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2013

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Earth Institute | Columbia University

Yale Center for Environmental Law & Policy

Contents

Acknowledgements: The authors gratefully acknowledge funding from the Samuel Family Foundation, and benefited from comments by Stephen Morse of the University of Surrey in the UK on an earlier draft of this paper.

Suggested Citation: de Sherbinin, A., A. Reuben, M. Levy, and L. Johnson. 2013. Indicators in Practice: How Environmental Indicators are Being Used in Policy and Management Contexts. New Haven and New York: Yale and Columbia Universities.

Indicators in Practice:
How Environmental Indicators are Being Used in Policy and Management Contexts

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Abstract: The number and type of indicators used for assessing environmental sustainability around the world have proliferated dramatically within the last few years. From a count of nearly zero just two decades ago, environmental indexes now number in the hundreds. While much has been published on the technical aspects of indicator construction, much less attention has been given to the actual management and policy uses of environmental indicators. Whether environmental indicators are performing a true service in the policy arena is still an open question. This paper addresses this gap by reviewing the impacts of indicators in policy and management contexts generally and in the environmental policy context specifically. We examine the theoretical role that indicators may play in informing or driving policy decisions (e.g., by simplifying choices, highlighting trends, or holding decision makers accountable) and examine case studies of indicator uses around the world derived from a survey of indicator efforts, to identify factors that affect how indicators are used. Where possible we identify best practices for designing effective indicators that can drive policy decisions.

1. Introduction

There has been a rapid expansion in the development and use of indicators and indices (where an index comprises a number of indicators) to inform environmental policy and management decisions in the past few decades, and climate change seems to be increasing the demand for indicators (e.g. USGCRP 2012a and 2012b). However, while much has been published regarding the technical construction of indicators, much less attention has been given to the actual management and policy uses (Unander, 2005; Hezri and Hasan, 2005; POINT, 2011; Morse, 2011). This report reviews the impacts of indicators in policy and management contexts generally and the environmental policy context specifically. The purpose is to take stock of the growing number of efforts to use indicators to measure and manage environmental problems, whether at national or subnational scales, and to identify lessons and principles that may be transferable – i.e. 'good practices'. We accomplish this through a literature review and a summary of responses to a survey that was conducted in collaboration with colleagues at the Asian Institute for Energy and Environment Studies (AIEES) in Korea. The survey resulted in case studies assembled from around the world describing how environmental indicators are being used to inform and to improve environmental governance by nation states, businesses, and civil society (see Annex 1).

In this paper we examine the use of indicators in management and policy processes with a critical eye towards areas where indicators can better facilitate the incorporation of science and data into policy decisions - and thereby improve governance of the world's resources. Section 2 provides background on indicators in policy contexts and major global-scale indicator efforts; Section 3 looks at three uses of indicators; Section 4 identifies factors affecting the roles and influence of indicators; and Section 5 looks at the way forward for action and research. Supplementary online material features case studies of indicator efforts in a number of countries.

2. Background

Around the world and across economic and social sectors, long-standing headline performance indicators are used to inform policy decisions and manage progress towards policy goals. In the economic arena indicators such as gross domestic product (GDP) and rates of inflation are used to gauge the vitality of an economy and to guide policy. For developing countries, many track scores from the Human Development Index (HDI) or the group of indicators associated with the Millennium Development Goals (MDGs) to assess their progress towards social and economic development. In some cases, such as under the U.S. "No Child Left Behind" program, indicators are built into a policy from the start to track progress in addressing a particular problem, in this case the challenge of raising educational outcomes in underperforming schools. These are but a few examples of the indicators in use around the world which are well established and have proven influence over the policy and management processes of their respective arenas.

In the environmental realm, however, there is considerable disagreement over what should be measured, how disparate environmental measurements should be aggregated into composite indices, and what existing or proposed indices best describe the health of the physical world. Although there have been efforts since the Earth Summit in 1992 to identify key environmental indicators with which to track environmental problems and policy responses (e.g., the UN Commission on Sustainable Development's list of 58 sustainable development indicators; see Pintér et al. 2005), and compendiums of indicators are produced on a regular basis (e.g., World Resources Institute's *World Resource Report* and the now defunct *EarthTrends*), existing global composite environmental indices have failed to gather the international backing required to earn a place for environmental performance alongside GDP and social development statistics in informing policy decisions.

Since 1995, when Jonathan Lash of the World Resources Institute declared, "there is no remotely similar number [to GDP] to indicate how the environment is fairing" (Hammond et al., 1995: vii), several leading indices/approaches have emerged that have had sufficient longevity to be analyzed and even adopted by some countries. These include the Ecological Footprint (and its close cousin, WWF's Living Planet Index), the Environmental Sustainability Index (ESI) and its successor, the Environmental Performance Index (EPI), and extended national accounts such as Green Accounts and the Genuine Progress Indicator. In addition to these, there are several hundred other new sustainability indicators in use or development (Böhringer and Jochem, 2007; Parris and Kates, 2003; IISD, *undated*) as well as a growing number of climate vulnerability and resilience indicators (Chen et al., 2011; Füssel, 2009). The major indicators – Ecological Footprint, EPI, and Green Accounts – have all attracted attention in the media, among academics, and, to a more limited extent, among policy makers, yet all suffer from drawbacks that limit their use.

The Ecological Footprint, an environmental indicator developed by the Global Footprint Network, measures consumption impacts in units of hectares of biologically productive land. It has been adopted by environmental NGOs (the WWF Living Planet Index; Loh et al., 2005) and a number of countries. It has succeeded in framing discussions on global sustainability in terms of consumption of resources in excess of a country's (or any jurisdiction's) natural resource endowment – the so-called "ecological deficit". But it provides little guidance to policymakers seeking to address a range of environmental issues beyond the reduction of consumption.

The Yale/Columbia Environmental Sustainability Index (ESI) and its successor, the Environmental Performance Index (EPI), cover a wide range of environmental parameters and have had policy impacts in a number of countries such as South Korea and Malaysia (see Annex 1 case studies). Pilot efforts have sought to adapt the EPI methodology in Abu Dhabi (AGEDI, 2009) and China (YCELP et al., 2011; Hsu et al., 2012), with independent work underway in Malaysia and Tunisia. The EPI in particular has helped to identify key policy priorities and frame ways of measuring progress towards their attainment in a format that resonates with policy audiences. But it suffers from data deficiencies that reflect broad problems in global environmental monitoring efforts around the world. Further, it inadequately captures the environmental impacts of trade flows.

The Green Accounts program of the World Bank was developed to measure the value and benefits of ecosystems to provide countries with more information to assess the true costs and benefits of projects that may threaten the integrity of important ecosystems (ClimateWire and Friedman, 2012). Green Accounts and its close cousin, Environmental Accounts (Bartelmus, 2001), are based on frameworks that include environmental assets that are commercially exploited, with final scores expressed in economic, currency-based value. Though these programs have been successful in certain countries at bringing attention to the economic impacts of environmental degradation (and the potential economic benefits from environmental protection) they have historically been over-reliant on "official" statistics. Furthermore, some object to the reduction of complex environmental problems to a simple cost-benefit analysis that omits spiritual and other intangible aspects, noting that in some cases it may be deemed economically beneficial to harm the environment.[1]

Box 1. Definition of Environmental Indicator and Environmental Index

We use "**environmental indicator**" to mean metrics derived from observation (i.e., data) that are used to identify indirect drivers of environmental problems (e.g., population or consumption growth), direct pressures on the environment (e.g., overfishing), environmental conditions (e.g., air pollution concentrations), broader impacts of environmental conditions (e.g., health outcomes), or effectiveness of policy responses (OECD 1991). Indicators can either represent current status or trends (e.g., percent change or slope over some specified time period). To make them comparable across jurisdictions, indicators are generally denominated. Examples include water availability per capita, particulate matter concentrations in micro-grams per cubic meter, or tons of fish catch per ton of fish catching capacity (Prescott-Allen, 2001).

We use "**environmental index**" to mean an aggregate of environmental indicators, which generally implies conversion to common units (or a unitless scale) and application of weights (i.e., averaging, adding, or application of other mathematical operators). Indices specify an architecture that identifies constituent high-priority issues with all metrics calculated on a common scale.

[1] Green accounting efforts can also be politicized. In China, the Green GDP effort was "doomed from the start," according to the Jamestown Foundation (2011), which found that "Despite initial central government support for the project, local recalcitrance, bureaucratic infighting, and elite party politics eroded support and led to its demise" (p.1).

Aside from other critiques, all of these initiatives, with the possible exception of Green Accounts, could be described as “supply” approaches that do not respond to any direct demand on the part of policy makers *per se*. Their developers are seeking to frame environmental issues in certain ways, and they then seek to provide tools for decision makers to address issues raised by those assessments. Because these indicators did not originate from the policy community or environmental ministries, their uptake in policy processes has necessarily been slow.

Throughout the world there are a growing number of efforts to use indicators—at scales from global to local—to measure and manage environmental problems. Given the drawbacks of existing environmental indices, the lack of firm consensus about what needs to be measured in the environmental arena, and the profusion of views on the utility of environmental indicators in the policy process, it is appropriate to assess the current status of indicator usage, and in so doing, to identify ways that environmental indicators *are* having an impact on policy processes and management decision-making.

3. The Use of Indicators

In her review of the interaction between decision makers and science providers, McNie (2006) writes, “Useful scientific information … improves environmental decision-making by expanding alternatives, clarifying choice and enabling decision makers to achieve desired outcomes” (p.17). In the quest to create and provide so-called “useful” information, indicators have the ability to separate true content from noise and “increase data relevance” (McNie, 2006: 17). We would argue, furthermore, that if properly packaged and presented, scientific information also improves the likelihood that actions will be taken by raising the salience of environmental issues, identifying performance gaps, and holding decision makers accountable.

Indicators can play a number of useful roles in the policy process. Environmental indicators can help to *describe* issues by reducing complexity in policy relevant ways, and to *diagnose* problems through the analysis of trends or correlations with other indicators, helping analysts to *discover* patterns within and across units of analysis. This can help researchers and policy makers to understand underlying processes and identify best and worst practices. Indicators also help society to *deliberate* about desired futures and possible solutions to environmental concerns, grounding debates in empirical reality. Finally, if properly developed and framed, indicators can help to *drive* action, helping society to navigate to its desired future and holding policy makers and program managers accountable.

The most direct role that indicators play, in every stage of the policy process, is the synthesis and communication of complex data (OECD 2008). In the theory and study of the policy process, “policy learning” depends on a number of events, of which the generation and incorporation of information (i.e., data) into policy decisions is a critically important one (Sabatier and Jenkins-Smith, 2003). It is no surprise then that incorporating accurate data into policy decisions is a near necessity in the environmental arena, where science is typically incomplete and uncertainty is high (Bradshaw and Borchers, 2000). Indeed indicators and indexes may be particularly useful in the environmental arena where uncertainty over long term impacts or cause and effect is often held as a reason for inaction or indecision. Referring to what they call the "science-policy gap," Bradshaw and Borchers (2000) write, "Generally speaking, whereas scientists may be familiar with the conditions of scientific uncertainty, the public and policy makers often seek certainty and deterministic solutions. In some cases, the social and cultural standards superimposed on those of science may become critical constraints to effective decision making" (p.1).

Indicators synthesize knowledge needed for policy learning. Indicators are often a means to integrate data into planning, to set and track progress towards goals, to determine the levels and scales of implementation and policy action, and to inform and assess specific decisions, general policy directions, and community values (Hezri 2004). The European Union funded Policy Use and Influence of Indicators (POINT) project, in its examination of the role and influence of indicators in the European policy context, found that indicators play three primary roles (POINT 2011):

1. An **instrumental role** – through the direct use of indicators to manage environmental problems or improve environmental conditions through monitoring programs.
2. A **conceptual role –** the use of indicators to shape ideas in public debates, focusing on framing issues and the promotion of certain world views.
3. A **political role** - where indicators are used to legitimize (or delegitimize) policies or policy actors, which includes both outright legitimization for tactical purposes or symbolic use of indicators by policy actors.

The following sub-sections – which elaborate on these three uses – draw heavily on the work of the POINT project.

3.1. Instrumental Use of Indicators in Environmental Policy

The instrumental use of indicators implies a seamless science-policy interface where scientifically generated data are incorporated directly in decision making processes in a transparent way that leads to improved results. In the European context, the POINT project found that indicators are rarely used in instrumental ways or in direct management contexts. The evidence they collected (largely through case study analysis and dialogue with stakeholders) suggests that the direct tracking of progress and management of environmental problems through indicators is generally confined to well structured and narrowly defined technical problems, and also to situations in which there is consensus over the definitions and interpretations of specific indicators as well as problem definitions and policy solutions (POINT, 2011: 14). But even their influence on policies can be difficult to assess:

> Direct, instrumental use of indicators by policymakers seems … to be rather the exception than the rule, thus confirming findings concerning the role of research and expert knowledge in policymaking more generally. Scientific assessments, evaluations, scenarios and the like often influence policies indirectly and through largely unforeseen pathways, e.g. by gradually shaping frameworks of thought. (POINT 2011: 7)

This finding confirms what researchers have long known, namely that "pure instrumental use [of data-driven evaluations] is not common" (Weiss et al., 2005: 14). The POINT researchers emphasize, however, that these latter, non-instrumental uses are important in their own right, and that indicators can play an important role in framing problems conceptually or reinforcing political processes. We turn to this in the next two sub-sections.

The instrumental use of indicators implies that decisions are made directly on the basis of an indicator score. Case studies in the Supplementary Online Materials (SOM) that meet this criteria are the Danish Action Plan for the Aquatic Environment (Annex 1, Section 3), which uses a number of variables to track nutrient enrichment in waterways to design programs that meet targets, and the Millennium Challenge Corporation (Annex 1, Section 7), which uses indicators to select countries that are eligible for grants from the U.S. government.

3.2. Conceptual Use of Indicators

The conceptual and political uses of indicators are often difficult to disentangle. According to Gudmundson (2003):

> "Indicators also represent particular ways to conceptualize problems and solutions. Indicators are not merely technical or "innocent" instruments for stronger surveillance and reporting. They are also elements in what has been termed as a political struggle over the contents of the process of 'ecological modernization' of society (Gudmundson, 2003: 1)."

The conceptual use of indicators relates less directly to the pure input of knowledge into policy decisions and has more to do with influencing opinions and shaping thoughts. As such its influence is perhaps the most indirect of the three uses here considered. Weiss et al. (2005: 14) write of conceptual uses: "Decision makers might not base their next decision on the evidence, but they often found themselves influenced in more subtle ways in the longer term" by the way the architecture of indices frame the issues. Given their role in shaping opinions, there is also an argument for inclusivity in the process of designing an indicator itself. According to UNESCO & SCOPE (2006: 4), "Since most of the legitimacy of indicators comes from their framing and conceptualization, stakeholders must be involved from the outset."

Conceptual uses have been described as "enlightenment" inducing, and they can best be understood by considering the role indices play when they are included in discussions and debates. Hezri and Dovers (2006) refer to this as the potential "communicative function" of indices, where discursive use of metrics finds them "enlightening and informing the worldviews and values of developers and users" (95). Does the index identify and bring problems to the policy agenda? Does it frame issues in a new way? Reinforce existing policy agendas or challenge the status quo? Indicators are being used conceptually when they create frameworks for conversations.

Of the conceptual uses of sustainability indicators in the European case studies, the POINT team wrote:

> "Contrary to the other indicator studies, the composite indicators of sustainability were seen to function *mainly* in conceptual roles, helping policy actors to adhere to the specific world visions these different composite indicators were built upon … helping to diffuse such visions and ideas and to support alternative thinking and new concepts rather than leading to political action (POINT, 2011: 11)."

Good examples of the conceptual use of indicators include the EPI, which seeks to frame issues in terms of discrete sets of environmental issues with identifiable performance targets that are actionable by policy makers (Emerson et al., 2012), and the Ecological Footprint, which frames environmental problems as a function of over-consumption of resources (Wackernaegel et al., 2002).. The EPI's impact has been to draw attention to the merit of quantitative, outcome-oriented environmental policy. The Ecological Footprint's impact has been to draw attention to the fundamental role of resource consumption and the salience of physical limits. Both of these indices represents a conceptual framing of environmental issues, directing attention to what the authors believe are the most important actions for improving environmental conditions.

3.3. Political Use of Indicators

The political use of indicators describes the role indicators play in supporting or undercutting existing or proposed policy decisions. Within this category, indicators may be used *tactically* (e.g., they may be used to delay or spur action on an issue) or *symbolically* (e.g., they may be used to assure constituents that an action is being taken based on the best available information) (Shulha et al., 1997; Hezri, 2004). Often indicators and assessments can be used to justify what decision makers want to do anyway (Weiss et al., 2005).

Indicators become especially politicized in contexts where they are used to reward or punish those deemed responsible for performance, whether managers or politicians, and they may be subject to data manipulation should the enforcement agency also be responsible for monitoring. For example, there have been allegations that China's official city and province level environmental statistics have been manipulated by government officials fearful of repercussions for poor performance from the central government (Guan et al., 2012; Hsu et al., 2012). If indicators become overly politicized, or the stakes become high, there can also be overt cheating, as in case of teachers under the U.S. government's No Child Left Behind policy falsifying students' standardized exams in order to make their schools score higher (Goldstein, 2011), as well as gaming the system so that performance appears to be stronger than it actually is.

Examples of potential political roles of indicators include the use of non-performance on environmental targets to penalize or marginalize political opponents in China (Hsu et al. 2012), the effect of the 2002 ESI scores in spurring a national soul searching among top political leaders in South Korea (Annex 1, Section 4), and the public celebration over a high ranking in the 2012

EPI by the government of Latvia despite modest attention to past EPIs in which the country did not score so highly.

In their analysis, the POINT team found that indicators played a politicized role more often than an instrumental role and less often than a conceptual role. In summation of their findings they wrote:

> "Looking across the different case studies we believe that we see a change in the role of indicators, which follows the different phases of policy-making – the conceptual role being more prominent in the policy preparation phase where indicators are proposed and selected, while instrumental and political roles dominate the policy implementation phases (POINT, 2011, 11)."

4. Factors affecting the roles and influence of indicators

Despite the many roles that well-formed indicators may play in the policy process, environmental indicators have often failed to be effectively utilized for policy action. What factors can account for the ready uptake of some indices into the policy process while other, seemingly similar, indices languish for want of attention?

4.1. Resonance

To describe the eventual influence, or lack thereof, of indicators, Hezri and Dovers (2006) draw on the theory of resonance, where resonance "connotes a situation where an indicator 'strikes a chord' with its intended audience" (92). As the POINT study discovered, indicators are most useful if they are widely accepted and resonant with a majority of stakeholders (POINT, 2011).

Hezri and Dovers (2006) contend that indicator resonance is the result of an interaction between *content* and *legitimacy*. The content has to do with the validity, reliability, and timeliness of the indicators. Hence, according to this theory, an indicator based on better data will gain greater resonance and policy impact.

Legitimacy concerns the degree to which indicators incorporate appropriate viewpoints from relevant stakeholders, are consistent with dominant political and social norms, and are produced in a way that is seen as sufficiently transparent and fair. Hezri and Dovers (2006) note that "representation of a broad range of views for a fully informed product is a precondition for indicator resonance across society. Substantive inputs by potential users increase the sense of institutional ownership of the product, which in turn increases the likelihood of its persistence" and, we might add, policy uptake (92). Information that is "legitimate", McNie writes (2006), is perceived to be "free from political bias" and "has the interests of the user in mind" (20). These views are confirmed by UNESCO & SCOPE (2006: 4): "For indicators to be effective in the political arena, they need to be credible, legitimate and relevant to policy priorities. Achieving this requires processes which are inclusive and where the divergent views of users and stakeholders are aired and explored."

Many successful indicator efforts, such as Arizona Indicators (Annex 1, Section 7) and the QUEST Project in British Columbia (Rothman et al. 2003), had mechanisms for incorporating stakeholder input into index creation. Yet care needs to taken with what is meant by the term "stakeholder"; in many cases a stakeholder may simply mean representatives of different branches of government or various government agencies. Casting a wider net for stakeholders to involve in the policy process is a strategic way to improve policy uptake, though such "involvement is more often advocated than realized" (Parsons, 1995: 467). Notable side benefits of increased stakeholder participation in index creation include "the contribution of 'local knowledge' and improved cost effectiveness" (McNie, 2006: 25).

Hezri and Dovers (2006) note that the legitimacy of a given indicator will necessarily vary by audience as a function of the intent of the indicator. In other words, who finds an indicator legitimate will depend on who is doing the evaluating and why the indicator was created. Box 3 describes the potential reasons for creating an indicator.

Box 3. Why create an indicator.

Why an indicator was created will influence who finds it legitimate. These are some of the main reasons for creating an indicator (from Failing and Gregory (2003) via Hezri and Dovers (2006)):

1. to discriminate among competing hypotheses (for scientific exploration);
2. to structure understanding of issues and conceptualize solutions;
3. to track performance as determined by results-based management;
4. to discriminate among alternative policies either for specific decisions or general policy directions; and
5. to inform general users (public, stakeholders, community).

To understand the success and resonance of an indicator we must first consider "who" it was created for. Scientists, for example, may respond strongly to a type 1 indicator, policy makers to a type 3.

4.2. Salience

In their analysis of the policy impacts of global environmental assessments, Clark et al. (2006) add *salience* to the larger concept of resonance, arguing that it is as critical as legitimacy and credibility (content) to the final uptake of indicators in policy processes. They write, "The information produced by an assessment process is salient, when potential users believe that the information is relevant to their decision making" (p.15). As with legitimacy, saliency can be fostered by having an assessment process that "co-produces" knowledge by involving potential users in the creation process. Importantly, they add, such a process should seek to build "the capacity of various actors to contribute to assessments and to understand the information they produce" (p.19). They conclude that producers should focus on the process if they want to craft an assessment that will have policy relevance. This approach has led to trans-disciplinary science that engages stakeholders from the outset in the framing of research questions (Hackmann and St. Clair 2012, Pahl-Wostl et al. 2012), and could well serve as a model for indicator development. A significant challenge, however, is the resources and time required to engage a wide range of stakeholders in indicator design.

Salience may grow (or diminish) with time, as policy makers become more familiar with an indicator or index framework and methodology. Indicator influence on policy action is generally a slow and gradual process, where information must be presented, understood and embraced by a minimum threshold of stakeholders and policy actors (Innes, 1998). Additionally, numerous successive measurements must be taken and presented before it becomes possible to identify trends or compare policy outcomes through the use of indicators. This notion is similar to Sabatier and Jenkins-Smith's assertion that policy analysis must consider time frames of 10 years or more to accurately record the process and impacts of policy decisions. The identification of an indicator as "successful" may thus be a result of when the indicator is considered rather than whether the indicator is actually effective in the long run (Hezri and Dovers, 2006). By the same token, one-off indicator efforts such as the *Wellbeing of Nations* (Prescott-Allen 2001) are unlikely to have a long-term impact. Country requests to the Yale/Columbia team for assistance in developing environmental performance indicators rose substantially after the second release of the EPI in 2008; but interest could have easily waned had there not been a sustained effort.

As the POINT researchers identified, indicators are often institutionalized only when a policy framework is relatively stable and existing structured policies are already in place. The conceptual use of indicators, on the other hand, may operate long before these structured policies are formed, and therefore it may be difficult to find empirical evidence for their effectiveness. To summarize, for indicators to be implemented as instruments in decision-making, they must be relevant to the intended user, scientifically justifiable and measurable, and reflect conditions and priorities of the target audiences (POINT, 2011).

4.3. Context

The uses of indices or indicators in policy practices are necessarily influenced by stakeholder values (as noted in the above discussion of resonance), which may change over time and create new contexts for indices to influence the political process. In an examination of indicator impacts on Australian policy, Hezri and Dovers (2009) found that changing social values, which first warmed and then cooled to the prioritization of the environment in national debates across a thirty year cycle, nicely predicted the extent to which environmental metrics, and aggregate "sustainability" indices, were utilized in the formation of laws and policies.

Who created a given index will also influence its final use. In the systems described by Hezri and Dovers (2009), indicator systems were derived from government policies and implemented at government behest. These indicators were therefore representative of the priorities of the system and more likely to engender policy change or influence policy development. The POINT (2011) analysis of UK energy policy found that energy policy actors were quite unaware of indicators being published by outside groups, and therefore they could not be acted upon. This finding further reinforces the idea that indicators should be tailored and developed for their intended audience and users, and, we might add, well marketed when developed outside the intended user's community.

For this review we collected case studies of environmental indicator efforts that could be thought of as provisionally successful, meaning they have played some measurable role in informing policy decisions. It may be no coincidence then that the majority of the cases in Annex 1 represent government-led efforts (eight out of ten) with NGOs or universities largely playing supportive or collaborative roles.

The case of the International Energy Agency (IEA) provides a nice contrast to the UK energy policy case study. The IEA has advocated, since its inception, for the development of indicators for analyzing sustainability issues in the energy sector by disaggregating information to reveal links behind driving forces pertaining to energy use and emissions across the world (Unander, 2005). In the early 2000's the IEA developed a series of energy indicators that have provided a flexible platform for informing policy decisions at the international level over time.

4.4. Rankings and Media Outreach

Rankings are a common device for attracting media and policy maker attention. Many rankings appear in the U.S. media such as rankings of colleges and universities, rankings of states by educational attainment and social development, and rankings of cities in terms of livability. Globally, the Human Development Index ranks are influential among developing country policy makers and the Global Competitiveness Index results are tracked by many emerging economies, since it can influence overseas direct investment.

The ESI and EPI have successfully employed rankings to set up a competitive dynamic among countries. Experience has shown that high level policy makers pay attention to their ranking relative to neighbors or countries at similar development levels. They often respond by first questioning the data and methodology, and then, after further discussions, engaging in an analysis of performance on sub-components. The desire to improve one's image, if not always the on-the-ground reality, is a powerful motivator.

Press conferences and outreach campaigns have become the standard tools for bringing attention to environmental indicators. For example, the Global Footprint Network (GFN) has a well orchestrated campaign through the Internet and outreach materials to encourage governments and individuals to think more about their consumption and approaches for reducing the environmental footprint of their activities. The annual announcement of Earth Overshoot Day, which is the day of the year by which the world population has consumed its sustainable "budget" in renewable and nonrenewable resources (in 2012 it was August 22), much like the periodic resetting of the Doomsday Clock by the Bulletin of Atomic Scientists, draws public attention to an important issue of global consequence. Recently Wackernagel (2011) has drawn analogies between the global financial crisis precipitated by over-valuation of assets leading to overdrawing of financial accounts and the global environmental crisis precipitated by overdrawing nature's accounts, thus capitalizing on public concern over the economy.

Clearly without some level of media and public attention no "outside" indicator effort (meaning an effort that was not developed directly by government) that seeks to instigate change can gain traction in the public mind or influence policies. Crucially, the public, once informed, may apply pressure on decision-makers to strengthen environmental regulations.

5. Going forward – future action and research

The influence of indicators is greater when connections are strengthened between targeted users and indicator developers. By achieving agreement among actors to identify a problem, resulting objectives, goals and measures will enhance the likelihood of indicators playing a significant role in policymaking (POINT, 2011). It is important to evaluate and recognize the needs of a policy system, and the key leverage and access points for information, and what types of indicators are appropriate for proper learning and utilization. Stakeholders, meaning both policy makers and the civil society representatives most affected by an environmental issue, should be involved in these processes to facilitate learning and help identify areas where indicators are needed for impacts in policies. Many policy makers are not involved in indicator development processes, which means they are unaware of indicators that may be valuable guides for decision-making.

Because many factors influence the utilization of indicators in policy processes, several challenges must be addressed before there can be effective integration of indicators within policy systems (Hezri, 2004). Indicator producers should make an effort to ensure the indicators they produce are capable of stimulating policy learning. Indicators should be easy to understand and capable of being unambiguously interpreted (Böhringer and Jochem, 2007), and their production should be a transparent and understandable process (POINT, 2011). Indicators should be relevant to the political agenda and be suited for the system (Hezri, 2009). Indicators are not always embraced for direct influence in policy making processes, but they can play a role in informing stakeholders, sparking advocacy, and making vital information available for monitoring and evaluating processes and management.

The POINT project represented an important first step in research on this topic, yet there remain regional gaps in understanding how indicators are used in other cultural and political contexts. For example, there is a rapid adoption of environmental indicators in Asian countries, most often spearheaded by governments, yet adoption has lagged in Africa and Latin America. This could be because of different political cultures, such as the difference between some southern European countries, where indicators are produced for EU and European Environment Agency reporting requirements but are rarely used, versus Nordic countries where they are both produced and used (POINT, 2011).

Moving forward, more research is needed to determine the actual roles indicators are playing in policy processes, the extent to which indicators influence policy processes, and how indicators are being used by different stakeholders and actors. There are many cases of successful utilization of indicators in policy due to their promotion and proper identification of uses and users. To further explore the utilization and impacts of indicators in policies and management processes, developers can help by identifying successful cases of indicator usage, as well as cases where indicators had little impact. It is essential that proper recognition is made of the intended audience of indicators, because this type of communication begins the process of learning and exploring ideas. Once the users are identified, the actual direct and indirect roles indicators are playing in processes can be determined. As a result, opportunities are created for indicator developers and users to showcase efforts and facilitate social learning and understanding.

Finally, more serious attention needs to be given to the statistical methods and construction of aggregate indices, especially with the advent of time-series indices (e.g. the Ecological Footprint and the 2012 Pilot Trend EPI) (Ebert and Welsch 2004). As Böhringer and Jochem (2007) point out, normalization and weighting schemes have significant impacts on aggregate indices, and, since different approaches can easily result in the reporting of apparent improvements or deterioration in environmental conditions over time that are independent of the actual “state” of the environment, insufficient attention to the statistical aspects of aggregation can result useless if not misleading information for policy.

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Annex 1. Case Studies

The following case studies were compiled from multiple sources, including an online survey distributed by the authors (see Annex 2), profiles by indicator developers, and research by the authors. Sources are listed at the end of each case study. Source information for each case study is provided at the end of that subsection. Additional case studies are periodically released via the EPI web site at http://epi.yale.edu.

1. Africa Case Study

Energy, Environment and Development Network for Africa

Energy resources and policies are major topics for sustainability goals around the world. To begin addressing these issues in Africa, the Energy, Environment and Development Network for Africa (AFREPREN/FWD) was initiated in 1987 by a group of experts as a non-governmental organization.

AFREPREN/FWD has a range of focal areas including Energy Sector Reform, Energy Services for the Urban Poor, Renewables and Energy for Rural Development, and Special Studies of Strategic Significance. The program also aims to identify cleaner alternatives from among renewables, and to establish efficiency priorities and strategies in conjunction with national and international organizations.

AFREPREN/FWD is fundamentally diverse and is managed by a Steering Committee of advisors for energy technology and services as well as a Policy Advisory Panel. A secretariat oversees the management and coordination of the energy program. A target group of participants is invited to national policy seminars including government representatives, senior decision makers (e.g., members of parliament), energy regulatory agencies, local authorities, national electricity utilities, independent power producers, rural and urban energy institutions, financial institutions (involved in energy sector investment), small credit institutions (targeting low income rural and urban enterprises), representatives of informal sector enterprises, associations of manufacturers, and private and public sector institutions (interested in the provision of modern energy).

AFREPREN/FWD's research projects rely on important indicators for measuring performance including socio-economic and energy data. Key indicator data is obtained from a variety of sources and published in the African Energy Data and Terminology Handbook and through AFREPREN/FWD's occasional papers. Specifically, these indicators include electricity consumption, petroleum consumption, electricity intensity and related economic data.

AFREPREN/FWD has adopted several strategies for investigating energy issues, trends, investments, and environmental implications. One of the program's focal points, Special Studies of Strategic Significance, addresses new and emerging issues with potential implications for African countries. These issues have included adapting and implementing modern biofuel technologies, the substitution of oil and coal by natural gas, and environmental and socio-economic impacts of large-scale energy development (e.g., large scale dams, coal mines, and oil pipelines).

The AFREPREN/FWD program has significantly contributed to promoting cleaner energy investments and developing new energy strategies and policies on regional, national and international levels. With over 300 active contributors, the large numbers of stakeholders involved in AFREPREN/FWD's initiatives greatly influence energy policy, investment, and research.

As a result of AFREPREN/FWD's initiatives, assessments have been carried out for major organizations, such as the African Development Bank, to help identify renewables and efficiency priorities. AFREPREN/FWD has also contributed to energy strategies for the World Bank and the UN, along with other major international bodies. Regionally, the organization has initiated cleaner energy investment support initiatives and associated policy research capacity building studies in 19 African countries.

Sources

Case study written by YCELP and CIESIN staff. Source documents include: AFREPREN/FWD – Energy, Environment and Development Network for Africa Web site, http://www.afrepren.org/index.htm, African Energy Data and Terminology Handbook (2003-2004), http://www.afrepren.org/datahandbook2/databk.htm, and AFREPREN/FWD occasional papers, http://www.afrepren.org/Pubs/occasionalp.htm.

2. Cambodia Case Study

The Tonle Sap Rural Water Supply and Sanitation Sector Project of Cambodia

Adequate water supplies and sanitation are among the greatest challenges in public health related to the environment. Cambodia has suffered from high rates of diseases as a result of inadequate water and sanitation resources, and although Cambodians have made improvements, their rural water coverage remains one of the lowest in Asia. As a result, the government of Cambodia has developed the national water supply and sanitation policy, which established the objective that "every person in rural communities has sustained access to safe water supply and sanitation services and [is] living in a hygienic environment by 2025."

In efforts to improve access to water and sanitation for rural people living around Tonle Sap Lake in Cambodia, the Ministry of Rural Development and the Asian Development Bank (ADB) initiated the Tonle Sap Rural Water Supply and Sanitation Sector Project (TSRWSSP) in 2006.

This project aims to increase the percentage of the rural population with access to a safe water supply to 50% and sanitation facilities to 30% by 2015, and the project is in line with the Cambodia Millennium Development Goals (CMDG) targets. In addition to these CMDGs, the project aims to reduce child mortality due to waterborne diseases by half of the 1990 level.

The primary objective of the Cambodian government is to improve the well being of people throughout the country - particularly focusing on rural areas, which are home to 85% of the population. To track the needs and progress of the TSRWSSP, project managers rely on water quality and performance indicators. A water quality index has been developed for monitoring and reporting indicator data from the target provinces involved with the TSRWSSP initiatives. Additionally, performance indicators allow the monitoring of progress for reaching project and CMDG targets. Performance indicator data is obtained from reports and statistics from government agencies, development partners, non-governmental organizations, and the ADB project performance and audit reports.

The TSRWSSP's initiatives are applied to Cambodia provinces around Tonle Sap Lake, such as Kompong Chhnag, Pursat, Battambang, Siem Reap and Kompong Thom, and to communes under the supervision of these provinces. Based on consultation with provincial authorities and the use of indicator data, the project has recognized 18 districts as needing improvements throughout these five provinces. Water quality and performance indicators for these managed areas are presented in the TSRWSSP Project Completion Report (2010).

As a result of the TSRWSSP, local and national policy makers have strengthened targets for water and sanitation access in villages from 50% to 90% and 30% to 75% respectively. The project is expected to provide clean water and sanitation facilities to approximately 1,760 villages in the provinces Tonle Sap Lake. Because of the project's successes thus far, the Cambodian government and the ADB are now approving a second phase to the project.

Sources

Case study submitted by Professor Sethy of the Royal University of Phnom Penh in Cambodia. Source materials include: *The Report and Recommendation of the President to the Board of Directors on a Proposed Grant to the Kingdom of Cambodia for the Tonle Sap Rural Water supply and Sanitation Sector Project* by the Asian Development Bank, The Tonle Sap Initiative: Future Solutions Now http://www.adb.org/projects/tonle_sap/water-supply.asp.

3. Denmark Case Study

Danish Action Plan for the Aquatic Environment

The Danish Action Plan for the Aquatic Environment (APAE) addresses pollution of Denmark's rivers, lakes, groundwater, and marine waters. Several action plans focus on specific links between urban, industrial, and agricultural sectors and the aquatic environment.

APAE was developed in 1987 and includes several action plans to assess ecosystems and the key causes of environmental problems. These action plans contribute to APAE's objective of improving ecosystems in accordance with environmental targets. Several cases have been implemented to demonstrate links between agricultural and environmental sustainability. These are important lessons learned for policy development and implementation, and achieving the goal of environmental rehabilitation.

APAE is a national initiative in Denmark with regional monitoring programs implemented in each of the 14 Danish counties. Several important stakeholders are involved in APAE including regional water authorities and national authorities, such as the Danish Environmental Protection Agency (EPA), the National Environmental Research Institute (NERI), and the Geological Survey of Denmark (GSD).

APAE is focused on reducing nitrogen and phosphorus discharge into water systems. A monitoring program has been established to analyze nutrient discharge and effects on aquatic biological communities.

Regional authorities for each Danish county are responsible for monitoring the reduction of nutrients in groundwater and surface water. NERI and GSD monitor open sea and atmospheric deposition while planning and coordinating annual reporting.

APAE uses several indicator initiatives to evaluate environmental policy performance. Nitrogen emissions to the aquatic environment are an important indicator category for evidence-based policy. The following are objectives of the APAE III action plan, which include indicators and environmental targets:

- Reduction of the phosphorus surplus in agriculture by 50%. Instruments include a tax on mineral phosphates in feed and intensified research in feed efficiency and treatment of livestock manure.
- Reduction of phosphorus leaching to water bodies by establishing 10-meter crop-free buffer zones along rivers, streams and lakes, and by restoration of wetlands.
- Reduction of nitrate leaching by 13% (the result of the previous Action Plans I and II is a reduction by 50%) using set aside, agri-environmental measures, mandatory catch crops and further requirements for the utilization of the nitrogen content in livestock manure.

- Protection of neighbors, protection zones where framing facilities are not allowed within 50, 100 and 300 meters distances, depending on the number of neighbors and the size of livestock herd.

The following table includes a list of Danish national surface water monitoring programs:

Name	**Variables**	**Geographic Coverage**	**Institutions**
Rivers and Streams			
Nation-wide Monitoring Programme Monitoring of streams	Chemical and physical variables Microinvertebrates	Nation-wide, 261 sampling sites in approx. 125 river systems	Responsible: NERI Database: NERI Reporting: NERI
Nation-wide Monitoring Programme Monitoring of springs	Chemical and physical variables	Nation-wide, 58 springs	Responsible: NERI Database: NERI Reporting: NERI
Nation-wide Monitoring Programme Monitoring of agricultural watersheds	Chemical and physical variables on soil water, drainage water, ground water, and river water.	6 agricultural watersheds	Responsible: NERI Database: NERI & GSD Reporting: NERI & GSD
Inventory of biological assessment of river quality	Macroinvertebrates Quality classification grades	Nation-wide, 10,000 sampling sites	Responsible: EPA Database: EPA Reporting: EPA
Lakes			
Nation-wide Monitoring Programme Monitoring of Lakes	Chemical and physical variables in lake water and tributaries. Phyto- & zooplankton, fish, and macrophytes. Sediment composition	Nation-wide, 37 lakes	Responsible: NERI Database: NERI Reporting: NERI
Coastal and marine areas			
Nation-wide Monitoring Programme	Chemical and physical variables. Phyto- &	Nation-wide, 200 coastal sampling sites and	Responsible: NERI Database: NERI Reporting: NERI

Monitoring of coastal and open marine waters	zooplankton, zoobenthos, and macrophytes. Sediment composition	80 offshore samplings sites.	

Results

The uses and impacts of indicators from the Danish APAE were evaluated by POINT as a EU Framework Program project, and indicator uses varied throughout management practices. Indicators were annually published in monitoring reports. Key indicators from the system's initiatives were combined with indicators on measures to produce annual status notes and evaluations. Indicators were embraced in negotiations among civil servants, environmental NGOs, and the agricultural organization. Stakeholders used evaluations and indicators to negotiate the Action Plan, and members of Parliament used indicators and evaluation results as a basis for posing questions to the responsible institution.

As a result of the uses of indicators by many stakeholders involved in the Danish APAE, changes occurred to the system to enhance effectiveness. If evaluation results showed a lack of compliance with targets, measures in the Aquatic Environment Action Plans were strengthened. Targets were not set as a result of evaluation and indicators, but rather as a requirement of the EU Water Framework Directive, which is a community framework for water protection and management. However, measures were selected based on studies informed by monitoring and embracing agri-environment indicators used in the system.

Sources

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4. Korea Case Studies

The Air Quality Index for Seoul, South Korea

When Korea was ranked 136th out of 146 countries in the 2002 Environmental Sustainability Index, and 120th out of 122 countries for air quality, the South Korean government and major stakeholders recognized that air quality needed major attention.

The Ministry of Finance, Ministry of Construction and Transportation, Ministry of Commerce, Industry and Energy, and Ministry of Environment worked together with “The Alliance,” a group of non-governmental environmental organizations and major auto industries throughout Korea to start addressing urban air quality. The initiative focused particularly on the Seoul Metropolitan Area of South Korea where the primary concern is $PM_{10,}$ which has both environmental and human health impacts.

South Korea uses PM_{10} and other air quality indicators to track performance and evolve management practices. Seoul Air Quality established a comprehensive Air Quality Index (AQI) measuring PM_{10}, ozone, nitrogen dioxide, carbon monoxide, and carbon dioxide, and the *Environmental Statistics Yearbook 2010*, published by the Ministry of Environment, South Korea, provides the indicator data needed to track performance over time.

Seoul has 52 continuous monitoring stations, collecting air quality data, including data on ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter measurements of 10 micrometers or less (PM_{10}). The broader metropolitan area, which encompasses 27 cities, has 75 monitoring locations, and electronic billboards throughout the city display the AQI measurements to the public.

The government implemented several policies to help reach strengthened air quality standards, which were strengthened from 80 micrograms/m^3/year and 150/day in 1993 to 50/year and 100/day in 2007. The ‘Total Load Management System for Factories’ addresses factory emissions, and it requires that major pollutants, such as PM_{10} and $NO_{x,}$ be reduced to half their current levels by 2014. New policies addressing vehicle emissions provide financial support for low-pollution diesel vehicles, emission-reducing equipment, low-pollution engines, low NO_x burners, and the “early retirement” of vehicles generating higher pollution.

To address emissions in the public transportation sector, compressed natural gas (CNG) buses are being introduced throughout cities over time, with the number increasing from 74 in 2001 to 2,746 in 2002 and 23,000 in 2010. The Bus Rapid Transit System (BRT) was also established to create bus lanes in the center of roads for more efficient traffic flows, and congestion fees are collected at specific tunnels.

Additionally, public parks are being used as a management effort to address air quality. Governments are expanding green space with a goal of 10 million pyeong (3.3m^2 per person) by the year 2020, constructing Seoul Forest to create five separate parks and transforming the Nanjido landfill site into a park.

Sources

Case study written by the Asian Institute for Energy, Environment and Sustainability (AIEES), Seoul National University. Source materials include: *Environmental Statistics Yearbook 2010* by the Ministry of Environment Republic of Korea, http://eng.me.go.kr/main.do, and Seoul Air Quality – Climate Change Information http://cleanair.seoul.go.kr/main.htm, and Special Measures for Air Quality Improvement in the Seoul Metropolitan Area, Ministry of Environment.

The Volume Based Waste Fee System of Korea

Waste management has major effects on human and environmental health and is a major source of environmental pollution. After failing to effectively manage wastes, South Korea sought to restructure their policies on the decentralization of waste management. In the early 1990s, the Local Autonomy System for waste was introduced, and the focus of South Korea's government changed from waste collection and processing to the reduction and reuse of waste as a resource.

The evolution of waste management policies in South Korea has evolved over time. Initially, the Local Autonomy System for waste management was introduced in 1948, but was adjourned in 1962 because military and local governments were independently handling their wastes based on the Wastes Cleaning Act. Members of the Wastes and Resources Bureau, the Ministry of Environment worked together with a group of non-governmental environmental organizations, major auto and recycling industries, and local governments and residents from all regions throughout Korea to begin redirecting strategies towards reducing and reusing waste as a resource.

South Korea uses annually reported waste and economic data to track waste management development and progress overtime. Data is collected through the Ministry of Environment of South Korea and utilized as indicators for monitoring progress and adjusting practices or policies as needed. Indicators for waste data include total waste production, recycling and final waste processing quantities, and quantities produced per capita. Indicators for economic benefits include the reduction in processing expenses, waste reduction effects – amount of waste reduction, increased recycling effect – increased recyclables value, and amounts of increased recyclables.

To ensure successful reduction of wastes, a Volume-based Waste Fee System was implemented along with the development of waste deposit and waste treatment charge systems. These new systems resulted in a drastic reduction of household waste generation from 1.33 kg/capita/month in 1994 to 1.03 kg/capita/month in 2004. Landfills or incineration rates decreased from 84.6% in 1994 to 42.2% in 2007. The collection of recyclables has increased 226% from 1994 to 2007, and the recycling rate increased from 15.4% in 1994 to 57.8% in 2007. Additionally, industries and technologies for recycling have begun to develop and methods for processing wastes have changed.

Sources

Case study written by the Asian Institute for Energy, Environment and Sustainability (AIEES), of the Seoul National University. Source materials include *Some Success Stories of Korean Environmental Policies: Waste Reduction and Recycling* by the Ministry of Environment Republic of Korea, http://eng.me.go.kr/main.do, and *30 Years of the Environment* by Ministry of Environment Republic of Korea.

The Water Shed Management Act of Korea

Two accidents in 1991 and 1994 led to the contamination of the Nakdong River in Korea. The incidents led to the release of volatile organic pollutants, including dichromethane, into the drinking waters of the Busan Metropolitan Area and Gyeongsangnam Province. Carcinogenic compounds, such as benzene and toluene were later discovered, and two massive fish kills occurred in the Yeongsang and Imjin Rivers. Following the Nakdong pollution incident, regional management conflicts, and the release of Korea's water quality ranking in the 2002 Environmental Sustainability Index, stakeholders recognized water quality as a collective action problem for Korea.

The Ministry of Environment, Ministry of Construction and Transportation, Ministry of Commerce, Industry and Energy, Ministry of Health & Society, Ministry of Home Affairs, Ministry of Land, Transport and Maritime Affairs, and Ministry of Food, Agriculture, Forestry and Fisheries, and the Board of Audit and Inspection worked together with the National Assembly Civil Society, a group of non-governmental environmental organizations, and members of the private and residential sectors to launch a multi-sectoral approach to begin addressing issues of water quality.

Addressing water quality is a major focus of South Korea's initiatives due to its involvement in environmental and human health. Three special acts on watershed management were implemented in 2002, which covered four major rivers throughout South Korea. Additionally, in 2004 a Total Management Daily Loads (TMDL) system was developed as a comprehensive measure for nonpoint source pollution management. These new systems for water quality were applied to the Seoul Metropolitan Area, Busan and Baegu metropolitan areas, and have now spread to over 66 major cities.

Stakeholders use indicators pertaining to water quality data for monitoring and guiding management practices and policies. Indicators include data for BOD_5 and total phosphorus, both measurements for improving and maintaining the quality of water in rivers and ecosystem vitality. Data is collected through the Ministry of Environment, Republic of Korea, to provide the necessary indicator data needed to track performance over time.

There have been significant changes in water policy development including extending the powers of the Ministry of the Environment, expanding budgets for environmental issues, and strengthening regulations for environmental protection. The three acts on Watershed Management and Community Support have heavily influenced practices surrounding water quality throughout Korea. Underground water monitoring stations have been established at 2,499 locations throughout the nation to help analyze water quality trends over time. These stations provide measurements of dissolved oxygen, total organic carbon, pH, and other parameters including volatile organic compounds.

Currently, 66 local governments enforce the mandatory Water Pollution TMDL System. Monitoring requirements were strengthened during a second planning period in 2011, and targets and margins of safety were established to help analyze progress for individual and unit watersheds. Also, Waterfront Zone Systems, or riparian buffer zones, are required as part of the water quality acts to help manage nonpoint pollution sources.

Sources

Case study written by the Asian Institute for Energy, Environment and Sustainability (AIEES), of the Seoul National University. Source materials include *Some Success Stories of Korea Environmental Policies* by the Ministry of Environment Republic of Korea, http://eng.me.go.kr/main.do.

5. Kuwait Case Study

Environmental Indicators and Monitoring Information Systems of Kuwait

Environmental sustainability is one of the major challenges Kuwait is facing in achieving the Millennium Development Goals (MDGs). Data for environmental performance indicators is limited for important issues in Kuwait, such as the consumption of ozone-depleting substances and carbon dioxide emissions. Although Kuwait has performed well in other areas related to MDGs and has reached 100% population coverage for safe drinking water and basic sanitation resources, the government of Kuwait recognized the need to develop and utilize additional indicators to address other important environmental goals.

To begin addressing the need for environmental data, the Kuwait Environment Public Authority (KEPA) has developed environmental indicators in collaboration with authorities and several UN organizations (i.e., UNDP Country Office in Kuwait and UNEP/ROWA in Bahrain). Indicator data is collected for air and water quality, natural reserves and protected areas, and wastewater through a national monitoring program. The environmental indicators are used by various bodies throughout Kuwait including KEPA departments and staff members, policy makers, national authorities and organizations, scientists, researchers, academicians, students, voluntary organizations, conservation-focused institutions, and citizens.

In 2009, KEPA decided to embark upon an initiative to gather comprehensive environmental data into a centralized repository, the Environmental Monitoring Information System of Kuwait (eMISK) Geo-Environmental Database. The eMISK system database has been transformed into a data analysis and decision-making system, and indicator data is used to publish the online Kuwait Air Quality Index and Kuwait Drinking Water Quality Index.

eMISK is also a key tool for KEPA in its duties and mandates for environmental monitoring, and the system manages all aspects of environmental factors. The eMISK system helps support the development and adoption of policies and practices contributing to the conservation and sustainable use of the environment, creates credible knowledge on the state and value of environment in Kuwait through assessment, analysis, and reporting of environmental data, promotes and disseminates environmental knowledge to all levels of the Kuwaiti society through Kuwait's Official Environmental Portal, and is a center of excellence for training in geo-environmental analysis throughout the region.

The development and dissemination of environmental indicators have resulted in the use of indicator data to inform the public and decision makers on important environmental issues and trends in Kuwait. The geo-environmental database and the environmental indicators produced by eMISK are being used in the development of the "Environmental Status Report for the State of Kuwait" and the "1st National Communication on Climate Change Convention" which are currently under preparation by the Environment Public Authority (EPA) in collaboration with UNEP/ROWA in Bahrain.

Additionally, the environmental indicators produced by eMISK are being used to guide the management decision-making process in Kuwait. For example, the continuous monitoring of the marine environmental indicators in Kuwait justified and facilitated the decision-making process at KEPA and the Supreme Council for the Protection of the Environment (at the Prime Minister Cabinet) that resulted in theapproval of two major future projects for the "Assessment of Damage and the Rehabilitation the Marine Environment and Habitats in Kuwait" and establishment of a "Comprehensive Marine Inventory". Similarly, another two major inventories will be conducted to cover the industrial sector and the terrestrial environment.

Sources

Case study written by Mohammad D. Al Ahmad of KEPA. Source documents include: http:www.emisk.org, http://www.beatona.net, *eMISK Project Plan*, *eMISK Geo-environmental Database Design and Data Model*, *eMISK Design and Development Document*, *The Environmental Strategy of the State of Kuwait* by Kuwait Environmental Public Authority and UNDP-Kuwait, *Country Report on the Millennium Development Goals: Achievements and Challenges 2003*, http://www.undp-kuwait.org/mdg/Kuwait_MDG_Report_2003_Eng.pdf, *Country Report on the Millennium Development Goals: Progress Report 2005*, http://www.undp-kuwait.org/mdg/KUW_MDG_2005_Eng.pdf, and *Country Report on the*

Millennium Development Goals: Progress Report 2010, http://www.undp-kuwait.org/mdg/English-Kuwait MDG 2010.pdf.

6. Malaysia Case Study

Environmental Quality Indicators of Malaysia

After a self-assessment study of the 2010 Environmental Performance Index results for Malaysia, policy and academic stakeholders recognized the need to assess performance and address the growing importance of environmental sustainability in the new economic model of Malaysia through gathering and developing important environmental indicator data.

Malaysia's self-assessment study was conducted by the Ministry of Natural Resources and Environment in collaboration with the University of Teknologi Malaysia in response to Malaysia's scores and rankings in the global Environmental Performance Index. Following the assessment and recognition of the need to address issues related to sustainability, the Department of Environment (DOE) of Malaysia has developed several programs to monitor, collect, and distribute important data related to environmental performance to help ensure sustainable development through a process of nation building. These programs are aimed at providing valuable information to improve awareness and monitor change over time. The Environmental Quality Indicators (hereafter "EQI") was initiated as a program to monitor air, water, and marine quality. Monitoring stations throughout Malaysia were strategically chosen and implemented for this program.

The EQI installed two monitoring programs that address air and water environmental performance: The Air Pollution Index (API) and the River Water Quality Index (WQI). The API was established to provide the public with easy-to-understand information about air pollution. The API is similar to the Air Quality Index (formerly called Pollutant Standard Index) developed by the U.S. Environmental Protection Agency. Air pollution levels are determined according to internationally recognized ambient air quality measuring techniques. The WQI was also established to evaluate river water quality status in relation to pollutant load categorization and class designation using National Water Quality Standards for Malaysia.

Indicator data for the API and WQI are collected through the Government of Malaysia and published in their Environmental Quality Report (2010). These indicators are based on measurements of pollutant data considered important for human and environmental health. Raw data comes directly from this project's continuous monitoring program and include data on O_3, CO, NO_2, SO_2, and PM_{10} for the API and BOD, COD, NH_3, N, SS and pH for the WQI.

API indicator data is transformed into an easy to understand index of air pollution for the public. Air pollution levels are determined according to the internationally recognized ambient air quality measuring techniques. The API is presented in ranges of numbers and colors to describe daily air quality conditions for regions throughout Malaysia.

API	Descriptor
0 – 50 (green)	Good
51 – 100 (yellow)	Moderate
101 – 200 (orange)	Unhealthy
201 – 300 (red)	very unhealthy
> 300 (dark red)	Hazardous

Indicator data for the WQI is based on levels of important water-quality parameters and is translated into three classes: clean, slightly polluted, or polluted. These classes are determined in relation to pollutant load categorization and class designation according to National Water Quality Standards for Malaysia.

EQI programs are applied nationally for uses by national and local policy makers, academia, and the general public. The API and WQI allow time-based measurements of pollution, helping to create transparency and accountability. The programs also allow the DOE to create betterment of services to consumers, businesses and governmental sectors. Additionally, the successes of these programs have resulted in the launch of the Malaysia 2012 Statewide EPI Index.

Sources

Case Study written by Professor Rahmalan Bin Ahamed, Dean of Research and Sustainability Research Alliance Coordinator, Universiti Teknologi Malaysia, Johor Bahru, Malaysia. Source documents include: *A Guide to Air Pollution in Malaysia* by the Department of Environment Malaysia (2000), *Malaysia Environmental Quality Report 2005*, *Malaysia Environmental Quality Report 2010*, Malaysia Meteorological Air Pollution Monitoring Network, http://www.met.gov.my/index.php, and *National Water Quality Standards for Malaysia*, http://www.wepa-db.net/policies/state/malaysia/river.htm.

7. U.S. Case Studies

Arizona Indicators

Major environmental issues in Arizona include the sustainable use of land, water, and energy. To begin addressing these issues so as to protect the quality of life for all current and future residents, Arizona Indicators was initiated as a project aimed at centralizing data to demonstrate the state's status on sustainability topics. The goal of this project is to promote informed decision-making at the individual, community and policy level by fostering data-driven dialogue and civic action through the presentation of actionable metrics, public opinion data, and expert analyses.

Arizona Indicators began in 2007 with support from major sponsors, Arizona State University and the Arizona Community Foundation, and today is managed by Morrison Institute for Public Policy at Arizona State University. Arizona Indicators is organized into 11 broad content areas. The project Web site presents interactive data visualizations, mapping tools, and policy analyses on a variety of issues in order to increase public awareness and support evidence-based policy-making. Content for the site is primarily developed by ASU scholars with input from numerous community experts and stakeholders.

Sustainability indicator metrics associated with air and water quality, energy and land use are provided to help influence public policy initiatives. These include data for ozone, PM_{10}, MCL violations, health-based violations, temperature and climate, and energy statistics. Indicator data is acquired from a variety of sources, including the U.S. Environmental Protection Agency, the Arizona Department of Health Services, the National Oceanic and Atmospheric Administration, the U.S. Energy Information Administration, local airport authorities, and city water departments.

Members of the media, students, public officials and others use the sustainability metrics presented by Arizona Indicators to advance the conversation about making Arizona a sustainable state with a high quality of life for all residents. The project recently hosted an expert panel discussion for the Sustainable Cities Network on the topic of the urban heat island phenomenon, leading to the release of a policy brief. These efforts demonstrate how the project uses metrics from the site to highlight timely issues and then takes it one step further by convening stakeholders for candid conversations about the policy implications.

Sources

Case study written by the CIESIN and YCELP staff, and reviewed by an Arizona Indicators staff member. Source materials include http://arizonaindicators.org/.

Millennium Challenge Corporation

The Millennium Challenge Corporation (MCC) is a global initiative offering two grant programs to countries that are committed to improving their policy performance. MCC recognizes that sustainable economic growth and a healthy environment are related, and the initiative utilizes performance indicators for selecting countries into funding programs and monitoring a country’s progress and improvement throughout the grant period.

The U.S. Congress initiated MCC during the second Bush administration in January 2004 to provide foreign assistance to countries committed to good governance, economic freedom, and investments in their citizens. The MCC program is managed by a Board of Directors that uses a four-step process to select countries for the assistance program. Within the selection process candidates are issued Country Scorecards, which provide scores relative to other country scores across a range of indicators. Countries must exceed the median value of countries in their income cohort for 3 indicators in each category in order to be considered as candidates for funding.

The Natural Resources Management Indicator (NRMI) is used as one of the MCC's 17 selection criteria to determine which countries are eligible for funding compacts with the US government. The NRMI is a composite index developed by a joint initiative between Columbia University's Center for International Earth Science Information (CIESIN) and the Yale Center for Environmental Law and Policy (YCELP). The NRMI is comprised of four indicators related to natural resource management: 1) eco-region protection; 2) access to improved sanitation; 3) access to improved water; and 4) child mortality. In 2011 the NRMI was broken into two components, a Natural Resource Protection Indicator comprised solely of the eco-region protection indicator, and a Child Health Indicator, being comprised of access to sanitation, access to water, and child mortality.

Once eligible for the program, a country must continue its reform process and seek to maintain and improve its overall policy performance on the indicators. MCC tracks the performance progress of each country throughout the grant period and continues to track progress at the end to assess how its activities have affected poverty and economic goals. Several elements are considered in choosing selection indicators for measuring a country's performance. These include development by a third party, time series consistency, country coverage and comparability, use of analytically rigorous methodology and objective and high-quality data, linkage to policies that can be influenced by government within a two to three year time frame, and the theoretical or empirical linkage to economic growth and poverty reduction.

Countries must follow guidelines on the environment, applying in some cases international good practice. Countries must also carry out projects to mitigate adverse environmental impacts. Based on the type of project implemented, Environmental Impact Assessments (EIA) or environmental management plans are required to evaluate potential risks, identify alternatives, and best approach or improvements to prevent, mitigate, or compensate. The continual performance monitoring and evaluation allows MCC to reform its processes and achieve the highest level of success possible.

The inclusion of the NRMI among the selection criteria for the MCC has heightened the interest of a number of countries in the subcomponents, especially the eco-region protection indicator. This has provided an incentive for countries to submit updated and improved protected area boundary data to the UNEP World Conservation Monitoring Centre, which maintains the World Database on Protected Areas. In one country, the indicator has actually prompted an expansion of the area gazetted under its protected area system, and has spurred direct interactions with the UN Population Division, which produces the child mortality indicator.

In summary, there is ample evidence that scores on the NRMI have drawn attention from the highest level of government in a number of countries, which helps improve data flows to international data custodians and, in some cases, spurs direct policy action.

Sources

CIESIN and YCELP staff and the MCC Web site, and reviewed by Andria Hayes-Birchler of the MCC staff. Source materials include http://www.mcc.gov/.

Annex 2. Survey Instrument

As part of the release of 2012 Environmental Performance Index in January 2012, the Yale Center for Environmental Law and Policy (YCELP) and the Center for International Earth Science Information Network (CIESIN) of Columbia University are planning to publish profiles focusing on the use of environment indicators in policy contexts and for management decision making. Along with the profiles, we plan to extract general principles for the successful use of indicators in these contexts. Any personal information provided by you will be kept confidential. We would appreciate it if you could respond to a few questions regarding your initiative. Please feel free to provide reference web sites or documentation along with your responses.

Participation in this study is completely voluntary. You are free to decline to participate, to end participation at any time for any reason, or to refuse to answer any individual question without penalty. You are responsible for ensuring this information is not confidential through your organization. You may also request that the summary be submitted to you for approval prior to its publication on our Web site or report. Please make your requests to epi@ciesin.columbia.edu.

1. **Name of Initiative:**

2. **Contact Information:**

Name and Title:

Agency/Organization:

Email Address:

Telephone:

Web site for the initiative:

3. **Please provide background on the genesis of the initiative.** (Who made the decision to use indicators to track environmental parameters for management purposes and why? If there is an overall mission statement, vision, purpose, or goal, please provide that here.)

4. **What geographic area does this initiative apply to?** (e.g. country name(s), city name(s), provincial name(s))

5. **Who are the stakeholders?** (Who is involved in developing the indicators and who is using them? Examples might include statisticians, academics, local policy makers, national policy makers, and/or the general public.)

6. **What is/are the specific environmental system(s) being managed?** (examples: air quality, biodiversity, forest cover)

7. **What are your data sources?** (Using the table below, please specify data sources for each indicator you've developed or point us to documentation if that is easier. If the data source is "official statistics", please indicate if you understand how the raw data were collected.)

Indicator	Source	Raw Data Source
Example: Air Pollution Index	*Government of France, State of the Environment Report, 2010*	*Monitoring stations collecting data on PM2.5, S02, and NO2*

8. **How are indicators used to track management progress, and/or how have they affected policy processes and discussions? Please give a specific example if possible.**

9. **Please list the most important documents that describe and/or evaluate the indicator system, including their specific locations online if available.**