CBIT-GSP
CLIMATE TRANSPARENCY

Capacity Building Initiative for Transparency - Global Support Programme (CBIT-GSP) : Asia Region

Time Series, Recalculation, Verification, GWP Values, Quality Control and Quality Assurance

Jaypalsinh Chauhan

Asia Transparency Network Coordinator

20 March 2023

UN environment programme | copenhagen climate centre

gef UN environment programme

Time Series

- The time series is a crucial part of the greenhouse gas inventory, providing historical emissions trends and tracking national emission reduction strategies. It is essential to estimate emissions consistently, using the same method and data sources in all years. Using different methods and data could introduce bias, as it may reflect real changes in emissions or methodological refinements.
- An inventory is not just an estimate of a single year. It includes estimates for a number of years (time series of estimates)
  - Information on historical emissions trend
  - Tracking the effects of strategies to reduce emissions at the national level
- Annual estimates should be comparable
  - Should reflect the real annual fluctuations in emissions and removals

Time Series

- Therefore, emissions and removals in time series should be estimated consistently
  - Use of the same method and data sources in all years, where possible
- However, it is not always possible to use the same method and data sets for the entire time series due to a lack of data
- Emission inventories can track changes in emissions and removals through changing activity levels or changing emission rates, or both. The way in which such changes are included in methodologies can have a significant impact on time series consistency.
  - Changes in activity levels
  - Changes in emission rates
  - Capture, destruction, or combustion of emissions

Quality of Time Series and Documentation

- Comparison of the results of multiple approaches where it is possible to use more than one approach
  - Plotting and comparing the results of splicing techniques on a graph is useful
  - If alternative splicing methods produce different results, should consider which result is most realistic
- Comparison of recalculated estimates with previous estimates can be a useful check on the quality of a recalculation
  - However, higher tier methods may produce different trends than lower tier methods because they more accurately reflect actual conditions
- All recalculations and measures taken to improve time series consistency should be documented and reported
  - Reason of the recalculation
  - Effect of the recalculation on the time series
  - Splicing techniques used

Recalculation

- **Methodological changes** in a category involve switching to a different tier from the previous one, often driven by the development of new data sets. For instance, a country may use a higher tier method for an industrial category due to site-specific emission measurement data.

- **Methodological refinement** occurs when an inventory compiler uses the same tier to estimate emissions but applies it using a different data source or level of aggregation. For example, new data may allow for further disaggregation of a livestock enteric fermentation model, resulting in more homogenous animal categories or more accurate emission factors.

Recalculation

- **It is good practice to change or refine methods when:**
  - Available data have changed
  - The previously used method is not consistent with the IPCC guidelines for that category
  - A category has become key
  - The previously used method is insufficient to reflect mitigation activities in a transparent manner
  - The capacity for inventory preparation has increased
  - New inventory methods become available
  - Correction of errors

IPCC Splicing or Gap filling techniques

Splicing - Combining or joining of more than one method or data series to form a complete time series

When to use IPCC Splicing?

- Address a change in method and refinement (e.g., when Tier 2 method can only be applied to new data but Tier 1 is still used for historical data)

- Fill in Data gaps due to collection of period data

The 2006 IPCC Guidelines provide several splicing techniques

- Overlap
- Surrogate
- Interpolation
- Extrapolation

Selecting a gap filling technique requires an evaluation of the specific circumstances and a determination of the best option for the particular case

Summary of Splicing Techniques

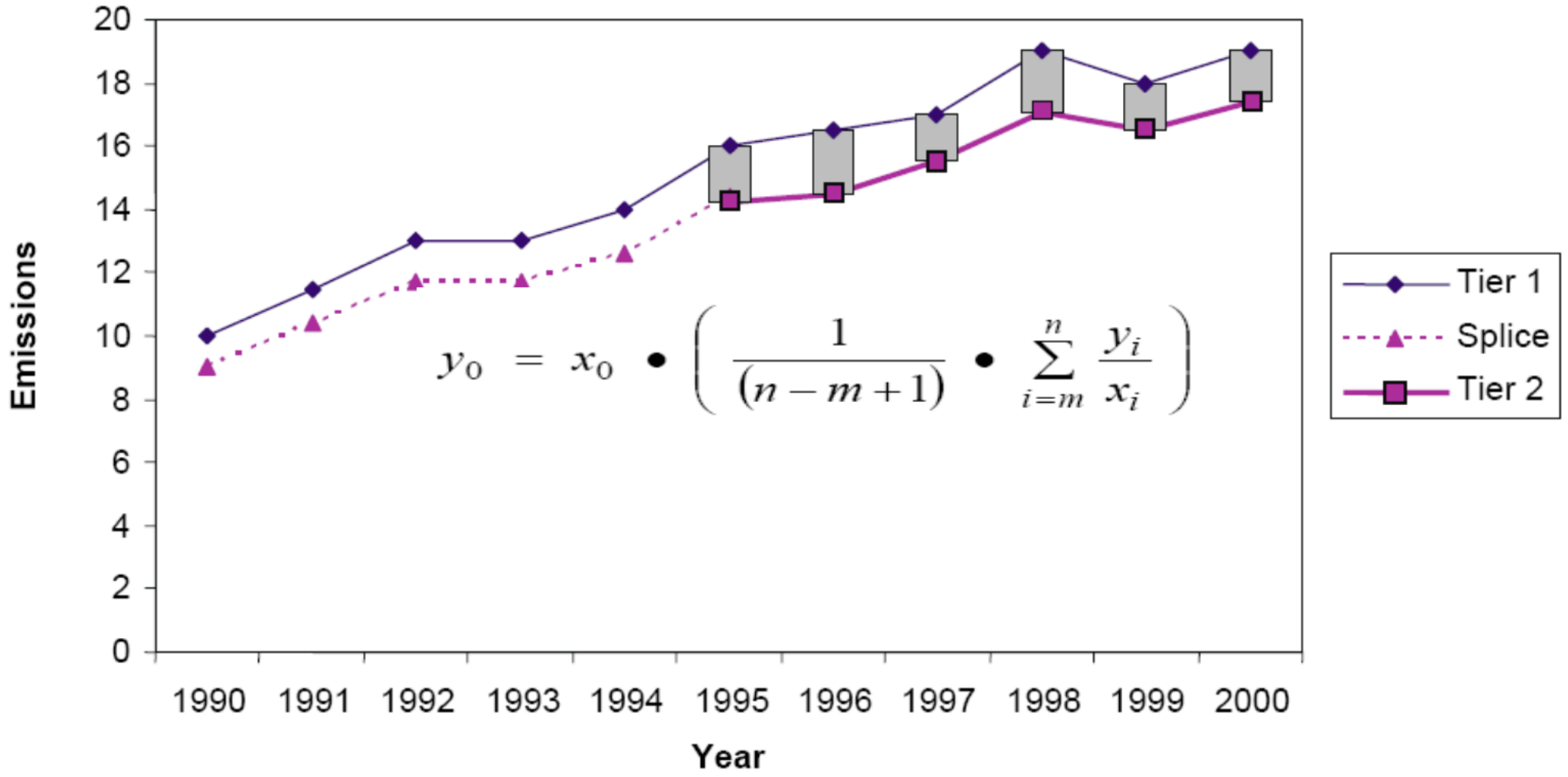
- Each technique can be appropriate in certain situation. It is good practice to perform the splicing using more than one technique before making a final decision

Approach	Applicability	Comments
Overlap	Data necessary to apply both the previously used and the new method must be available for at least one year, preferably more.	• Most reliable when the overlap between two or more sets of annual estimates can be assessed. • If the trends observed using the previously used and new methods are inconsistent, this approach is not *good practice*.
Surrogate Data	Emission factors, activity data or other estimation parameters used in the new method are strongly correlated with other well-known and more readily available indicative data.	• Multiple indicative data sets (singly or in combination) should be tested in order to determine the most strongly correlated. • Should not be done for long periods.
Interpolation	Data needed for recalculation using the new method are available for intermittent years during the time series.	• Estimates can be linearly interpolated for the periods when the new method cannot be applied. • The method is not applicable in the case of large annual fluctuations.
Trend Extrapolation	Data for the new method are not collected annually and are not available at the beginning or the end of the time series.	• Most reliable if the trend over time is constant. • Should not be used if the trend is changing (in this case, the surrogate method may be more appropriate). • Should not be done for long periods.
Other Techniques	The standard alternatives are not valid when technical conditions are changing throughout the time series (e.g., due to the introduction of mitigation technology).	• Document customised approaches thoroughly. • Compare results with standard techniques.

Overlap Approach

- When a new method is introduced but data are not available for early years in the time series (e.g. implementing a higher tier methodology)
- Develop a time series based on the relationship (or overlap) observed between the previously used and new method during the years when both can be used
- It is preferable to compare the overlap for multiple years to evaluate the relationship between the two methods
- If there is no consistent overlap between methods and it is not good practice to use the overlap technique

Overlap Approach: Consistent Relationship



Overlap Approach: Consistent Relationship

Overlap Approach

Example 1: Use the overlap approach to estimate GHG emissions for Tier 2 years 1990 – 2000, using the data below.

(See excel files for practical session)

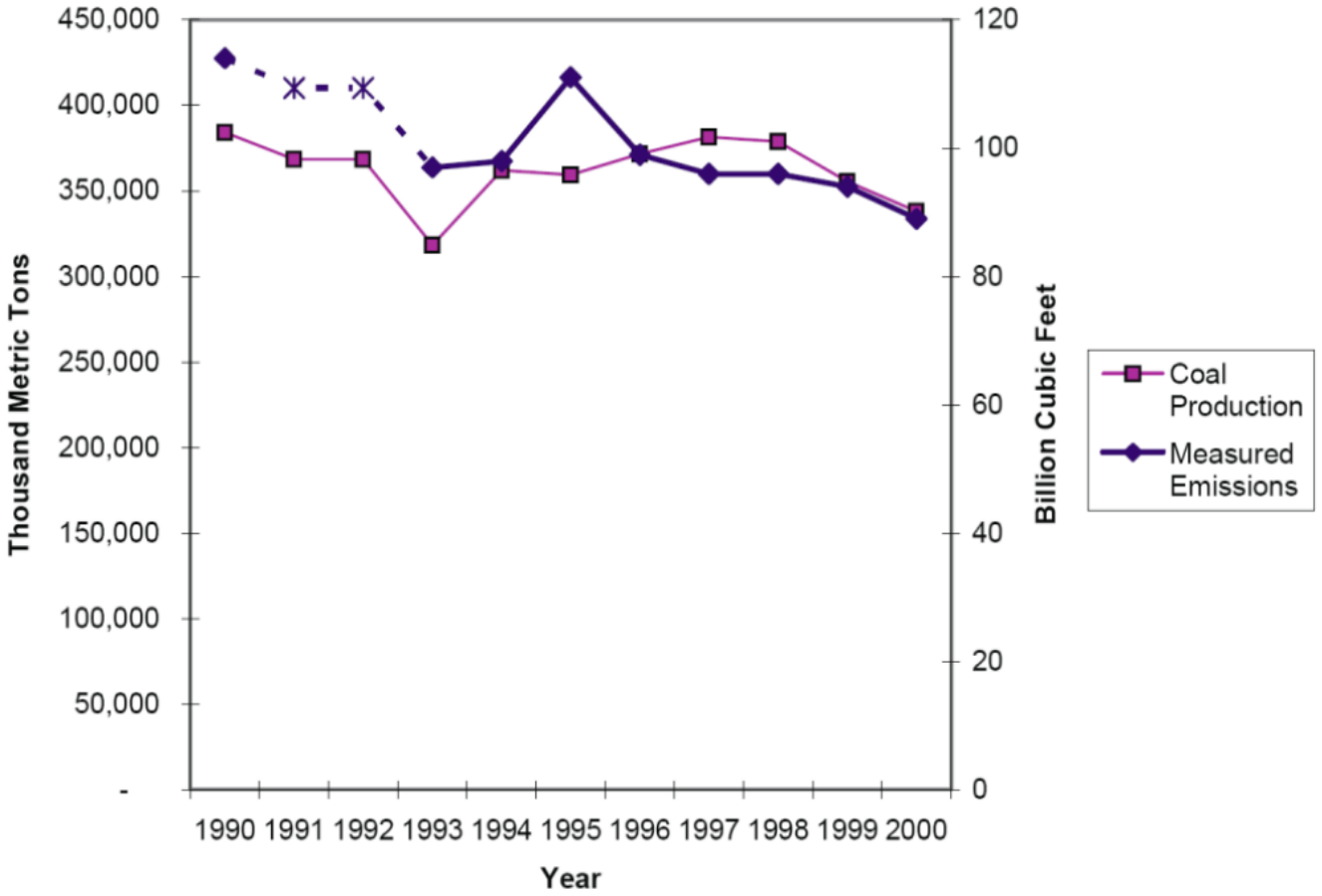
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Tier 1	10.0	12.0	12.5	13.0	13.5	13.9	15.0	15.1	15.0	16.1	17.0	17.9	18.6	19.9	20.5	21.0
Tier 2											15	16	16.8	17.7	18.8	19.1
Estimated/Overlap	9.0	10.8	11.2	11.7	12.1	12.5	13.5	13.6	13.5	14.5	15.3					

Surrogate Data

The surrogate method relates emissions or removals to underlying activity or other indicative data

Data (statistical) that is related to the emission (emissions may be proportional to production, vehicle distances travelled and population etc.)

Although the relationship between emissions/removals and surrogate can be developed on the basis of data for a single year, the use of multiple years might provide a better estimate



Surrogate Approach Steps

- Identify potential surrogate/proxy variables.
- If you have some actual data, calculate simple **correlation coefficients**:
  - ✓ You should have more than one year of actual data to establish a relationship with the surrogate parameter.
- If the correlation is not obvious, then consider more sophisticated **regression techniques** to see if a relationship between actual and surrogate parameter can be found.
- If you have no **actual data**, then you will **need to justify why the surrogate parameter is a legitimate proxy for actual variable(s).**

Example 2: Use the surrogate approach to estimate GHG emissions years 1990 – 2005, using the data below. (See excel files for practical session)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Measured Emissions (Yt)	y0	12.0	12.5	13.0	13.5	13.9	15.0	15.1	15.0	16.1	17.0	17.9	18.6	19.9	20.5	21.2
Surrogate data (St)	25.2	27.6	29.3	28.7	31.2	32.1	34.8	33.6	35	37.1	37.4	40.5	42.6	45.4	45.9	46.4
Estimated/Surrogate (	10.95652															
	y / s	0.43	0.43	0.45	0.43	0.43	0.43	0.45	0.43	0.43	0.45	0.44	0.44	0.44	0.45	0.46

Summary

- **We need consistent estimates of emissions/ removals for all years**
  - Same method and data sources should be applied to all years, if possible

- **Where this is not possible, inventory compilers should follow the time series consistency guidance to provide consistent estimates for all years**
  - Overlap/ Surrogate / Interpolation / Extrapolation /etc.

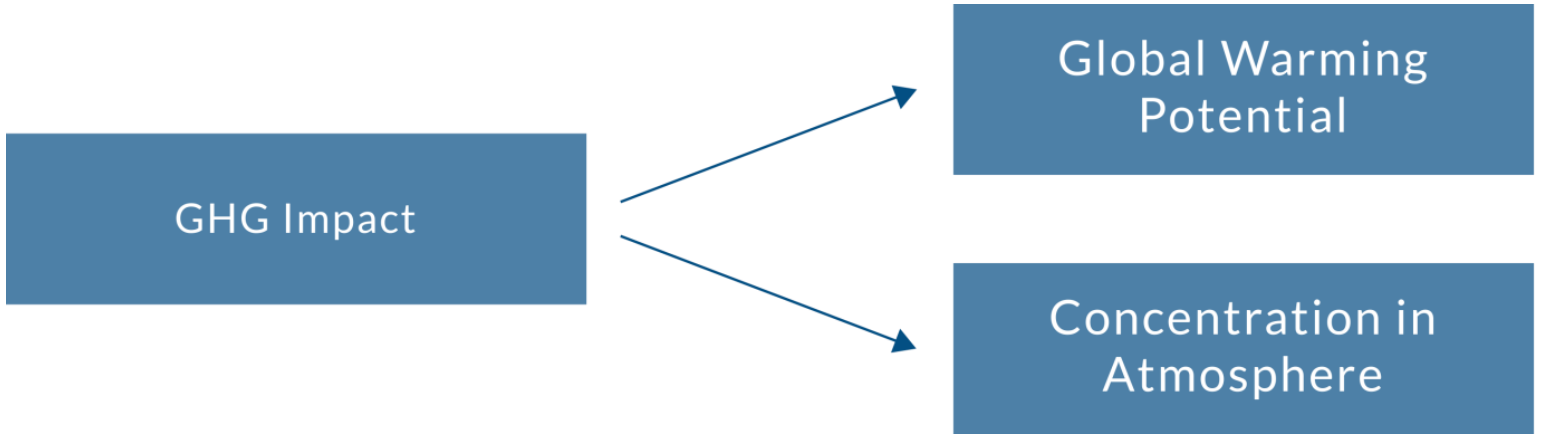
- **We need to ensure quality of time series**
  - Quality checks are applied to entire time series

- **All decisions, methods and reasons should be documented**

Global Warming Potential (GWP)

WHY ARE SOME GREENHOUSE GASES MORE POTENT THAN OTHERS?

The concentration level of a greenhouse gas in the atmosphere and the Global Warming Potential (GWP) of that gas combine to determine the impact it has on global warming.

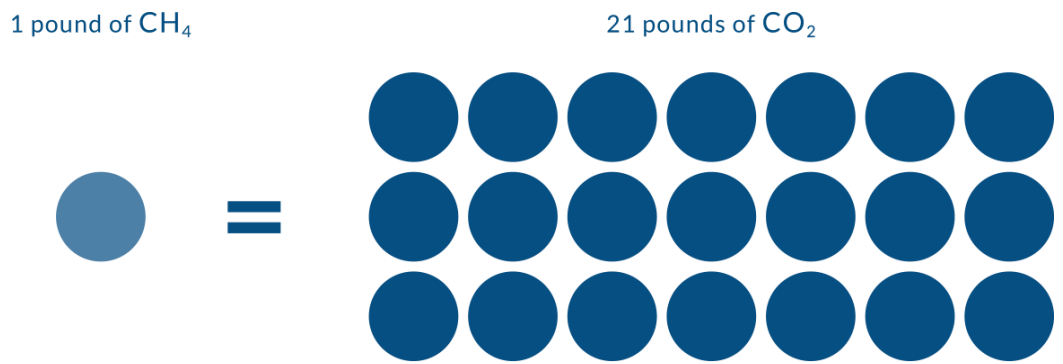


Global Warming Potential (GWP)

GLOBAL WARMING POTENTIAL (GWP)

Has the rather confusing definition of the "amount of warming that a gas will cause in the next 100 years, compared to the same volume of carbon dioxide."

GLOBAL WARMING EFFECT OF METHANE VERSUS CARBON DIOXIDE



Global Warming Potentials (GWP)

Global warming potential (GWP) values relative to CO_2

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265

Good Practice

- National inventories of anthropogenic greenhouse gas emissions and removals consistent with *good practice* are those,
  - which *contain neither over- nor under-estimates so far as can be judged,* and
  - in which *uncertainties are reduced as far as practicable.*

What do we need?

- A good QA/QC system
- Tools to focus resources on where we get the maximum benefit
  - Key Category Analysis
  - Uncertainty Management
- An inventory plan covering QA/QC, timing, deliverables and stakeholder involvement
- Consistent management to achieve this

What is “Quality Control”?

- System of routine technical activities to assess and maintain the quality of the inventory as it is being compiled

- Performed by personnel compiling the inventory

- QC system is designed to:
  - Provide routine and consistent checks to ensure data integrity, correctness, and completeness
  - Identify and address errors and omissions
  - Document and archive inventory material and record all QC activities

What is “Quality Assurance”?

- Planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process (preferably by independent third parties)

- Performed upon a completed inventory following the implementation of QC procedures
  - Verify that measurable objectives were met
  - Ensure that the inventory represents the best possible estimates given the current state of scientific knowledge and data availability
  - Support the effectiveness of the QC program

What is “Verification”?

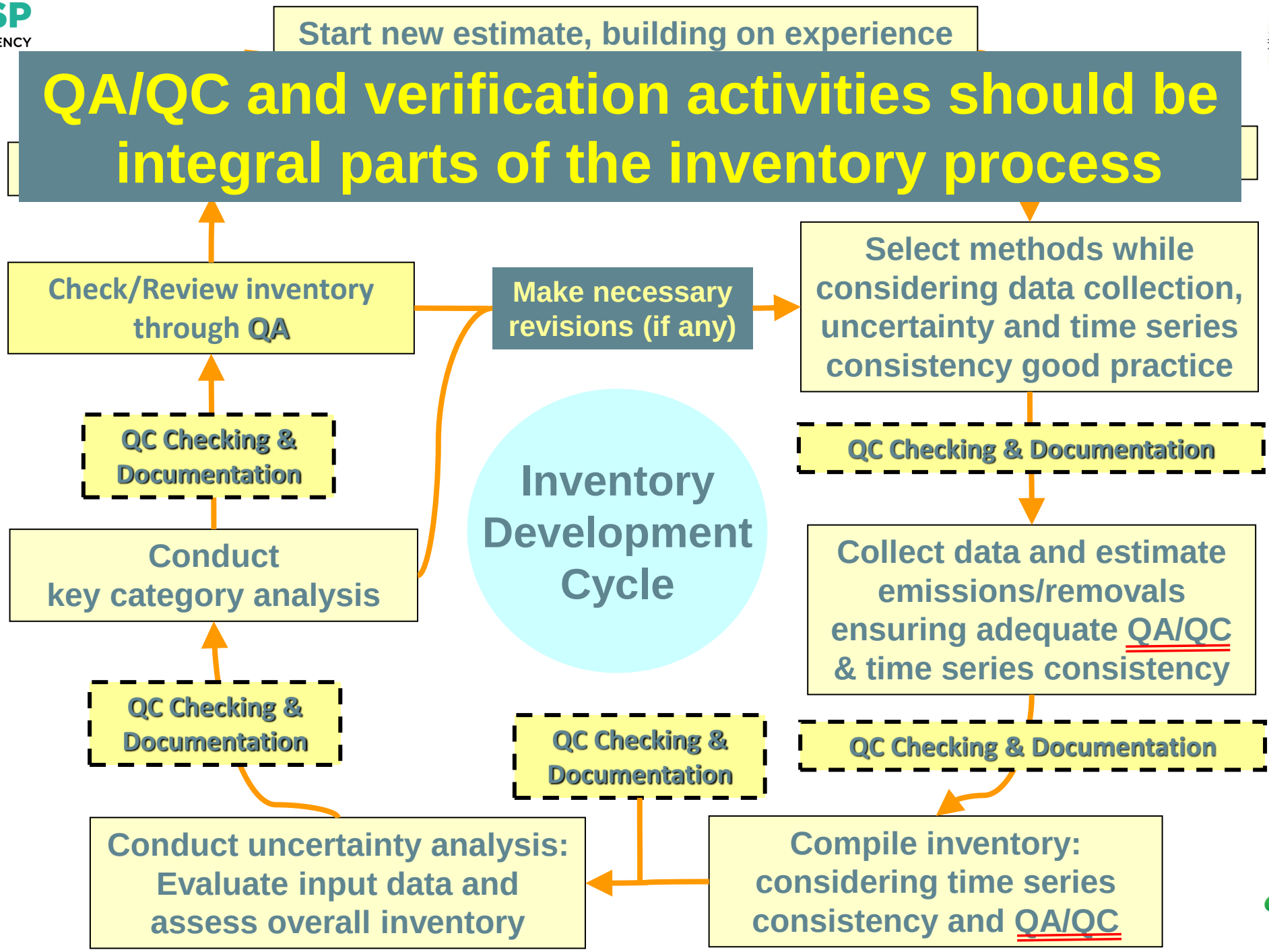
- Collection of activities and procedures conducted during the planning and development, or after completion of an inventory that can help to establish its reliability for the intended applications of the inventory

- Methods that are external to the inventory and apply independent data, including comparisons with inventory estimates made by other bodies or through alternative methods

- May be constituents of both QA and QC

CBIT-GSP
CLIMATE TRANSPARENCY

QA/QC and verification activities should be integral parts of the inventory process

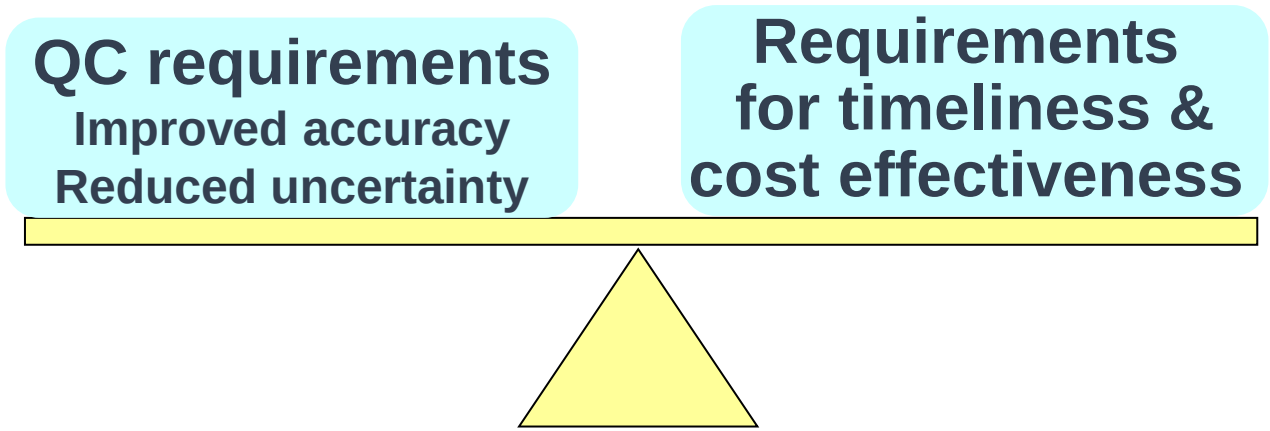


UN environment programme | copenhagen climate centre

gef UN environment programme

Practical Considerations

- Seek to achieve the balance of both requirements



- Also seek to enable continuous improvement of inventory estimates

Practical Considerations

- Try to identify where to focus more intensive analysis and review. To that end, some questions should be asked, for example:
  - Is this source/sink a key category?
  - Has the category been designated as key for qualitative reasons? For example:
    - ✓ Is there considerable uncertainty associated with the estimates for this category?
    - ✓ Have there been significant changes in the characteristics of this category, such as technology changes or management practices?
  - Does the methodology use complex modelling steps or large inputs from outside databases?
- No difference between confidential and publicly available data; both should carry descriptions of the measurement and calculation procedures and the steps taken to check and verify the values reported.

Major Elements

- Participation of an inventory compiler who is also responsible for:
  - coordinating QA/QC and verification activities, and
  - definition of roles/responsibilities within the inventory
- A QA/QC plan
- General QC procedures that apply to all inventory categories
- Category-specific QC procedures
- QA and review procedures
- QA/QC system interaction with uncertainty analyses
- Verification activities
- Reporting, documentation, and archiving procedures

Roles and Responsibilities

- The inventory compiler should:

  - Be responsible for coordinating the institutional and procedural arrangements for inventory activities.

  - Define specific responsibilities and procedures for the planning, preparation, and management of inventory activities.

QA/QC Plan

- Fundamental element of the system
- Should include a scheduled time frame for the QA/QC activities
- A key component – List of data quality objectives (preferably measurable)
- Important to accommodate procedural changes and a feedback of experience
  - The periodic review and revision of the QA/QC plan is an important element to drive the continued inventory improvement.
- It may be useful to refer to relevant standards and guidelines published by outside groups involved in inventory development.
  - For example, the International Organization for Standardization (ISO) introduced specifications for quantification, monitoring, and reporting of greenhouse gas emissions and removals (ISO 14064) in organizations.

General QC Procedures

- Generic quality checks applicable to all source and sink categories, related to:
  - Calculations
  - Data processing
  - Completeness
  - Documentation

See Table 6.1 in Chapter 6 in Volume 1.
The checks suggested in this table should be applied irrespective of the types of data used to develop the inventory estimates.

See also Appendix 6A.1 “QC checklists” in Chapter 6, Volume 1.

- Automated checks are encouraged where possible – to effectively check large quantities of input data
- In the cases where estimates are prepared by outside consultants or agencies, the inventory compiler should ensure:
  - the consultants/agencies are aware of the QC procedures, and
  - these procedures are performed and recorded.

CBIT-GSP
CLIMATE TRANSPARENCY

TABLE 6.1
GENERAL INVENTORY QC PROCEDURES

QC Activity	Procedures
Check that assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters are documented.	• Cross-check descriptions of activity data, emission factors and other estimation parameters with information on categories and ensure that these are properly recorded and archived.
Check for transcription errors in data input and references.	• Confirm that bibliographical data references are properly cited in the internal documentation. • Cross-check a sample of input data from each category (either measurements or parameters used in calculations) for transcription errors.
Check that emissions and removals are calculated correctly.	• Reproduce a set of emissions and removals calculations. • Use a simple approximation method that gives similar results to the original and more complex calculation to ensure that there is no data input error or calculation error.
Check that parameters and units are correctly recorded and that appropriate conversion factors are used.	• Check that units are properly labelled in calculation sheets. • Check that units are correctly carried through from beginning to end of calculations. • Check that conversion factors are correct. • Check that temporal and spatial adjustment factors are used correctly.
Check the integrity of database files.	• Examine the included intrinsic documentation (see also Box 6.4) to: - confirm that the appropriate data processing steps are correctly represented in the database. - confirm that data relationships are correctly represented in the database. - ensure that data fields are properly labelled and have the correct

UN environment programme | copenhagen climate centre

For more details, see Chapter 6 in Volume 1.

gef UN environment programme

Category-specific QC Procedures

- Complements general QC procedures
- Directed at specific types of data used in the methods for individual source or sink categories
- Applied on a case-by-case basis focusing on:
  - key categories
  - categories where significant methodological and data revisions have taken place

See also Appendix 6A.1 “QC checklists” in Chapter 6, Volume 1.

QA Procedures

- Activities outside the actual inventory compilation, performed preferably by third party reviewers who are independent from the inventory compiler
  - Expert peer review
  - Audits
- Priority should be given to:
  - key categories
  - categories where significant methodological and data revisions have taken place

QA/QC and Uncertainty Estimates

- Provide valuable feedback to each other on critical components of the inventory estimates and data sources that:
  - Contribute to both the uncertainty level and inventory quality
  - Should therefore be a primary focus of inventory improvement efforts

- Uncertainty analysis can provide insights into:
  - Weaknesses in the Estimate
  - Sensitivity of the estimate to different variables
  - The greatest contributors to uncertainty

Verification

- Activities to provide information for countries to improve their inventories
  - Comparisons of national estimates
    - Applying different tier methods
    - Comparisons with independently compiled estimates
    - Comparisons of intensity indicators between countries
  - Comparisons with atmospheric measurements

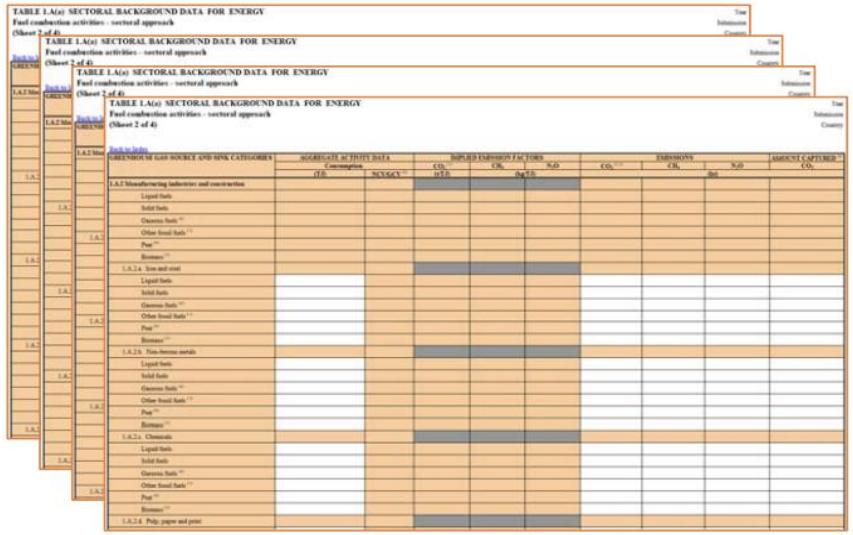
Documentation, Archiving and Reporting

- Document and archive all information relating to the planning, preparation, and management of inventory activities
  - Records of QA/QC procedures are important information to enable continuous improvement to inventory estimates.

- Report a summary of implemented QA/QC activities and key findings as a supplement to each country's national inventory

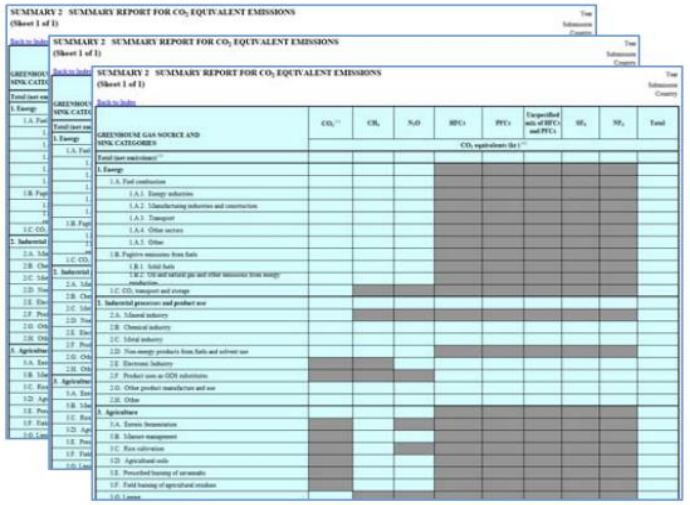
Common Reporting Tables (CRT)

- Prepared for the electronic reporting of information in the NIR of anthropogenic emissions by sources and removals sinks of GHGs
- Set of MS Excel workbook (containing 60 worksheets) for each reported year
- There are three types of table for each year
  - Sectoral Background Tables (white/orange cells) – Need to fill data at this layer
  - Sectoral Report Tables (green cells) – Automatically generated
  - Summary Tables/Cross-sectoral Tables (blue cells) – Automatically generated



Sectoral Background Tables

Sectoral Report Tables



Summary / Cross-sectoral / Trends Tables

Index of common reporting tables (CRT)

Table1	Energy
Table1.A(a)s1	
Table1.A(a)s2	
Table1.A(a)s3	
Table1.A(a)s4	
Table1.A(b)	
Table1.A(c)	
Table1.A(d)	
Table1.B.1	
Table1.B.2	
Table1.C	
Table1.D	
Table2(I)	IPPU
Table2(I).A-H	
Table2(II)	
Table2(II)B-Hs1	
Table2(II)B-Hs2	
Table3	Agriculture
Table3.A	
Table3.B(a)	
Table3.B(b)	
Table3.C	
Table3.D	
Table3.E	
Table3.F	
Table3.G-J	

Table4	LULUCF
Table4.1	
Table4.A	
Table4.B	
Table4.C	
Table4.D	
Table4.E	
Table4.F	
Table4(I)	
Table4(II)	
Table4(III)	
Table4(IV)	
Table4.Gs1	
Table4.Gs2	
Table5	Waste
Table5.A	
Table5.B	
Table5.C	
Table5.D	
Summary1	Summary Tables
Summary2	
Summary3	

Table6	Cross Cutting (Key Category, Recalculation)
Table7	
Table8s1	
Table8s2	
Table9	
Table10s1	Trend Tables
Table10s2	
Table10s3	
Table10s4	
Table10s5	
Table10s6	
Flex_Summary	Flexibility Provisions

Notation Keys

- "NO" (not occurring) for categories or processes, including recovery, that do not occur within a country.
- "NE" (not estimated) for activity data and/or emissions by sources and removals by sinks of GHGs that have not been estimated but for which a corresponding activity may occur within a country; Where "NE" is used by a country to report emissions or removals of CO2, N2O, CH4, HFCs, PFCs, SF6 or NF3, the country must indicate in both the NID and the CRT 9 why such emissions or removals have not been estimated.
- "NA" (not applicable) for activities under a given category that do occur within the country but do not result in emissions or removals of a specific gas; If the cells for categories in the CRT for which "NA" is applicable are shaded gray they do not need to be filled in.
- "IE" (included elsewhere) for emissions by sources and removals by sinks of GHGs estimated but included elsewhere in the inventory instead of under the expected category. Where "IE" is used, the country should indicate, in CRT 9 where in the inventory the emissions or removals for the displaced source or sink category have been included and explain the deviation.
- "C" (confidential) for emissions by sources and removals by sinks of GHGs where the reporting would involve the disclosure of confidential information.
- "FX" (flexibility) for cells where data is not available or reported because of a flexibility provision applied by a country that needed flexibility in the light of its capacity

Summary

- Inventories need to be credible and believable: they need to be of high quality.
- Good Practice helps to produce quality inventories.
- Keep in mind the indicators of quality “TACCC”.
- QA/QC and verification activities should be integral parts of the inventory process.
- Seek to achieve the balance of:
  - QC requirements
  - Requirements for timeliness & cost effectiveness
- Initial planning and good management is essential.
- Limited resources is not a barrier to Greenhouse Gas Inventory compilation.

www.climate-transparency-platform.org

Thank you for your attention !

CBIT-GSP
CLIMATE TRANSPARENCY

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

CBIT-GSP
Asia Network Coordinator

Jaypalsinh CHAUHAN
jaypalsinh.chauhan@un.org

CBIT-GSP
Global Coordinator

Fatima-Zahra TAIBI
fatima-zahra.taibi@un.org

CBIT-GSP
Project Officer

Susanne KONRAD
susanne.konrad@un.org

CBIT-GSP
Transparency Officer

Khetsiwe KHUMALO
khetsiwe.khumalo@un.org

CBIT-GSP
Project Officer

Juliette LUNEL
juliette.lunel@un.org

gef

UN environment programme

UN environment programme | copenhagen climate centre