Research article

A National Greenhouse Gas Inventory Management System for South Africa

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Abstract

South Africa has committed to reducing its contribution to the global GHG budget. It ratified the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The UNFCCC stipulates that Non-Annex 1 countries are required to submit inventory reports every two years as part of their Biennial Update Reports (BURs) or National Communications (NCs). To assist with this increased reporting a National GHG Inventory Management System (NGHGIS), with new internal procedures and capacities, is being developed. The NGHGIS has been designed to ensure transparency, consistency, comparability, completeness and accuracy of the GHG inventory. It ensures the quality of the inventory through planning, preparation and management of inventory activities. The NGHGIS has been set up in a web-based, collaborative platform that allows for document management, sharing and storage. The main components of the NGHGIS are the (a) organisational structure; (b) inventory preparation work plan where responsibilities are assigned; (c) data supplier and stakeholder lists; (d) input datasets (linked to the stakeholder list) providing information on required data, MOU's, and data due dates; (e) quality assurance and quality control (QA/QC) objectives, checks, logs and tools; (f) emission calculation method statements; (g) GHG inventory outputs which include estimation files, a trend viewer and a public website; and (h) improvement plans. In addition to the web-based system, new institutional arrangements and data flows have been proposed, the legal landscape has been mapped, draft MOUs for data suppliers have been drawn up and a detailed QA/QC plan has been developed. The final stage of the NGHGIS is the development of the data collection plan and technical guidelines for the Agriculture, Forestry and Other Land Use (AFOLU) and Waste sectors. The centralised NGHGIS will reduce the loss of information, improve continuity between inventories and assist in the timely completion of inventory updates.

Keywords

National system, GHG inventory, institutional arrangements, stakeholders, datasets, quality control

Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) stipulates that signatory parties (ratified by South Africa on 29/08/1997) are required to submit inventory reports that account the nations GHG sources and sinks. As part of the Conference of the Parties 17 (COP17) outputs, Non-Annex I parties, such as South Africa, are now required to submit inventories every two years as part of their Biennial Update Reports (BURs) and National Communications (NC). This regular reporting becomes challenging if countries do not have well established systematic approaches in place for developing their inventories. With well-developed and robust inventory systems this regular reporting becomes more manageable and the quality of inventories can be more easily improved upon (Damassa and Elsayed, 2013).

Furthermore, following the Paris Agreement (UNFCCC, 2015) which South Africa ratified on 11/01/2016, and with enhanced action in mind, all signatories need to be well informed of their mitigation and adaptation options. Countries need to understand the positive and negative co-impacts of climate action in order to make the right decisions on climate action. The Greenhouse Gas (GHG) inventories provide historical trends in emissions and removals from different activities in South Africa. This information is needed to provide timely decision making information to government, business and the public to capitalise opportunities and to avoid costly problems later on. This information also feeds into analysis of projections in GHG emissions and removals, and in the quantification of GHG savings from possible future action.

The core roles of the National GHG Inventory Management System (NGHGIS) are, therefore, to aid in the biennial compilation of the GHG inventories and contribute to South Africa's nationally determined contributions (NDCs) on adaptation, mitigation and investment requirements. As South Africa moves towards 2030, the system will also play a supporting role for actives such as Mitigation Potential Analyses, National Emission Trajectories, Desired Emission Reduction Outcomes, Carbon Budgets, Policies and Measures Assessments, Carbon Offset Scheme, Low-Emission Development Strategies and compliance reviews.

The aims of the NGHGIS are to:

- Establish robust institutional memory
- Enhance and maintain domestic capacity
- Identify institutional arrangements with roles and responsibilities
- Implement and maintain sustainable data management
- Support the co-ordination of all MRV activities
- Engage with the domestic and international community
- Produce timely and high quality outputs and
- Drive continual improvement

The aim of this paper is to introduce and describe the NGHGIS for South Africa and to increase transparency of the system.

Development of the NGHGIS

South Africa's National GHG Inventory Management System (NGHGIS) has been designed to ensure transparency, consistency, comparability, completeness and accuracy of inventories as defined in the *Good Practice Guidelines* (GPG) for preparation of inventories. It also contributes towards the enhanced transparency requirements defined in Article 13 of the Paris Agreement (UN, 2015). In accordance with Article 5 of the Kyoto Protocol (KP) (Kyoto Protocol, 1997) it ensures the quality of the inventory through planning, preparation and management of inventory activities. The system defines and allocates specific responsibilities in the inventory development process, including those related to choice of methods, data collection, processing and archiving, and quality assurance and quality control (QA/QC). The NGHGIS has been developed in SharePoint, which is a secure, web-based, collaborative platform that allows for document management, sharing and storage. Access to the system is password protected to ensure manageability, to minimize the number of people who can make alterations, corrections or updates to the system, and to protect confidential information. Different stakeholders can be given different levels of access. Components of the system, such as the public website, can be opened to the public. The Single National Entity (SNE) and inventory managers, compilers and reviewers to be involved in the inventory preparation process will be decided on and assigned with responsibilities during the initial GHG inventory preparation meeting. These contributors will then be logged onto the system for the duration of the process. At the start of each inventory preparation cycle the logins will be re-evaluated.

The NGHGIS consists of a number of components that support good practice activities and reinforce the institutional memory of South Africa's institutions. The key components are:

- Institutional arrangements and data flows
- Inventory preparation work plan
- Stakeholders
- Datasets
- Methods
- QA/QC
- Calculations
- Outputs and
- Improvements.

Institutional arrangements, data providers, data flows and quality control plans for other countries (both Annex 1 and non-Annex 1 countries) were reviewed and used as guidance for the development of these components. A description of each of the key components, along with comparisons to other countries, is provided below.

Institutional arrangements and organisational structure

The front page of the web-based national system provides the organisational structure and clearly lays out which organisations have which roles in the development and operation of the National System for GHG inventory production. It also presents the current and future data flows and system layout as discussed further in the section about stakeholders and data flows.

The Department of Environmental Affairs (DEA) is the central co-ordinating and policy-making authority with respect to environmental conservation. It is mandated by the National Environmental Management: Air Quality Act (Act 39 of 2004) to formulate, co-ordinate and monitor national environmental information, policies, programmes and legislation. The 1990, 1994 and 2000 inventories were compiled by the Council for Scientific and Industrial Research (CSIR), but since then South Africa has moved towards a more centralised system with DEA playing a more active role and taking over the management of the compilation process. This seems to be the general trend in other countries as well. In the majority of Non-Annex 1 countries reviewed the national entity is a research institute (Salas Cisneros, 2013; Gutierrez Arias et al., 2013; 2013a; Mauritius NIR2006), mainly because the expertise lie outside of the ministries, however, as climate change becomes more important and policies and acts are introduced at a national level then the ministries start to take over the role of the national entity (Bhattacharya, 2013). In the majority of the Annex 1 countries there is an appointed single national entity which is usually a ministry of environment or climate change (for example NZ NIR2014; German NIR2014; Norwegian NIR2014; UK NIR2014; Japan NIR2014).

Finances can also contribute to the ad hoc nature of institutional arrangements in non-Annex 1 countries as inventory development is often project based. As the inventory processes become more developed there is a general movement away from project based towards institutional base inventory systems (Kabuswe, 2014).

Currently DEA is responsible for collecting data and compiling the Energy, Industrial Processes and Product Uses (IPPU) and Waste sector inventories, while the compilation of the Agriculture, Forestry and Other Land Use sector (as well as the combining and compiling of the NIR) is out-sourced to consultants (Figure 1). This is not unusual as this is a complex sector that relates to a range of data and expertise (land management including forestry, farm management, Geographical Information Systems) not usually available and difficult to maintain within central government departments. Many countries successfully out-source these Agriculture, Forestry and Other Land Use services as well as other components of the inventory co-ordination and compilation without losing control of the overall GHG inventory outputs. The review indicates that Annex 1 countries generally have a hybrid approach which is described in the New Zealand inventory as centralised and distributed (NZ NIR2014). In this scenario the management and co-ordination of the inventory preparation and compilation are carried out in a centralised manner (i.e. one agency co-ordinates all processes), but sector specific work is designated to various agencies across the country. This is the approach which South Africa is starting to follow. Austria is the exception to this as it has a fully centralised approach, with all the work relating to the inventory being conducted within a single national entity, the *Umweltbundesamt* (Austrian NIR2014).

Several of the Non-Annex 1 countries (Miguez, 2012; Gutierrez Arias et al., 2013; 2013a; Salas Cisneros, 2013; Baffoe, 2014), make use of sectoral working groups to pool expertise. The adoption of sectoral coordinating institutions and/or working groups leverages a country's cross agency expertise and could additionally help spread the workload. By identifying in-country or existing staff and assigning them coordination responsibilities, there is an increased likelihood that technical and process knowledge will be retained, and a broader set of stakeholders will have ownership of the final product. This is an option which South Africa can consider in future, particularly for the larger Agriculture, Forestry and Other Land Use sector.

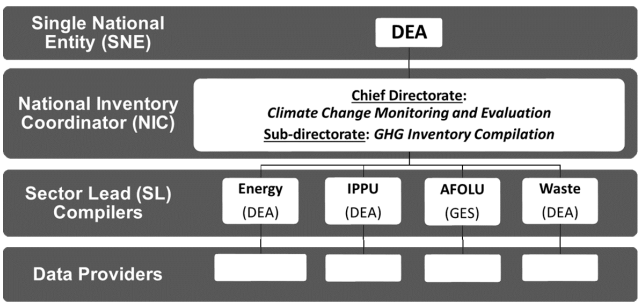

Figure 1: *Institutional arrangements for SA's GHG Inventory compilation.*

The review of other country institutional arrangements indicates that it is not essential for DEA to build in-capacity to compile all sectors of the inventory, as long as South Africa has sufficient resources available to manage external services and understands the key drivers and approaches for the GHG estimates. It is more important to make use of the wide range of existing expertise available from within and outside government.

In order to maintain continuity and build sustainability it would, however, be beneficial to seek and develop longer term (5-year) agreements with service providers for out-sourced expertise and experienced GHG inventory compilation and co-ordination support.

Inventory preparation work plan

To produce the inventory in a timeous manner it is essential for South Africa to develop a work plan and timeline. The work plan component of the national system provides a detailed plan of the inventory preparation process and this can be shared with stakeholders. It allows the co-ordinators to manage tasks and to engage sector experts and wider stakeholders in the planning and delivery of timely outputs. The work plan allows tasks to be assigned to stakeholders and progress on tasks to be tracked. Alerts can also be inserted into the system so that the inventory manager or compiler receives messages indicating when tasks are complete or overdue.

The work plan can take guidance from the recommended inventory preparation cycle that has been developed as part of the project. The cycle has 6 main steps (Figure 2), namely, plan, collect, compile, write, improve and finalise. It is recommended that South Africa focus its initial efforts on the following three phases:

- *Collect*: Data collection involves understanding what data is required, sourcing the data from various stakeholders, screening the data (for usefulness and appropriateness), selecting the appropriate data sets and quality checking the data (IPCC 2006 Guidelines). Once data is selected procedures need to be put in place so as to maintain a continuous supply of data. In order to ensure continuous inventory improvement, data gaps must be identified and measures taken to fill these gaps. Provision of guidelines on how new data should be collected or measured and what quality control procedures should be adhered to are recommended. The data collection procedures should also be reviewed periodically so as to maintain its integrity.

- *Compile*: Once data are selected and checked all information relating to the data needs to be recorded in the Inventory database. There is first the data input, which is followed by the completion of the uncertainty data sheets. Finally the metadata must be compiled. This involves documenting the names of the people responsible for incorporating the data, specific data calculation, data sources, uncertainty sources, recalculations undertaken and links to data or reference files.

- *Write*: The National GHG Inventory Report (NIR) is drafted based on the summary outputs from the inventory database. The report will also draw methodological and uncertainty information from the metadata and uncertainty files in the inventory database.

Throughout these phases the National System should consider the co-ordination and encouragement of quality control and quality assurance activities. Quality control and quality

assurance are an integral part of the inventory process. There are several quality control steps throughout the inventory improvement process which assess and maintain the quality of the inventory as it is being compiled and provides routine and consistent checks to ensure data integrity, correctness and completeness.

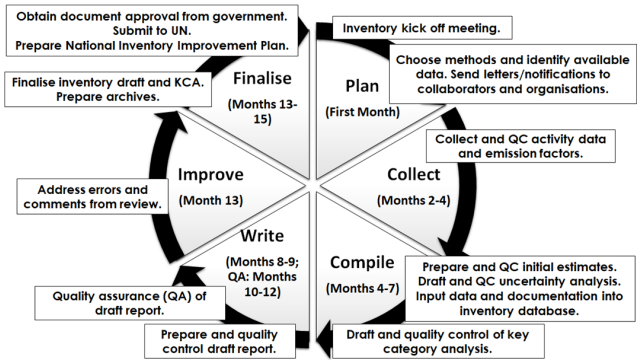

Figure 2: *Inventory preparation cycle with suggested timelines.*

Stakeholders and data flows

The national system provides a live list of all stakeholders engaged in the GHG inventory compilation. It identifies the stakeholder roles, logs details of their engagement with the GHG inventory activities and provides an essential reference point for co-ordination of future engagement activities. Connected to the list of stakeholders are templates for the elaboration of data supply agreements that can be set-up between the GHG inventory single national entity and the data providing stakeholder. Where appropriate, elaborated and agreed versions of these templates can be attached to the relevant stakeholder records so that agreed data supply is transparent and referenceable.

In South Africa data is sourced from many institutes, associations, companies and ministerial branches. At this stage there is a lack of legal and formal procedures for obtaining data and compiling the GHG emission inventory. This is common amongst Non-Annex 1 countries. The Industrial Processes and Product Use sector has, until now, had some formality in that DEA has requested data from industries through the umbrella organisation Business Unity South Africa (BUSA). Even so, this system has no legal obligation attached to. In all sectors input data is obtained on a voluntary system and relies on good relationships which have been built up over time. This system is however, no sustainable should relationships turn sour or if key compilers or contacts leave their organisations.

The draft GHG regulations (RSA GG, 2015) will bring some formality to the Industrial Processes and Product Uses sector, but formality needs to be developed in the other sectors as well. South Africa needs to move towards a formalized system, as is evident in Annex 1 countries where there are most often signed agreements between the leading institutions and the single national entity (for example Bulgarian NIR2014; German NIR2014; UK NIR2014). Germany not only has agreements between the SNE and the state secretaries, but also signed individual cooperation agreements with the relevant sector stakeholders (Roeser, 2015). In terms of the NGHGIS it is recommended that DEA develop legal instruments (e.g. MoUs) to regulate the Department's engagement with other institutions regarding: the formalisation of institutional and procedural arrangements; the alignment of government's inventory processes as well as to provide dispute resolution mechanisms and to protect confidential data and information. The legal instruments developed by DEA must accordingly regulate processes and activities in the department (e.g. in relation to confidentiality and ethical conduct); the relationship between the DEA and other line functionaries (e.g. the Department of Energy), municipalities and other organs of state (e.g. the National Energy Regulator (NERsa)); as well as the department's interaction with private institutions. As part of this project an intergovernmental and an industry/other non-state institution Memorandum of Understanding (MoU) have been drafted so as to address these issues in the future. These are both available on the NGHGIS.

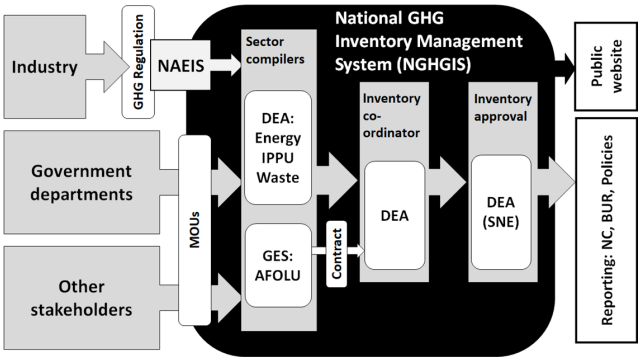

Figure 3: *Future organisational structure for SA's GHG Inventory compilation.*

In both Annex 1 and Non-Annex 1 countries national statistics are shown to play a prominent role in many inventories (Norwegian NIR2014; NZ NIR2014; Bulgarian NIR2014; Salas Cisneros, 2013; Mauritius NIR2006; Namibia SNC, 2011). In Norway, Statistics Norway (Statistisk Sentralbyrå (SSB)) is responsible for the official statistics on emissions to air and is one of three core institutes involved in inventory compilation. This is not the case in South Africa. DEA has had some discussions with Statistics SA and it is recommended that these discussions continue to determine whether their role as a data supplier for the inventory can be strengthened and whether Statistics SA can assist in steering new data collection processes.

The envisaged organisational structure and data flows for South Africa are shown in Figure 3. It is proposed that the GHG inventory data collection be integrated with the current National Atmospheric Emissions Inventory System (NAEIS) as is the case in most Annex 1 countries (e.g. Norwegian NIR2014; German NIR2014; UK NIR2014; Austrian NIR2016). Using the same structures for reporting both GHG's and air pollutants minimize duplication, reduce the reporting burden on data suppliers and makes use of the same resources for two tasks.

Datasets

The NGHGIS provides a list of datasets which allows the GHG inventory system co-ordinators, experts and other stakeholders to track the data used or needed for the GHG estimates. The datasets are linked to a stakeholder from the stakeholder list with associated elaborated data supply agreements (if relevant). This makes it clear for all stakeholders within the GHG inventory national system where datasets are sourced and the connection of organisations to data provision.

Method documentation

The methods and data source section of the NGHGIS allows the team and stakeholders to manage (create, share and store) the key documentation files describing the methods, data sources and assumptions. This is managed in a customised document library which includes metadata on the status and content of the method descriptions. The library also provides access to a templates with a pre-defined structure and embedded guidance and links to writing guidance that can be used when documenting GHG estimates.

The method statements, which are critical for continuity in the inventory, can apply to a single or group of category/subcategory/gas/fuels. A method statement can apply to a group of categories if the same method, assumptions and data sources are used. For example, where the same defaults and energy balance data are used for a number of categories and fuels. This will minimise repeated text and multiple references to data sources and assumptions. Method statements have a unique ID so that the methods can be linked to the appropriate sections of the inventory, as well as being linked to the required input data sets and quality control measures conducted on the data. The method statements contain information on the background of the emission source, data sources, datasets, method approach, assumptions, recalculations, improvements, QA/QC process, time series consistency, uncertainties and verification.

QA/QC procedures

South Africa does conduct QA/QC activities however there is no clear QA/QC process in place and roles and responsibilities are not clearly defined. A QA/QC plan is an important component of the inventory system. All Annex 1 countries have a QA/QC Plan or Quality Management Manual in place which generally follow the QA/QC guidance provided by the IPCC in terms of QA/QC plans. The majority of plans/manuals reviewed contained the following information:

- Definitions
- Quality objectives
- Roles and responsibilities
- General QC procedures
- Checklists for general QC checks
- Checklists for specific QC checks
- QA procedures

In some cases there are also details about the verification process (e.g. Denmark, Italy); QA/QC improvement plans (e.g. Iceland, Romania, Italy); reporting, documentation and archiving process (e.g. Iceland, Italy, Romania) and also qualitative uncertainty analysis (e.g. Italy, USA) (Nielsen et al., 2012; Hallsdottir and Guomundsson, 2007; Deaconu, 2013; Bernetti and Romano, 2006; EPA, 2002). The Tier 1 quality control checks outlined in 2006 IPCC Guidelines (IPCC, 2006; Chapter 6, Table 6.1) and the Good Practice Guidelines (IPCC, 2000; Chapter 8, Table 8.1) provide the basis for checks developed in all the countries. The various countries provide more detailed descriptions of their specific activities and procedures under each point.

QA activities in the reviewed countries take many forms, namely peer reviews, expert reviews, UNFCCC expert reviews, steering committee reviews, internal reviews, audits, bilateral reviews, public reviews stakeholder reviews, method and calculation validation exercises, in-depth sector and sub-sector reviews and working groups. All countries employ more than one of these activities, with peer reviews, expert reviews and the UNFCCC expert review being common to all countries. Some countries, such as Australia, Austria, Bulgaria, Finland and New Zealand, have their inventories audited. Audits can take the form of second and third party audits, accreditation audits, as well as data supplier audits.

Based on the review findings and as part of the NGHGIS a detailed QA/QC plan was developed for South Africa along with a recommended QA/QC cycle and timeframe (Figure 4). These documents are housed on the QA/QC plan component of the NGHGIS. The phases of the QA/QC process are:

- *QA/QC planning*: During the inventory planning meeting the review comments from the previous year's submission are considered and improvement plans are made for the upcoming submission. It is during this planning phase that the QA/QC plan is reviewed and improved. The planning stage includes the setting of quality objectives and elaboration of the QA/QC plan for the coming inventory preparation, compilation and reporting work and reviewing the quality control checks. The specific timeframes for the completion of each activity should be decided during this planning meeting;
- *Quality control*: All quality control activities are implemented during this phase;
- *Quality assurance*: All quality assurance procedures are completed during this phase;
- *QA/QC conclusions*: This phase is when all QA/QC activities are concluded and signed-off, and all documentation is finalised; and
- *QA/QC evaluation and improvement*: Results of the QA/QC process are evaluated and improvements are included in the planning phase of the following inventory cycle.

The QA/QC component of the NGHGIS includes:

- QA/QC objectives which provides a list of high level objectives along with a description of how the objectives will be met. These objectives are focused on ensuring all outputs from the GHG inventory system are fit for purpose with understood uncertainties/strengths and weaknesses. The objectives encompass the 2006 IPCC quality criteria (Transparency, Completeness, Comparability, Consistency

and Accuracy) and define objectives specific to South Africa's national circumstances. The quality objectives are reviewed when a new set of estimates or updates are planned and monitored;

- QA/QC checks which provides a library of all agreed and proposed QA/QC checks. This list identifies checks that should be implemented and where and when in the estimation and reporting processes. It provides an ID for each check so that the specific quality checks that are completed can be referred to in the calculation files or reports;
- QA/QC log which itemizes specific QA/QC activities undertaken by who and when. Evidence of the QA/QC (e.g. review reports) if needed or reference "emails" or filenames can be attached to the log for ease of access and transparency. It also provides a list of template checklist which need to be undertaken and the log will show which components are completed or which are overdue.

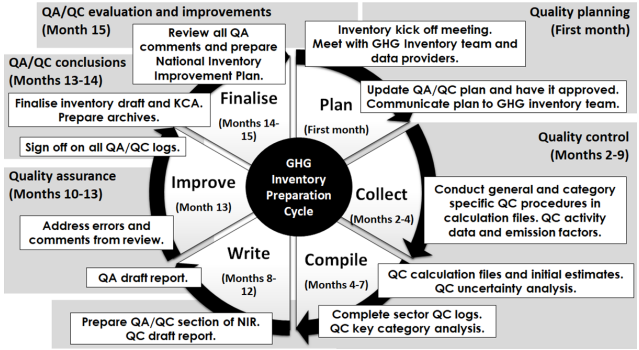

Figure 4: *Quality control procedures and timeframes for the GHG inventory.*

GHG emission inventory calculation files

The NGHGIS provides a library for sharing the calculations for the GHG estimates. It provides templates for the calculation files that facilitate efficient calculation and updates, support QA/QC activities, clear detailed documentation and aggregation of outputs for reporting. This also acts as an archive into which all of the relevant and essential calculation and background material for the GHG estimates can be preserved to safeguard against loss of institutional materials.

Calculation files were re-designed, based on international experiences, to make it easier to understand and follow the data in the calculation files, as well as incorporating aspects to make the QA/QC process easier. The following important improvements have been made to the calculation files:

- Incorporation of data for all years in the time series into one file to aid in the checking of time series consistency;
- Colour coding of all data in calculation files to assist in understanding where the data comes from or how it is derived;
- Addition of spark-lines (or trend lines) to the end of each row of data so that the compiler or review can do a quick visual check for inconsistencies in the data series;
- Incorporation of a standardised commenting system to enable information on methodology, or data queries, to be inserted directly into the calculation file. This assists reviewers and enables the QC process to occur alongside the inventory compilation; and
- Addition of the QA Analyst logging system to each sector file which pulls out all comments in the spreadsheets and creates a log of comments on the first page of the calculation file. This assists with tracking and transparency and enables the quality controller to see that all queries have been responded to.

Outputs

There are two components to the outputs on the NGHGIS. The first is the GHG emissions trend viewer. This can provide regular updates of the GHG inventory trends for national awareness raising and as input to progress tracking and analysis of future actions. This is possible once the data archive is working efficiently and the estimates can be aggregated into a transparent quality assured database.

The second component is the public website. A public presentation of the GHG inventory national system is being developed using summary data from the secure GHG inventory monitoring, reporting and verification (MRV) system. This public site could include interactive data on the GHG trends and associated indicators, summary lists of key stakeholders, datasets and improvements planned and implemented. It can also provide links to the detailed GHG estimates and to method descriptions for the GHG estimates. The site would provide a focal point for stakeholder engagement (e.g. for consultations) and to showcase the GHG inventory system to the international GHG mitigation community. A prototype has been developed to test out its usefulness.

Improvements

In this section of the NGHGIS a live list of improvement activities (proposed, planned and completed) are provided. The improvement plan is visible to all stakeholders with access to the MRV system. It acts as the focal point for logging and prioritising improvement suggestions, tracking live improvement activities and a resource for providing documentation of improvements and improvement needs in national reports (e.g. Nationally Determined Contributions, National Communications, and Biennial Update Reports).

Conclusions

The project to develop a sustainable GHG inventory national system for South Africa is expected to be concluded in December 2017. Through this project and other efforts to invest in expert capacity, South Africa is aiming to establish, in a functioning system, sustainable teams of experts managing transparent data in well-maintained tracking and planning (MRV) systems.

The NGHGIS is already functioning and evolving as South Africa continues to work on and deliver monitoring, reporting and verification activities for its Biennial Update Report and National Communications. The system helps South Africa to

manage a dynamic and changing spectrum of stakeholders. The structure (templates and lists) and accessibility (in a secure environment) of the system provides far greater transparency and improved continuity for the detailed work put into calculating GHG estimates. This facilitates the engagement of a wide range of stakeholders and contributors and offers the DEA added institutional memory, a place to collaborate and facilitate continuous improvement within a sustainable and secure framework. It also provides a backbone of structure and support for continuity and control.

The system is being tested with its ability to withstand the turnover of key staff and experts and the embedding of short term improvement projects over time.

Over the coming years South Africa's climate action reporters and decision makers will be supported with relevant and timely information by this system and its engaged teams for reporting, decision making and negotiation on climate action.

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