

# Evaluation of Enabling Factors for Sustainable National Greenhouse Gas Inventory in Developing Countries

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**Abstract**—This paper aims to evaluate potential factors that enable developing countries to update national greenhouse gas (GHG) inventories on a regular basis, by analyzing to what extent each factor differentiates frequency of submissions by countries of national communications and/or biennial update reports to the United Nations Framework Convention on Climate Change (UNFCCC). To this end, the following steps were taken: (1) identification of arrangements and processes for the preparation of national GHG inventories to be used as evaluation criteria; (2) grouping of developing countries by frequency of submissions, and selection of their national reports for evaluation; (3) scoring of the selected national reports against the evaluation criteria; (4) analysis of the assigned scores. The finding indicates that funding support under the UNFCCC has not been translated to building a capacity to produce regular inventories, suggesting that a potential value exists for another type of support that specifically meets the needs of developing countries to achieve a sustainable inventory system. As GHG inventories are the foundation for tracking progress towards mitigation goals, if the enhanced transparency framework outlined in the Paris Agreement is to be successfully implemented, capacity building on GHG inventory in developing countries should be given priority.

**Index Terms**—Capacity building, greenhouse gas inventory, reporting, transparency.

## I. INTRODUCTION

A national greenhouse gas (GHG) inventory identifies and quantifies a country's anthropogenic sources and sinks of GHGs. It is a foundation for accounting and tracking progress towards climate change mitigation goals [1]. However, many non-Annex I countries under the United Nations Framework Convention on Climate Change (UNFCCC) do not yet have the necessary capacity to produce regular inventories of their GHG emissions [2]-[5]. With more frequent reporting requirements under the Convention, non-Annex I countries need to build capacity to support more sustainable and robust systems for national GHG inventory preparation. Establishing such a system enables countries to meet reporting requirements under the UNFCCC. It also helps countries identify and prioritize mitigation actions, and track and report progress toward domestic emissions reduction goals [6].

National GHG inventories of non-Annex I countries are reported to the UNFCCC through national communications

(NCs) and biennial update reports (BURs). NCs provide information on national GHG inventories, measures to mitigate and to facilitate adequate adaptation to climate change, and other relevant information. NCs should be submitted every 4 years [7]. BURs provide an update of the information contained in NCs, including GHG inventories. The first BUR should be submitted by December 2014 and every 2 years thereafter [7]. However, capacities of developing countries to submit NCs and BURs on such a regular basis have been limited.

Whereas transparency, consistency, comparability, completeness, and accuracy are the key principles to be taken account of in preparation of GHG inventories [8], this paper is not intended to assess the quality of reported inventories in terms of these criteria. Instead, the present study aims to evaluate potential factors that enable countries to update national GHG inventories on a regular basis. In doing so, it will analyze to what extent each factor differentiates frequency of submissions by countries of national reports to the UNFCCC. To this end, it will conduct a critical desktop review of national GHG inventory and other relevant sections in submitted NCs and BURs. The paper begins by highlighting the increasing need for countries to build capacity to establish sustainable national GHG inventory systems. This is followed by the identification of a framework for evaluation and analysis. After presenting the result, this paper concludes with discussions about the implications of the findings on support for capacity building on national GHG inventory in developing countries.

## II. BACKGROUND

### A. Reporting Requirements for Developing Countries

Reporting is a fundamental requirement of the UNFCCC. It provides transparency, and is a basis for understanding and gauging the implementation of the Convention. Transparent reporting, combined with subsequent third-party consideration, helps to increase trust and confidence in the information reported [4], [5]. In accordance with the principle of common but differentiated responsibilities and respective capabilities, the required contents of national reports and the timetable for submissions of national reports are different between Annex I countries and countries not included in Annex I to the Convention (non-Annex I countries). Annex I Parties include the industrialized countries that were members of the Organisation for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition, including the Russian Federation, the Baltic States, and several Central and

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Eastern European States. Non-Annex I Parties are mostly developing countries.

NC is one of the commitments for all Parties under the Convention [9] (Article 4), and a national GHG inventory is an essential element of NCs. It is stipulated that all Parties shall develop and periodically update national inventories (Article 4.1(a)). It is also stated that each non-Annex I country 'shall make its initial communication within 3 years of the entry into force of the Convention for that Party', and Least Developed Country (LDC) Parties 'may make their initial communication at their discretion' (Article 12.5). The revised guidelines for the preparation of NCs from non-Annex I countries was adopted at the Conference of the Parties (COP) at its eighth session in New Delhi [8].

The Cancun Agreement [7], as adopted at COP16 in Cancun, Mexico, enhanced reporting through NCs (paragraph 60), stating that non-Annex I countries should submit their NCs every 4 years (paragraph 60(b)). This Agreement has also introduced BURs. It stipulates that developing countries, consistent with their capabilities and the level of support provided for reporting, should also submit BURs containing updates of national GHG inventories (paragraph 60(c)).

COP17 in Durban, South Africa [10] adopted the guidelines for the preparation of BURs by non-Annex I countries (paragraph 39). It defined a scope of BURs to be an update to the most recently submitted NC including national GHG inventory (annex III). It was agreed that non-Annex I countries should submit their first BUR by December 2014, and that LDCs and Small Island Developing States (SIDS) may submit BURs at their discretion (paragraph 41(a)). It was also decided that non-Annex I countries shall submit a BUR every 2 years, either as a summary of parts of their NC in the year in which the NC is submitted, or as a stand-alone update report (paragraph 41(f)).

The Paris Agreement [11], as adopted in COP21, established an enhanced transparency framework for action and support 'in order to build mutual trust and confidence and to promote effective implementation' (Article 13.1). The transparency framework will build on and enhance the transparency arrangements under the Convention, including NCs and BURs, taking account of the special circumstances of the LDCs and SIDS (Articles 13.3 and 13.4). One of the main purposes of the transparency framework is tracking progress towards achieving the Parties' individual nationally determined contributions (NDCs) (Article 13.5). In this respect, it is stipulated that each Party shall regularly provide a national inventory report (Article 13.7 (a)).

Financial support is essential for developing countries in preparation of their NCs and BURs. The Convention [9] stipulates that financial resources shall be provided to meet the cost incurred by developing countries in complying with their obligations to submit NCs (Article 4.3). The Cancun Agreement [7] also indicates that submissions by developing countries of BURs should be consistent with the level of support provided, as well as their capabilities (paragraph 60(c)). In these regards, the Global Environmental Facility (GEF), as an operational entity of the financial mechanism of the Convention, provides financial support. The GEF can provide up to US\$500,000 to each non-Annex I country for

funding the preparation of NCs, and up to US\$352,000 for BURs [12]-[14]. All non-Annex I countries, including LDCs and SIDS who may submit BURs at their discretion, are eligible to receive funding for the preparation of BURs [13].

The Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention (CGE) is a 'main channel' under the UNFCCC for the provision of relevant technical assistance for developing countries [14]. The CGE, at the request of the Convention, develops training materials and organizes workshops for the preparation of NCs and BURs.

#### *B. Prior Work of Evaluation on Reporting Capacity of Developing Countries*

Despite more frequent reporting requirements under the UNFCCC, as described in the previous section, capacities of developing countries have been limited. For instance, the internationally-set objectives for BURs are not being met. According to [5], although initial BURs were supposed to be submitted by the end of 2014 for all developing countries except LDCs and SIDS (a total of 71 countries), only 16 BURs had been submitted by 31 October 2015.

Reference [2] assessed GHG inventories of developing countries, by using compliance with the key inventory principles: transparency, consistency, comparability, completeness, and accuracy as an analytical framework. It pointed to a significant problem that exists in their reported inventories, and attributed it to a lack of a continuous inventory system, as inventory teams are only working temporarily on a project basis.

The institutional problems for national GHG inventory in developing countries have also been addressed by other studies. Reference [6] argues that, although a number of non-Annex I countries have completed two or more national GHG inventories as part of their submitted NCs, these were often produced with a long time lag between reports, creating challenges in building the long-term institutional capabilities, systems, procedures, and processes required for more frequent reporting of a national GHG inventory. A national inventory process is often managed as a time-delimited project, where funding is given to produce a specific NC and/or BUR. As the project cycle ends, there is a period of no funding or activity until the next project cycle begins. As a result, countries are often unable to retain the necessary technical knowledge, including staff experts, data, and methods documentation, and therefore must start over with each new inventory.

Similarly, [4] points to a lack of institutional arrangements, staff, and expertise in many developing countries to produce regular inventories. A country that hires staff or contracts experts for preparation of a national GHG inventory by using GEF support may not have resources to maintain these staff following completion of the report. Such a country would not have the ability to regularly collect information, and essentially must rebuild capacity for every report instead of being able to improve the reporting system over time.

Reference [3] also discussed the institutional capacity for preparation of national GHG inventories. Most countries can, through their own resources or foreign assistance, hire and/or train experts to prepare a report. However, a successful

completion of this project does not guarantee that the country has the institutional capacity to produce regular inventories. Meeting such regular and periodic responsibilities requires: training personnel and funding the institutions in charge of the inventory work; establishing a stable network where responsibilities and procedures are clearly defined; and, strengthening the regulatory framework by giving authority to agencies to collect data.

Reference [15] analyzed capacities of 37 Asian developing countries to develop national GHG inventories. In doing so, it applied four assessment categories and the criteria associated with each category: (1) international engagement (timely response), (2) institutional capacity (coordination capacity, continuous improvement, involvement of stakeholders, and availability of domestic financial resources), (3) technical capacity available (understanding of guidelines, national scientific capacities, and national statistical capacities), (4) technical capacity applied (transparency, consistency, comparability, completeness, and accuracy). It found that the capacities of 11 Asian developing countries remained low, whereas seven countries gained a capacity to enable regular communication of GHG inventories.

### III. FRAMEWORK FOR EVALUATION AND ANALYSIS

The contribution of this paper to the literature lies in the evaluation of potential factors that enable countries to update national GHG inventories on a regular basis, by analyzing to what extent each factor differentiates frequency of submissions by countries of national reports to the UNFCCC. To this end, the present study applied the framework used by [16] with modifications, and took the following four steps: (1) identification of arrangements and processes for the preparation of national GHG inventories that can be used as evaluation criteria; (2) grouping of developing countries by frequency of submissions, and selection of their submitted national reports (NCs and/or BURs) for evaluation; (3) scoring of national GHG inventory and other relevant sections in the selected national reports against the evaluation criteria; (4) analysis of the assigned scores.

#### A. Identification of Arrangements and Processes for National GHG Inventory

For identification of arrangements and processes for national GHG inventory, the present study builds upon the findings of [6]. Drawing upon case studies in Brazil, Colombia, India, Mexico, and South Africa, [6] identified seven good practices to sustain national GHG inventory systems: (1) sustained institutional arrangements, (2) identification and enabling of a lead agency to manage the national GHG inventory process, (3) sectoral coordinating institutions with well-defined roles, responsibilities, and processes, (4) detailed institutional mandates and data-sharing agreements, (5) processes to archive inventory information and retain institutional memory, (6) sustained financial resources, and (7) an iterative approach to improving the national GHG inventory system. These practices were also indicated by other sources [2]-[5] as necessary for countries to update inventory reports regularly.

They are commonly found in the criteria used by [15] to assess institutional capacity for national GHG inventory as well.

Building on these sources, the current study defined a set of key arrangements and processes to sustain national GHG inventory. This led to the development of evaluation criteria, which were subsequently used to interrogate national reports from non-Annex I countries. In this process, this paper established two separate criteria in relation to ‘sustained financial resources’: one concerning ‘external funding’, and the other ‘domestic funding’. This is based on the observation by [6] that, as GEF funds are provided in a payment-for-project manner, it is difficult to improve the national inventory system beyond the length of the GEF funding cycle without some minimum level of domestic funding. By setting ‘external funding’ and ‘domestic funding’ as two separate criteria, this paper should be better able to identify factors that differentiate the frequency of submissions of national reports. Detailed descriptions of each criterion are provided in Table I.

TABLE I: DESCRIPTIONS OF ARRANGEMENTS AND PROCESS TO SUSTAIN A NATIONAL GHG INVENTORY SYSTEM, AS IDENTIFIED BY [6] AS GOOD PRACTICES, AND APPLIED WITH MODIFICATIONS AS EVALUATION CRITERIA IN THE PRESENT STUDY

Sustained institutional arrangements	Permanent institutional arrangements for national GHG inventory that are regularly funded and staffed, enabling countries to cope with increased reporting frequency under the UNFCCC.
Identification and enabling of a lead agency to manage the national GHG inventory process	A lead agency within a national government to oversee the management of a national GHG inventory process, with responsibilities for coordinating the collection of data from sectoral institutions, compiling and submitting the inventory, developing data-sharing agreements, convening meetings, holding data providers and sectoral institutions to task, ensuring that quality assurance/quality control (QA/QC) procedures are followed, and ensuring the quality of the inventory as a whole.
Sectoral coordinating institutions with well-defined roles and responsibilities	Sectoral coordinators and/or sectoral working groups responsible for compiling activity data and completing an inventory for a specific sector. (Although the lead agency is responsible for managing the entirety of the GHG inventory process and compiling the overall inventory, the necessary data often reside within a range of ministries, research institutions, and private-sector entities).
Institutional mandates and data-sharing agreements	A defined set of roles, tasks, and time lines, established through the adoption of coordination or data sharing agreements, terms of reference, and/or memoranda of understanding.
Processes to archive inventory information and retain institutional memory	An ability to retain access to the data and methods used in previous inventories, as well as institutional memory regarding processes, participants, and lessons learned.
Sustained financial resources (1) External funding (2) Domestic funding	Multiple funding sources to support their national inventory system, including both external and domestic sources.
An iterative approach to improving the national GHG inventory system	An iterative approach to refining and making improvements to data, methods, and management processes for national GHG inventory over time.

TABLE II: LIST OF DATA SOURCES

List of non-Annex I countries (154 countries): <a href="http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php">http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php</a> (Retrieved April 11, 2017)
List of LDCs under the UNFCCC (48 countries): <a href="http://unfccc.int/cooperation_and_support/ldc/items/3097.php">http://unfccc.int/cooperation_and_support/ldc/items/3097.php</a> (Retrieved April 11, 2017)
List of SIDS under the UNFCCC (41 countries): <a href="http://unfccc.int/resource/docs/publications/cc_sids.pdf">http://unfccc.int/resource/docs/publications/cc_sids.pdf</a> (Retrieved April 11, 2017)
Submitted NCs from non-Annex I countries: <a href="http://unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653.php">http://unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653.php</a> (Retrieved April 11, 2017)
Submitted BURs from non-Annex I countries: <a href="http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php">http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php</a> (Retrieved April 11, 2017)
Years of ratification of the UNFCCC <a href="http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php">http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php</a> (Retrieved April 11, 2017)

TABLE III: GROUPING OF NON-ANNEX I COUNTRIES UNDER THIS STUDY

Group	Description of countries belonging to the respective groups under this study	Number of countries
Group 1	Non-Annex I countries, excluding LDCs and SIDS, which have submitted a NC three times or more, and whose national reports are available in English (*)	24
	Non-Annex I countries, excluding LDCs and SIDS, which have submitted a NC twice and a BUR at least once, and whose national reports are available in English (*)	10
	Sub-total	34
Group 2	Other non-Annex I countries, excluding LDCs and SIDS, which have ratified the UNFCCC more than 11 years, and whose national reports are available in English (*)	18

Note: (\*) Even if full documents are presented in other languages, where executive summaries of their national reports are available in English, such reports are also included.

### B. Grouping of Non-annex I Countries and Selection of Their Submitted National Reports

Non-Annex I countries were divided into two groups: One includes non-Annex I countries which have more frequently updated their national GHG inventories, and the other includes those whose updates have been less frequent. Under this study, the first group is defined as a group consisting of non-Annex I countries, excluding LDCs and SIDS, which have (1) submitted NCs three times or more, and (2) submitted a BUR at least once in addition to two NCs. The second group includes all the remaining non-Annex I countries, excluding LDCs and SIDS, which have ratified the Convention over 11 years. The first BUR received the same weight as the third NC, since a BUR is defined as an update to the most recently submitted NC including national GHG inventory [10]. LDCs and SIDS were excluded since they may submit their BURs at their own discretion [10]. LDCs may also submit their NCs at their discretion [9]. Ratification of the Convention for over 11 years is considered as necessary for submission of three NCs, since non-Annex I countries are required to submit their first NC within 3 years of entering the Convention, and subsequent NCs every 4 years thereafter [9], [10]. Non-Annex I countries that belong to each of the above two groups were identified at the relevant webpages of the UNFCCC, as specified in Table II.

Out of the above-identified non-Annex I countries, the countries whose NCs and/or BURs were prepared in English were targeted under this study. Even if full documents were presented in other languages, where executive summaries of their national reports were available in English, such reports were also included. The national reports were downloaded

from the relevant webpages of the UNFCCC, as indicated in Table II. The two groups of target countries as selected above were labelled as Group 1 and 2 respectively. The descriptions of the countries included in the respective groups are provided in Table III. A list of the countries is shown in the Appendix.

### C. Scoring of National Reports against Evaluation Criteria

Evaluation of the most recent national reports of the respective countries was conducted by scoring each report against the aforementioned criteria. Each criterion was scored on a three-point scale (0, 1 or 2). The specific requirements associated with each possible score varied among different criteria, but followed a consistent system in general except the criterion of ‘external funding’ (Table IV for a general scoring system; Table V for specific requirements; adopted from [16] with modifications).

TABLE IV: SUMMARY OF SCORING SYSTEM APPLIED IN THE CURRENT STUDY: THE RELEVANT SECTIONS IN THE SELECTED NATIONAL REPORTS WERE SCORED AGAINST EVALUATION CRITERIA. GENERAL CONDITIONS THAT MERIT THE ASSIGNMENT OF DIFFERENT SCORES ARE DESCRIBED BELOW (ADOPTED FROM [16] WITH MODIFICATIONS)

Score	Necessary conditions
0	No evidence of consideration for a particular criterion was apparent in relevant national reports. This suggests a particular arrangement or process in question may have been neglected.
1	Evidence exists of consideration of a particular criterion during the development of relevant national reports. This suggests a particular arrangement or process in question was recognized as being of some importance. However, the arrangements or processes remained underdeveloped, suggesting additional consideration may be required to sustain a national GHG inventory system.
2	Evidence exists of consideration of a particular criterion during the development of relevant national reports, and significant effort was invested to sustain a national GHG inventory system.

The scoring system is illustrated with the following example. One of the evaluation criteria is ‘processes to archive inventory information and retain institutional memory’. For a particular report to receive a score of 0 for this criterion, the report would have to fail to address the processes to archive inventory information and retain institutional memory, or fail to acknowledge the importance of such issues for sustaining a national GHG inventory system. A score of 1 would be assigned if the report acknowledged the necessity to develop processes to archive inventory information and retain institutional memory, or indicate that such processes are planned to be developed, but

failed to actually undertake or present evidence that such processes had been established. To receive a score of 2, the report would have to present evidence that such processes had been established.

Regardless of the care invested in articulating conditions by which scores are assigned, this evaluation process was unavoidably subjective. To minimize bias, scoring criteria were explicitly defined (Table V), and scores were assigned by the first author and then reviewed by the second author to detect any inconsistencies [16].

TABLE V: SCORING RULES FOR EVALUATING TO WHAT EXTENT EACH NATIONAL GHG INVENTORY CRITERION IS MET BY THE SELECTED NATIONAL REPORTS (ADOPTED FROM [16] WITH MODIFICATIONS)

Criterion	Score of “1” requires evidence that ...	Score of “2” requires evidence that ...
Sustained institutional arrangements	Relevant organizations have been designated.	Relevant organizations have been designated, and processes for interaction among these organizations have been defined.
A lead agency to manage the national GHG inventory process	An overall lead agency has been designated.	An overall lead agency has been designated, and its roles and responsibilities have been defined.
Sectoral coordinating institutions	Sectoral coordinating institutions have been designated.	Sectoral coordinating institutions have been designated, and their roles and responsibilities have been defined.
Institutional mandates and data-sharing agreements	The necessity of establishing institutional mandates and data-sharing agreements has been recognized, or there is a plan to address this issue.	Institutional mandates and data-sharing agreements have been established.
Processes to archive inventory information	The necessity of developing processes to archive inventory information has been recognized, or such there is a plan to develop such processes.	Processes to archive inventory information have been established.
External funding	GEF funds and other international financial resources have been secured to develop a national GHG inventory.	N/A
Domestic funding	The necessity of securing funding through national budgets and/or other domestic sources to sustain a national GHG inventory system has been recognized.	Funds from national budgets and/or other domestic sources have been secured to sustain a national GHG inventory system.
An iterative approach to improving the national inventory system	Gaps and constraints in a national GHG inventory have been recognized.	The improvement plan for a national GHG inventory has been continuously updated.

D. Analysis of the Assigned Scores

An independent-sample *t*-test was then performed to see whether significant differences exist in the scores for each of the eight criteria between Groups 1 and 2. Correlations between the scores for one criterion and those for another were also investigated for 28 pairs.

E. Limitations

A number of cautions apply to the aforementioned methods. First, the evaluation approach used here only assessed information contained within NCs and/or BURs. Non-Annex I countries are mandated to report national GHG inventories. According to the guidelines for NCs from non-Annex I countries [8], however, they are only ‘encouraged to describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories, as well as efforts to make this a continuous process, including information on the role of the institutions involved’. It is important to recognize that, even if not reported, significant investments of time and resources in developing the above procedures and arrangements may have occurred behind the scenes.

Secondly, as indicated by [5], national GHG inventory is an area where reporting under the UNFCCC has been most transparent and complete, as the guidelines are clear on what to measure and report, and the methods are available for how to do this. It should be recognized, however, that because of flexibilities allowed for non-Annex I countries, the level of detail contained in their reports varies.

Thirdly, whereas the most recently submitted national reports were studied, the timing of submission of such reports varies across countries. The submission years of the national reports examined under this study ranged from 2013 to 2017 for the countries of Group 1, and from 2003 to 2016 for Group 2. Thus, the examined reports from the countries of Group 1 tend to be more recent than Group 2. It is important to recognize that a country's capacity may have been improved over time.

Lastly, it also needs to be recognized that cases may exist where submissions of national reports were delayed due to other factors than preparation of national GHG inventory. Given the above-mentioned limitations, the need for more bottom-up and longitudinal investigative approaches that provide insight into the status and change in capacity for the preparation of national GHG inventories has to be emphasized.

IV. RESULTS

Table VI presents mean values of the assigned scores in each criterion for the respective groups. The mean values of the scores for the Group 1 countries are higher than those of Group 2 for every criterion. As for Group 1, the highest value is found in the criterion ‘overall lead agency’, followed by ‘institutional arrangements’. Almost all Group 1 countries have designated an overall lead agency, and more than half of them have defined its role and responsibilities. The lowest mean value is found in ‘domestic funding’, indicating that there are still a limited number of developing countries that have secured domestic funds for national GHG inventory systems. The mean value in ‘sector coordinating agency’ is similarly low. Less than half of Group 1 countries have designated such agencies, indicating that cases are still dominant where a single lead agency handles overall coordination without assignments of sector coordinating agencies. This suggests that much room exists for line

ministries or agencies to strengthen their own capacities to coordinate preparation of their respective sector GHG inventories in many developing countries.

TABLE VI: RESULTS OF INDEPENDENT SAMPLE T-TEST BETWEEN GROUPS 1 AND 2

	Mean values		t (*)	p (*)
	Group 1 (n <sub>1</sub> = 34)	Group 2 (n <sub>2</sub> = 18)		
Institutional arrangements	1.4118	0.4444	6.1245	0.0000
Overall lead agency	1.5294	1.0000	4.2027	0.0000
Sector coordinating agency	0.6176	0.1111	3.1756	0.0013
Data sharing agreements	0.7647	0.0556	4.5231	0.0000
Archiving	1.1471	0.2222	4.6177	0.0000
External funding	0.9412	0.8889	0.6630	0.2552 (**)
Domestic funding	0.6176	0.0000	4.8724	0.0000
Continuous improvement	1.3235	0.7778	2.9203	0.0026

Notes: (\*) one-tailed, (\*\*) not significant at .05.

As for Group 2, the highest mean value is found in the criterion ‘overall lead agency’, followed by ‘external funding’. The mean value of the assigned scores in ‘external funding’ for Group 2 countries indicates that virtually all the developing countries have received GEF and other international funding. The mean values in the other criteria are generally low for Group 2.

Table VI also presents the results of independent-sample *t*-tests for the assigned scores between the two groups. It shows that significant differences exist in the assigned scores between the groups for all eight criteria except ‘external funding’. The *t*-value is highest for the criterion ‘institutional arrangements’, followed by ‘domestic funding’, ‘archiving’, and ‘data sharing agreements’, indicating that differences between the groups are most significant for these criteria. On

the other hand, the *t*-value is lowest for ‘external funding’ with a *p*-value above the significance level at 0.05. As mentioned above, virtually all the countries, no matter which Group they belong to, have accessed the GEF and other external funding sources. Although GEF funding has been instrumental to support developing countries in completing and submitting their national reports, this has not made significant differences in terms of frequency of updating national GHG inventories.

The correlations between the scores for one criterion and another were also investigated for 28 pairs of criteria, and the results are presented in Table VII. It was found that the correlations between ‘external funding’ and all the other criteria are weak, with their computed *p*-values above the significance level at 0.05. This suggests that having accessed GEF funding has not necessarily been translated into building capacities that enable updating inventories on a regular basis.

Table VII also shows that all remaining pairs have sufficiently strong positive correlations. The computed *p* values are below 0.05 for all of these pairs, meaning that the correlations are statistically significant. These findings point to the necessity to recognize that factors that enable sustainable national GHG inventory do not exist in isolation. For example, an overall lead agency and sector coordinating agencies are more likely designated, and their roles and responsibilities are more likely defined in countries that received high scores for the criterion of ‘institutional arrangements’. Data sharing agreements are more likely established and inventory information is more likely archived in countries with institutional arrangements as well. In addition, an iterative approach to improving the national GHG inventory system more likely exists in countries with processes to archive inventory information. Besides, such countries tend to have secured domestic funds for national GHG inventory. These findings point to the importance of a holistic approach to develop a sustainable national GHG inventory system.

TABLE VII: CORRELATIONS OF SCORES FOR EIGHT CRITERIA CONCERNING SUSTAINABLE NATIONAL GHG INVENTORY (P-VALUES IN BRACKETS)

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
(A) Institutional arrangements	1							
(B) Overall lead agency	.6764 [.0000]	1						
(C) Sector coordinating agency	.6182 [.0000]	.4881 [.0002]	1					
(D) Data sharing agreements	.5644 [.0000]	.6630 [.0000]	.5570 [.0000]	1				
(E) Archiving	.6648 [.0000]	.5522 [.0000]	.5992 [.0000]	.6049 [.0000]	1			
(F) External funding	.0316 [.8246]	.1815 [.1981]	-.0232 [.8714]	.0072 [.9602]	.1057 [.4558]	1		
(G) Domestic funding	.4317 [.0013]	.4633 [.0005]	.3544 [.0099]	.6094 [.0000]	.4791 [.0003]	-.0422 [.7675]	1	
(H) Continuous improvement	.4610 [.0006]	.5430 [.0000]	.4686 [.0005]	.5628 [.0000]	.5768 [.0000]	.1632 [.2477]	.3941 [.0038]	1

Note: Numbers in *italics* indicate that the correlations are not significant at .05.

## V. DISCUSSION

With increased reporting frequency under the UNFCCC, and motivated by a variety of domestic low-carbon

development objectives, a number of developing countries are seeking to develop a more sustainable and robust national GHG inventory system [6]. The GEF has been an important source of funding to support countries in submitting national

reports to the UNFCCC. However, the needs of developing countries to build a capacity for sustainable national GHG inventory still remain. This suggests that a potential value exists for another type of support, provided on a multi- or bilateral basis, to specifically meet such capacity building needs.

In order to strengthen a country's capacity to periodically and systematically prepare national GHG inventories, for example, the additional support may assist the following activities: (1) examine existing arrangements for preparing national GHG inventories, and assess the current capacity of an overall lead agency, sectoral agencies, and other relevant organisations; (2) recommend ways to improve national GHG inventory arrangements; (3) draft or update a work plan, a guidebook, and/or a checklist for preparing national GHG inventories; (4) draft or update a memorandum of understanding between inventory compilers and data providers to clarify their roles and responsibilities, and a schedule of data provision; (5) develop or update a database to be used for estimating GHG emission and removal; and (6) draft or update a technical document on procedures of inventory compilation.

Alternatively, the support may give more focus to continuous and systematic improvement of technical aspects of national GHG inventories. For instance, the following activities may be assisted: (1) conduct a technical review of the previous inventory, in terms of the methods and assumptions used, as well as availability and appropriateness of activity data, emission factor, and other parameters; (2) identify priority issues to be addressed, and consider potential ways to address each issue; (3) discuss with relevant organisations, such as inventory compilers, data providers, and technical and/or scientific experts, and agree on improvement methods and procedures to address priority issues; (4) develop a GHG inventory improvement plan based on the consensus with relevant organisations; and (5) conduct inventory improvement activities, such as improvement of data coverage and methodologies to be used. Since there is much room for line ministries or agencies to strengthen their own capacities to prepare their respective sector GHG inventories, as aforementioned, the support may focus on particular sectors of priority for recipient countries.

In order to secure funding from the national budget, the support may also include facilitating communications with key policy makers with respect to the importance of national GHG inventory for planning and tracking climate change mitigation policies. It is also important for developing countries to learn good practices from each other, and such opportunities may be supported as well.

As indicated above, there is a range of possible approaches to support for capacity building with regard to national GHG inventory. Whereas GEF funding provides a relatively standardized support aiming at completion of national reports, the additional support should be tailored to context-specific needs and circumstances of recipient countries. In addition, as presented in the previous section, it needs to be recognized that factors that enable sustainable national GHG inventory do not exist in isolation. Instead, they are connected with each other, and therefore a holistic perspective is necessary in designing the additional support.

## VI. CONCLUSION

The future transparency framework outlined in the Paris Agreement and its accompanying Decision 1/CP.21 [11] represents an evolution from the existing transparency system. As discussed by [17], several features of the existing transparency system under the UNFCCC will remain in place, such as an emphasis on reporting of national GHG inventories, and biennial tracking of progress towards climate change mitigation objectives. In the meantime, the future transparency framework is likely to increase the overall frequency and quality of information on GHG emissions and removals. Capacities of developing countries to update national GHG inventories on a regular and sustainable basis, however, have been limited. Capacity building will be, therefore, important if the enhanced transparency framework is to be successfully implemented. As GHG inventories are the foundation for accounting and tracking progress towards mitigation goals, supporting developing countries in achieving a sustainable national GHG inventory system should be given priority.

## APPENDIX

List of countries included in Groups 1 and 2

Group	List of countries (as of April 11, 2017)
Group 1	<p>Non-Annex I countries, excluding LDCs and SIDS, which have submitted a NC three times or more, and whose national reports are available in English:</p> <p>Albania, Armenia, Azerbaijan, Brazil, Chile, Egypt, Georgia, Ghana, Jordan, Kyrgyzstan, Lebanon, Mexico, Namibia, Republic of Korea, Republic of Moldova, Saudi Arabia, Swaziland, The former Yugoslav Republic of Macedonia, Tajikistan, Turkmenistan, United Arab Emirates, Uruguay, Uzbekistan, Zimbabwe</p> <p>Non-Annex I countries, excluding LDCs and SIDS, which have submitted a NC twice and a BUR at least once, and whose national reports are available in English:</p> <p>Bosnia and Herzegovina, China, India, Indonesia, Israel, Malaysia, Montenegro, South Africa, Thailand, Vietnam</p>
Group 2	<p>Other non-Annex I countries, excluding LDCs and SIDS, which have ratified the UNFCCC more than 11 years, and whose national reports are available in English:</p> <p>Botswana, Cameroon, Democratic People's Republic of Korea, Iran, Kazakhstan, Kenya, Kuwait, Mongolia, Nigeria, Oman, Palestine, Pakistan, Philippines, Qatar, San Marino, Serbia, Sri Lanka, Syria</p>

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