National Greenhouse Gas Inventory Manual of Procedures

September, 2015

Procedures for Planning and Managing National Greenhouse Gas (GHG) Inventory in Ghana

Table of Contents

Acronyms

AD	-	Activity Data
AFOLU	-	Agriculture, Forestry, and Other Land Uses
BUR	-	Biennial Update Report
EPA	-	Environmental Protection Agency
EU	-	European Union
GHG	-	Greenhouse Gas
GHGIG	-	GHG Inventory Guidelines
GPG	-	Good Practice Guidance
ICA	-	International Consultation and Analysis
IPCC	-	Intergovernmental Panel on Climate Change
LECBP	-	Low Emissions Capacity Building Project
MESTI	-	Ministry of Environment, Science, Technology, and Innovation
MOU	-	Memorandum of Understanding
NC	-	National Communication
NIR	-	National Greenhouse Gas Inventory Report
NSGHGI	-	National System for GHG Inventory
QA/QC	-	Quality assurance and quality control
QC	-	Quality Control
SOP	-	Standard Operating Procedure
TCCCA	-	Transparency, Consistency, Comparability, Completeness, and Accuracy
TOR	-	Terms Of Reference
UNDP	-	United Nations Development Program
UNFCCC	-	United Nations Framework Convention on Climate Change

Acknowledgement

The UNDP Low Emission Capacity Building (LECB) Programme is a country-driven initiative that promotes essential cooperation between relevant institutions, engaging the public sector and industry in a concerted effort to design and implement approaches to low emission development that are consistent with national development priorities. National counterparts are supported to strengthen technical and institutional capacities to identify and formulate Nationally Appropriate Mitigation Actions (NAMAs) and Low Emission Development Strategies (LEDS) in the public and private sectors, and to strengthen the underlying greenhouse gas inventory management and Measurement, Reporting and Verification (MRV) systems.

The LECB Programme runs through 2016 and is active in 25 countries: Argentina, Bhutan, Chile, China, Colombia, Costa Rica, the Democratic Republic of Congo (DRC), Ecuador, Egypt, Ghana, Indonesia, Kenya, Lebanon, Malaysia, Mexico, Moldova, Morocco, Peru, Philippines, Tanzania, Thailand, Trinidad and Tobago, Uganda, Vietnam and Zambia.

The programme is supported through generous contributions from the European Commission, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the Government of Australia.

More information can be found at www.lowemissiondevelopment.org

This product was developed under the LECB Programme, with generous funding from the European Commission (EC), the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the Australian Government.

Glossary

Inventory year and time series - National inventories contain estimates for the calendar year during which the emissions to (or removals from) the atmosphere occur. Where suitable data to follow this principle are missing, emissions/removals may be estimated using data from other years applying appropriate methods such as averaging, interpolation and extrapolation. A sequence of annual greenhouse gas inventory estimates (e.g., each year from 1990 to 2000) is called a time series. Because of the importance of tracking emissions trends over time, countries should ensure that a time series of estimates is as consistent as possible.

Inventory reporting - A greenhouse gas inventory report includes a set of standard reporting tables covering all relevant gases, categories and years, and a written report that documents the methodologies and data used to prepare the estimates.

National territory - National inventories include greenhouse gas emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction.

Anthropogenic emissions and removals - Anthropogenic emissions and removals means that greenhouse gas emissions and removals included in national inventories are a result of human activities. The distinction between natural and anthropogenic emissions and removals follows straightforwardly from the data used to quantify human activity. In the Agriculture, Forestry and Other Land Use (AFOLU) Sector, emissions and removals on managed land are taken as a proxy for anthropogenic emissions and removals, and inter-annual variations in natural background emissions and removals, though these can be significant, are assumed to average out over time.

National system - includes all institutional, legal and procedural arrangements made within a Party for estimating anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

Good practice – is a set of procedures intended to ensure that GHG inventories are accurate in the sense that they are systematically neither over- nor underestimated as far as can be judged, and that uncertainties are reduced as far as possible. Good practice covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties and data archiving and reporting to promote transparency.

Key category - is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHG in terms of the absolute level of emissions, the trend in emissions, or both.

Energy sector emissions - This category includes all GHG emissions arising from combustion and fugitive releases of fuels. Emissions from the non-energy uses of fuels are generally not included here, but reported under Industrial Processes and Product Use Sector.

Industrial Process and Product Use emissions - Emissions from industrial processes and product use, excluding those related to energy combustion (reported under 1A), extraction, processing and transport of fuels (reported under 1B) and CO_2 transport, injection and storage (reported under 1C).

AFOLU sector emissions - Emissions and removals from forest land, cropland, grassland, wetlands, settlements, and other land. Also includes emissions from livestock and manure management, emissions from managed soils, and emissions from liming and urea application. Methods to estimate annual harvested wood product (HWP) variables are also covered in this category.

Waste sector emissions - Methane is produced from anaerobic microbial decomposition of organic matter in solid waste disposal sites. Carbon dioxide (CO_2) is also produced but CO_2 from biogenic or organic waste sources is covered by the AFOLU Sector. Emissions of halogenated gases should be accounted in IPPU. Long-term storage of carbon in SWDS is reported as an information item. Solid waste composting and other biological treatment. Emissions from biogas facilities (anaerobic digestion) with energy production are reported in the Energy Sector (1A4). Incineration of waste and open burning waste, not including waste-to-energy facilities.

Emissions from waste burnt for energy are reported under the Energy Sector, 1A. Emissions from burning of agricultural wastes should be reported under AFOLU (3C1). All non-CO_2 greenhouse gases as well as CO_2 from fossil waste should be reported here for incineration and open burning. Methane is produced from anaerobic decomposition of organic matter by bacteria in sewage facilities and from food processing and other industrial facilities during wastewater treatment. N2O is also produced by bacteria (denitrification and nitrification) in wastewater treatment and discharge.

Methodological tiers and choice - The IPCC inventory methodology is divided into various levels or tiers. Generally, the higher the number designating the tier, the more detailed is the methodology and the more accurate are the emission estimates. Tier 1 represents the minimum, or default, methodology. If sufficient data are available, a Party can also try to apply a higher tier. Tiers 2 or 3 involve more elaborate methods which could be either source category-specific or technology based. These methods require more detailed data and/or measurements for their application. In the case where a national methodology exists, and is consistent with the IPCC Guidelines, it is highly advisable to use the national methodology. The national methodology used should be fully documented in order to allow the reader to understand why this particular method is better than the default one proposed by the IPCC.

1. Things to know about this manual

1.1 Objective of this document?

The objective of this consultancy service is to prepare a GHG inventory manual for all sectors, as captured by the IPCC and Ghana's national circumstances. The manual will provide guidance to both data providers and inventory data compilers on the national GHG inventory process.

1.2 What is the use of this document

Over the years, Ghana's GHG inventory system has evolved from an ad hoc working group of few experts, to a more structured and inclusive one that has incorporated several institutions and expertise. Invariably, for a national GHG inventory process to be more sustainable and responsive to the increasing demand and robustness required by the UNFCCC, the sustenance of a national system is vital. But to ensure that the inventory process will fulfill current and future demands in a consistent and timely manner, irrespective of the people or experts involved, there is the need for a guidance document that operationalizes the IPCC inventory processes into basic steps, which can be easily followed.

The need for such a guidance document is even more relevant, at a time that Ghana has modelled its inventory system around existing institutions in the various sectors of accounting and is still exploring mechanisms to mainstream the national inventory process into the various sectoral operations of relevant institutions in the country. These mainstreaming activities also come with the inclusion of experts who might need capacity-building. But importantly, the quest for consistency in the GHG accounting and reporting also means that changes in the personnel involved at the various institutions or any related anomalies may not affect the capacity of these institutions to deliver.

This operational manual is being designed to serve as the basic reference material for the actual processes involved in the GHG inventory cycles for Ghana. This includes the Biennial Update Reports (BUR), the National GHG Inventory Report (NIR), and the National Communications. It is expected that the manual will be a living document for Ghana's GHG inventory process, which will be updated periodically to capture the complexities of the operational aspects and activities that characterize the planning, preparation and management phases of GHG inventory in Ghana.

1.3 How to use the GHG inventory manual

This manual is only a reference guide for the GHG inventory process in Ghana. It is by no means intended to replace the IPCC guidance and guidelines for GHG accounting. Users are highly encouraged to consult the IPCC manual extensively and follow the guidance and recommendations to the later.

This reference manual however unpacks the rudimentary activities that characterize the various phases of the inventory process in a simplified way and with practical examples that have been drawn from experiences in undertaking three GHG inventories in Ghana. This will enable experts involved in the inventory process to establish and maintain links with routine data providers, consider best practices that have worked so far and also pay attention to grey areas that need particular attention in the course of the accounting process, and not reinvent the wheel. Users will find useful illustrations of practical approaches that were used in accomplishing fundamental tasks such as accessing data and managing the minutest activities which ultimately culminate in the GHG report.

1.4 Who are the target users of this manual

The manual is intended for experts and practitioners involved in the planning, preparation and management of Ghana's GHG inventory process. Particularly, the manual is intended for inventory compilers in the four sectors of accounting under the existing national system and Staff of the EPA who will be in charge of the general cross-cutting issues and overall compilation of the GHG inventory report. The manual can also be useful as a teaching material for university programs, which could bring students and lecturers closer to the inventory process. Components of the contents of this material could be mainstreamed into related courses to serve as a mechanism to improve the understanding and use of the inventory estimates.

1.5 What this plan does not cover

This manual only covers the step-by-step approach in the three phases of the inventory. It by no means replaces the IPCC guidance and the procedures outlined in it. It is also important to emphasize that periodically, this manual should be updated to capture the evolving nature of the experts and institutions involved in the inventory. The IPCC guidance remains the ultimate material to guide the GHG inventory process

1.6 Structure of the manual

The GHG manual is appropriately sectioned into five. Section one provides the contextual background to the document, by highlighting some basic information to know about the manual. This is followed by an introductory section and an assessment of the existing national systems and institutional arrangements for GHG inventory in section three. Section four focuses on the standard operating procedures for the GHG inventory in Ghana, and section five concludes the manual with updates and improvement mechanisms for the GHG inventory manual.

1.7 Methodology used to prepare the manual

The preparation of this manual involved two major methodological approaches. The first step was largely a desk study of available literature on the execution of the GHG inventory so far. This involved a review of previous national communication and GHG

inventory reports, as well as documents on the institutional arrangements and national system for GHG inventory.

The next approach was to engage the inventory compilers from the various sector level task groups to document the procedures and approaches they used in sourcing for data, mobilizing tasks group team members and the modalities used in engaging group members to generate the GHG estimates. Thus information was generated on the basic activities which characterized the planning, preparation and management phases of the inventory.

The people contacted in this work to generate information, were engaged individually, there is therefore the need to engage a wider stakeholder group to validate the procedures outlined in the study as a true workable manual. Invariably the engagements with the sector level task group members aided a better understanding of the modalities for the executing the national inventory and the associated report that emanates. However, this also offers the opportunity to illicit information on what works, the challenges associated with the various phases of the inventory and intended mechanisms to address them.

2. Introduction

The introduction provides the context of this manual by highlighting on the overall global framework for tracking the impacts of climate change policies and actions on greenhouse gas emissions through GHG inventory at the national level.

2.1 Overall context

There is strong scientific evidence supporting the reality of climate change. Its impacts pose a threat to the economic development of nations across the globe. Developing countries like Ghana are largely at risk to climate change because their economies are intrinsically dependent on climate-sensitive sectors of the national economy. Ghana's response to climate change seeks to simultaneously address the risks climate change poses to its socio-economic development and pursue opportunities that stem from the development of a low emissions growth path. There is a concern that the impacts of climate change will erode recent development gains. The related desire to move towards a climate-resilient economy is a key driver, and as such, climate adaptation and sustainable development in the context of Ghana's development needs are central to Ghana's climate policy. Mitigation as a third – but arguably less central – pillar.

It can be concluded that economic development is the key priority that underpins Ghana's view on climate change. Climate adaptation and resilience are uncontested priorities. Climate mitigation policies, in contrast, are either implemented at the lowest possible cost, or because implementing them actually promotes economic development in the longer term. There are a series of policies with a mitigation effect (e.g. fossil fuel subsidy removal and the switch from oil to natural gas in thermal electricity generation) are first and foremost implemented for economic or fiscal reasons, while, as a co-benefit, contributing to climate mitigation. International financial aid for mitigation and related opportunities are also actively exploited and pursued.

At the global level, Ghana is a Party to both the UNFCCC and Kyoto Protocol therefore ensure to the implementation of the convention in the country. In this regard Ghana has been reporting to the convention through the preparation and submission of its national communication (NATCOM) and biennial update report (BUR) in response to Article 4, paragraph 1(a) and Article 12, paragraph 1(a), of the Convention.

So far, Ghana has submitted 3 national communications and then lately, its first BUR. In the future, countries will be expected to meet the strict 4-year and 2-year reporting cycle and its associated review. It will mean that Ghana will have to begin to further strengthen its national system for conducting GHG inventories in order to meet the new reporting regime. The new reporting regime does not only request for information on national greenhouse gas inventory to be include in the NATCOM and the BUR, it also

demands that Ghana put in place a sustainable system of producing high quality inventories. The objective of a national GHG inventory is to determine the magnitude of national GHG emissions and removals that are directly attributable to human activity. The development of an inventory manual of procedures will assist inventory compilers in executing the national inventory on a more regular basis, with the accuracy and consistency that is needed and within schedule, by describing the "who, what, where, when and how" of the GHG inventory planning, preparation and management for Ghana.

2.2 Current state of GHG Inventory in Ghana

Ghana produces standalone national inventory reports (NIR) every time it submits NATCOM and BUR. So far two of such reports have been produced. The latest NIR covered estimation of direct GHGs (CO_2, CH_4 and N_2O) 1990-2012 for 4 economic sectors using the 2006 IPCC guidelines. The activities in the 4 economic sectors covered in the inventory were Energy, Industrial Process and Product Use (IPPU) Agriculture, Forest and Other Land Uses (AFOLU) and Waste (see table 1).

The preparation of the national GHG inventory took nearly 18 months to complete which is 6 month ahead of time. The inventory preparation was coordinated by the Environmental Protection Agency (EPA). As the inventory entity, the EPA was responsible for planning and management of the inventory. Different line ministries and agencies were given the task to conduct sector-specific inventory. For example, the Energy Commission, Forestry Commission and the Ministry of Food and Agriculture were responsible for the planning, estimation and reporting of the Energy and AFOLU sector emissions respectively. For each of the line ministries and agencies that conducted specific sector emission estimation, they were responsible for identifying data sources, data request and processing, making methodological choices, estimation and reporting of sector emissions.

When the sector level inventories are ready, they are submitted to the EPA for quality assurance checks and review before compilation. The compilation include putting together the individual sector spreadsheet which contain estimates for different years to generate single aggregate data of national emission totals for the entire 22 year time series. The aggregate national totals is used to generate trends, analysis of emissions by sectors and on gas-by-gas basis. The results from the trends, sectors totals and gases together with the individual sector reports is used to produce the national inventory report (NIR).

The draft NIR and the associated tables are subjected to third party informal technical review. The purpose of the review it to identify errors and check consistencies at the earliest possible stage of the compilation before the NIR is submitted officially to the UNFCCC. Although many improvements have been introduced in the inventory preparation especially in the last inventory for the purpose of ensuring that it is credible and reliable, a lot remains to be done. That is why Ghana has committed to the continuous reforms in the inventory. The reforms covered 4 mains pillars of the

inventory focusing on institutional arrangement, data management, methodological and protocol and continuous training. The preparation of this manual forms of part of the on-going reforms.

TABLE 1 : STATUS OF GHG INVENTORY IN GHANA

Parameters	NIR 1	NIR 2	NIR 3
Base year	1990	2000	2006
Inventory years	1990-2000	1990-2006	1990-2012
Year submitted to UNFCCC	2001	2011	2015
IPCC Guidelines used	Revised 1996 Guidelines	Revised 1996 Guidelines and 2003 GPG	2006 Guidelines
Inventory sectors	Energy, Industrial Processes, Agriculture Land use change and Forestry and Waste	Energy, Industrial Processes, Agriculture Land use, Land use change and Forestry and Waste	Energy, Industrial Processes and Product Use Agriculture, Forestry and Other Land Use and Waste
Direct GHG covered	CO_2,CH_4, N_2O & PFCs		
Indirect GHG covered	-	CO, SO_2	

2.3 Brief Description of national GHG inventory cycle

Ghana GHG activities are categorized into 4 main stages based on the 2006 IPCC guidelines for national GHG preparation. It is a continuous cycle which starts from review, planning, preparation, management and compilation as illustrated in figure 1. Each phase focuses on delivering specific results upon which subsequent activities are built on. At the review stage, all feedback from the preceding inventory are collated and evaluated as input into the planning of the new inventory. The planning involves team formation, organizing training programme, drafting and signing MOUs, identification of data sources and request of data. In the preparation phase, data are processed, methods are evaluated and sector estimates are produced. The activities in the management phase is cross-cutting. They involve activities that are relevant and applicable to data gathering, data processing, GHG estimation, data archiving, reporting and reviewing. QA/QC procedures is the major activity implemented in the management phase of the inventory.

FIGURE 1: GHANA'S INVENTORY CYCLE

2.4 How does the GHG manual tie into the on-going reforms

The preparation of the GHG manual is in line with the reforms that are taking place in the inventory. The manual together with the QA/QC plan developed by another team fulfill the aspects of the reforms which aims at documenting steps and protocols used in the GHG inventory. The two documents will not only be beneficiary to the aspects of the reform on documenting methodology and protocol, they will also serve as useful resources for the inventory team. For the existing team members, the GHG manual can be reliable reference material, particularly, in ensuring that the sector experts conduct the estimation using consistent approaches.

In addition, during third party technical review of the national inventory, this manual will be a good information source for cross-checking how the inventory has been prepared in line with the principle of transparency. For those who join the inventory team for the first time, the manual will be used to give them hands-on orientation through training programmes. Now that Ghana has plans to further devolve the inventory task to facility operators, the manual will be a useful guide in the designing and rolling out plant level inventories. The manual could also be resourceful for data owners who supply data to the compliers. At least, the data providers will get to know the type of data needed, the format and above all, how the methodology used to generate the data could be revised to meet the needs of the GHG inventory.

2.5 Focus of the GHG manual

The manual contains specific steps in the inventory as defined in the UNFCCC reporting guidelines for non-Annex 1 Parties and the IPCC 2006 manual and packaged in a logical sequence from planning, preparation and reporting of the inventory. The aim is to assess the existing inventory steps, put them together in a systematic structure and communicate to the inventory teams to follow. They will therefore be on how to streamline inventory cycle to become more responsive to the high frequency reporting regime. In so doing, emphasis will be placed on which identified specific tasks will be performed each phase of the inventory, roles and responsibilities, timelines and budget. It is also important to note that, the manual will be updated on regular time period particularly during the beginning a new inventory cycle. The information that will be used to do the updating will emerge from new or revisions in international decision that border on preparation of GHG inventory prepared by non-Annex 1 parties, feedback from formal and informal technical multilateral review of previous national inventory reports and list of planned improvement activities. Any such revisions or updates in the manual will be a collective decision on inventory team. The team will decide on the merit of the updates, which aspects inventory activities should be modified and to what extent will the changes or updates contribute to the long-term improvement of the inventory.

3. Review of the national system for GHG Inventory

This section is a review of the existing inventory cycle in connection with the planning, preparation and management phases of the inventory. The review seeks to explore and understand the strengths and weaknesses in the inventory cycle, and how to introduce further improvement on it.

3.1. Brief overview of the national system

Ghana has established a national system that is capable of producing high quality and defensible GHG emission on timely basis. As far as possible, the national systems ensures a robust, transparent complete, comparable and accurate estimation of GHG. The system undergoes regular improvements based on the gaps identified during every inventory. During each inventory cycle, new reforms are introduced in the national system as part the continued improvement efforts to ensure long-term sustainability of the national inventory preparation. The national system comprises of the following components as indicated in 2014 NIR (EPA, 2015): institutional arrangement and their collaborative mechanism, data management system, the inventory cycle and the methodology used in the national accounting which is anchored on legal framework.

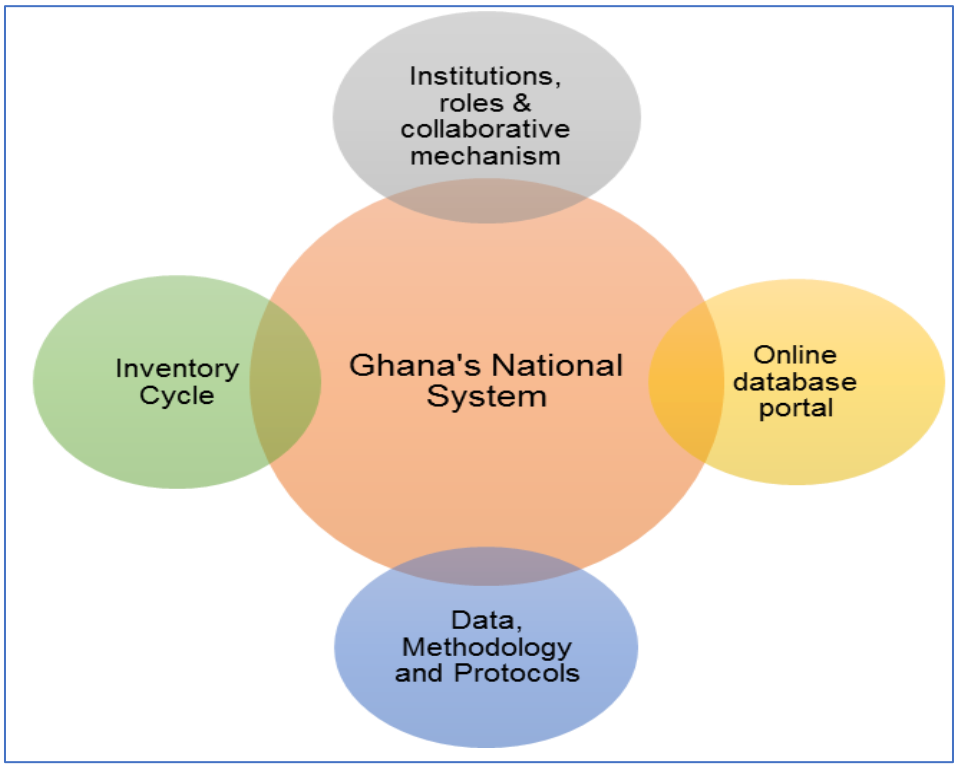

FIGURE 2: ELEMENTS OF THE NATIONAL SYSTEM FOR GHG INVENTORY (SOURCE: NIR, 2015)

3.1.1. Assessment of institutional arrangements for GHG Inventory

Ghana has just submitted its third inventory to the UNFCCC. For the first time, an elaborate and improved national system, with a more permanent institutional arrangements was created and tested. This improved national system effectively replaced the ad hoc working group that was used to execute the previous inventories. The revised institutional arrangements, which constitutes the national system for executing all subsequent GHG inventories involved nearly thirty experts from sixteen different public and private institutions. The roles and, responsibilities of each institution and their reporting lines are arranged to reflect the levels of interlinkages contained in the respective memoranda of understanding (see annex 1) for undertaking tasks relating to the inventory. The EPA was established by Act 490, 1994 and is designated as the national entity for the preparation of Ghana's national GHG inventory.

The EPA functions as the "single national entity". As the "single national entity" the EPA collaborates with the inventory stakeholders in the various sectors to undertake management of activity data and emissions factors, compilation of emission estimates from the sectors, quality control/quality assurance, improvement planning, and preparation of the reports. The Ministry of Environment Science Technology and Innovation (MESTI) is responsible for the official approval and endorsement of NIR and onward submission to UNFCCC. Within the EPA, the UNFCCC Focal Point and Climate Change unit is the national inventory entity and is directly responsible for the management of the entire inventory process. The unit ensures that delivery of the inventory is timely, of good quality and above all meets international standards.

The current institutional design attempts to comprehensively improve upon the previous arrangement, which was generally ad hoc and not backed by any formal collaborative mechanism. Additionally, in the ad hoc institutional arrangement, inventory capacity and the overall coordination was extensively concentrated in most of the frontline agencies.

The current institutional arrangement seeks to contribute to addressing the gaps identified in the ad hoc institutional arrangement by facilitating wider participation of major state and non-state agencies, having clear institutional roles and reporting lines and decentralizing the GHG inventory activities from frontline agencies to research, academic and partner sector institutions, while ensuring that inventory activities and data generation is also mainstreamed into existing routine tasks of these agencies and institutions. These objectives are very important in making sure that the entire national inventory system is able to respond to the emerging reporting needs in any future mechanism (NAMAs and REDD+) more effectively and efficiently.

The current institutional arrangement was formulated in four (4) interactive hierarchical levels. At the top of the hierarchy, institutions played oversight and strategic role in providing direction to the entire inventory process as well as interface the inventory process with the national communication process.

The EPA, which has the statutory mandate for the GHG inventory and is singularly responsible for the overall planning delivery and reporting of the national process. The office of the UNFCCC focal point at the EPA is responsible for the overall technical coordination. The output of the activities at the next lower level feeds into the higher tier and is supervisory and technical in nature. Five institutions constitute the supervisory team. Each team member is responsible for a different component of the national inventory, including, inventory compilation, QA/QC management, uncertainty assessment, generalist activities/international GHG specialist, national archiving and documentation etc.

In the four sectors of accounting, the Energy Commission is the lead institution in the Energy sector accounting, the Forestry Commission is the lead in the AFOLU accounting, the Manufacturing Industry Department of the EPA is the lead institution for the IPPU sector, and the Waste sector was led by the Built Environment Department of the EPA. Figure 2 illustrates the institutional arrangement and national system for the Ghana's GHG inventory.

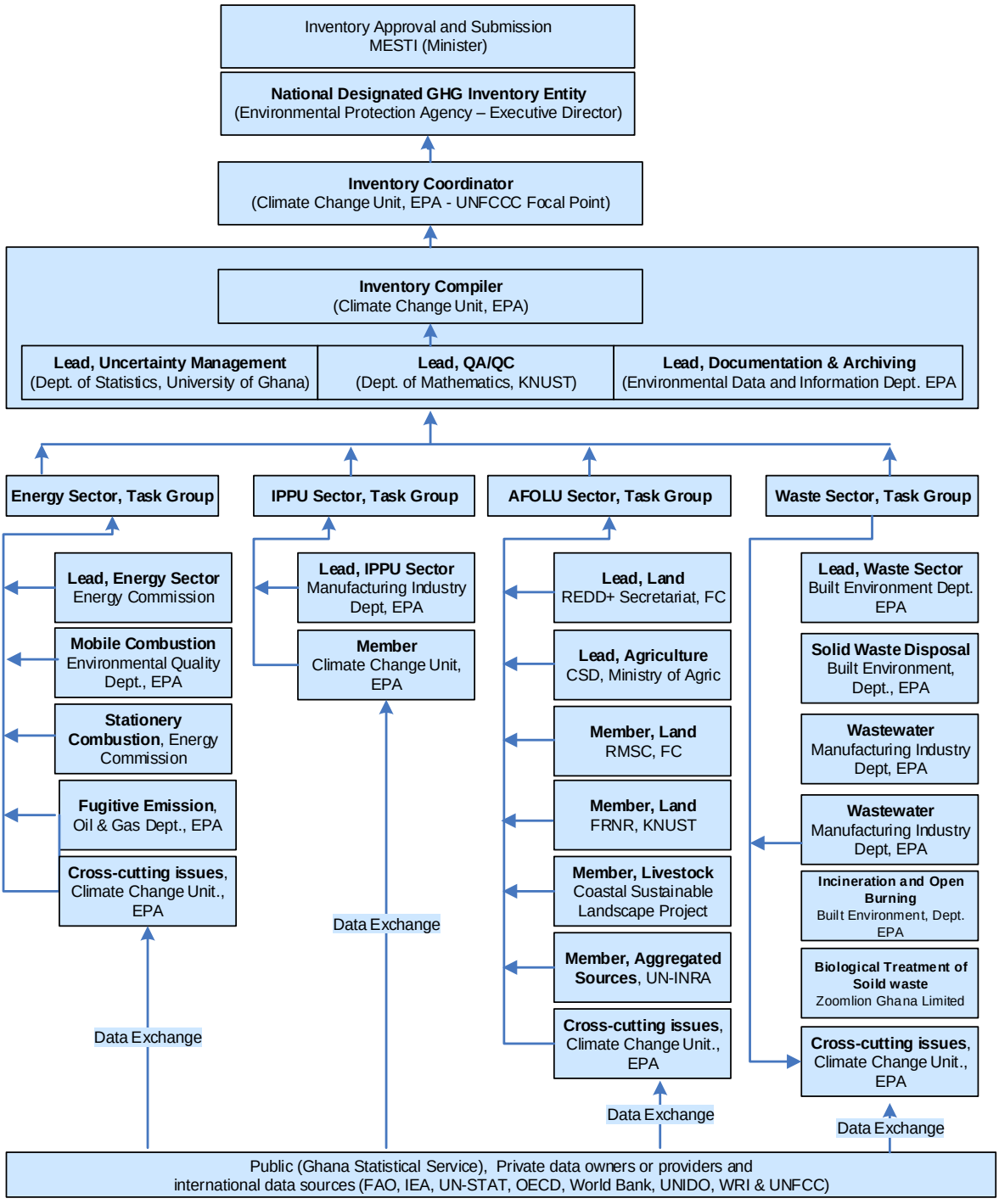

FIGURE 3: INSTITUTIONAL ARRANGEMENT AND NATIONAL SYSTEM FOR THE GHG INVENTORY

Under the current arrangement, the inventory compiler also serves as the generalist. The uncertainty management lead, QA/QC lead and the documentation and archiving lead are responsible for cross-cutting issues both at national and sector levels. The four working groups that were responsible for completing inventory for the four inventory sectors. Each working group has a lead. The membership is drawn from public and private organizations. In addition, there are a number of institutions that supply data to the inventory compliers. The inventory entities and their roles are provided in the table 2.

TABLE 2: FUNCTIONAL GHG INVENTORY ENTITIES AND THEIR ROLES/RESPONSIBILITIES

Inventory task	Lead Institution	Specific tasks
Approval and submission of inventory report	Ministry of Environment, Science, Technology and Innovation	Reviews and approves of national inventory report. Uses of inventory estimates to inform policy. Provides overall policy direction to the national inventory compilers.
Designated National Entity (DNE)	Environmental Protection Agency – Executive Director	Overall technical oversight and coordinates timely deliverables. Develops programs and strategies which will ensure long-term improvements in the inventory system. Dissemination and awareness creation on all the inventory products.
National Inventory Coordinator	UNFCCC Focal Point	UNFCCC Focal Point acts as the inventory coordinator to oversee the entire inventory on behalf of the Agency. Plans the preparation of the inventory and provides operational, management and technical oversight. Reports directly to the DNE for onward transmission to its Board of Governors and Ministry of Environment, Science Technology and Innovation. Manages all MoUs, contracts, and information agreements to facilitate efficient delivery of all contracts, data, tasks and agreements.
Inventory Compiler	Climate Change Unit, EPA (Lead, Mitigation Analysis and Reporting)	Reports directly to the UNFCCC focal point and works with the GHG working teams. Creates schedule based on the inventory cycle timelines and all the inventory preparation steps that need to be completed prior to, and after, the due date, taking into account the time needed to complete each of those steps. In the event of the inventory undergoing review (internal or external), the compiler will interface between reviewers and the inventory experts. Responsible for data and document management, which is critical to the long-term improvement of the inventory.

		Act as the receiver of inventory files from the working groups – all worksheets and text and would be responsible for putting the pieces together into one unified inventory document. Doubles as the generalist for the inventory. This implies that, the complier ensures that all the inventory activities, which border on issues such as decisions and choices to undertake recalculation, key category analysis, completeness and reporting are consistent with IPCC GPGs both at the level of the inventory and also at the sector level. Ensures new developments concerning the inventory are thoroughly discussed and implemented. The compiler works closely with the sector leaders in order to make the sector inventory internally consistent.
Lead, QA/QC	Mathematics Department, KNUST	Responsible for the planning and implementation of QA/QC activities. Together with the inventory complier design and oversee the implementation of QA/QC plan.
Lead, Uncertainty Management	Department of Statistics, University of Ghana, Legon	Design and perform tier-1 uncertainty assessment of the entire inventory and at least for the key categories. The design must be fully consistent with the 2006 IPCC. Generates simple-to-implement worksheet that inventory sectors will use with great utility, in the estimation of sector-level key category uncertainty estimation. On the basis of the 2006 IPCC, produce simple steps for the management of uncertainties in the sectors and at the inventory levels.
Lead Documentation and Archive	Environmental Data and Information Management Dept. EPA	Design and ensure complete references for all data in line with QA/QC protocols. Document all responses to internal and external review comments. Ensure all information and data are collected in a consistent manner for purposes of later reference and archived with other inventory materials. Design data storage and documentation procedures for the inventory. Implement and manage central database infrastructure that will be put in place. Ensure sector group leads complete the documentation-tracking log for onward transmission to the inventory compiler.
Lead, Sectors	Energy Commission Forestry Commission	Conduct comprehensive assessment of GHG data requirements of the sector, identify the sources and access them with the support of the inventory coordinator/compiler using appropriate channels and document all the data and processes involved.

	Crop Services Directorate, MoFA MID, EPA Built Environment, Dept. EPA	Collect, collate, process and update all GHG and related data in the sector, and take final decisions on which processed data qualifies to be used in the inventory on the basis of agreed conditions in the QA/QC plan. Submit all processed data and any other data to the central database hosted at the Environmental Protection Agency and keep back-ups in the organization that act sectors lead. Liaise with the inventory compiler at EPA to undertake comprehensive review of available methodological choices and make sound methodological choices on the basis of its applicability to the estimation of GHG emissions. Estimate GHG emissions for all categories and gases under sectors using appropriate factors/ GWPs and ensure that the processes/assumptions for the estimation, including the software used, are consistent with the IPCC guidelines and fully documented. Conduct key category analysis for the sector and uncertainty assessment in collaboration with the generalist and the uncertainty management lead. Compile all the sector estimates in the worksheets into "detailed" and "synthesis" reports, including clearly prioritized plans for improvements to be incorporated into the national inventory report. Create and maintain hard and soft copies of all information, data, and estimates at the sector level and for onward transmission to the Environmental Protection Agency as the inventory documentation and archiving depository. Consult with the inventory compiler to discuss and agree on cost involved in activities that can be done within the quarter in the inventory year. The rate and mode for requesting funds will be discussed and agreed ahead of every inventory cycle.

Source: 2014, NIR (EPA, 2015)

3.1.2 Operational procedures for the GHG inventory

Figure 3 shows the operational outline of the procedures associated with the activities of the sectors that constituted the national system for the third GHG inventory. Superimposed on the national system, figure 3 depicts the actual operational activities of the various tasks groups as was executed under the third GHG inventory. Data preparation and evaluation was primarily carried out at the task group level, a harmonized dataset in the appropriate format were then inputted into the IPCC datasheets for each sector and subsequently worked in the IPCC software and database for the generation of the estimates. Once the estimates were generated, the groups begun the report writing process and subsequent deposition of the estimates and data in an online database.

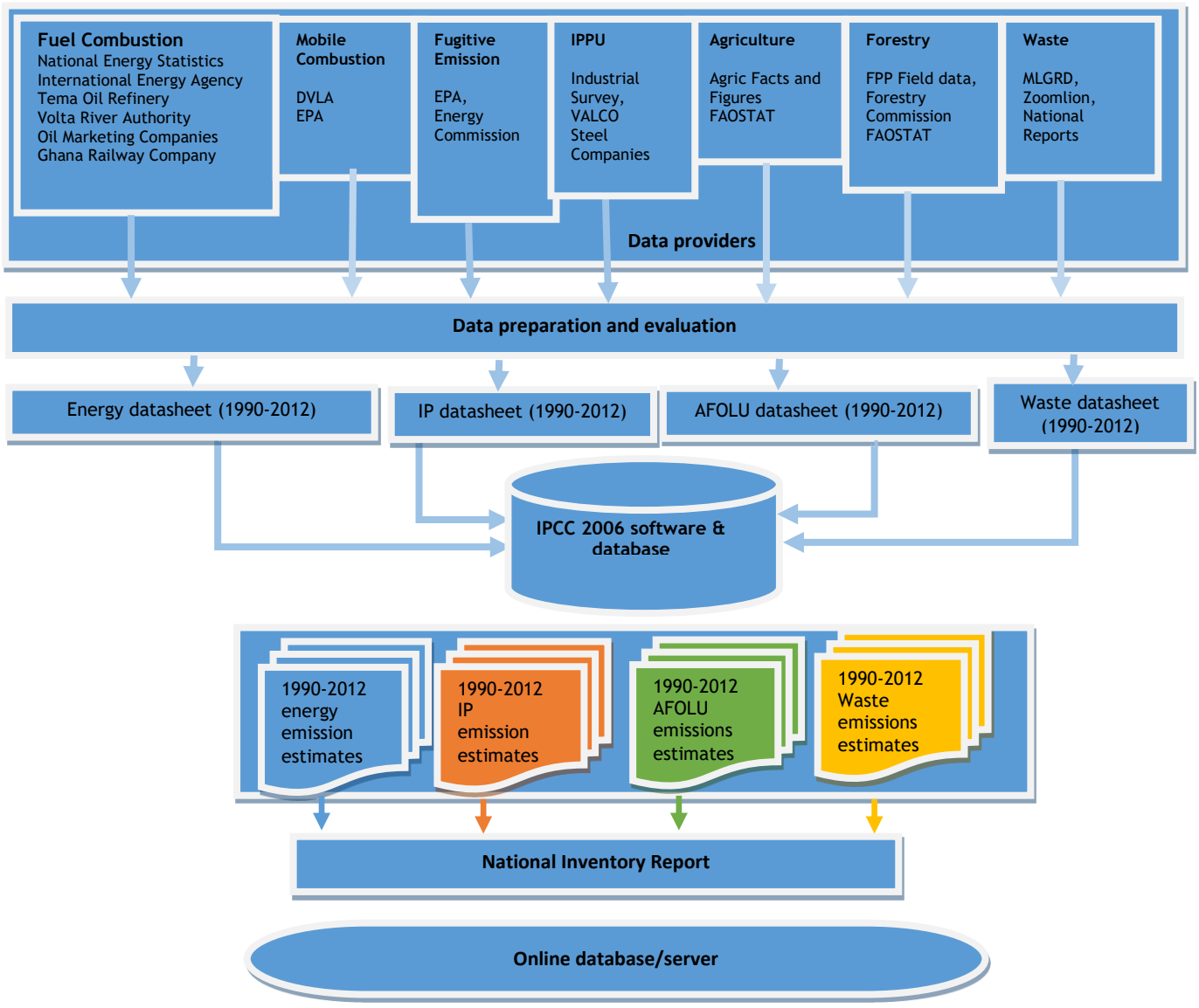

FIGURE 4: SUMMARY OF GHG INVENTORY STEPS (SOURCE: NIR, 2015)

3.1.3 Means of data acquisition and management

The lead inventory sector institution is responsible for the identification and sourcing of all datasets at the national and international levels in collaboration with the inventory compiler. As much as possible, the sector's lead institution, identifies all the data needs and the institutions where the data will be sourced. After initial contacts with the data owners/providers, the sector lead institution directly requests the data from the source with the administrative help from the EPA.

In instances where EPA receives request from the sector lead institution, data requests are made to relevant institutions indicating what form of data is required, years of coverage, data format and the main use of the data in the inventory through an official letter (see annex 2 for copy of data request letter). The EPA data request letters, especially those to industrial plants, usually make reference to the relevant provisions to the EPA, Act 490, which allows EPA access to certain level of information. The collected data goes through several steps of documentation procedures to ensure proper referencing. Initial technical and quality evaluation of the data is done before transmission to the working teams. All data are documented and stored in the online database for archiving and retrieval.

3.1.4 Information technology set-up behind inventory data management system

During the current inventory period, Ghana set up an online database system which hosts all inventory data and related information (see figure 3). The database helped in streamlining documentation and archiving of all GHG data, reports and publications. The database contains; (a) all inputs datasets from each sector; (b) datasheets for each sector; (c) emission estimates from the IPCC software for all sectors from 1990-2012, (d) IPCC 2006 software database, (f) completed QA/QC templates for sectors, and (g) all reports and documentations.

The IT infrastructure of the database (server, backend database resources) is managed by the IT team of EPA. The general public and the GHG inventory team have access to the online database through this IP address 197.253.69.38 or www.epa.gov.gh/tnc. Although the general public can search for the publicly available data from the database, the GHG inventory members have access credential that allow them to (a) upload, (b) query, and (c) retrieve data from the database. Publication of data on the database is restricted to the administrator. The IPCC software has backend database file which contains data inputs and emission results for the sectors. The software allows different access levels, giving users access to the relevant sections of the database. In this regard, one "super user log-in ID" was created for the inventory complier to allow access to data for all the sectors. The members of the sectors were given "log-in credential" that only allowed them to access their relevant sections. When all the sector database files were completed, the sector lead institution submitted them to the inventory compilers, who created a "single inventory database file" containing all data for all the sectors for the period (1990-2012). The inventory data, individual results sheets and the database file were sent to the administrator of the online database for archiving and publication on the internet.

3.1.5 Data Sources

3.1.5.1 Selection of Emission Factors

Emission Factors were mainly obtained from: (a) facility-level plants; (b) country-specific or regional and international studies and IPCC Emission Factor Database (EFDB). In the selection of EFs, the following factors were considered: (a) representativeness of EFs generated at facility-level and country-specific studies and (b) applicability of the EFs generated from regional and international sources. In the inventory, default emissions factors from the IPCC EFDB were commonly used, however, in cases where country or region specific emission factors existed, priority was given to it. An overview of the methods and emission factors applied for the calculations of the emissions is presented in table 4.

Table 3: Mapping of methods and emission factors

GHG Source and Sink Categories		CO_2		CH_4		N_2O		PFC-CF_4		PFC-C_2F_6		HFCs	
		Meth	EF	Meth	EF	Meth	EF	Meth	EF	Meth	EF	Meth	EF
1.	Energy	T1, T2	D, CS	D, T1	D, CS	D, T1	D, CS						
1.A	Fuel Combustion	T1,T2	D, CS	T1,T2	D, CS	T1,T2	D, CS						
1.A1	Energy Industries	T1	D	T1	D	T1	D						
1.A2	Manufacturing Industries and Construction	T1	D	T1	D	T1	D						
1.A3	Transport	T1,T2	D, CS	T1,T2	D, CS	T1,T2	D, CS						
1.A4	Other Sectors	T1	D	T1	D	T1	D						
1.B	Fugitive Emissions			T1	D								
1.B1	Solid Fuels			NO	NO								
1.B2	Oil and Natural Gas			T1	D								
1.B3	Other Emission from Energy Production			NO	NO								
2	Industrial Process	D, PS	D, PS	NE	NE	NE	NE	T2	PS	T2	PS	NE	NE
2.A	Mineral Products	D	D	NE	NE	NE	NE						
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO						
2.C	Metal Production	T2	PS	NE	NE	NE	NE	T2	PS	T2	PS		
2.D	Non-Energy Products from Fuels and Solvent Use	T1	D										
2E	Electronics Industry	NO	NO	NO	NO	NO	NO						
2.F	Product Uses as Substitutes for Ozone Depleting Substances											NE	NE

3	Agriculture, Forestry, and Other Land Use	T1,T 2	D, CS	T1	D	T1	D						
3.A	Livestock			T1	D								
3.B	Land	T2	CS										
3C	Aggregate sources and non-CO2 emissions sources on land	T1	D	T1	D	TI	D						
4	Waste	T1	D	T1	D	T1	D						
4.A	Solid waste disposal			D	D	D	D						
4.B	Biological Treatment of Solid Waste			TI	D	T1	D						
4.C	Incineration and Open Burning of Waste	T1	D	TI	D	T1	D						
4.D	Wastewater Treatment and Discharge			T1	D	T1	D						

***Key**: CS= Country-Specific, PS= Plant-Specific, NE = Not Estimated, NO=Not Occurring, D = Default IPCC methodology and emission factor, EF = Emission Factor, Meth=Methods, T1, T2 - Levels of Tiers*

3.1.6.2 Sources of activity data

The inventory was prepared using data from a combination of sources from national and international institutions. During data collection, priority was given to data that have been generated in the country. In cases where the required data was not available in the country, the data from international organization's such as FAO, IEA, World Bank, etc. were used. Table 4 provides an overview of the data used in the inventory.

Table 4: Description of activity data sources

Sector		Data Type	Data Source	Principal Data Providers
1. Energy Sector				
1.A1	Energy Industry	Fuel types, Fuel consumption, supply Crude oil and petroleum products production, Imports and exports	National Energy Statistics Refinery Product Balance National Energy Plan IEA Database	Energy Commission, National Petroleum Authority, Tema Oil Refinery, Ministry of Energy and Petroleum, Thermal Electricity Generation Utility Companies (VRA, Sunon Asogli, Takoradi International Company TICO and other independent power producers etc, and the IEA
1.A2	Manufacturing Industry and Construction	Fuel types, fuel consumption, supply, Feedstock, Fuels for Non-energy Use	National Energy Statistics Industry survey data, 2013 National Industry Census, 2003	Energy Commission, Manufacturing Industry Department of the Environmental Protection Agency, Manufacturing and Construction Industries, Ghana Statistical Service.

1.A3	Transport	Fuel Types, fuel Consumption by Vehicles, Aviation, Rail and Navigation, Number of Registered vehicles, Vehicle Types	Vehicle registration Database, Petroleum Product Sales Data, Railway Fuel Consumption data, Water Transport Fuel Consumption Data	Energy Commission, Environmental Quality Department of Environmental Protection Agency, Driver Vehicle Licensing Authority, Oil Marketing Companies (particularly, Shell Ghana Limited, Total Ghana Limited), Ministry of Transport, Ghana Railway Company, Volta Lake Transport Company, Ghana Bunkering Services
1.A4	Other Sectors	Fuel consumption per fuel type	National Energy Statistics National Energy Plan, National Census Report, Ghana Living Standard Survey Report	Energy Commission Ghana Statistical Service
1.B	Fugitive emissions from fuels	Gas flared, Gas produced, Gas injected and Gas consumed on site, Refinery input (crude oil)	Oil Exploration and Production Data Oil refinery data in the Energy Statistics	Ghana National Petroleum corporation Oil Exploration and Production, Companies Environmental Protection Agency Tema Oil Refinery
1. Industrial Process and Product Use				
2.A	Mineral Industry	Industrial production and Plant specific emission factors	Environmental Reports EPRPD Database Industry Survey Industrial data from facilities.	Volta Aluminum Company Limited Tema steel works, Aluworks Environmental Protection Agency
2.C	Metal Industry			
2.D	Non-Energy Products from Fuels and Solvent Use	Amount of non-energy use of diesel and kerosene		
2. Agriculture, Forestry and Other Land use				
3.A1 and 3.A2	Enteric Fermentation & Manure Management	Animal population, Fractions of manure, management practices	Agriculture Facts and Figures FAOSTAT Expert Judgment	Ministry of Food and Agriculture – Statistics Research and Information Directorate, UN Food and Agriculture Organization, AFOLU Team
3.B1	Forest land	Land use maps, land use change map, land use change matrix	Forest Preservation Program, 2012	Forestry Commission, Ghana
		biomass estimates for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil stratifications and ecological zone maps	IPCC database	IPCC

		Industrial round wood	RMSC, FAOSTAT	Forestry Commission, Ghana FAO
		Wood fuel production	Energy Statistics	Energy Commission
		Areas affected by fire	Expert Judgment	AFOLU Team
3.B2	Cropland	Land use maps, Land use change map, Land use change matrix	Forest Preservation Program, 2012	Forestry Commission, Ghana
		biomass estimate for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil classification and ecological zone maps	IPCC database	IPCC
3.B3	Grassland	Land use maps, Land use change map, Land use change matrix	Forest Preservation Program, 2012	Forestry Commission, Ghana
		biomass estimate for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil classification and ecological zone maps	IPCC database	IPCC
3.C1	Biomass burning	Areas affected by fire in cropland, forestland and grassland	Expert Judgment	AFOLU Team
		Mass fuel available for burning	Forest Preservation Program, 2012	Forestry Commission, Ghana
3.C3	Urea application	Annual Urea consumption figures	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
3.C4	Direct N_2O emissions from managed soils	Annual generic NPK consumption	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
3.C5	Indirect N_2O emissions from managed soils	Annual crop production in tonnes per annum		
3.C6	Indirect N_2O emissions from manure management	Animal population (cattle, goats, sheep, swine, donkey, poultry, horse)	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
		Fractions of manure management practices	Expert Judgment	AFOLU Team
3.C7	Rice cultivation	Annual rice production areas	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate

		Proportions of annual rice production area under rain fed, irrigated and upland systems	National Rice Development strategy	Ministry of Food and Agriculture
4. Waste				
4A	Solid Waste Disposal	Waste Generation, Population Figures, Composition, amounts of waste deposited, means of disposals and their various percentages	Published national reports, Ghana Statistical Services, Sanitation Directorate of MLGRD, World Bank Country Database, Private Waste Management Companies and Civil Engineering Department, KNUST, EPA	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Private Waste Management Companies(Zoomlion Ghana Limited, Waste care, etc.), and NGOs Academia (Civil Engineering Department, KNUST), Second National Communication Report from EPA.
4B	Biological Treatment of Solid Waste	Fraction of waste composted, number of compost plants	Private Waste Management	Private Waste Management Companies (Zoomlion Ghana Limited) and NGOs. Expert judgment by the Waste Team
4C	4C.1 Waste Incineration	Amount and types solid waste incinerated, type of incinerator including capacities and combustion efficiencies	Ghana Health Services, Ministry of Local Government and Rural Development,	National Environmental Sanitation Strategy Action Plan document and Ghana Health Service Facts and Figures, and Expert Judgment by the Waste Team
	4C.2 Open Burning of Solid Waste	Population, proportion of population burning waste, duration of burning in number of days per year, fraction of waste burnt relative to the total amount treated.	Published national reports, Ghana Statistical Services, Sanitation Directorate of MLGRD,	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Expert Judgment by Waste Team
4D	4D.1 Domestic wastewater treatment and discharge	Population, Wastewater Generated per year, Wastewater treated per year, Wastewater Treatment Systems and their various percentages, Protein Consumption, GDP/capita	Ghana Statistical Services, Sanitation Directorate of MLGRD, World Bank, Ghana Health Service, Ministry of Food and Agriculture	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Multiple Cluster Indicator Survey data World Bank Country Database, FAO Expert Judgment by Waste Team
	4D.2 Industrial wastewater treatment and discharge	Industrial coverage, Total Industry Product Quantity of wastewater generated Type of Wastewater Treatment / discharge System	Industry survey	Industrial Outputs data collected during national survey, EMPs Expert Judgment by Waste Team

3.1.6 Description of methodologies

The emissions inventory has been conducted from a series of steps and using a range of data from diverse sources. The emissions were not directly measured but were estimated through the application methodologies that link emissions to data on observable economic activities in the country. The estimation of the emissions and removals used a combination of: (a) country-specific methods and data; (b) IPCC methodologies and (c) emission factors (EFs).The methods were consistent with the 2006 IPCC guidelines for national greenhouse gas inventories (IPCC 2006) and are to the extent possible, in line with international practice. Generally, tier 1 IPCC methodology were applied, however there were selected categories such as transport (1.A3), land (3B), IPPU (2C) and solid waste disposal (4a) for which higher tier (tier 2) methodology were used.

3.1.6.1 Methods of estimation

On the whole, the methodology for Ghana's GHG inventory has seen some improvements towards a combination of tier 1 and tier 2 estimation methods that capture (a) new country-specific activity data; (b) a shift from the Revised 1996 IPCC guidelines to the 2006 guidelines and (c) uncertainty assessment. Detailed descriptions of methods chosen are provided in the relevant section of the report. The estimation of emissions/removals in the categories was based on the methods described in the 2006 IPCC Guidelines. The selection of the methods was guided by the decision-tree illustrated in figure 5. Generally, tier1 IPCC methodology was applied to most of the sectors, except in cases where available national data allows adoption of a higher tier. For example, the availability of facility level data from Volta Aluminum Company (VALCO) enabled the use of tier 2 methodology for the estimation of emission from aluminum production.

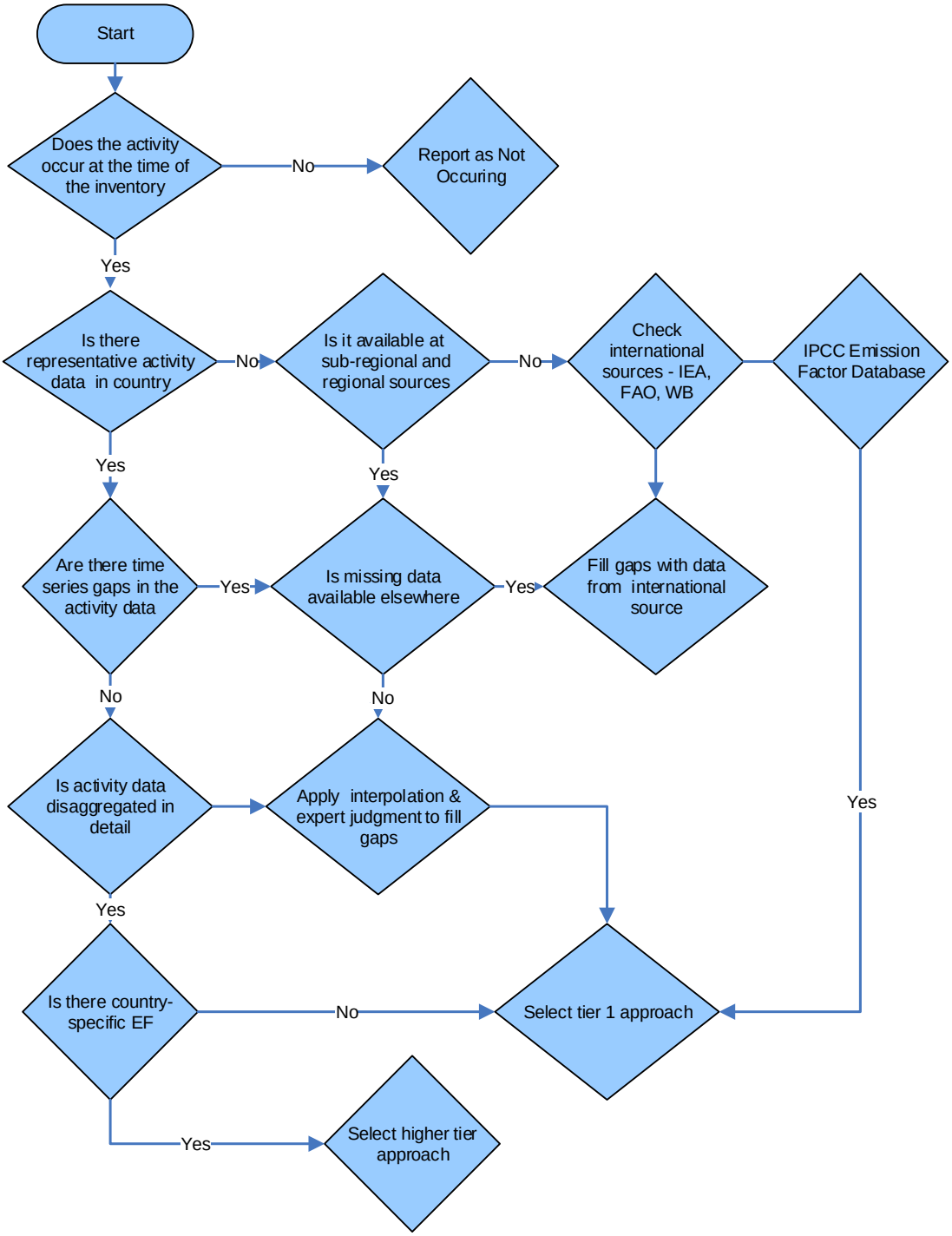

FIGURE 5: DECISION TREE FOR THE SELECTION OF METHODS

3.2 Reforms in the national system

The review of the national inventory report pointed out to a number of reforms that were introduced in national GHG inventory system during the last inventory preparation. These were as follows:

- harmonization of the existing institutional arrangements and its underpinning collaborative mechanisms;
- Decentralization of the inventory task to key ministries.
- creation of awareness and capacity improvement of key institutions that are involved in the preparation of the inventory;
- structural support for the continuous data collection on GHG inventories;
- Introduction of an online data archiving system.

Although these reforms have been introduced, a lot more needs to be done before it becomes fully operational. One of the reasons why reforms have not fully taken off is that the national cycle is still in a transition phase and thus a lot of time is needed to concretize the reforms. The reforms also did not address the need preparing GHG inventory plan. Therefore the preparation of this plan is expected to fulfill one of the inventory reform objectives.

3.3 Suggested reforms in the existing national system and mechanisms for full implementation

It is instructive to note that as much tremendous gains were made in establishing a more permanent national system with decentralized roles and responsibilities relating to specific tasks in the various sectors, which is made up of relevant institutions and agencies, there are still gaps that remain which will need to be addressed in order to further strengthen the current national system to deliver its outputs. These reforms came about after a thorough discussion by the team members during a stock-taking exercise.

[A] Decentralization of the tasks to the relevant line ministries

A major milestone in Ghana's GHG inventory is the creation and operationalization of the current institutional arrangements which constituted the national system for the GHG inventory. This institutional arrangements decentralized the inventory activities to relevant sectors, thus commencing a renewed phased of mainstreaming GHG inventory into the routine tasks of the relevant institutions and agencies. Having tested this institutional arrangements under the third national inventory, it is important to document the opportunities and challenges that characterized the planning, preparation and management phases of the inventory, to serve as beacons to guide subsequent inventories.

The greatest opportunity with the current national system, as opposed to the erstwhile ad hoc working arrangements that existed was that the GHG inventory process was for once seen to be a national exercise that was inclusive and not an "EPA activity", thus, most institutions identified with the contents of the reports and willingly accepted the challenge of getting involved. The institutions also willingly permitted their staff to engage in the sector task group meetings and sometimes even offered facilities to be used during meetings. But getting involved and ensuring that the institutions will be able to deliver on their mandate was an enormous task that required various levels of collaboration that spanned from individual to the institutional levels. In order to ensure that the institutional arrangement will not remain a paper exercise, Memoranda of Understandings (MoU) were signed with the lead institutions with clear terms of arrangements to govern the relationship among the various inventory partners.

But this approach of signing MoUs have inherent challenges which must be addressed. There is still the need to further ensure that the decentralization processes will move beyond the seemingly contractual agreement under the MoU approach, to a fully mainstreamed intervention that will capture activities relating to the inventory as part of the routine exercises of the designated institutions within the sector task groups. In moving forward, a fully mainstreamed approach will ground the inventory in institutional ownership and the inventory cycle will have a smooth transition from one reporting regime to the other.

Furthermore, in managing expectations, a fully mainstreamed inventory regime will reduce major funding limitations that characterized the implementation of the current institutional arrangements. It is also imperative to understand that in finding a way to further institutionalize the decentralization process, various routine data and sectoral reporting regimes that are generated by the agencies and institutions captured within the national system cannot remain disconnected from the GHG inventory and its data requirements. For instance, the Forest Resources Assessment reports by the FC to the FAO has very relevant data that are of interest and value to the GHG inventory. Can these processes be linked with the data needs of the GHG inventory in way that these routine reports will have major co-benefits for each other? This could reduce the challenges associated with setting up parallel systems to generate data.

It is also unquestionable that the heartbeat of the national system is the expertise of the personnel constituting the inventory team. In as much as the MoU formalizing the institutional arrangement between the EPA and the institutions created the platform for major participation, a critical gap that clearly manifested during the inventory cycle of the third NIR was consistency of the personnel involved in the sector level task groups. Though the institutions allocated personnel to the inventory, over the period, some diverted their attention to other tasks assigned to them, thereby weakening team composition and further burdening the remaining team members.

This was not a case of lack of commitment, but a clear situation of "firefighting", where team members were attending to more pressing but relevant activities, thus prioritizing other activities over the inventory. There are other situations where team members

take a back seat in the course of the inventory process and assign other colleagues to take over. This situation created a huge effect on meeting the timelines allocated to the completion of various activities. That is the new entrants will have to be updated on what has been done, and in some instances, the process has to be halted for a while to train and bring the new officers to speed with the technicalities of the inventory process, before the whole team could proceed. In moving forward, the MoU can be reformed to go beyond securing institutional commitment to participate in the inventory, by getting the signing authority to permanently allocate staff who can have the time to work on the inventory activities during the inventory cycle. On the other hand, the inventory activities could be assigned to specific officers as part of their job schedule, which will count towards their performance and other appraisal mechanisms. This will ensure that the inventory activities are fully mainstreamed into the institutions.

[B] Data management system

The creation of Ghana's national system for GHG inventory was developed at time that the ad hoc arrangement proved quite challenging in moving forward with subsequent inventories. But this clearly focused on the institutional arrangement with particular focus on the inventory planning and preparation, but the management phase, with regard to archiving was limited. Thus, data, inventory sheets, and other supporting documents, including reports were mostly kept by individuals, sometimes with very limited back-up options. In this regard, a web based data management system was created to basically serve as a mechanism to host data in a way that can be accessed anytime by authorized personnel. But also with additional benefits of creating a platform where data providers can conveniently share information by uploading in real time. This is an effective way to regularly collect data in a pool and avoid the situation where inventory personnel "chase" data.

But ultimately, beyond the inventory, this web based platform will serve as a pool of data which can be useful to researchers etc for other purposes aside the inventory. The establishment of the web based platform satisfied a critical component of the management phase of the inventory, which is archiving. Having tested the functioning of the platform under the third inventory, it is imperative to note a few issues which could be addressed to further strengthen the application of the web based platform in particular and the entire inventory as a whole. Invariably, it is assumed that the data and the systems for generating the inventory report already exists, hence funding for the inventory activities only focuses on data preparation and reporting. But most of the data issues are still not captured to guarantee continuous supply of inventory data. Therefore, there is the need to map out long term projects and routine data collection activities of the various institutions to generate data that will also be used in the inventory.

There are two sets of data that are critical to the inventory, i.e activity data and emission factors. The inventory largely depends on the IPCC database for emission factors, however, with regard to activity data, the inventory team rely mostly on internal institutions and agencies to provide or share information. This is a particular

area that needs a lot of fine tuning and improvement to enhance estimation and delivery of the inventory outputs. But moving forward also, systems must be put in place to generate a more country specific data to couple the sourcing of activity data to improve on the certainty of the estimates. This could be one of many ways:

- **Recognizing the data providers in the report: in** as much as most data providers willingly provide data without any hesitation whatsoever, there were others, mostly private data generators who are not obliged to share their data but to do so purely in the name of contributing towards a national exercise. These private data generators produce data under their own expense. In order to ensure that these data providers will feel encouraged to continually provide data, it is important for systems to be put in place to recognize these institutions and individuals.

  Other data generators, mostly researchers also hold on to their data, based on the fact that they have not published the information, hence would not like to make the data public. Ultimately, once data exists that can be useful for the inventory, mechanisms should be established to access these datasets. Possibly, a MoU could be signed with these researchers to make their data available with the condition that the data will only be available to the inventory tasks team for only the purposes of the inventory and not accessible to any other person. This suggestion is only to give an indication to the fact that the designated authority could be more innovative in reaching out to data generators to make valuable data available to the inventory team.

- **Repackaging data from routine data providers**: Most government institutions provide very valuable activity data for the inventory, but because these datasets are not generated for purposes of inventory, major limitations are inherent in them, which affects the quality of the estimates. For instance, data from the agricultural facts and figures from the Ministry of Agriculture were used in the third national inventory. In as much as this data set proved very useful, there were major challenges that were encountered in using this data set for the estimates in the AFOLU sector.

  It is therefore imperative for EPA to link up with the Ministry of Agriculture to explore avenues to improve on that exercise to supply robust data. Similar engagements should be held with the Energy Commission on the data from the energy statistics, DVLA transport data, waste data from the District and Municipal Assemblies, land based data from the Forestry Commission and finally engaging with the Research institutes and universities to use the data needs of the inventory, particularly emission factors to inform research activities in the various sectors.

[C] Continuous training

It is very clear that capacity abounds in various components of the inventory estimation and reporting, and people are very much willing to get engaged in the inventory activities. However, over the years, there has been clear manifestations of lack of expertise in the use of the IPCC software and other estimation processes, hence training programs have been major inception activities to bring the sector level inventory team members to speed, and ensure that the knowledge level of all the members are at par.

Nevertheless, there are no mechanisms to ensure that these training programs are embedded in the use of the national system for the execution of the inventory. Until the sector level institutions allocate permanent officers to take part in the inventory, continuous training will have to be a critical component of the whole process to guarantee consistency in the estimation and reporting of the inventory. Efforts have been put in place to get the inventory team members on the UNFCCC annex 1 GHG inventory roaster to serve as a capacity-building platform for personnel involved in the inventory. But all the team members cannot be engaged to undergo the IPCC training. Hence the strategy to employ is a trainer-of trainer's program which will ensure that within each core team, there are experts to offer learning avenues for the other colleagues and build additional expertise on the job as the inventory activities progress. Furthermore, the need for continuous training and capacity enhancement necessitates the need for the GHG inventory manual. That is why the manual is very relevant to provide guidance to new experts who join the inventory team. The manual will also serve as a good reference material which will serve as the foundation for the use of the national system in churning out the GHG inventory report.

Given that the sector level lead institutions are largely government institutions, systems and collaborative mechanisms should be put in place to mainstream the trainings needs for the GHG inventory into the training programs of the MMDAs. This can only be achieved if the lead institutions begin to accept the GHG inventory as part of their core activities, which requires the same priority and attention as given to other activities.

4. Steps that underpin the GHG Manual of Procedures

This section provides the overview of the inventory steps in the inventory cycle. The description of the individual steps which form the basis of the GHG manual.

4.1 Overview of the manual procedures

The procedures for planning and managing the national GHG inventory cover a spectrum of tasks which constitute the inventory cycle. It contains a set of activities, which the inventory team implements in sequence in order to produce national inventory report, submit and subject to official international review. The individual tasks should be organized in a structured order so that the delivery of the inventory become more efficient and time bound. The purpose is not to necessarily introduce additional tasks to what already exist, but to make sure that the current practices are clearly defined. Where new tasks are to be introduced, for example, at this stage of the inventory, it is important Ghana ensures that there is a link with the international consultation and analysis (ICA) process, therefore the manual of procedures (MOP) will seek to dovetail into the inventory practices.

The inventory cycle has been organized into 4 stages which include (figure 4): (a) planning, (b) preparation, (c) management and (d) compilation. Each stage focuses on specific set of actions which must be delivered purposely to meet the objectives. The implementation of the activities of each stage of the inventory will not be mutually exclusive but rather the output of each stage will serve as input to the subsequent stage. The inventory will be planned within a biennial timeframe following commencement. The planning stage focuses on putting together all the necessary competent personal and clearly define steps that will be used in collecting data, conducting the estimation, reporting and reviewing. The planning stage is considered the cornerstone of the inventory for which a great deal of efforts and time is needed. It is at the preparation stage that data sources are identified and methodological choices are made using decision tree approach. The major output here is the individual sector spreadsheets which will be put together into a national datasheet for analysis. The activities in the management stage is cross-cutting and is applicable at every stage of the inventory. At the compilation stage, the national trends, sector and gas-by-gas analysis are retrieved from the inventory datasheet and subsequently used to prepare the NIR. In addition, the NIR and associated tables are subjected to the ICA review process.

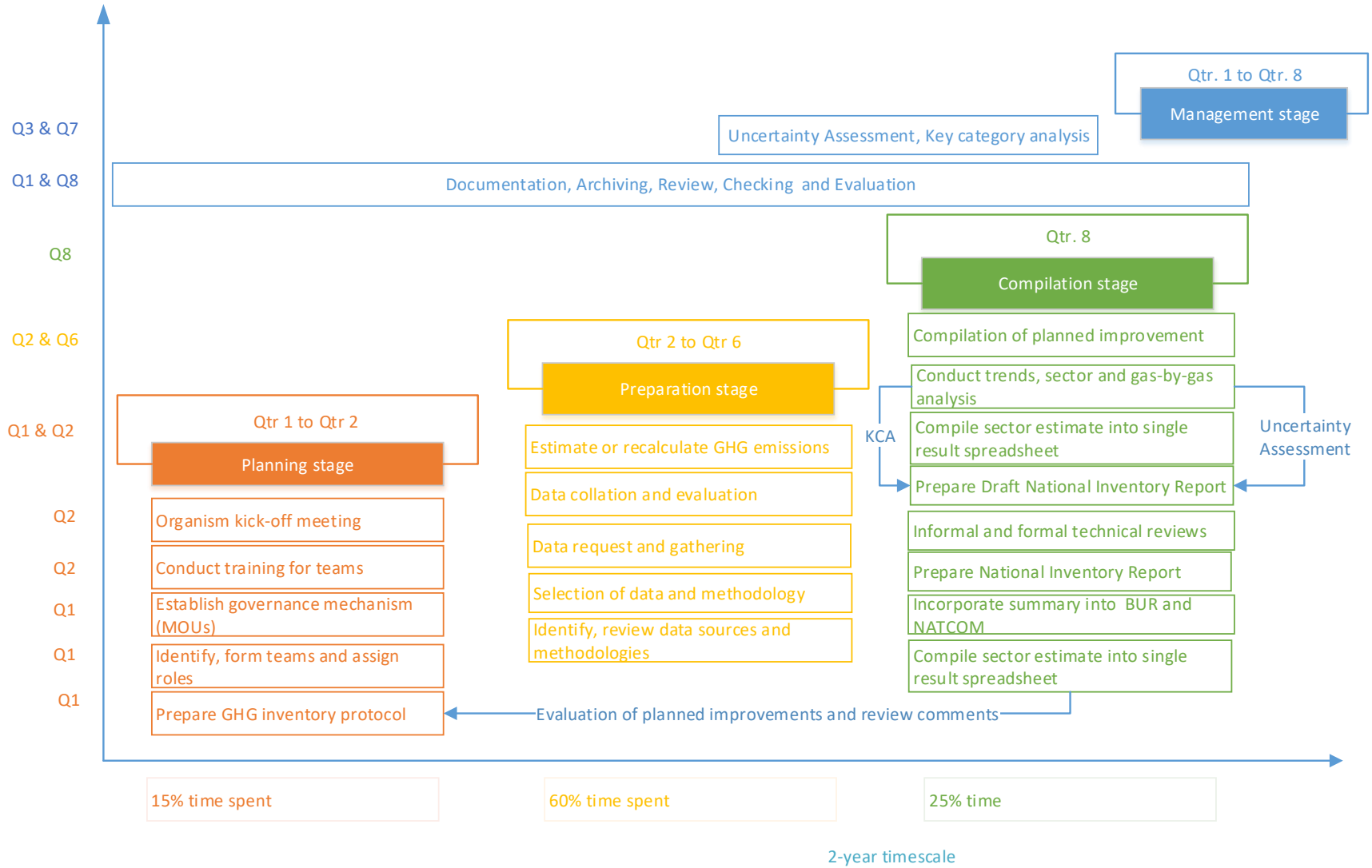

FIGURE 6: CHART SHOWING THE INVENTORY CYCLE

4.2 Description of inventory steps

4.2.1 Planning stage

The planning stage is the stage where the sector institution responsible for the inventory initiates commencement of new inventory cycle. It cover a number of preparatory activities upon which the entire inventory exercise will be executed. The teams, their roles and responsibilities and training will be determined at this stage. It is also at this stage that all the matters relating to logistics, the terms of the MOU or any agreement among the inventory must be discussed and agreed on. One of the challenges the NIR, 2014 highlighted was the fact that, the terms of the MOU also were decided by the EPA and the inventory institutions, the full implementation still remained largely unsatisfactory. Therefore it will be useful to have an objective review of the MOU and together with the partners agree on realistic activities and timelines. Usually such discussions will take place in the kick off meeting. During the kick-off meeting issues such as logistics, budgeting, timelines and the frequency of reviews meetings will be discussed. The EPA as the responsible inventory institution will lead this stage. In addition, it will be important to invite the major data providers and facility owners who will be supplying plant-level data to the inventory compilers to participate in the meeting.

It is projected that the planning phase of the inventory will take average of 15% of the total inventory timeframe. It is therefore important that overall allocation of time to the various stage feed into the planning of time management. The issue of time management must also be discussed in the kick off meeting. From what have been presented in the 2014 NIR and reviewing other countries national system, it will be useful for the inventory compilers in Ghana to develop strategies to help them comply with the timeline they set for themselves. This is one of the ways to make the inventory efficient. At least the EPA should have additional responsibility of ensure that the inventory teams respect the timeline at all times. The expectation is that, at the planning stage the following deliverables will be produced: comprehensive inventory work plan; overall and "sector" working protocols; identification of and formation working groups and MOU.

4.2.1.1 Activities in the planning stage

There are 5 major activities (figure 4) that need to be executed at planning stage before the commencement of the actual preparation. The detail descriptions of the activities have been provided below:

[A] Prepare GHG Inventory Protocols

The protocols for the preparation of the overall inventory and sector are the standard preparation procedures which will be put together in simple spreadsheet by the EPA. The procedures will contain specific detailed instructions that all inventory partners have to discuss and agree to follow throughout the inventory. The content of the instructions will be tailor-made to UNFCCC reporting requirements, the IPCC

methodological needs, and feedback from technical reviews of previous NIR and prioritized planned improvements.

As much as possible, the inventory team must make sure that specific tasks in the instructions must be followed at each stage of the inventory. This is one of the important ways to ensure that inventory becomes more efficient. For example, the sector lead institutions could be assigned the responsibility of ensuring that sections of the instruction that is applicable to a particular sector is fully implemented, documented and reported back in the sector report. The reporting should focus on the extent to which the sector experts used the instructions, the challenges they faced and the specific measures needed to improve on them. The instructions will give concrete guidance that need to be adhered in order to: (a) complete various sections of the inventory on time; (b) ensure consistency across source categories and in a format that allows swift compilation of the sector inventory into a single aggregate; (c) perform adequate quality control checks, documentation, reviewing and archiving. The GHG protocol will be written in a simple and unambiguous language to cover the following

- Detailed timeline with all products and deadlines.
- Matrix detailing institutional responsibility
- Information on how the inventory will be prepared including: file management, QA/QC procedures, uncertainty assessment, reporting instructions (content and format), documentation and archiving procedures

With respect to sector-specific protocols, the instructions will address specific source-level issues such as internal deadlines, data sharing among teams, editorial directions and additional information on responsibilities.

[B] Identify and Form Working Groups

During the third inventory cycle, new working groups were constituted into 4 groups to work prepare the inventory for the energy, IPPU, AFOLU and waste sectors. Each working group will be made of; at most, 4 relevant institutions with one acting as lead institution. The Energy Commission, Forestry Commission, Ministry of Food and Agriculture, Built Environment and Manufacturing Industry Departments of EPA were the lead institution. Each institution in the group is represented by competent officer. Each inventory team working in a particular sector is responsible for planning, preparation, management and compilation of the sector inventories. So far the groups performed their task creditably well nevertheless major changes are needed to be made in the existing teams to make it work efficiently. In this respect, it will be necessary to identify new institutions to take up the role of documentation, QA/QC and uncertainty assessment.

The membership of the working team must be assessed to know whether or not new members are to be brought on board. Especially for those experts who are no longer capable of joining the team because they have either been promoted, taken up new duties, moved on to another institution or transferred to another department/region, it is important to find replacement. There are situations where existing institutions may

denominate new people to join the team. When new people join the team it is important to take them through the rudiments of the inventory, what is expected of them and above all, ensure they understand the workings of the standard instructions that has been adopted for that inventory cycle. The new team member must be also be taken through the QA/QC procedures to become abreast of the need to safeguard its quality.

[C] Establish collaborative mechanisms

During the last inventory, memorandum of understanding (MoU) was adopted as the collaborative mechanism to govern the working relationship between EPA and the inventory institutions. The EPA was responsible for drafting the MoU and ensuring that the provisions of the MoU are implemented. Although the MoUs were signed with the major inventory institutions, still there are areas that need to be revamped. During the kick-off meeting, all the inventory partners must discuss and agree on realistic items that should go into the MoU. In addition, to the MoU the EPA should consider to refer to the necessary sections of the EPA Act, Act 490 that gives them powers to collect data from industries. It will facilitate access to data from industries now that the inventory compiler will be exploring facility-level reporting.

[D] Develop/revise inventory work plan

The inventory work plan describes anticipated tasks, who will do them and by what date, deliverables and the budget. The work plan also defines the objectives, the scope of the work, the tasks needed to accomplish the objectives, the staff that are responsible for each task, and the timeline for completing all tasks. The work plan has audience larger than the inventory team and thus its timelines must be consistent with the biennial reporting time horizon as well as that national communications. So far Ghana established 2 year inventory cycle. Therefore the work plan has been designed to be consistent with the 2 year timeframe.

With the coming on board of the ICA process, it will be good to include the dedicated timelines for the ICA process in the inventory cycle. This is because the completion of the ICA will mark the end of one cycle. The evaluation of feedbacks from the ICA, the technical reviews and the planned improvement list could also be part of the revision of the work plan at the beginning of a new inventory cycle. The current inventory cycle and the proposed new additions is presented in table 5. The cycle starts with review of previous emission estimation methods and estimates, identification and formation of the teams, allocation of tasks, and the data collection and evaluation for the compilation of the inventory. The cycle is completed by external independent review.

In addition, the result of the key category analysis (KCA) will be used to inform the identification of priorities or areas in the inventory that need more resources and attention in the current inventory cycle.

[E] Organize kick-off meeting and training for inventory teams

Before commencement of the inventory exercise, targeted training should be offered to the inventory teams. The kick-off training will focus on building capacity of new members of the working groups on the various IPCC guidelines GPGs and most importantly the IPCC software for estimating GHG emissions in the various sectors. Particular attention will be given to the various crosscutting issues in the inventory and how it would be implemented at the sector level. This will ensure readiness of the various teams. Additionally, during the kick-off meeting, pertinent organizations and logistical matters must be discussed. Some of the issue the kick-off meeting could consider in the agenda might include: revision of the MoU, training needs, data request, and any changes in international decisions that are likely to affect the way the inventory is conducted etc. Figure 7 shows the summary of activities in the planning phase.

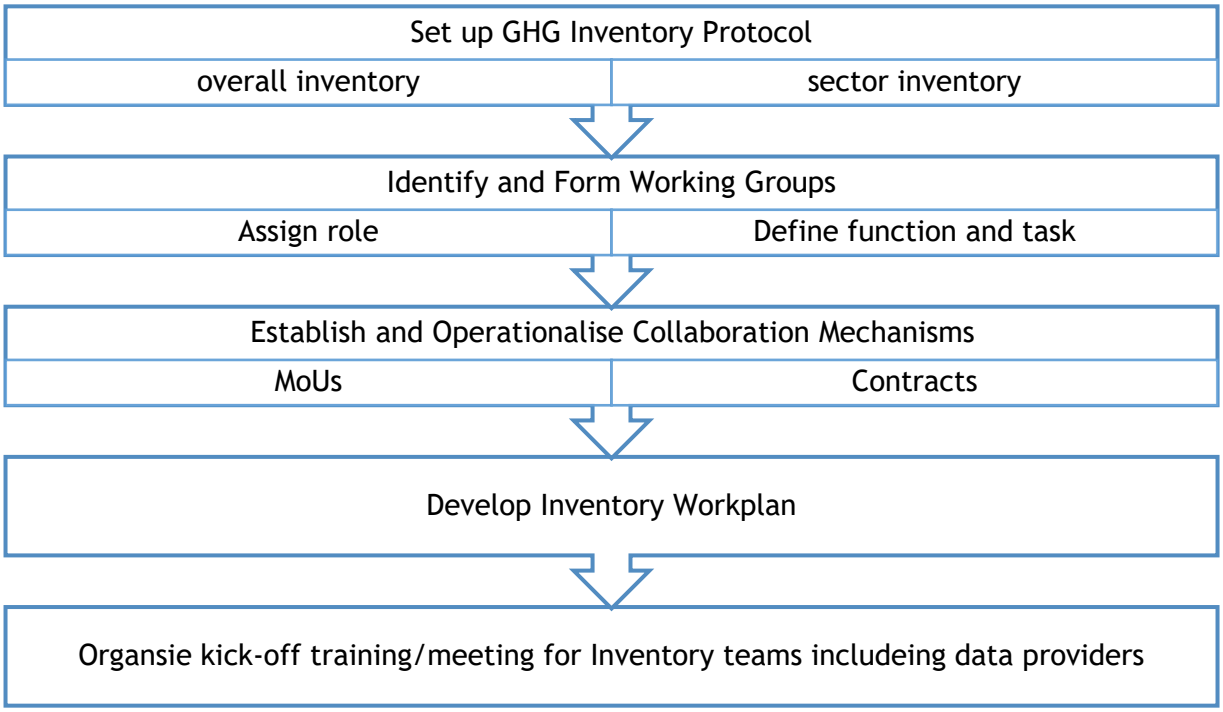

FIGURE 7: SUMMARY OF TASKS IN THE PLANNING PHASE

.

Table 5: Schedule of inventory tasks

Inventory Stages	Task and Deliverables	Completed by Deadline	Responsible Entity (ies)	Priority for next inventory [1]
Planning stage	Review of preview estimates, procedures, feedback from ICA, comments from informal technical review, and list of planned improvement.	Q1	All	Very high
	Establish Inventory protocols. The protocol will contain instructions and procedures for preparing the inventory.		Inventory coordinator and DoM	High
	Validate and distribute protocols/instruction manuals to the teams and actors in the inventory.		EPA & all sectors	High
	Identify and form inventory-working groups for the inventory sectors and crosscutting issues.		EPA	Low
	Formulate and sign MOU among inventory institutions. The MOU define specific functions of inventory institutions relating to estimation etc.		Inventory Compiler and FC, EC, MID, EQ, CSD, BED	Very High
	Organize maiden meeting of working group	Q2		High
	Training for inventory teams to ensure readiness and distribute overall and sector inventory instructions, provide relevant training to teams.			Medium
	Organize kick-off meeting.			High
Preparation Stage	Identification and review of data sources including choices of data, methodologies and software.	Q2	Inventory compiler and FC, EC, MID, EQ, CSD, BED	Very High
	Data request, data review, evaluation and documentation			Very High
	Set-up sector data documentation and archiving files (soft and hard) and start using them		All Entities	Low
	Review performance of GHG online-database and where necessary making changes in order to work efficiently.		Inventory Complier	Medium
	Review performance of data storage server and where possible making necessary corrections		EDD, GSS	Medium
	1st Quarter review meeting	Q2	Inventory Compiler	Low
	GHG estimation. Work sheets and text files for each source/removal due each entity	Q3 to Q5	FC, EC, MID, EQ, CSD, BED	Very High
	All sector work sheets and documentations submitted national inventory compiler	Q6		High
	Compile zero order draft of composite inventory and submit to inventory coordinator	Q6	Inventory compiler	High

[1] Priority attention in terms of allocation of time and financial resources as well as adhering to strict timelines will be given to activities rated as High and Very High in the next inventory cycle. This is because, these activities will support efficient delivery of the inventory.

Management stage	Distribute zero order draft for internal review and submit comment to inventory compiler	Q6	Inventory compiler and QA/QC coordinator	Medium
	Distribute source files (worksheets) and internal review to lead institutions		Inventory compiler	Medium
	Incorporate internal comments, observations and corrections		FC, EC, MID, EQ, CSD, BED	High
	Collect uncertainty values from sectors and quantify uncertainty for the overall inventory.		DoS, QA/QC and Inventory compiler	Very High
	Compile second order draft of inventory and revise work sheets		Inventory compiler	High
	Compile second order draft of composite inventory, source files and submission to inventory compiler and external reviewers (QA)			High
	External review of second order inventory (QA) submit	Q7	External reviewers	High
	Comments to Inventory Compiler			Medium
	2nd Quarter review meeting	Q6	Inventory coordinator	High
	Incorporate external comments and revise work sheets for all sectors	Q7	FC, EC, MID, EQ, CSD, BED & inventory compiler	Medium
Compilation Stage	Draft improvement strategy for each sector due inventory compiler	Q7	FC, EC, MID, EQ, CSD, BED	Medium
	Collect all pertinent paper and electronic source materials for archiving place in archive due national archiving and documentation institution	Q8	GSS, EDD & inventory compiler	High
	Compile final Inventory and preparation of key category analysis		Inventory compiler & FC, EC, MID, EQ, CSD, BED	High
	Compile inventory improvement strategy due inventory coordinator			Medium
	Compilation of National Inventory Report (NIR)		Inventory Coordinator and FC, EC, MID, EQ, CSD, BED	Very High
	NIR submitted to National Inventory Entity for incorporation into National Communication and Biennial Update Report		Inventory Compiler	Medium
	Dissemination of NIR – Submission to UNFCCC, inventory is available for public release.		National Inventory Entity	High
Technical Review through ICA	Appoint technical Liaison person for ICA who will act as the point of contact between the TTE and the Ghanaian team	Q8 to Q10	Inventory Compiler/ National Inventory Entity	High
	Compile all comments, feedback and planned improvement list		Inventory Compiler/	High

Key: EC – Energy Commission; DoM – Dept. of Mathematics, KNUST; FC-Forestry Commission; BED – Built Environment Dept., EPA, MID – Manufacturing Industry Dept., EPA, CSD – Crop Service Directorate, MoFA; GSS – Ghana Statistical Service; EDD – Environment Info & Data Management Dept.,

4.2.2 Preparation Stage

The preparation phase of the inventory will take an average of 60% of the total inventory timeframe of two years. The main outputs of this phase will be the national GHG inventory and other documents. This is also the phase that has the most human involvement, and actually tests the operational feasibility of the institutional arrangements that has been put in place (figure 8). Given that it is the dominant stage, in terms of time spent, this phase presents the most challenges, which should be looked at in order to generate the required information. Most of these challenges have been presented in the final section of this manual.

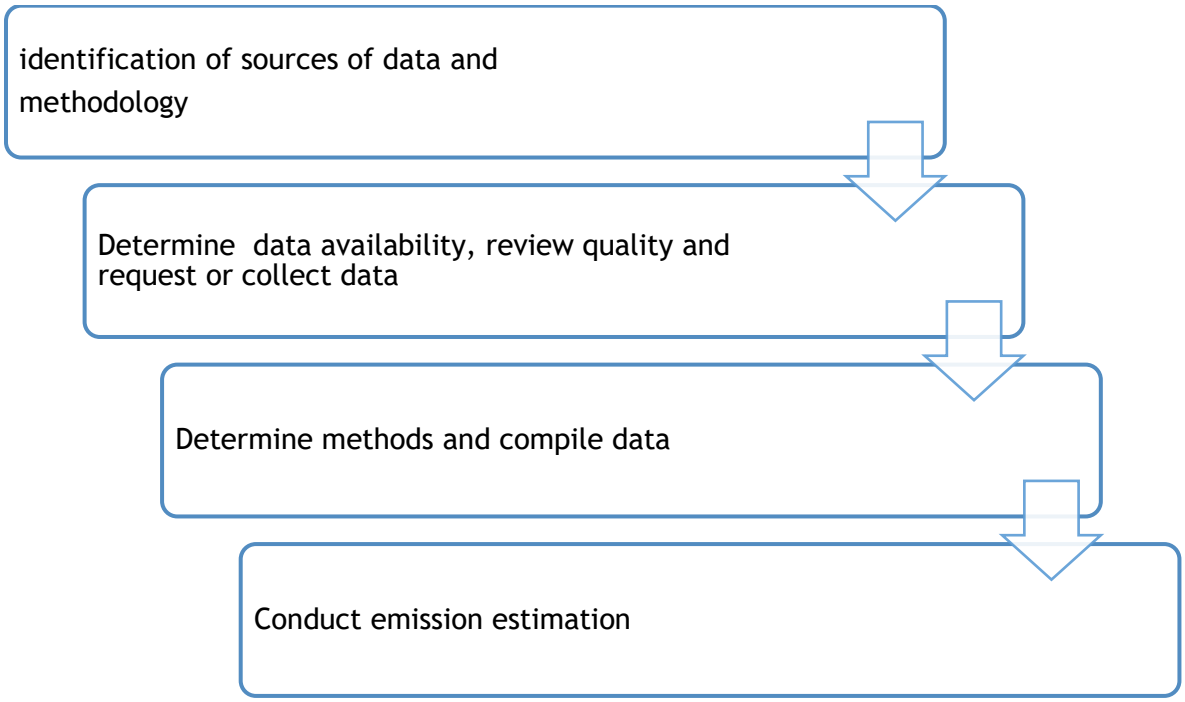

FIGURE 8: SUMMARY OF ACTIVITIES IN THE PREPARATION STAGE

[F] Identification of data sources and methodology

This activity is fundamental to the inventory. It helps the team to compile a thorough register of all sources of data and methodology intended for the inventory. All the sources in the register will be assessed in order of importance by grading them according to its accessibility, reliability and acceptability. The identification of the data sources also includes routine data generators, such as the Ministry of Agricultures, Agriculture facts and figures report, to others that are one time, and generated by projects, such as the data generated by the Forest Preservation Project of the Forestry Commission. This component is one of the important activities that must be handled very carefully, because the estimates largely depend on the activity data that will be collected from the different sources. The use of routine datasets from the agencies and institutions present minimal challenges, as compared to the onetime data that is generated by private individuals, private companies and projects. Thus, particular attention should be paid to sourcing for data beyond the routine data providers.

[G] Determine data availability; review its quality and request data

This step entails assessing the availability and quality of activity data, conversion factors emission factors and where necessary make a request of the data from the appropriate source (table 6). Completion of this step is necessary before an appropriate method can be chosen and all the data required by that method compiled. Collection of activity data will be one of the most time-consuming tasks in inventory preparation. There are a number of barriers to activity data collection, which might include:

- The lack of data for a certain year or complete lack of data for many years
- An inconsistent time series of data due to changes over time in definitions, survey methods, etc.
- Sometimes the data classification systems used in a country is completely different from either international standards or the IPCC inventory format.
- Access to activity data may be restricted (e.g., confidential industry data)

It is important to remember that assessment of the availability and quality of activity data, conversion factors and emission factors is an iterative process. Because resources are limited, this activity will always be constrained by available resources. For example some industrial data may be considered confidential, hence companies are mostly unwilling to share these datasets, because they perceive that giving such data out could amount to exposing a strategic information to competitors. On occasions where they give the data, they aggregate it in a way that the details are lost, thus making it only applicable in a general context. This is particularly the case for the domestic airlines in estimation in sourcing fuel data.

TABLE 6: DATA SOURCES FOR THE INVENTORY

Sector		Data Type	Data Source	Principal Data Providers
1. Energy Sector				
1.A1	Energy Industry	Fuel types, Fuel consumption, supply Crude oil and petroleum products production, Imports and exports	National Energy Statistics Refinery Product Balance National Energy Plan IEA Database	Energy Commission, National Petroleum Authority, Tema Oil Refinery, Ministry of Energy and Petroleum, Thermal Electricity Generation Utility Companies (VRA, Sunon Asogli, Takoradi International Company TICO and other independent power producers etc, and the IEA
1.A2	Manufacturing Industry and Construction	Fuel types, fuel consumption, supply, Feedstock, Fuels for Non-energy Use	National Energy Statistics Industry survey data, 2013 National Industry Census, 2003	Energy Commission, Manufacturing Industry Department of the Environmental Protection Agency, Manufacturing and Construction Industries, Ghana Statistical Service.

1.A3	Transport	Fuel Types, fuel Consumption by Vehicles, Aviation, Rail and Navigation, Number of Registered vehicles, Vehicle Types	Vehicle registration Database, Petroleum Product Sales Data, Railway Fuel Consumption data, Water Transport Fuel Consumption Data	Energy Commission, Environmental Quality Department of Environmental Protection Agency, Driver Vehicle Licensing Authority, Oil Marketing Companies (particularly, Shell Ghana Limited, Total Ghana Limited), Ministry of Transport, Ghana Railway Company, Volta Lake Transport Company, Ghana Bunkering Services
1.A4	Other Sectors	Fuel consumption per fuel type	National Energy Statistics National Energy Plan, National Census Report, Ghana Living Standard Survey Report	Energy Commission Ghana Statistical Service
1.B	Fugitive emissions from fuels	Gas flared, Gas produced, Gas injected and Gas consumed on site, Refinery input (crude oil)	Oil Exploration and Production Data Oil refinery data in the Energy Statistics	Ghana National Petroleum corporation Oil Exploration and Production, Companies Environmental Protection Agency Tema Oil Refinery
4 **Industrial Process and Product Use**				
2.A	Mineral Industry	Industrial production and Plant specific emission factors	Environmental Reports EPRPD Database Industry Survey Industrial data from facilities.	Volta Aluminum Company Limited Tema steel works, Aluworks Environmental Protection Agency
2.C	Metal Industry			
2.D	Non-Energy Products from Fuels and Solvent Use	Amount of non-energy use of diesel and kerosene		
5 Agriculture, Forestry and Other Land use				
3.A1 and 3.A2	Enteric Fermentation & Manure Management	Animal population, Fractions of manure, management practices	Agriculture Facts and Figures FAOSTAT Expert Judgment	Ministry of Food and Agriculture – Statistics Research and Information Directorate, UN Food and Agriculture Organization, AFOLU Team
3.B1	Forest land	Land use maps, land use change map, land use change matrix	Forest Preservation Program, 2012	Forestry Commission, Ghana
		biomass estimates for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil stratifications and ecological zone maps	IPCC database	IPCC
		Industrial round wood	RMSC, FAOSTAT	Forestry Commission, Ghana

				FAO
		Wood fuel production	Energy Statistics	Energy Commission
		Areas affected by fire	Expert Judgment	AFOLU Team
3.B2	Cropland	Land use maps, Land use change map, Land use change matrix	Forest Preservation Program, 2012	Forestry Commission, Ghana
		biomass estimate for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil classification and ecological zone maps	IPCC database	IPCC
3.B3	Grassland	Land use maps, Land use change map, Land use change matrix	Forest Preservation Program, 2012	Forestry Commission, Ghana
		biomass estimate for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil classification and ecological zone maps	IPCC database	IPCC
3.C1	Biomass burning	Areas affected by fire in cropland, forestland and grassland	Expert Judgment	AFOLU Team
		Mass fuel available for burning	Forest Preservation Program, 2012	Forestry Commission, Ghana
3.C3	Urea application	Annual Urea consumption figures	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
3.C4	Direct N_2O emissions from managed soils	Annual generic NPK consumption	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
3.C5	Indirect N_2O emissions from managed soils	Annual crop production in tonnes per annum		
3.C6	Indirect N_2O emissions from manure management	Animal population (cattle, goats, sheep, swine, donkey, poultry, horse)	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
		Fractions of manure management practices	Expert Judgment	AFOLU Team
3.C7	Rice cultivation	Annual rice production areas	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate
		Proportions of annual rice production area under rain fed, irrigated and upland systems	National Rice Development strategy	Ministry of Food and Agriculture

4. Waste				
4A	Solid Waste Disposal	Waste Generation, Population Figures, Composition, amounts of waste deposited, means of disposals and their various percentages	Published national reports, Ghana Statistical Services, Sanitation Directorate of MLGRD, World Bank Country Database, Private Waste Management Companies and Civil Engineering Department, KNUST, EPA	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Private Waste Management Companies(Zoomlion Ghana Limited, Waste care, etc.), and NGOs Academia (Civil Engineering Department, KNUST), Second National Communication Report from EPA.
4B	Biological Treatment of Solid Waste	Fraction of waste composted, number of compost plants	Private Waste Management	Private Waste Management Companies (Zoomlion Ghana Limited) and NGOs. Expert judgment by the Waste Team
4C	4C.1 Waste Incineration	Amount and types solid waste incinerated, type of incinerator including capacities and combustion efficiencies	Ghana Health Services, Ministry of Local Government and Rural Development,	National Environmental Sanitation Strategy Action Plan document and Ghana Health Service Facts and Figures, and Expert Judgment by the Waste Team
	4C.2 Open Burning of Solid Waste	Population, proportion of population burning waste, duration of burning in number of days per year, fraction of waste burnt relative to the total amount treated.	Published national reports, Ghana Statistical Services, Sanitation Directorate of MLGRD,	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Expert Judgment by Waste Team
4D	4D.1 Domestic wastewater treatment and discharge	Population, Wastewater Generated per year, Wastewater treated per year, Wastewater Treatment Systems and their various percentages, Protein Consumption, GDP/capita	Ghana Statistical Services, Sanitation Directorate of MLGRD, World Bank, Ghana Health Service, Ministry of Food and Agriculture	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Multiple Cluster Indicator Survey data World Bank Country Database, FAO Expert Judgment by Waste Team
	4D.2 Industrial wastewater treatment and discharge	Industrial coverage, Total Industry Product Quantity of wastewater generated Type of Wastewater Treatment / discharge System	Industry survey	Industrial Outputs data collected during national survey, EMPs Expert Judgment by Waste Team

Source: 2014 NIR

[H] Determine methods and compile data

Once an initial assessment of data availability and quality is completed, the appropriate inventory methodology can be determined. In reality, this is sometimes an iterative process, i.e., after data availability and quality are assessed, an initial method is chosen, and more data collection ensues during which more or less data, or data of better or worse quality, are uncovered, and then the initial method or a different method (or different approach with the same method) is finally chosen. The IPCC GPG manuals contain decision trees to help Parties choose the methodology most suited to national circumstances. The IPCC guidance is organized into tiers that differ mainly in their level of accuracy and complexity.

The higher tiers typically require more disaggregated activity data and source-specific, technology-specific, region-specific and/or country-specific emission factors. The most appropriate estimation method depends on whether a source is key, what data are available, and the level of financial and human resources that are available. If a source is key, the IPCC GPG encourages countries to use the good practice methods for key sources, which are usually Tier 2 or higher, although this is not always the case. Once the method is chosen, the requisite activity data, conversion factors and emission factor must be compiled. The estimation of emissions/removals in the categories is mostly based on the methods described in the 2006 IPCC Guidelines. The selection of the methods was guided by the decision-tree illustrated in figure 9.

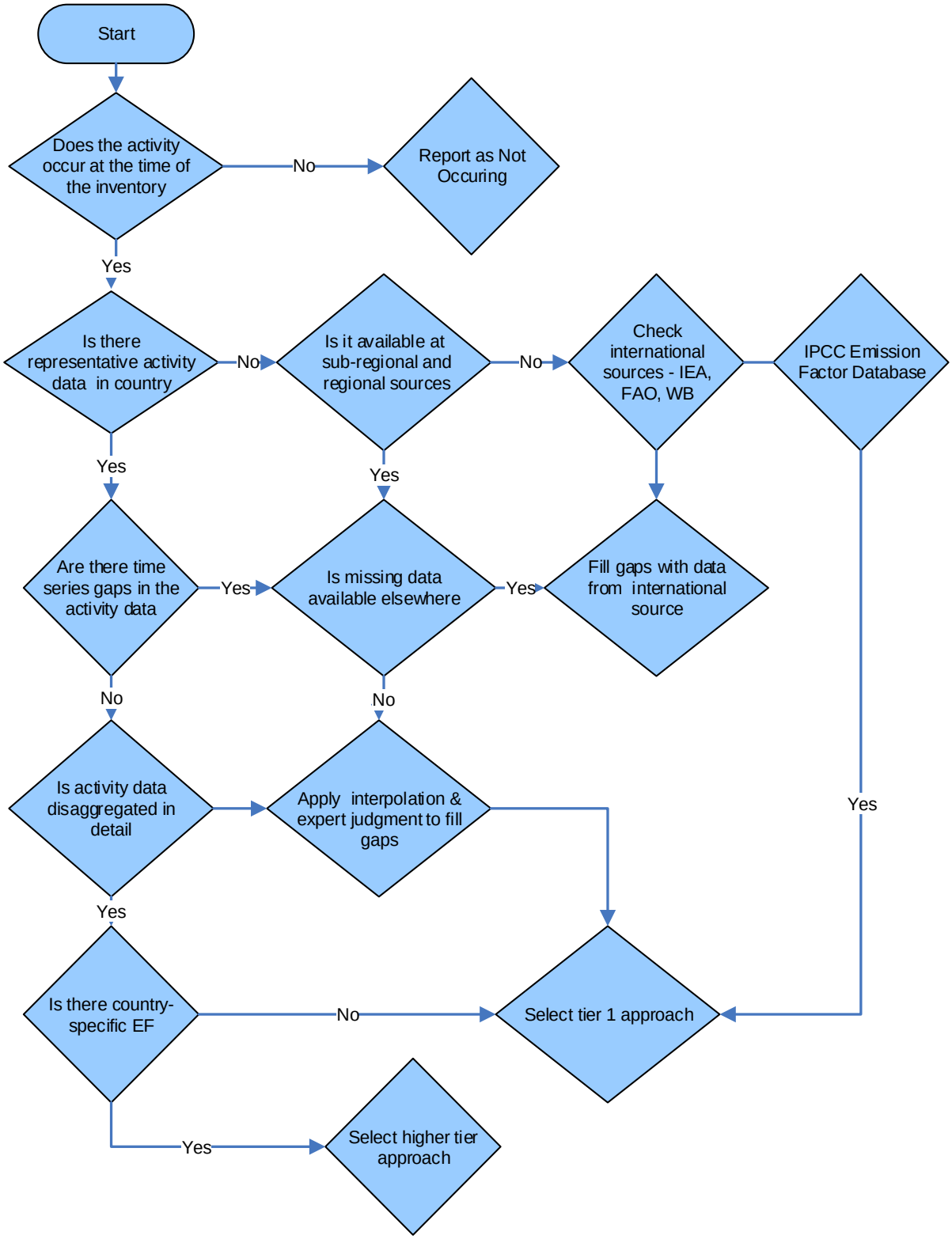

FIGURE 9: DECISION TREE FOR CHOICE OF METHODOLOGY AND DATA (SOURCE: 2014 NIR)

[I] Conduct emission estimation
Under this activity, the sector working groups will prepare the inventory calculation spreadsheets and the inventory text sections. If the inventory team is using the IPCC software, then data will only need to be inputted into the worksheets and tables. The major issues to consider and pay attention to, are QA/QC checks on every stage of data input to ensure that the right entries are being made, the appropriate inventory year has been chosen and everything is in order. The figure below illustrates the sequence of activities for the preparation phase of the inventory.

4.2.3 Management Phase

The management phase will include a set of activities, which will be implemented both at the sector level and at the level of the inventory. 30% of the entire inventory time will be spent at the management phase. An initial activity that characterizes the management phase of the inventory is the QA/QC procedures and uncertainty analysis. The current QA/QC practices in the inventory is broadly derived from the recommendations in the IPCC guidelines. These procedure have been duly captured in the complimentary manual to this manual, which specifically focuses on the QA/QC activities. The next activity that follows is the activities relating to key category analysis. Guidance on the steps for the identification of key categories has been elaborated in the 2000 and 2003 IPCC Good Practice Guidance.

The guidance explains that key category has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both. Ghana identified the key categories for the inventory using the tier 1 level and trend assessments as recommended in the IPCC Good Practice Guidance and adopted by COP decision 13/CP 9. This approach identifies sources that contribute to 95% of the total emissions or 95% of the trend of the inventory in absolute terms.

The next component of the management phase is activities relating to reporting, documentation and archiving. The report writing is done at the sector task group level, after which the general compilation is done. Currently, documentation and archiving has moved a further step forward with the creation of the web based storage system. At this level, the inventory team engages with the web management personnel to upload all the datasheets and estimates and reports. A final activity that completes the management phase of the inventory is mechanisms to undertake inventory improvements interventions. This ultimately sets the scene for the commencement of the next cycle. The activities that constitute the management phase of the inventory are captured in sequence in figure 10.

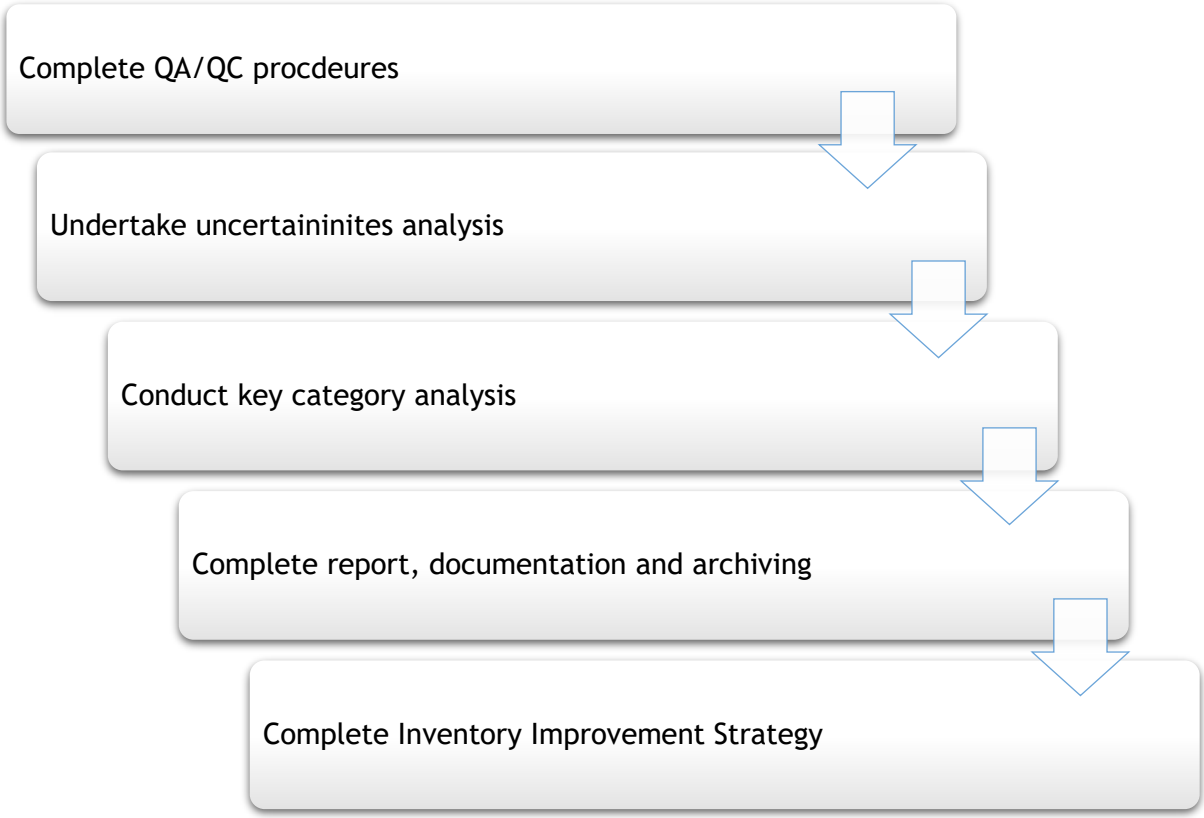

FIGURE 10: SUMMARY OF ACTIVITIES IN THE MANAGEMENT STAGE

5. Strategies for Long-term Improvements

This section focuses on mechanisms to improve the national system and compilation of the GHG inventory report. It involves institutional mechanisms and procedural issues, as well as training activities to ensure a very consistent and robust reporting cycle of Ghana's GHG inventory in the near, medium and long terms.

5.1 Context for long-term improvements

Ghana's GHG inventory has gone through a cycle in which estimation and compilation of the report was practically done by individuals to a current system where the inventory process has been streamlined into relevant sector institutions and agencies. This trajectory in its self is a tremendous improvement that has had multiple benefits to the inventory process, and has ensured that the compilation and reporting of the inventory outcomes will be sustained and remain responsive to current and emerging demands as well as satisfying the robustness required in the submission of the three major documents to the UN, i.e. National Communication, Biannual Update Report and the National Inventory Report. However, in as much as the current arrangements have chalked success, there are major bottlenecks that need attention. These issues are mostly around capacity improvement and strategies to strengthen the institutional arrangements in the near, medium and long terms.

5.2 Near term strategies

Though the existing institutional arrangements for the inventory has successfully produced outputs which have been used to meet Ghana's reporting obligations under the UNFCCC, it has not been without its own challenges, which necessitated the need to overhaul it and make it more sustainable and responsive to emerging and current developments in presenting national communications as well as the GHGI. The new institutional arrangement has been developed to utilize existing structures and institutions to ensure sustainability. It is also meant to adequately fill gaps that have been identified in the existing institutional arrangement. However, it is apparent that in order for the new system to take over and provide the expected outputs, there is the need to identify obvious challenges and difficulties which could stall the attainment of the aims behind the development of the new system. Specifically, the modalities under the near term are intended to offer immediate responses and framework within which the inventory process will continue to operate and meet its outputs, while further systems are put in place in the medium and long terms.

In the near term;

- Since the mainstreaming interventions are still in the early phases, it is important to maintain key experts who might be outside of the current institutional arrangements to provide technical backstopping and facilitation of the tasks in the sector level task groups. This will ensure that there is adequate time for the new personnel involved under the new institutional arrangement to update themselves with the assigned tasks and responsibilities. It will also ensure the smooth transfer of roles and capacity to the structures under the new system, and offer a good boost to a solid foundation for the implementation of the new arrangements. Ultimately, such an arrangement will ensure that there is a bridging mechanism linking the existing institutional arrangement to the new one. Thus a possible disconnect and total halt of the inventory process could be avoided.

- Moving forward, it is important to engage a core group of experienced experts who have been involved in the GHG inventory in the various sectors over the years to train and mentor assigned personnel under the new institutional arrangement. This will improve the human resource strength for the estimation and generation of information. It also constitutes a critical component of smooth operation of the new arrangement.

- There is also the need to provide logistics and the necessary facilities to initiate and empower the institutions to adequately take over the roles and tasks involved in the assigned inventory process.

- The institutions involved in the new arrangement should commit staff and establish a clear mechanism for the implementation of the assigned roles in the inventory within their set-up.

- It is also important for a thorough needs assessment to be done for the implementation of the inventory to be established, so as to ensure that resources are geared towards specific planned improvement mechanism.

5.3 Medium-Long term strategies

Even though some specific tasks will be met in the short term, for the ultimate sustainability of the new institutional arrangement and the compilation of the GHG report, there is the need for more holistic and targeted activities, which will ensure that the established system has robust mechanisms for the implementation of the inventory. Given that the new arrangements and the associated responsibilities might be totally new to most of the institutions involved, it is necessary to have framed mechanisms in place that will guide its establishment and operation. To meet the objective of sustainability and continuity, most of the modalities that will constitute the framed activities to guide the smooth operation of the new arrangements could be phased in the medium and long terms. This will allow for adequate planning, planned capacity development and leveraging sustainable funding mechanisms to strengthen the institutions beyond individuals. In the medium to long terms, the following tasks are envisaged;

- There is the need to have a continual training mechanism in place that will ensure that the people involved in the inventory are on top of the methodologies and technical issues associated with the implementation of the inventory. This planned capacity building component should be modeled around the planned improvements envisaged under each inventory regime. This will ensure that specific capacity gaps are being identified and provided to meet the requirements of the inventory. These targeted measures to address the planned improvements under each inventory cycle is a progressive approach to ultimately strengthen the processes for executing the inventory and also reduce the uncertainties around the inventory estimates.

- The existing funding arrangements for the inventory will definitely be inadequate for the arrangements under the new institutional arrangements. Though leverages to utilize the existing structures and mandates of the institutions involved are core drivers for the new arrangement, the associated cost in mainstreaming a totally new inventory procedure into the operations of these institutions should be provided, so as to ensure that bureaucracies and bottlenecks are limited. Ultimately, budgetary provisions should be made under various budget lines in these institutions to complement the funding provisions for the inventory.

- To entrench the activities of the inventory in the institutions involved, there will be the need to dedicate staff and logistics for the inventory. These will ensure that the inventory gradually rolls out to be a specialized component of the mandates of the institution. But importantly, given the stringent timelines and technicalities involved in the inventory, it is imperative that people involved in

the inventory are not burdened with other roles in their institutions which will lead to delays and inefficiencies in the delivery of assigned outputs.

References

1. Environmental Protection Agency. (2011). National Greenhouse Gas Inventory Report for 1990-2006. Available at http://unfccc.int/resource/docs/2007/arr/nir_1990-2006.pdf. Accessed on 18/07/2015.

2. Ghana's Third National Communications to the UNFCCC. 2015. Environmental Protection Agency, Ghana. Iota

3. IPCC, 2006. Good practice guidance for the estimating Greenhouse Gases. IPCC.

4. Managing the National Greenhouse Gas Inventory Process, 2012. UNDP.

5. National Greenhouse Gas Inventory Report. 2015. Environmental Protection Agency, Ghana.

6. Reporting on climate change user manual for the guidelines on national communications from non-Annex I Parties. UNFCCC, 2003.

7. United Nations Framework Convention on Climate Change. (2014). Guidelines and manuals for the preparation of non-Annex I national reports and International Consultation and Analysis. Available at http://unfccc.int/national_reports/non-annex_i_natcom/guidelines_and_user_manual/items/2607.php. Accessed on 02/06/2015.

8. United Nations Framework Convention on Climate Change. (2014). Modalities and guidelines for International Consultation and Analysis (ICA). Available at http://unfccc.int/national_reports/non-annex_i_natcom/cge/items/8621.php. Accessed on 10/07/2015.

9. USEPA, 2011. Developing a national greenhouse gas inventory system (Template IV: Quality Assurance/Quality Control Measures