Chapter 8: Environmental Accounting and Indexes

8.1 Introduction

Many discussions about environmental issues emphasize how we (as individuals, communities or countries) would be better stewards of the environment if we considered all the costs associated with environmental damage. We often hear the statement that we need to account for the "true" or "full" costs when we make a decision. There are two major assumptions in this statement. The first is that if we could see all of the costs, we would make the rational decision that would be best for both our immediate and long-range future. Whether humans are able to make decisions based simply on their own rational judgment of the overall benefits is still open for debate and, in fact, has been a very interesting debate in history, sociology, political science, economics and religion which we won't be able to resolve here. The second assumption (implication really) is that there is available information on the "true" or "full" costs and that we are ignoring or simply failing to use. This chapter will demonstrate the value of attempting to account for more than the immediate financial costs of human activities. It will also demonstrate how to distinguish pertinent information from nonessential information **AND** how to implement systems that can help us to make informed decisions based on this information.

Environmental accounting is very useful when faced with what was referred to earlier as “simple” or “information” problems (see Chapter 2). In these types of problems either we have all the information we need to reach a solution or it requires obtaining particular information through additional research ("information problem"). In the case of a simple problem, environmental accounting is a crucial part of monitoring and evaluating the progress of the chosen approach. We must verify that the actions accomplished the intended goal, that the solution was cost effective and did not exceed our budget, and that the long-range outcome was beneficial. For example, if we were planting trees along a stream, we might be very interested in improvements in the turbidity of the stream, shade cover during the summer heat, success of the trees planted, and time and money spent. We would also need to be able to collect this information at a fraction of the cost of the total project. Even though it seems as if those parameters would be easy to collect, they take someone's time and money to do properly. The results of many small restoration projects are never tracked because the cost of subsequent monitoring was either not planned for or considered to be too expensive. In the case of "information problems" it is important to determine both what information needs to be collected and what will be required in order to record and collect that information. As the information load increases, so does the time and effort it takes to examine, analyze and evaluate the data to make a purposeful decision. Some information problems are as simple as needing to assess the potential impacts of several choices. For example we might want to compare putting in several bio-swales vs. one large wetland at the end of the pipe. The best answer would depend on many local factors that need to be studied. Other information problems might require a much more sophisticated set of strategies to map out what research has to be done and what information will need to be collected from initial attempts, pilot projects or even stage one of a large project.

Environmental accounting procedures are an active area of research. People are trying to find out how to effectively extend the power of environmental accounting to problems that include conflicting social and economic values and to contexts that might contain surprises. The crucial issues for dealing with multiple values, such as individuals vs. society or different valuations between individuals, is that environmental accounting has no objective mechanism to handle these value conflicts. Several approaches are being tried and they are discussed below. Surprises, or unintended consequences, are also a major challenge for accounting systems because these systems are designed to provide particular types of information and a surprise, by definition, is the result of an unintended outcome has a fundamentally different quality than was expected. One response to this challenge is to use accounting to create indicators that can be used along with scenarios to make data-driven decisions in spite of substantial uncertainty.

There are several key aspects that accounting usually focuses on and a range of levels of aggregating the data. Several key terms are listed in table 10.1 that describe how much something is worth (in dollars), how much is owed and the revenue.

Table 8.1 Accounting definitions

Term	Definition
Asset	Potentially tradable
Liability	Costs that are owed
Equity	Total wealth (= assets – liabilities)
Income or revenue	Money brought in
Expenditures or cost	Money paid out
Discount rate	Interest rate, such as 5% per year
Present net value	Back calculated dollar value from an amount in the future, using the discount rate.

When data is collected, the values are assigned to show up in a system of accounts. This system of accounts will contain categories for like information that are meaningful and can be shared with decision makers. A major goal for accounting is to set up an array of accounts that captures all the information necessary, without double-counting and without duplication. For example, if one wanted to track the success of a riparian restoration project one might keep track of costs on plants, site preparation, planting, and monitoring. Even though data would be collected during site preparation and planting one wouldn't want to double count that as monitoring. It is also important to decide whether surveying and initial information gathering gets counted as monitoring or as site preparation. Also, it is necessary to determine what information is required to make subsequent decisions. If one were collecting information to inform the volunteers where and what to plant, one would need spatially explicit data for soil and micro-climate that would be favorable to the different types of plants. If, however, the overall goal of the project's sponsors was to prevent soil erosion, then one should provide measurements on soil loss and stream turbidity and not spend money and effort describing location and biodiversity. The accounting system must be tailored to the decisions that will need to be made, not collecting everything possible and sorting it out later. Accounting systems deal with different levels of information needs by collecting information at the base level and aggregating this, through analysis and evaluation, into metrics, indicators and indices. These will be discussed in a following section.

8.2 Several examples

Before continuing, let's examine several simple examples of how environmental accounting can help solve problems. More detailed problems are presented later.

Bioswale Effectiveness: Probably the easiest example to understand is performing an accounting procedure to verify that we are getting what we paid for on a project. Imagine that we are planning to use a bioswale to clean up the water coming off of a parking lot. In this case, environmental accounting is to a stock-and-flow systems approach (Chapter 5). We would measure the pollutants coming right off the parking lot and then measure the flow of pollutants into the stream at the end of the bio-swale. After correcting for the volume of flow and looking for potential losses or compounding factors, we would be able to claim that the pollutants of interest (such as heavy metals or oil) were less at the end of the bioswale than at the edge of the parking lot. We don't know where they went, but we know the bioswale did its job.

Urban Tree Health: A more complicated example might be to set up an accounting system for city employees who work with the urban trees to determine if the trees are getting healthier or sicker. Instead of lumping all of the work activities into a single account, such as time spent trimming trees, we could divide the description of tree trimming into categories that the employees could estimate. We might have three categories: trimming of healthy trees, removal of sick trees, and protective maintenance of trees. These categories may also make sense because these activities require different tools and supplies. For instance, if the public works department budget shows an increase in removing sick trees it is an indication that something might be going wrong. The challenge is not to over-burden the employees with information that will never be used but to collect enough information that will be useful to decision makers and analysts. Finding the balance requires knowledge and experience.

Economics is a powerful discipline that uses tools for analysis of human behavior and markets. There is a wide range of sub-disciplines for Economics that are useful to scientific environmental management. Environmental economics addresses the following issues with appropriate assumptions and at appropriate scales. These include determining human preferences and tradeoffs, values of resources, and studying which processes and activities can be monetorized. In contrast to economics, accounting practices are more focused on setting up a system that will collect information required to make a specific type of decision. The procedure would include deciding what to measure, how to track and make decisions based on those measurements, how to provide support for businesses in charge of measurements, and how to tailor the approach so that it applies to many enterprises, from not-for-profits to profit-driven businesses. Thus the focus of accounting is to set up systems to collect objective data that can be used for decision-making and the focus of economics is to understand how humans allocate resources.

It has probably become clear that environmental accounting is similar to other approaches in this book. For example, there are many similarities between an accounting approach and a stock-and-flow system (Chapter 5). Understanding the four types of problems (described in Chapter 1) helps characterize which problems are amenable to a straightforward accounting approach. Some accounting problems, though, build on a rigorous biophysical systems model that must be constructed first. A good example of that will be setting national accounts for water quality and amount (described below). Traditional environmental accounting has difficulty dealing with uncertainty and unintended consequences, but there are new variations that are addressing this. An example of how to use accounting to create indicators that can be used in scenario analysis is provided below. Scientific adaptive management (Chapter 18) requires rigorous monitoring and assessment protocols that derive from environmental accounting procedures. Attempts at accounting for environmental and social impacts often are a crucial heuristic device to illuminate gaps or failures in the current system.

Environmental entrepreneurs (Chapter 19) employ innovations in technology and institutions to fill these gaps in service or function. The problems that aren't easily addressed are those that include the range of individual and social values (described in Chapter 11). Thus, even though environmental accounting doesn't "solve" problems that contain high levels of uncertainty or human values, the process helps to frame and track problems.

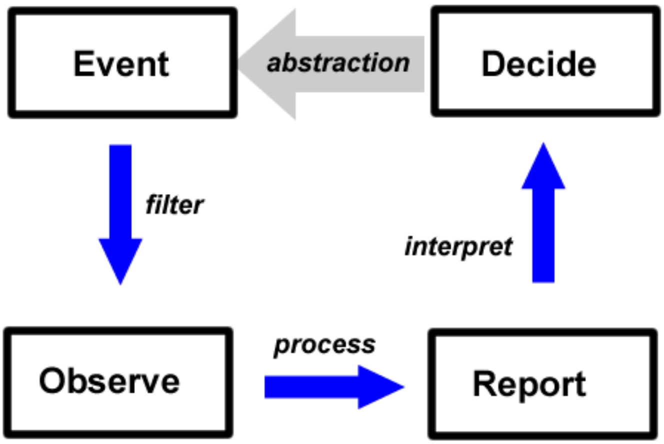
The two biggest challenges, alluded to above, for environmental accounting are to deal with human values in an objective and systematic manner and to construct systems with the right level of complexity. Attempts to incorporate values and objective facts always run up against philosophical and ethical roadblocks. There is continual debate among philosophers about the "is/ought" problem and the conclusion is that one can't get from facts to values. This means that on a philosophical basis, one can't set up a purely objective accounting process that will lead to making value decisions. Judgments will always have to be made by people in a separate process, such as a market or election. Accounting systems can aid these decisions by providing and certifying that the information has a degree of completeness and validity. Similarly, the issue of who should make decisions is dealt with by environmental ethics. The argument ranges from one extreme, in which it is believed that scientists should remain at arms-length from decision-making (and only provide information), to another extreme, in which it is believed that scientists and other people with close personal experience with the system being controlled should actively participate in the decision because they have the best understanding (Norton 2005). Acknowledging that environmental accounting faces philosophical and ethical issues will help us use this approach more judiciously.

8.3 Setting up an accounting system to support a decision

The purpose of environmental accounting is to create a system to generate information that can be used in the decision process. The prerequisites for setting up accounts include defining the question to be answered or decision to be made, identifying who will make this decision and characterizing as specifically as possible the information that will be needed. The characterization of the information should identify which non-overlapping categories will be established and the sources for each type of information.

The actual process of accounting consists of three steps that turn a real event into an "abstraction" that can be used for managers to make decisions:

- a real event happens
- that is perceived and filtered by the accounting method to create an observation and places information in one of the pre-established categories
- multiple observations are processed to create a report
- the report is interpreted by the decision makers
- accounting deals with what is observed, reported and frames how this information is interpreted



from Darrell Brown - "the hammer"

This accounting method is very similar to how we have described the scientific method. The role of accounting is to decide the criteria for applying filters, which is similar to the discussion about whether science only looks at objective data and leaves value decisions to managers or whether, in post-normal science, the values are brought right in at the beginning and considered. For accounting, the filter may be to only consider assets, liabilities and equities that can be represented by dollars. Similar to traditional science, traditional accounting has strengths but the underlying method may have to be adapted to address values and facts. Gross (2012) describes "mode 2 science" that would be a good parallel to the modifications required for traditional accounting to be extended. In mode 2 science, there is a shift to more problem solving and experimental forms of research in the public arena. Mode 2 as a "moral program for new types of science and not just an analysis of changes" will require co-learning at the core of the participatory process. There has to be negotiations at the boundary of scientific facts and values with the wider society which can only happen when the public is involved and there is a new definition of "scientific authority".

One of the goals in accounting is "completeness", which is the accounting for everything that is relevant without double counting. This is important because if the quantity being counted is being paid for, the purchaser needs to know that that quantity hasn't been paid for already. A good example of this challenge is the tracking of forested land that is being set aside for conservation. The benefits of setting this aside are preserving biodiversity and carbon sequestration, i.e. keeping the carbon fixed in the trees and soil rather than allowing the forests to be cut. This latter approach, called Reduction of Emissions from Deforestation and Destruction (REDD) attempts to account for all the carbon tied up in the trees that would have been released. It is difficult enough to measure and estimate the amount of carbon in trees and soils. But there is another challenge. What if an agency or NGO makes a deal with a company not to log a particular plot of land? The carbon is fixed in that particular parcel. But what if the logging company then deforests an adjoining or even remote plot instead? The intent of the accounting process was to decrease carbon emissions, but for obvious reasons it failed. This situation occurred in Bolivia (ref), where there was a very aggressive plan for REDD. The sticky point was that the logging operations, which have limited capacity, could simply go across the border and cut trees elsewhere. Such challenges are not easy to resolve.

There are many different "flavors" of environmental accounting. Each of the variations has particular benefits and weaknesses. Several of these are listed below.

Triple Bottom Line – Uses multiple types of accounting assets that don't all have to be harmonized to monetary quantities. Usually the three accounts are economic, social and natural capital. This approach makes the progress in social and natural capital apparent, but strategic decisions still depend on the judgment of the relative value of the three accounts.

Ecological Footprint – Collapses all activities onto one dimension of its carbon production or reduction. This carbon budget is then expressed as the amount of average arable land it would take to offset this carbon production. This provides for a very dramatic and easily understood description of human impact. It is difficult to expand this footprint to account for social or other ecological functions. A simple carbon budget might be preferable for accounting purposes so that water and other environmental impacts could be accounted for separately.

Water footprint or embedded water – The total amount of water used in products and services is calculated from the beginning on through to consumption and disposal, i.e. the life-cycle of the product or service. This approach is very good at emphasizing the collateral water use such as how much water it takes to put a pound of beef on the dinner table or the amount of water used to create and then wash or dispose of different types of diapers. The focus on water is useful given that this resource is becoming scarce around the world. However, like the carbon footprint or other single-attribute accounting systems, it is difficult to combine this with other metrics because of double counting. For example, water, energy and land are all involved in the production and disposal of diapers. It is not appropriate to merely sum the impacts since they overlap.

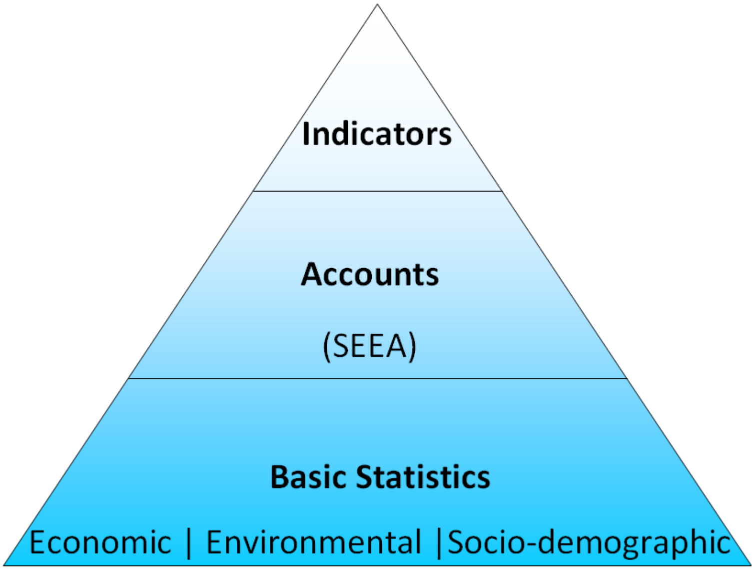
Ecosystem Services and Natural Capital – The accounting aspect of these economic concepts is to monetorize the values of ecosystem services (such as clean water production) or the capital value of the natural resources (such as a healthy forest). A major benefit of this approach has been to show that investments in green infrastructure, such as marshes or forests, are a reasonable economic alternative to hard infrastructure such as sewage treatment plants or dams for flood control. There is resistance to the over-use of these approaches because they fail to account for the non-monetary aspects of nature and thus seem to be making a pre-judgement that those values cannot be used as a basis for decisions.

Total community development – This approach accounts for improvements in human conditions and their surroundings in terms of the capabilities of the people. This accounting system is the partner to a different type of economics espoused by Senn and Nussbaum that focuses on how people develop capabilities to lead a meaningful life and the value of the freedoms that enable this development. Although the focus is primarily socio-economic, for much of the world's poorer people, environmental conditions are a major determinant in their well-being.

8.4 Accounts-metrics-indicators

Environmental information can be described as having three layers. The first three of these (basic statistics, accounts and metrics/indicators) form the information. The indicators can be aggregate multiple indices together to create indexes. Indexes will be described in the next section.

Figure 8.2 The "information pyramid" (pulled from references-notes****).



Data and basic statistics are collected through monitoring and research. There are many forms of data that derive from work in economic, environmental and social research. The overwhelming magnitude of the data makes data management (storage and retrieval) strategies crucial but also makes it difficult for casual users to access in a meaningful way. For example, for Upper Klamath Lake in Oregon there are over a million data points available on-line to anyone but these represent different locations, times and methods. It takes a sophisticated data analysis approach to sort through this much information to find answers to a particular question.

Accounts are essentially bins into which the data can be pre-sorted. These accounts should be set up before collection and have agreed upon methodologies. There are two goals for setting up accounts: identify a strategy that will collect enough information so as not to miss any important process (completeness), and use the accounts as a method to avoid double counting of some aspect of the problem (non-duplication). It is a skill to set up these accounts because it involves the theory of what data is available melded with the very practical understanding of how the information will be used to make decisions.

The apex of the pyramid is the construction of simple metrics or indicators. These are derived from the information collected but are crafted to convey a message about the system that is clear and easily understood on its own. These indicators can be derived from qualitative data (*** more here). Some indicators follow the response system and are called “lagging indicators”, while others may predict an important change and are called “leading indicators”. According to Jakobsen (****) the key characteristics of indicators are:

- relevant, pertain to something you need to know
- stakeholders can understand them easily, they are intuitive for public
- reliable and give the same message in different situations
- based on accessible data that can be obtained in time to act

There are three basic types of indicators that address the state of the environment, sustainability or performance relative to a stated objective or management goal. Charts and maps are often very good tools to present an indicator. Take, for example, a map that shows the flood stage along a river. This easily conveys both the danger from floods at those locations above flood stage, but also is a leading indicator for what will happen downstream. Other simple yet powerful indicators are the number of people who are currently seeking employment or the number of permits to build new houses that are issued on any given day. Some environmental indicators combine several factors into a scale. The threat of forest fires is based on how dry the forest is (cumulative effect of recent precipitation), the current temperature, and the projected weather forecast. This is presented with simple "speedometer" signage along forested highways with the intent to get people to be even more careful when the meter says "high" or "extreme" fire danger. Such indicators might seem obvious if you are familiar with that area, but can be very useful in getting the attention of someone driving through the region. I don't know what changes in behavior is actually being solicited by the Forest Service since throwing cigarettes from a car is already a crime, but maybe it helps people remember the consequences.

8.5 Indexes

Indexes are the compilation of data from indicators and basic metrics. Many of these contain a large number of data sources and are weighted. Most indexes contain so many pieces of data and are calculated with such complicated formulae that the workings aren't intuitive to the general public. Indexes are very useful for tracking longer trends or larger scale processes, but, because they have high information and analysis demands, they aren't useful for short-term management.

There are several common indexes that we see all the time, such as the Dow Jones Average, GDP, and Consumer Price Index. These are widely used to make financial decisions and actually have a big impact on how we think about our human activities. Using the wrong or biased set of information to make decisions can steer society in the wrong direction. There is significant discussion about using strictly economic indexes or adopting some indexes that include social and environmental attributes. A recent book by Vice President Al Gore (2013) critiques the gross domestic product index and states that GDP "is based on absurd calculations that completely exclude any consideration of the distribution of income, the relentless depletion of essential resources, and the reckless spewing of quantities of harmful waste into the atmosphere, oceans, rivers, soil and biosphere." You don't need an index to tell what Gore thinks of using the GDP. In a more measured volume, Stilgitz, Sen and

Fitoussi (2010) argue that GDP is a mis-measure of our real economic performance because it ignores a wide range of services and impacts of the economy. They recommend shifting the "emphasis from measuring economic production to measuring people's well being".

Fortunately, there are a many indexes being developed and tested that address human and ecological well-being. It is not sufficient that a good set of data and indicators be compiled into an index; the index has to be tested for reliability and decision makers need to make a commitment to assess their progress based on these indexes. For example, it might be interesting if a state were to declare that it was making decisions based on the Genuine Happiness Index (see the table below), but if the actual effectiveness of the state government depends on taxes, then the state employment and economic indexes would be more useful. Of course it would be nice if everyone were happier, but if there is no support (financial) for taking such actions, then it is an empty exercise. Using indexes to make decisions requires paying attention to the entire accounting cycle of deciding what needs to be measured, setting up a system to get that information, and making a decision.

Table 8.3 Example indexes that measure environmental and social progress. This table was adapted from van der Kerk (****).

Name	Short description	reference
SSI	22 indicators in 5 categories and information easily compiled	

Human Development I	UNDP, good for developing countries	
Env Sustain Index	Requires a large amount of data	
Environmental Performance Index	6 categories and 16 indicators, focuses on dimensions in the Milenium Development Goalls	
Genuine Progress Indicator	Similar to ISEW as a "green" GDP, can be used to track investments in different sectors	See Maryland
Ecological Footprint	Published by WWF, converts all consumption into units of land needed to meet that carbon demand	
Millenium Development Indicators	Established by the UN to measure development goals in developing countries, not sustainability	
Happy Planet Index	Life satisfaction x life expectancy/community ecological footprint, very intuitive index	
Gross National Happiness	Matrix of indicators, in use in Bhutan	

8.5 Using indicators with scenarios

Scenarios are different forecasts for the future. Although general scenarios, such as those presented in the Millenium Ecosystem Assessment, are very useful for imagining the consequences of our actions and inactions, more defined scenarios can be useful for environmental planning. These scenarios have to apply to specific regions and time and have markers for progress.

Indicators have three purposes when used with scenarios. First, they need to be designed and matched to the problem in order to support expected decisions. This is the normal function for indicators in an accounting system. The second function of these indicators is to involve broader participation from stakeholders and the public by describing clear and interesting mileposts. This is not "greenwashing" marketing; instead, it attempts to identify the results that the community wants to see accomplished. Third, these indicators serve as the basis for quantitative simulation modeling that can illustrate the system behavior. For example, the Maryland Genuine Progress Indicator website has interactive simulation models available to the public that allows them to see the possible future outcomes from the investment in different projects right now. Scenarios with matched, measurable indicators become more and more important as the problems become more complex and public involvement is required for any true progress.

8.6 Examples of environmental accounting

****each of these will be expanded to text with a picture*

Tir Gofal system for agri-environmental preservation in Wales

assigning a value on pieces of habitat depending on its quality
goal was to preserve and care for agricultural, environmental and historical parts of the landscape
http://www.cpat.org.uk/services/tirgofal/tirgofal.htm
http://www.tynybrynfarms.com/tir-gofal.htm

Tualatin Water District/Clean Water Services
need to meet temperature requirements in the Tualatin River
could use equipment to cool water down before release (more expensive)
could arrange to have trees planted all along the Tualatin River upstream of their release (much less expensive - and has other ecological benefits, such as bank stabilization)
only one of these can be bonded (the capital equipment) because it is the only solution that has an "asset"
could change the definition of asset or change the law about what can be bonded (instead of paid for out of operating expenses)

refer to similar case in BC where discount rate made the whole difference

REDD vs. Palm Oil Plantation to save biodiversity
Borneo
depending on the nature of the soil and forest - get different prices for saving the carbon
\$10 to \$33 per metric ton CO_2
\$2 to 16 per metric ton in the cost efficient areas
<!-- do they really mean ton of CO_2 or ton of carbon?-->
Carbon accounting in a forest that might burn

8.7 Summary

Environmental accounting is the process of setting up information systems that are designed to monitor events and provide on-going decision-making support. There are many examples of environmental accounting informing major policy or economic decisions. The methods for accounting attempt to provide complete information without missing crucial information or double counting any pieces of data. Data and raw information is processed with statistics for reliability and trends. This processed information is usually sorted into different accounts to track specific aspects of the problem. Indicators are used to clearly represent the data to a broad audience. Many different sources of information may be combined into indexes. There are several familiar economic or financial indexes that are commonly used, but the environmental community is trying to replace or augment the use of those with indexes that track human or ecosystem well-being.

