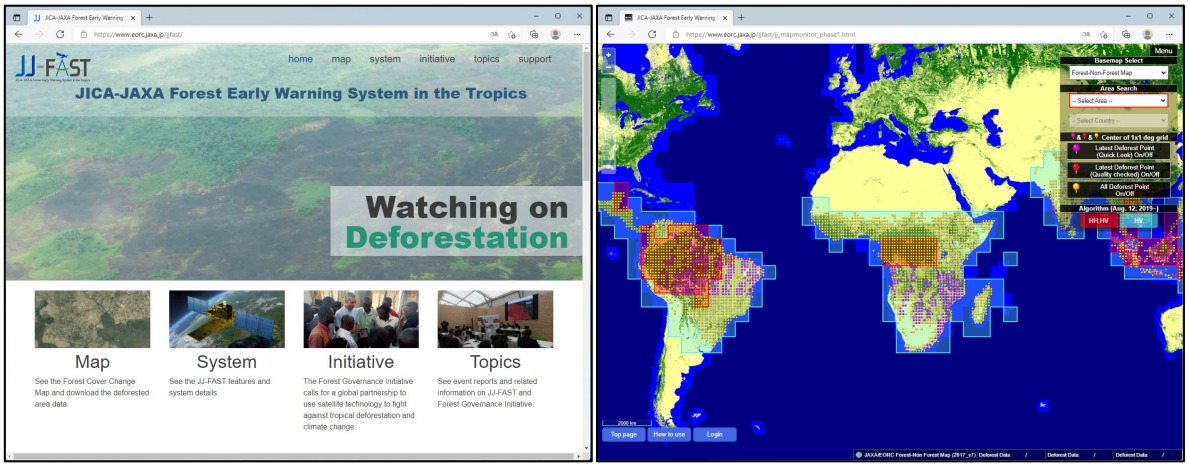

Figure 3. JJ-FAST web page (continued on next page).

(c) (d)

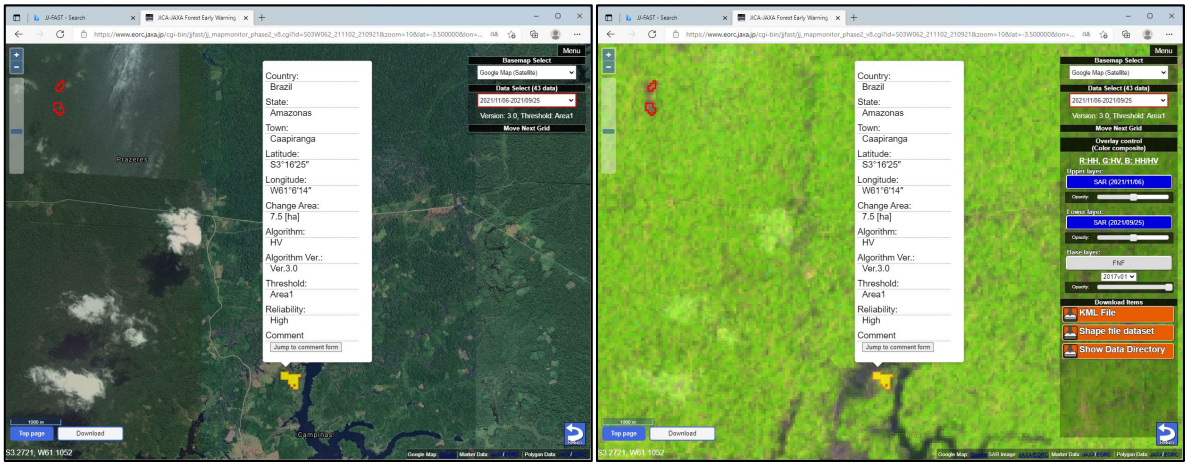

Figure 3. JJ-FAST web page (continued).

1.5 User promotion

JICA and JAXA conducted field surveys in seven countries to validate JJ-FAST's accuracy and improve the algorithm (Table 4). In five of these countries, they also held seminars for government officials and other stakeholders. Surveys with local forestry officials and discussions at seminars have promoted JJ-FAST use. In response to requests from users, the algorithm has been improved to detect deforestation in smaller areas. Further, JICA and JAXA held an international conference on JJ-FAST in Tokyo in 2017, inviting government officials from many developing countries and other international and domestic stakeholders. In addition to a series of seminars held in developing countries, they have conducted training courses in Japan and online (due to COVID-19 restrictions) since 2016. The purpose of the training course is to promote sustainable forest management using remote sensing/GIS technologies, including JJ-FAST; 47 government officials from 17 countries have participated so far.

Table 4. JJ-FAST field surveys and regional seminars.

Region	Country	Year	Survey	Seminar
South America	Peru	2016	✓	✓
	Brazil	2017	✓	
Africa	Botswana	2017	✓	✓
	Gabon	2017	✓	✓
	Mozambique	2018	✓	
	Cameroon	2019	✓	✓
Asia	Indonesia	2018	✓	✓

2. Results

2.1 Provision of deforestation information

JJ-FAST has detected many deforested areas in the tropics since the start of operation in November 2016. Figure 4 shows the number of deforested areas for each PALSAR-2 observation cycle (14 days). When JJ-FAST started its operation, it released deforestation information for six months, so the information is available sincethe 48th cycle in May 2016. Then, starting from the 130th cycle (July 2019), the Quick Look product (i.e., the automatic processing results) has been released, and the number of detected deforested areas has rapidly increased. In total, the Quick Look and Quality Check products have released information on 2,893,049 deforested plots by November 2021.

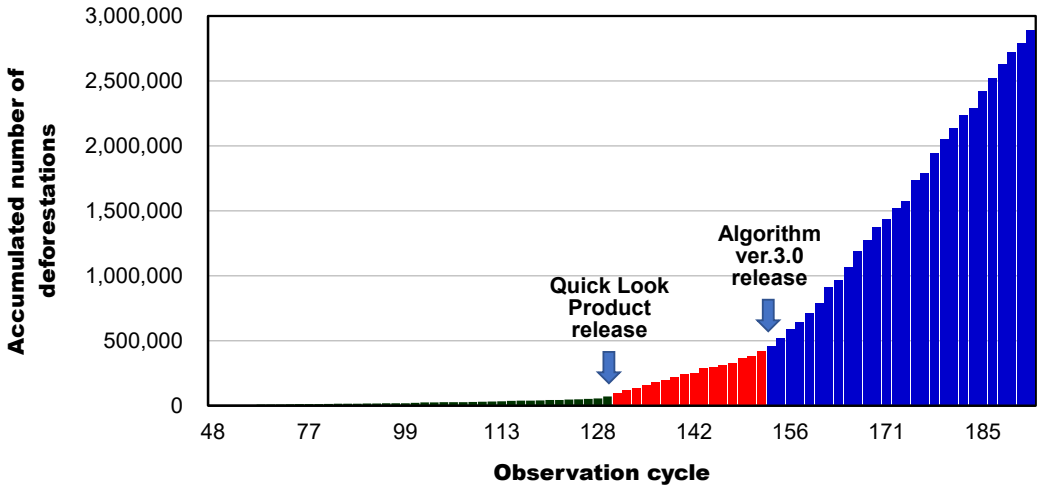

Figure 4. The accumulated number of deforested plots detected by JJ-FAST (including Quick Look and Quality Check products by November 2021).

Examining the results for each country, many deforestations were detected in Brazil, Indonesia, and Bolivia (Figures 1 and 5), with these three countries alone accounting for more than half (55%) of the total.

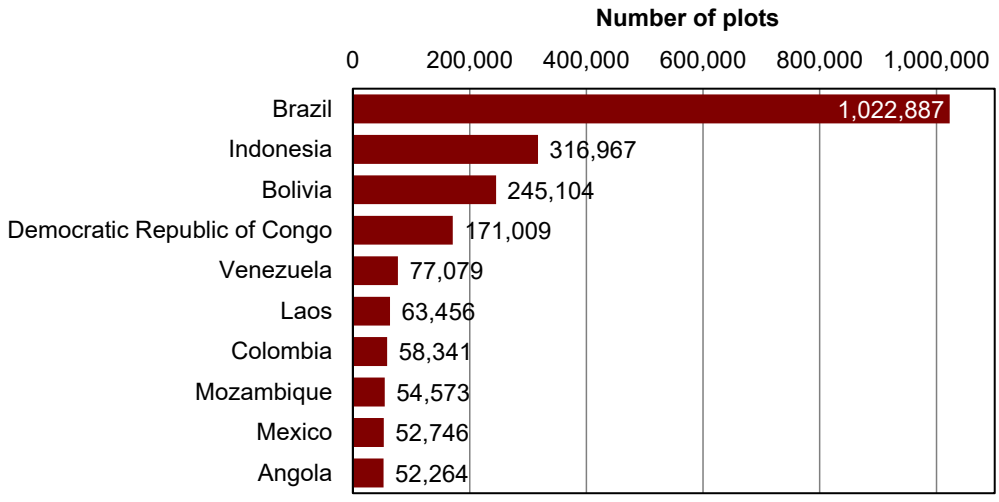

Figure 5. Top 10 countries with the most deforestation detected by JJ-FAST (as of November 2021).

2.2 Application in Brazil

Brazilian authorities use JJ-FAST to monitor deforestation and control illegal deforestation in rainy and cloudy periods.

Their control of illegal deforestation starts with detecting deforestation by the National Institute for Space Research (INPE) using multiple optical satellites under the Near Real-Time Deforestation Detection System (DETER). Because detecting deforestation optically during the rainy season presents technical difficulties, the Brazilian government uses multiple deforestation early warning systems (EWSs) to solve technical issues such as cloud effects and interrupted satellite observation intervals to make constant deforestation detection possible throughout the year. Suspected deforestation data (for which illegality is unknown at this stage) are sent from INPE to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), the regulatory agency dealing with illegal deforestation. IBAMA and its branches then compare deforestation data from DETER, JJ-FAST, and other EWS data against satellite imagery, a database of legal land use, and additional sources. When there is a high probability of illegal deforestation, the authority moves to law enforcement, sometimes with the support of the federal police and other institutions.

Figure 6 compares the deforested areas detected in the Brazilian Legal Amazon[2] in 2019 by JJ-FAST and the Global Land Analysis and Discovery (GLAD), a global deforestation monitoring system using optical satellite Landsat imaging[3]. GLAD detects more deforestation than JJ-FAST from April to October, when there is less cloud cover due to the GLAD's resolution to detect deforested areas of 0.1 ha or more, surpassing JJ-FAST (2 ha). Meanwhile, from November to March, the area detected by JJ-FAST is more significant than by GLAD. This period is the rainy season, indicating that radar sensors are more effective in detecting deforestation than optical sensors, which are vulnerable to cloud cover. In addition, IBAMA's fieldwork with JJ-FAST information has found that JJ-FAST can detect early-stage deforestation. These features have allowed JJ-FAST to be used in IBAMA's monitoring operations extensively.

Thus, in Brazil, forest conservation efforts are made possible by the integrated use of information from several EWSs and land-use planning, the governance system to dispatch enforcement officials to areas where there is a high possibility of illegal deforestation and to allow them to enforce the law, and collaborative work among multiple agencies.

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[2] the largest socio-geographic division designated by the Brazilian government

[3] covering the entire tropical region, operated by the University of Maryland with support from Global Forest Watch

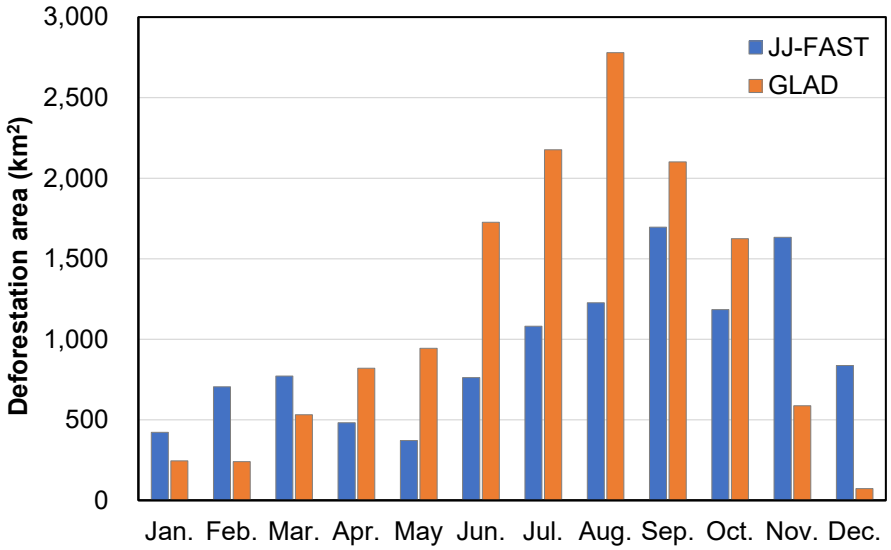

Figure 6. Monthly deforestation area comparison between JJ-FAST and GLAD in the Brazilian Legal Amazon[4].

2.3 Potential use in tropical countries

As summarized in Table 2, JJ-FAST covers almost all tropical forests in the world; thus, tropical countries can benefit from using JJ-FAST to detect and control illegal deforestation. There are some desirable technical conditions to optimize the use of JJ-FAST:

1. An environment where data from multiple EWSs, including JJ-FAST, can be obtained and integrated to identify deforested areas.

2. Cases where optical satellites are not sufficient for complete ground observation.

3. A relatively large area of deforestation (plots of more than 2 ha are frequent).

We have also identified the following conditions for the effective use of JJ-FAST to control illegal deforestation, taken from the experience of Brazil:

4. A government-based system exists, including the deployment of law-enforcement officials to control illegal deforestation.

5. Mechanisms exist to share information on deforestation at the central and regional levels.

6. Mechanisms exist for collaboration among relevant agencies and central and local governments to combat illegal deforestation.

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[4] Okonogi H., Yamada E., and Morita T. (2022) Eyes on the Planet: Toward Zero Deforestation. in *Breakthrough: The Promise of Frontier Technologies for Sustainable Development*. Brookings Institution Press. (Figure 6 is based on Table 8-1 of this book)

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