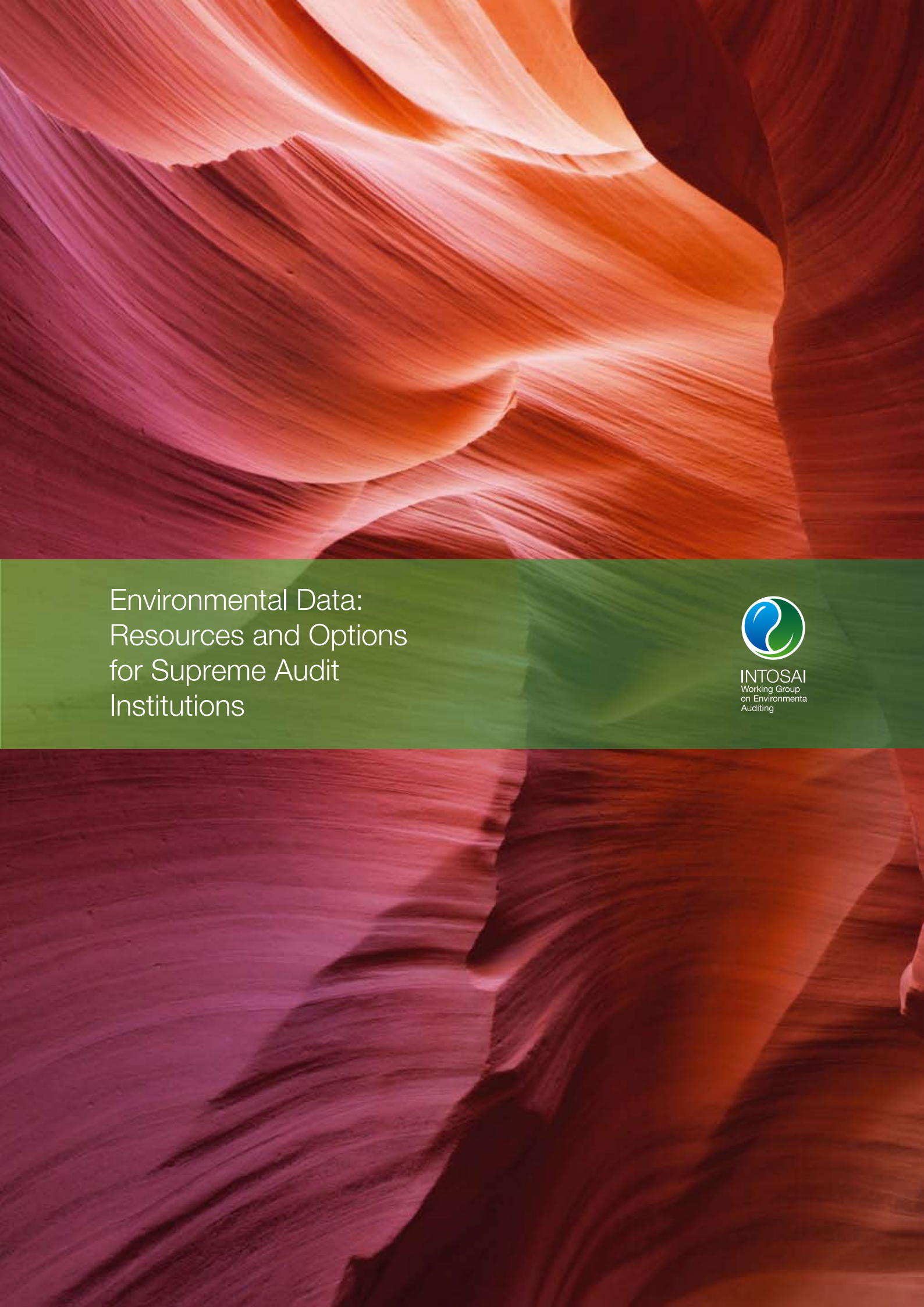

Environmental Data: Resources and Options for Supreme Audit Institutions

INTOSAI
Working Group
on Environmenta
Auditing

This publication was prepared by the INTOSAI Working Group on Environmental Auditing (WGEA). The WGEA aims to encourage the use of audit mandates and audit methods in the field of environmental protection and sustainable development by Supreme Audit Institutions (SAIs). The WGEA has the mandate to

- help SAIs gain a better understanding of environmental auditing issues,
- facilitate exchange of information and experiences among SAIs, and
- publish guidelines and other informative materials.

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FOREWORD & ACKNOWLEDGEMENTS

This research paper was written by the Office of the Auditor General of Canada (OAGC) and the United States (US) Government Accountability Office (GAO) with the assistance of the Botswana Office of the Auditor General, Estonia National Audit Office, Office of the Auditor-General Namibia, New Zealand Office of the Auditor-General, Supreme Audit Office of Poland, and Tanzania National Audit Office.

Collecting and analyzing environmental data is often a critical step in conducting environmental audits. The Working Group on Environmental Auditing (WGEA)'s Sixth Survey on Environmental Auditing revealed that Supreme Audit Institutions (SAIs) conduct an increasing number of environmental audits, and that the most common obstacles to developing and conducting those audits include insufficient data on the environment and insufficient monitoring and reporting systems. The OAGC and GAO agreed to lead the research effort in response to the WGEA Work Plan 2011–2013. The research paper discusses the main ways that SAIs use environmental data; some key sources of environmental data that are available to audit institutions at the global, regional, and other levels, as well as key considerations when using such data; and a variety of tools and methods that audit institutions can use when high-quality environmental data are lacking.

I would like to thank the authors of this research paper, as well as the following institutions for their support in reviewing select sections of this document and providing information that proved to be very helpful as it was developed: State Supreme Audit of Albania; Australia National Audit Office; Chamber of Accounts of the Republic of Azerbaijan; Office of the Comptroller and Auditor General of Bangladesh; Bhutan Royal Audit Authority; Botswana Office of the Auditor General; Brazilian Court of Audit; Bulgaria National Audit Office; National Audit Office of the People's Republic of China; Office of the Comptroller General of the Republic of Colombia; Office of the Comptroller General of Costa Rica; State Audit Office of the Republic of Croatia; Audit Office of the Republic of Cy prus; Supreme Audit Office of the Czech Republic; Denmark National Audit Office;

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Readers are invited and encouraged to consult this paper as well as information on other WGEA products and services at the INTOSAI WGEA website: www.environmental-auditing.org

We hope you will find this document useful.

Auditor General of Estonia
Chair of INTOSAI WGEA

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ACRONYMS & ABBREVIATIONS

EU – European Union
FAO – Food and Agriculture Organization of the United Nations
GAO – United States Government Accountability Office
GHG – greenhouse gases
GIS – geographic information system
GPS – global positioning system
IPCC – Intergovernmental Panel on Climate Change
INTOSAI – International Organization of Supreme Audit Institutions
ISSAI – International Standards of Supreme Audit Institutions
ISO – International Organization for Standardization
NGO – non-governmental organization
OAGC – Office of the Auditor General of Canada
SAI – Supreme Audit Institution
SINTEF – Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology
UK – United Kingdom
UNEP – United Nations Environment Programme
UNFCCC – United Nations Framework Convention on Climate Change
UNSD – United Nations Statistics Division
US – United States
WGEA – Working Group on Environmental Auditing
WHO – World Health Organization
WMO – World Meteorological Organization

EXECUTIVE SUMMARY

Environmental data—systematically collected qualitative or quantitative information about the environment—have become an increasingly important audit tool as Supreme Audit Institutions (SAIs) conduct more environmental audits.[1] However, SAIs have reported that they often face challenges such as insufficient or low-quality environmental data when conducting environmental audits. In response to these challenges, the International Organization of Supreme Audit Institutions (INTOSAI) Working Group on Environmental Auditing (WGEA) Work Plan 2011–2013 [2] identified environmental data as a research topic. This research paper summarizes ways SAIs have used environmental data in audits, key sources of environmental data available to SAIs and key considerations when using such data, and tools and methods SAIs may use when high-quality data are lacking.

Based on our review of audit reports, literature, and questionnaire responses, we found that SAIs have used environmental data across all audit stages—from planning an audit to reporting results. Specifically, SAIs have used environmental data to identify pressing environmental issues to audit and to scope audits effectively; to evaluate the government's program effectiveness, environmental risk management, and environmental data collection and reporting; and to provide context for audit findings that illustrates the significance of the issues.

SAIs have access to a range of national, regional, and global sources of information on the environment, some of which are linked to international standards. Spatial information that cuts across administrative boundaries may also be useful. International statistical agencies have defined key characteristics of high-quality data; however, based in part on international audit standards, SAIs must keep in mind other issues as well. For example, before using environmental data for audits, SAIs should consider whether the quality of the data is sufficient and appropriate for the purpose of the audit. There are a variety of resources available to SAIs to assess the data quality from key sources, such as international data collection standards, and in some cases, data quality assessments specific to a key source. SAIs must carefully consider how they wish to use environmental data and then assess whether the limitations of the data prevent their intended use.

When high-quality environmental data are not available, options still exist for SAIs to plan and conduct audits. For example, SAIs may be able to use related data to estimate unavailable data or develop their own data through a survey. SAIs may also decide that the absence of high-quality data will be a central audit message. SAIs should consider certain factors in deciding which options to pursue, including the quality of alternative data sources, the costs of generating or obtaining data, and the expected use of the data in the audit.

Looking toward the future, we have observed that environmental program managers are using geographic information systems (GIS) more and that SAIs may also be using this technology in auditing. Also some non-governmental organizations and governments are using social networking tools to monitor environmental issues. Such tools and other trends present new opportunities as well as challenges for SAIs that use environmental data in their audits.

[1] For more information on environmental auditing please consult the website for the INTOSAI Working Group on Environmental Auditing at: www.environmental-auditing.org
[2] See the WGEA 10th Steering Committee minutes and the WGEA Work Plan 2011–2013.

1.

INTRODUCTION

Supreme Audit Institutions (SAIs) are conducting more and more environmental audits, according to the Working Group on Environmental Auditing (WGEA)'s Sixth Survey on Environmental Auditing.[3] In this survey, SAIs reported that they often faced data challenges when conducting audits, including insufficient data on the state of the environment and insufficient monitoring and reporting systems. For example, although environmental programs need scientific data to assess environmental conditions, these data often do not exist, are of poor quality, or are not in a readily accessible format. These data challenges can affect a SAI's ability to conduct audits and develop meaningful findings, conclusions, and recommendations.

In response to these concerns, the WGEA Work Plan 2011–2013[4] identified environmental data as a research topic; the Office of the Auditor General of Canada (OAGC) and the United States (US) Government Accountability Office (GAO) agreed to lead the research effort, with subcommittee members from Botswana, Estonia, Namibia, New Zealand, Poland, and Tanzania. The WGEA Work Plan suggests that the research paper identify general tips on and examples of where and how to find data (nationally, regionally, and globally) and explore what have been the most innovative methods that SAIs have used to collect data.

In this section, we describe the objectives, scope, and methods of our research, including a definition of environmental data, and outline how the research paper builds upon related WGEA work (Appendix I). We also explore differences between how program managers and SAIs use environmental data. We then describe responsibilities for producing environmental data and key considerations SAIs should keep in mind when collecting data.

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[3] WGEA, 2010. *The Sixth Survey on Environmental Auditing – 2009.*

[4] See the WGEA 10th Steering Committee minutes and the WGEA Work Plan 2011–2013.

1.1. SCOPE OF RESEARCH PAPER

Objectives.

The key objectives for this research paper are to

- describe the main ways that auditors use environmental data;
- broadly identify key sources of environmental data available to SAIs and key considerations when using such data; and
- identify tools and methods SAIs may use when high-quality environmental data are lacking.

This research paper is intended to provide SAIs with information on and practical examples of how they can identify potential sources of environmental data and use this data in auditing. We rely on case studies to illustrate the experiences of SAIs around the world. The appendices to this paper provide resources for SAIs, including detailed descriptions of case studies mentioned in the body of the research paper and environmental data sources based on key characteristics, such as the environmental topic and geographic region. As an additional companion to this research paper, we created an electronic database of environmental data sources that may be useful to SAIs as they plan and conduct environmental audits. Some of the appendices and databases are not included in full in this paper. They are published separately and only in electronic form on the WGEA website. While the content of this research paper is directed to SAIs, audit organizations at any level may find this information useful.

Definition of Environmental Data

For the purposes of this research paper, we are defining environmental data as systematically collected qualitative or quantitative information about different components of the environment (e.g., air quality, water quality and quantity, natural resources, ecosystems, environmental health impacts) or human activities and sectors that affect the environment (e.g., agriculture, waste, and land development). Our definition encompasses both qualitative data—descriptive, often narrative information that can describe conditions in relative terms—and quantitative data—information expressed as an amount or numerical measure of a particular condition. As noted in the examples throughout this research paper, we found that SAIs can use environmental data in a variety of forms, from relatively unprocessed information such as physical observations, to highly processed information such as output from complex computer models used to predict the future global climate patterns.[5] Environmental data may undergo several steps of processing, depending on the information needs of the user. For example, an audited entity could collect precipitation data from a monitoring station and then analyze it to develop an average annual rainfall statistic. The audited entity could next combine the average annual rainfall statistic with other statistics, such as annual withdrawal rates of ground and surface water to develop a national water quantity indicator.[6] On the basis of our review of audit reports, we also found that SAIs have used environmental data in a variety of formats including narrative or quantitative descriptions, satellite or other photographic images, and maps.

[5] For example, a SAI might use output from an atmosphere-ocean general circulation model as a primary source in an audit evaluating the government's response to climate change risks. See section 4.1.2 for further examples.

[6] As defined by the Food and Agriculture Organization of the United Nations (FAO), "indicators are a measure or a statistical value expressed in a meaningful way that provides an indication of the condition or direction over time of performance of a defined process or achievement of a defined outcome...Indicators enable decision-makers to assess progress towards the achievement of intended outputs, objectives and outcomes." FAO, 2006. *Water Monitoring: Mapping Existing Global Systems and Initiatives,* Stockholm. p.11.

Methods.

To describe the main ways that auditors use environmental data and to identify tools and methods SAIs may use when high-quality data are lacking, we reviewed audit reports identified through WGEA guidance, minutes from meetings, volumes of Greenlines Newsletter, and SAI websites. Using these reports, we identified 97 potential case studies that are relevant to how SAIs use environmental data, along with options to pursue when high-quality data are lacking. With help from our subcommittee members, we contacted other SAIs to find more information and illustrative examples. On the basis of these efforts, we selected 16 case studies to represent a variety of environmental audit types, natural resources, environmental issues, and geographic regions. These case studies capture a mixture of perspectives from developed and developing countries. We limited the scope of our research paper to the selected case studies. These case studies cannot be generalized to all SAIs and do not encompass all possible ways that SAIs can use environmental data or respond to the lack of data. Appendix II provides information about the case study audit reports. The detailed case studies, including how they used environmental data, are available separately in the publications section of the WGEA website.

To identify key sources of environmental data that are available to SAIs and key considerations for SAIs when using environmental data, we reviewed the websites of international organizations, international standards for data collection, relevant data quality assessments, and SAIs' data quality guidance papers. The organizations whose information we reviewed included global organizations such as the United Nations' (UN) Food and Agriculture Organization (FAO), and regional organizations such as the European Environment Agency. We also examined data sources assembled by non-governmental organizations. Finally, we considered the kinds of data sources that may be available at a national level. Appendix III summarizes the approach we took to the search. The detailed results are available separately in the publications section of the WGEA website.

To identify other information and case study examples, we submitted questions for the WGEA Secretariat to distribute to SAIs. We received responses from 37 SAIs, which we reviewed and included in our analysis. We also incorporated comments and information provided by workshop participants during a parallel session at the 14th WGEA Assembly Meeting in November 2011.

1.2. RELATED WGEA WORK

This research paper builds upon the work of several WGEA guidance and research papers. Several of the guidance documents developed by the WGEA recommend identifying the environmental risks or threats as a first step when choosing audit topics. According to the guidance, environmental data can be a valuable tool in identifying such risks. For instance, the 2010 guidance on how SAIs can audit mining practices notes that data can be useful to understand specific country conditions and the main threats associated with the mining life cycle.[7] WGEA research papers have also noted issues with environmental data. In particular, the 2007 WGEA report on Evolution and Trends in Environmental Auditing commented on the ongoing challenge of obtaining and using high-quality environmental data and adequately using the data to support management decisions.[8] This research paper is also closely linked with other WGEA research papers included in its Work Plan 2011–2013:

- Auditing Water Issues: An Update on the Experiences of Supreme Audit Institutions, 2013
- Environment and Sustainability Reporting, 2013
- Integration of Fraud and Corruption Issues into the Auditing of Environmental and Natural Resource Management, 2013

See Appendix I for more information on related WGEA work.

[7] WGEA, 2010. *Auditing Mining, Guidance for Supreme Audit Institutions, p. 36.*

[8] WGEA, 2007. *Evolution and Trends in Environmental Auditing, pp. 48–49.*

1.3. COMPARISONS OF HOW SAIs AND PROGRAM MANAGERS USE ENVIRONMENTAL DATA

As indicated in literature we reviewed and interviews we conducted with program managers, audited entities may generate or use environmental data for a wide range of reasons. One key purpose is to assess how well their programs are working—sometimes this is done by using performance indicators. For example, a manager could evaluate an air quality program by generating data and indicators to compare the air quality in different locations [9] or by examining trends in air quality over time. [10] Program managers may also refer to other established sets of indicators, such as those presented in the UN Environment Programme's Global Environmental Outlook.

Managers can also use data when planning their programs. For example, if they assess the state of the environment, they can then evaluate the need for certain programs, and can estimate the funds needed to achieve program goals. For example, program managers could collect data on the population sizes of species to determine which species are at-risk and then to decide what management action may be needed. [11]

On the basis of our review, we found that program managers also generate or use environmental data for other purposes:

- *Develop predictive environmental models to compare program alternatives.* For example, forestry managers use models to project the future state of forests in terms of the amount of wood that can be harvested, and other desirable values, such as biodiversity.[12] Managers then use these predictions to determine what kind of management interventions, such as tree planting or fire suppression, will be needed to achieve sustainable forests in the future.
- *Monitor and enforce compliance with environmental regulations.*[13] For example, governments that control emissions of ozone-depleting substances may need to limit emissions from their own operations as well as from regulated industries and commercial activities. [14]
Accordingly, program managers may want to generate or collect data about the use of such substances, along with the degree of compliance. Managers could use these data to help plan and direct enforcement resources.

- *Determine the environmental effects from planned projects or from completed or abandoned projects.* For example, constructing or dismantling a dam may affect fisheries upstream and downstream from the dam.[15] Program managers can use measurements of water flow and fish habitat in the environmental assessment process to predict the impact of dam construction.

- *Inform scientific or regulatory decisions.*[16] For example, when evaluating pesticides, regulators may seek information about the toxicity of the pesticides, how they spread in the environment, and which plants and animals may be vulnerable to their use.[17]

Because the primary function of SAIs is government oversight, SAIs often have purposes for environmental data that are related to but distinct from those of program managers, according to the audit reports and literature we reviewed. For example, a program manager might use water quality data to determine what regulatory measures are needed to comply with an international agreement governing a shared water resource. However, an auditor might use the same data to determine the extent to which the government had taken steps to ensure compliance, and so might focus on the success of enforcement measures. Exhibit 1 provides additional examples of distinctions between program managers' and SAIs' use of data (see also section 2 of this research paper).

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[9] See the World Health Organization website, http://www.who.int/phe/health_topics/outdoorair/databases/en/index.html (accessed 1 February 2012), which compares the results across over 1,000 cities worldwide.
[10] See, for example, the evaluation of the air quality programs in the UK: http://uk-air.defra.gov.uk/library/annualreport (accessed 6 February 2012).
[11] See, for example, http://www.fws.gov/endangered/improving_ESA/listing_workplan.html (accessed 18 January 2012).
[12] See the FAO definition of sustainable forest management http://www.fao.org/forestry/sfm/24447/en/ (accessed 16 January 2012).
[13] See WGEA, 2004. *Environmental Audit and Regularity Auditing, p. 14.*
[14] See, for example, the European Commission's website: http://ec.europa.eu/clima/policies/ozone/index_en.html (accessed 18 January 2012).
[15] See the FAO description of these impacts http://www.fao.org/DOCREP/004/Y2785E/y2785e03.htm (accessed 16 January 2012).
[16] See, for example, the publications of the International Agency for Research on Cancer: http://www.iarc.fr/en/publications/list/monographs (accessed 16 January 2012).
[17] See, for example, the description of pesticide registration requirements from Indonesia

Exhibit 1: Examples of Distinctions Between How Program Managers and SAIs Use Environmental Data

Environmental program function	How program managers use data	How SAIs use data
Assess environmental risks and develop approaches to manage risks from environmental emergencies, such as oil spills	Determine the risks and potential risk management strategies linked to different environmental issues	Determine whether the government properly assessed and managed environmental risks
Manage long-term environmental liabilities, such as nuclear contaminated sites	Identify contaminated sites and manage their associated risks	Determine the extent to which the environmental program is identifying and managing contaminated sites in a timely and effective manner
Monitor and report on environmental quality	Assess the quality of natural resources	Determine whether the government has appropriate mechanisms in place to measure and report environmental quality conditions

Section 3 of this research paper describes how the original purpose of the data and the possible use of the data by SAIs will affect their decisions about whether to use a particular data source in the audit.

1.4. RESPONSIBILITIES FOR PRODUCING ENVIRONMENTAL DATA

As illustrated by international auditing standards and the audit examples we considered, audited entities are generally responsible for generating or collecting environmental data that relates to their own programs. The production and appropriate use of environmental data may be viewed as part of the internal control systems of audited entities since this use is part of how program managers ensure their programs are working as planned. The INTOSAI International Standards for Supreme Audit Institutions note:

> It is the responsibility of the audited entity to develop adequate internal control systems to protect its resources. It is not the auditor's responsibility. It is also the obligation of the audited entity to ensure that controls are in place and functioning to help ensure that applicable statutes and regulations are complied with, and that probity and propriety are observed in decision making. However, this does not relieve the auditor from submitting proposals and recommendations to the audited entity where controls are found to be inadequate or missing.[18]

On the basis of the audit reports we reviewed, we found that internal audit and evaluation functions may also be seen as part of audited entities' internal control systems. These internal systems are used to determine if programs are achieving their intended goals and objectives.[19] In such cases, the role of SAIs is to complement these internal functions.[20]

If the audited entities have high-quality information and are tracking their performance and program results, SAIs may be able to use the audited entities' environmental data. However, SAIs would need to evaluate whether the information is appropriate as the basis for findings (see section 3.2).

[18] INTOSAI, 2001. *Basic Principles in Government Auditing: ISSAI 100, p.6.*
[19] See, for example, http://www.oag-bvg.gc.ca/internet/English/parl_oag_201106_03_e_35371.html#hd3b, paragraphs 3.1 and 3.2 (accessed 18 January 2012).
[20] See, for example, ISSAI INTOSAI GOV 9150, *Coordination and Cooperation between SAIs and Internal Auditors in the Public Sector.*

2.

MAIN WAYS THAT SAIs USE ENVIRONMENTAL DATA IN AUDITS

On the basis of our review of audit reports and SAI questionnaire responses, we found that SAIs have used environmental data to

- plan audits, including selecting topics, samples or case studies;
- conduct audits, including assessing how well governments manage programs, environmental risks, and environmental data; and
- provide context for audit findings and recommendations.

As illustrated in the case studies that follow, SAIs have examined a variety of natural resources and environmental topics, using environmental data ranging from highly technical and computer-generated data to relatively simple data, such as physical observations.

2.1. USING ENVIRONMENTAL DATA TO PLAN AUDITS

Some SAIs have used environmental data to identify potential audit topics or to modify the audit's scope based on the data available. We found several examples of SAIs using environmental data to identify audit topics. For example, the SAI of Honduras used environmental data to identify areas of high environmental concern for future audits and to determine where its work would have the maximum impact.[21] The SAI of Cyprus decided to audit its government's system for protecting drinking water supplies based on data indicating poor drinking water quality,[22] and the SAI of Slovenia chose to audit waste management programs after reviewing data on the amount of recycled municipal waste that did not meet national and European Union (EU) waste targets.[23] Similarly, the SAI of Azerbaijan decided to audit national forest management practices based in part on its review of environmental data on the location and size of forests, funds allocated for forest rehabilitation, and sanctions for violating forest management legislation.[24]

SAIs have also modified the topics and scope of their audits based on environmental data. For example, the SAI of Bhutan found that the data it needed on drinking water quality tests were unreliable; in response, the SAI adjusted its audit scope.[25] In another instance, the SAI of Bulgaria narrowed the scope of its audit on climate change adaptation measures by analyzing data on precipitation levels, river volumes, and average temperatures to determine the severity of climate change issues and select affected regions to study.[26] The case studies below further illustrate how SAIs have used environmental data to identify audit topics and modify audit scope.

Case Study 1—Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine

In a 2011 joint audit, the SAIs of Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine used environmental data to select the audit objectives covered in their report entitled Joint Report on the Results of the Coordinated Parallel Audit on Protection of the Black Sea against Pollution. Specifically, the SAIs decided to investigate marine pollution in the Black Sea based on their review of environmental data documenting the depletion of marine resources. The SAIs also used environmental data to refine the audit's scope. For example, the SAIs selected a sample of coastal cities for site visits by assessing the cities' level of risk, based on waste volume and the condition of their sewage systems. Findings relevant to environmental data include these:

- nitrogen and phosphorous pollution from agricultural, domestic, and industrial sources is the main challenge in the Black Sea;
- countries bordering the Black Sea have established an environmental monitoring system to collect data, but limited funding for this system adversely affects the quality and quantity of environmental data that is available to manage monitoring duties effectively; and
- data collected by countries are not always comparable, due to differences in national standards across the region, which create gaps in the availability and reporting of data that impede the region's ability to achieve its pollution reduction targets.

The SAIs recommended that the coastal countries should (1) increase the number of waste water treatment plants and the level of treatment to reduce pollutants; (2) increase efforts to reduce illegal dumping; and (3) harmonize monitoring programs and standardize sampling procedures. The SAIs also recommended that the Black Sea Commission develop data quality assurance and quality control procedures for all the data and information on its activities.

[21] Response of the SAI of Honduras to the questionnaire distributed by the WGEA Secretariat.
[22] Audit Office of the Republic of Cyprus, 2009. *Water Quality and Quantity Management.*
[23] Response of the SAI of Slovenia to the questionnaire distributed by the WGEA Secretariat. Also see Court of Audit of the Republic of Slovenia, 2010. *Managing Municipal Waste.*
[24] Response of the SAI of Azerbaijan to the questionnaire distributed by the WGEA Secretariat. Also see Chamber of Accounts of the Republic of Azerbaijan, 2008. *Audit of the Formation and Effective and Assigned Use of Proceeds in the Forest Preservation and Reproduction Fund.*
[25] Bhutan Royal Audit Authority, 2011. *Drinking Water Supply and Sanitation Audit.*
[26] Response of the SAI of Bulgaria to the questionnaire distributed by the WGEA Secretariat.

Case Study 2—New Zealand

The SAI of New Zealand used data on geographic and water-related factors affecting drinking water demand to select a sample of eight local authorities as case studies for its 2010 audit entitled *Local Authorities: Planning to Meet the Forecast Demand for Drinking Water.* The data supported the audit's determinations that

- some local water authorities had not effectively managed supplies of drinking water and did not expect to meet the forecasted demand for drinking water;
- some of the local authorities did not have the high-quality data they needed to prepare reliable demand forecasts and measure demand for drinking water; and
- small authorities, because of their size, faced greater challenges than other authorities in managing future demand for water services.

The SAI recommended, among other things, that local water authorities use accurate and up-to-date information to prepare forecasts for drinking water demand, and verify the reliability of these forecasts. Following the audit, two of the local authorities reviewed made changes such as upgrading a main water supply system treatment plant and installing water meters that, according to the SAI, will improve how the authorities monitor, manage, and predict water demand.

2.2. USING ENVIRONMENTAL DATA TO CONDUCT AUDITS

We found that, when conducting audits, SAIs have used environmental data

- to assess the progress of environmental programs toward targets and goals, including compliance with laws and treaty obligations;
- to evaluate practices for assessing and managing environmental risks, including risks arising from environmental emergencies such as toxic waste spills; and
- to evaluate government practices for managing environmental data, including data collection and reporting, and to develop findings on how inadequately managed data affect government programs.

2.2.1. ASSESSING GOVERNMENT PROGRESS AGAINST TARGETS AND GOALS

SAIs have used environmental data to measure progress toward the goals of national environmental programs. For example, the SAI of China used water quality data and environmental statistics to determine the effects of local government programs on water pollution and to evaluate local authorities' implementation of national environmental policies.[27] The SAI of Costa Rica assessed the benefits of a national conservation program by working with experts to develop audit-specific environmental indicators to determine the program's effect on conservation efforts over time.[28] The SAI of Canada used data from environmental management plans to assess whether program managers who are responsible for federal protected areas for wildlife had met their management plan targets for those areas.[29]

[27] Response from the SAI of China to the questionnaire distributed by the WGEA Secretariat. See also, National Audit Office of the People's Republic of China, 2008. *Water Pollution Prevention Performance Audit of Three Lakes and Rivers.*
[28] Office of the Comptroller General of Costa Rica, 2011. *Evaluation on the Effects of the Payment for Environmental Services Program Implemented by the Government of Costa Rica,* DFOE-AE-08-2011.
[29] Office of the Auditor General of Canada, 2008. *Status Report of the Commissioner of the Environment and Sustainable Development: Chapter 4 – Federal Protected Areas for Wildlife.*

SAIs have also used environmental data to assess how well governments have complied with environmental laws and treaty obligations. For example, the SAI of the United Kingdom (UK) used data on municipal waste and waste infrastructure projects to assess whether the UK government met its EU waste obligations.[30] The SAI of Canada used data estimating greenhouse gas (GHG) emissions to assess whether the government met targets established by the Kyoto Protocol,[31] and the SAI of Estonia examined whether government entities collected data on greenhouse gases as required by the EU and UN.[32]

SAIs have also used data to measure compliance at the national level, such as when the SAI of India used data measuring air and water pollutants to determine whether the government enforced national environmental quality standards for ports and marinas.[33] In another case, the SAI of Saudi Arabia used data on chemical and industrial waste to assess how well petrochemical companies complied with national environmental laws.[34] The case studies below further illustrate how SAIs can use environmental data to evaluate how effective programs are and how well governments comply with environmental laws.

Case Study 3—Bhutan

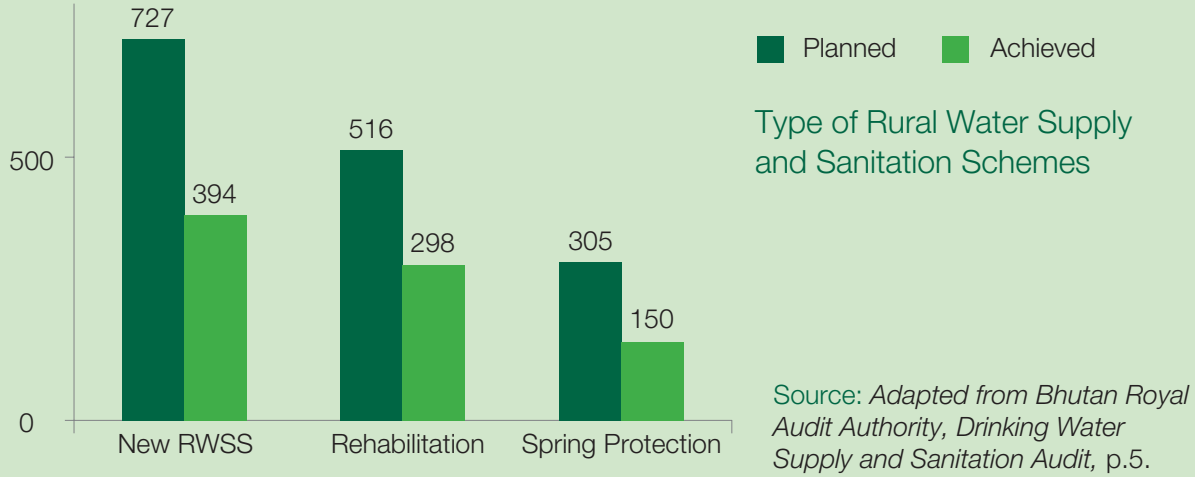
In a 2011 report from the SAI of Bhutan, entitled Drinking Water Supply and Sanitation Audit, the SAI used environmental data on the government's management processes and project delivery in 14 districts and 6 municipalities to assess whether the government managed rural water supply and sanitation projects adequately and efficiently. The SAI physically observed the state of latrines and other sanitation projects (called schemes); analyzed available data on how planned schemes were implemented and how accurate preliminary surveys of water resources were; and reviewed water quality tests and monitoring records.

From its analysis, the SAI found that

- the ministry did not adequately maintain the infrastructure or monitor water quality as required by law. For example, ministry data showed that over a quarter of the schemes were low functioning or non-functional;
- the entity within the ministry charged with implementing the schemes did not properly plan and prioritize them, which the SAI concluded could result in higher costs and a shift of benefits away from the communities included in the original plans (Exhibit 2); and
- inconsistencies existed in how the ministry planned and surveyed areas before constructing the schemes, such as measuring water resources during the rainy season as opposed to during drier months, which resulted in inaccurate measurements.

The SAI recommended, among other things, that the ministry put in place targets and performance measures, including national water quality standards, and analyze performance data on a timely basis. The SAI also recommended that the ministry monitor and physically inspect the schemes routinely, and maintain information management systems.

Exhibit 2: Planned and Implemented Rural Water Supply and Sanitation Schemes in Bhutan



Source: *Adapted from Bhutan Royal Audit Authority, Drinking Water Supply and Sanitation Audit,* p.5.

[30] National Audit Office of the United Kingdom, 2009. *Department for Environment, Food and Rural Affairs: Managing the Waste PFI Programme.*
[31] Office of the Auditor General of Canada, 2009. *Report of the Commissioner of the Environment and Sustainable Development: Chapter 2 – Kyoto Protocol Implementation Act.*
[32] Estonia National Audit Office, 2009. *State's Efforts in Reducing Greenhouse Gas Emissions.*
[33] Office of the Comptroller and Auditor General of India, 2006. *Environmental Management by Mumbai Port Trust.*
[34] Response from the SAI of Saudi Arabia to the questionnaire distributed by the WGEA Secretariat.

Case Study 4—Colombia

In a 2008 report entitled Environmental Management of Mining Activities: Carbon and Gravel at Carmen De Carupa, Cucunuba, Guacheta and Sutatausa Municipalities, the SAI of Colombia assessed water quality from selected mines to determine whether the mines contaminated the water and whether they complied with national environmental standards. Besides analyzing environmental data, the SAI physically inspected more than 27 mines to check on current conditions.

Based on its analysis, the SAI found that

- mining activities were negatively affecting drinking and agricultural water supplies in violation of environmental laws;
- mining activities had altered the course and volume of water and aquatic life due to increased sediment, changes in the water's pH levels, and introduction of chemical pollutants, all of which exceed the maximum levels permitted by law; and
- there was a loss of vegetation cover due to erosion and a lack of reforestation.

The SAI did not provide recommendations in its audit but conducted a follow-up report in 2010 on the environmental impacts of mining. The SAI is conducting another audit on illegal mining.

2.2.2. EVALUATING GOVERNMENT PRACTICES FOR ASSESSING AND MANAGING ENVIRONMENTAL RISKS

SAIs have used environmental data to assess a government's knowledge of environmental risks and monitoring capabilities. For example, the SAI of Canada reviewed databases of incident reports on oil and chemical spills from ships to evaluate whether government databases contained the complete and reliable information that the government needed to plan its response effectively.[35] SAIs also sample data to determine how governments manage environmental degradation. For example, the SAI of Latvia sampled data on the government's efforts to prevent and respond to forest and marine damage to assess whether the government managed those liabilities sufficiently.[36]

Environmental data can also help evaluate how government entities manage environmental risks, such as those linked to hazardous waste. For example, the SAI of the US evaluated how the US government managed the rising costs of hazardous waste clean-up by reviewing government data on the rehabilitation of contaminated sites.[37] SAIs have also used environmental data to evaluate how well a government prepares for and responds to environmental emergencies and manages the related financial costs. For example, the SAI of Norway used data from government flood and landslide risk maps to determine whether local authorities had access to the maps when developing and implementing national objectives on floods and landslides.[38]

The case studies below further demonstrate how SAIs have used environmental data to evaluate government entities' emergency and risk management.

[35] Office of the Auditor General of Canada, 2010. *Report of the Commissioner of the Environment and Sustainable Development: Chapter 1 – Oil Spills from Ships.*
[36] State Audit Office of the Republic of Latvia, 2010. *Compliance of the Administration of Compensation of Losses Cause to the Environment with the Provisions of Regulatory Enactments and the Effectiveness of Loss Compensation.*
[37] US Government Accountability Office, 2010. *Superfund: EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites Are Expected to Be Added to the National Priorities List,* GAO-10-380.
[38] Office of the Auditor General of Norway, 2010. *The Office of the Auditor General's Investigation into the Efforts of the Authorities to Limit Flood and Landslide Hazards.*

Case Study 5—Tanzania

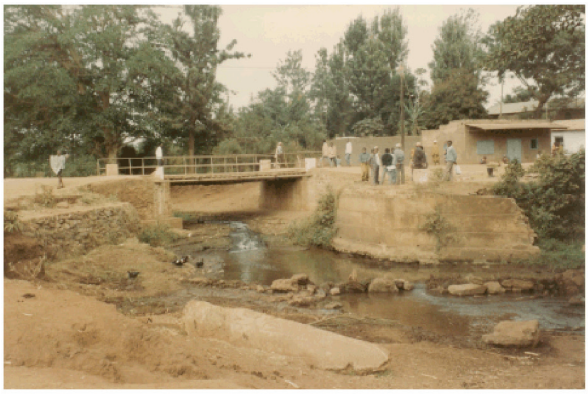
In the 2007 report *A Performance Audit of the Management of Prevention and Mitigation of Floods at Central, Regional and Local Levels of the Government of Tanzania: A Case Study of Floods in Babati,* the SAI of Tanzania analyzed government data and photographs of flooded areas and flood prevention structures from the 1990s and 2000s, and combined them with site visits, to evaluate government responses to flood emergencies and management over time.

The SAI found that

- the government lacked effective disaster management and planning. For example, poorly maintained flood prevention structures created a high risk of damage from future floods; and
- the government's tree planting program was ineffective because inhabitants of the areas cut down the trees for firewood, and cattle ate the seedlings.

The SAI recommended that the government design flood prevention structures to account for the likelihood of increased flood risks and complete their construction in a timely manner, and that the government entity consult with engineers and include lessons learned from previous floods. The SAI also recommended, among other things, that local town planners consider flood risks when allocating land and ensure that preventive structures and measures are installed in flood-prone areas.

Exhibit 3: Impact of Flooding on the Mrara Bridge



Source: Tanzania National Audit Office.

To the left are the remains of the Mrara Bridge after floods in 1990 washed it away. To the right is a picture of the same place a few months later depicting pieces of concrete from the original bridge in the foreground and the remaining abutment of Mrara bridge to the right. In the background is the temporary bridge.

Case Study 6—Australia

In its 2010 report *Administration of Climate Change Programs,* the SAI of Australia used environmental data to evaluate how well government agencies assessed and managed programmatic risks for five grant programs designed to reduce greenhouse gas emissions and promote renewable energy technologies. Among other things, the SAI reviewed data on the structure and implementation of the programs, including their objectives and risk assessments, their application processes, and the government's measurements and reporting on outcomes.

On the basis of the data, the SAI found that

- some grant programs lacked clear and measurable objectives, merit-based assessments of the grant applications, and performance measurement and reporting;
- officials managing one program did not adequately anticipate the foreseeable risk of high demand for photovoltaic systems offered by the program in certain types of buildings; and
- some grant programs lacked risk assessments or did not develop strategies to mitigate identified risks, some of which were observed. In the case of one program, the government did not anticipate receiving an insufficient number of grant proposals that met the program's criteria, which was a risk it could have identified by consulting with industry on potential grant applicants.

The SAI recommended, among other things, that the agencies: (1) identify and manage risk through the lifecycle of a program; (2) assess and select projects that make efficient use of financial resources and meet program objectives and criteria; and (3) monitor project performance and report on whether program objectives are being achieved. The government made significant changes to the programs following the audit, including terminating some programs and completely changing the delivery mode in others.

2.2.3. EVALUATING GOVERNMENT PRACTICES FOR MANAGING ENVIRONMENTAL DATA

In some cases, SAIs will not use environmental data directly themselves, but will examine the quality or quantity of the data that managers generate, and study how the data are produced and managed. Using this approach, SAIs can assess the quality of information that is available to managers for program-related decisions. For example, the SAI of Bulgaria analyzed the quality of monitoring data entered into the international Black Sea Monitoring System, and found that the government did not systematically collect water samples as required.[39] Similarly, the SAI of Uganda examined the quality of government monitoring data on the disposal of medical waste to determine if data quality affected the government's management of a waste disposal program.[40] In another example, the SAI of Switzerland examined the quality of the government's methods for calculating greenhouse gas emissions by comparing calculations of national air pollution with those of neighbouring governments.[41] The case studies below illustrate how SAIs have used environmental data to evaluate how well government entities manage this type of data and to study the potential effects of low-quality data on effective program management.

[39] Accounting Chamber of Ukraine, Bulgaria National Audit Office, Chamber of Control of Georgia, Romanian Court of Accounts, Accounts Chamber of the Russian Federation, Turkish Court of Accounts, 2011. *Joint Report on the Results of the Coordinated Parallel Audit on Protection of the Black Sea against Pollution.*
[40] Office of the Auditor General of Uganda, 2005. *Management of Medical Waste in Selected Government Hospitals 2005.*
[41] Swiss Federal Audit Office, 2008. *Combating Air Pollution: Evaluation of the Steering Tax on Volatile Organic Compounds (VOC).*

Case Study 7—Botswana

In a 2005 report entitled Performance Audit Report on Fishing Industry in Botswana by Fisheries Division – Department of Wildlife and National Parks, the SAI of Botswana examined data on fishing activities from monthly and quarterly fishing reports and visited program areas to determine (1) the extent to which the Fisheries Division collected information to devise long-term management plans for fisheries; (2) whether the Division measured results achieved from programs protecting fish and the environment; and (3) the extent to which the Division conducted monitoring and inspection activities.
From its analysis of the fishing report data, the SAI found that the lack of data negatively affected the Division's ability to manage its fisheries effectively. For example

- the form for recording daily fish catches did not provide enough detail of fishermen's operations, and fishermen did not accurately report the weight of their catches;
- the government did not collect an adequate number of forms because it was unable to access or identify fishing areas;
- the government had not assessed current fish stocks to develop a long-term management and sustainable use strategy;
- the government had not developed a fisheries database, and the data it used were incomplete (e.g., the government did not have an inventory to systematically monitor fish stocks); and
- the government did not use consistent reporting formats for all areas, and its annual reports did not have sufficient information to evaluate the effectiveness of the fish management programs.

The SAI made several recommendations, including that the government (1) develop an alternative method to improve quality of data by increasing inspections, (2) develop mechanisms to track and report on sustainable use of fish resources, and (3) develop and maintain a consolidated inventory of fish species.

Case Study 8—Netherlands

In a 2006 report entitled National Ecological Network, the SAI of the Netherlands reviewed the government's management of data on efforts to protect biodiversity by linking together nature areas, known as the national ecological network. The SAI assessed whether the network had performance objectives, assessed whether its progress could be monitored, and evaluated how well networks were implemented to date.
The SAI found that a lack of quality data affected the implementation of the national ecological network. For example

- the government's data for monitoring network progress were incomplete, unreliable, and inconsistent;
- the government used a number of inconsistent measuring and monitoring systems (e.g., data on the network's size varied due to different definitions and calculation methods); and
- the government departments involved did not agree on the division of monitoring and reporting responsibilities and did not have information on data quality.

The SAI recommended that the government develop an integrated plan of environmental quality targets and closely monitor their progress, and that the government develop a policy framework and implementation plans.

2.3. USING ENVIRONMENTAL DATA TO PROVIDE CONTEXT FOR AUDIT FINDINGS

SAIs have used environmental data to provide context for and highlight audit findings, such as the impacts of program weaknesses. For example, the SAI of Estonia used environmental data describing the waste and pollution reduction benefits of recycling programs to highlight the importance of recycling as an issue.[42] Photographs can provide visual data that illustrate the effects of poor program management. [43] For example, the SAI of Botswana photographed medical waste sites to show poor management of hospital waste.[44]

SAIs have also used environmental data describing the relative performance of other governments to provide context for audit results. For example, as shown in Exhibit 4, several European SAIs, in a joint audit led by Denmark, used data on implementation of controls on waste from ships to compare compliance among their respective governments.

Exhibit 4: National Contingency Plan Status

Source: Coordinated Parallel Audit, *Joint Final Report on II Audit of Implementation of Provisions of the Convention on the Protection of the Marine Environment of the Baltic Sea Area (The Helsinki Convention): Pollution from Ships in the Baltic Sea,* January 2005.

The case study below further illustrates how SAIs can use environmental data to provide context for and describe the significance of audit findings.

Case Study 9—Turkey

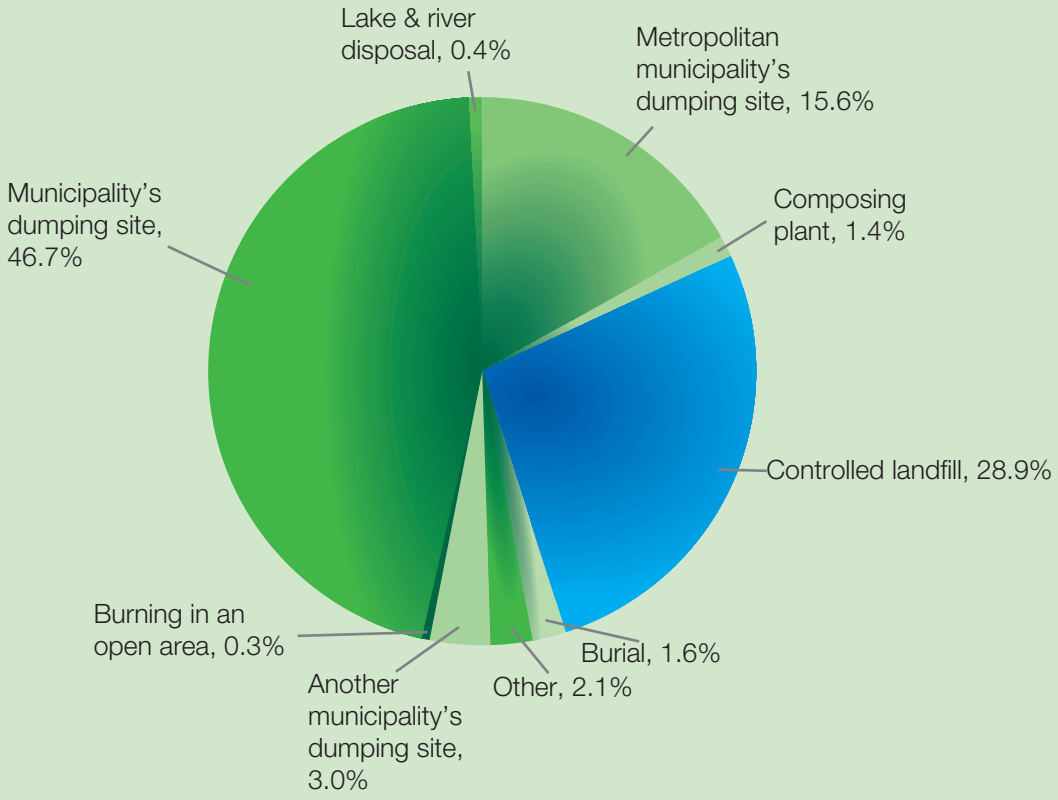
In a 2007 report, *Waste Management in Turkey: National Regulations and Evaluation of Implementation Results,* the SAI of Turkey used environmental data to illustrate, among other things, the importance of the government's waste management efforts. Specifically, the SAI reported that each person, on average, produced waste nearly 10 times his or her weight every year. The SAI also used data on the number and capacity of sanitary landfills to show that a lower percentage of Turkey's waste was dumped into these controlled landfills than into illegal areas, such as natural spaces and municipalities' dumping sites. To describe the magnitude of the issue of hazardous waste, the SAI reported data on the quantity of hazardous waste that was illegally incinerated or dumped in landfills each year. Such examples frame the issue of waste management for the reader and provide context. From these data, the SAI found that

- more than half the hazardous waste went to landfills or illegal dumping grounds, instead of being properly disposed of at a dedicated hazardous waste facility;
- most municipalities did not deliver solid waste services, and they properly disposed of 28.9 percent of collected
- the government lacked data on waste and on the environmental impacts of certain types of waste, among other things.

42 Estonia National Audit Office, 2010. *Effectiveness of Collection and Recovery of Packaging Waste.*
43 For the purposes of this research paper, photographs meet our definition of environmental data when they are systematically collected. For example, photographs taken over a period of time can track the progress of government entities on environmental projects, such as waste clean-up or disaster response. See the case study from the SAI of Uganda in Section 2.2.2 as an example of using historical photographs to audit flood response and prevention efforts.
44 Botswana Office of the Auditor General, 2007. *Clinical Waste Management at the Referral Hospitals: Princess Marina, Nyangabgwe and Lobatse Mental Hospital.*

The SAI recommended that the government (1) establish waste disposal systems to ensure that private entities producing hazardous waste properly manage that waste and its associated liabilities; (2) strengthen municipalities' financial, institutional, and technical capacities by creating model waste management units and determining standards; and (3) prepare guides and standardize training on license and permit procedures, as well as on managing data collection, recording, and sharing.

Exhibit 5: Solid Waste Disposal Methods in Turkey



Source: Adapted from Turkish Statistical Institute courtesy of the Turkish Court of Accounts.

3.

SOURCES OF ENVIRONMENTAL DATA FOR SAIs AND RELATED KEY CONSIDERATIONS

As discussed in the previous section, SAIs may use different kinds of environmental data in doing their work, drawing on information from a wide variety of sources. This section describes and categorizes into four groups some of the sources of environmental data available to SAIs; the groups are national, regional, global and spatial sources. It also summarizes the results of a search we conducted to identify sources that may be useful for SAIs. SAIs may use the information from these sources to complement data coming from the audited entity. Recognizing that SAIs also need access to information about data quality for any source they use, this section also describes and discusses relevant international standards for environmental data collection as well as data quality assessments that are publicly available.

3.1. KEY SOURCES OF ENVIRONMENTAL DATA AVAILABLE TO SAIs

SAIs may draw on different environmental data sources, depending, in part, on the way they plan to use the data. On the basis of our review of the different kinds of data sources and how SAIs have used them, we have distinguished four categories of data sources based on the geographic scale that applies, with different possible uses of the data identified in each category:

- **National** data sources provide information on the characteristics of a single country. Such data sources include the data that auditors would normally obtain from audited entities but could also include data from other entities. For example, national statistical agencies may collect data about the industries that are subject to environmental regulations.
- **Regional** data sources provide environmental data for a specified geographic region or economic-political association. Such data sources may be based on geophysical or ecosystem divisions, such as countries that border a single body of water (e.g. the Caribbean), and are usually aggregated from national sources. SAIs may use regional data sources when conducting transboundary co-operative audits if certain issues cross national boundaries. SAIs can also use such sources to compare the performance of a given country with that of its neighbours.
- **Global** data sources provide data covering most of the world, usually separated by country. If environmental issues touch countries in several parts of the world, SAIs may find that global data sources are the most useful as a point of comparison. Examples of such global issues include climate change, control of ozone-depleting substances, and regulation of persistent organic pollutants.
- **Spatial** data, also called geospatial data or geographic information, describe the distribution of phenomena on the surface of the earth.[45] Such data are usually not aggregated to a single national average value, which means that SAIs can use such data to identify specific geographic locations within a country where environmental problems are most severe. Spatial data may be reported in national, regional, or global data sources.

We describe each of these data sources in more detail below. Appendix III lists 56 data sources we identified that SAIs may be able to use in searching for environmental data, with an emphasis on global and regional sources. (The details of these data sources are available separately in the publications section of the WGEA website.) Some examples from the results of the search are given in Exhibit 6, illustrating the variety of information available to SAIs. Several of the sources are portals, giving access to many other individual databases.

Exhibit 6 – Examples of Sources of Environmental Data

- The GEMStat data source is designed to share surface and ground water quality data sets collected from the GEMS/Water Global Network, including more than 3,700 stations, close to 4.3 million records, and over 100 parameters.
- The Global Biodiversity Information Facility provides access to over 300 million data records, many with geographic coordinates, giving information about different species around the world. The data can be searched by species, by country, or by database.
- The International Tanker Owners Pollution Federation summarizes the number and locations and sizes of accidental oil spills from ships. The data go back to 1970 and provide a global perspective.
- The Environmental Performance Index ranks 163 countries on 25 performance indicators tracked across 10 policy categories, covering both environmental public health and ecosystem vitality.
- The Emergency Events Database contains essential core data on the occurrence and effects of over 18,000 mass disasters in the world from 1900 to present.

[45] See the United Nations Environment Programme and International Institute for Sustainable Development Training Manual for Integrated Environmental Assessment.

3.1.1. NATIONAL DATA SOURCES

As part of our research, we sent a questionnaire to SAIs through the WGEA Secretariat asking what sources of environmental data they relied on and for what purposes.[46] On the basis of the results of this questionnaire and our review of environmental audits, we noted that SAIs often rely on national data sources. The key sources tend to be data that audited entities generate directly and use in program management. Depending on the audit, SAIs may also find it valuable to consider relevant information that is available from other national government entities, such as related departments or ministries. For example, departments of public health may have data on water-borne diseases, [47] or statistical agencies may have data on particular economic sectors.[48]

Using such sources may help give a more complete view of the environmental issue, if the audited entity has a limited mandate or if its responsibilities are shared with other departments. However, SAIs may find it difficult to use data from other entities if the data from various sources are defined and collected using different conceptual frameworks. For example, industry departments might classify corporations based on the number of employees,[49] whereas an environment department might classify them by the type of pollution they generate.[50] Some of the key entities that may have information relevant to a given environmental issue are natural resource departments, that is, those entities responsible for land management, agriculture, forestry, and fisheries.[51]

National statistical agencies may also produce environmental data. There may be advantages to using these data because statistical agencies are politically independent and place a high priority on quality control.

As noted during a WGEA workshop, [52] SAIs may find it useful to consider information from other levels of government, such as regions or municipalities within the country, court records (which have the advantage of being subject to independent tests for accuracy), and media reports (which may help identify criticisms of the audited entity).

In some cases, SAIs may obtain national information from third-party non-government sources, such as industry, academic institutions, specialized consultants, or environmental non-governmental organizations (NGOs). Each of these sources has its own potential strengths and weaknesses. For example, academic researchers may have data covering only the span of their research project. SAIs may also need to consider the potential for biases of some third parties.

With non-government sources, the SAI's ability to obtain access to data may be limited.

The availability of data in electronic form is particularly important for environmental data, especially when combining the data with spatial information (see section 3.1.4 below), however SAIs may find that relevant national data sources are not available digitally. For example, land use maps and aerial photos, video recordings, and physical samples (e.g. for water quality) are a few of the data sources that may not be digitized.

By drawing on multiple data sources, SAIs can compare information to determine if data are consistent. For example, the SAI of Brazil examined the systems used to control the movement of forest products in that country, highlighting inconsistencies between different systems and a risk of fraud.[53]

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[46] During the summer of 2011, the WGEA Secretariat distributed a questionnaire to SAIs. A total of 37 responses
[47] See, for example, as a consolidation of national statistics: http://www.wssinfo.org/ (accessed 6 February 2012).
[48] As an example see the summary from the Australian Bureau of Statistics: http://www.abs.gov.au/websitedbs/c311215.nsf/22b99697d1e47ad8ca2568e30008e1bc/28fc9c0e90001f0aca2576c70021f6e0!OpenDocument (accessed 6 February 2012).
[49] For example, to determine if they are small, medium or large corporations.
[50] For example, to identify which corporations will be subject to specific regulations regarding toxic substances.
[51] The division of responsibilities among departments will vary by national government. This list is intended to include those that might have the most direct connection to environmental management.
[52] Parallel session on environmental data research project in Buenos Aires, 10 November 2011.
[53] Response from the SAI of Brazil to the questionnaire distributed by the WGEA Secretariat.

3.1.2. REGIONAL DATA SOURCES

SAIs can get regional environmental data from a variety of public and private sources. Environmental data may be collected and organized based on formal or voluntary political or economic associations. For example, the Organization of American States, a voluntary political organization of 35 independent states, has established a Department of Sustainable Development. The department publishes information on several common environment and natural resource issues in the western hemisphere. In contrast, the Organization for Economic Co-operation and Development (OECD) is an economic organization of 31 countries from various geographic regions. The OECD Environmental Data Compendium provides harmonized data on how economic activity affects the environment. [54]

International organizations have also created some regional data sources. For example, the United Nations Environment Programme (UNEP) launched the Regional Seas Programme in 1974, partly to address the need for "sound environmental management to be coordinated and implemented by countries sharing a common body of water." [55] Currently, 143 countries participate in 13 Regional Seas programs under UNEP. As the coordinator of the programs, UNEP takes the lead for publishing environmental assessments and reports. These include the Regional Seas Reports and Studies series, which may provide data for auditors that would not otherwise be available from strictly national sources. For example, in 2007, a report on the mangroves of western and central Africa gave an integrated regional view of the threats to mangroves, as well as national profiles.[56]

Regional data sources can provide SAIs with valuable points of comparison in similar countries. For example, SAIs in Europe can use data from the European Environment Agency to assess how well their country is meeting environmental commitments relative to other, similar countries.[57]

SAIs may also benefit from data from adjoining countries, because regional sources may provide information on components of the environment that are shared across national borders. Such components include river flows, water quality in shared water bodies, air quality, and migratory bird and animal populations. Regional data can provide a basis for regional coordinated audits. For example, in 2004 the SAIs in Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Russia conducted a coordinated and parallel audit on preparedness to combat pollution from ships in the Baltic Sea.[58] That audit relied on data about oil spills in the Baltic Sea. Similarly, the SAIs of Turkey and the Ukraine used data from the Black Sea Commission when conducting an audit of pollution sources affecting the Black Sea.[59]

When specific agreements exist between countries to manage shared environmental issues, regional data sources can be used to evaluate the performance of the countries that are parties to the agreements.

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[54] Organization for Economic Cooperation and Development, "OECD Environmental Data Compendium": http://www.oecd.org/document/49/0,3746,en_2649_34283_39011377_1_1_1_1,00.html (accessed 18 March 2012)

[55] United Nations Environment Programme, "Regional Seas Programmme: About": http://www.unep.org/regionalseas/about/default.asp (accessed 18 March 2012)

[56] United Nations Environment Programme, 2007. *Mangroves of Western and Central Africa. UNEP-Regional Seas Programme/UNEP-WCMC.*

[57] See, for example, European Environment Agency, 2011. Eionet Priority Data Flows. May 2010 – April 2011.

[58] The National Audit Office of Denmark, The State Audit Office of Estonia, The State Audit Office of Finland, The German Federal Court of Audit, The State Audit Office of Latvia, The State Control of the Republic of Lithuania, The Supreme Chamber of Control of the Republic of Poland, and The Accounts Chamber of the Russian Federation, 2005. *Joint Final Report on II Audit of Implementation of Provisions of the Convention on the Protection of the Marine Environment of the Baltic Sea Area (The Helsinki Convention). Pollution from Ships in the Baltic Sea.*

[59] Responses from the SAIs of Turkey and the Ukraine to questionnaires distributed by the WGEA Secretariat.

3.1.3. GLOBAL DATA SOURCES

A wide variety of global data sources, including quantitative and qualitative databases, are organized around single issues (e.g., invasive species) or general themes (e.g., climate change or other international agreements); collections of related information (e.g., data linking human health and climate change); and inventories of variables and indicators. Most of the data sources listed in Appendix III and described in further detail in a separate addendum on the WGEA website are global sources.

Global data sources are produced by many different groups, including international organizations, such as the FAO, and global NGOs. Most of the global data sources we reviewed originated with national governments, which means that any inaccuracies or inconsistencies in national data will affect these data sources. In some cases, however, the data are produced independently of national governments. As discussed below, several international organizations, such as the OECD Secretariat or the secretariats of international conventions (e.g. Basel Convention), try to exercise quality control over the data they get from national governments. In the case of the OECD Secretariat, the organization complements its quality control with separate surveys of member countries.

Our review of questionnaire responses and case studies indicate that SAIs tend to use global data sources for context or background to an audit topic. For example, auditors from the SAI of the Netherlands obtained data on plastic found in the stomachs of birds from a global NGO and provided these data as context to highlight the importance of the topic for an audit on marine pollution from ships.[60] Other options include using such data to assess how well audited entities complied with international agreements and comparing the audited entity with similar entities in other countries to identify good practices that might apply to the audited entities.

3.1.4. SPATIAL DATA SOURCES

Some environmental data are collected in a way that allows them to be presented on maps or manipulated to create maps. These spatial data may be collected and reported in national, regional, or global data sources. We have described spatial data sources separately because they raise some unique considerations for SAIs. The data in these sources, which include satellite observations or data from GIS, may be collected uniformly across administrative or political boundaries. The best-known examples of such data sources are probably the maps and satellite images available from information providers such as Google. Other examples include data sources derived from observations of water quality based on watershed boundaries [61] or from air quality measurements taken in cities around the world.[62]

SAIs may find spatial data sources particularly useful when they are examining environmental issues that have an explicit geographic aspect, such as establishing protected areas, or monitoring the distribution of air pollutants and identifying pollution sources. Spatial data sources can also be used to select samples from different regions, to identify high risk areas, and to identify patterns in the data that may not be evident without a spatial presentation. For example, in Exhibit 7, the patterns in the kinds of agricultural systems in various parts of the world do not respect national boundaries. This means that SAIs auditing agricultural management practices may find it useful to look outside their own countries to identify good practices. SAIs may also use spatial data to analyze the regions they are considering from several different perspectives or to assess the combined effects of different environmental factors. SAIs may also choose to use spatial data sources to report audit results, to help make the findings more tangible.

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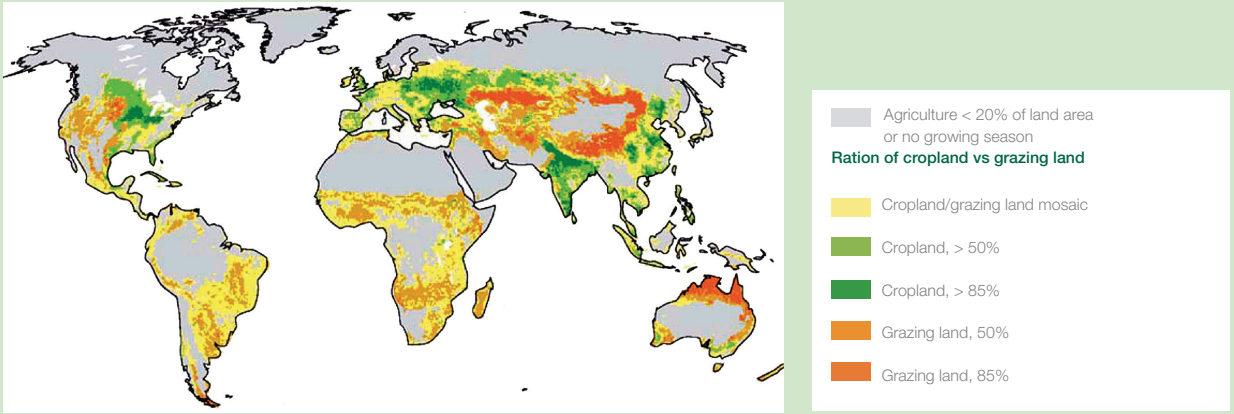
60 See the website of Netherlands Court of Audit for a brief description of this follow up audit: http://www.courtofaudit.com/english/Publications/Audits/Introductions/2010/12/Marine_Pollution_from_Ships_Impact_Assessment_2010 (accessed 17 January 2012).

61 See, for example, the Mekong River: http://www.riob.org/IMG/pdf/Dominique_Fougeirol_RIOB_Debrecen_Mekong.pdf (accessed 18 March 2012) and http://www.mrcmekong.org/ (accessed 18 March 2012).

62 See, for example, the analysis prepared by the World Bank: http://go.worldbank.org/3RDFO7T6M0 (accessed 18 March 2012).

Exhibit 7: Global Distribution of Agricultural Systems [63]



Sources: Re-drawn from Sebastian 2006, derived from FAO and IIASA 2000, Ramankutty 2002, Ramankutty 2005, and Sieber and others 2006.

The resolution of spatial data such as satellite images can be a key consideration for SAIs when deciding how or whether to use such data sources. The resolution will determine what kinds of physical features, or changes in them, one can expect to detect. For example, in an audit touching upon forest management, spatial data with a low resolution may not be able to detect differences between forest regions. Fortunately, in recent years, digital data that provide spatial resolution as fine as a few metres are becoming more readily available.

The use of data tied to geographic locations makes databases much more complex because of the need to record both what is happening and where, using geographic coordinates. The result is a greater demand on quality control. The challenge for SAIs of assessing the quality of the database is also greater. Finally, SAIs that are considering using spatial data sources need access to the tools and expertise to manipulate the data in a knowledgeable way.

3.1.5. COMPLEMENTARY INFORMATION AND TOOLS RELATED TO DATA SOURCES

SAIs may find that some environmental data sets are not easy to understand if they contain detailed or complex scientific information. It may be helpful to consult the complementary information—including data documentation—and other tools that organizations providing the data often include to help explain the data and support SAI's data quality assessments, as described in section 3.2.2 of this paper.

Data documentation can tell SAIs what the data represent—that is, what the data measure, what measurement units are used, and how the units and key categories are defined. A simple example is to clarify whether distances are recorded in miles, kilometers, or some other unit. A more complicated example is found in the World Bank's Little Green Data Book, where the definition of the variable "agricultural land" includes not only cropland and cultivated pastures, but also "natural" grazing lands,[64] such as wild prairie. [65] Audits dealing with such subjects would need to be clear about these definitions before this data source could be used appropriately.

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[63] Source: http://www.unep.org/geo/geo4/report/05_Biodiversity.pdf , p.16 of 36 (accessed 18 March 2012).

[64] World Bank, 2011. *The Little Green Data Book.* p. 229 (p. 339 of PDF). To get to the The Little Green Data Book from the World Bank homepage (http://www.worldbank.org/), follow the path Topics > Environment > Data & Statistics > The Little Green Data Book . The webpage for the book is: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTDATASTA/0,,contentMDK:21061322~isCURL:Y~pagePK:64168445~piPK:64168309~theSitePK:2875751,00.html (accessed 17 January 2012). This is the source at row number 34 in the summary table for the catalogue.

[65] This clarifying point is taken from the FAO source that *The Little Green Data Book* cites as the source of its definition: http://unstats.un.org/unsd/environment/agriculturalland.htm (see notes at bottom of webpage) (accessed 17 January 2012).

Much data documentation describes the methods used to develop a data set. Documentation of methods can help to identify assumptions, quality controls and standards, and other aspects of the data set that may be critical for setting limits on the scope and conclusions of an audit. Thorough data documentation will also include a discussion of key uncertainties and their origins. The key question for SAIs is whether the uncertainties preclude using the data as they would like. As discussed in section 3.2.2, SAIs can make this decision based on the quality controls and other factors.

The techniques used to collect data may also affect how the data can be used. For example, the World Resources Institute's *Reefs at Risk* 2011 report explains that data on marine pollution and damage were reported voluntarily. As a result, pollution and damage levels may be underestimated.[66] When data collection devices are automated, the instruments need to be calibrated and standardized, and any changes need to be documented. For example, moving a climate monitoring station even a short distance can sometimes result in an abrupt shift in data trend lines.[67] Ideally, SAIs will understand the methods and instruments underlying the data they intend to use.

Finally, a data source organization may also offer tools to support users directly as they access and make appropriate use of the data. Reports or data compilations that focus on specific topics, time periods, or geographic locations may also include overall conclusions that may be useful to SAIs. For example, the Global Biodiversity Information Facility's "Data use cases" webpage gives examples of how the data have been used in the past. [68] Such examples may suggest ways of using the data for the purposes of an audit.

SAIs may obtain more direct support from tutorials and other guidance. For example, the website for the UNEP's Global Environmental Outlook offers both a tutorial and a user's guide. These tools lead users through examples of products that can be generated using the Outlook's data resources.[69] Where these kinds of tools are available, SAIs may be less likely to misinterpret or misuse the data. Even in the simplest of data uses, SAIs may find it worthwhile to consult people with a good technical knowledge of the environmental data and their appropriate use.

Additional references regarding complementary information and guidance are included in Appendix IV.

3.2. WHEN USING KEY CONSIDERATIONS ENVIRONMENTAL DATA

Before using environmental data from any source, SAIs must assess whether the data are sufficient and appropriate for the purpose of an audit. In this section, we describe the characteristics of data that SAIs can use to judge its quality. We also highlight some of the key considerations for SAIs when they are assessing the quality of environmental data they might use. These considerations as well as available tools for SAIs to assess data quality are discussed in relation to specific data sources in this section and Appendix III of this paper.

[66] World Resources Institute, 2011. *Reefs at Risk*, p.17 (p. 31 of PDF), third row of table. The report is at: http://pdf.wri.org/reefs_at_risk_revisited.pdf (accessed 17 January 2012).
[67] This information was taken from an interview with a Meteorological Service of Canada scientist for the audit on adapting to climate impacts by the SAI of Canada.
[68] The data use cases can be accessed from the GBIF homepage: http://www.gbif.org/ (accessed 17 January 2012). The GBIF database is in Appendix III.
[69] See the webpage: http://geodata.grid.unep.ch/extras/tutorial.php (accessed 17 January 2012). The GEO Environmental Data Explorer is in Appendix III.

3.2.1. KEY CHARACTERISTICS OF DATA QUALITY

National and international statistical agencies have worked together to define the characteristics of high-quality data, as well as the indicators and performance measures based on those data. In 2010, at the request of the United Nations Statistics Division (UNSD), an international group of experts identified the elements of a generic national quality assurance framework, including key characteristics of high-quality data, such as relevance and accuracy. Their analysis compared the elements of quality identified by statistical agencies around the world and resulted in a common proposed framework for data quality, as shown in Exhibit 8.[70]

On the basis of our review of INTOSAI standards and audit reports, we found that SAIs have similar criteria for evaluating the quality of the data they use. International audit standards for evidence, such as INTOSAI's *Performance Audit Guidelines: ISSAI 3000-3100,* [71] focus on whether there is sufficient and appropriate evidence to form an audit opinion. According to the ISSAI 3000-3100, sufficiency refers to the *quantity* of evidence while appropriateness refers to the *quality* of evidence.[72] The characteristics of high-quality data developed for the UNSD and listed below in Exhibit 8 may influence the appropriateness of the information, and hence what evidence is sufficient for audit purposes. Exhibit 8 also describes additional data quality considerations for SAIs when applying these characteristics to environmental data.

Exhibit 8: Characteristics of High-quality Data and Additional Data Quality Considerations for SAIs

Characteristics of High-quality Data	Additional Data Quality Considerations for SAIs
Relevance. Relevance reflects the degree to which the information meets the needs or requirements of clients, users, stakeholders, or the audience.	SAIs may use data for purposes different from those of the program manager who generated the data. As a result, the relevance of the data may differ for the program manager and the SAI. [73]
Accuracy and reliability. Accuracy reflects the degree to which the information correctly describes the phenomenon it was designed to measure. Reliability concerns whether the data consistently over time measure the reality that they are designed to represent.[74]	Audit organizations may wish to pay particular attention to situations in which the organization generating the data manages the data and may have an economic or political interest in matters related to the data, such as in minimizing reported environmental damage. How environmental data are collected and reported, and by whom, may affect their reliability.
Timeliness and punctuality. Timeliness refers to how fast—after the reference date or the end of the reference period—the data are released or made available. Punctuality refers to whether data are delivered on the dates promised, advertised, or announced.	SAIs may be interested in whether the data are available quickly enough to support the management decisions that will rely on them, as in the case of disasters when a rapid response is essential. They may also find that there is a trade-off between timeliness and accuracy and reliability.

[70] See UNSD website: http://unstats.un.org/unsd/dnss/QualityNQAF/nqaf.aspx#un (accessed 18 January 2012).

[71] INTOSAI, 2004. *Performance Audit Guidelines: ISSAI 3000-3100.*

[72] INTOSAI, 2004. *Performance Audit Guidelines: ISSAI 3000-3100, p. 108,* See http://www.issai.org/media(890,1033)/Performance_Audit_Guidelines_E.pdf (accessed 18 March 2012). ISSAI also issued Performance Audit Guidelines: Key Principles: ISSAI 3100 in 2010. See http://www.issai.org/media(871,1033)/ISSAI_3100_E.pdf (accessed 19 April 2012).

[73] For example, a program manager working with a database on oil spills might be most interested in where and when the spills occurred. A SAI might be interested in the same database to determine if different reporting companies or government inspectors were taking a consistent approach.

[74] While this definition of reliability is specific to the characteristics of high-quality data developed for the UN Statistics Division, the phrase "data reliability" is also used more generally to refer to the accuracy and completeness of the data, given the uses they are intended for. Unless otherwise noted, we use the more general definition of data reliability in other sections of this paper.

Exhibit 8: Characteristics of High-quality Data and Additional Data Quality Considerations for SAIs

Characteristics of High-quality Data	Additional Data Quality Considerations for SAIs
Accessibility and clarity. The data and metadata [75] can be found or obtained without difficulty, are presented clearly and in such a way that they can be understood, are available and accessible to all users on an impartial and equal basis in various convenient formats, and are affordable, if not offered free of charge.	Some data may not be available in electronic form, creating challenges for some SAIs. Language or technical requirements for using the data may limit how auditors use some data sources, such as complex GIS databases. Auditors may also face legal barriers to using or reporting some kinds of environmental data, such as proprietary data.
Coherence and comparability. The data are consistent internally and over time and are produced using common standards with respect to scope, definitions, classifications, and units. Users should be able to combine and make joint use of related data from different sources.	Environmental data may not be collected in the same way at all locations, which may pose problems for SAIs if more than one country is involved in a transboundary audit. The use of international standards can help address this challenge. For some global environmental concerns, such as persistent organic pollutants regulated under the Stockholm Convention, comparable measurements are essential to obtain a clear picture of the international distribution of these pollutants. [76]
Availability of metadata. Users should have access to information concerning the underlying concepts, variables and classifications used; the methodology used to collect and process data; and indications of the quality of the data—in general, sufficient information to understand all of the attributes of the data, including their limitations, for informed decision making.	SAIs may be interested in metadata underlying the environmental data they are considering using, as well as the quality controls applied when environmental data were collected and analyzed. This information may help them to determine how much they can rely on the data. Information about quality controls can also help SAIs assess the systems the audited entity uses to obtain and manage environmental data.

Source: First column adapted from Expert Group on National Quality Awareness Framework. [77] Considerations described in the second column come from the results of a workshop at the WGEA meeting in Buenos Aires in November 2011 and sections 2 through 4 of this research paper.

The additional data quality considerations for SAIs reflect their mandates and responsibilities. As discussed in section 2, environmental data are not always used for audit findings, and so the intended use of the data must also be considered. The next subsection describes some of the factors that SAIs can consider when they decide how or whether to use the data.

[75] Metadata is defined by the Expert Group on National Quality Assurance Framework as "Data that defines and describes other data." For example, information about the statistical accuracy of a set of soil quality measurements would be metadata.
[76] Guidance on the Global Monitoring Plan for Persistent Organic Pollutants Preliminary version, February 2007. Amended in May 2007. Available from: http://chm.pops.int/Implementation/GlobalMonitoringPlan/Overview/tabid/83/Default.aspx (accessed 18 January 2012).
[77] See UNSD website: http://unstats.un.org/unsd/dnss/QualityNQAF/nqaf.aspx#un (accessed 18 January 2012).

3.2.2. HOW SAIs CAN ASSESS DATA QUALITY

INTOSAI standards [78] and other guidance [79] we reviewed identified several factors SAIs should consider when assessing the sufficiency (quantity) and appropriateness (quality) of data for use in an audit. According to the guidance we reviewed, data assessments are made in the broader context of the particular characteristics of the audit and the risk associated with the possibility of using inappropriate data. To determine the extent of the data assessment needed and to use limited resources efficiently, SAIs may want to consider the following key factors:

- ***The data's use and expected importance in the final report.*** If the data will be used to support audit findings or recommendations, the SAI may want to perform a more thorough data assessment than if the data are used solely for background context or to identify potential audit topics.

- ***Data reliability results from previous examinations of the data provider's or audited entity's records and quality control practices.*** A SAIs' past experience or the experience of other SAIs with the data provider's or audited entity's record and quality control practices may be factors to consider. In particular, negative findings regarding the data management practices of the the data provider or the audited entity may call for a more rigorous data assessment.

- ***Whether complementary evidence reinforces or contradicts the findings developed using the data.*** If independent sources provide strong evidence that contradicts the findings developed from the data, the SAI may want to assess the data more rigorously than when independent evidence corroborates the findings developed from the data.

- ***Sensitivity of the topic and degree of risk associated with using the data.*** For audits on sensitive or controversial topics—both from the audited entity's and the public's perspective—the risk associated with publishing findings based on the data may be elevated because the audit report may receive greater attention or be widely quoted. SAIs may want to consider whether using questionable data, even with appropriate caveats, could have significant negative consequences for the decisions of policymakers and others. In such cases, SAIs may deem the data to be insufficiently reliable and using them unjustified. [80] A similar data quality consideration is whether the source of the data has a vested interest in the outcome of the analysis, which could undermine the reliability of the data and also increase the risk associated with using them.

SAIs can undertake a variety of activities to conduct a data assessment, such as
- reviewing existing information about the data, such as external data assessments, reports, or studies;
- conducting interviews with officials responsible for managing the data to determine such things as the quality of the underlying data (metadata), and how and when officials entered the data into databases or records management systems;
- performing tests on the data to identify the extent of inconsistencies, completeness, or errors;
- tracing data in computer systems to and from source documents; and
- reviewing selected internal quality controls for data or records management systems.

As shown in Exhibit 9 below, deciding which activities to undertake is a multi-step process, as the outcome of certain steps may lead to other steps to gather more information. As noted above, SAIs would follow a similar process when considering whether to use data collected or held by third parties. However, in such cases, SAIs may not have the same access to information about how the data were collected and analyzed and so may find it more difficult to assess their quality and to judge how the data could be used. When obtaining data from third parties, SAIs may also want to consider the cost of obtaining or using the data relative to its benefits. If the data are more expensive than warranted by their expected use or importance in the report, SAIs may want to consider alternative options. Tools and information for assessing data quality specific to certain data sources are described further in the companion document to this paper on the WGEA website entitled "Environmental Data: Resources and Options for Supreme Audit Institutions—Detailed Description of Data Sources", in the quality assessments section for each source.

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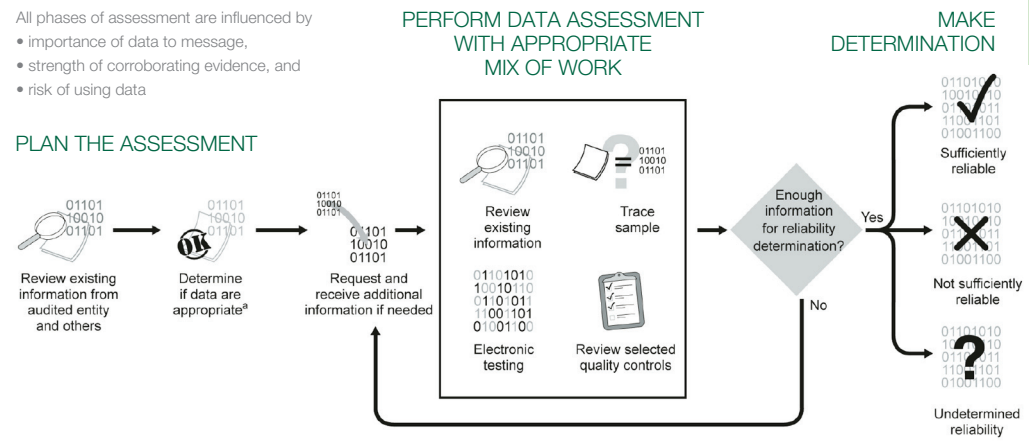
[78] INTOSAI. 2004. *Performance Audit Guidelines: ISSAI 3000-3100*
[79] GAO. 2009. *Assessing the Reliability of Computer-Processed Data, GAO-09-680G.*
[80] See GAO. 2009. *Assessing the Reliability of Computer-Processed Data, p.9; and INTOSAI. 2004. Performance Audit Guidelines: ISSAI 3000-3100, p.108.*

Exhibit 9: Framework of the Data Reliability Assessment Process



[a] After a review of initial information, SAIs may determine that the data are not appropriate for answering the research question (e.g., the database may not contain relevant data elements).
Sources: GAO

Also, INTOSAI standards state that when computer-processed data are significant to the findings of the audit, the SAI may want to take extra precautions to obtain sufficient and appropriate evidence that the data are accurate and reliable. [81] These standards also state that if the reliability of an information system is the primary objective of an audit, the audit team should review the system's quality controls.

Once the data assessment is complete, SAIs will use professional judgment to determine whether the data are sufficient and appropriate for the audit's purpose within the context of the overall audit. Different audit teams evaluating the same data may make different determinations about whether to use the data in their reports, depending on the characteristics of the audit and its associated risks. For example, one audit team may review fisheries management data to examine a controversial topic, such as fraud and corruption, and decide that to use the data would present too much risk, given their audit's purpose. Another audit team may review the same data and decide to use them to develop general findings on a less controversial topic, such as describing the impact of fisheries management practices on fish populations. If an audit team determines that the data are not sufficient and appropriate for the audit's purpose or have undetermined reliability, SAIs have several options to develop findings, as described further in section 4 of this paper.

3.2.3. RELEVANT INTERNATIONAL DATA COLLECTION STANDARDS FOR ASSESSING DATA QUALITY

As discussed previously in this paper, when deciding whether to use a particular data source and trying to assess how reliable it is, SAIs may find it useful to identify which standards have been used to produce the data. Standards for data quality help ensure that data sources are accurate and consistent among related data sets. These standards may be developed and applied at various stages of data collection and management. Standards may also be set at many different geographic scales, from individual monitoring sites to global data compilations. For example, states around the Arctic Ocean have worked together to set standards for how they collect and report measurements of toxic substances in the environment. [82]

[81] INTOSAI, 2004. *Performance Audit Guidelines: ISSAI 3000-3100, p 62.*
[82] See, for example, http://chm.pops.int/Portals/0/Repository/GMP/UNEP-POPS-GMP-RMR-WEOG-ANX2.English.PDF (accessed 22 January 2012).

Standards are particularly important for organizations that are responsible for collating and combining data from several different sources (e.g., the FAO, the OECD, and national and international statistical agencies). Several international organizations such as the EU and the UN have mandatory requirements for how nations are to provide data to them. This may be particularly important in the case of international environmental conventions. Such standards are useful to SAIs, as the standards may provide some assurance of the quality of the specific database. An example of mandatory standard requirements is Eurostat, the EU's statistics body. In 2005, Eurostat developed (and in 2011 revised) a European Statistics Code of Practice, [83] which sets the standard for developing, producing, and disseminating European statistics.

Frameworks and guidance, such as manuals, are another type of standard. They may not be mandatory but they list recommended steps, direction, and concepts so that nations can produce quality data. An example of this kind of standard is the Framework for the Development of Environment Statistics developed by the Environment Statistics Section of the UNSD in 1984. National statistical offices still use the framework to develop and organize environmental and related socio-economic statistics. As a second example, the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, issued its revised Guidelines for National Greenhouse Inventories in 2006. The guidelines help countries to compile complete, national inventories of GHG, and are structured to enable countries to produce reliable estimates of their emissions and removals of these gases no matter what the country's experience or resources. [84] The International Organization for Standardization has set similar standards for quantifying and reporting GHG emissions and removals.

When SAIs are considering the environmental standards that may apply to a particular data source, one challenge is to understand the nature of the standards, in part because they may not cover all aspects of a particular data source. For example, questions of sampling design and risk management are included in the World Meteorological Organization's (WMO) *Guide to Hydrological Practices* [85] and *Guide to Climatological Practices,* [86] but many other standards are silent on such issues. In such cases, SAIs may need to use other methods to determine if the data are suitable.

Another step is to examine the documentation of compliance with the standards. Many standards spell out how compliance is to be documented. This documentation may be particularly valuable for SAIs in assessing the reliability of the data source. As part of this assessment, SAIs may need to determine if the standards have evolved and take account of the standards that were in place when data were collected.

3.2.4. HOW SAIs CAN USE EXISTING DATA QUALITY ASSESSMENTS FOR KEY DATA SOURCES

Data quality assessments highlight the strengths and limitations of the source. They may help SAIs decide about whether and how to use a particular data source. The assessments can also help auditors determine if the entities they audit have used the data source appropriately.

One common type of data quality assessment is peer review. For example, parties to Annex I of the Kyoto Protocol submit annual reports on their GHG emissions; these reports then go through an international expert peer review against the UN Framework Convention on Climate Change (UNFCCC) quality requirements. [87] Detailed information about this process, and all expert review reports, are available on the UNFCCC website.[88] In other cases, such as the FAO's global Forest Resources Assessment for 2010, comments on trends in data quality are embedded throughout its conclusions on specific research questions. The report notes, for instance, a lack of clarity in individual countries' methods for developing data on growing timber stock. [89] This would mean that auditors should examine these data carefully when deciding whether and how to use them. In Appendix IV, we provide further examples of data quality assessments for some of the data sources.

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[83] The European Statistics Code of Practice: http://epp.eurostat.ec.europa.eu/portal/page/portal/quality/code_of_practice (accessed 18 January 2012).
[84] 2006 IPCC Guidelines for National Greenhouse Gas Inventories: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html (accessed 18 January 2012).
[85] The Guide to Hydrological Practices: http://www.whycos.org/hwrp/guide/index.php (accessed 18 January 2012).
[86] The WMO Guide to Climatological Practices (draft 3rd edition): http://www.wmo.int/pages/prog/wcp/ccl/guide/documents/WMO_100_en.pdf
[87] Kyoto Protocol Article 8, paragraphs 1-3: http://unfccc.int/resource/docs/convkp/kpeng.pdf (accessed 17 January 2012).
[88] See the UNFCCC Annex I GHG Inventories webpage at http://unfccc.int/national_reports/annex_i_ghg_inventories/items/2715.php for entry to the documentation of requirements and methodologies (accessed 17 January 2012).
[89] FAO, 2010. Forest Resources Assessment. p. 41 (p.75 of PDF), conclusions section. Available at http://www.fao.org/forestry/fra/fra2010/en/ (accessed 17 January 2012).

4.

OPTIONS AVAILABLE TO SAIs WHEN HIGH-QUALITY ENVIRONMENTAL DATA ARE LACKING

After assessing the quality of data from a particular source, SAIs may find that the data are not of sufficient quality for the audit. Many SAIs in both developing and developed countries have reported challenges in planning and conducting audits when they lack high-quality environmental data. In our review of audit reports and SAI questionnaire responses, we found that several options are available to SAIs in such a situation. In this section, we discuss examples of options available to SAIs when (1) related data exist and (2) no data exist. We also describe considerations for SAIs when they decide which option to use for their audit work.

4.1. OPTIONS WHEN RELATED DATA ARE AVAILABLE

When the desired data are not available from the audited entity or other sources, alternative data may be used. For example, SAIs can estimate unknown environmental data from other known information and can develop or use existing models that combine alternative environmental data. When using related data, SAIs should consider their sufficiency and appropriateness for the audit's purpose, as described in Section 3.2.

4.1.1. THE USE OF RELATED DATA TO ESTIMATE UNAVAILABLE DATA

When SAIs lack high-quality environmental data, they may use alternative types of data that relate to, or help estimate, unavailable data. For example, the SAI of Morocco noted that similar data from government agencies other than the audited entity can act as benchmarks to estimate unavailable data. Another way of estimating unavailable data is to compare several data sources. SAIs may need to consider certain issues when using data estimates, such as how reliable and credible the estimates are.[90] Estimates can also affect how a SAI reports the data in its audit work. For example, SAIs may need to qualify the estimates by framing them in terms of upper or lower bounds. The case studies below illustrate how SAIs can respond to a lack of high-quality environmental data by using estimates.

Case Study 10 — Slovenia and Croatia

In their 2007 joint audit report, *Audit Report of the Court of Audit of the Republic of Slovenia and the State Audit Office of the Republic of Croatia on the Conservation of Biodiversity on the Area of the Planned Regional Parks Snežnik and KoĐevsko Kolpa and in Risnjak National Park*, the SAIs of Slovenia and Croatia used estimates of the growth rate of the endangered brown bear, wolf, and lynx populations to determine whether their respective countries were complying with the international Convention on Biological Diversity.

Because the exact number of brown bears is unknown, the Croatian SAI analyzed bear population estimates given in hunting plans and estimates made by experts to develop its own estimates how many bears there were. In 2005, the Croatian government stated that the bear population probably ranged from 600 to 1,000 bears. The SAI compared these estimates over time. It also analyzed other indicators such as damage to property and the spread of brown bears to new areas to determine if the bear population had increased.

Among other findings, the SAIs found that

- the Croatian government had not consolidated, processed, or presented data on damage caused by bears. The SAI found that the data collected were incomplete because some hunters did not respond to a government questionnaire;
- the Slovenian government lacked data on the growth rates of bear, wolf, and lynx populations and did not appropriately control their populations.

The SAIs jointly recommended that the governments define common methods for monitoring animal populations and exchanging data, and implement joint measures to conserve forests and measure progress, among other recommendations.

[90] Refer to section 3.2 for more information on assessing the quality of environmental data.

Case Study 11— Norway and the Russian Federation

In a 2007 parallel audit report, *The Office of the Auditor General's Investigation of the Management and Control of Fish Resources in the Barents Sea and the Norwegian Sea—A Parallel Audit Conducted by the Office of the Auditor General of Norway and the Accounts Chamber of the Russian Federation,* the SAI of Norway compared estimates on illegal overfishing to determine how serious the problem was. The audit objectives for both SAIs' separate parallel audits were, among others, to assess how well the governments of Russia and Norway achieved joint fishery management agreements and how much illegal cod fishing was being done.

Because of a lack of data on overfishing, the SAI of Norway reviewed shipment inspection forms to help them develop estimates of overfishing. The SAI also collected estimates from several government entities and two Norwegian research institutes, the Institute of Marine Research and the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), which independently developed overfishing estimates. To estimate Russian overfishing levels in the Barents Sea, the SAI of Norway compared Norwegian government entity estimates to those from two private research institutes, which both arrived at higher estimates than the Norwegian government.

Exhibit 10: Different Estimates of Russian Cod Catches in 2004 and 2005 (rounded off to the nearest whole 1,000 tonnes)

	ESTIMATED CATCH 2004	ESTIMATED OVERFISHING 2004	ESTIMATED CATCH 2005	ESTIMATED OVERFISHING 2005
DIRECTORATE OF FISHERIES	292 000 - 320 000	79 000 - 107 000	315 000	101 000
INSTITUTE OF MARINE RESEARCH	Not estimated	Not estimated	367 000	153 000
SINTEF, high estimate	361 000	148 000	427 000	213 000
SINTEF, low estimate	300 000	87 000	354 000	140000

Source: Office of the Auditor General of Norway.

The SAIs found that cod fishing exceeded the joint Norwegian-Russian quotas, and that Norwegian and Russian authorities did not agree on the extent of overfishing because they were using different methods to estimate and because the supporting data were uncertain.

4.1.2. THE USE OF MODELS TO COMBINE RELATED DATA AND IDENTIFY TRENDS

SAIs may use models to combine related environmental data to evaluate how effective programs are. Models tend to be more complex than estimates and can be used to represent complex relationships among factors, as well as to integrate data to evaluate environmental programs. For example, aerial photographs could become the basis for developing a spatial model that illustrates changes in land use over time. SAIs can use computer models to compare data from several sources to determine whether the data maintained by the audited entity are reliable. For example, the SAI of Brazil used modeling software to compare data from multiple databases to identify inconsistencies among the systems.[91]

[91] Response from the SAI of Brazil to the questionnaire distributed by WGEA.

SAIs can also evaluate a government entity's modeling efforts that draw upon environmental data, or the impact of models on program effectiveness. For example, the SAI of the US assessed whether the government incorporated sufficient information such as actual monitoring data on pollutant levels in its model to determine water quality, and evaluated how appropriate the model's assumptions were.[92] Before using models, SAIs should consider several issues, including their own capacity to use and evaluate models, the cost-effectiveness of using models, and the availability of the models compared to other alternatives. The case study below illustrates how SAIs can respond to the lack of environmental data through modeling.

Case Study 12—United States

In its 2008 report, Natural Catastrophe Insurance: Analysis of a Proposed Combined Flood and Wind Insurance Program, the SAI of the US used environmental hazard models from a private firm to combine data on weather-related events and property exposure to estimate potential wind-related losses for a proposed national program. Among other things, the SAI evaluated the impact of a proposed combined wind and flood insurance program in terms of (1) the steps the government would need to take to set premium rates that would reflect all future costs; and (2) how the program could affect policy holders, insurance market participants, and the federal government. The SAI found that

- a combined flood and wind program could increase the federal government's exposure to financial loss;
- insurers of a combined wind and flood insurance program would likely be limited to mostly high-risk properties, since property owners interested in such a program would likely be those who knew they faced a high risk of loss; and
- a combined insurance policy would likely be of interest in hurricane-prone areas where insurers can exclude wind damage coverage.

4.2. OPTIONS WHEN NO HIGH-QUALITY OR RELATED ENVIRONMENTAL DATA EXIST

Several options are available to SAIs when no high-quality or related environmental data are available. For example, the lack of data could become a key message in the audit if the SAI finds that the government lacks sufficient data to manage a program effectively. SAIs can also consult individual experts or scientific panels, and use their opinions to form the basis for findings. Alternatively, SAIs can develop their own data to meet the audit's needs through questionnaires, surveys, or physical observations from site visits.

4.2.1. THE USE OF THE ABSENCE OF DATA AS THE AUDIT'S CENTRAL MESSAGE

SAIs can make the lack of high-quality environmental data an audit finding by, for example, reporting on the data's incompleteness and poor reliability. For example, the SAI of Uganda reported that the government lacked records for waste management to show that it properly disposed of medical waste.[93] SAIs can also focus the audit's message on the impact of a lack of data on how the program is managed. For example, the SAI of Estonia reported that because data were unavailable, governments could not provide evidence that they had complied with laws for preserving nature habitats.[94] Data unavailability can also affect government entities' ability to make decisions. For example, the SAI of Canada found that a government entity did not have enough data on oil spill risks to predict oil spills and effectively plan emergency responses.[95] The case studies below illustrate how SAIs have made the lack of data a central audit message.

[92] US Government Accountability Office, 2005. *Chesapeake Bay Program: Improved Strategies Are Needed to Better Assess, Report, and Manage Restoration Progress, GAO-06-96.*
[93] Office of the Auditor General of Uganda, 2005. *Management of Medical Waste in Selected Government Hospitals.*
[94] Estonia National Audit Office, 2008. *Protection of Valuable Forest Habitats in the Natura 2000 Network.*
[95] Office of the Auditor General of Canada, 2010. *Report of the Commissioner of the Environment and Sustainable Development: Chapter 1 – Oil Spills from Ships.*

Case Study 13—Bhutan

In a 2008 audit report, Audit on Waste Management, the SAI of Bhutan analyzed selected data from the waste management records of municipalities and found that the data were incomplete or absent. The SAI focused on two growing municipalities and examined the following objectives, among others: (1) identify the composition and quantities of waste; (2) measure the effectiveness of waste management systems; and (3) identify waste management improvements. Because data on solid waste were unavailable, the SAI relied primarily on interviews with officials and site visits to obtain information.

The SAI found, among other things, that

- the municipalities had not maintained reliable data on solid waste, which may have prevented the government and other researchers from drawing conclusions on waste management policy;
- a landfill had been continuously burning, but the lack of data prevented the SAI from determining when the fire started; and
- the municipalities did not maintain records on construction and demolition waste, so the SAI used observations from site visits as evidence that contractors dumped unwanted construction materials at illegal dumping grounds.

One of the SAI recommendations was that the municipalities maintain proper records on solid waste management.

Exhibit 11: Construction waste dumped in town area near Changlam. (Changzamtog, Thimphu)

Source: Bhutanese Royal Audit Authority.

Case Study 14—Canada

In its 2010 report, Report of the Commissioner of the Environment and Sustainable Development: Chapter 1—Oil Spills from Ships, the SAI of Canada found that three government entities responsible for managing marine pollution from ships lacked complete and reliable data on oil spills. The SAI examined how three government entities monitored and assessed responses to oil and chemical spills in ocean waters and the Gulf of St. Lawrence. The SAI sampled data from a government pollution incident reporting database to assess how the government entities monitored and evaluated responses to pollution incidents.

Based on its review of the data, the SAI found that

- the Canadian Coast Guard did not sufficiently document its responses to spills, and the database was incomplete and unreliable. For example, the reports within the database did not detail the Coast Guard's response efforts or the results of those actions;
- oil spill estimates varied significantly each year because of data entry errors, and the database lacked a quality assurance system to detect such errors;
- the government did not store data in a single place, and the three government entities did not collect all the same information on the incidents, such as socioeconomic damages or environmental impacts; as a result, the database contained incomplete and unreliable information on responses to oil spills; and
- the Canadian Coast Guard lacked data on what oil spill risks existed and whether its capacity to respond to oil spills could adequately address those risks, because it had not conducted a risk assessment of its oil spill response capacity since 2000.

The SAI recommended, among other things, that the Canadian Coast Guard implement a quality assurance program for its database and establish procedures to consistently document information on the results of oil spills.

4.2.2. THE USE OF OPINIONS FROM EXPERTS OR OTHER RELEVANT PARTIES AS THE BASIS FOR FINDINGS

Another option when high-quality data are lacking is to consult with experts or other relevant parties to get opinions to support audit findings. SAIs may use a variety of methods to collect these views such as interviews, focus groups, structured questionnaires or surveys, or they may contract with a consultant to gather relevant opinions. For example, the SAI of Estonia used expert opinions about the conditions of certain habitats to identify and describe inconsistencies or other gaps in government data relevant to their field.[96] SAIs can also combine expert opinion with other data. For example, the SAI of Bhutan obtained expert opinions and drew on relevant literature to assess a national forest inventory.[97]

SAIs can also use the opinions of other relevant parties, such as stakeholders or program recipients, to develop audit findings. For example, a SAI can use a survey to collect views from stakeholders to assess how effective programs are over a period of time. For example, the SAI of Switzerland worked with the country's customs agency to survey companies to determine the impact of air emission tax policies between 2000 and 2006.[98] Depending on the SAI's needs and resources, SAIs can also use consultants to gather opinions for them. For example, the SAI of the UK used a consultant to survey farmers' opinions on certain agricultural schemes to determine if they were beneficial and the process was easy to understand.[99]

According to INTOSAI auditing standards, SAIs should consider the competence, capabilities, and objectivity of those whose expertise is required to obtain needed information.[100] When deciding whether to obtain opinions from experts or third parties, SAIs should consider whether the experts and other parties represent a range of viewpoints and certain types of expertise are required to speak on the issue. Also, SAIs should consider whether a single expert opinion can be the basis for a finding or whether a panel of experts is more appropriate for the specific topic.[101] The case study below illustrates how SAIs can use opinions when high-quality data are lacking.

Case Study 15—Estonia

In a 2007 report entitled *Efficiency of the Organisation of Environmental Monitoring,* the SAI of Estonia used expert opinion and a focus group to help support its evaluation of the government's environmental monitoring practices. Specifically, the SAI evaluated whether the government determined monitoring needs and effectively implemented monitoring efforts, among other objectives.

To support its findings, the SAI solicited expert opinion about the location and number of monitoring sites, and about how easy it was for local officials to obtain and understand the data. The SAI also formed a focus group comprised of ministry officials and environmental experts. The focus group analyzed existing government data and found that the data were not accessible or clear.

Based on expert and focus group opinions, the SAI found that

- in some areas of environmental monitoring, the number of monitoring stations exceeded international guidelines, and was greater than in similar systems in other countries;
- scientists needed to know the exact information they wanted to access before asking the government for the results, which made it difficult to obtain and analyze information to identify trends; and
- the monitoring data were not user-friendly. For example, the maps of monitoring stations did not have accompanying notes detailing what activities the station carried out and where the monitoring results could be found. Also, data lacked descriptions of how they were measured and sampled.

The SAI recommended, among other things, that the Minister of the Environment determine monitoring needs and take into account users' needs when planning monitoring efforts and analyzing and presenting results.

96 Estonia National Audit Office, 2008. *Sustainability of Management of State Forest, 9 September 2010; and Protection of Valuable Forest Habitats in the Natura 2000 Network.*
97 Response from the SAI of Bhutan to the questionnaire distributed by the WGEA Secretariat.
98 Swiss Federal Audit Office, 2008. *Combating Air Pollution: Evaluation of the Steering Tax on Volatile Organic Compounds (VOC).*
99 National Audit Office of the United Kingdom, 2010. *Defra's Organic Agri-Environment Scheme*
100 INTOSAI, 2009. *Financial Audit Guideline: Audit Evidence: ISSAI 1500, p.584.*
101 Ibid, p.575

4.2.3. THE DEVELOPMENT OF ALTERNATIVE DATA TO MEET THE AUDIT'S NEEDS

When faced with a lack of high-quality environmental data, SAIs can develop their own data to support audit findings—such as compliance with national laws—through site visits or photographs. For example, the SAI of Paraguay inspected a sample of sites affected by tanneries to determine whether the tanneries in the selected area were complying with environmental laws. SAIs can also develop test data to demonstrate how feasible it is to collect such data when SAIs are thinking about recommending that the government collect new data.

When deciding whether to develop new data, SAIs should consider how cost-effective the work will be, what impact the data will have on the audit work, and whether the SAI has the capacity or expertise to develop the data. For example, if a SAI collects water quality samples, it may need to have the samples collected by a specialist and analyzed in a certified laboratory to ensure that standardized methods and quality controls were applied. A SAI may also need a specialist's assistance to properly interpret the data. SAIs should also consider whether they can develop data covering all the relevant areas, whether they would need to use a sample that would be statistically representative, or whether their data, and possibly conclusions, would be more limited. If they ask for computer-processed data as part of a survey, SAIs should consider including questions on data reliability in their surveys. The case study below illustrates how SAIs can develop their own data through physical observations to support audit findings.

Case Study 16—Paraguay

In its 2007 report entitled, Contamination of the Guazu Stream by Tanneries, the SAI of Paraguay used physical observations to determine whether tanneries were complying with environmental laws and negatively affecting water quality. The SAI visited and inspected sites affected by tanneries in a local jurisdiction to discover the adverse effects of tanneries on the areas and to conduct file reviews, among other things.

On the basis of its physical observations and file reviews, the SAI found that

- there were foul odors, a proliferation of flies due to decomposing organic materials in the river, and other types of solid residues and liquid waste in the waters; and
- the existing conditions negatively affected the immediate surroundings as well as the city, reducing the quality of life of the inhabitants.

The SAI recommended that the municipality establish plans and implement measures to rehabilitate natural spaces and residential areas affected by the tanneries; implement measures to comply with environmental laws on air and water contaminants; and implement measures to determine the locations of tanneries, among other recommendations.

5.

FUTURE DIRECTIONS IN THE USE OF ENVIRONMENTAL DATA

In conducting our literature review and case studies on how SAIs use environmental data, we observed some significant trends and opportunities that SAIs may wish to consider. Specifically, we observed that program managers are expanding their use of data from GIS and from other new tools, such as social networking, to manage their programs. These tools and other trends create opportunities for SAIs themselves to use the tools and the resulting data. At the same time, these tools and trends create challenges arising from the need to audit different kinds of environmental data. This section illustrates some of these new trends. We have not attempted to provide a comprehensive analysis of all of the key trends, but rather to highlight some trends that came to our attention and that raise questions that other SAIs may wish to consider.

We observed that managers of environmental programs are relying more and more on GIS, combined with satellite-based observations, to measure results and manage their environmental programs. As an example, the Ethiopian Wolf Conservation Programme prepared maps of a recent rabies outbreak based on several different layers of information, including points (e.g., locations where affected wolves were found), lines (e.g., waterways), regions (e.g. province or country), and notes (e.g. scale, values). These maps were then used to track wolf deaths from rabies contracted from dogs—a major threat to the endangered species—against previous data on pack location and viable habitats. The result was more efficient vaccine targeting.[102]

Such tools also place demands on program managers. To use GIS and satellite technology in this way, they need to maintain sophisticated on-the-ground data collection capabilities to validate and calibrate remotely sensed data, and to devise back up plans if problems arise. They also need the expertise to use the technology appropriately and need good quality controls to ensure the integrity and accuracy of the data used as inputs.

These spatial data tools may be useful to SAIs in their audits to evaluate environmental programs and issues. The 2010 WGEA guidance paper entitled Auditing Forests: Guidance for Supreme Audit Institutions describes how SAIs can use GIS technology in auditing forest management, for instance to determine the extent of deforestation, illegal logging activities, and illegal land use, or to identify the locations of forest fires.[103]

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[102] See article "Conservation Group Uses GIS to Help Save Rare Ethiopian Wolves" at http://www.esri.com/news/arcwatch/0510/feature.html, (accessed 7 February, 2012).
[103] WGEA, 2010. *Auditing Forests: Guidance for Supreme Audit Institutions.*

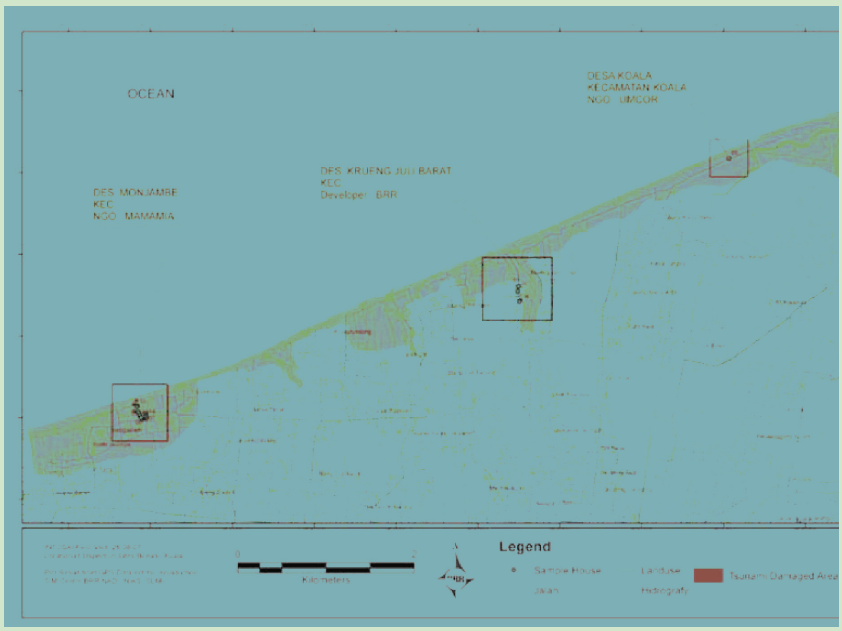
We noted several examples where SAIs have already applied GIS technology in their audits and related activities:

- In its 2009 report entitled *The Office of the Auditor General's Investigation into the Efforts of the Authorities to Limit Flood and Landslide Hazards*, the Norwegian Office of the Auditor General analyzed how aware municipalities were of national GIS and global positioning system (GPS) mapping data and used these data to identify areas prone to floods, quick clay, avalanches, and rockslides. The data showed a varying degree of national mapping and varying awareness of the existing maps among municipalities.

- In a 2010 WGEA guidance paper entitled *Auditing Forests: Guidance for Supreme Audit Institutions,* the Indonesia Audit Board described several limitations to using GIS data, including its high cost and technological requirements. In response, the SAI met its modeling needs by using Ministry of Forestry land coverage data, satellite imagery obtained from the National Institute of Aeronautics and Space, and Google Earth data. Also, the SAI primarily used open-source GIS software to supplement its single-user licensed GIS software.

- As part of an INTOSAI task force, the Netherlands' SAI used GIS data to evaluate the transparency and accountability of tsunami relief payments. Specifically, the SAI used GIS to examine whether homes rebuilt with relief payments complied with government regulations on appropriate rebuilding sites, which were established to reduce future flood risk (Exhibit 12). More generally, the SAI identified GIS as a useful tool for auditing disaster aid, because it can help assess whether disaster aid flows overlap with areas of need. The SAI also said that GIS can be helpful to SAIs for all stages of an audit, from planning the audit to communicating results. [104]

Exhibit 12: Mapping compliance of rebuilt homes with government regulations to reduce flood risk in Aceh, Indonesia



Source: Joint Board of Geospatial Information Societies and United Nations Office for Outer Space Affairs, 2010. *Geoinformation for Disaster and Risk Management: Examples and Best Practices:* http://www.un-spider.org/about/portfolio/publications/jbgis-unoosa-booklet pdf pp 83—87 (accessed 20 March 2012).

[104] Netherlands Court of Audit, 2008. *Lessons on Accountability: Transparency and Audit of Tsunami-Related Aid.* See also, Joint Board of Geospatial Information Societies and United Nations Office for Outer Space Affairs, 2010. *Geoinformation for Disaster and Risk Management: Examples and Best Practices:* http://www.un-spider.org/about/portfolio/publications/jbgis-unoosa-booklet (accessed 20 March 2012).

We also observed the use of social networking tools to collect monitoring data on environmental issues, such as oil spills and wildlife activity.[105] Government agencies and non-governmental organizations have used some of the same capabilities to involve citizens directly in tracking environmental phenomena, such as changes in water quality.[106] Examples of this approach cover a wide range of different issues:

- Namibia's Ministry of Environment and Tourism set up a short message service (SMS) Internet hotline to allow members of the public to report directly and anonymously to the authorities their suspicions of illegal rhinoceros poaching.

- During the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, the nongovernmental organization Public Laboratory for Open Technology and Science generated high-resolution satellite maps showing the size of the spill based on data collected by individual residents and compiled using the Internet. To collect the data, residents used helium-filled balloons and digital cameras to capture images. The images were geographically referenced and compiled into a map of the spill.

- Cornell University's Citizen Science Central hosts a clearing house of Internet sites where users can post individual observations of species. These observations are housed in geographically referenced online data repositories that track individual observations of wildlife and the timing of plant phases, such as first blooms. In some cases, new observations can be used to expand existing long-term data collection initiatives, such as an effort to inventory biodiversity in the Adirondack mountain range in the northeastern US. These data could be used by government land managers to track the presence of endangered or invasive species, among other uses.

We have not identified any uses of environmental data by SAIs derived from social networking sources. With program managers drawing on such information more and more as an integral part of their monitoring systems, SAIs will need to be able to evaluate the quality of the data that result. For example, SAIs may be concerned about quality controls, such as training and the use of expert judgments.

In addition, microchip and wireless technologies are offering program managers new options for data collection. For example, fisheries managers are using tracking devices on fish to map how different regions of the ocean are used in situations when human observers are not feasible.[107] Such technologies entail challenges such as ensuring that the sensors are operating accurately. These technologies will also place additional demands on SAIs to understand the strengths and limitations of such data sources. We have not identified any use of these technologies by SAIs.

Finally, with tight and, in some cases, shrinking government budgets, program managers will be under more pressure to demonstrate results. This situation may lead them to place greater weight on environmental data and the indicators derived from the data to show that their programs are working as intended. To reduce costs, they may also shift away from on-the-ground data collection efforts to methods that estimate or model the results. Such changes may affect how performance is measured and potentially how both program managers and SAIs evaluate programs.

Another result of shrinking budgets may be that program managers may increase their emphasis on partnerships and on finding ways to coordinate efficiently with other parties. Different levels of government and other players may discuss who will do what, and who will pay for what.[108] Program managers may also shift to using data that others generate and maintain. One example is the Global Biodiversity Information Facility, an international organization governments created to encourage free and open access to biodiversity data.[109] However, it may be difficult for SAIs to obtain access to environmental data and to get enough information about the data to ensure that they can be used appropriately and in keeping with good auditing practices.

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[105] See article "Tapping Social Media's Potential To Muster a Vast Green Army" at http://e360.yale.edu/feature/tapping_social_medias_potential_to_muster_a_vast_green_army/2424/ (accessed 22 January 2012).
[106] See http://www.worldwatch-europe.org/node/34 (accessed 22 January 2012).
[107] For example, E. Chassot, S. Bonhommeau, G. Reygondeau, K. Nieto, J. J. Polovina, M. Huret, N. K. Dulvy, and H. Demarcq, 2011. "Satellite remote sensing for an ecosystem approach to fisheries management." *ICES Journal of Marine Science 68,* 4 (2011) pp.651-666.
[108] A current example of this is the discussion between the Canadian federal government, the provincial government of Alberta, and industry over the design, implementation, and funding of the environmental monitoring program for the oil sands development in northern Alberta.
[109] See http://www.gbif.org/ (accessed 6 February 2012).

6.

CONCLUSION

This research paper has focused on areas that have often caused problems for SAIs in the past: how to use environmental data effectively in their audits, what key sources of environmental data are available, and alternative options when the necessary data are not available or are of poor quality. Through an examination of case studies assembled with the aid of SAIs from around the world, we have highlighted how SAIs have used environmental data. Additionally, we have provided information on some of the data sources that are available to SAIs when they seek to understand the key environmental issues facing their countries and the entities they audit, as well as information about how SAIs can assess the quality of data from these sources. Notably, we have also explored some of the options available to SAIs when high-quality data are lacking. We hope that this research paper is a valuable stepping stone for SAIs, so that they can use environmental data more effectively in their future audits, understanding both the advantages and disadvantages of different approaches and of different data sources.

APPENDIX I: RELATED WGEA WORK

This research paper builds upon the work of several WGEA guidance and research papers. The following published guidance developed by the WGEA comments on the importance of environmental data, for example to help identify the environmental risks or threats when choosing audit topics:

- ***Auditing Forests: Guidance for Supreme Audit Institutions, 2010.*** SAIs can use GIS and GPS data in audits. For example, GIS facilitates SAIs' ability to target audits to high-risk areas, but SAIs may also incur start-up costs to obtain the technology and training they need to use GIS and GPS correctly.
- ***Auditing Mining: Guidance for Supreme Audit Institutions, 2010.*** SAIs can use environmental data to understand current conditions and major threats linked with the mining life cycle. Such data can help SAIs customize their approaches for auditing minerals and the impact of mining on natural resources.
- ***Auditing Fisheries: Guidance for Supreme Audit Institutions, 2010.*** SAIs can use environmental data on fisheries resources and on threats to those resources when selecting and designing fisheries audits. Relevant information sources on threats include government agencies, universities, NGOs, international organizations, local and state councils, laws, and the media.
- ***Auditing Biodiversity: Guidance for Supreme Audit Institutions, 2007.*** SAIs can use environmental data to understand biodiversity and associated threats, as well as government responses to them. This guidance provides SAIs with options to choose topics and design audits, and offers practical information by describing actual audits of biodiversity.
- ***Guidance on Conducting Audits of Activities with an Environmental Perspective, 2001.*** SAIs can use environmental data to plan and conduct environmental audits. This guidance offers SAIs practical advice on developing environmental audit methods and practices.

The following published WGEA research papers have also noted issues with environmental data, including the importance of closing gaps in environmental data to better inform management decisions:

- ***Environmental Accounting: Current Status and Options for SAIs, 2010.*** Environmental accounting links environmental data to economic data. This research paper provides an updated review of the status of environmental accounts, and lists the ways that SAIs can help their nation develop environmental accounts or audit existing environmental accounts.
- ***Evolution and Trends in Environmental Auditing, 2007.*** This research paper states that weaknesses in data from government sources are a common challenge in environmental audits. According to this paper, every audit that can help identify weaknesses in government data management systems can contribute to overall improvements in these systems, and decision making based on the data, as well as improved accountability and reporting.

This WGEA research paper is also closely linked with other research papers included in the WGEA Work Plan 2011–2013:

- ***Auditing Water Issues: An Update on the Experiences of Supreme Audit Institutions, 2013.*** This research paper examines water problems that governments face, such as adequacy of water-related data, and describes governments' efforts to respond to these emerging issues. It also analyzes SAIs' audits of a range of water issues, focusing on innovative methods SAIs have used to analyze and report on water challenges.
- ***Environment and Sustainability Reporting, 2013.*** Sustainability reporting integrates reporting on social and environmental issues. This research paper highlights some concerns about how reliable environmental data are and what the role of SAIs is in auditing the assurance of sustainability reports.
- ***Integration of Fraud and Corruption Issues into the Auditing of Environmental and Natural Resource Management, 2013.*** This research paper states that lack of access to high-quality data makes measuring fraud and corruption more challenging, and that insufficient transparency and lack of access to information are major factors in weak governance and lack of accountability in the environmental and natural resource sectors.

APPENDIX II: CASE STUDIES FROM SELECTED AUDITS

The following audits were used as case studies in this paper because of their use of environmental data. We have also indicated where each case study is used in the body of the report. A companion document in the publications section of the WGEA website gives the details of these case studies (see "Environmental Data: Resources and Options for Supreme Audit Institutions—Detailed Information about Case Studies").

Country	Date	Report Title	Case Study Number
Australia	2010	Administration of Climate Change Programs	6
Bhutan	2008	Audit on Waste Management	13
Bhutan	2011	Drinking Water Supply and Sanitation Audit	3
Botswana	2005	Performance Audit Report on Fishing Industry in Botswana by Fisheries Division – Department of Wildlife and National Parks	7
Bulgaria, Georgia, Romania, Russian, Federation, Turkey, and Ukraine	2011	Joint Report on the Results of the Coordinated Parallel Audit on Protection of the Black Sea Against Pollution	1
Canada	2010	Report of the Commissioner of the Environment and Sustainable Development: Chapter 1 – Oil Spills from Ships	14
Colombia	2008	Environmental Management of Mining Activities: Carbon and Gravel at Carmen De Carupa, Cucunuba, Guacheta and Sutatausa Municipalities	4
Estonia	2007	Efficiency of the Organisation of Environmental Monitoring	15
Netherlands	2006	National Ecological Network	8
New Zealand	2010	Local authorities: Planning to meet the forecast demand for drinking water	2
Norway and the Russian Federation	2007	The Office of the Auditor General's Investigation of the Management and Control of Fish Resources in the Barents Sea and the Norwegian Sea – a Parallel Audit Conducted by the Office of the Auditor General of Norway and the Accounts Chamber of the Russian Federation	11
Paraguay	2007	Contamination of the Guazu Stream by Tanneries	16
Slovenia and Croatia	2007	Audit Report of the Court of Audit of the Republic of Slovenia and the State Audit Office of the Republic of Croatia on the Conservation of Biodiversity on the Area of the Planned Regional Parks Snežnik and Kočevsko Kolpa and in Risnjak National Park	10
Tanzania	2007	A Performance Audit of the Management of Prevention and Mitigation of Floods at Central, Regional and Local Levels of the Government of Tanzania: A Case Study of Floods in Babati	5
Turkey	2007	Waste Management in Turkey: National Regulations and Evaluation of Implementation Results	9
United States	2008	Natural Catastrophe Insurance: Analysis of a Proposed Combined Flood and Wind Insurance Program	12

APPENDIX III: KEY SOURCES OF ENVIRONMENTAL DATA

To provide a useful resource to SAIs, we scanned some of the available environmental data sources on the Internet and observed that there are hundreds of websites containing information related to thousands of different environmental variables.

We conducted a more focused search to identify selected useful sources. We chose sources that are readily available, that are supported by well-established organizations with responsibilities for environmental data, and that provide reasonable coverage of the main environmental issues and WGEA themes. The sources are also limited to those for which at least one of the languages used on the website is English. We excluded national sources, since they would only apply to one country, so the emphasis is on global and regional data sources. The search was not comprehensive—as a result, there are many sites that could be added to results. The intent, however, was simply to provide a starting point for specific searches that SAIs might conduct.

On the basis of this search, we selected 56 data sources. Some of these sources are "portals" and provide links to other websites, in some cases compiling many different external data sources too numerous to be reviewed individually. The details on each source include the kind of environmental data they contain and the relevant WGEA themes [110] and regions [111] they apply to. We identified at least one source for each WGEA theme and WGEA region. While we have targeted environmental data, some of these sources could also be combined with sources of economic or social data to analyze sustainable development issues.

Users of this list of data sources should recognize that we have not audited the information on each data source, and that our assessment of the contents of each source was based on readily available information. So, for example, in cases where we did not identify a quality assessment, this should not result in a conclusion that no data assessment was done.

This appendix refers to two companion documents available separately in the publications section on the WGEA website. The first document is an Excel spreadsheet entitled "Searchable Summary – Key Sources of Environmental Data" summarizing the key characteristics of each data source: the name, a brief description, what aspects of the environment are included, what kinds of data it contains, and the geographic regions for which data are available. This will allow users of this report to sort the different sources according to their needs and readily identify the most appropriate sources. The second document, a data catalogue, contains a detailed description of each of the data sources according to a standard set of characteristics. Each source in the spreadsheet is cross-referenced to a page giving a detailed description the data catalogue. In the remainder of this Appendix, we give a detailed description of the different fields in the data source catalogue and a list of the 56 data sources described in more detail in the companion documents.

[110] The WGEA themes are air, ecosystems, governance, human activities and sectors, natural resources, waste, water, and other.
[111] The WGEA regions are Africa, Asia, Caribbean, Central America, Europe, Middle East, North America, South America, and South Pacific.

DESCRIPTIONS OF DATA FIELDS IN ENVIRONMENTAL DATA: RESOURCES AND OPTIONS FOR SUPREME AUDIT INSTITUTIONS—DETAILED DESCRIPTION OF DATA SOURCES

Data Source Index Number: This field contains the cross-reference to the row identifier in the summary table which summarizes some of the key characteristics of each data source.

Data Source Name: This field contains the name of the database or other data source that may be useful to SAIs. (Note that this is not the name of the website or the location of the data source.) This field is also used in the summary table to help users find the data sources they want.

Types of Environmental Data: This field contains information about the types of data found in the data source, where it is possible to identify this information easily. This field is also used in the summary table to help users find the data sources they want. A list of possible types and sub-types has been used to categorize the environmental data:

State of the environment

- Severity of different environmental issues
- Independent information about the status of environmental quality
- Independent information about the trends in environmental quality

Environmental risk assessment

- Independent information about environmental risks
- Estimates of expected costs to manage environmental liabilities
- Independent information about new or emerging risks

Environmental practices and performance

- Performance of the national environmental agency when tracking environmental clean ups (e.g. hazardous waste or oil spills)
- Performance of the national environmental agency in relation to monitoring and reporting requirements (e.g. completeness and quality)
- Environmental scope of management programs
- Performance of other countries in relation to monitoring and reporting requirements
- Independent information about good systems and practices for monitoring and reporting

Environmental compliance and enforcement

- Independent information about compliance with national environmental regulations

Environmental consequences of management weaknesses

- Consequences of management failure
- Consequences of insufficient management effort

WGEA Themes: This field indicates which WGEA themes relate to the data in the data source. The themes are Air, Ecosystems, Governance, Human Activities and Sectors, Natural Resources, Waste, Water, and Other. This field is also used in the summary table to help users find the data sources they want.

Geographic Scope of Data: This field can either be “regional” or “global”. “Global” is used for data sources that cover all or almost all countries. “Regional” is used if the data source only applies to some regions. If it is a regional data source, the corresponding WGEA geographic regions are given. This field is also used in the summary table to help users find the data sources they want.

Data Source Description:
This field briefly describes the data source and its contents. The description will distinguish between actual data sources and portals to a number of data sources. If the data source is a portal, then the description will focus on this aspect, rather than on thoroughly characterizing all the linked sources. If the source is mainly based on data available elsewhere (e.g., using greenhouse gas inventory data from United Nations Framework Convention on Climate Change (UNFCCC) to create an indicator assessment specific to one country or region), then this is noted.

Data Source Organization:
This field contains the name of the organization that provides the data source, and, if necessary, a very brief description of the organization. Where possible and readily available, primary sources are used instead of derivative sources that may simply repackage the same information.

Access to the Data:
This field contains information about how SAIs can obtain the data. This may include a web link, or other information. This field will indicate both where to access the data and the nature of that access mechanism (e.g. whether the database can be searched or the source is just a static report).

Geographic Coverage:
This field describes the geographic scope of the data and the level of resolution available, if appropriate. Information that may be provided in this field includes (a) spatial resolution (e.g. can the user obtain data specific to individual countries, regions within countries, or cities within regions? Or, if the data are spatial, what size are the spatial units (pixels)?) and (b) any information about regional or national coverage that is not already captured in the information about which WGEA regions apply. For data sources that are portals to other databases, this field should distinguish between the coverage of the portal versus the coverage of the linked data sources.

WGEA Regions:
This field indicates if the data are organized by WGEA regions or similar regional boundaries. If the relevant WGEA regions can be easily identified, then they are listed in this field. (Other geographical groupings, such as BRIC countries or Mediterranean countries, will be mentioned in the Geographical Coverage field.) This field is also used in the summary table to help users find the data they want.

Temporal Coverage:
This field describes the time span of data available, how often the data are collected (e.g. monthly, annual), and how old the most recent data are, if appropriate. Other relevant information may be included here, such as the general time span of the datasets. For example, the earliest date may be an outlier, or there may be gaps in the data.

Earliest / Most Recent Date:
If this information is available, this field gives the absolute earliest data point available, and the most recent one, regardless of whether they are outliers.

Frequency:
This field indicates the frequency with which the organization publishes or prepares the data. For example, the temporal resolution might be monthly climate data, but the reports containing those data might be published annually. This field refers to publication dates; the field “temporal coverage” refers to data collection. For databases that may be constantly updated, this field will indicate that there are “ongoing updates”.

Link to International Agreements:
This field indicates whether the data are collected or used in response to the requirements of international agreements, and, if so, which ones. This field only includes those cases where the agreements are the reason for collecting or reporting the data, or the agreements have requirements for their signatories that relate directly to the data source. (This field will be completed by drawing on sources such as the UN compendium of international agreements.)

Metadata:
This field indicates what documentation of the data is available, so that users can assess its suitability for their purposes. If this documentation is available, this field would also contain information about how to obtain it. The documentation could include the terms and categories used to define and organize the data, the methods used to obtain the data, and quality assurance and quality control steps taken during data collection and synthesis.

Quality Assessments:
This field indicates whether quality assessments are available for the data source, and, if so, what the results were. This will be primarily based on assessments done by the source organizations, as well as by experienced users familiar with the data and with data quality expectations (e.g. international statistical agencies). These kinds of quality assessments are normally done separately from the processes of collecting, synthesizing, and reporting the data.

Related Data Sources:
This field indicates whether there are closely linked data sources.

Comments:
This field is used to provide additional information about the data source relevant to its potential use by SAIs.

THE LIST OF THE DATA SOURCES THAT FOLLOWS IS EXPANDED AND DESCRIBED IN THE COMPANION DOCUMENTS.

Global

1. Carbon Dioxide Information Analysis Center (CDIAC)
2. Center for Hazards and Risk Research, Columbia University
3. CIESIN Columbia University, Socioeconomic Data and Applications Centre (SEDAC), Compendium of Environmental Sustainability Indicator Collections (CESIC), “Environmental Sustainability”
4. Convention on Biological Diversity, “Global Biodiversity Outlook 3”
5. Convention on Biological Diversity, “Biosafety Clearing-House”
6. Emergency Events Database of the World Health Organization Collaborating Center for Research on the Epidemiology of Disasters (CRED)
7. European Commission, directory of greenhouse gas monitoring and reporting
8. FAOSTAT, Forestry
9. Food and Agriculture Organization (FAO) of the United Nations, “AQUASTAT”
10. Food and Agriculture Organization (FAO) of the United Nations, Agro Maps
11. Food and Agriculture Organization (FAO) of the United Nations, “The State of World Fisheries and Aquaculture, 2010”
12. Food and Agriculture Organization (FAO) of the United Nations, Statistics (FAOSTAT)
13. Food and Agriculture Organization (FAO) of the United Nations, Wastewater Database
14. Food and Agriculture Organization (FAO) of the United Nations, “Global Forest Resources Assessment 2010”
15. Global Biodiversity Information Facility, “GBIF Data Portal”
16. Global Invasive Species Database (GISD)
17. Intergovernmental Panel on Climate Change, “Data Distribution Centre”
18. International Energy Agency (IEA), “Statistics and Balances”
19. International Food Policy Research Institute, “Food Security, Farming, and Climate Change to 2050”
20. International Maritime Organization, “Directory of information sources on research and development, preparedness, and response to oil spills”
21. International Network for Environmental Compliance and Enforcement (INECE), Forums
22. National Aeronautics and Space Administration, Global Change Master Directory (GCMD)
23. National Oceanic and Atmospheric Administration (NOAA), National Snow and Ice Data Center (NSIDC)
24. National Oceanic and Atmospheric Administration (NOAA), “EcoWatch”
25. National Reports of Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
26. National Reports of Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer
27. Organization for Economic Cooperation and Development, “Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes”
28. Organization for Economic Cooperation and Development (OECD), “Environmental Outlook to 2030”
29. The International Tanker Owners Pollution Federation Limited, “Data and Statistics”
30. The World Bank, “Data Topics”
31. The World Bank, The Little Green Data Book 2010 (based on World Development Indicators 2010)
32. United Nations, Department of Economic and Social Affairs, Division for Sustainable Development, “Trends in Sustainable Development”, reports for years 2006 through 2011
33. United Nations Environment Programme, “Environmental Data Explorer”
34. United Nations Environment Programme, Global Environmental Monitoring System, Water Programme
35. United Nations Environment Programme, “Ozone Secretariat: Assessment Panels”
36. United Nations Environment Programme, “Regional Seas Programme”
37. United Nations, Environment Statistics Database
38. United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory Data
39. United Nations, “GRID Arendal”

40. United Nations, “Global Assessment Report (GAR) on Disaster Risk Reduction – 2009”
41. United Nations, “World Water Development Report”
42. United States Department of Agriculture, National Invasive Species Information Center
43. World Glacier Monitoring Service (WGMS)
44. World Health Organization and United Nations Environment Programme, The Health and Environment Linkages Initiative (HELI): “Environment and Health in Developing Countries: Priority risks and future trends”
45. World Health Organization, Global Health Observatory Public Health and Environment
46. World Resources Institute, “Earth Trends: Environmental Information”
47. World Resources Institute, “Reefs at Risk: revisited”
48. Yale University, “Environmental Performance Index 2010”

Regional

49. European Environment Agency Indicator Assessment: Production and Consumption of Ozone Depleting Substances
50. European Environment Agency, “Datasets”
51. European Environment Information and Observation Network, “European Topic Centre on Air Pollution and Climate Change Mitigation”
52. North American Carbon Program (NACP)
53. Organization for Economic Cooperation and Development. Environmental Data Compendium
54. Organization for American States, Department of Sustainable Development, “Homepage”
55. Organization of American States, “Payment for Ecosystem Services Database”
56. United Nations Department of Economic and Social Affairs, Division for Sustainable Development, “Trends in Sustainable Development Reports – Africa Report” (2008-2009)

See the companion document in the publications section of the WGEA website entitled “Environmental Data: Resources and Options for Supreme Audit Institutions—Detailed Description of Data Sources” for details about the individual data sources.

APPENDIX IV: BIBLIOGRAPHY AND ADDITIONAL REFERENCES

BIBLIOGRAPHY

- Audit Office of the Republic of Cyprus, 2009. Water Quality and Quantity Management. [Online]. Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Cyprus_s_eng_Water-Quality-and-Quantity-Management.pdf [Accessed 31 May 2012].
- Botswana Office of the Auditor General, 2007. Clinical Waste Management at the Referral Hospitals: Princess Marina, Nyangabgwe and Lobatse Mental Hospital. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/ENG_Full_Botswana_waste_report.pdf [Accessed 31 May 2012].
- Chamber of Accounts of the Republic of Azerbaijan, 2008. Audit of the Formation and Effective and Assigned Use of Proceeds in the Forest Preservation and Reproduction Fund. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Azerbaijan_s_eng_State-fund-on-environmental-protection.pdf [Accessed 31 May 2012].
- Chassot, E. et al., 2011. Satellite remote sensing for an ecosystem approach to fisheries management. ICES Journal of Marine Science. [Online] 68, (4), pp.651-666. Available at http://icesjms.oxfordjournals.org/content/68/4/651.full.pdf+html [Accessed 31 May 2012]
- Court of Audit of the Republic of Slovenia, 2010. Managing Municipal Waste. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Slovenia_f_slov_Managing%20Municipal%20Waste.pdf [Accessed 5 June 2012].
- Estonia National Audit Office, 2010. Effectiveness of Collection and Recovery of Packaging Waste. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Estonia_f_eng_Collection-and-Recovery-of-Packaging-Waste.pdf [Accessed 31 May 2012].
- Estonia National Audit Office, 2008. Protection of Valuable Forest Habitats in the Natura 2000 Network [Online]. Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Est_f_eng_natura2000.pdf [Accessed 31 May 2012].
- Estonia National Audit Office, 2009. State's Efforts in Reducing Greenhouse Gas Emissions. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Estonia_s_eng_States%20Efforts%20of%20Reducing%20GHGs.pdf [Accessed 31 May 2012].
- Estonia National Audit Office, 2010. Sustainability of Management of State Forest. [Online] Available at http://www.riigikontroll.ee/DesktopModules/DigiDetail/FileDownloader.aspx?AuditId=2152&FileId=11309 [Accessed 31 May, 2012].
- European Environment Agency, 2011. Eionet Priority Data Flows May 2010 – April 2011. [Online] Available at http://www.eea.europa.eu/publications/eionet-priority-data-flows-may-2/at_download/file [Accessed 31 May 2012].
- Eurostat, 2011.The European Statistics Code of Practice [Online] Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/quality/code_of_practice [Accessed 18 January 2012].
- Food and Agriculture Organization, 2010. Forest Resources Assessment. [Online] Available at http://www.fao.org/forestry/fra/fra2010/en/ [Accessed 31 May 2012].
- Food and Agriculture Organization, 2006. Water Monitoring: Mapping Existing Global Systems and Initiatives. [Online] Available at http://www.fao.org/nr/water/docs/UNW_MONITORING_REPORT.pdf [Accessed 31 May 2012].
- Fraser, Caroline. 2011. "Tapping Social Media's Potential To Muster a Vast Green Army." Yale Environment 360. 11 July 2011. [Online] Available at http://e360.yale.edu/feature/tapping_social_medias_potential_to_muster_a_vast_green_army/2424/ [Accessed 22 January 2012].
- Gordon, Christopher et al. 2010. "Rabies Threatens This Endangered Species in Africa: Conservation Group Uses GIS to Help Save Rare Ethiopian Wolves" Esri Arcwatch May 2010. [Online] Available at http://www.esri.com/news/arcwatch/0510/feature.html [Accessed 7 February 2012].
- Global Mountain Biodiversity Assessment. ND. Mountain Biodiversity Portal. [Online] Available at http://gmba.unibas.ch/portal/portal.html [Accessed 6 June 2012].
- Hayles, Alexandra. 2011. "Citizen Scientists Pave the Road for Better Information on Nature and the Environment." 8 April 2011. [Online] Available at http://www.worldwatch-europe.org/node/34 [Accessed 22 January 2012].
- International Agency for Research on Cancer. ND. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. [Online] Available at http://www.iarc.fr/en/publications/list/monographs [Accessed 16 January 2012].

- International Finance Corporation, 2009. Emerging Risk: Impacts of Key Environmental Trends in Emerging Asia. [Online] Available at: http://www1.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/publications/publications_report_emergingrisk__wci__1319577710199 [Accessed 5 June 2012].
- International Institute for Sustainable Development, 2009. Assessing Vulnerability and Adaptive Capacity to Climate Risks: Methods for Investigation at Local and National Levels. [Online] Available at http://www.iisd.org/publications/pub.aspx?pno=1181 [Accessed 6 June 2012].
- INTOSAI, 2001. ISSAI 100. Basic Principles in Government Auditing. [Online] Available at http://www.issai.org/media(629,1033)/ISSAI_100_E.pdf [Accessed 31 May 2012].
- INTOSAI, 2010. INTOSAI GOV 9150. Coordination and Cooperation between SAIs and Internal Auditors in the Public Sector. [Online] Available at http://www.issai.org/media(802,1033)/INTOSAI_GOV_9150_E.pdf [Accessed 31 May 2012].
- INTOSAI, 2010. ISSAI 1500. Financial Audit Guideline: Audit Evidence. [Online] Available at http://www.issai.org/media(736,1033)/ISSAI_1500_E_Endorsement.pdf [Accessed 31 May 2012].
- INTOSAI, 2004. ISSAI 3000. Performance Audit Guidelines. [Online] Available at http://www.issai.org/media(879,1033)/ISSAI_3000_E.pdf [Accessed 31 May 2012].
- Intergovernmental Panel on Climate Change, 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds.). [Online] Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html [Accessed 31 May 2012].
- Joint Board of Geospatial Information Societies and United Nations Office for Outer Space Affairs, 2010. Geoinformation for Disaster and Risk Management: Examples and Best Practices. [Online] Available at http://www.un-spider.org/about/portfolio/publications/jbgis-unoosa-booklet [Accessed 20 March 2012].
- National Audit Office, 2010. Defra's Organic Agri-Environment Scheme. [Online] Available at http://www.nao.org.uk/publications/0910/organic_farming.aspx [Accessed 31 May 2012].
- National Audit Office, 2009. Department for Environment, Food and Rural Affairs: Managing the Waste PFI Programme. [Online] Available at http://www.nao.org.uk/publications/0809/managing_the_waste_pfi_program.aspx [Accessed 31 May 2012].
- National Audit Office of the People's Republic of China, 2008. Water Pollution Prevention Performance Audit of Three Lakes and Rivers. Beijing: National Audit Office of the People's Republic of China.
- Netherlands Court of Audit, 2008. Lessons on Accountability: Transparency and Audit of Tsunami-Related Aid. [Online] Available at http://www.courtofaudit.com/dsresource?objectid=68836&type=org [Accessed 31 May 2012].
- Office of the Auditor General of Canada, 2008. Status Report of the Commissioner of the Environment and Sustainable Development: Chapter 4 – Federal Protected Areas for Wildlife. [Online] Available at http://publications.gc.ca/pub?id=332024&sl=0 [Accessed 31 May 2012].
- Office of the Auditor General of Canada, 2009. Report of the Commissioner of the Environment and Sustainable Development: Chapter 2 – Kyoto Protocol Implementation Act. [Online] Available at http://publications.gc.ca/pub?id=351491&sl=0 [Accessed 31 May 2012].
- Office of the Auditor General of Norway, 2010. The Office of the Auditor General's Investigation into the Efforts of the Authorities to Limit Flood and Landslide Hazards. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Norway_s_eng_Efforts%20of%20Authorities%20to%20Limit%20Flood-Landslide%20Hazards.pdf [Accessed 31 May 2012].
- Office of the Auditor General of Uganda, 2005. Management of Medical Waste in Selected Government Hospitals. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/ug268eng05ar_ft_managementmedicalwaste.pdf [Accessed 31 May 2012].
- Office of the Comptroller and Auditor General of India, 2006. Environmental Management by Mumbai Port Trust. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Summary_Environmental%20management%20by%20Mumbai%20Port%20Trust.pdf [Accessed 31 May 2012].
- Office of the Comptroller General of Costa Rica, 2011. Evaluation on the Effects of the Payment for Environmental Services Program Implemented by the Government of Costa Rica. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/CostaRica_s_eng_Payment-for-Environmental-Services-Program.pdf [Accessed 31 May 2012].
- State Audit Office of the Republic of Latvia, 2010. Compliance of the Administration of Compensation of Losses Caused to the Environment with the Provisions of Regulatory Enactments and the Effectiveness of Loss Compensation. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Latvia_s_eng_Administration_of_Environmental_loss.pdf [Accessed 31 May 2012].

- Swiss Federal Audit Office, 2008. Combating Air Pollution: Evaluation of the Steering Tax on Volatile Organic Compounds (VOC). [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/sz258eng08ar_sum_voc.pdf [Accessed 31 May 2012].
- The National Audit Office of Denmark, The State Audit Office of Estonia, The State Audit Office of Finland, The German Federal Court of Audit, The State Audit Office of Latvia, The State Control of the Republic of Lithuania, The Supreme Chamber of Control of the Republic of Poland, and The Accounts Chamber of the Russian Federation, 2005. Joint Final Report on II Audit of Implementation of Provisions of the Convention on the Protection of the Marine Environment of the Baltic Sea Area (The Helsinki Convention). Pollution from Ships in the Baltic Sea. [Online] Available at http://www.environmental-auditing.org/Portals/0/AuditFiles/Denmark_joint_f_eng_EnvMonitoringBalticSea.pdf [Accessed 31 May 2012].
- United Nations Environment Programme, 2007. Guidance on the Global Monitoring Plan for Persistent Organic Pollutants Preliminary version. [Online] Available at http://chm.pops.int/Implementation/GlobalMonitoringPlan/Overview/tabid/83/Default.aspx [Accessed 31 May 2012].
- United Nations Environment Programme, 2007. Mangroves of Western and Central Africa. UNEP-Regional Seas Programme/UNEP-WCMC. [Online] Available at http://www.archive.org/details/mangrovesofweste07corc [Accessed 31 May 2012].
- United States Government Accountability Office, 2009. Assessing the Reliability of Computer-Processed Data. GAO-09-680G. [Online] Available at http://www.gao.gov/assets/80/76691.pdf [Accessed 31 May 2012].
- United States Government Accountability Office, 2005. Chesapeake Bay Program: Improved Strategies Are Needed to Better Assess, Report, and Manage Restoration Progress. GAO-06-96. [Online] Available at http://www.gao.gov/assets/250/248291.pdf [Accessed 31 May 2012].
- United States Government Accountability Office, 2010. Superfund: EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites Are Expected to Be Added to the National Priorities List. GAO-10-380. [Online] Available at http://www.gao.gov/assets/310/304124.pdf [Accessed 31 May 2012].
- Working Group on Environmental Auditing, 2010. Auditing Forests: Guidance for Supreme Audit Institutions. [Online] Available at http://www.environmental-auditing.org/LinkClick.aspx?fileticket=fbx%2fbAlVeFU%3d&tabid=128&mid=568 [Accessed 31 May 2012].
- Working Group on Environmental Auditing, 2010. Auditing Mining: Guidance for Supreme Audit Institutions. [Online] Available at http://www.environmental-auditing.org/LinkClick.aspx?fileticket=Ffqb%2f3zmeZ8%3d&tabid=128&mid=568 [Accessed 31 May 2012].
- Working Group on Environmental Auditing, 2010. The Sixth Survey on Environmental Auditing – 2009. [Online] Available at http://www.environmental-auditing.org/LinkClick.aspx?fileticket=X19ppkMSplE%3d&tabid=129&mid=569 [Accessed 31 May 2012].
- Working Group on Environmental Auditing, 2007. Evolution and Trends in Environmental Auditing. [Online] Available at http://www.environmental-auditing.org/LinkClick.aspx?fileticket=91RsG1vxtGs%3d&tabid=128&mid=568 [Accessed 31 May 2012].
- Working Group on Environmental Auditing, 2004. Environmental Audit and Regularity Auditing. [Online] Available at http://www.environmental-auditing.org/LinkClick.aspx?fileticket=LvHmglevYf0%3d&tabid=128&mid=568 [Accessed 31 May 2012].
- World Bank. Air Pollution in World Cities (PM10 Concentrations). [Online] Available at: http://go.worldbank.org/3RDFO7T6M0 [Accessed 18 March 2012].
- World Bank. Global Partnership for Wealth Accounting and the Valuation of Ecosystem Services (WAVES). [Online] Available at http://www.wavespartnership.org/waves/ [Accessed 6 June 2012].
- World Bank, 2011. The Little Green Data Book. [Online] Available at http://go.worldbank.org/I4FEE5EU50 [Accessed 31 May 2012].
- World Database on Protected Areas. Incorporating the UN List of Protected Areas [Online] Available at http://www.wdpa.org/ [Accessed 6 June 2012].
- World Health Organization. Database: outdoor air pollution in cities. [Online] Available at http://www.who.int/phe/health_topics/outdoorair/databases/en/index.html [Accessed 1 February 2012].
- World Meteorological Organization, 2008. Guide to Hydrological Practices [Online] Available at: http://www.whycos.org/hwrp/guide/index.php [Accessed 18 January 2012].
- World Meteorological Organization, 2011. Guide to Climatological Practices (draft 3rd edition) [Online] Available at: http://www.wmo.int/pages/prog/wcp/ccl/guide/documents/WMO_100_en.pdf [Accessed 18 January 2012].
- World Resources Institute. Climate Analysis Indicators Tool. [Online] Available at, http://cait.wri.org/ [Accessed 6 June 2012].
- World Resources Institute, 2011. Reefs at Risk. [Online] Available at http://www.wri.org/publication/reefs-at-risk-revisited [Accessed 31 May 2012].

ADDITIONAL REFERENCES – GENERAL BACKGROUND, METHODS, AND GUIDANCE

This section includes additional materials that may be helpful for those seeking either an introduction or a more in-depth examination of some of the technical material discussed in this paper.

Asian Development Bank:
Handbook on Environmental Statistics 2002:

http://www.adb.org/documents/handbooks/environment/default.asp

The Handbook of Environment Statistics is one of the major outputs of the Regional Technical Assistance 5860: Institutional Strengthening and Collection of Environment Statistics in Selected Developing Member Countries. It attempts to address some of the existing methodological gaps in the field of environment statistics.

Biodiversity Indicators Partnership:
National Biodiversity Indicators Portal:

http://www.bipindicators.net/globalnationallinkages

This portal, a companion site to the 2010 portal, is designed to be a comprehensive resource for nations and regions looking to select and develop biodiversity indicators. In addition to providing online guidance and support, it also includes nations' experiences and lessons learnt from indicator development.

ECOLEX:
Environmental Law:

http://www.ecolex.org/ecolex/ledge/view/SimpleSearch;DIDPFDSIjsessionid=F32D2D5C344C4A9EC9B88BC01EC87230

ECOLEX is an information service on environmental law, operated jointly by FAO, the International Union for Conservation of Nature, and UNEP. The ECOLEX database includes information on treaties, international "soft" law and other non-binding policy and technical guidance documents, national legislation, judicial decisions, and law and policy literature.

Food and Agriculture Organization of the United Nations:
Corporate Document Repository: Guidelines for the Routine Collection of Capture Fishery Data:

ftp://ftp.fao.org/docrep/fao/003/x2465e/x2465e00.pdf

These guidelines were written for designing data collection programs. The guidelines focus on the relationship between typical questions asked by policy-makers and managers and the data required for providing reliable answers.

International Energy Agency:
World Energy Outlook Report Series:

http://www.worldenergyoutlook.org/

The 2010 edition provides projections of energy demand, production, trade and investment, fuel by fuel, and region by region to 2035. It includes, for the first time, a new scenario that anticipates future actions by governments to meet the commitments they have made to tackle climate change and growing energy insecurity.

International Federation of Red Cross and Red Crescent Societies:
Disaster Management: International Disaster Response Laws Database:

http://www.ifrc.org/en/what-we-do/idrl/publication/

This database is a collection of international legal documents (such as treaties, resolutions) relevant to international disaster response operations. Documents at the international level include: treaties, resolutions and declarations of intergovernmental organizations, guidelines, model agreements, and other "soft" standards.

International Network for Environmental Compliance and Enforcement:
Principles of Environmental Compliance and Enforcement Handbook 2009:

http://www.inece.org/principles/index.html

The Handbook provides guidance for designing effective requirements, setting priorities, monitoring compliance, conducting enforcement response, and measuring program performance.

International Organization for Standardization:
ISO 14000 – Environmental Management:

http://www.iso.org/iso/iso_catalogue/management_standards/environmental_management.html

The 14000 series addresses various aspects of environmental management. ISO 14001:2004 and ISO 14004:2004 address environmental management systems. The other standards and guidelines in the series address specific environmental aspects, such as labeling, performance evaluation, life cycle analysis, communication, and auditing. ISO 14064 and ISO 14065 address standards and guidelines for greenhouse gas accounting and verification respectively.

UN Department of Economic and Social Affairs: National Reports

http://www.un.org/esa/dsd/dsd_aofw_ni/ni_index.shtml

Each year since 2003, the Division of Sustainable Development has compiled reports which countries submit on one of the Division's annual themes. For example in one year, countries submitted national reports on: chemicals, mining, sustainable consumption and production patterns, transportation, and waste management.

OECD Environmental Indicators: Development, Measurement, and Use:

http://www.oecd.org/dataoecd/7/47/24993546.pdf

This reference paper describes the core set of environmental indicators (CEI) used by the OECD, and other indicator sets, including Key Environmental Indicators (KEI) and Sectoral Environmental Indicators (SEI), Indicators Derived from Environmental Accounting; and Decoupling Environmental Indicators (DEI). The paper also describes the purpose of the indicators and how they can be used.

OECD International Futures Programme: Emerging Risks in the 21st Century: An agenda for action 2003:

http://www.oecd.org/dataoecd/20/23/37944611.pdf

This report focuses on five risk clusters which present threats to vital sectors such as health services, transportation, energy, and food and water supplies: natural disasters; technological accidents; infectious disease; terrorism-related risks; and food safety. The report also examines the forces driving changes in these domains and identifies hazard assessment and response challenges facing OECD countries.

United Nations Conference on Trade and Development (2002): Guidance Manual on Accounting and Financial Reporting for Environmental Costs and Liabilities:

http://www.unctad.org/en/docs/iteeds4c1_en.pdf

The introduction section of this report may be useful for auditors new to the subject of environmental cost and liability reporting.

United Nations Development Programme: Human Development Report 2007/08, Climate change and forced migration: Observations, projections and implications.

http://www.iisd.org/pdf/2008/climate_forced_migration.pdf

In 1990, the IPCC noted that millions of people could be displaced by shoreline erosion, coastal flooding, and agricultural disruption as a result of climate change. This paper discusses the historical difficulty in predicting the impact of climate change on human migration due to data reliability issues and how this may change with the improvements in assessments and predictions. The paper also discusses potential policy responses.

United Nations Environment Programme and World Health Organization: New and Emerging Environmental Threats to Human Health (2008):

http://web1.unep.org/health-env/pdfs/TD-New-and-emerging-threats.pdf

This report highlights some of the new and emerging environmental risk factors African countries have to cope with in terms of public health challenges. Some of the issues addressed include infectious disease and mosquito-borne disease, radiation, dioxins, and e-waste.

United Nations Environment Programme: Assessment of Capacity Gaps and Needs of South East Asia Countries in Addressing Impacts, Vulnerability and Adaptation to Climate Variability and Climate Change 2010:

http://www.unep.org/climatechange/mitigation/sean-cc/Portals/141/doc_resources/VulnerabilityAssest/Assessments%20capacity%20gaps%20&%20needs_summary.pdf

This report provides information on the status and vulnerability at national and regional level in member states of the Association of South East Asian Nations. There are several common approaches, methods, toolkits, policies and research in water, agriculture and the socio-economic sectors. The study highlights overlaps and gaps in these sectors, which may facilitate capacity building and experience sharing activities among the member countries for south-south cooperation.

United Nations Environment Programme: The Arctic and International Agreements:

http://www.grida.no/files/publications/environment-times/poltimesp10.pdf

This page lists five multilateral environmental agreements and briefly explains their relevance to Arctic ecosystems and indigenous people. The summaries are organized into four areas: area of work, issues affecting Arctic ecosystems and indigenous peoples, relevant activities, and need for future work.

United Nations Environment Programme:
Manual on Compliance with and Enforcement of Multilateral Environmental Agreements:
http://www.unep.org/dec/docs/unep_manual.pdf
This manual provides advice on best practices for states from the negotiation phase through the national implementation, compliance, and enforcement phases of multilateral environmental agreements. Within the manual, brief text boxes of high-profile agreements provide a brief summary of reporting requirements and how to access the specific reporting database for each agreement, if available.

United Nations Environment Programme:
Integrated Environmental Assessment Training Manual:
http://www.unep.org/geo/GEO_assessment.asp
There are eight modules to this training manual which include national integrated environmental assessment process design and organization, monitoring, data and indicators, and monitoring, evaluation, and learning.

United Nations Statistics Division:
Country Practices on National Official Statistics:
http://unstats.un.org/unsd/dnss/gp/searchgp.aspx
The Country Practices Database, established in 2000, provides reference material from countries on the 10 Fundamental Principles of Official Statistics, in particular, examples of policies and practices in various national statistical systems for implementing the Principles.

United Nations Statistics Division:
National Data Quality Assurance Frameworks:
http://unstats.un.org/unsd/dnss/QualityNQAF/nqaf.aspx
The Generic National Quality Assurance Framework template is intended to provide the general structure within which countries that choose to do so can formulate and put in place national quality frameworks of their own or further enhance existing ones. These frameworks are used to ensure the quality of official statistics.

United Nations:
The Commission on the Measurement of Economic Performance and Social Progress:
http://www.un.org/en/ga/president/65/initiatives/Harmony%20with%20Nature/Stiglitz-Sen-report-ENG.pdf
This report identifies the limits of GDP as an indicator of economic performance and social progress and considers other, potentially more relevant, indicators of social progress. Chapter Three of the report is focused on sustainable development and the environment.

United Nations:
World Water Development Report (2009):
http://www.unesco.org/water/wwap/wwdr/index.shtml
This report provides an overview of the state of the world's freshwater resources and provides decision-makers with the tools to implement sustainable water use policies. The reports provide a mechanism for monitoring resource changes and tracking progress towards achieving targets, particularly those of the Millennium Development Goals (MDGs). They also offer best practices as well as in-depth theoretical analyses to help stimulate ideas and actions for better stewardship in the water sector.

United Nations:
Millennium Development Goals Indicators: Goal 7 – Ensure Environmental Sustainability:
http://mdgs.un.org/unsd/mdg/Data.aspx
This site presents the official data, definitions, methodologies and sources for more than 60 indicators to measure progress towards the Millennium Development Goals. The data and analyses are the product of the work of the Inter-agency and Expert Group (IAEG) on MDG Indicators, coordinated by the United Nations Statistics Division.

United States Department of Agriculture:
National Invasive Species Information Centre Economic impacts; International Impacts:
http://www.invasivespeciesinfo.gov/economic/intl.shtml
These papers address the evaluation and economic impacts of invasive species at the global, regional, national, and local levels. Links to international laws and regulations also provides information on guidelines produced by international organizations, global and regional conventions, international organizations that deal with invasive species legislation, as well as other resources.

United States Environmental Protection Agency:
A Practical Guide to Estimating Cleanup Costs (2001):
http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1027&context=usepapapers&sei-redir=1#search="estimating+cleanup+costs+for+environmental+liabilities"
Cost estimates are frequently developed to evaluate cleanup options in support of an assessment of environmental liabilities. This paper presents a guide to developing a cleanup cost estimate.

www.environmental-auditing.org