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The 7th Greenhouse Gas Inventory System Training Workshop

Activity Data, Conversions and Comparison with International Database

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UNOSD United Nations Office for Sustainable Development
ESCAP
United Nations Climate Change
ipcc Intergovernmental Panel on Climate Change

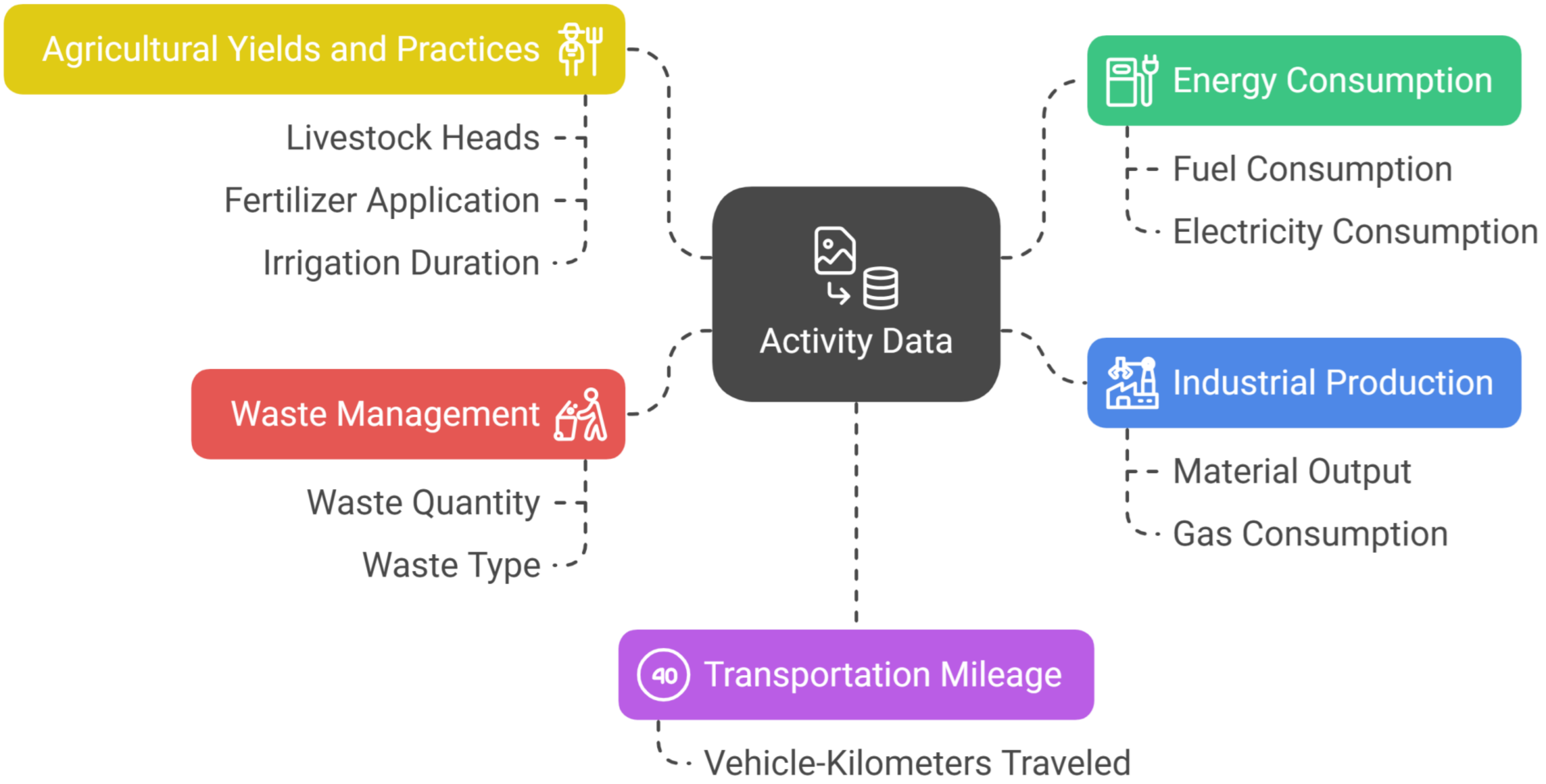
The Cornerstone of GHG Inventories: Understanding Activity Data

- Activity data (AD) serves as the quantitative bedrock for estimating greenhouse gas emissions and removals. Without precise and comprehensive activity data, the accuracy and credibility of national GHG inventories are fundamentally compromised.

- Activity data represents quantitative measures of human activities that either generate or sequester greenhouse gases. These data are the fundamental input, often referred to as the "backbone," for calculating emissions and removals. The core principle of GHG estimation is encapsulated in the equation: GHG Emission/Removal = Activity Data (AD) × Emission Factor (EF).

The Cornerstone of GHG Inventories: Understanding Activity Data

Activity Data in Various Sectors



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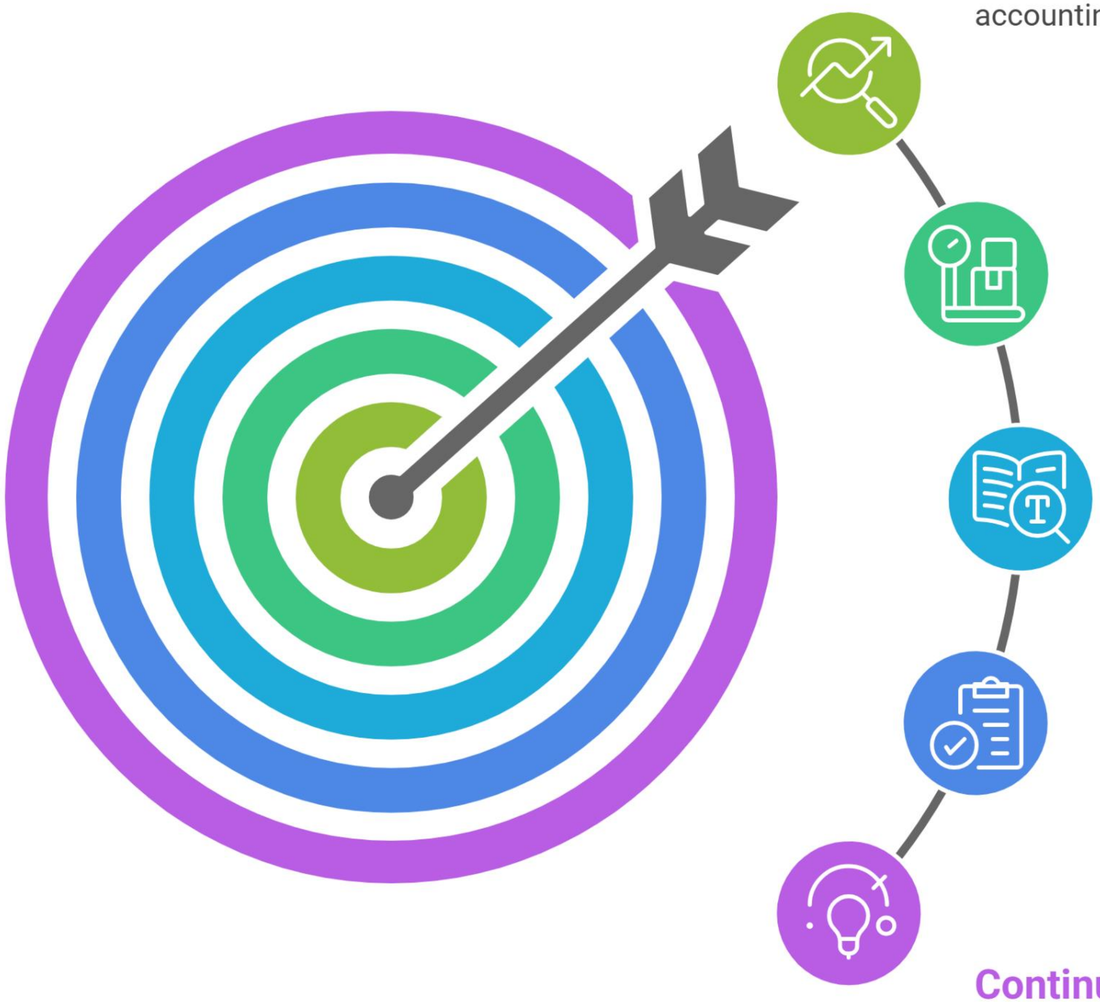
The Indispensable Role of ADs in Emissions Calculation and Reporting Accuracy

The precision of activity data is not merely a technical detail; it is crucial for accurately quantifying emissions and ensuring the integrity of carbon accounting.

High-quality, comprehensive, and reliable activity data underpins several critical aspects of GHG inventory and reporting



Precision of Activity Data

Core to accurate carbon accounting

Accuracy and Reliability

Ensures genuine reflection of environmental impact

Transparency and Comparability

Enhances credibility and international trust

Policy Relevance

Supports effective climate policy design

Continuous Improvement

Identifies emission reduction opportunities

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Activity Data and Economic Growth

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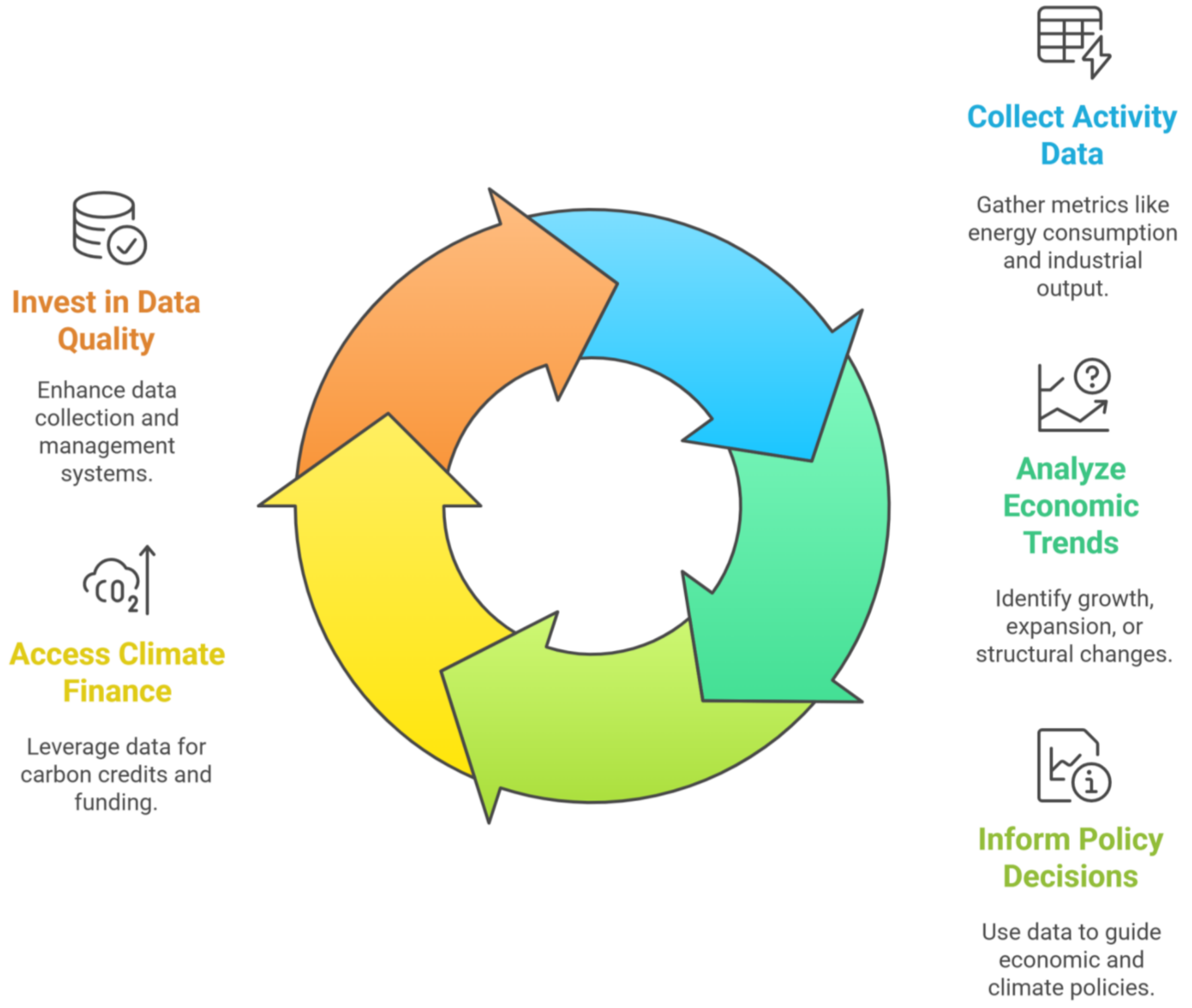
- **Activity data doubles as an economic barometer** – trends in energy use, industrial output, or agricultural yields reveal shifts in growth, industrialisation, and structural change, making its accuracy vital for aligning development and climate goals.
- **High-quality data unlocks climate finance** – robust, transparent activity datasets underpin credible GHG inventories and verifiable carbon credits, a critical revenue stream for LDCs and SIDS.
- **Strategic national asset** – investing in rigorous data systems is no longer just compliance; it is an economic imperative that strengthens policy decisions, attracts investment, and funds climate-resilient development.



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Examples of Activity Data and Corresponding Emission Factors by Sector

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Sector	Activity Data Example	Unit of Activity Data	Corresponding Emission Factor Example	Unit of Emission Factor	GHG Emitted
Energy	Gasoline Consumption	Liters	2.3 kg CO_2 / liter gasoline	kg CO_2 / liter	CO_2
IPPU	Cement Production	Tonnes	0.52 tonnes CO_2 / tonne Cement	tonnes CO_2 / tonne	CO_2
Agriculture	Cattle Population	Head	55 kg CH_4 / head / year	kg CH_4 / head / year	CH_4
Waste	Municipal Solid Waste Generated	Tonnes	0.05 tonnes CH_4 / tonne waste	tonnes CH_4 / tonne	CH_4

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Strategic Data Collection and Ensuring Data Integrity

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The credibility of a national GHG inventory relies heavily on the strategic collection of activity data and the rigorous maintenance of its integrity.

Primary data:

Primary data, originating directly from a country's operations or supply chain, is generally considered the most precise option for GHG inventory compilation. Its collection involves actively conducting specific measurements or surveys to obtain direct information about a product, process, or activity.

Secondary data:

Secondary data refers to information that has been collected and published by other entities, making it readily available for use.

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Methods for Primary Data Collection

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Advantages of Primary Data: Primary data offers high accuracy, representativeness, and direct relevance to the specific process or activity being assessed. It ensures consistency in data collection and provides direct control over the process, thereby minimizing potential biases.

Challenges of Primary Data Collection: Despite its advantages, collecting primary data can be time-consuming and costly, especially for extensive studies. It may not always be readily available, making comprehensive data collection challenging. Furthermore, rigorous verification is required to ensure its quality and prevent human errors.

1 Direct Measurements

Data from monitoring equipment, utility bills, and production logs provide evidence for activity data. This includes fuel use and electricity consumption.

2 Surveys and Censuses

Surveys with suppliers for transportation details and national livestock censuses are common methods. These help in counting animal populations.

3 Laboratory Experiments

Laboratory experiments determine emissions generated for specific chemical reactions. This provides accurate data for analysis.

4 Customer Surveys

Customer surveys help understand how consumers use products, impacting downstream emissions. This provides insights into product usage patterns.

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Methods for Primary Data Collection

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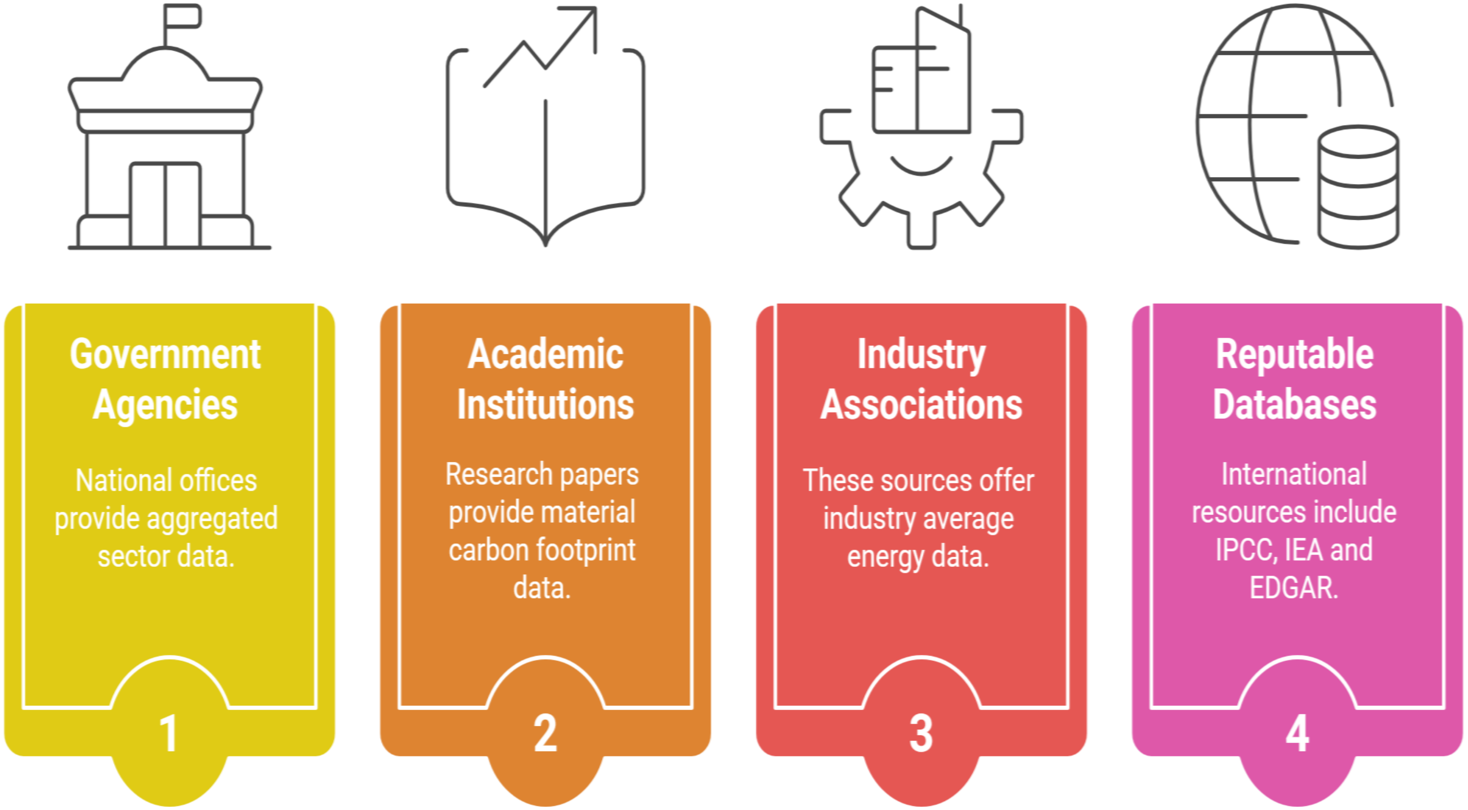
Benefits of Secondary Data: Secondary data is cost-effective and accessible, saving considerable time and resources compared to primary data collection. It offers a wide range of existing data sources for diverse applications, providing a good overview, especially for initial carbon footprint assessments and identifying emission hotspots.

Limitations of Secondary Data:
A significant drawback of secondary data is its inherent lack of specificity and lower accuracy compared to primary data, which can limit the granularity of carbon reduction strategies. Over-reliance on secondary data without transparency can erode the credibility of reported emissions.



Comparison of Primary vs. Secondary Data Sources for GHG Inventories

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Feature	Primary Data	Secondary Data
Definition	Data collected directly from source for the specific purpose.	Data collected and published by others, often for different purposes.
Sources/Examples	Utility bills, meter readings, production logs, supplier-specific data, national surveys/censuses, lab experiments.	IPCC EFDB, national statistical offices, industry reports, scientific literature, international databases (IEA, EDGAR).
Advantages	High accuracy, representativeness, relevance, consistency, direct control over collection.	Cost-effective, time-saving, readily available, broad applicability, good for initial overview.
Disadvantages	Time-consuming, costly, potentially limited availability, requires rigorous verification.	Lower specificity/granularity, less accurate, may lack nuance, over-reliance can erode credibility.
Optimal Use Cases	Key categories, material hotspots, direct operational emissions, critical suppliers.	Smaller emission sources, initial assessments, gap-filling, downstream categories where direct data is infeasible.

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Optimal Approach: The Hybrid Model

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- The most robust and informative results in GHG inventory compilation often come from a hybrid approach, combining both primary and secondary data sources.
- This strategy involves focusing primary data collection on "material hotspots" – those emission sources that significantly contribute to the overall GHG emission (e.g., Key Categories with high GHG impacts).
- Secondary data is then used to provide broader coverage or to fill gaps where direct measurement is impractical or less impactful (e.g., smaller emission sources).
- Crucially, transparency about the percentage of emissions calculated using secondary data is vital to maintain stakeholder trust and reporting credibility. This strategic allocation of resources ensures that efforts are concentrated where they yield the greatest impact on inventory quality and policy relevance, rather than attempting to achieve the highest tier for all categories, which may be impractical for many nations.

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Best Practices for Data Integrity: Robust QA and QC Procedures

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Establish QA/QC Plan

Develop a structured plan before calculations

Implement QA/QC Activities

Execute planned activities

Ensure Transparency

Make processes and data clear

Maintain Accuracy

Verify data precision

Achieve Consistency

Ensure uniformity over time

Enable Comparability

Allow comparison across entities

Ensure Completeness

Include all relevant data

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Best Practices for Data Integrity: Robust QA and QC Procedures

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- **QC Activities (Routine Checks):** Quality Control (QC) involves routine and consistent checks throughout the inventory development process to verify data integrity, correctness, and completeness. Specific QC activities include:
  - **Accuracy Checks:** Tying activity data (e.g., fuel use, electricity consumption) back to solid evidence such as utility bills, meter readings, invoices, or production logs, and meticulously maintaining copies of all source documents.
  - **Consistency Checks:** Ensuring that standardized measurement techniques are applied consistently across all data collection points.
  - **Arithmetic Checks:** Verifying calculations for errors.
  - **Cross-Checks:** Comparing national estimates against independently published estimates and checking national activity data against international statistics or default data.
  - **Standardized Procedures:** Utilizing approved standardized procedures for all emission calculations and measurements.
- **QA Activities (Systematic Reviews):** Quality Assurance (QA) involves a planned system of review and audit procedures conducted by personnel who are *not* actively involved in the inventory development process. This often includes the involvement of external experts to provide an unbiased assessment.

Best Practices for Data Integrity: Robust QA and QC Procedures

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Inventory Management System : Formalizing the entire inventory preparation process through an Inventory Management System is a best practice. It ensures consistency year after year, making annual reporting more routine and readily verifiable. It should not be static; they must evolve with the country's circumstances and system improvements.

Continuous Improvement: The process of GHG inventory compilation should be viewed as an iterative cycle of continuous improvement. Each verification cycle presents a valuable opportunity to learn and refine the system. Findings from verifications, such as noted weaknesses in record-keeping, should be actively used to strengthen the system for subsequent cycles. Ultimately, the goal is to integrate GHG data management into the broader national governance frameworks, recognizing that carbon emissions have significant financial implications (e.g., energy costs, carbon pricing). Managing this data with the same rigor as financial data is considered sound business practice.

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Key Elements of a Robust QA/QC Plan for AD

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QA/QC Principle	Key Element of Plan	Specific Activities/Checks
Transparency	Organizational Structure & Documentation	Develop a written QA/QC plan before calculations. Identify QA/QC personnel and timelines for plan distribution. Maintain copies of all source documents.
Accuracy	General QC Procedures & Category-Specific QC	Tie activity data to solid evidence (utility bills, meter readings, invoices, production logs). Conduct accuracy checks and verify data integrity. Perform checks for arithmetic errors.
Consistency	Standardized Procedures & Documentation	Use approved standardized procedures for emission calculations and measurements. Ensure standardized measurement techniques are applied consistently. Formalize processes in an Inventory Management System (IMS).
Comparability	General QC Procedures & Review/Audit	Check national estimates against independently published estimates and international statistics. Conduct external expert reviews.
Completeness	General QC Procedures & Documentation	Verify data completeness at every stage of inventory preparation. Ensure all relevant source categories are included.
Continuous Improvement	Review/Audit Procedures & IMS Evolution	Regularly review and modify the QA/QC plan to reflect new processes and implement improvements. Treat verification cycles as opportunities for learning and strengthening the system. Integrate GHG data management into broader governance frameworks.

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Translating Activity into Emissions: Conversion Methodologies

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The transformation of raw activity data into quantifiable greenhouse gas emissions is a critical step in the inventory process, relying on the careful application of emission factors and tiered methodologies as outlined by the IPCC.

- The Core Equation: Activity Data x Emission Factor = GHG Emissions
- At the heart of GHG emission estimation lies a fundamental equation: Emissions = Activity Data × Emission Factor.
- **Activity Data (AD):** As previously discussed, this is the quantitative measure of the extent of a human activity that causes emissions or removals, such as the amount of fuel consumed or the number of livestock.
- **Emission Factor (EF):** This is a coefficient that specifies the quantity of greenhouse gas emitted or sequestered per unit of activity. For instance, it could be expressed as kilograms of methane per head of cattle per year, or kilograms of carbon dioxide per terajoule of fuel.

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Understanding Emission Factors: Default vs. Country-Specific Values

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The choice and application of emission factors significantly influence the accuracy of the final emission estimates.

- **Default Emission Factors:** The IPCC Guidelines provide a comprehensive set of default emission factors for various sources and gases. These are global average values, typically employed in Tier 1 methodologies when country-specific data is unavailable.
- **Country-Specific Emission Factors:** Good practice guidance strongly advocates for the use of country-specific emission factors whenever possible, as they more accurately reflect national circumstances, technologies, and practices. These factors are often developed through national research programs, direct measurements, or detailed studies.

The adoption of country-specific emission factors is crucial for enhancing the accuracy and representativeness of national inventories, particularly for key categories that contribute significantly to a country's overall emissions.

Understanding Emission Factors: Default vs. Country-Specific Values

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- **Dynamic Nature of Country-Specific EFs:** Unlike static default values, some countries have proactively updated their country-specific emission factors based on new statistical data or expert judgment, making them more dynamic and reflective of current realities. The IPCC's 2019 Refinement also introduced updated values for some emission factors, addressing new technologies and production processes.

Examples of Country-Specific Adjustments:

- Korea, for instance, calculated a CO_2 emission factor for anthracite coal that was approximately 11.8% lower than the 2006 IPCC default value, based on their national fuel analysis. This demonstrates how unique national characteristics, such as specific fuel composition, can lead to significant deviations from global averages.
- In the agriculture sector, Tier 2 approaches enable the development of country- or basin-specific emission factors for livestock. This can involve stratifying animal populations by agro-ecological zone or breed, or by using specific models that account for local conditions.
- For the waste sector, inventory agencies are encouraged to compare country-specific data, such as biochemical oxygen demand (BOD) in domestic wastewater, against IPCC default values, and to thoroughly document any observed differences and their justifications.

IPCC Tiered Approaches: Navigating Methodological Complexity (Tier 1, Tier 2, Tier 3)

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The IPCC Guidelines offer a flexible, tiered approach to estimating GHG emissions, allowing countries to select methodologies based on their data availability, technical capacity, and the significance of the emission source.

- **Tier 1 (Basic):**
  - **Complexity:** This is the most basic methodological approach.
  - **Application:** It utilizes default equations and global average emission factors, combined with country-specific activity data.
  - **Limitations:** Tier 1 is associated with the highest level of uncertainty. Its simplicity means it may not adequately reflect nuanced changes in specific activities or the impact of mitigation actions. For example, Tier 1 methods for livestock emissions are generally unsuitable for measuring the effects of changes in animal production or productivity on GHG emissions.
  - **Usage:** It is typically applied when limited data is available or for source categories that are not considered "key categories" (i.e., those that do not contribute significantly to national emissions or trends). Historically, the vast majority of Parties initially used a Tier 1 approach for many emission sources, such as livestock.

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IPCC Tiered Approaches: Navigating Methodological Complexity (Tier 1, Tier 2, Tier 3)

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Tier 2 (Intermediate):

- **Complexity:** This represents an intermediate level of methodological complexity, offering greater accuracy than Tier 1.
- **Application:** Tier 2 methods employ country- or basin-specific emission factors, which are typically developed by each country to better represent average values for their specific conditions.
- **Usage:** These methods are generally considered more accurate and are particularly suitable for Measurement, Reporting, and Verification (MRV) of mitigation actions. They can effectively reflect changes in production systems and productivity, making them valuable for assessing the impact of specific climate policies. Many countries have transitioned to Tier 2 for key categories, such as cattle populations, to improve the precision of their inventories.
- **Uncertainty:** Tier 2 emission factors are estimated to have an uncertainty of approximately ±20%, a significant improvement over Tier 1's ±30% to ±50%.

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IPCC Tiered Approaches: Navigating Methodological Complexity (Tier 1, Tier 2, Tier 3)

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Tier 3 (Most Demanding):

- **Complexity:** This is the most demanding method in terms of complexity and data requirements.
- **Application:** Tier 3 approaches involve direct measurements on a mine-specific or plant-specific basis, often incorporating sophisticated process-based modeling. Technology-specific emission factors are crucial for Tier 3 applications.
- **Advantages:** When properly applied, Tier 3 methods yield the lowest level of uncertainty.
- **Usage:** This tier is ideal for significant emission sources where highly detailed data is available, and the highest level of accuracy is required.

IPCC Tiered Approaches: Navigating Methodological Complexity (Tier 1, Tier 2, Tier 3)

Tier Level	Complexity	Methodology	Data Requirements	Uncertainty Level	Application Context/Suitability
Tier 1	Basic	Default Emission Factors (EFs)	Limited	Highest (e.g., ±30-50%)	Non-key categories, initial assessments, limited data availability.
Tier 2	Intermediate	Country/Basin-specific EFs	Moderate	Medium (e.g., ±20%)	Key categories, MRV of mitigation actions, reflects changes in production systems.
Tier 3	Most Demanding	Direct Measurement/Process-based modeling	Extensive/Detailed	Lowest	Significant emission sources, high accuracy required, detailed process understanding.

IPCC Tiered Approaches: Navigating Methodological Complexity (Tier 1, Tier 2, Tier 3)

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- **Higher-tier methods enable effective policy design** – Tier 2 and above allow for detailed tracking of mitigation impacts (e.g., livestock productivity improvements), making them essential for evaluating real-world outcomes and designing targeted interventions.
- **Emission factors must evolve** – They are not static; regular updates are needed to reflect new data, science, and national circumstances. Countries should institutionalize mechanisms for periodic review and refinement.
- **Balance complexity with capacity** – Inventory systems must strike a practical balance between methodological rigor and data availability; prioritizing key categories for higher-tier methods while applying a mixed-tier approach is often the most feasible strategy.

Benchmarking for Transparency: Comparing National Data with International Standards

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Systematic comparison of national activity data and derived emissions against international benchmarks is a fundamental practice for enhancing transparency, identifying areas for improvement, and fostering global consistency in GHG reporting.

- **IPCC Guidelines and Methodologies:** The Intergovernmental Panel on Climate Change (IPCC) provides the globally recognized methodological foundation for national GHG inventories, including the 2006 IPCC Guidelines and its subsequent 2019 Refinement. These guidelines contain default emission factors and methodologies that serve as crucial benchmarks for national reporting.
- **IPCC Emission Factor Database (EFDB):** This is a widely recognized and regularly updated library of emission factors and other relevant parameters, accompanied by background documentation. It acts as a valuable resource for inventory compilers seeking to develop or validate country-specific methodologies.

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Benchmarking for Transparency: Comparing National Data with International Standards

Other Relevant Databases

- **EDGAR (Emissions Database for Global Atmospheric Research):** This database provides global GHG emissions data, frequently used for broad international comparisons.

- **Climate TRACE:** This initiative offers independent emissions estimates by leveraging satellite and remote sensing data combined with artificial intelligence. It provides a complementary perspective to self-reported data, enhancing overall transparency.

- **World Bank and UN Statistics:** These organizations provide essential socio-economic data, such as population and Gross Domestic Product (GDP), which are often used in conjunction with GHG data for per capita or intensity-based comparisons.

Systematic Comparison: Methodologies for Analyzing National Data Against International Benchmarks

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Assess Uncertainty

Evaluate data reliability

Aggregate and Disaggregate Data

Analyze data at different levels

Perform Sectoral Comparisons

Evaluate sector performance

Cross-check with IPCC Software

Verify emissions using IPCC software

Compare Implied Emission Factors

Analyze IEFs against benchmarks

Conduct Time-Series Analysis

Track trends over time

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Identifying and Analyzing Gaps and Discrepancies in National Reporting

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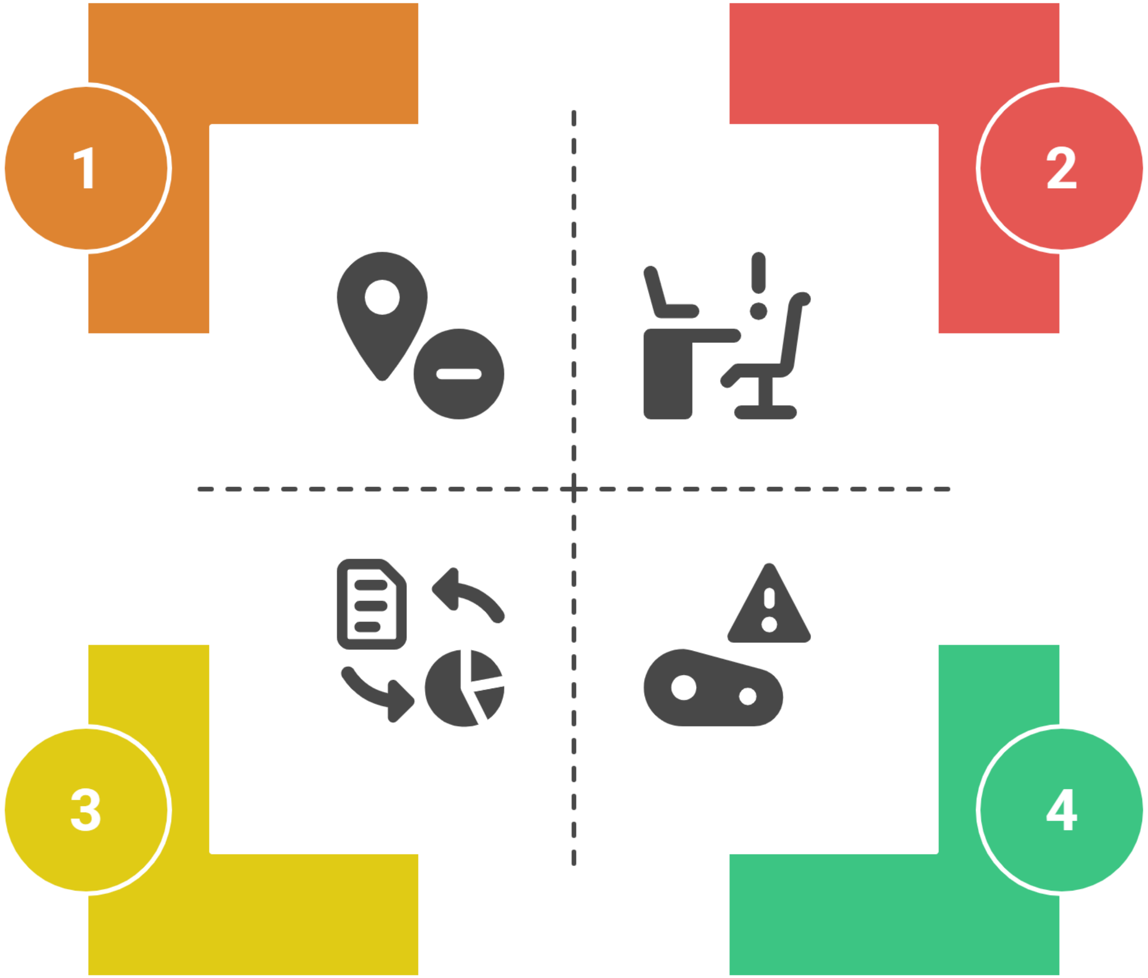

Data gaps

Data gaps severely limit the accuracy of GHG assessments.

Insufficient institutional arrangements

Insufficient institutional arrangements significantly hinder effective inventory compilation.

Methodological discrepancies

Methodological discrepancies cause minor variations in reporting.

Lack of alignment

Lack of alignment leads to minor reporting inconsistencies.

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Identifying and Analyzing Gaps and Discrepancies in National Reporting

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Type of Discrepancy/Gap	Specific Examples	Impact on Inventory	Relevant International Benchmark/Guidance
Data Gaps	Missing activity data (e.g., fuelwood consumption, off-road transport, industrial wastewater). Lack of high-resolution satellite data.	Reduced completeness, increased uncertainty, reliance on default values.	UNFCCC reporting guidelines, IPCC Guidelines (2006, 2019 Refinement).
Methodological Differences	Use of older IPCC guidelines (e.g., 1996 vs. 2006). Inconsistent GWP values. Underestimation of indirect N_2O emissions.	Lack of comparability across time series and with other countries, potential for inaccurate emission trends.	UNFCCC ETF requirements, IPCC Guidelines (2006, 2019 Refinement), IPCC AR5 GWP values.
Underestimation/Overestimation	Lower reported CH_4 emissions from oil/gas compared to atmospheric inversions. Lower reported N2O emissions from tropical countries.	Misrepresentation of national climate impact, hindering effective mitigation planning.	Atmospheric inversion studies, IPCC Guidelines (for robust estimation).
Institutional/Capacity Issues	Insufficient institutional arrangements, inadequate financing, limited technical capacity, reliance on ad-hoc teams. Lack of formal energy balance.	Inconsistent data flow, delays in reporting, lower data quality, difficulty in sustaining inventory efforts.	UNFCCC (Article 5, Kyoto Protocol), IPCC Good Practice Guidance (institutional arrangements).
Lack of Alignment	Discrepancies between REDD+ reporting to donors and UNFCCC reporting.	Duplication of effort, data re-analysis burden, potential for inconsistent figures across different reports.	UNFCCC reporting guidelines (for harmonized reporting).

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Advancing Transparency: Key Takeaways and Recommendations

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Continuous Journey and Strategic Investment

- GHG inventory reporting requires ongoing strategic investment and adaptive approaches to enhance data quality and reporting consistency
- Analysis provides actionable insights for aligning with global transparency requirements and improving overall inventory systems

Proactive Adaptation to Global Trends

- Paris Agreement's ETF and IPCC guideline refinements drive steady progression toward greater detail
- Nations should proactively adapt inventory systems rather than merely reacting to new reporting requirements
- Forward-thinking approach involves anticipating future needs for granular data, higher methodological tiers, and enhanced verification processes

Strategic Positioning and Benefits

- Proactive stance helps countries avoid future compliance burdens and positions them as leaders in climate transparency
- Enhanced transparency can unlock greater international support and investment for national climate actions
- Strategic investment in inventory systems creates competitive advantage in global climate finance and cooperation

Prioritizing Data Quality and Consistency for Robust Inventories

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The accuracy and credibility of national GHG inventories are directly contingent upon the quality and consistency of the underlying activity data.

- Implement and rigorously adhere to **comprehensive QA and QC procedures**, as stipulated by IPCC Good Practice Guidance. This includes establishing robust internal controls, meticulously documenting methodologies within an Inventory Management System, and regularly verifying activity data against primary source documents.
- Adopt a **strategic hybrid approach** to data collection, prioritizing the gathering of primary data for key emission categories and material hotspots, while transparently utilizing secondary data to address gaps or for less significant sources. The proportion of emissions calculated using secondary data should be explicitly disclosed to maintain transparency.
- Invest in **developing and strengthening national data collection infrastructure**, including systematic surveys, national censuses, and leveraging existing national statistical organizations, to ensure continuous, reliable, and comprehensive data flows.

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Strengthening Institutional and Technical Capacities for Reporting

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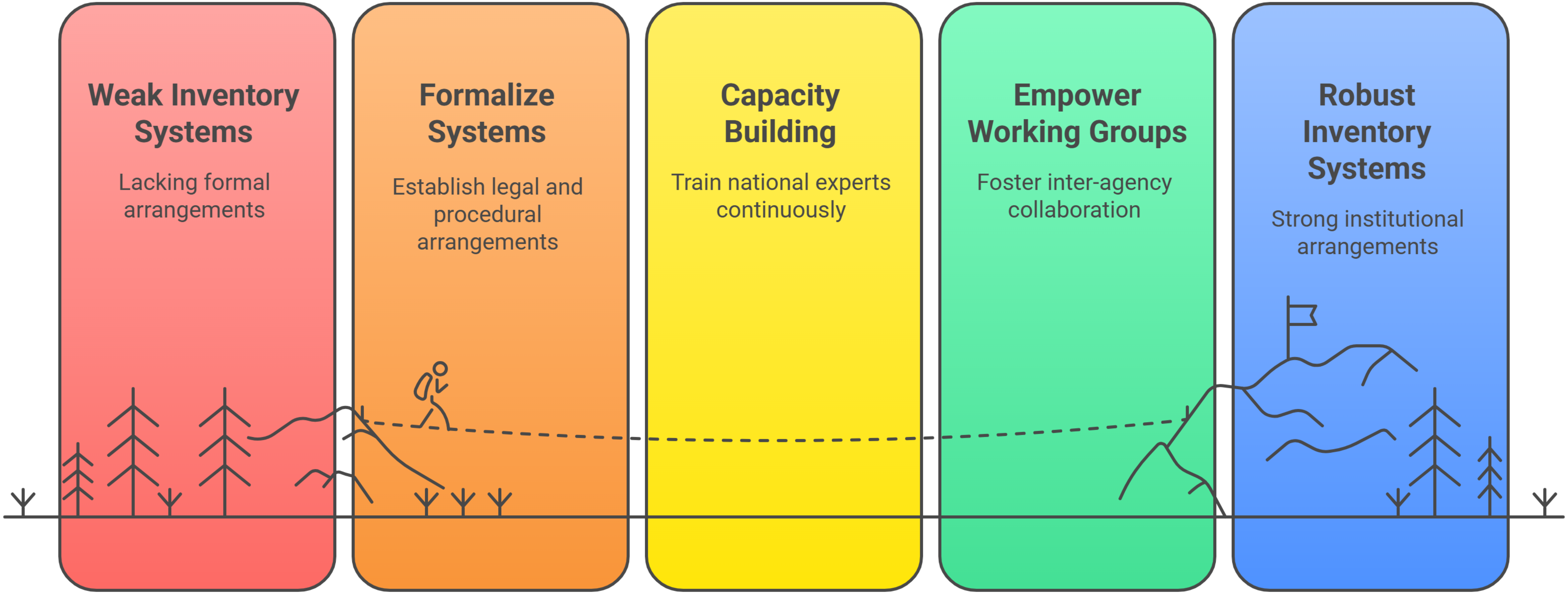

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Fostering International Collaboration and Knowledge Exchange

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Limited Inventory Comparability

Inconsistent, isolated national data

Engage with Databases

Benchmark data against global trends

Participate in Workshops

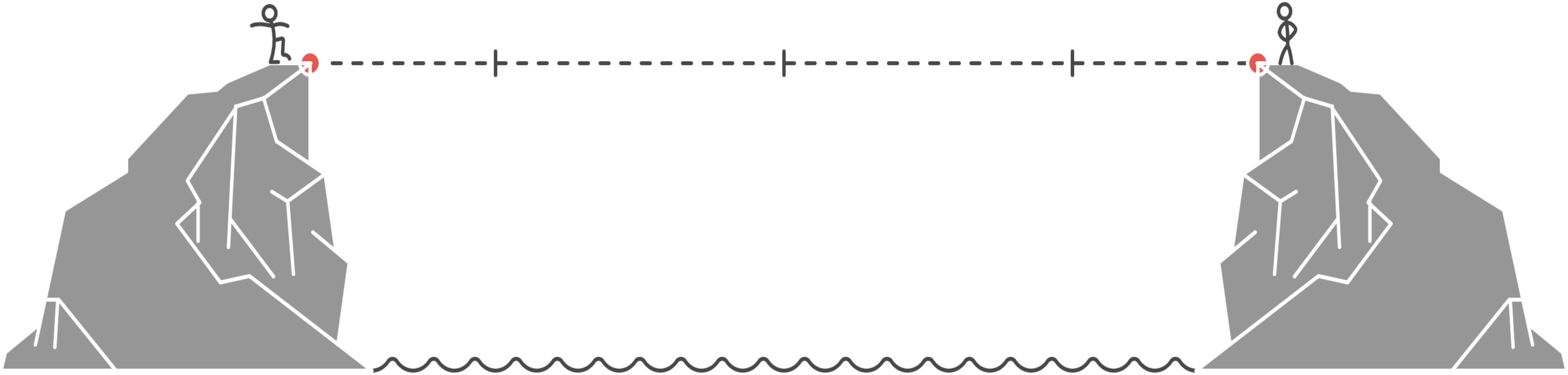
Share experiences, learn best practices

Leverage Support Programs

Overcome data gaps, build systems

Enhanced Inventory Comparability

Robust, transparent national systems



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Proposed Next Steps for Continuous Improvement and Global Alignment

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GHG inventory development is fundamentally an iterative process that necessitates ongoing refinement and adaptation. To ensure continuous progress and global alignment:

- Develop and regularly update a **comprehensive National Inventory Improvement System**. This plan should be informed by findings from internal QA/QC processes, technical reviews, and comparisons with international benchmarks. Priority should be given to improvements in key categories and areas identified with high uncertainty.
- Progressively transition towards **higher IPCC tiers** (Tier 2 and Tier 3) for key emission categories. This transition should be undertaken where data availability and technical capacity allow, as it significantly enhances accuracy and supports more granular and effective mitigation analyses.
- **Invest in national research and studies** aimed at developing and continuously updating country-specific emission factors. This ensures that the emission factors used accurately reflect national circumstances, specific technologies, and recent advancements, moving beyond reliance on generic default values.
- **Embrace and integrate technological advancements**, such as remote sensing and artificial intelligence, into data collection, analysis, and verification processes. This ensures that national inventories remain at the forefront of scientific best practice and can meet evolving transparency demands.

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Thank you for your attention !

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Please reach out to us for any question, comments or suggestions!

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