INTOSAI Working Group on Environmental Auditing

Research Project on Environmental Data

Expanded Outline for Discussion

7 October 2011

Executive Summary [to come]

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1.   Introduction

Supreme Audit Institutions (SAIs) are conducting an increasing number of environmental audits over time, according to the Working Group on Environmental Auditing (WGEA)'s Sixth Survey on Environmental Auditing.[1] However, SAIs often face challenges when conducting these audits. Audit institutions reported that insufficient data on the state of the environment and insufficient monitoring and reporting systems are the most common obstacles to developing and conducting environmental audits. Based on these findings, the WGEA Work Plan 2011-2013[2] identified environmental data as a research topic. The Office of the Auditor General (OAG) of Canada and the U.S. Government Accountability Office (GAO), in conjunction with our subcommittee members, volunteered to conduct a research project on environmental data that will explore general tips and examples on where and how to find environmental data, as well as describe some of the innovative methods SAIs have used when data are lacking.

Objectives. The key objectives for this project are to:

1. describe the main ways that auditors use environmental data and key considerations when using such data;

2. broadly identify key sources of environmental data available to SAIs; and

3. identify tools and methods SAIs may use when high quality environmental data are lacking, using case studies to illustrate the experiences of different audit organizations.

Accordingly, this report is intended to provide SAIs with information and practical examples to help in planning and conducting environmental audits. Specifically, we will use case studies to illustrate different experiences of SAIs around the world. We will also include a database of environmental data sources that may be useful to SAIs as they plan and conduct environmental audits. The appendices will provide further information on how to identify key environmental data sources based on the audit topic and resource covered, as well as more detailed information on the case studies referred to in the body of the report.

Methods. To achieve the first and third objectives, we reviewed audit reports from WGEA and SAI websites. We also performed targeted outreach to SAIs to obtain additional information on case studies we had identified as well as additional case studies to ensure that we obtained a diverse array of illustrative examples. To identify key considerations for SAIs when using environmental data, we conducted internet and literature searches and reviewed data quality guidance papers from several SAIs.

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[1]INTOSAI Working Group on Environmental Auditing (2010): *The Sixth Survey on Environmental Auditing - 2009*

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

To achieve the second objective, we reviewed international organizations' websites, international standards for data collection, and relevant data quality assessments. The organizations we reviewed included global organizations, such as United Nations' Food and Agriculture Organization, 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.

For all of the objectives, to identify additional information and case study examples, we submitted questions that the WGEA Secretariat distributed to SAIs. We received responses from 36 SAIs, which we reviewed and incorporated into our analysis. We limited our scope to selected case studies, which while illustrative, cannot be generalized to all SAIs and do not encompass all the ways in which SAIs can use environmental data or respond to the lack of data (see Appendix I).

At key points during the research project, we benefited from the input of members of the project sub-committee: Botswana, Estonia, Namibia, New Zealand, Poland, and Tanzania.

2.   Background

Sufficient and reliable information on the state of the environment is critical to understanding and addressing environmental issues at the national and international level. Environmental data can be a powerful tool to help environmental program managers assess the effectiveness of their efforts to protect and manage natural resources, as well as target resources efficiently. Audit institutions may also be secondary users of this environmental data because the data can help them oversee the government agencies implementing programs. This section will provide a brief introduction to key issues underlying the development and use of environmental data by program managers and the different ways that environmental data might be useful to SAIs.

2.1   What are the Different Types of Environmental Data?

For the purposes of this report, 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). This definition encompasses a variety of related concepts, such as "data", "statistic", and "indicator", all of which can provide useful information for SAIs. This subsection will describe these concepts to provide readers with an understanding of the different types of environmental data.

2.2   How do Managers of Audited Agencies Use Environmental Data?

Based on literature we reviewed and past audit reports, we noted that audited entities may generate and use environmental data for a wide range of different purposes. One key purpose is to assess how well their programs are working. This is central to the "Plan-Do-Check-Improve" management principles built, for

example, into the International Organization for Standardization's formal standards for process and quality controls, such as the ISO 14000 standards for environmental management. The need to assess programs often leads to environmental data being used for performance indicators. Managers may also generate and use environmental data to:

- assess the state of the environment and to identify what programs may be needed, and at what level of funding;

- develop models to predict the future state of the environment, for example, to compare management alternatives;

- measure compliance with environmental regulations either by their own organizations or by the organizations they regulate;

- determine the environmental effects from projects, or from completed or abandoned projects, such as contaminated sites; and

- inform scientific judgments, for example about the toxicity of different substances.

This subsection will describe some of these uses and provide examples of the kinds of data that would be used in each case.

2.3   Why do SAIs Need Environmental Data?

Audit organizations do not have the same core needs for environmental data as program managers. [We will insert a table here that summarizes the differences in the uses of environmental data between managers and auditors.] Based on literature we reviewed and our examination of cases where SAIs have used environmental data, we found that environmental data can help auditors:

- select audit topics that have the biggest impact;

- select audit samples that will allow them to use their resources most efficiently;

- provide independent information about the progress audited entities are making on environmental commitments (such as climate change);

- communicate the importance of audit findings; and

- strengthen the case for audit recommendations, for example by comparing performance with that of other countries.

Section 4 (below) will describe the main ways that SAIs use environmental data. This subsection will distinguish the uses of data by SAIs from those by program managers.

2.4   Responsibilities for Producing Data

The responsibility for producing environmental data will usually rest with the audited entity. Some SAIs take the position, referring to their applicable professional standards, that it is the responsibility of entity management to produce data documenting program performance. Based on literature describing

audit practices in different countries, internal audit and evaluation functions within the audited entities are sometimes responsible for determining if programs are functioning as they should, and the role of SAIs is then to complement this internal function. If the audited entities have high quality information and are tracking their performance and program results, SAIs may be able to rely on these sources of environmental data. If SAIs assume some of the responsibility for obtaining environmental data themselves or from third parties, this will raise questions of the needs for expertise, capacity, independence, and reliance on third party data. This subsection will briefly describe some of these issues and the implications for the needs of SAIs for environmental data.

2.5   Related WGEA Work

This report will build upon the work of several WGEA guidance and research papers. For example, the 2010 WGEA publication, *Auditing Forests: Guidance for Supreme Audit Institutions*, explores how SAIs can use geographical information systems (GIS) and Global Positioning Satellite data in both planning and conducting forest audits. This subsection will describe key related guidance, with a more complete listing of references in an appendix.

3.   Key Considerations for Determining Data Quality

Before using environmental data from any source, SAIs must determine whether the data are of sufficient quality for the audit's purpose. There are several key considerations for determining data quality, including availability, reliability, timeliness, and compatibility. Audit organizations can also tailor their efforts to determining data quality by considering how the data will be used in the final report and what the risks of using the data might be. This section will outline the key considerations for assessing data quality and tools that SAIs can use to guide them through the process.

3.1   Characteristics of High Quality Data

Several different organizations, including national and international statistical agencies, have devoted considerable effort to defining the characteristics of high-quality data. They have also addressed what constitutes good indicators and other performance measures based on that data. Drawing from our examination of this literature, this subsection will provide a brief summary of the main characteristics, describe potential tradeoffs between the different characteristics, and provide selected examples. The next subsection will describe some of the judgments that SAIs can make when they decide how the data will be used, including the relative importance of the different factors. The key characteristics include:

- **Relevance.** Do the data describe the phenomenon of interest?

- **Availability.** How easy are the data to obtain? Are there barriers to using it, such as cost, technical requirements, lack of documentation, or security issues?

- **Reliability**. Are the data accurate, that is, are they free from errors? What quality control checks are in place? Are the data well-documented so that users can understand their limitations? Is the organization generating the data independent?

- **Timeliness**. Are data available quickly enough to support the decisions that will rely on them? What is the time lag between the time the data are collected and the time they are available for use? Are the data reported on time? (This will be much more important for environmental emergencies or natural disasters.) There may sometimes be tradeoffs between reliability and timeliness.

- **Compatibility**. Are the data collected consistently over time and among regions of the country? Are the data collected by different organizations compatible, for example with respect to definitions and the application of standards? (Adherence to international standards will make it easier to compare results among different countries.) There may sometimes be tradeoffs between relevance to a particular issue and compatibility with methods used in other areas.

3.2   How Can SAIs Determine Data Quality?

Before using environmental data from any source, SAIs must determine whether the data are of sufficient quality for the audit's purpose. When making this determination, SAIs may consider the following factors:

- to what extent the data exhibit characteristics of high quality data, as described above,
- the data's expected importance in the final report,
- whether there is complementary evidence that reinforces the findings, and
- level of risk of using the data.

For example, if the data will be the sole support for audit findings, the SAI may want to perform a more robust data reliability assessment, than if the data are used for background context. If there is a risk that using data of questionable reliability could have significant negative consequences, the SAI would also want to perform a risk assessment by considering such things as whether the data relate to a sensitive or controversial subject, or will be widely quoted. This subsection will describe factors that SAIs might consider when making data quality determinations and provide examples of tools that may assist SAIs in making these determinations. Helpful tools will be included in Appendix III.

4.   Main Ways that SAIs Use Environmental Data in Audits

Many SAIs around the world use a variety of environmental data to plan audits, conduct audits, and clarify audit results. These data can provide key support for selecting an audit topic, refining its scope, and developing audit findings and recommendations. As illustrated below, data used by SAIs cover a variety of natural resources and environmental topics, and can range from highly technical computer-generated data sets to relatively simple formats, such as physical observations. Audit organizations can also

use data to provide context for the reader and highlight the significance of audit findings and recommendations. This section will describe the main ways that SAIs use environmental data across the range of audit work and include case studies to illustrate these uses in various countries around the world.

4.1 Using Environmental Data to Plan Audits

Some SAIs use environmental data to plan audits, such as to identify potential audit topics, as well as to modify the audit's scope if the necessary data to conduct the audit are unavailable. For example, if an SAI wanted to audit the government's management of urgent environmental concerns, the SAI could use environmental data to identify topics of national interest, such as drought. In addition to selecting audit topics, SAIs can also use environmental data to refine their audits' scope, such as when they select samples for detailed audit work. This subsection will describe ways that SAIs use environmental data to select audit topics and refine audit scope and will include case study examples (see below for examples of case studies that may be included). In addition to the text descriptions, we plan to include text boxes and tables with key information that ease comparisons across countries.

Ukraine

In its 2011 audit report, *Joint Report on the Results of the Coordinated Parallel Audit on Protection of the Black Sea Against Pollution*, the Accounting Chamber of Ukraine and other SAIs in countries bordering the Black Sea used environmental data from governments' pollution monitoring reports submitted to the Black Sea Commission and data on the depletion of marine natural resources to select the audit topic. The SAIs also refined the audit's scope by focusing on high-risk areas and issues by sampling coastal cities based on the cities' level of threats, such as high waste volumes and inadequate sewage systems.

New Zealand

In its 2010 audit report, *Local authorities: Planning to meet the forecast demand for drinking water*, the Office of the Auditor General used data from the long-term council community plans, expert opinions, and five geographic and water-related factors for drinking water demand to select eight local authorities as case studies. Such factors included population growth, water shortages, and whether water demand forecasting and management best practices were in place. The performance audit reviewed the local authorities' drinking water demand forecasts over the next 10 years, and their strategies for managing that demand.

4.2 Using Environmental Data to Conduct Audits

When conducting audits, environmental data can be used in three broad ways:

- to assess progress against targets and goals, such as those measuring program effectiveness or compliance with laws;
- to evaluate practices for assessing and managing environmental risks, such as environmental emergencies; and
- to evaluate practices for managing environmental data, including data collection and reporting.

This subsection will describe ways that SAIs use environmental data to conduct audits and will include case study examples. In addition to the text descriptions, we plan to include text boxes/tables with key information that ease comparisons across countries.

4.2.1 Assessing Progress against Targets and Goals

Audit organizations may find environmental data useful when measuring environmental performance against specific evaluation criteria, such as program goals, international treaties, or compliance with national laws. For example, SAIs can use environmental data to measure whether an environmental program has managed natural resources to meet program goals or is in compliance with national environmental laws. Audit organizations can also use data to show that government entities have met their targets in international agreements, such as the Kyoto Protocol on climate change. This subsection will describe ways that SAIs can use environmental data to assess progress and will include case study examples.

Bhutan

In its 2011 report, *Drinking Water Supply and Sanitation Audit*, the Royal Audit Authority evaluated whether the Ministry of Health effectively implemented drinking water supply and sanitation projects primarily through physical observations of selected towns and Ministry data. The SAI found that the Ministry poorly maintained infrastructure and inadequately evaluated the projects as required by law, and that the Ministry did not properly plan and prioritize the projects. It concluded that not doing so could increase costs and shift the number of projects away from the communities included in the original plans.

Colombia

In its 2008 report, *Environmental Management of Mining Activities: Carbon and Gravel at Carmen De Carupa, Cucunuba, Guacheta and Sutatausa Municipalities*, the Office of the Auditor General assessed data collected by the Institute of Hydrology, Meteorology, and Environmental Studies to determine that selected carbon mines did not comply with environmental standards.

4.2.2 Evaluating Practices for Assessing and Managing Environmental Risks

In addition to assessing environmental programs against established goals and requirements, SAIs may also use environmental data in their evaluation of a government entity's management of environmental risks. For example, a SAI could use data describing current trends in the state of the environment to assess how well a government entity has identified and responded to emerging environmental risks such as climate change. Similarly, a SAI could use environmental data to evaluate how well a government prepares for and responds to environmental emergencies or manages associated financial costs. For example, a SAI could evaluate the extent to which government entities have managed the cost of storing and cleaning up hazardous waste. This subsection will describe ways that SAIs can use environmental data to evaluate their government's management of environmental risks and will include case study examples.

Tanzania

In its 2007 audit 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 National Audit Office evaluated government responses to flood emergencies and management. The SAI compared photographs taken in 1990 and 1991 with those of later years and found that embankments were poorly maintained to withstand future flood capacity. The SAI also performed physical observations and found that the government entity's tree planting program was ineffective.

Australia

In its 2010 report, *Administration of Climate Change Programs*, the National Audit Office evaluated how well the government assessed and implemented risk mitigation strategies for grant programs designed to reduce greenhouse gas emissions and promote renewable energy technologies. In particular, the SAI reviewed grant programs' risk assessments and their completion dates to determine, among other things, that the treatment options or controls did not always mitigate identified risks, and many of those risks materialized throughout the course of the programs, such as unexpected demand for a solar homes program.

Canada

In its 2007 report, *Atomic Energy of Canada Limited: Report Presented to Board of Directors Special Examination Report*, the

Office of the Auditor General evaluated the financial costs associated with nuclear waste and decommissioning nuclear sites. The SAI reviewed data on strategic planning from Atomic Energy of Canada Limited – a federal Crown corporation responsible for nuclear-related activities – and found significant deficiencies regarding long-term funding requirements.

4.2.3 Evaluating Practices for Managing Environmental Data

In addition to using data to evaluate achievement of targets and management of environmental risks, SAIs can also evaluate how well government entities manage environmental data. Specifically, SAIs can assess the format or quality of the audited entity's environmental data to formulate findings in such areas as data reliability and timeliness. (This is in contrast to using the content of the data to assess such things as program effectiveness or compliance with laws.) For example, SAIs can evaluate the extent to which government entities have sufficient and appropriate data to manage their environmental programs effectively. In doing so, the SAI can assess how well government entities have managed data on past environmental conditions, the current state of the environment, and future trends. This subsection will describe ways that SAIs can use environmental data to evaluate practices for managing environmental data and will include case study examples.

Botswana

In its 2005 report, *Auditing Fishing Industry in Botswana*, the Office of the Auditor General examined data from monthly and quarterly fishing reports to determine the extent to which the Fisheries Division monitored fishing activities. The SAI found that the Fisheries Division's reports varied in detail, and determined that the record form used to monitor fishermen's catches was inadequate due to, among other things, many fishermen being illiterate. It also found that the Division did not systematically monitor fishermen's compliance with sustainable fishing techniques, and did not collect adequate information regarding fish stocks and fishing activity.

4.3 Using Environmental Data to Provide Context for Audit Findings

Environmental data can be a powerful tool to provide context for the reader and highlight the significance of audit findings, such as the potential consequences of program deficiencies. For example, data on illegal dumping in forests could be used to provide context for the consequences of a poorly managed hazardous waste program. This subsection will describe ways that SAIs can use environmental data to provide context for the audit findings and will include case study examples.

Turkey

In its 2007 report, *Waste Management in Turkey: National Regulations and Evaluation of Implementation Results*, the Court of Accounts cited data from the Ministry of Environment and Forestry and data from the national statistics office, TURKSTAT. It found that that the percentage of waste dumped into landfills was less than the waste dumped into illegal areas, such as natural spaces. The SAI also cited TURKSTAT data on the tonnes of hazardous waste incinerated or dumped in landfills annually to describe the magnitude of the issue.

5.   Sources of Environmental Data

This section will describe the sources of environmental data available to SAIs. It will summarize the results of a detailed search to identify data sources that may be useful for SAIs. This information may complement data coming from the audited entity. Recognizing that SAIs also need access to information about data quality and reliability for any source they use, this section will also describe and discuss relevant international standards for environmental data collection and publicly available data quality assessments for the key data sources identified in section 5.1. Selected case studies and examples will be used in the text and detailed summaries will be provided in Appendix II.

5.1   Key Sources of Environmental Data Available to SAIs

This subsection will summarize the different data sources that SAIs may use according to whether they are seeking national, regional, or global information. It will provide some overall observations about the roughly 65 data sources we have documented at the regional and global level. It will also draw on our review of the relevant literature, case studies assembled through a questionnaire to SAIs, and direct contact with SAIs regarding their use of environmental data. This subsection will also include information about "borderless" data sources – data that is collected without regard for political boundaries. It will conclude with a sub-subsection commenting on complementary information and tools that can assist the users of these data sources.

5.1.1   National Data Sources

This sub-subsection will describe the key national data sources and some of the key considerations associated with using them. The description will focus on the kinds of data sources, as opposed to specific databases. National data sources are those which provide information only on the characteristics of a single country. For most audits, the key data source will be the audited entity, but we will describe the relevant information that could come from other national government entities (e.g. departments of public health), statistical agencies, or other levels of government, such as regions or municipalities within the country. We will also describe some of the considerations associated with obtaining information from non-government sources, such as academic institutions or environmental non-

governmental organizations. While the focus of our discussion of regional and global data sources (below) is on digital, Internet-based sources, the description of national data sources will also include a variety of other kinds of sources. We will provide selected examples of the use of different kinds of data sources.

Data from adjoining countries may also be useful to SAIs because such sources may provide relevant information for components of the environment that move across national borders. These include water flowing in rivers, water quality in shared water bodies, air quality, and migratory birds and animals.

5.1.2   Regional Data Sources

This sub-subsection will describe the key regional data sources and some of the key considerations associated with using them. Regional data sources are those sources which 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 those countries that border a single body of water (e.g. the Caribbean), and are usually aggregated from national sources. Regional data sources can also provide valuable points of comparison with similar countries. For example, SAIs in Europe can use data from the European Environment Agency to assess how their country is performing in terms of meeting environmental commitments relative to other similar countries. We will summarize some of the key observations from the regional databases presented in Appendix II, and comment on some of the key considerations when using such databases. We will provide selected examples of their use by SAIs.

5.1.3   Global Data Sources

This sub-subsection will describe the key global data sources and some of the key considerations associated with using them. Global data sources are those for which data are available across most of the planet. The wide variety of data sources includes quantitative, qualitative, spatial and non-spatial databases. The information may be based on a single issue (such as invasive species), a general theme (climate change or an international agreement), a collection of related information (such as data linking human health and climate change), or an inventory of different variables and indicators. In many cases, the data are aggregated from national sources. We will summarize some of the key observations from the global databases presented in Appendix II, and comment on some of the key considerations when using such databases. We will provide selected examples of their use by SAIs.

5.1.4 "Borderless" Data Sources

This sub-subsection will describe the key "borderless" data sources and some of the key considerations associated with using them. We have used this term for data that are collected uniformly without regard for administrative or political boundaries. These sources are a subset of the regional and global data sources described above, but they are distinct from the other sources in those same categories where the information is collected and reported according to political or administrative boundaries. "Borderless" data include data from satellite observations, or from geographic information systems. The best known examples of such data are probably the maps and satellite images available from Google or other similar information providers. Other examples include the data coming from observations of water quality based on watershed boundaries, or air quality taken from cities around the world. We will summarize some of the key observations from these kinds of databases presented in Appendix II, and comment on some of the key considerations when using such databases. We will provide selected examples of their use by SAIs.

5.1.5 Complementary Information and Tools

This sub-subsection will very briefly describe some of the complementary information and tools and some key considerations associated with using them. These include user guides, documentation of data sources, general introductions to certain kinds of databases, descriptions of methods, and so on. The information will not be a comprehensive or authoritative list, but is intended to be a starting point for other information. This information and the tools we will mention here will be intended to help SAIs use the data sources more effectively or more knowledgeably. Additional references will be included in the Appendix.

5.2 Relevant International Standards for Environmental Data Collection

Some data standards are tied directly to particular data sources by the responsible countries. 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. Other data standards have been developed independently of particular databases and are intended to be applied to all similar data collection efforts. An example is use of laboratory reference standards. In other cases, international organizations (e.g. OECD, FAO, or the European Environment Agency) have taken on responsibilities to ensure the quality of the data they report. This subsection will briefly describe these standards and the implications for SAIs when working with these data.

5.3 Data Quality Assessments for Key Data Sources

Some of the data sources we assembled had been assessed in terms of the quality of the data they contain. Such information can help SAIs when deciding

which data sources to use, and when evaluating the use of such sources by the entities they are auditing. This subsection will summarize the information the project team has identified; more details will be found in the Appendix in relation to specific data sources.

6. Options Available to SAIs When High Quality Environmental Data Are Lacking

Many SAIs in both developing and developed countries face challenges in planning and conducting audits when they lack high quality environmental data. Notably, the lack of available data on the state of the environment was highlighted as a key obstacle facing SAIs in the WGEA's Sixth Survey on Environmental Auditing.[3] Based on our research, we found that there are a number of options available to SAIs when high quality environmental data do not exist. Different options exist depending on whether related data are available or if no data are available. The choices of audit organizations among the options may be influenced by a variety of factors, including the quality of potential related data sources, the costs of generating estimates or obtaining data, and expertise and capacity within the SAI. Using case studies as illustrative examples, this section will provide information on alternative options that SAIs have used when high quality environmental data are lacking.

6.1 Options When Related Data Are Available

This section will provide information on options that may be available to SAIs when the data they are seeking are not available from the audited entity or other sources, but when related data can be used. This includes approximating unknown environmental data using other known information, using estimates, and developing or using models that combine other environmental data. Related data can come in a variety of forms and have varying degrees of specificity or certainty. This subsection will describe options that SAIs might use when high quality, directly relevant data are not available for audit purposes, but related data are available. Case study examples will be used to illustrate these options.

6.1.1 Using Related Data to Estimate Unavailable Data

When audit organizations lack high quality environmental data, they may use other data that may relate to, or help estimate, the absent data. For example, if a SAI lacks data on air quality, it could estimate air quality using available public health data on respiratory diseases. Tables and diagrams can be useful tools to illustrate the relationships between the unknown condition and the data used by the SAI. There are certain considerations for SAIs when using estimates of environmental data, such as the reliability and credibility of the estimate, the estimate's upper and lower bounds, and how SAIs plan to use the estimate in their audit work. This subsection will describe options that SAIs might use when

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[3] See WGEA (2010): The Sixth Survey on Environmental Auditing - 2009.

related data are available to develop estimates. Case study examples will be used to illustrate these options.

Croatia and Slovenia

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 Kočevsko Kolpa and in Risnjak National Park*, the SAIs of Croatia and Slovenia estimated unavailable data. For example, they estimated the rate of increase of the brown bear population by analyzing related indicators, such as increased property damage and the spread of the bear population to new geographic areas.

Norway

In their 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 Office of the Auditor General collected estimates of illegal fishing from the Directorate of Fisheries, the Coastguard, and the police register of criminal cases, and conducted three questionnaire surveys. It also employed consultants from the Fridtjof Nansen Institute to help conduct the investigation. A Norwegian research foundation, SINTEF Fisheries and Aquaculture, assisted with the statistical analysis relating to the estimate of overfishing. The investigation showed that cod fishing exceeded the Joint Norwegian-Russian Fisheries Commission's quotas.

6.1.2   Using Models to Combine Related Data and Identify Trends

Audit organizations may use models which combine related environmental data to create an integrated analysis of environmental conditions that is otherwise unavailable. Specifically, SAIs can use their own models to assist them in developing findings and recommendations, or in evaluating the relevance and appropriateness of the audited entity's models. For example, a SAI could use a model to develop future flooding scenarios based on how well a program has reduced flood risk for a certain area. Similarly, a SAI could develop or use a model with different inputs or relationships between the data to test the assumptions underlying the audited entity's model. 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. Before using models for their audit work, SAIs will want to consider several issues, including their SAI's capacity to use and evaluate

models, the cost effectiveness of using models, and the availability of the models relative to other alternatives. This subsection will describe options that SAIs might use when data to build models are available. Case study examples will be used to illustrate these options.

United States

In a 2008 report, *Natural Catastrophe Insurance: Analysis of a Proposed Combined Flood & Wind Insurance Program,* the Government Accountability Office combined data on historical flood, hurricane, and tornado hazards to develop natural hazard risk maps for the proposed combined flood and wind insurance program. The GAO also contracted with a private firm to use wind-modeling technology to combine data on weather-related events and property exposure to estimate potential wind-related losses for the proposed program.

6.2   Options When No or Only Low Quality Environmental Data Exist

This subsection will provide information on options that may be available to SAIs when no or only low quality environmental data exist. Options include using the lack of adequate environmental data as the audit's central message, using expert opinion or focus groups to form the basis for findings, and developing alternative data to meet the audit's needs. Case study examples will be used to illustrate these options.

6.2.1   The Absence of Data Can Become the Audit's Central Message

Audit organizations can use the lack of high quality environmental data as an audit finding by, for example, describing the data's lack of completeness and reliability. Audit organizations may also report on the implications of the lack of data. In addition, the SAI may find that the data, although not absent, may not be reliable enough to serve the intended purpose. In using this option, there are several considerations for SAIs, including the significance of the lack of data regarding government entities' decisionmaking and the importance of the data to demonstrate progress on meeting targets and goals. This subsection will describe how SAIs might use the absence of data as the central message for an audit and will include case study examples.

Bhutan

In its 2008 audit report, *Audit on Waste Management*, the Royal Audit Authority analyzed selected municipalities' waste management records and found they were incomplete or absent. The SAI found that the municipal authorities did not have reliable data on such things as the quantity of solid waste, and that

maintaining complete and reliable data would facilitate the government's efforts to form waste management policies.

6.2.2 Expert Opinions or Focus Groups Can Form the Basis for Findings

Audit organizations may consult with experts (e.g., individuals or a panel of experts) to obtain additional data on the topic and to support audit findings. For example, SAIs can use expert opinions to provide judgments on projected scenarios and future environmental risks for which no data exist. Audit organizations may also first consult experts on specific policy matters, such as freshwater security, to assist the SAI in providing options for the government entity to consider. In addition to individual experts and expert panels, SAIs may also obtain other opinions by drawing on relevant literature, based on specific criteria. When using experts, there are several considerations for SAIs, including whether experts with the relevant expertise are available, whether they can provide independent judgments on the subject matter, and the cost effectiveness of consulting experts. This subsection will describe how SAIs might use expert opinion or focus groups to form the basis for findings, and will include case study examples.

> **Estonia**
>
> In its 2007 audit report, *Efficiency of the Organisation of Environmental Monitoring*, the National Audit Office used focus groups and an expert to evaluate the Estonian Environment Information Centre's comprehensiveness and organization of environmental data. It found that that the government did not monitor all necessary environmental data or organize it in a manner that allowed it to analyze and draw conclusions for policy decisions.

6.2.3 Audit Organizations Can Develop Alternative Data to Meet the Audit's Needs

Audit organizations, when faced with a lack of high quality environmental data, may obtain their own data to support audit findings through, for example, a questionnaire, a formal survey, or site visits. Potential reasons for SAIs to develop their own data include:

- to collect information from the recipient, or end user, of an environmental program as opposed to the government entity;

- to develop data that span several agencies or departments to develop broader conclusions than existing data allow; and

- to describe local conditions via physical observations and photography and to document agency noncompliance.

When deciding whether to develop data, SAIs should consider cost effectiveness and the impact of the data on the audit work, as well as the capacity or availability of the expertise to develop the data. This subsection will describe how SAIs might develop alternative data and will include case study examples.

Paraguay

In its 2007 report, *Contamination of the Guazu stream by tanneries*, the Comptroller General performed physical observations of the audited area and found that tanneries caused foul odors in neighboring residential areas and contaminated nearby streams.

7. Future Directions in the Use of Environmental Data

This section will provide information on future trends in environmental data for environmental program managers and consequently, auditors of environmental programs. This was not a major focus of the research project, but, through our review of the literature and case studies regarding the use of environmental data by SAIs, we observed some significant trends and opportunities. In particular this section will discuss how program managers are expanding their use of geographic information systems (GIS) to manage their programs, and how SAIs may also use this technology to conduct performance audits and program evaluations. This section will also discuss how some nongovernmental organizations (NGOs) have begun to use social networking tools to create real-time monitoring data on environmental issues, and how SAIs may potentially apply this type of data in audit work. This section is not intended to be a comprehensive analysis of all of the key trends, but rather to highlight some important trends that came to our attention and that raise questions that other SAIs may wish to consider.

7.1 Future Directions in How Managers Use Environmental Data

During our review of the literature regarding environmental data, including a separate project on environmental monitoring by the Office of the Auditor General of Canada, we identified some significant trends that are creating challenges and opportunities for managers of environmental programs. These trends are affecting how managers generate and use environmental data; this will then affect what data are available to SAIs and how they can use the data. This subsection will briefly describe some of these trends; the next subsection will describe the implications for SAIs. These trends include:

1. Environmental program managers are increasingly relying on geographic information systems combined with satellite-based observations, as a tool to measure results and manage their environmental programs. This has implications for the kinds of systems and tools needed to manage and manipulate the data.

2. With microchip and wireless technologies, managers have new options for remote automated sensors. For example, fisheries managers are

using tracking devices on fish to map how different regions of the ocean are used.

3.   Some NGOs have used social networking sites to create monitoring data on environmental issues, such as oil spills and wildlife activity. Government agencies have also used some of the same capabilities to involve citizens directly in tracking environmental phenomena, such as changes in water quality.

4.   Performance measurement has always been closely linked to program evaluation. With tight and, in some cases, shrinking government budgets, managers will be under increased pressure to demonstrate results, and to place greater weight on environmental data, and the indicators derived from the data. They may also shift away from expensive data collection efforts to methods to estimate or model the results.

7.2   Future Directions for SAIs

These same kinds of tools may be useful to SAIs in their audits to evaluate environmental programs and issues. Some SAIs have already applied GIS technology in their audits and related activities. For example, the 2010 WGEA guidance paper entitled *Auditing Forests: Guidance for Supreme Audit Institutions* describes how SAIs can use GIS technology in auditing forests, such as to determine the extent of deforestation, illegal logging activities, and illegal land use. While we have not found any case studies of SAIs using social networking data in an audit to date, this type of information may become more prevalent in the future. While we noted that government entities have typically been the managers of environmental data in the past, as data become more decentralized and community-driven, SAIs may find that alternative sources contain the most relevant and up-to-date information. As such data become more common, SAIs may want to consider the extent to which social networking and other unconventional sources of data may be relevant to their work and what special data quality considerations may be required. This subsection will describe how future trends in environmental data may affect the methods that SAIs consider when planning and conducting audits. Case study examples will be used to illustrate these ideas.

Norway

In its 2009 report, *The Office of the Auditor General's Investigation into the Efforts of the Authorities to Limit Flood and Landslide Hazards*, the Office of the Auditor General analyzed the extent to which municipalities are aware of national GIS and GPS mapping data, and the extent to which municipalities use those modeling tools to identify areas that are prone to floods, quick clay, avalanches, and rockslides. The data showed a varying degree of national mapping and that not all municipalities were aware of the mapping technology.

8.   Observations

This section will describe the report's main conclusions about how SAIs use environmental data, what data sources exist, and what options may be available to SAIs when high quality environmental data are unavailable.

Appendix I: Case Studies from Selected Audits

Each case study identified below will have a separate page with detailed information about the audit and its relevant use of environmental data, with a reference to the section it supports in the body of the report.

Country	Date	Report Title
Australia	2010	Administration of Climate Change Programs
Bhutan	2008	Audit on Waste Management
Bhutan	2011	Drinking Water Supply and Sanitation Audit
Botswana	2005	Auditing Fishing Industry in Botswana
Canada	2007	Atomic Energy of Canada Limited: Report Presented to Board of Directors Special Examination Report
Colombia	2008	Environmental Management of Mining Activities: Carbon and Gravel at Carmen De Carupa, Cucunuba, Guacheta and Sutatausa Municipalities
Estonia	2007	Efficiency of the Organisation of Environmental Monitoring
New Zealand	2010	Local authorities: Planning to meet the forecast demand for drinking water
Norway	2009	The Office of the Auditor General's Investigation into the Efforts of the Authorities to Limit Flood and Landslide Hazards
Norway	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
Paraguay	2007	Contamination of the Guazu stream by tanneries
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
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
Turkey	2007	Waste Management in Turkey: National Regulations and Evaluation of Implementation Results
Ukraine	2011	Joint Report on the Results of the Coordinated Parallel Audit on Protection of the Black Sea Against Pollution
United States	2008	Natural Catastrophe Insurance: Analysis of a Proposed Combined Flood and Wind Insurance Program (GAO-08-504)

Appendix II: Key Sources of Environmental Data

This appendix will contain two linked sets of documents. The first is a single table 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. The second set of pages will contain a detailed description of each of the data sources according to a standard set of characteristics. Each source in the summary table will be cross-referenced to a page giving a detailed description.

A. Summary of Sources of Environmental Data

This summary will list each of the data sources with their key characteristics in a single table. We intend to also make this table available as an Excel spreadsheet – this will allow users of this report to sort the different sources according to their needs and readily identify the most appropriate sources. The following pages illustrate what this table will look like.

[see separate file]

B. Detailed descriptions of Information Sources

This part of this appendix will provide detailed descriptions of each of the information sources. The following pages are intended to illustrate what the descriptions will look like, with a few sample pages.

INTOSAI Working Group on Environmental Auditing

Research Project on Environmental Data

Data Source Index Number: XX
Data Source Name: Intergovernmental Panel on Climate Change, "Data Distribution Centre"
Types of Environmental Data: State of the Environment *(Independent information about the trends in environmental quality/quantity)* and State of the Environment *(Future projections/scenarios of the state of the environment)*
WGEA Themes: Air, Water, Human activities and sectors
Geographic Scope of Data: Global/International and Regional
Data Source Description: The Data Distribution Centre of the IPCC provides climate, socio-economic, and environmental data, both from the past and also in scenarios projected into the future. Technical guidelines on the selection and use of different types of data and scenarios in research and assessment are also provided. Acknowledging that changes in environmental conditions other than climate may need to be considered when conducting climate change impact and vulnerability assessments, the Environmental Data pages of the DDC provide access to baseline and scenario data for a range of non-climate conditions in the atmospheric, aquatic and terrestrial environments. These include data on atmospheric composition (e.g. carbon dioxide, ozone), land use and land cover, sea level, and water availability and quality. Most projections are consistent with the driving factors and emissions presented in the Special Report on Emissions Scenarios (SRES).
Data Source Organization: Data is provided by co-operating modelling and analysis centres. The Data Distribution Centre is overseen by the IPCC Task Group on Data and Scenario Support for Impact and Climate Analysis.
Access to the: IPCC Data Distribution Centre homepage: http://www.ipcc-data.org/ddc_envdata.html , observational temperature datasets: http://www.ipcc-data.org/obs/ar4_obs.html , and IPCC Reports may be accessed at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml
Geographic Coverage: Both global and regional level data.
WGEA Regions: All regions.
Temporal Coverage: Baseline data are provided from either an average of the 1960-1990 period or for a year in the early 1990s for each of the regions. Other datasets for some temperature and climate related data begin from the mid-1800s.
Earliest / Most Recent Date: E: 1990; MR: 2006.
Frequency: IPCC Assessment Reports have generally been published every five to six years. Many other reports and supplementary materials are published every year.
Link to International Agreements: UNFCCC
Metadata: [to come]
Quality Assessments: [to come]
Related Data Sources: Permanent Service for Mean Sea Level: http://www.psmsl.org/ , the Publications and Data webpage may be accessed at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml
Comments: Technical Guidelines and other Supporting Material may be accessed at: http://www.ipcc-data.org/guidelines/index.html

Data Source Index Number: XX
Data Source Name: Hazardous Waste Movements (Basel Convention)
Types of Environmental Data: 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, and Performance of other countries in relation to monitoring and reporting requirements)* and Environmental Compliance and Enforcement *(Independent information about compliance with national environmental regulations)*
WGEA Themes: Waste
Geographic Scope of Data: Global/International

Data Source Description:
      Website contains an inventory of national reports, status of national reporting, and a section where parties can find out what and how other Parties are reporting about its export and import data on hazardous and other wastes.
Data Source Organization:
      Data are derived from the 175 national parties to the Convention. Website is maintained by the Secretariat of the Basel Convention International Environment House.
Access to the Data:
      Main webpage is available at: http://www.basel.int/   The 'Reporting Database', 'National Reports' and other related information may be accessed through the National Reporting tab at: http://www.basel.int/natreporting/index.html
Geographic Coverage:
      National statistics from the 175 national parties to the Convention.
WGEA Regions:
      None.
Temporal Coverage:
      Variable as the information is submitted by national entities at various times.
Earliest / Most Recent Date:
      E: 1997; MR: 2009.
Frequency:
      Variable.
Link to International Agreements:
      The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
Metadata:
      None identified.
Quality Assessments:
      None identified.
Related Data Sources:
      None identified.
Comments:
      None

Data Source Index Number: XX
Data Source Name: Global Biodiversity Information Facility, "GBIF Data Portal"
Types of Environmental Data: State of the Environment *(Independent information about the status of environmental quality/quantity)*
WGEA Themes: Ecosystems
Geographic Scope of Data: Global/International
Data Source Description: GBIF enables free and open access to biodiversity data. The focus is on making biodiversity data available for scientific research, conservation and sustainable development. Users may search the database for data on a specific species or group of organisms, data on the species recorded in a particular country, territory or island, and/or explore other datasets from data publishers or data networks.
Data Source Organization: Information available for approximately 12,712 datasets from 339 data publishers.
Access to the Data: GBIF Data Portal homepage: http://data.gbif.org/welcome.htm
Geographic Coverage: Can search biodiversity data by country.
WGEA Regions: Not regionally aggregated.
Temporal Coverage: Variable.
Earliest / Most Recent Date: E: N/A; MR: 2011.
Frequency: Variable.
Link to International Agreements: No explicit link.
Metadata: Information on "Metadata Requirements for Datasets" found at: http://www2.gbif.org/GBIF-metadata-strategy_v.06.pdf
Quality Assessments: [To come]
Related Data Sources: [To come]
Comments: An online tutorial is available for new users.

Data Source Index Number: XX
Data Source Name: Global Invasive Species Database
Types of Environmental Data: State of the Environment *(Independent information about the status of environmental quality/quantity)*
WGEA Themes: Ecosystems
Geographic Scope of Data: Global/International

Data Source Description:
    Users may search the database by species name or by country/location. Information pages about the number of invasive species in a country as well as characteristics of the species (ecology and distribution) found in a selected country may be accessed. A management page also provides information about prevention and mitigation options, and case study information and references from around the world. The Global Invasive Species Database focuses on invasive alien species that threaten native biodiversity and covers all taxonomic groups from micro-organisms to animals and plants in all ecosystems.
Data Source Organization:
    The Invasive Species Specialist Group of the Species Survival Commission of the IUCN-World Conservation Union.
Access to the Data:
    Global Invasive Species Database, homepage: http://www.invasivespecies.net/database/welcome/
Geographic Coverage:
    Individual countries.
WGEA Regions:
    Not aggregated regionally.
Temporal Coverage:
    Current invasive species, species unclassified, and native species are all listed for each country. Historical data are not provided.
Earliest / Most Recent Date:
    Only current species are listed.
Frequency:
    Updated as new information becomes available.
Link to International Agreements:
    [To come]
Metadata:
    [To come]
Quality Assessments:
    [To come]
Related Data Sources:
    [To come]
Comments:

Appendix III: Decision Tree for Data Reliability of Computer-Processed Data [to come]

Appendix IV: Bibliography and Website List [to come]