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SUMMARY REPORT OF GEOLOCATION DATA COLLECTION TOOLS, FUNCTIONALITIES, FORMATS AND INTEGRATION POTENTIAL

ADVANCING TRACEABILITY, LEGALITY AND SUSTAINABILITY IN INDONESIA (ATLAS) PROJECT - 2026

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Abbreviations

Abbreviation	Stand for	Description
API	Application Programming Interface	A standardised interface that enables seamless communication and data exchange between software systems.
ArcGIS	Arc Geographic Information System	A comprehensive GIS platform for spatial data management, mapping, and advanced geospatial analytics. Developed by ESRI (Environmental Systems Research Institute, Inc)
ATR/BPN	Agrarian and Spatial Planning / National Land Agency	Indonesian government authority responsible for land administration, registration, and spatial planning governance.
CSV	Comma-Separated Values	A widely used, lightweight file format for storing structured tabular data in plain text.
EUDR	European Union Deforestation Regulation	A regulatory framework ensuring that products entering the EU market are not linked to deforestation activities.
GeoJSON	Geographic JavaScript Object Notation	A standardised format for representing geospatial data structures using JSON for interoperability.
GPS	Global Positioning System	A satellite-based navigation system providing accurate geolocation and time information globally.
GPX	GPS Exchange Format	An XML-based format designed for storing and exchanging GPS data such as routes and tracks.
KML/KMZ	Keyhole Markup Language / Zipped KML	File formats used to visualise and share geospatial data in mapping tools like Google Earth.
NDPE	No Deforestation, No Peat, No Exploitation	A sustainability policy framework aimed at eliminating environmental and social risks in supply chains.
PDF	Portable Document Format	A platform-independent file format for consistent document presentation and sharing.
QA/QC	Quality Assurance / Quality Control	Systematic processes to ensure data and outputs meet defined quality standards and reliability criteria.

QGIS	Quantum Geographic Information System	An open-source GIS application for spatial data analysis, visualisation, and geoprocessing.
REST	Representational State Transfer	A widely adopted architectural style for designing scalable and stateless web services over HTTP.
RSPO	Roundtable on Sustainable Palm Oil	A global multi-stakeholder organisation promoting certified sustainable palm oil production.
SHP	Shapefile	A commonly used geospatial vector data format for storing location, shape, and attribute information.
SOAP	Simple Object Access Protocol	A protocol for exchanging structured information in web services using XML-based messaging.
SPKS	Serikat Petani Kelapa Sawit	An Indonesian organisation advocating for the rights and sustainability of independent oil palm farmers.
STDB	Surat Tanda Daftar Budidaya	An official certification document for registering plantation cultivation activities in Indonesia.
VPS	Virtual Private Server	A virtualised hosting environment that provides dedicated server capabilities within a shared infrastructure.

1. EXECUTIVE SUMMARY

This report summarises findings from an ATLAS project survey on geolocation data collection tools and systems used across Indonesia's palm oil supply chains. The objective is to understand the functionalities of the tools and inform improvements in interoperability, traceability, and compliance with sustainability and deforestation-free requirements.

The survey of 11 organisations in Indonesia's palm oil sector indicates that geolocation data collection is already widely practised, but the overall digital ecosystem remains fragmented and insufficiently integrated to support efficient traceability and EUDR readiness.

Organisations typically rely on a combination of dedicated GPS devices, mobile data-collection applications such as KoboToolbox, GIS software, spreadsheets, and file-based data exchange. Garmin GPS devices remain a common field tool for collecting spatial data, while KoboToolbox is widely used for farmer and plantation attributes. Shapefile and KML/KMZ remain the dominant data formats. Although these formats provide broad compatibility, data is still frequently transferred through manual export/import processes, limiting interoperability and creating additional administrative effort.

Field operations are strongly dependent on offline-capable and Android-based tools, reflecting the limited internet connectivity often encountered in remote plantation areas. Connectivity is consistently identified as the most significant operational challenge, affecting data transfer, synchronisation, and field productivity. Other important constraints include high integration and development costs, incompatible systems and formats, limited API availability, data-quality issues, and gaps in technical capacity.

The findings suggest that the main challenge to EUDR readiness is not the absence of geolocation data, but the fragmentation of the systems used to collect, validate, store, and exchange that data. Many organisations still maintain information across separate GPS devices, mobile applications, Excel files, local storage, and basic cloud folders. This creates manual workflows, increases the risk of errors, weakens audit trails, and makes traceability and compliance verification more difficult.

Deforestation risk assessment is already widely practised, but approaches are not yet standardised. Organisations primarily use forest and land-cover datasets, including Global Forest Watch and government maps, together with plantation boundaries and satellite imagery. Risk assessments are generally based on spatial overlap with forests or conservation areas, historical land-cover change, and legal land status. However, analysis remains largely dependent on manual GIS overlay, while high-risk cases are typically followed up through field verification.

The survey also shows a relatively clear vision of the ideal future workflow. Organisations envisage an end-to-end process covering planning and preparation, field collection, processing and validation, integration and analysis, reporting and utilisation. They want spatial and attribute information—including plantation boundaries, farmer profiles, and legality documents—to be captured together during a single field process. Importantly, respondents want quality control to take place during data collection rather than after field teams return to the office.

The single most impactful improvement identified by respondents is automated, real-time quality assurance and quality control (QA/QC). A unified mobile platform that combines GPS tracking, polygon creation, digital forms, and real-time validation could identify geometry errors, missing attributes, overlaps, and potential conflicts with protected areas while fieldwork is still underway. This would reduce the need for re-surveys, improve data accuracy, and make datasets more immediately suitable for audit and compliance purposes.

Finally, integration with government systems is the most important missing capability. Respondents highlighted the need for direct connectivity with ATR/BPN for land legality, the Ministry of Forestry for forest and conservation status, and e-STDB for plantation registration and certification. Automated access to these authoritative datasets would enable real-time validation of land status and reduce the need for manual cross-checking, thereby accelerating certification, permitting, traceability, and EUDR compliance processes.

Overall Conclusion

The Indonesian palm oil sector has substantial experience and capacity in collecting geolocation data, but the value of this data is constrained by fragmented tools, manual data exchange, weak interoperability, and limited integration with authoritative government systems. The priority is therefore not simply to collect more data, but to establish an integrated, offline-capable, mobile-first workflow with real-time QA/QC, centralised data management, automated risk analysis, and direct connections to government and certification systems. Such integration would significantly improve data quality, reduce field and administrative costs, strengthen traceability, and accelerate EUDR readiness.

2. INTRODUCTION

2.1. About the ATLAS project

The Advancing Traceability, Legality, and Sustainability in Indonesia (ATLAS) project supports Indonesian stakeholders in strengthening traceability, improving data collection, and advancing legal and deforestation-free production in the palm oil and timber sectors. Through technical assistance, capacity building, and stakeholder engagement, the project aims to enhance the ability of public and private sector actors to meet traceability and legality requirements while promoting more sustainable and inclusive supply chains.

A key focus of ATLAS is strengthening supply-chain traceability through geolocation mapping and digital tools, with particular attention to improving smallholder farmers' access to and capacity to use these tools. The project also supports smallholders and Indonesian authorities in meeting relevant standards and promotes awareness and dialogue between Indonesia and the European Union on the benefits and market opportunities associated with legal, traceable, and deforestation-free production.

This publication contributes to these objectives by examining geolocation data collection tools used in Indonesia's palm oil sector and documenting their functionalities.

2.2. Background

Strengthening traceability and legality in Indonesia's palm oil supply chain is essential to maintain access to EU and global markets, particularly in response to regulations such as the EUDR. Transparent and reliable geolocation and legality data are critical to demonstrate deforestation-free and compliant production.

Indonesia has made progress through national systems such as smallholder registration platforms (e.g., e-STDB). However, many smallholders and supply chain actors still face challenges in data collection, documentation, and system integration.

ATLAS project addresses these gaps by improving geolocation-based traceability, enhancing data interoperability, and strengthening stakeholder capacity—especially for smallholders. Understanding the current tools, data formats, and system integration is a key step toward building more efficient, transparent, and scalable traceability systems.

2.3. Objective

The objective of this report is to assess the current landscape of geolocation data collection tools and systems used across Indonesia's palm oil sector. This includes understanding their functionalities, data collection processes, and the types of data generated.

The report aims to identify gaps, challenges, and opportunities for improving data interoperability and system integration among stakeholders. Ultimately, it seeks to support more efficient coordination, strengthen traceability, and enhance compliance with sustainability and deforestation-free requirements.

2.4. Methodology

The methodology for developing this report involved the following steps:

1. Creating and designing the survey form.
2. Implementing the form using the Google Forms platform.
3. Distributing the Google Forms survey link to respondents (partners/stakeholders).
4. Monitoring survey results from respondents and addressing any questions they may have.
5. Following up with respondents who have not yet completed the survey form in a proper and courteous manner.
6. Analysing the survey results and preparing a report.

RESULTS

In this section, the survey forms completed by respondents are analysed. Survey was conducted between January and March 2026. The content is organised into several sections to facilitate data processing and support clear, well-founded conclusions from the analysis.

2.5. Section 1: Respondent Info and Data Collection

2.5.1. Category of Organisation

Organisation	Count of Organisation
NGO	6
Service Provider (Training and Database system)	3
Certification Body	1
Palm Oil Company	1
Total	11

TABLE 1: CATEGORY OF ORGANISATION

2.5.2. Estimated annual data collection volume

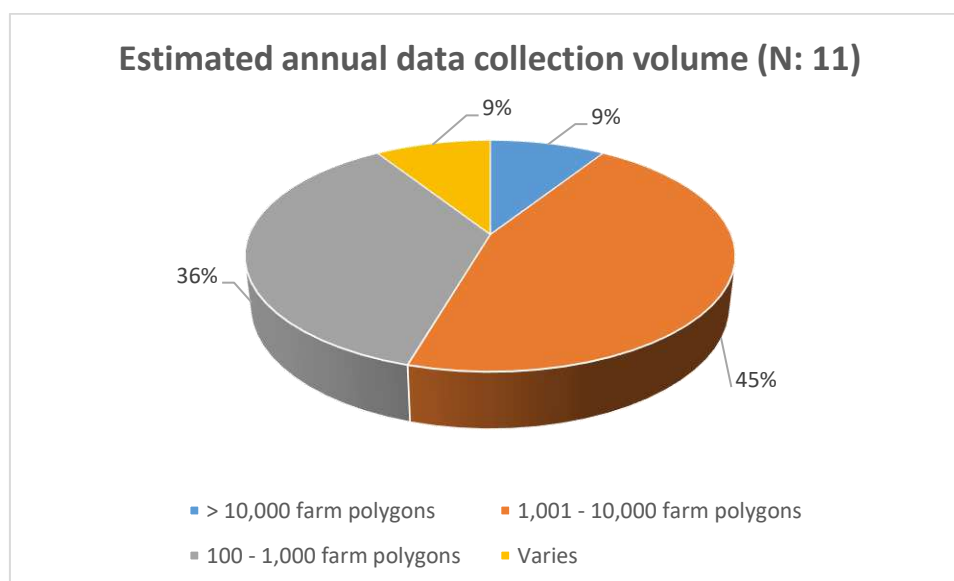


FIGURE 1: ESTIMATED ANNUAL DATA COLLECTION VOLUME

2.6. Section 2: Geolocation Data Collection

2.6.1. Tool/software for field survey

Tool/software for field survey	Count of Responses	Percent
Garmin GPSMAP	8	73%
KOBO Toolbox	4	36%
Avenza Maps	3	27%
Esri ArcGIS	3	27%
QGIS	2	18%
AgriTrace	1	9%
Appsheet	1	9%
DJI Pilot 2	1	9%
Green Point (FORTASBI application)	1	9%
smartphones	1	9%
SW Maps	1	9%

TABLE 2: TOOL/SOFTWARE FOR FIELD SURVEY (N:11)

2.6.2. Main function of the tool

Main function of the tool	Count of Responses	Percentage
GPS coordinate collection (points)	10	91%
Polygon mapping	10	91%
Data forms/attribute collection	7	64%
Data validation/quality check	7	64%
Offline data collection	6	55%
Real-time data synchronisation	6	55%
Photo/attachment capture	6	55%
Map overlay	1	9%

TABLE 3: MAIN FUNCTION OF THE TOOL (N:11)

2.6.3. Equipment required to run the survey hardware/software

Equipment required to run the survey hardware/software	Count of Responses	Percentage
Computer/laptop for setup	9	82%
Dedicated GPS device (Garmin; Trimble; etc.)	8	73%
Smartphone (Android)	8	73%
Drone	5	45%
Tablet	4	36%
Smartphone (iOS/iPhone)	2	18%

TABLE 4: EQUIPMENT REQUIRED TO RUN THE SURVEY HARDWARE/SOFTWARE (N:11)

2.6.4. The input format of the tool

The input format of the tool	Count of Responses	Percentage
Shapefile/SHP	9	82%
KML/KMZ	8	73%
GPX	3	27%
QGIS Geopackage	3	27%
CSV/Excel with coordinates	2	18%
GeoJSON	2	18%

TABLE 5: THE INPUT FORMAT OF THE TOOLS (N:11)

Note: Few tools can be inserted by basic information or basemap from outside source as an input. It is useful for field verification

2.6.5. The output format produced by tool

The output format produced by tool	Count of respondents	Percentage
Shapefile/SHP	9	82%
KML/KMZ	8	73%
GPX	3	27%
QGIS Geopackage	3	27%
CSV/Excel with coordinates	2	18%
GeoJSON	2	18%

TABLE 6: THE OUTPUT FORMAT PRODUCED BY TOOLS (N:11)

Note: The output data is the data taken from field

2.6.6. What geolocation data do you collect in the field

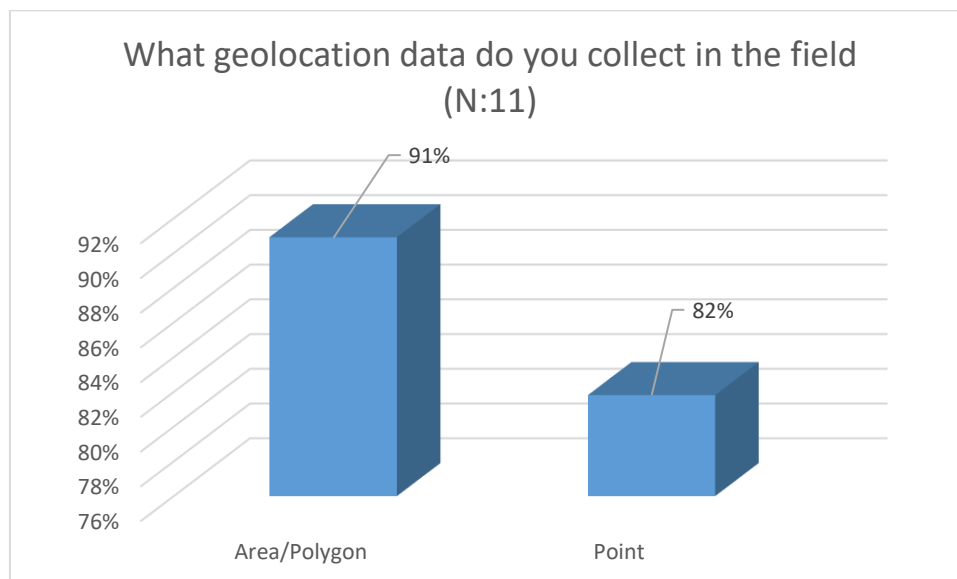


FIGURE 2: WHAT GEOLOCATION DATA DO YOU COLLECT IN THE FIELD

2.6.7. Integration Capabilities

Integration Capabilities	Count of responses	Percentage
Manual export/import	9	82%
Direct sync with cloud platforms	4	36%
API available (REST, SOAP, etc.)	1	9%
Don't know	1	9%
Integration with Kobotoolbox Server	1	9%

TABLE 7: INTEGRATION CAPABILITIES (N:11)

2.6.8. Operating systems supported by the device

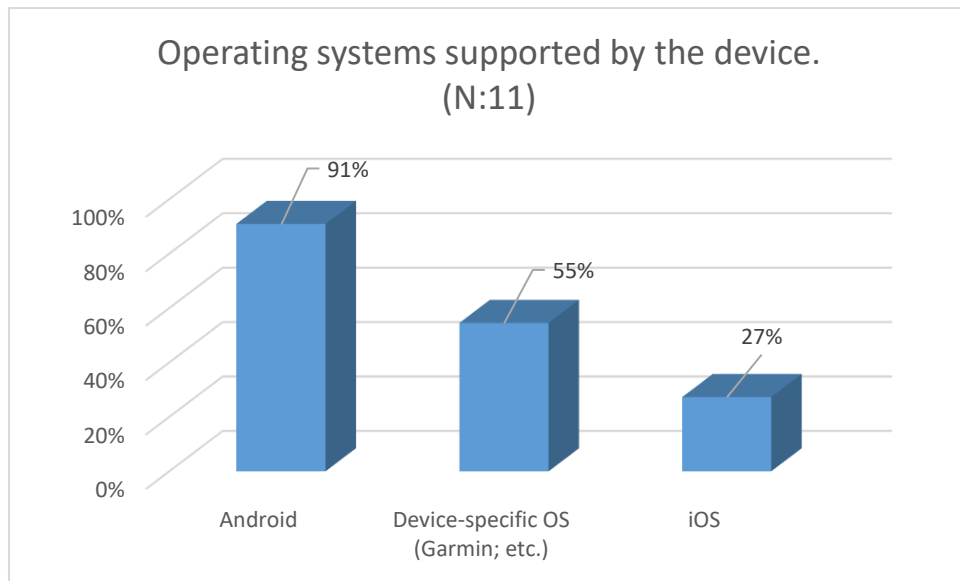


FIGURE 3: OPERATING SYSTEMS SUPPORTED BY THE DEVICE

2.6.9. Desktop/Laptop operating systems supported by the device

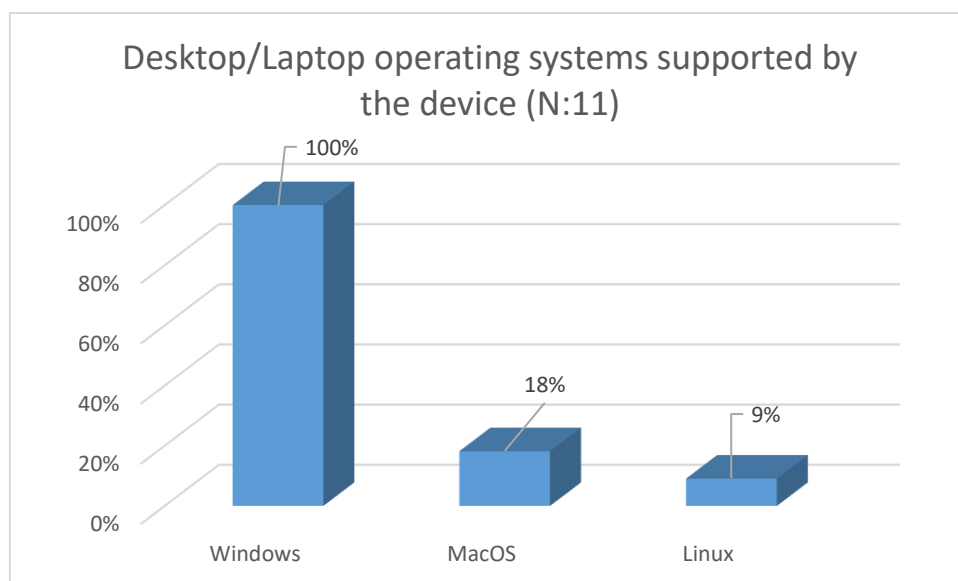


FIGURE 4: DESKTOP/LAPTOP OPERATING SYSTEMS SUPPORTED BY THE DEVICE

2.6.10. Important Findings of Section 2

- **Geolocation workflows remain fragmented** – Most organisations use multiple separate tools (GPS, mobile apps, GIS software), creating inefficiencies in field-to-office workflows.
- **Dedicated GPS devices remain the primary field tool** – Garmin GPS dominates spatial data collection, while KoboToolbox is widely used for attribute data, showing a clear split between spatial and non-spatial systems.
- **Shapefile and KML/KMZ remain the operational standard** – These formats dominate both input and output, reinforcing compatibility but limiting more modern, flexible integration options. With latest technology, conversion from one format data into others (ex. SHP to GeoJSON) is extremely easy to do.
- **Manual export/import is the main integration model** – Most organisations still transfer data manually, highlighting weak interoperability and slow data synchronisation.
- **Offline and mobile-first capability is essential** – Android-based tools and offline functionality are critical for field operations, especially in remote areas with limited connectivity.

2.7. Section 3: Workflow And Challenges

2.7.1. Tools used for geolocation data retrieval

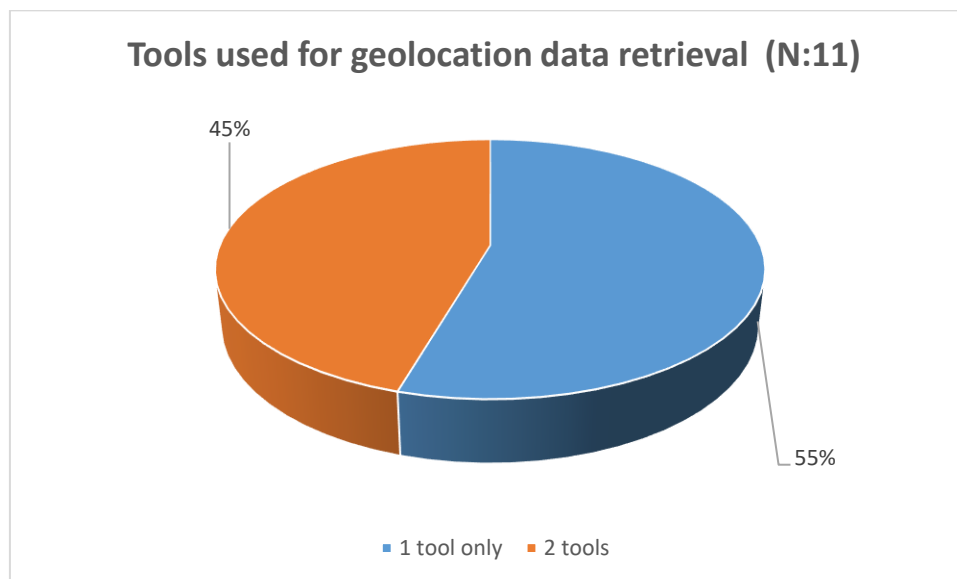


FIGURE 5: TOOLS USED FOR GEOLOCATION DATA RETRIEVAL

2.7.2. Data transfer between devices

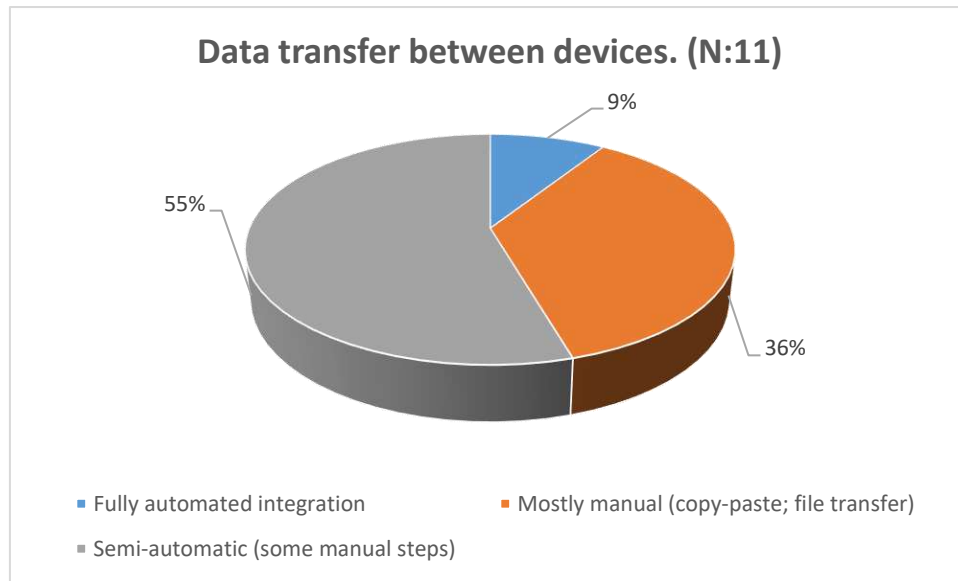


FIGURE 6: DATA TRANSFER BETWEEN DEVICES

2.7.3. Biggest Technical Challenges

Biggest Technical Challenges	Count of responses	Percentage
Internet connectivity in field areas	7	64%
High integration development costs	6	55%
Data accuracy/quality issues	4	36%
Lack of API/integration options	4	36%
Limited technical skills in team.	4	36%
Incompatible data formats between tools.	3	27%

TABLE 8: BIGGEST TECHNICAL CHALLENGES (N:11)

2.7.4. Data storage system used by organisation

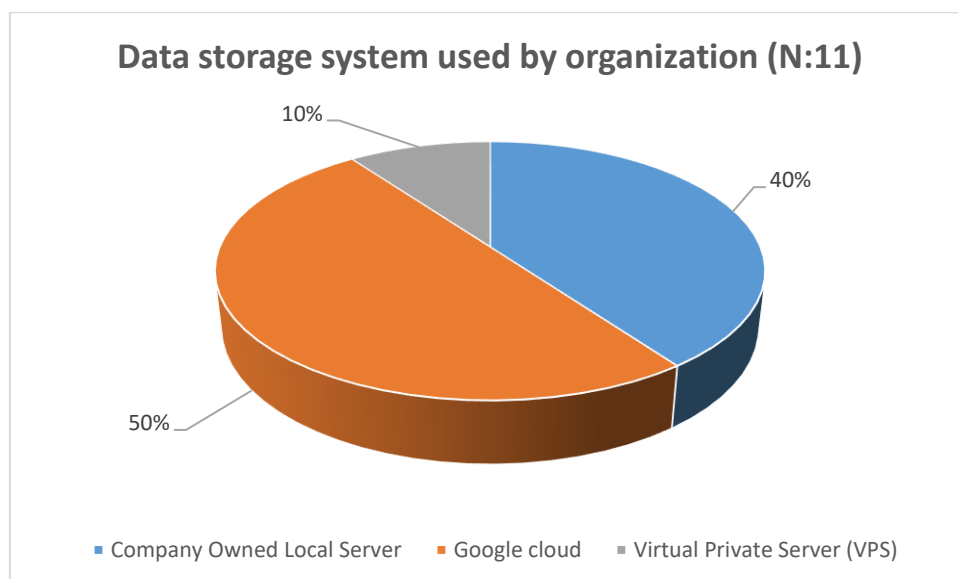


FIGURE 7: DATA STORAGE SYSTEM USED BY ORGANISATION.

2.7.5. EUDR Compliance Readiness: Is your current device ready to meet EUDR requirements?

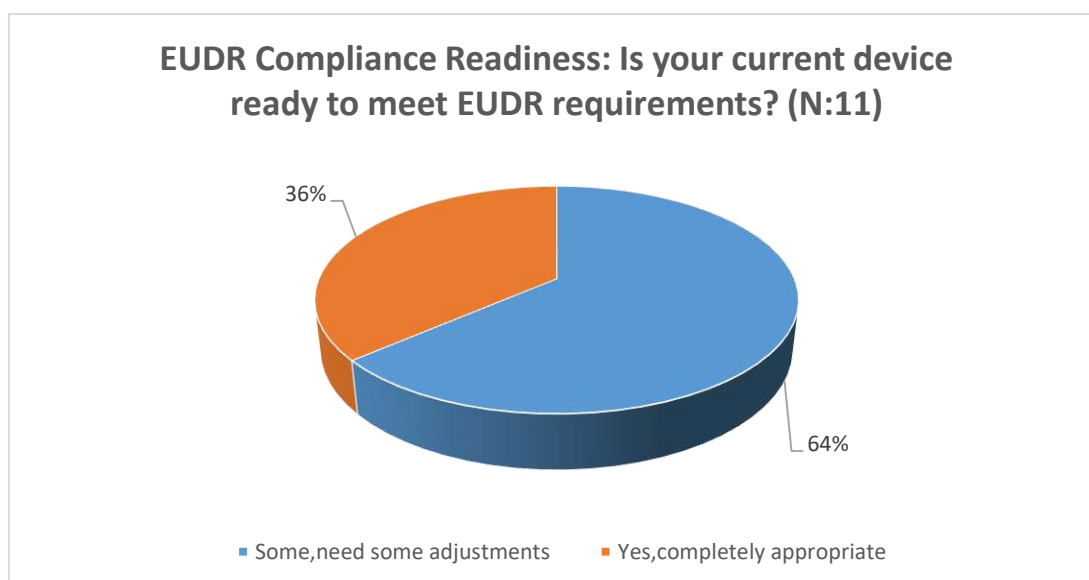


FIGURE 8: EUDR COMPLIANCE READINESS: IS YOUR CURRENT DEVICE READY TO MEET EUDR REQUIREMENTS?

2.7.6. Important Findings of Section 3.

- **Geolocation workflows are operational but not fully integrated** – Organisations generally follow a structured workflow from field data collection to storage and reporting, but tool-to-tool connectivity remains limited and fragmented.
- **Internet connectivity is the biggest operational challenge** – Limited network access in field locations remains the most frequently reported barrier, directly affecting data transfer, synchronisation, and field efficiency.
- **Data integration remains costly and complex** – High development costs, incompatible data formats, and limited API availability continue to slow system integration and automation efforts.
- **Data quality and technical capacity remain key risks** – Accuracy issues and limited team technical skills create bottlenecks in validation, processing, and compliance readiness.
- **EUDR readiness is progressing, but system gaps remain** – While organisations are actively preparing for traceability and compliance requirements, stronger interoperability, better data management, and government system integration are still needed to achieve full operational readiness.
- **Key barriers preventing EUDR readiness**
 - a. **Fragmented software ecosystem** – Organisations use separate tools (GPS devices, KoboToolbox, QGIS, Excel) for spatial and non-spatial data, creating disconnected workflows and increasing data inconsistencies.
 - b. **Manual data transfer methods** – Most respondents still rely on manual export/import and file sharing, which slows validation, increases human error, and weakens audit trails.
 - c. **Non-centralised storage systems** – Data is often stored in spreadsheets, local devices, or basic cloud folders without structured databases, making traceability and compliance verification more difficult.

- d. **Limited system integration** – Very few tools provide API-based connectivity, preventing automated synchronisation with government databases and certification platforms required for EUDR compliance.

In summary: EUDR readiness is mainly constrained by fragmented tools, manual workflows, and weak data integration—not by lack of data collection itself.

2.8. Section 4: Deforestation risk analysis

2.8.1. Do you use forest maps (and other conservation areas) to overlay with plantation polygon data to assess deforestation risk

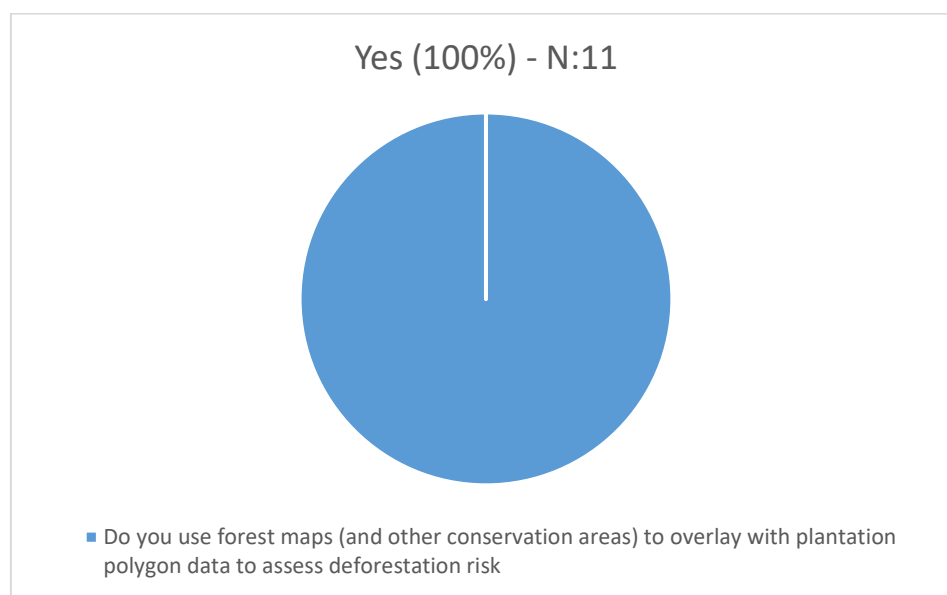


FIGURE 9: USE FOREST MAP?

2.8.2. Which map do you use

Some organisations use a combination of different maps.

Which map do you use	Count of responses	Percentage
Global Forest Watch	6	55%
Simontana	4	36%
FAO Deforisk (AIM\$Forests)	2	18%
Nusantara Atlas	2	18%
ETH Zurich	1	9%
Geoportal MenLHK	1	9%
Geospatial Forestry and Regional Spatial Maps	1	9%
Hansen et al	1	9%
Land cover analysis from USGS and Sentinel	1	9%
Maps issued by the government	1	9%
Ministry of Forestry Map Data	3	27%
SIGAP KLHK and the Basic Land Model	1	9%
Third Party	1	9%

TABLE 9: WHICH MAP DO YOU USE(N:11)

2.8.3. How you use map technology for analysis

How you use map technology for analysis?	Count of responses	Percentage
Using GIS applications (QGIS/ArcGIS)	10	91%
Using a web-based platform	5	9%

TABLE 10: HOW YOU USE MAP TECHNOLOGY FOR ANALYSIS (N:11)

2.8.4. Data types used for deforestation risk analysis

Data types used for deforestation risk analysis	Count of responses	Percentage
Land cover maps	10	91%
Conservation area maps	9	82%
Satellite imagery	9	82%
Land boundary data (plantation/agricultural boundary polygons)	8	73%
Land permit/license data	7	64%
Customary territories	4	36%
Legal concession areas	4	36%
Indicative HCS data from ETH Zurich	1	9%
Self-declaration survey (answered directly by farmers)	1	9%
Third Party	1	9%

TABLE 11: DATA TYPES USED FOR DEFORESTATION RISK ANALYSIS (N:11)

2.8.5. How often is a deforestation risk analysis conducted

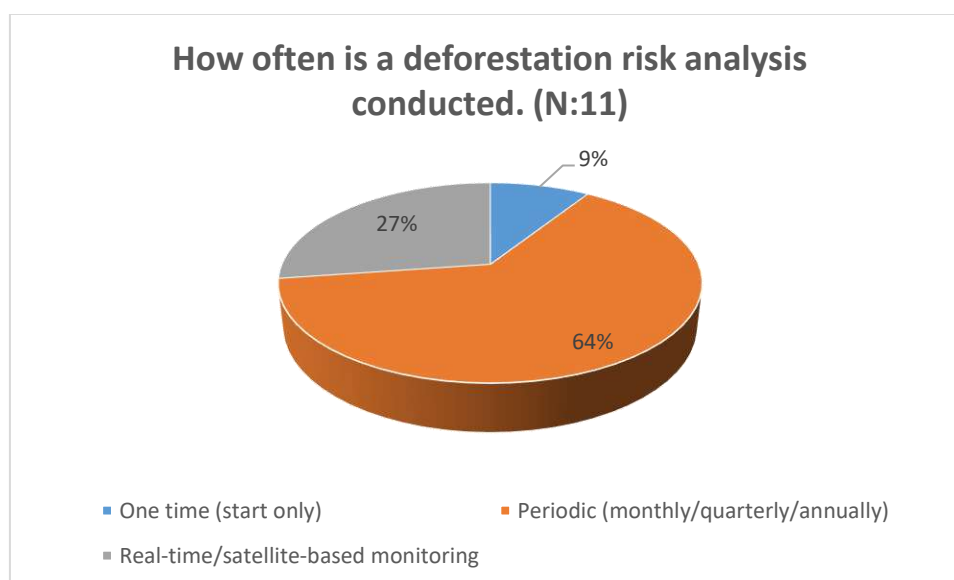


FIGURE 10: HOW OFTEN IS A DEFORESTATION RISK ANALYSIS CONDUCTED

2.8.6. Methods used to detect potential deforestation

Methods used to detect potential deforestation	Count of responses	Percentage
Manual spatial overlay	10	91%
Land cover change analysis (time-series)	8	73%
Combination of several methods	3	27%
Normalised Difference Vegetation Index (NDVI)/Vegetation Index	2	18%
Early warning system	1	9%
Landscape matrix	1	9%
Third Party	1	9%

TABLE 12: METHODS USED TO DETECT POTENTIAL DEFORESTATION. (N:11)

2.8.7. How deforestation risk levels are classified in your area

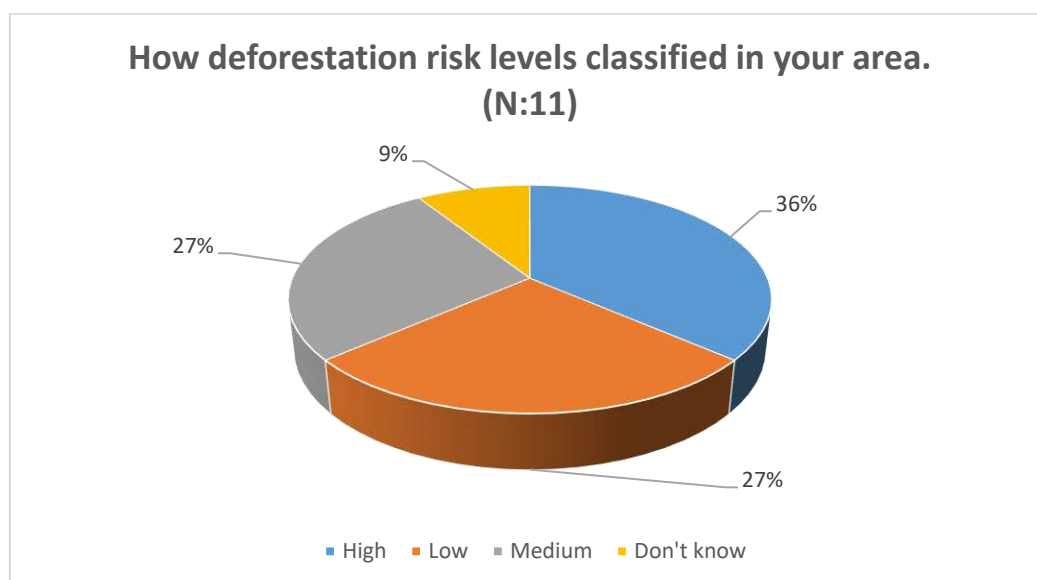


FIGURE 11: HOW DEFORESTATION RISK LEVELS CLASSIFIED IN YOUR AREA

2.8.8. Criteria used to determine the level of risk in your organisation

Criteria used to determine the level of risk in your organisation	Count of responses	Percentage
Overlapping areas	10	91%
History of deforestation around the site	8	73%
Legal land status	6	55%
Proximity to protected forest areas	6	55%

TABLE 13: CRITERIA USED TO DETERMINE THE LEVEL OF RISK IN YOUR ORGANISATION (N:11)

2.8.9. Actions taken if a high risk of deforestation is found in your organisation

Actions taken if a high risk of deforestation is found in your organisation	Count of responses	Percentage
Field verification	10	91%
Suspension of on-site activities	5	45%
Farmer assistance	4	36%
Reporting to relevant parties	4	36%
Assistance to farmers	1	9%
Performing layered verification	1	9%
Promote the protection of existing forest cover through regulations	1	9%
Proposing social forestry schemes for state forest areas (optional)	1	9%

TABLE 14: ACTIONS TAKEN IF A HIGH RISK OF DEFORESTATION IS FOUND IN YOUR ORGANISATION (N:11)

2.8.10. Are the analysis results used for compliance with sustainability standards/regulations?

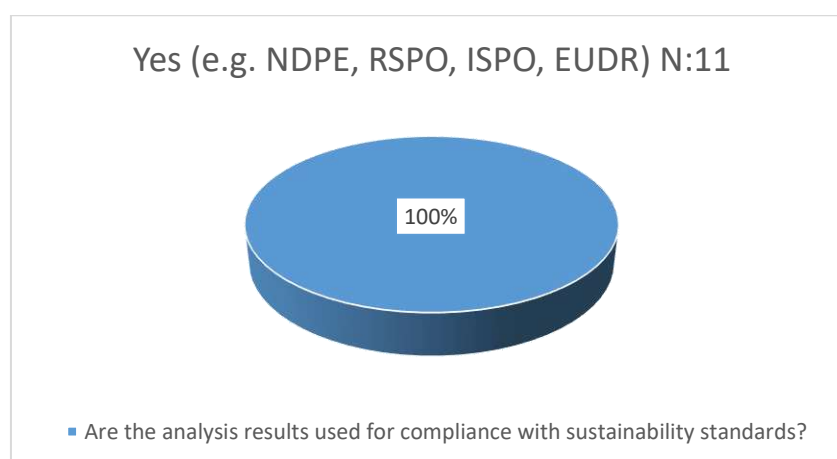


FIGURE 12: ARE THE ANALYSIS RESULTS USED FOR COMPLIANCE WITH SUSTAINABILITY STANDARDS/REGULATIONS?

2.8.11. Main challenges in conducting a deforestation risk analysis in your organisation

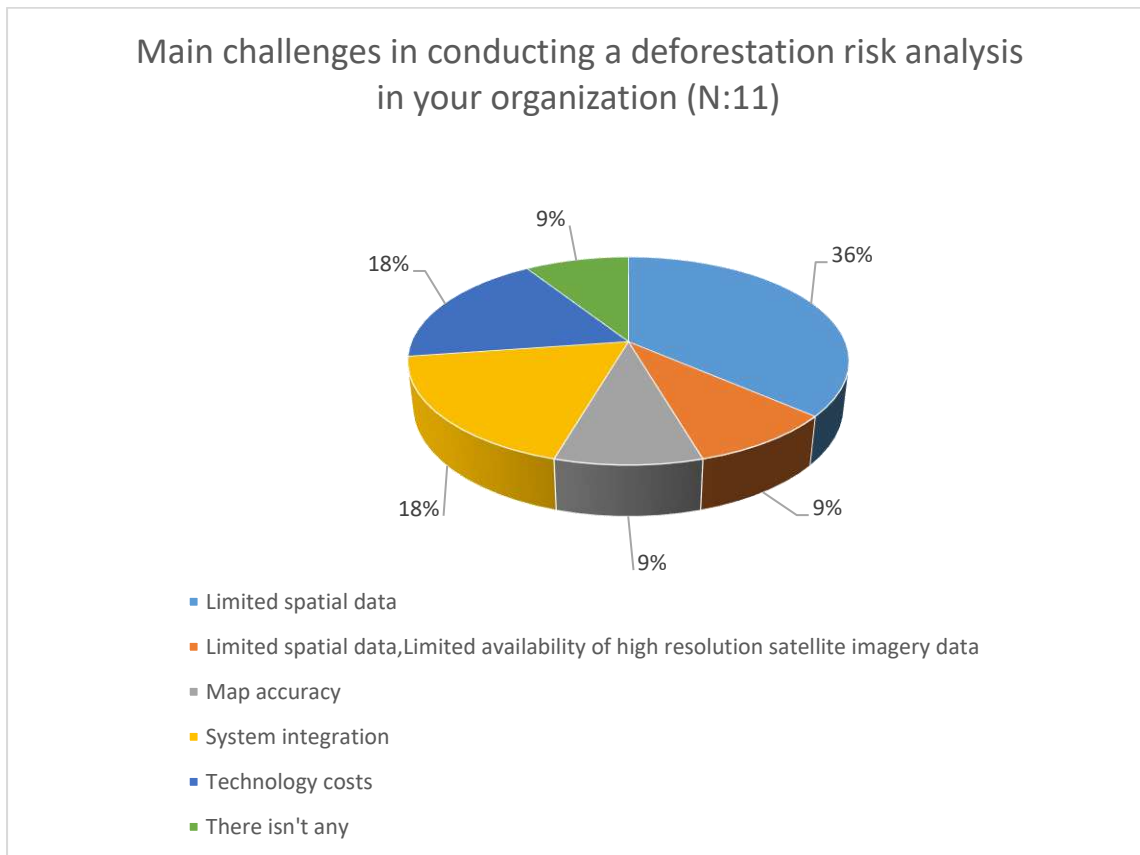


FIGURE 13: MAIN CHALLENGES IN CONDUCTING A DEFORESTATION RISK ANALYSIS IN YOUR ORGANISATION.

2.8.12. Important Findings of Section 4

- **Deforestation risk analysis is widely adopted but not standardised** – Most organisations already conduct spatial risk assessments, but methodologies, tools, and classification systems vary significantly across respondents.
- **Forest and land cover maps are the primary analysis foundation** – Global Forest Watch and government forest maps are the most commonly used reference layers, combined with plantation boundary data and satellite imagery.
- **Manual spatial overlay remains the dominant method** – Most respondents still rely on manual GIS-based overlay analysis, indicating limited automation and slower risk detection workflows.
- **Risk classification is driven by spatial overlap and historical land change** – Overlapping with forest or conservation areas, historical deforestation patterns, and legal land status are the main criteria used to determine risk levels.
- **Field verification remains the primary response to high-risk findings** – Organisations prioritise on-site verification before taking corrective action, showing that field validation remains critical for confirming deforestation risks and compliance decisions.

2.9. Section 5: Essay Questions (Summarised)

2.9.1. Describe your ideal geolocation data workflow from field data collection to final reporting

1. Planning & Preparation

Define project goals and standards. Train staff and farmers on tools (GPS, mobile apps) and prepare base maps (satellite imagery, land parcel data).

2. Field Collection

Collect spatial data (points, polygons) using GPS, mobile apps (Avenza, AgriTrace, KoboToolbox), or drones. Simultaneously gather farmer profiles, plantation details, and legal documents (land certificates, IDs) via digital forms.

3. Processing & Validation

Convert raw data (tracks to polygons) and standardise formats (SHP, GeoJSON). Perform quality control (fix gaps, overlaps) and overlay with official data (forest zones, land registries) to verify compliance.

4. Integration & Analysis

Upload clean data to central platforms (e.g., e-STDB, SPKS). Add regulatory attributes (traceability, deforestation risk) and conduct spatial analysis (area calculations, overlap assessments).

5. Reporting & Utilisation

Generate maps and summary reports. Use verified outputs for certification (e-STDB, RSPO) and supply chain traceability, ensuring an auditable trail from field to final decision-making.

2.9.2. What single improvement to an existing tool would have the biggest impact on your work?

Automated, real-time Quality Assurance/Quality Control integrated directly into field data collection tools. This would allow errors (geometry, attributes, overlaps with protected areas) to be detected and corrected on the spot, eliminating re-surveys, accelerating processing, and ensuring data is audit-ready from the moment it is collected.

Other notable improvements include:

- Unified platforms that combine GPS, forms, and polygon creation into one app (replacing separate tools like KoboToolbox + GPS).
- Tighter integration between legality data (KoboToolbox) and spatial data (GPS/Avenza) to streamline certification.
- Free, full-featured mobile mapping apps with offline capabilities.

2.9.3. What integration with other systems is most important but currently missing?

Integration with government databases and applications—particularly for land legality (ATR/BPN), forest area status (Ministry of Forestry), and certification systems (e-STDB). This missing link creates synchronisation gaps between field conditions and official government data, forcing manual verification and slowing certification, permitting, and program delivery (e.g., Sarpras, PSR). A direct, automated connection would enable real-time validation of land status and streamline compliance.

2.9.4. Important Findings of Section 5

Ideal Geolocation Data Workflow

- **End-to-end workflow is well understood** – Respondents clearly articulated a five-stage ideal workflow: Planning & Preparation → Field Collection → Processing & Validation → Integration & Analysis → Reporting & Utilisation.
- **Training and preparation are recognised as critical first steps** – Ideal workflows emphasise training staff and farmers on tools (GPS, mobile apps) and preparing base maps (satellite imagery, land parcel data) before field collection begins.
- **Simultaneous spatial and attribute collection is desired** – The ideal workflow captures GPS points/polygons together with farmer profiles, plantation details, and legal documents (land certificates, IDs) in a single field session.
- **Validation should happen immediately, not later** – Respondents want quality control (fixing gaps, overlaps, geometry errors) to occur during field collection, not after returning to the office.
- **Central platforms are the intended endpoint** – Cleaned, validated data should upload directly to central platforms (e.g., e-STDB, SPKS) for certification (RSPO, e-STDB) and supply chain traceability.

Single Most Impactful Tool Improvement

- **Automated, real-time Quality Assurance/Quality Control is the top priority** – The single most requested improvement is integrated, real-time quality control that detects geometry errors, attribute mistakes, and overlaps with protected areas instantly during data entry.
- **Real-time validation would eliminate re-surveys** – Respondents emphasised that on-the-spot error detection would remove the need for costly return trips and ensure data is "audit-ready" from the moment of collection.
- **Unified platforms are highly desired** – Organisations want a single application that combines GPS tracking, digital forms, and polygon creation, replacing the current need for separate tools (e.g., KoboToolbox + GPS devices + Avenza Maps).
- **Better integration between legality data and spatial data** – Respondents specifically requested tighter integration between farmer/legal data (currently often in KoboToolbox) and spatial data (GPS/Avenza) to streamline certification processes.
- **Free, full-featured offline mobile mapping apps remain a need** – Cost and offline functionality continue to be barriers; respondents desire robust mobile mapping tools that work without internet access at no cost.

Most Important but Missing System Integration

- **Government system integration is the #1 gap** – The most critical missing integration is with government databases, particularly:
 - **ATR/BPN** (land legality and land registration)
 - **Ministry of Forestry** (forest area status and conservation zones)
 - **e-STDB** (certification and plantation registration systems)
- **Manual verification is a major bottleneck** – Without direct integration, organisations must manually cross-check field data against official government data, causing significant delays.
- **Slow certification and permitting** – The lack of automated connectivity slows down certification (e-STDB, RSPO), permit processing, and government program delivery (e.g., Sarpras, PSR).
- **Real-time land status validation is the desired solution** – Respondents want a direct, automated connection that enables real-time validation of legal land status and forest area boundaries directly from official sources.

3. CONCLUSION

The survey findings show that geolocation-based data collection is already an established practice among organisations working in Indonesia's palm oil and agricultural supply chains. Stakeholders are actively using GPS devices, mobile applications, GIS software, and central platforms to support land mapping, farmer registration, traceability, certification, and sustainability compliance. This demonstrates a strong operational foundation for improving supply chain transparency and meeting emerging regulatory requirements such as the European Union Deforestation Regulation (EUDR).

However, the current ecosystem remains highly fragmented. Most organisations still depend on multiple separate tools for collecting spatial and non-spatial data, with manual export/import remaining the dominant method for transferring information between systems. This fragmented workflow creates inefficiencies, increases the risk of data inconsistencies, and weakens auditability—key requirements for EUDR compliance and broader traceability systems.

The findings also highlight that technical and operational barriers continue to limit efficiency. Poor internet connectivity in field areas, limited API-based integration, incompatible data formats, and non-centralised storage systems remain major challenges. These constraints slow data synchronisation, complicate verification processes, and increase dependency on manual quality control. As a result, organisations face higher operational costs and longer turnaround times for compliance preparation.

In the area of deforestation risk analysis, adoption is widespread, but methodologies remain inconsistent. Organisations use a variety of maps, datasets, and manual spatial overlay methods to assess land-use risks, but there is no common framework or standardised process. This variation may affect the consistency and reliability of deforestation assessments, particularly for compliance-driven reporting.

A clear strategic opportunity emerges from this study: the need for integrated, mobile-first, and user-friendly systems that combine geospatial data collection, attribute data capture, real-time QA/QC, and automated system integration. Stronger interoperability—especially with government systems such as ATR/BPN, Ministry of Forestry databases, and e-STDB—will be critical to improve land legality verification, streamline certification processes, and strengthen traceability.

Moving forward, strengthening digital integration, standardising workflows, and improving data governance will be essential to support scalable, reliable, and audit-ready supply chains. These improvements will not only enhance operational efficiency but also position organisations to meet international sustainability standards and regulatory compliance more effectively.

4. MATRIX: TOOLS, FUNCTIONALITIES, FORMATS AND INTEGRATION POTENTIAL

Tool / System	Primary Functionality	Input Format	Output Format	Integration Potential
KoboToolbox	Digital form-based data collection (farmer profiles, surveys, attributes)	Form inputs (text, numeric, multiple choice), GPS points	CSV, XLS, JSON	Moderate – can integrate via API but limited direct spatial integration
Avenza Maps	Field mapping and spatial data collection (offline capable)	GPS points, tracks, polygons, georeferenced maps (PDF/GeoTIFF)	KML, KMZ, SHP	Moderate – supports export but limited direct system interoperability
GPS Devices (Garmin, etc.)	Capture precise geolocation data (points, tracks, boundaries)	Satellite signals (coordinates)	GPX, CSV	Low to Moderate – requires manual processing for integration
AgriTrace / Similar Apps	Integrated farm mapping and traceability data collection	GPS data + farmer/plot attributes	SHP, GeoJSON, database records	Moderate to High – designed for traceability, but depends on platform connectivity
Drones (UAVs)	High-resolution spatial data capture and mapping	Aerial imagery	Orthomosaic images, GeoTIFF	Moderate – requires processing software before integration
GIS Software (e.g., QGIS, ArcGIS)	Data processing, validation, spatial analysis, mapping	SHP, GeoJSON, raster, tabular data	Maps, SHP, GeoJSON, reports	High – strong interoperability and analysis capability
Google Forms	Basic survey data collection (non-spatial or limited spatial input)	Form inputs (text, multiple choice)	Google Sheets (CSV)	Low – limited spatial capability and integration
Central Platforms (e.g., e-STDB, SPKS systems)	Data storage, traceability, compliance verification	Structured datasets (spatial + attribute)	Reports, dashboards, validated datasets	High – key integration hub, but currently limited connectivity with field tools