

Early warning systems

Turning satellite data into action against deforestation

Regional governments in Peru are strengthening how they respond to deforestation. With support from the Swiss SECO-funded Subnational Public Finance Management programme, they are using satellite data and early warning systems to monitor vulnerable areas of Amazonian forest and make better-informed surveillance and control decisions.

Through staff training, historical analysis of forest cover, digital tools and practical technical assistance, nine Regional Conservation Areas covering 2.8 million hectares now have validated historical baselines and stronger technical capacity. Automated reporting tools are also being introduced, while regional authorities are beginning to use the evidence to update patrol plans and target areas under greatest pressure.

The experience shows how affordable technology, inter-agency coordination and investment in local capacity can help public institutions build more effective and sustainable forest monitoring systems.

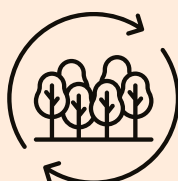


Park rangers patrolling the Cordillera Escalera Regional Conservation Area. Source: Subnational PFM programme.



2.8 million hectares across nine Regional Conservation Areas

The programme is supporting monitoring and conservation management across nine Regional Conservation Areas in Cusco, Loreto and San Martín – around 75 percent of the total area under regional conservation management in Peru.



Nine validated deforestation baselines for better decisions

For the first time, participating Regional Conservation Areas have standardised evidence showing where forest loss occurred, how much was lost and what caused it.



Stronger local technical capacity

Regional teams have been trained in geographic information systems, remote sensing and satellite-image analysis, reducing reliance on external specialists.



Faster, more consistent monitoring

Open-source tools are being introduced to automate the processing and reporting of deforestation alerts, shortening the gap between detection and management decisions.



Satellite evidence is guiding action

Authorities are using satellite data to update surveillance plans, improve patrol routes and complement satellite monitoring with drone surveillance to target areas under pressure.



A practical model for other regions

The methods, tools and proposed national guidance offer a scalable approach for other resource-constrained territories facing similar forest-monitoring challenges.

The challenge: turning forest data into timely action

A vast forest under growing pressure

Peru has one of the world's largest forest areas. Just over 72 million hectares are forested and around 94 percent of this is Amazon rainforest – an area larger than Switzerland and France combined (FAO, 2021).

Forest loss has increased significantly. Peru lost an average of 115,000 hectares a year between 1990 and 2000, rising to 172,000 hectares a year between 2010 and 2020 (FAO, 2021). Agricultural expansion is the main driver. Illegal gold mining, illegal logging, illicit crops and new roads also contribute, often in combination (Koelle and Garcia Soto, 2025).

Why regional conservation areas matter

Peru's protected natural areas conserve biodiversity and associated cultural, landscape and scientific value. They also support sustainable development. Some are managed nationally by the National Service for Natural Areas Protected by the State (SERNANP), while others are managed by regional governments and are known as Regional Conservation Areas.

Regional Conservation Areas cover 3.6 million hectares, or 2.8 percent of Peru's territory (SERNANP, 2025). They protect ecosystems and species, maintain services such as water regulation, pollination and carbon storage and support the sustainable use of natural resources by local communities.

The gap between detection and response

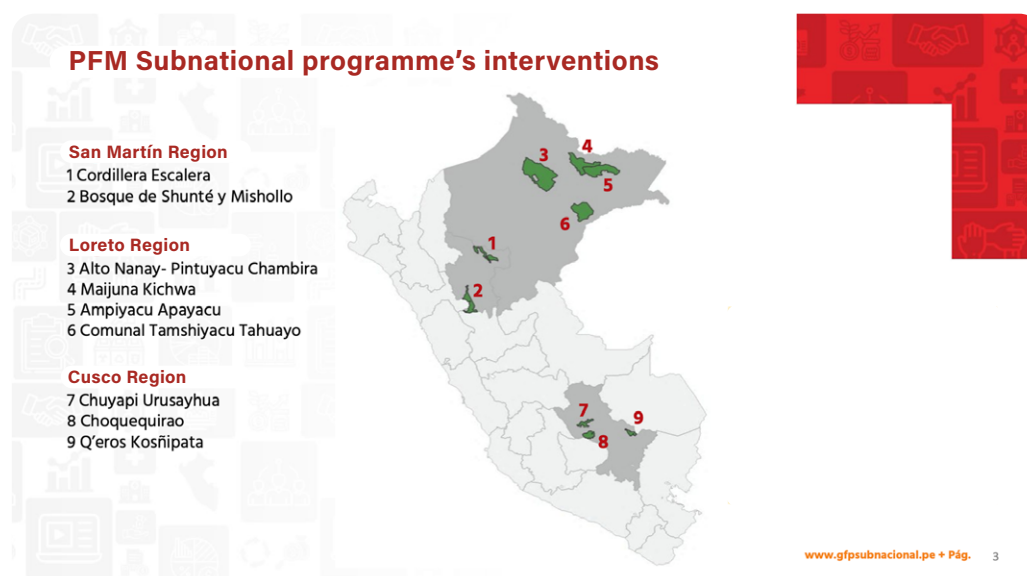
Satellite imagery is the most scalable way to monitor forest cover across large, remote territories. It enables systematic observation, comparison over time and the generation of near real-time information. Yet regional authorities often lack the systems and capacity to turn this information into timely action. Problems include:

- **Skills gaps:** Technical teams have limited experience with remote sensing, geographic information systems and satellite-image analysis.
- **Fragmented processes:** Alert analysis and field verification are often manual, fragmented and poorly integrated.
- **Missing baselines:** There is no consistent historical baseline against which to assess changes over time.
- **Slow response:** Reporting is not sufficiently automated or connected to operational decisions.

These constraints delay the response to forest loss and make it harder to direct scarce surveillance resources where they are most needed.

The response: building an early warning system

The Subnational PFM programme developed a practical response centred on local capacity, reliable historical information, accessible technology and the use of evidence in surveillance decisions. The work covers nine Regional Conservation Areas in Cusco, Loreto and San Martín. Together, they span 2.8 million hectares – around 75 percent of the total area of all Regional Conservation Areas in Peru and approximately 4 percent of the Peruvian Amazon.



Regional Conservation Areas supported by the Subnational PFM programme. Source: Subnational PFM programme.

The table below shows how the programme responds to the main barriers:

Identified problem	Programme response
Limited capacity in geographic information systems and remote sensing, creating reliance on external specialists	Training for regional staff in geographic information systems, remote sensing and satellite-image processing
No comparable, systematised historical deforestation baselines	Preparation and validation of historical baselines for analysis and monitoring
Manual and fragmented processes for analysing and verifying alerts	Open-source tools to automate processing and generate reports every two weeks
Limited use of geospatial evidence to prioritise surveillance and control	Technical support to apply the information in patrol planning and other management decisions

Main gaps in deforestation monitoring and the programme's response. Source: Subnational PFM programme.

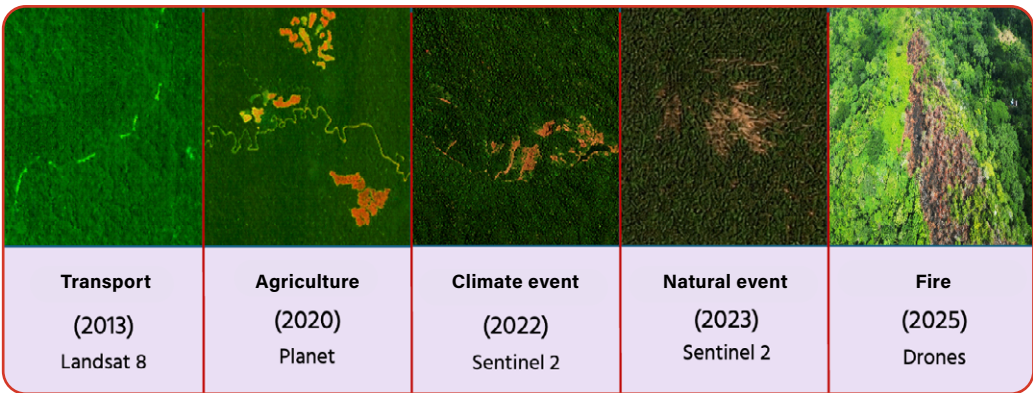
Building local technical capacity

The work began with training specialists and park rangers in geographic information systems, remote sensing and satellite-image processing. This enables regional teams to generate and analyse specialised information more independently, sustainably and at lower cost.

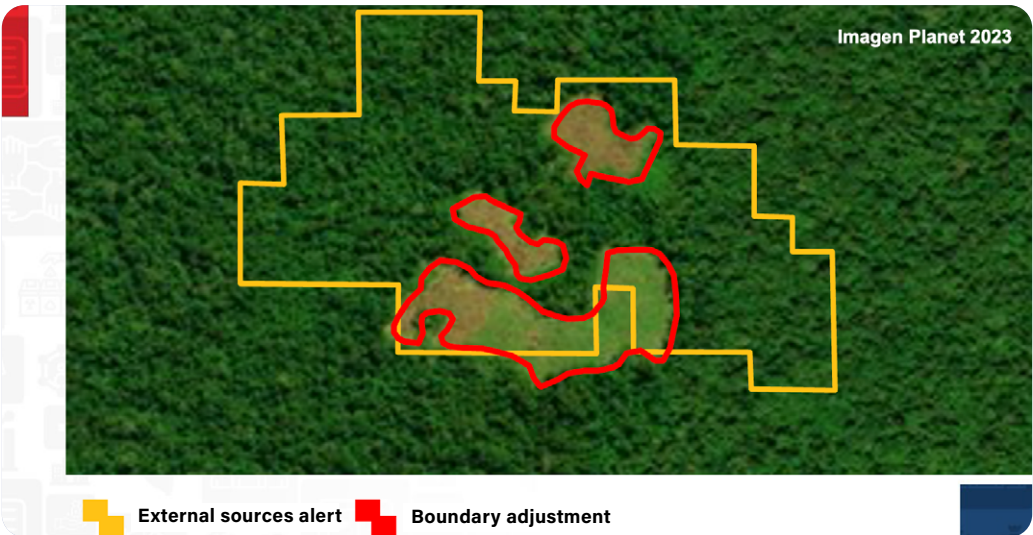
Creating a reliable historical baseline

Between April and November 2025, the programme worked with conservation area managers and SERNANP to prepare nine historical deforestation baselines. These show the location, extent and causes of forest loss in each area and its surroundings.

The analysis used official data and satellite images covering 2001 to 2024. Specialists compared images from different years, distinguishing permanent forest loss from temporary or misleading changes in imagery, such as shadows and flooding. Each event was classified as human-caused deforestation, natural forest loss or a false alert. Higher-resolution images, quality controls and technical validation improved the accuracy of the final maps.



Photographic indicators of the causes of deforestation. Image prepared by the Subnational PFM programme.



Accuracy of identified alerts compared with alerts from external sources. Image prepared by the Subnational PFM programme.

Automating alerts and reports

Since November 2025, the programme has been introducing open-source tools to automate the processing and reporting of deforestation alerts every two weeks. The aim is to improve consistency and reduce the time between detecting a change in forest cover and providing information that management officials can use.

Connecting information with field action

The baselines are already informing diagnostic work, surveillance plans and strategies for in-person and remote patrols. The Subnational PFM programme and SERNANP are also working to institutionalise the approach through two instruments expected in 2026: a methodological guide for monitoring deforestation in Amazon forests within the system of protected areas and a protocol for managing deforestation alerts in Regional Conservation Areas.

Results: stronger capacity and better targeted surveillance

Nine validated baselines

For the first time, the nine participating conservation areas have standardised and validated information on changes in forest cover. The baselines identified a cumulative loss of 9,808 hectares. Human-caused deforestation accounted for 49 percent, mainly from agriculture. Natural forest loss accounted for 37 percent and false or previously unverified alerts for 14 percent.

Within the human-caused losses, agriculture accounted for 37 percent of the total, livestock farming for 4 percent, transport for 3 percent and other causes for 5 percent (Basel Institute on Governance, 2025a–c).

More independent regional teams

Training has strengthened the ability of regional teams to generate and interpret geospatial evidence without relying as heavily on external assistance. This helps retain expertise within public institutions and lowers ongoing costs of environmental monitoring.



Training led by the Subnational Public Financial Management programme. Source: Subnational PFM programme.

Faster information for decisions

Automated processing and reporting are improving the timeliness and consistency of information used for environmental surveillance. They also support coordination between regional governments and SERNANP by making it easier to integrate regional evidence with national monitoring systems.

Access to recent, sufficiently detailed satellite imagery remains important. Cooperation with Peru's Space Agency, CONIDA, offers a sustainable way to access higher-resolution images, improve accuracy and reduce the need for separate purchases.

Evidence guiding patrols

The information is already shaping practical decisions. In Loreto, three of the four participating conservation areas began updating their surveillance and control plans using the new baselines. Across Cusco, Loreto and San Martín, managers are using the evidence to target patrols, optimise routes, complement drone surveillance and focus limited resources on areas facing the greatest pressure.

Making the system part of routine, low-cost forest management

The programme is leaving regional governments with skills, data and tools that can strengthen forest management over the long term. Historical baselines, trained staff and automated alert processing create a practical foundation for more consistent surveillance and evidence-based decisions.

The experience also shows that effective remote monitoring does not always require expensive proprietary systems. Accessible technologies can deliver strong results when they are supported by sound methods, quality assurance and sustained institutional ownership.

Supporting biodiversity and climate goals

Better management of Regional Conservation Areas supports Peru's national biodiversity goals and contributes to Target 3 of the Kunming–Montreal Global Biodiversity Framework, known as the 30x30 target. This calls for at least 30 percent of the world's land and sea to be effectively conserved by 2030.

Examples from three regions

San Martín: identifying threats more precisely

In the Bosques de Shunté y Mishollo Regional Conservation Area, the baseline identified more than 1,900 hectares of forest loss by 2024. Around 40 percent was caused by human activity, mainly agricultural expansion.

The locally detailed analysis made it possible to quantify forest loss more accurately, identify its causes, avoid double-counting and generate evidence for patrols, technical reports, enforcement action, complaints and coordination with relevant authorities.



Local teams patrolling and evaluating the state of a deforested area. Source: Subnational PFM programme.

This Regional Conservation Area remains in a good state of conservation, with approximately 97 percent of its 191,000 hectares having no recorded impacts.

Loreto: combining satellites and drones

The programme supports four Regional Conservation Areas in Loreto (Ampiyacu Apayacu, Alto Nanay Pintuyacu Chambira, Comunal Tamshiyacu Tahuayo and Maijuna Kichwa) covering around 2.2 million hectares. In these remote, highly biodiverse territories, the baselines are helping authorities update surveillance plans, improve patrol routes and target areas under greatest pressure.

The programme has also trained drone pilots to complement satellite monitoring and field surveillance. The four areas now have eight pilots accredited by Peru's Ministry of Transport and Communications.



One of the eight new drone pilots certified by Peru's Ministry of Transport and Communications. Source: Subnational PFM programme.

Cusco: quantifying a positive trend

The programme supports three Regional Conservation Areas in Cusco: Choquequirao, Chuyapi Urusayhua and Q'eros Kosñipata. The historical baselines showed that forest loss has declined since 2021. This positive trend had not previously been systematised by the regional government and now provides a reference for management, decisions and future monitoring.

Lessons for effective early warning systems

The experience offers six practical lessons for other regions and countries.

1

Facilitate institutional coordination. Cooperation between regional governments, SERNANP and specialised public bodies improves data quality and helps ensure that monitoring responds to real surveillance and enforcement needs.

2

Build a historical picture. Systematised information over time makes it possible to identify trends, distinguish causes and prioritise actions using objective evidence.

3

Invest in local skills. Training specialists and park rangers helps reduce reliance on external support and keeps technical capacity within regional institutions.

4

Use affordable technology. Open-source and otherwise accessible tools reduce implementation and maintenance costs. This makes the approach easier to replicate in resource-constrained settings.

5

Link alerts to action. Monitoring systems deliver value only when their results guide patrols, update surveillance plans and target interventions in high-pressure areas.

6

Plan for the response. Faster satellite data alone is not enough. Police, armed forces, environmental prosecutors and other authorities also need clear coordination arrangements, equipment, transport and resources to act in remote areas.

Why this matters for development partners

This work shows what targeted investment in regional government capacity can achieve:

- **Stronger institutions:** Regional teams are better equipped to monitor deforestation across biodiverse Amazonian territories and act on the evidence.
- **Practical knowledge:** The programme has produced tested methods for remote monitoring, geospatial analysis and alert management that can be adapted elsewhere.
- **Global benefits:** Better forest protection supports carbon storage, climate regulation, biodiversity and local livelihoods.

The approach can help regional authorities – in Peru and elsewhere – better identify threats to forests and respond with limited resources.

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About this publication

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