GFZ Helmholtz Centre for Geosciences

Country-identified R&D Needs

GFOI R&D Activities (July 2025 – June 2026) for Strengthening Country Engagement in Support of AFOLU monitoring and reporting activities

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GFOI Global Forest Observations Initiative

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Introduction

Within the CCN1 of the ESA Project "Support to the R&D Coordination for the Global Forest Observations Initiative", Work Package (WP) 6 focuses on strengthening country engagement to enhance the use of Earth-Observation (EO) data in national decision-making related to the Agriculture, Forestry and Other Land Use (AFOLU) sector. It supports countries in aligning the use of global EO products with their national priorities and fosters the exchange of practical experiences across regions. The first six months initiated technical dialogues, launched the first global GFOI R&D survey, and began documenting success stories and regional removals-related discussions. The second six months finished the analysis of the survey, carried out in-depth interviews, published the three success stories, and delivered a set of 2026 – 2027 R&D recommendations based on country engagements.

This report is intended as a public-facing summary of findings from the country engagement activities conducted under WP6, and is addressed to a broad audience including national forest monitoring practitioners, international partners, researchers, and policy stakeholders working in the AFOLU sector. It draws on the following complementary sources of evidence: the 2025 GFOI R&D Needs Analysis Survey, which captured structured responses from 76 national and regional government representatives across Africa, Asia-Pacific, and Latin America and the Caribbean; targeted interviews following this survey, and discussions on removals which culminated on the April 2026 Technical Workshop on Forest Losses and Gains held in Villa de Leyva, Colombia, organized by IDEAM and WilpaCD, which provided the opportunity for in-depth exchange with national teams from seven LAC countries and key international partners. These activities in combination offer a grounded and regionally differentiated perspective of where national forest monitoring systems from different countries stand, what is currently holding them back, and where targeted R&D investment and guidance development could make significant contributions.

1. Survey Findings

Survey Overview and Respondent Profile

The 2025 GFOI R&D Needs Analysis was conducted across three regions: Africa, Asia-Pacific, and Latin America and the Caribbean. Of 76 total respondents, 78% were national or regional government representatives, reflecting the survey's focus on operational MRV practitioners rather than researchers. The LAC region contributed the largest share (51%), partly reflecting active GFOI engagement in the region. Africa, at 20%, is likely under-represented relative to the scale of the challenge there.

In addition to the survey, there were structured interviews initiated with institutions in Colombia (IDEAM), Mexico (CONAFOR), Guatemala (INAB/MARN), Vietnam (FIPI), Paraguay (INFONA), Republic of Congo (CNIAF), Ecuador (MAE), and Cambodia (MOE). Virtual meetings and in person meetings were held to validate and explore the responses of the survey in more detailed countries.

Table 1. Respondents profile by region

Region	Respondents	% of Total	Profile of respondents
Africa	15	20%	Mostly from government institutions, with strong infrastructure gaps
Asia-Pacific	22	29%	Mostly from government institutions, representing diverse landscapes: SE Asia, Pacific Islands, Suriname
Latin America and the Caribbean (LAC)	39	51%	Mostly from government institutions, the largest respondent group

This summary presents findings from the 2025 GFOI R&D Needs Analysis Survey, drawing on responses from 76 national and regional government representatives across Africa, Asia-Pacific, and Latin America and the Caribbean (LAC). It is complemented by evidence from the April 2026 Technical Workshop on Forest Losses and Gains held in Villa de Leyva, Colombia, which brought together national forest monitoring teams from seven LAC countries alongside international partners including Google Earth Engine, FAO, the World Bank, ART, and WRI.

The central finding shows that National Forest Monitoring Systems are technically mature but institutionally fragmented. Countries can identify what they need, and they can often describe what good practice looks like. What they cannot yet do is reach operational scale, either because they lack access to tools that already exist, or because science has not yet produced guidance they can use in official reporting.

Methodology for Survey Analysis: The Constraint type framework

Analysis of survey responses reveals two distinct types of constraints preventing countries from advancing NFMS capacity. This framework organizes all recommendations in this report.

Access Constraints: High data costs, limited satellite coverage, and inadequate infrastructure prevent countries from using tools and methods that already exist. The binding constraint is access. Future actions should focus on access to data, infrastructure, and deployment of open-source tools. Respondents from Africa presented the clearest examples of access constraints.

Methodology Constraints: Countries have institutional capacity and can operate existing tools; however they have reached the limits of current IPCC guidance, particularly for carbon removals, peatlands, tropical wetlands, and non-CO_2 gases. Respondents from Latin America and parts of Asia-Pacific exemplify methodology constraints.

Most countries exhibit elements of both constraint types, with strong workflows for deforestation monitoring alongside incomplete methodology for estimating and reporting forest-based removals. The framework is applied at the level of specific functions, not entire countries.

The most urgent cross-cutting gap identified across both constraints is forest-based CO2 removals monitoring. All national monitoring systems encountered in this analysis were built around tracking emissions from deforestation and degradation, while removals remain poorly integrated due to missing removal factors, inadequate time-series data, and methodological uncertainty. This gap is becoming an obstacle to finance, as ART-TREES, NDC reporting cycles, and results-based payment mechanisms increase the precision demands on national removals accounting.

Areas of Survey Analysis

1.3.1 Gaps and Utilization of Earth Observation Data

Underutilized Sensor Types:

Across all three regions, LiDAR is the most consistently underutilized sensor, cited by 67–79% of respondents, followed by radar (SAR) and very high-resolution (VHR) optical imagery. Cost is the dominant reason, particularly in LAC (85%) and Asia-Pacific (82%). The LiDAR gap is especially consequential for removals monitoring: above-ground biomass estimation in recovering secondary forests depends on canopy structure data that freely available optical satellites cannot provide.

Table 2. Most underutilized sensors by region

underutilized Sensor	Africa (n=15)	Asia-Pacific (n=22)	LAC (n=39)
LiDAR	67%	73%	79%
Radar (Sentinel-1, ALOS)	27%	59%	69%
Very High-Res Optical (VHR)	47%	64%	51%
Hyperspectral Imagery	53%	41%	38%

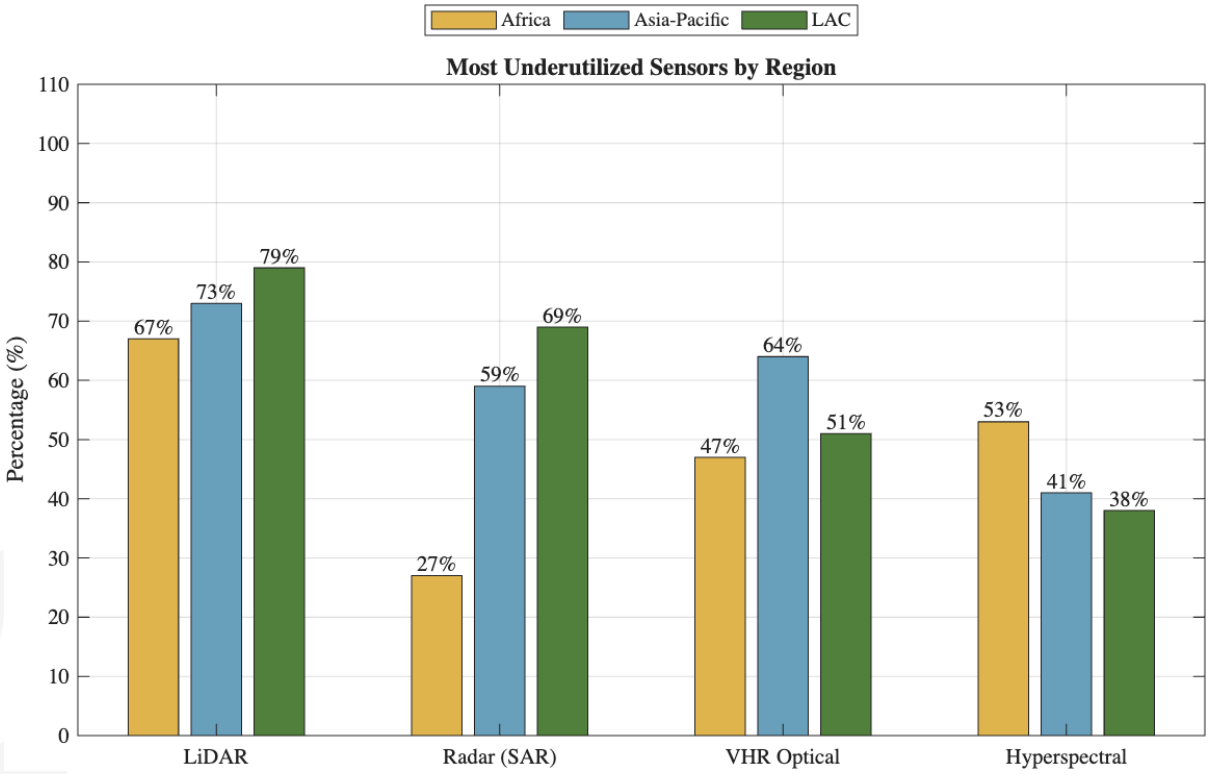

Figure 1. Most underutilized sensors by region

Reasons for Underutilization

High cost of data and processing is the dominant barrier across all regions, but its interaction with other barriers differs by region. In Africa, limited regional data availability (60%) compounds cost constraints, suggesting market and infrastructure failures beyond affordability alone. In LAC most respondents point out cost as a main barrier. However, they related cost with airborne LiDAR, and capacity to access already processed space LiDAR. In LAC and Asia-Pacific, unclear IPCC guidance (36–46%) emerges as a significant secondary barrier, reflecting methodology constraints from countries that could use these sensors but lack methodological frameworks for integrating outputs into compliant reporting.

Table 3. Reasons for sensors underutilization by region

Barrier to EO Use	Africa (n=15)	Asia-Pacific (n=22)	LAC (n=39)
High cost of data/processing	67%	82%	85%
Lack of technical capacity	47%	73%	54%
Limited availability in region	60%	50%	28%

Barrier to EO Use	Africa (n=15)	Asia-Pacific (n=22)	LAC (n=39)
Unclear IPCC guidance on use	7%	36%	46%

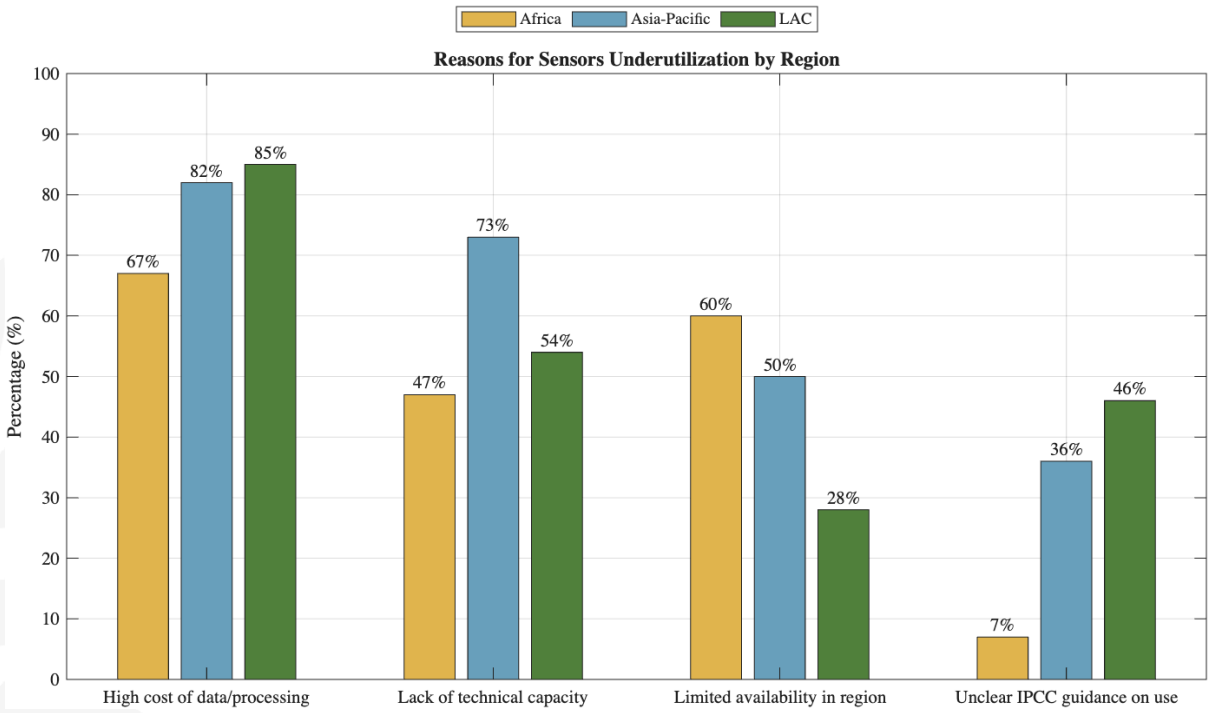

Figure 2. Reasons for sensor underutilization by region

1.3.2 Space Data and Field Data Integration

Current Integration Status:

Full integration of space data with field data remains rare across all regions. Only two respondents in each region described their systems as fully integrated. The majority landed in "partial integration". However, based on the responses the partial integration category involved enormous variation, from sophisticated multi-source workflows with known gaps, to systems where satellite and field data are processed in entirely separate institutional pipelines that never interact. For example, one institution produces activity data, and another institution produces emission factors. In this example, the institution with the mandate for conducting the National Forest Inventory (NFI) and deriving emission factors often uses other national stratification maps, and the combination of these two pipelines is poorly done or non-existent.

Table 4: Status of the integration of NFI and EO

Integration Status	Africa (n=15)	Asia-Pacific (n=22)	LAC (n=39)
Fully integrated	13%	9%	5%
Partially integrated	47%	36%	54%
Poorly integrated	33%	—	—
Not integrated at all	7%	—	—

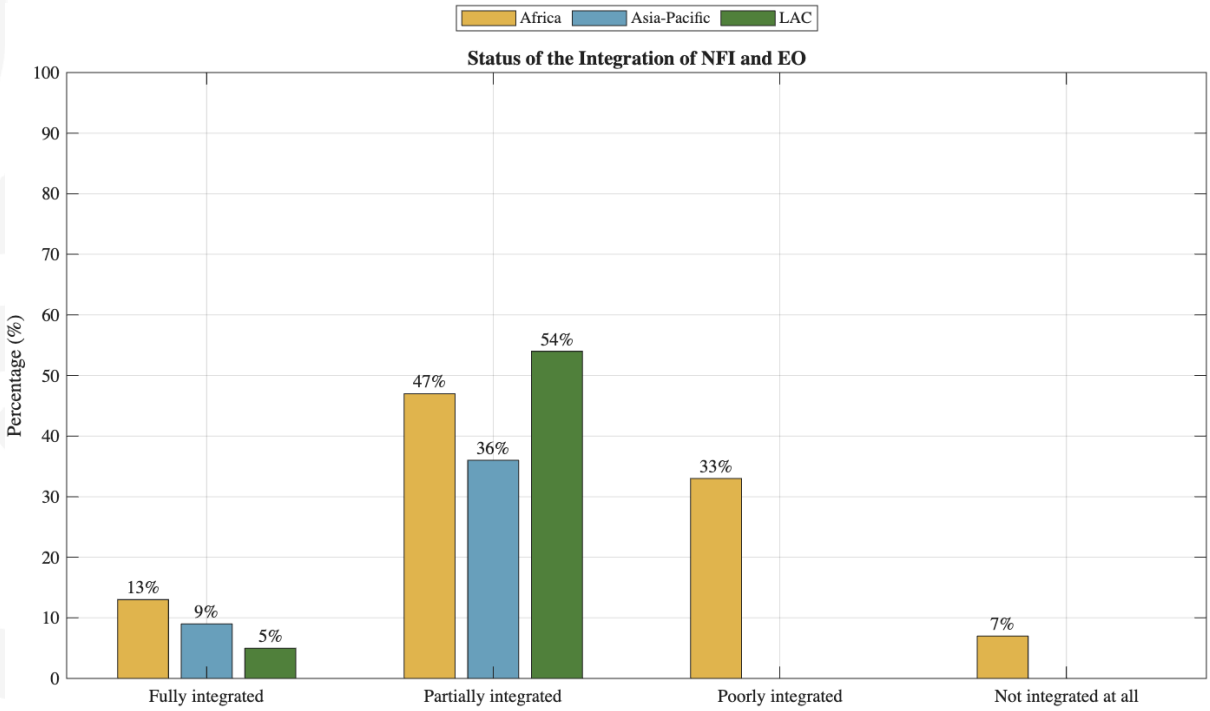

Figure 3. Status of the integration of NFI and EO

Lack of integration reflects three compounding structural barriers that appear together across all regions: funding gaps (69–87%), technical skills and software limitations (54–73%), and inconsistent data formats or protocols (40–59%). Fixing one barrier without the others does not unlock progress. Lack of integration represents a category where most countries experience both, access and methodology constraints.

1.3.3 Innovation Priorities for Tier 2/3 Readiness

This category represents the innovations that respondents think would most support their move toward IPCC Tier 2/3 reporting. Respondents across all regions converged on a near-identical

priority list. Automated satellite-field integration workflows lead in Africa (93%). National-scale biomass estimation tools are equally prioritized across all three regions (~63%). Soil carbon models linked to satellite data rank high in LAC (56%) and Africa (50%), reflecting the importance of peatlands and agroforestry.

Table 5: Innovations priorities for Tier 2/3 readiness by region

Innovation Priority	Africa	Asia-Pacific	LAC
Automated satellite plus field integration	93%	64%	64%
National-scale biomass estimation tools	64%	64%	62%
Improved emission/removal factors with satellite information	57%	45%	44%
Improved calibration/validation campaigns	50%	45%	36%
Soil carbon models linked to EO	50%	23%	56%

Africa's top priority, automated satellite-field integration at 93%, is an access constraint signal. The binding constraint is not having a working integration pipeline at all. Getting the basic workflow running is the prerequisite for everything else. The 93% figure reflects a region that is blocked at the foundation, or a very limited establishment of comprehensive forest monitoring systems.

LAC and Asia-Pacific show a different pattern. They also prioritize integration and biomass tools, but the secondary priorities, improved emission and removal factors via EO (44–57%), calibration and validation campaigns (36–50%), and soil carbon models (23–56%), point to a methodological constraint. These regions have successful data integration workflows to some extent. However, what they are missing is the scientific basis that supports their next steps for estimation once their data is assembled, for example how to derive removal factors, how to validate outputs against IPCC standards, how to model soil carbon in tropical peatlands and agroforestry systems that current IPCC guidance does not adequately cover.

1.3.4. Priority Ecosystems and Missing Methods

Ecosystem Gaps Across Regions:

Ecosystem R&D priorities map directly to regional landscape realities, but the two constraints framework reveals that similar-looking gaps represent different kinds of problems depending on

the region. The table below shows high demand across all ecosystems in all regions. The question is not which ecosystems are flagged, but why are they flagged. Gaps for ecosystem-specific data could be due to lack of access or processing capabilities of particular datasets (access constraint), or lack of established data processing methods and supporting guidance (methodology constraint).

Table 6. Ecosystems gaps across regions

Ecosystem	Africa (n=15)	Asia-Pacific (n=22)	LAC (n=39)
Agroforestry systems	67%	77%	62%
Mangroves	40%	55%	62%
Peatlands	60%	27%	49%
Dry forests	27%	45%	62%
Grasslands / Savannas	47%	32%	38%

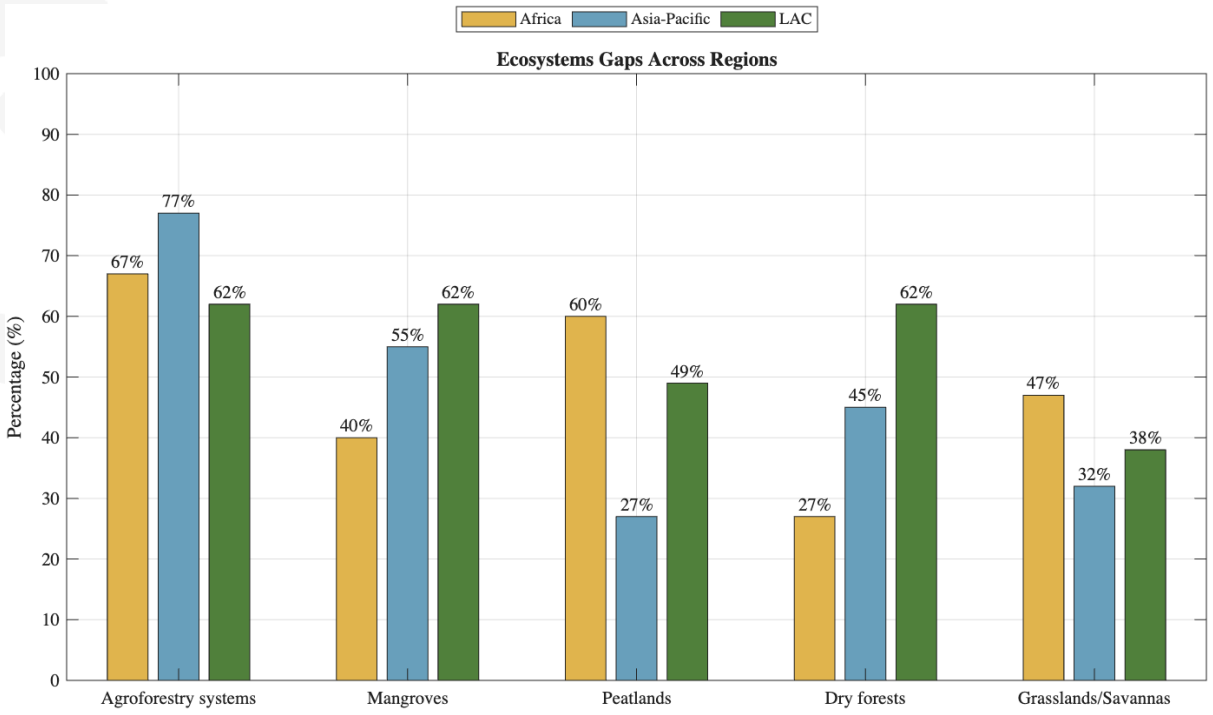

Figure 4. Ecosystems gaps across regions

Agroforestry is flagged at 62–77% across all three regions, the most cross-cutting gap in the entire survey. This is a methodology constraint everywhere. It shows that agroforestry systems are spectrally complex, heterogeneous, and poorly addressed by existing IPCC guidance and satellite

data classification methods regardless of whether a country has good infrastructure or not. No amount of better data access resolves the fact that current biomass estimation methods were not designed for agroforestry mosaics. This is a method gap, not an access gap, and it demands R&D investment.

Peatlands show a different story, where the same ecosystem is flagged for different reasons. Africa's 60% reflects an access constraint in large part. Countries know peatlands are critical (particularly in the Congo Basin), but lack the in-situ data, processing infrastructure, and regional coverage to monitor them. LAC's 49% is more of a methodology constraint: countries like Colombia and Peru have monitoring capacity but are hitting the limits of IPCC peatland guidance for tropical contexts.

Dry forests and grasslands are particularly important in Africa and Central America and are among the most underserved ecosystems in satellite data method development globally yet show relatively lower flagging rates in this survey. This could point to underrepresented samples from countries in the survey. Dry forest monitoring is harder to prioritize when basic infrastructure gaps (access constraint) dominate the institutional agenda.

Mangroves present the clearest access and methodological constraint across Asia-Pacific and LAC (55–62%): countries have coastal monitoring capacity and strong policy motivation from blue carbon markets but lack both, methodology and guidance to integrate soil carbon stocks with canopy change detection at the precision required by crediting frameworks.

Missing In-Situ Data:
The table shows high demand for field data across all regions, but the reasons countries lack that data, and therefore what needs to be done about it differ by region.

Table 7. Missing in situ-data by region

Missing In-Situ Dataset	Africa	Asia-Pacific	LAC
Peat depth / peat carbon content	67%	55%	82%
Mangrove soil carbon data	60%	36%	54%
Degradation data (fire occurrence)	40%	45%	56%
Land use / land cover ground truth	47%	55%	46%
Forest inventory / tree plot data	47%	45%	38%

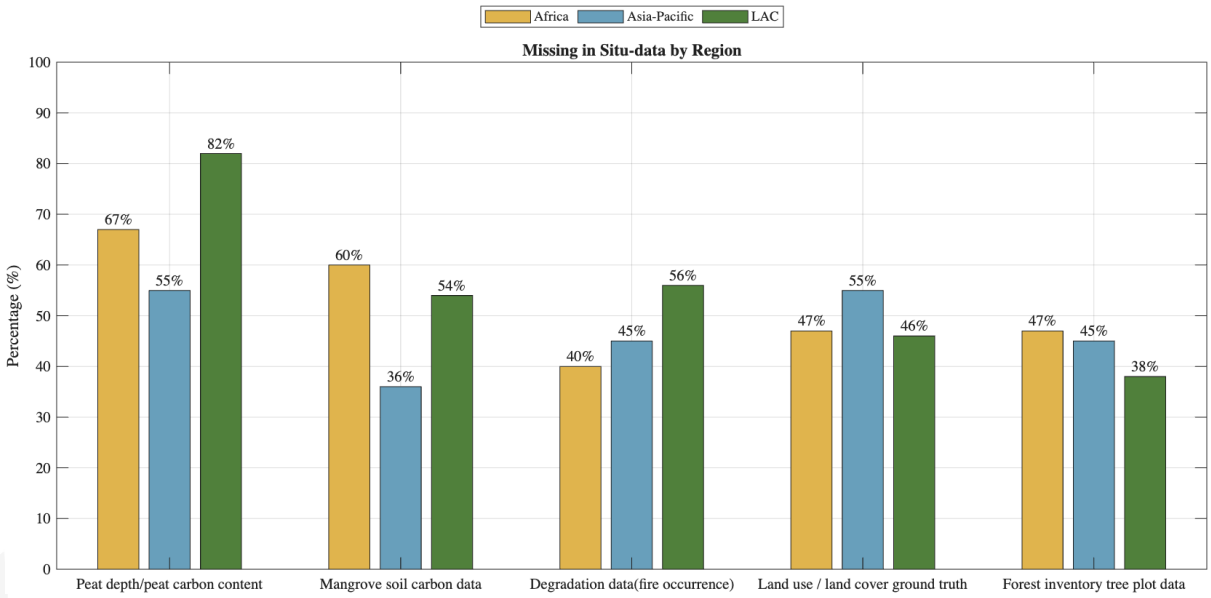

Figure 5. Missing in-situ data by region

Peat depth and peat carbon content is the most universally cited missing dataset, flagged by 67% in Africa, 55% in Asia-Pacific, and 82% in LAC, making it the highest single data gap in the entire survey. But its peat-associated data gaps differ by constraints. In Africa, the absence of peat data is predominantly an access constraint problem, as there are very limited sustained field measurement programs, no regional networks of permanent plots, and limited institutional infrastructure to acquire, store, and process peat depth surveys across the Congo Basin. The gap is one of access and investment. In LAC, where the 82% figure is the highest in the survey, the constraint is more methodological, where countries like Colombia and Peru have monitoring institutions and field capacity, but are running into lack of clear guidance for tropical peatland carbon accounting. Having better data would not resolve this, they also need better methodological guidance on how to progress from data to reporting requirements.

Mangrove soil carbon data follows a similar pattern. Africa's 60% reflects an access constraint, where coastal monitoring programs are underfunded and lack the equipment and personnel for systematic soil core campaigns. Asia-Pacific's lower rate (36%) likely reflects some progress through regional blue carbon initiatives, and LAC's 54% is driven by the blue carbon market demand and ART-TREES crediting requirements, which require soil carbon stocks to be estimated separately from above-ground biomass, a methodological standard that existing field protocols were not designed to meet. This is a methodological constraint, the field data protocol needs to be redesigned, not just funded.

Degradation data, such as fire occurrence, logging intensity, selective harvesting is flagged at 40–56% across all regions and is primarily a methodological constraint. Data collection methods exist for degraded forest ecosystems. What does not exist is consensus on how degradation events should be, defined, recorded, classified, and integrated into national GHG inventories in a way that is consistent across reporting standards. Countries collecting fire occurrence data find that IPCC

guidance for converting observations into emission and removal factors is insufficient for tropical forest contexts, particularly for low-intensity degradation that does not register clearly in remote sensing outputs.

Land use and land cover ground truth data, and forest inventory and tree plot data, are flagged at similar rates across all regions (38–55%). These are the foundation of any Tier 2 or Tier 3 reporting system, and their consistent flagging at moderate levels across all three regions reflects that ground truth collection is expensive, logistically difficult, and institutionally fragile regardless of tier. However, the nature of fragility differs. In Africa, it is largely an access constraint, where field campaigns are funded sporadically, data is not systematically archived, and plot networks are not maintained between measurement cycles. In LAC and Asia-Pacific, it is a methodological constraint, where plot networks exist but the protocols are not harmonized across institutions, making it difficult to aggregate data into regional estimates or to use plot data for validating satellite-derived products.

1.3.5 International Collaboration

The international community tends to fund the same collaboration mechanisms globally, technical assistance, tool development, training, without differentiating by either access or methodological constraints. Access-constrained countries need partnership that builds the foundation such as data access, infrastructure, sustained field presence, and decision-support tools. Methodological constrained countries need R&D investment, methodological frameworks and validation protocols that translate research into reporting-ready products. Both are international responsibilities.

Preferred Collaboration Mechanisms:

Technical assistance from space agencies (ESA, NASA, among others) is the most universally demanded form of international collaboration, cited by 59–87% of respondents. Africa stands out with the highest demand for co-developing IPCC-aligned methods (67%), reflecting the need for methods that fit African landscape contexts, which include dry forest, savannas, and agroforestry landscapes. GFOI/CEOS tools and platforms are valued by 55–64%, providing a direct mandate for GFOI's continued platform and methods development work.

Table 8. Preferred collaboration mechanism by region

Collaboration Mechanism	Africa	Asia-Pacific	LAC
Technical assistance from space agencies	87%	59%	69%
Data access and capacity building	73%	50%	64%
GFOI/CEOS tools and platforms	60%	55%	64%

Collaboration Mechanism	Africa	Asia-Pacific	LAC
Funding for national R&D institutions	60%	59%	51%
Co-developing IPCC-aligned methods	67%	32%	59%
Joint research with universities	47%	45%	38%

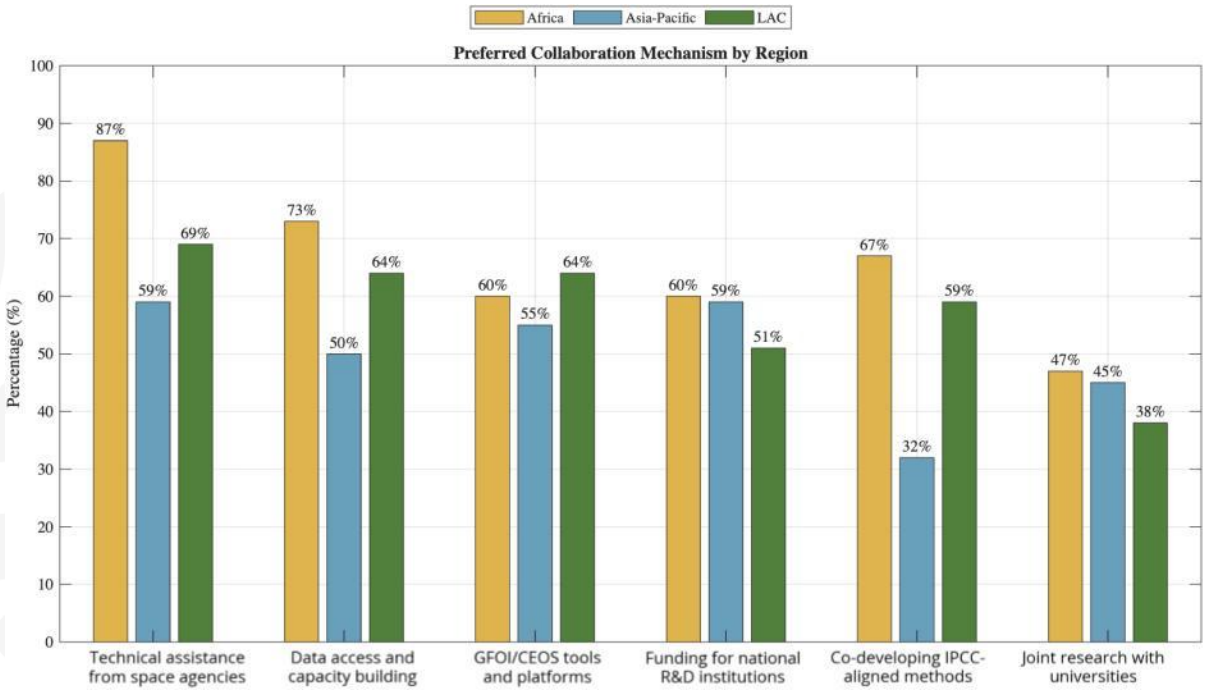

Figure 6. Preferred collaboration mechanism by region

Africa's main request is technical assistance from space agencies at 87% is an access constraint request. Space agency engagement means data access agreements, processing support, and hands-on capacity to get basic workflows running. The 67% for co-developing IPCC-aligned methods is also significant and slightly surprising for a region with strong access constraint characteristics. It suggests African institutions are aware that even if they solve the access problem, the methods do not yet fit their landscape contexts (dry forests, savannas, agroforestry). That awareness is emerging within a predominantly access-constrained region.

LAC and Asia-Pacific's relatively lower demand for space agency technical assistance (59–69%) and stronger emphasis on GFOI/CEOS tools and platforms (64%) and co-developing IPCC-aligned methods (32–59%) are methodological constraint signals. These regions are not primarily asking for someone to help them access data, they are asking for better tools and better science to work with the data they already have.

Top R&D Funding Priorities:

When asked what they would prioritize with flexible R&D funding, respondents across all three regions converged on biomass and degradation algorithm development as the single highest

priority, cited by approximately 77–80% across regions. This ~78% consensus is the clearest mandate in the entire survey and should anchor the GFOI R&D workplan for 2026–2028. Satellite data and GHG integration tools follow as the second shared priority (~54–59%). Africa uniquely elevates policy decision-support systems (47%), reflecting greater demand to translate monitoring output into actionable government decisions.

Table 9. Top research and development funding priorities

R&D Funding Priority	Africa	Asia-Pacific	LAC
Prototype algorithms for biomass/degradation	80%	77%	77%
National EO–GHG integration tools	53%	59%	54%
Pilot decision-support systems for policy	47%	23%	36%
Improve EO platform interoperability	27%	18%	33%
Calibration / validation campaigns	33%	14%	23%

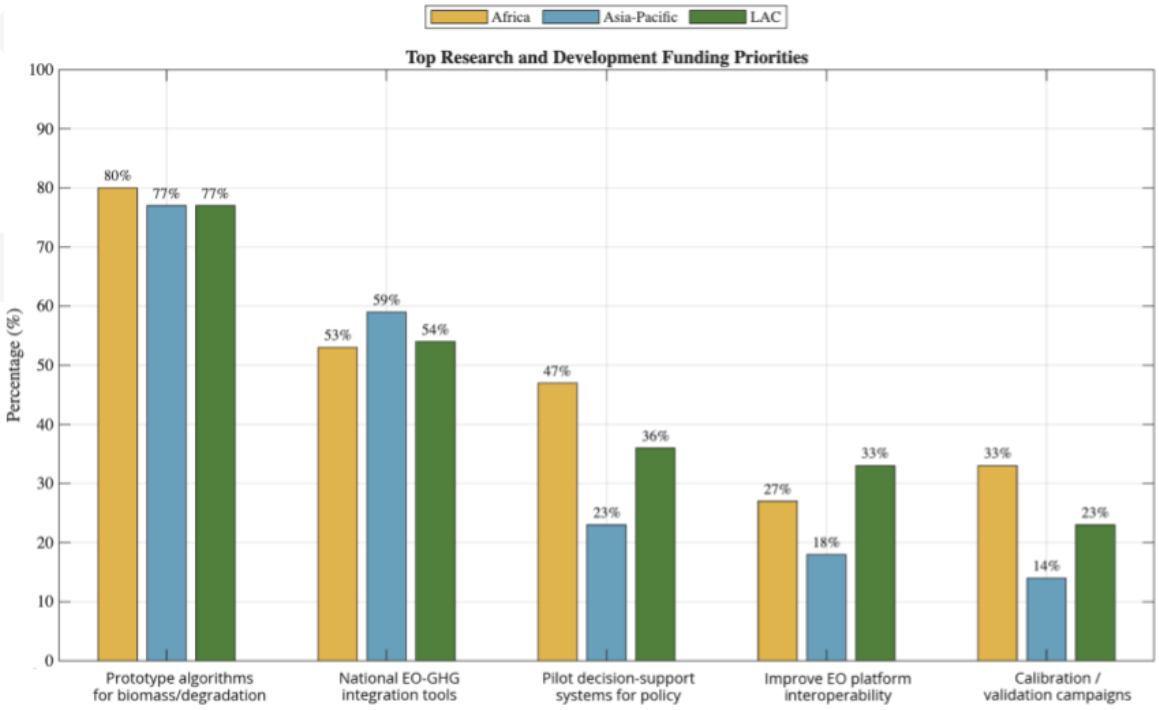

Figure 7. Top research and development funding priorities

For Africa, developing better biomass algorithms is responding to an access constraint. The algorithms they need are ones that work with the data that they can access. Often this data is

lower-resolution, sparser, less frequently updated. The research agenda they need prioritizes robustness under data-poor conditions.

For LAC and Asia-Pacific, the algorithm request is to respond to a methodological constraint. They have data but existing algorithms do not handle secondary forest recovery, agroforestry structure, or peatland dynamics adequately. They need more sophisticated algorithms.

Africa's unique elevated number of policy decision-support systems (47% versus 23–36% elsewhere) is the clearest methodological constraint signal. In this case even if we get better science, we need help translating monitoring outputs into decisions that government ministries can act on. That translation between technical MRV outputs and policy action is a gap. LAC and Asia-Pacific, operating at a higher technical baseline, have crossed that translation gap already.

Most urgent R&D needs related to non-CO_2 greenhouse gases in the AFOLU sector

The survey points to a consistently overlooked problem, methane from tropical wetlands and peatlands, and nitrous oxide from agricultural soils. These gases are not tracked well in most national inventories, not because countries don't know they matter, but because the methods to measure them reliably don't yet exist for tropical contexts. This issue is getting harder to ignore, as countries improve their CO_2 accounting, the gap left by unquantified methane and nitrous oxide becomes larger and more exposed to scrutiny in international reporting.

Table 10. Most urgent research and development needs for atmospheric emissions

Non-CO_2 R&D Priority	Africa	Asia-Pacific	LAC
CH_4 flux estimation from wetlands	73%	50%	59%
Improved emission factors for non-CO_2	33%	41%	59%
Linking EO to process-based models	40%	45%	46%
N_2O from agricultural soils	53%	18%	41%
Mapping of land management practices	53%	59%	31%

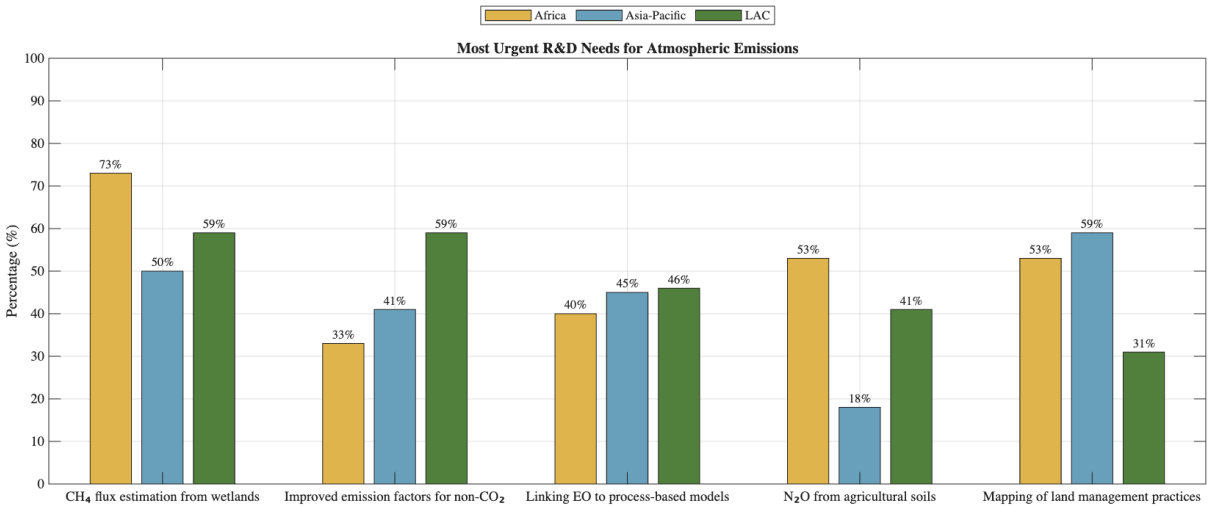

Figure 8. Most urgent R&D needs for atmospheric emissions

Methane flux from wetlands is the top non-CO_2 priority in Africa at 73% and remains high in LAC (59%) and Asia-Pacific (50%). The Congo Basin alone justifies the urgency. It is home to one of the largest tropical peatlands. N_2O from agricultural soils ranks second in Africa (53%) and LAC (41%), reflecting the reality that in many countries the forest-agriculture boundary is not difficult to differentiate, shifting cultivation and agroforestry mean soil emissions cannot be separated from forest carbon accounting.

The technical problem is that neither gas can be estimated directly from satellite imagery. Both require process-based biogeochemical models fed by satellite information inputs, inundation extent, soil moisture, vegetation type, and other datasets, and no agreed methodology exists for doing this in a way that satisfies IPCC reporting standards. Through the two-constraint framework, this is a methodological constraint problem in every region. Countries with strong infrastructure are hitting the same ceiling as those without, because the ceiling is the science. This is where GFOI, working with IPCC, is best placed to act by producing guidance.

Survey Analysis Conclusion

The 2025 GFOI R&D Needs Analysis set out to ask what countries need. What it found is more precise and more useful than a wish list: countries know exactly what they need, they can articulate it clearly, and they are largely stuck not because the will is absent but because the international system keeps offering the same solutions to structurally different problems. Access constrained countries need data, infrastructure, sustained presence, and the translation layer between monitoring outputs and policy decisions. Methodologically constrained countries need a frontier, algorithms that go beyond current IPCC guidance, methodological frameworks for ecosystems that existing tools were not designed for, and validation protocols that turn promising research into reporting-ready practice. The two-tier framework can be used as a diagnosis, and like any diagnosis, its value is not in naming the condition but in reducing the situations in which inadequate support is being offered.

2. Defining R&D Needs for monitoring removals

This section synthesizes survey findings with evidence from a series of interactions with countries that started on September 22, 2025 with online interactions, and culminated in April 2026 with insights from the Google supported Technical Workshop on Forest Losses and Gains in Villa de Leyva, Colombia, which brought together national teams from Brazil, Colombia, Costa Rica, Guatemala, Mexico, Paraguay, and Peru alongside Google Earth Engine, FAO, the World Bank, ART, and WRI.

A consistent finding across all online country interactions and all presentations at Villa de Leyva, reinforced by the R&D survey, is that **national monitoring systems were built to track emissions, specifically deforestation and degradation, and that removals remain institutionally marginalized.** This is an asymmetry built into NFMS, and it is becoming a policy liability as international frameworks increasingly require credible removals accounting.

Brazil excludes secondary vegetation from its national GHG Emissions Report due to missing historical time-series data. Colombia has identified 8,500 hectares of verified restoration but is using a single national removal factor of 2.7 tCO_2/ha. Paraguay is building its first removals monitoring protocol. Peru lacks removal factors for coastal and highland forests entirely. These are the four most technically advanced REDD+ countries in LAC.

The policy stakes are significant: under ART-TREES, currently the most financially attractive jurisdictional carbon standard, removals credits are issued only for non-forest to forest transitions, with a reference crediting level of zero for natural forest. The entire financial value of removals accounting rests on methodological precision that most countries attending the workshop do not yet possess. Costa Rica, the most advanced country at the workshop, is pursuing the shift from $5/credit (FCPF) to $10+/credit (ART-TREES) precisely because its removal methodology is rigorous enough to support that transition.

The most technically consequential work presented at Villa de Leyva was the chronosequence-based biomass recovery estimation framework developed and presented by Daniela Requena Suarez (GFZ), applied to Peru's National Forest Inventory plot data.

Chronosequence analysis uses a space-for-time substitution approach. Forest sites at different ages, and their biomass values are used to reconstruct the trajectory of biomass recovery over decades. The field visit to La Microcuenca de la Quebrada Chaina, a post-fire restoration site with plots ranging from 5 to 10 years post-planting, demonstrated this method directly. Participants from seven countries collected plot data using the Colombia NFI design and processed it to derive recovery rates.

The Peru application produced removal estimates of rapid early biomass recovery at 7.6 Mg/ha/yr in years 1–10, declining to 2.0, 1.2, and 0.9 Mg/ha/yr in subsequent decades, with plots reaching ~89% of undisturbed above-ground biomass at 34 years post-disturbance.

The chronosequence method is compatible with existing NFI plot designs used by Peru, Colombia, Guatemala, and Mexico. It produces country-specific removal factors, precisely the input currently missing from most national systems. The bottleneck for countries to use chronosequences might be the absence of GFOI-endorsed operational guidance for applying it in official reporting contexts. This kind of guidance was requested by countries during the workshop.

For the generation of Activity Data, mapping what is recovering is a challenge. Removal factors are only half of the removals accounting equation. The other half is activity data that shows where regeneration is happening, across what area, at what rate. Current methods such the use of GEE embeddings or the CCDC outputs have not been formally validated against IPCC activity data standards in a reporting context. Countries expressed strong interest in both tools but cannot use them in official submissions without a documented validation protocol. This could potentially be an activity that the R&D Component could address.

Country teams operate across multiple coexisting standards simultaneously, FCPF (now winding down), ART-TREES, national NDC reporting, and Article 6 requirements, each with different methodological demands and financial incentives. ART-TREES requires natural forests and plantations to be tracked separately, five-year pre-history non-forest status to be demonstrated, and removal factors to be re-evaluated every five years accounting for tree mortality.

A significant shared challenge is the nesting problem. Countries must ensure subnational carbon projects do not double-count with national reporting and must align national methodologies with Article 6 requirements simultaneously.

3. Recommendations for research

The following are recommended activities for the GFOI R&D Component and broader community, which have been categorized by their potential implementation timeframe, where short-term refers to immediate actions achievable in 1-2 years, medium-term refers to actions that can be achieved within 3 years, and long-term can be achieved as part of multi-year process, oftentimes taking 3+ years:

- ***Recommendation 1:*** Develop GFOI-endorsed operational support material/guidance for chronosequence-based removal factor development. Support material can cover site selection criteria, minimum plot design standards linked to existing NFI designs, statistical models for biomass recovery trajectories, uncertainty propagation, and alignment with ART-TREES and IPCC Tier 2 requirements. This would be in the format of an operational document, not a research paper. *(Timeframe: medium-to-long term)*

- ***Recommendation 2:*** Develop operational examples of how removals accounting is actually incorporated into national reporting systems. Many technical discussions remain highly theoretical. GFOI could therefore support the development of detailed case studies documenting how countries such as Costa Rica, Nepal, others, are handling practical issues including secondary forest definitions, uncertainty treatment, and alignment with ART-TREES. (*Timeframe: short term)*
- ***Recommendation 3:*** The R&D survey shows that countries across all regions face similar gaps in forest inventory and ground-truth data. At the same time, many countries are running separate field campaigns to meet the requirements of IPCC Tier 2, ART-TREES, and FCPF. A key opportunity for GFOI would be to convene a process to define a minimum common set of field data standards, so that one field campaign can serve multiple reporting frameworks. This would reduce duplication, lower costs, and improve consistency across national forest monitoring efforts. *(Timeframe: medium term)*
- ***Recommendation 4:*** Support focused research on estimating forest removals in agroforestry landscapes, which was identified as the main ecosystem gap across all three regions, and on dry forest recovery, which is a priority in Africa and Central America. These ecosystems were not covered during the Villa de Leyva workshop. *(Timeframe: medium term)*
- ***Recommendation 5:*** Support focused research to link satellite wetland mapping (using SAR data such as Sentinel-1 and ALOS-4) with methane (CH_4) estimates in tropical peatlands. Priority regions include the Congo Basin, the Amazon-Orinoco, and Southeast Asia. Since methane from wetlands is a major non-CO_2 emissions gap, especially in Africa, this work should be strengthened through international collaboration. *(Timeframe: medium-to-long term)*
- ***Recommendation 6:*** Another attainable area for GFOI involvement would be the development of practical guidance around uncertainty communication. Many countries are hesitant to report estimates with high uncertainty. GFOI could help normalize transparent reporting approaches that clearly communicate uncertainty ranges, assumptions, and limitations without discouraging countries from beginning implementation. This may be especially important for removals, degradation, peatlands, and non-CO_2 gases where uncertainty will remain inherently high for some time. *(Timeframe: short-to-medium term)*

Conclusions

The findings presented in this report show the evident gaps between scientific progress and operational practice in national forest monitoring. Insights from the survey show that support can be achieved by the development of guidance and sustained scientific partnerships that match the specificity of the constraints and challenges of national forest monitoring systems. The two-constraint framework used to analyze the survey results distinguishes experiences in which NFMS are blocked by access barriers or by methodological limitations. This approach is offered as a practical diagnostic tool for prioritising international support more effectively.

The most urgent shared priority to emerge from both the survey and the Villa de Leyva workshop is the monitoring and reporting of forest-based removals. Across all regions, national monitoring systems remain structurally oriented toward emissions, while removals remain institutionally marginalised despite growing policy and financial demands from frameworks such as ART-TREES, NDC reporting cycles, and Article 6. Closing this gap would require not only better algorithms and field protocols, but operational guidance that countries can use in official reporting contexts.

The R&D Component will use the recommendations outlined in this report to inform its workplan for 2026–2028. Country engagement will remain central to this work: the partnerships established through the survey and workshop processes are not a one-time input but the foundation for an ongoing exchange between science and practice that GFOI aims to sustain.

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