1. INTRODUCTION

During the early 1980's, the term sustainable development was first introduced. Through the Brundtland Report in 1987, sustainable development was concretized, and then popularized during the Rio conference in 1992. By formulating and defining the term, the recognition of the links between economic, social and environmental sustainability is exposed and the idea of considering all three aspects in decision making was hence introduced. Although, the definition of sustainable development is vague, and several interpretations have been published, the task of integrating economy, society and the environment in planning and decision making has begun in Sweden. Although the three aspects of development should be integrated at all stages of planning and decision making, experts are needed to provide ideas as to how to reach sustainability within their special fields. The experts need to work with tools which both monitor the progress towards economic, social and environmental sustainability, and which clarify the results for the policy and decision makers to enable the integration. While recognizing the multifaceted nature of sustainable development, this thesis will focus on a tool for environmental sustainability.

1.1 The Need for Environmental Indicators

Most Swedish municipalities have acknowledged a variety of environmental problems and have worked ambitiously to reduce their activities' impacts on nature. The municipalities have commenced mitigation projects, formulated environmental policies, and set up concrete environmental goals where the ultimate aim is a sustainable co-existence with nature.

However, there is now a need for an evaluation of what has been accomplished. The course of action is moving from the issue of defining sustainable development and commencing mitigation projects to the evaluation of environmental policies and assessing the progress in achieving environmental goals. Furthermore, many deadlines for environmental goals have expired and there is a need to measure if these goals have been attained. For some of the goals, it has already been confirmed that they have not been reached and, therefore, to facilitate reaching present and future goals, some form of a progress report is required. Success is more likely with a continuous update of a municipality's progress in attaining a goal than setting a goal and not until the date of expiration, investigating if it has been achieved. The latter scenario, which is the present one, means a time period without knowledge of the extent to which the goal is achieved by the environmental action programs in the municipality. For example, there is no knowledge if the implementation of stricter emission rates should be implemented to increase the chances of attaining the goal (see fig 1.1).

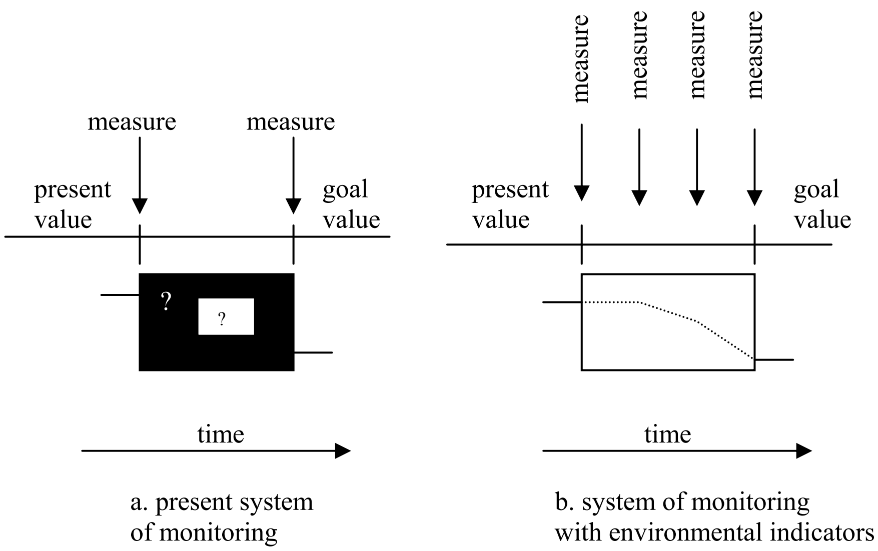


Fig 1.1: Making several measurements while working towards an environmental goal, will facilitate successful results rather than working in a "black box", in oblivion of the distance to the environmental goal. Furthermore, within the implementation period, new information may require the alteration of the goal value which would require up-to-date data on present environmental impacts.

Environmental indicators have been suggested as an option for measuring the success of environmental policies and to serve as a basis for decisionmakers in their strive to reduce society's impacts on the environment. Chapter 40, §40.4 of Agenda 21 states, "indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems" (Hammond et al.[1], p. 6).

It has been recognized that "there is a widening sea of data but, in comparison, a desert of information" (Mitchell[2], p. 2). There is plenty of environmental data, but it is very detailed and fragmentary, which makes it less useful in policy and decision making[3]. This information cannot serve as measuring rods or yardsticks to measure policy initiatives against the goals[3]. Indicators, on the other hand, can be a tool to produce information since it reduces a large quantity of data into a simpler form[2]. Information that has been reduced in complexity for a clearly defined purpose, is easier to handle and to grasp for decision and policy makers.

Indicators are already used by everybody in making everyday decisions[3]. For example, cloud cover, outdoor temperature and sunlight are quickly evaluated when deciding what clothes to wear[3]. These daily life indicators are selected because of their information content and their easy digestibility[3]. Also, in the sphere of economy, several quantitative indicators already exist. Unemployment rates, GNP, debt burden, inflation, balance of payments etc are familiar to everyone and, considering the panic they can cause amongst politicians, have shown the power of single numbers when their implications are understood[1].

Quantitative indicators with similar qualities are required for monitoring the progress in combating society's impact on the environment and for policy evaluation. Several nations (Holland[1], Canada[1], Sweden[4], Great Britain[5], USA[5]) and international organizations (OECD[1], UN[5], EU[5], Baltic 21[5]) are presently developing environmental indicators. In Holland, on the national level, environmental indicators have been integrated into the policy and decision making process. The Dutch indicators were a success in that progressively stricter policy targets were set when the information provided by the indicators was understood by the national policy and decision makers[1]. In Sweden, approximately 40 municipalities have begun developing some form of environmental indicators[5]. However, much more work is needed and the procedure for indicator development must be polished in order for environmental indicators to become commonly accepted by all groups between the public and the state head and to be accepted around the world.

1.2 What is a Quantitative Indicator?

A quantitative indicator has two characteristics. It quantifies information so its significance is more apparent, and it improves communication by simplifying information about complex phenomena[1]. Indicators are simpler and more readily understood than statistics or other kinds of scientific data[1]. They also expose important relationships in a larger system[5]. Although, indicators are a compromise between scientific accuracy and the demand for concise information, they can be used for planning and communication. Planning, in the sense that they aid in problem identification and policy assessment, and communication, in the sense of notification or warning[3].

It is important to remember that indicators are not simply measurements of society's present impacts on the environment[3] (see definition of terms, pg 4) They are usually constructed in such a manner that the present impacts are compared to a situation that is regarded as more desirable than the present one[3]. The reference situation could be one of the past or the future[3]. Thus, an indicator exposes a trend rather than plain parameter values. Furthermore, since an indicator is supposed to give more information than what the parameter value or statistical data offers[4], indicators are not presented by themselves. They are put into a context, through written explanations, from which it is possible to infer what is indicated[4].

1.3 The Framework for this Thesis

Purpose

The purpose of this thesis is to develop and arrive at a conception of environmental indicators that can be utilized as a tool by Svedala's local government for monitoring their progress in achieving their formulated environmental goals. Also, the environmental indicators that I produced are described and analyzed with regards to their adequacy as measurements of society's present impacts on the environment and as a tool for policy and decision making.

Definition of Terms
Throughout the paper, environmental indicators are seen as a tool for monitoring the progress in achieving *environmental sustainability*. However, it is important to note that the term environmental sustainability is used although many indicators monitor the progress of attaining environmental goals which do not directly result in environmental sustainability. Nevertheless, the goals are, a step towards environmental sustainability. For example, the reduction of NO_x emissions from the traffic sector by 40% will not result in a sustainable environment with regard to the natural nitrogen cycle, but it is a step in the right direction.

The primary purpose of environmental indicators is to monitor society's *present* impacts on the environment. In the case of monitoring the environmental state and the pressures exerted on nature by society, present refers to past activities which have not had their effect until now, and today's activities which have an immediate effect on the environment. However, in the case of monitoring activities, present refers to activities that are occurring although their impacts may not be known yet. Present is also used when discussing the inclusion of *present* values when designing environmental indicators. Here, present refers to the year when indicator values are calculated.

The methodological issues of the thesis are discussed in chapter 2, "Methodology".

Outline
The general structure of the thesis is based on the strategy for indicator development suggested by Mitchell[2]. He recommends five steps for developing indicators of which the first three are discussed in the methodology (chapter 2) since they were already fulfilled prior to the commencement of the thesis and thus, constitute the conditions for the thesis. Svedala municipality, which serves as a case study, is also introduced in chapter 2, as well as, the method for data collection and literature. Returning to the steps for indicator development, chapter 3 deals with the fourth step in which the indicator properties are to be determined. A description and an analysis of the process for determining the indicator properties is offered with regard to the theories found in literature and the practical work performed for the case study. Chapter 4 then provides a list of the indicators developed for the case study while chapter 5 offers an evaluation of the indicators against a list of criteria (Mitchell's 5th step) compiled during literature research. The last chapter of the thesis contains the conclusions and a discussion of future work with environmental indicators.

2. METHODOLOGY

2.1 The Case Study: Svedala Municipality

Svedala municipality was used as a case study for developing environmental indicators for three main reasons. First, an extensive environmental policy had already been presented to the local council for approval and acceptance, meaning that the municipality was ready for commencing the next step of monitoring their progress in achieving the goals included in the policy. It was actually the environmental department who advertised for aid in developing environmental indicators for Svedala municipality. Secondly, the relative smallness of the municipality was believed to facilitate the necessary data collection for the indicator values. The area of the municipality is merely 219 km^2 and the population with regard to the area is only 81 inhabitants/km^2 [6]. Furthermore, Svedala municipality has no larger cities or towns, just the three small communities of Svedala, Bara and Klågerup. Also, the number and size of industries are relatively small and only one stream (Sege å) runs through the municipality. However, the smallness did not turn out to be an advantage since there were still many problems with collecting data. A third reason for choosing Svedala municipality was the fact that approximately 75% of the municipality's area is of national interest environment-wise[7]. This is a great motivation to increase the awareness of the environmental situation and to increase the efforts in attaining the environmental goals so ecotypes, animal and plant species, etc are not lost.

2.2 The Logic of Indicator Development

Developing environmental indicators is a large and complex task. If the indicators are to be a useful tool for policy and decision makers, in addition to, be a good measurement of progress, the options of indicator characteristics need to be considered. Furthermore, there are several requirements of environmental indicators, and to include all of them adequately in one indicator is complicated. The sequence for considering these requirements in the development process is also difficult. Hence a strategy to provide a logical framework for the development of indicators was searched for in literature. Only three clear strategies were found. Thörig et al.'s[8] strategy focused on developing indicators based on environmental utility space which was not relevant to the case study of Svedala municipality. The strategy presented by Kuik and Verbruggen[3] is quite similar to the third strategy, proposed by Mitchell[2], but it focuses more on identifying natural systems and does not include the important evaluation of the indicators as in Mitchell's strategy. Hence, the strategy suggested by Mitchell, based on the following series of steps, was chosen:

1. define the objectives of the indicators and their user group,
2. define environmental sustainability,
3. define the issues,
4. decide the indicator properties, and
5. evaluate the indicators[2].

Some of these steps had already been completed prior to the beginning of this thesis when the environmental policy was formulated by the environmental department of

Svedala's local government. How the environmental department completed two of the steps is described below while the last two steps which are the basis for my thesis are described and analyzed in chapters 2, 3 and 5.

Defining the Objectives of the Indicators

According to Mitchell's strategy, the first step is to define the objectives of the indicators and to identify the user group. The aim of all indicators is to encourage action, but the more specific objectives must be identified, such as to document trends, diagnose cause and effect, assess status, or act as an early warning of change[2]. For the case study, the main objective of the indicators was to evaluate the progress in attaining the formulated environmental goals. As for the user group, the personnel at the environmental department was chosen since the project was run by the environmental department and they had requested the information that could be provided by the indicators.

Defining Environmental Sustainability

The second step in which environmental sustainability is defined, had been completed prior to the commencement of my thesis. The municipality's definition of sustainability is based on the ruling by the Swedish Parliament in 1993 stating that the national environmental policy would be based on the principle of ecocycles[9]. Consequently, to attain a society which functions in accordance with the natural ecocycles the four fundamental conditions for societal development formulated by The Natural Step was adopted by the municipality [9]. The four conditions are:

1. "A substance extracted from the lithosphere must not systematically accumulate in the ecosphere" (Azar et al.[10], p. 91)
2. "Society produced substances must not systematically accumulate in the ecosphere" (Azar et al.[10], p. 91)
3. "The physical conditions for production and diversity within the ecosphere must not become systematically deteriorated" (Azar et al.[10], p. 92)
4. "The use of resources must be efficient and just with respect to meeting human needs" (Azar et al.[10], p. 92)

Defining the Issues

Mitchell's (1996) third step is defining the issues to be monitored by the indicators[2]. Again, since Svedala is a municipality, susceptible to directives from the national and regional level, the identified issues at these levels need to be mentioned to understand the local government's choice of issues. In 1993, specific environmental issues were decided upon and national goals were formulated[9]. At the regional level (Skåne), the counties of Malmöhus and Kristianstad divided the environmental issues into thirteen groups which were then reorganized into five groups by the local government of Svedala[9]. The five groups are: (i) land, water and biodiversity, (ii) acidification and eutrophication, (iii) health threats – polluted air, noise and radon, (iv) disrupted ecocycles – metals and organic toxins, and (v) greenhouse effect and ozone depletion[9]. For each group, a set of environmental goals were formulated which further defines the issues to be monitored by indicators.

Defining Indicator Properties

Mitchell's fourth step requires the decision of indicator properties. In collaboration with the environmental department, certain properties of environmental indicators were decided upon. The indicators were to be non-monetary and retrospective (see discussion and analysis in chapter 3). They were also to resemble the indicators already produced by the Environmental Delegation in Lund, both in their design, as a ratio, and in their presentation, as a graph with a time axis. Furthermore, the slope of the curve should be positive if the trend of the monitored issue was in favor of the environment. For example, if CO_2 emissions were reduced, the curve should have a positive slope. Raw data can, therefore, not be used directly (see fig 3.13 a) but has to be transformed through ratios designed to give a positive slope if the trend is in favor of the environment (see fig 3.13 b).

Evaluating the Indicators
To fulfill the final step of Mitchell's strategy an evaluation of the indicators with regard to desirable indicator characteristics and program objectives was performed. The desirable characteristics were determined through literature studies. The most frequently reoccurring requirements in the literature were compiled and used for the evaluation (see chapter 5). Of all the literature studied, Kuik & Verbruggen, Mitchell and Liverman et al. had the most extensive lists of requirements.

In short, since monitoring the progress of attaining the environmental goals was the objective of the indicator development, I decided that the goals should be the basis for designing indicators. Hence, with Lund's format for environmental indicators in mind, I designed a suitable environmental indicator for each environmental goal. In chapter 4, each environmental goal coupled with its respective environmental indicator can be found.

2.3 Scope and Limitations

As previously stated, indicators were developed to monitor the progress in achieving environmental sustainability and not the entirety of sustainable development. Furthermore, the indicators were designed specifically for Svedala municipality. The indicators that were designed, will not be presented individually nor in detail. Instead, their general characteristics will be exposed through the discussions and analysis. In addition, the thesis focuses on the development of indicators for Svedala municipality and not on analyzing the environmental situation based on the information provided by the indicators.

The main limitation for the thesis was time, 20 weeks, and this affected the thesis in two aspects. First, there was only time to produce a couple of graphs for the indicator values. However, more graphs will be produced and will be submitted to Svedala's environmental department together with the data that was collected. Secondly, the difficulties in designing indicators, as discussed in chapter 4, are in part due to the time limit as well. The vaguely formulated goals required time for research to determine what needed to be monitored.

2.4 Data Collection

Besides, developing environmental indicators, data was also collected to give the indicators a value. The data sources that were contacted were the local government, the County Administrative Board of Malmöhuslän, National Statistics Office of Sweden as well as the consulting agency VBB and relevant companies for energy, recycling and sewage treatment. The time limit of 20 weeks, restricted the amount of data that could be collected for computing indicator values since so many data sources had to be contacted. The lack of data consequently resulted in indicator values for only about 50% of the indicators. Nevertheless, each indicator value that has been computed, will be used in producing a graph with a time axis, which then are to be used by the environmental department in their annual report and in informing the public and the local government of the present environmental situation.

2.5 Literature

There is a plethora of literature on indicators for environmental sustainability in the forms of investigatory commissions, reports and academic writings. The focus of the individual publications varies from promoting the idea of using indicators for monitoring sustainable development (Liverman[11]) to determining the best indicator properties (Gilbert[12], Azar[10]). Also, from designing strategies for indicator development (Mitchell[2], Thörig[8]) to creating criteria lists for the indicators. Furthermore, the spatial scopes vary from developing indicators for a small ecosystem (Kuik & Verbruggen[3]) to a global environmental issue (Hammond et al. [1])and from locally developed indicators (Thörig[8]) to internationally decided indicators (Alfsen[4]).

The primary debate in the literature rests with which category of environmental indicators is the best. Are monetary indicators superior to physical indicators and should environmental state indicators or societal activity indicators dominate? Several case studies and examples are published to prove that one category is better than the other. There are also intense discussions on what should be monitored and what type of reference values should be used.

From this plethora of literature, a great deal of information was extracted and incorporated into the thesis to give background, theories and for analytic comparisons with the indicators developed for Svedala municipality. The five steps for indicator development used in the case study of Svedala municipality was found in Mitchell's article[2]. The discussion on the various indicator categories was enabled through reading Hammond et al.'s article[1], Kuik & Verbruggen[3] and Ulrika Carlsson's case study of Gotland[13]. The indicator properties were not determined completely individually, but in part, extracted from Lund municipality's annual report[14] as well. Furthermore, the list of criteria for the evaluation of the indicators was compiled from Kuik & Verbruggen[3], Mitchell[2], and Liverman[11].

The rest of the literature found in the reference list, aided in gaining a general overview of the situation regarding environmental indicator development.

3. THEORETICAL APPROACHES TO DETERMINING THE ENVIRONMENTAL INDICATOR PROPERTIES

As stated in chapter 2, the first three steps of Mitchell's strategy for indicator development had already been fulfilled prior to the commencement of the thesis. Hence, the fourth step, in which the properties of the indicators should be decided upon, became the starting point for the case study. Several aspects had to be considered to determine the properties, and thus, the following questions were posed: (i) which category of indicators were to be used (monetary or non-monetary indicators, retrospective or predictive indicators and which parts of the causal chain should the indicator monitor), (ii) how should the indicator values be presented, and (iii) how should the indicators be designed?

The order of the three questions created a logical strategy for determining the properties. First, the type of indicator was decided, which is important since the type determines how the indicator should be presented and designed. The choices between monetary or non-monetary and retrospective or predictive indicators was done in collaboration with the environmental department. The options of indicator types with regard to the causal chain was a personal choice. Secondly, by deciding the presentation form of the indicator values, the design of the indicator is more specifically determined. Deciding on the presentation form was also done in collaboration with the environmental department while, the final step of determining the indicator design was done independently.

3.1 Indicator Categories

Through literature studies, a wide variety of indicators was discovered with different characteristics. My readings of this literature has led to the following schematic overview of the many types of indicators (see figure 3.1). A discussion of the choices between the indicator types for the case study on indicator development is also provided below.

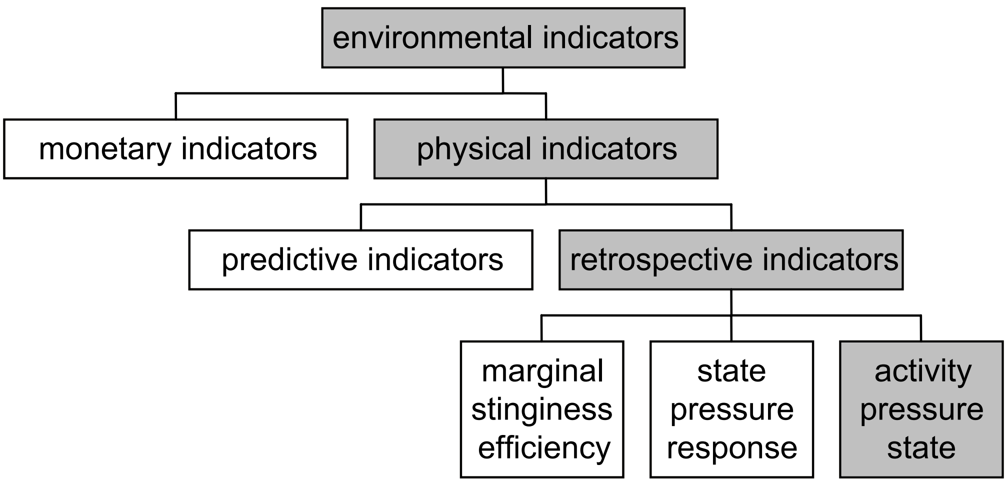


Fig 3.1: The categorization of environmental indicators. The indicator types chosen for Svedala municipality are shown in the shaded boxes.

Monetary or Non-monetary Indicators (Physical Indicators)
The simplest division is between monetary and non-monetary indicators (physical indicators)[15]. Monetary indicators reflect aspects of the progress in reaching environmental sustainability through the use of monetary measures, e.g., Indicator of Weak Sustainability and Generational Environmental Debt[15]. However, any study regarding environmental economics, which includes cost-benefit analysis, discounting, imputing values for non-priced goods, hedonic price method or contingent valuation method, will reveal the unavoidable problem of putting a price tag on the environment or on the loss of nature[16]. Due to these theoretical and practical problems associated with monetary measures, they will most probably never be used extensively to depict the progress in reaching environmental sustainability[15]. Furthermore, the credibility of monetary indicators could easily be questioned due to the many assumptions and speculations regarding the price tagging. Policy and decision makers need credible, reliable and easily digestible information to base their actions on. Hence, the idea of integrating environmental aspects into the economic sphere via monetary indicators has basically been dismissed. It is, therefore, more befitting to concentrate on the physical environmental indicators.

The indicators developed for Svedala municipality were designed as physical indicators rather than monetary indicators. Physical indicators, describe the present situation in a much clearer manner. The environmental problems are not hidden behind an amount of monetary units but are depicted in their true values, e.g., percent of lost forest. Furthermore, with physical indicators, reference values can be used as a comparison of the present environmental situation with a more desirable situation. In the case of monetary indicators, reference values would only complicate the matter since two price tags would have to be determined for the comparison; e.g., the monetary value of a tree in 1950 and today's value. Physical indicators would be needed anyway, to determine the environmental situation in 1950 and today, in order to be able to place a price tag since a price tag should reflect the environmental situation.

Although monetary measures may be futile for depicting progress in achieving environmental sustainability, they can be useful in the decision making process for determining the feasibility of implementing certain environmental policies. This however, lies outside the scope of the thesis.

The physical environmental indicators can, in turn, be categorized via two different approaches. Firstly, if they are predictive or retrospective. Secondly, the indicators can be differentiated according to which part of the causal chain they assess. The causal chain refers to the various steps in which society physically interacts with the environment.

Predictive or Retrospective Environmental Indicators
Predictive environmental indicators provide information about the future societal impacts on the studied environmental variables. This kind of information, which usually is based on mathematical models, is highly attractive for strategic planning and management. Predictive indicators may represent a complex system by means of a stock, flow (measured as change in stock value) or a ratio between stocks, flows, or stock and flow. Since single stock, flow or ratio values have no relevant predictive meaning a reference value must be included in the indicator such as a current value, a

historic value (threshold – analytically based) or a subjective value (targets – representing a condition assumed necessary for reaching sustainability). [3]

Since future values of the indicator must also be generated, a forecasting technique is necessary. There are many techniques, e.g., trend extrapolation, regression models and simulation models, and they have their own advantages and disadvantages with regard to reliability, transparency and data requirements, to mention a few. [3] Hence, because the resulting values from forecasting techniques are uncertain and questionable, it is important to not rely on the generated values completely, but rather, use them as a conceivable future scenario if a simulation model was used.

According to Kuik and Verbruggen (1992), the most appropriate manner for constructing predictive environmental indicators, is to develop simulation models for producing trajectories of future values of selected environmental variables, with explicitly defined reference values[3]. However, even if predictive indicators are useful for policy and decision making, in theory, they are disputable since scientifically reliable information can only be obtained through retrospective methods[3]. Therefore, retrospective indicators continue to play an important role in policy and decision making.

Retrospective indicators include indicators for both historical trends and policy evaluation. The numerical values of the indicators, expose for the historic period considered, if the environmental quality has reached or is maintained at the desired levels. If these numerical values are compared to reference values (e.g. historical situations, economic targets, health standards), the effectiveness of policies that were in effect during that period can be assessed. [3]

All the environmental indicators designed for Svedala municipality can be categorized as retrospective. Although, most policy and decision makers are demanding predictive indicators, an analysis of the past and present situation is necessary to understand the location of the "point of origin" for the policies and decisions. Knowledge of the present is required to determine the required course of future actions. The retrospective indicators can, however, be used to predict the future. Take forestry as an example. Say, physical indicators exist for the clearing of forests since 1930. In 1950, it was discovered that the rate of clearing was too great and mitigation measures were introduced. The 1970 values for forest clearing indicators would then expose the success of the mitigation measures implemented in 1950. Using this information, mitigation measures to be introduced in 1998 can be formulated in a similar manner if the past measures were successful or differently if they failed. The policy and decision makers can look to the past measures to learn and predict the effects of the presently formulated measures, of course, under the condition that all other aspects regarding the issue are similar.

Indicators According to the Causal Chain

Indicators can also be categorized according to which part of the causal chain they monitor. The causal chain refers to the various steps in which society physically interacts with the environment[13]. There are various perceptions of how society interacts with the environment, resulting in various manners of grouping indicators.

State, Pressure, Response Indicators
Hammond et al. (1995), base their indicators on a model of human interactions with the environment. According to them, there are four types of interactions (see fig 3.2).
- source: the depletion of resources and degradation of biological systems as people extract substances from the environment which are of use in economic activity[1],
- sink: the flow back of pollution and wastes into the environment from both the transformation of natural resources by industrial activity into products and the usage of these products[1],
- life support: the reduction of the environment's ability to provide essential life support services, due to, expansion of human activities and the encroachment or degradation of ecosystems[1], and
- impact on human welfare: polluted air and water and contaminated food, directly affect human health and welfare[1].

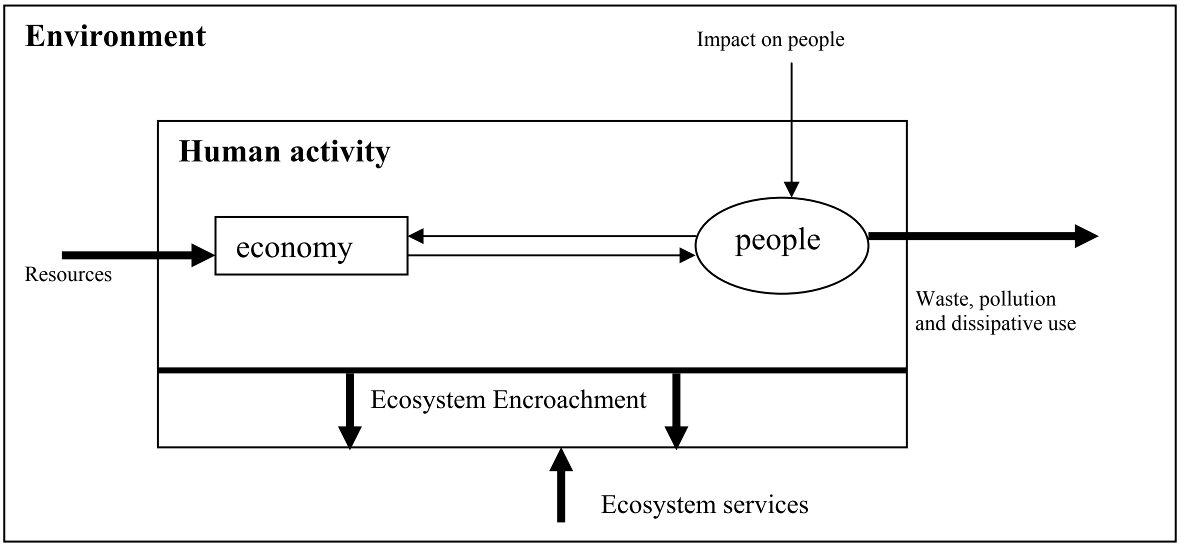


Fig 3.2: A model of human interaction with the environment (Hammond et al.[1], p.115).

With this model of human interaction with the environment, Hammond et al. (1995) came up with a conceptual framework for environmental indicators that stresses the societal response. Their indicators are grouped as pressure, state and response indicators and their monitoring stages are shown in figure 3.3.

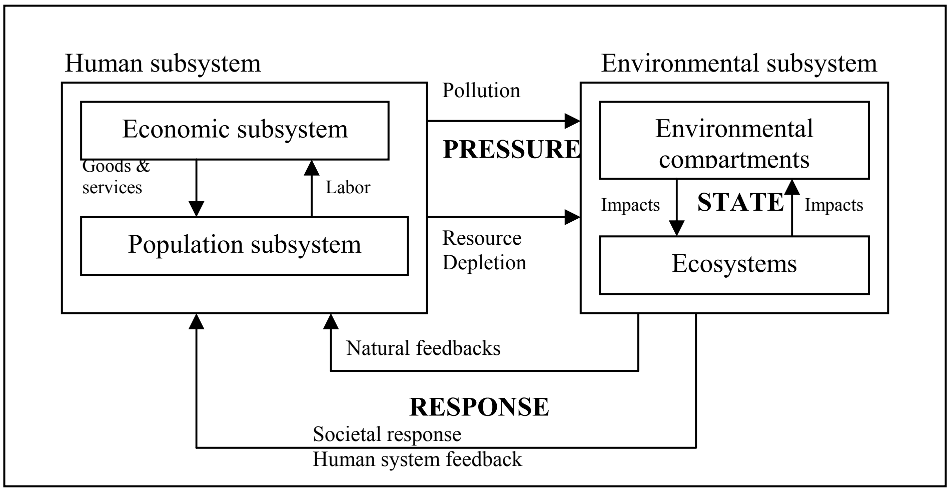


Fig 3.3: The monitoring stages of pressure, state and response indicators (Hammond et al.[1], p. 11).

Hammond et al.'s indicators (state, pressure and response) answer the following three questions respectively: (i) what is happening to the state of the environment or natural resources?, (ii) why is it happening?, and (iii) what are we doing about it?. The state and pressure indicators monitor the same aspects of society's physical interaction with nature as in the case described previously, but the response indicators, monitor the efforts taken by society through policies to mitigate degradation of the environment[1]. It is important to note that pressure indicators, although descriptive regarding the state of the environment, also provide feedback on whether the policies meet stated goals and are, therefore, useful in monitoring policy performance[1].

Marginal, Stinginess and Efficiency Indicators
A second manner of describing the societal interactions with the environment, is defined by Sören Bergström (1994) and is based on an economic input-output model (see fig 3.4)[14].

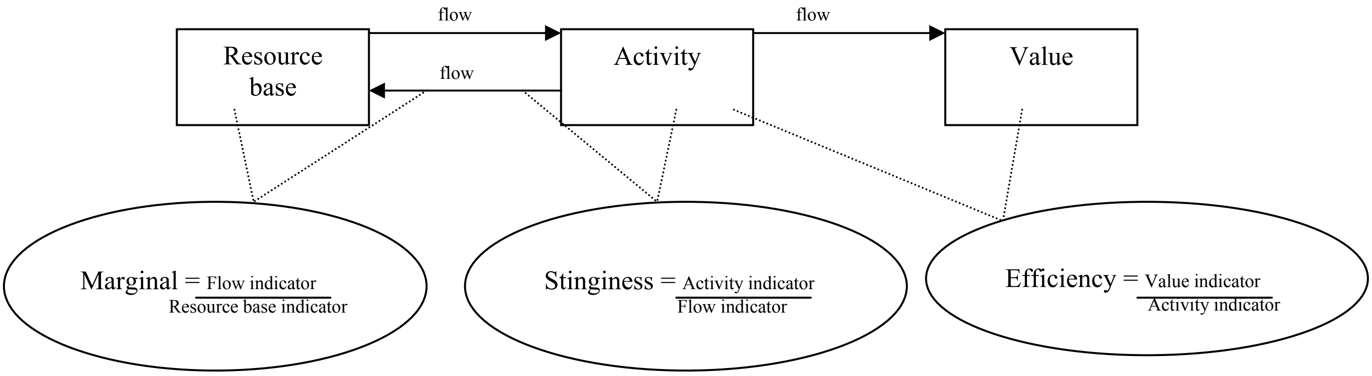


Fig 3.4: A model for the three different types of indicators suggested by the sustainable development records method (adapted from Bergström, S.[17], pp. 126-128).

The resource base, refers to the extracted natural resources necessary for an activity. The activity, is the actual transformation of the natural resources to a product, and value, represents the actual product. Take energy production as an example, hydropower, uranium or oil is needed to produce electricity and, thus, they constitute the resource base. The distribution network, production of electricity and administration, constitute the activity component. The actual electricity produced and its usage, constitutes the value component of the model[14].

The aim is to make the negative environmental effects of each component of the production chain as small as possible. Therefore, marginal, stinginess and efficiency indicators have been designed to monitor the various components' effects on nature. The marginal indicators, reflect the relationship between an activity's resource usage and the resource base, while the stinginess indicators reflect the efficiency of activities in their resource usage and emissions of pollution and wastes. The efficiency indicators, monitor the value we obtain from an activity in relation to what we put into the activity[14].

Societal Activity, Environmental Pressure, Environmental State/Quality Indicators
The main two societal interactions with nature in Carlson et al.'s (1997) model are, exchange and manipulation (see fig 3.5). Exchange refers to the extraction of energy and matter from nature (from deposits, funds and natural flows) and the return of energy and matter to nature through emissions. Manipulation, on the other hand, considers the displacement of nature (societal activities, e.g. construction of highways, which disturbs or forces ecological systems to retreat), reshaping of nature's structure (e.g. damming of rivers, ploughing or ditching), and guiding of processes and flows (e.g. manipulation of genes or agricultural practices). [13]

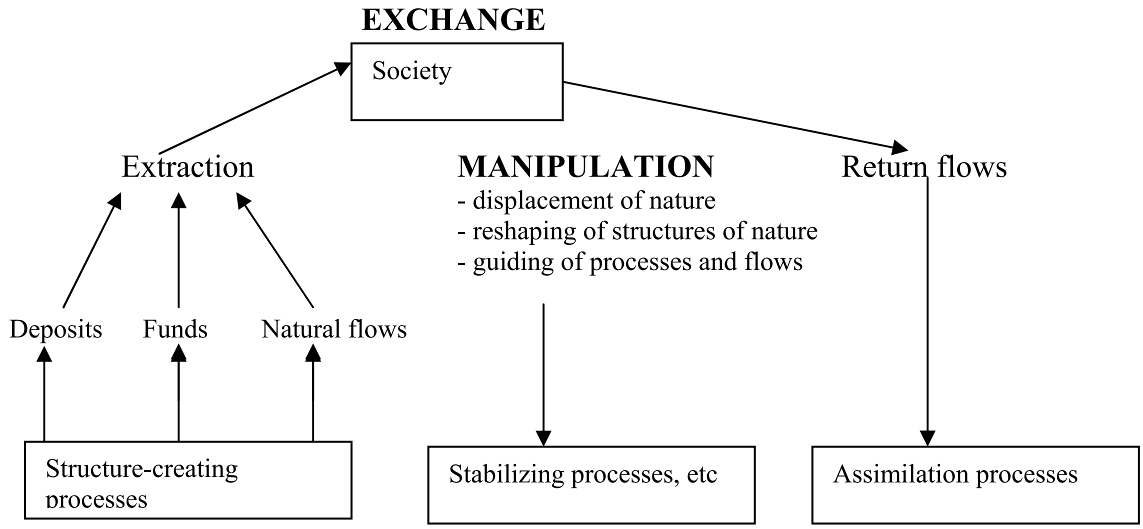


Fig 3.5: general mechanisms of how society physically interacts with nature (Carlson et al.[13], p. 5).

Society, both extracts and returns substances to nature but nature's capacity for structure-creating of substances and assimilation of substances is limited. In addition, when nature is manipulated, nature's capacity for stabilization is often reduced[13].

Considering the structure of the causal chain, indicators could then be grouped according to:

- societal activity indicators, which indicate the activities occurring within society, e.g. use of extracted minerals, production of toxic chemicals, recycling of material etc[10]
- environmental pressure indicators, which indicate human activities that directly influence the state of the environment, e.g. emission rates of toxic substances[10]
- indicators of the state of the environment or environmental quality indicators, which indicate the state of the environment, e.g. the concentration of heavy metals in soils and pH levels in lakes[10]

Comments on the choice of indicator categories
Until present, most of the indicators that have been developed and used around the world, belong either to the group of environmental pressure or environmental quality indicators[10]. This is due to historical reasons. Since the indicator groups focus on different aspects, they were used accordingly. For example, gathering data on the state of the environment was important at first, and thus, state indicators were used. When the degradation of the environmental state was discovered, there was a need for identifying and monitoring the causes (pressure indicators). Also, the pressure indicators could be used to increase public awareness to alter the pattern of behavior and activities causing the pressures. This is basically where we are today, trying to prevent environmental degradation at the source by boycotting certain industries, changing our lifestyles, etc and therefore, societal activity indicators have been introduced.

It is important to note that the various categorization methods for physical indicators regarding the causal chain, overlap and that the names given to identify the various groups of indicators is nothing more than denominations. The purpose of the indicators and their field of application will determine the framework model and consequently, the terms used for the indicator groups. The indicator groups focus on different aspects in the model and can therefore, be used for various aims. For example, in increasing public awareness, state indicators are effective while activity indicators are powerful in creating environmental degradation warning systems.

The main point lies in the system thinking, i.e., to construct a framework model for the aspects to be monitored. Whether one of the three previously described models are chosen or a new model is constructed, is not relevant with regard to which is the better. None of the three models is the best one in itself. It is rather a question of its logic in application. Without a framework, indicators could be chosen randomly and might not be representative of the monitored system nor relevant to the policy and decision makers.

Based on this free choice, the framework model chosen for the case study was Carlson et al.'s model (1996) which monitors the environmental state, environmental pressures and societal activities. This manner of grouping the indicators suited the development of indicators for monitoring the achievement of Svedala's goals best for two reasons. First, the goals are formulated in such a way that their focus of abatement can easily be grouped as activity, pressure or state. For example, the goal stating that the usage of fertilizer and chemical pesticides should gradually decrease has its focus on a societal activity. The goal stating that SO_2 levels in the atmosphere should be reduced to background levels clearly focuses on an environmental pressure. For more examples, see the tables in chapter 4 where the indicator group is provided for each goal. The second reason for choosing activity, pressure and state indicators is that I found that they can serve as important feedback loops for policies at a municipal level aimed to abate or prevent environmental degradation. The feedback loop can be followed in two directions. In one direction (1, 2, 3, 4, 5, 6, 7 and 8 in figure 3.6) critical disturbances in nature can be brought to attention and mitigation measures can be taken and then assessed, while in the opposite direction (5, 6, 7, and 8 in fig 3.6) precautionary measures can be monitored.

For the first feedback loop, the environmental quality indicators reflect the state of monitored natural systems and can signal when the carrying capacity has been exceeded and when action must be taken (e.g., the eutrophication of a lake). From here, the pressures exerted by society on the natural systems creating the problem can be determined (e.g., the amount of nitrogen transported in a river). Once the pressure(s) has been identified, its source in society can be determined (e.g. the usage of fertilizer). With the identification of the source(s), mitigation measures can be decided upon (e.g., reduction in fertilizer usage). After the mitigation measures have been in effect for a period of time, and they have had an impact on the societal activities and environmental pressures, the environmental quality can again be used, but this time to assess the effectiveness of the mitigation actions of preventing further environmental degradation (e.g., has there been a reduction in the eutrophication of the lake).

The second feedback loop which monitors the effects of precautionary measures, i.e., a control of activities that exert pressures on the environment and might lead to environmental degradation, would start with indicators monitoring societal activity. From here, the indicators monitoring environmental pressures and environmental quality would be used to assess if the control of the activities has had a positive effect on the environmental state. Using the same example as for the first feedback loop, the stages would now be first, a policy to abate eutrophication by a reduction in fertilizer usage. The effects of the policy would then be evaluated by monitoring the usage of fertilizer (activity), the amount of transported nitrogen in the river (pressure) and finally the degree of eutrophication in the lake (state).

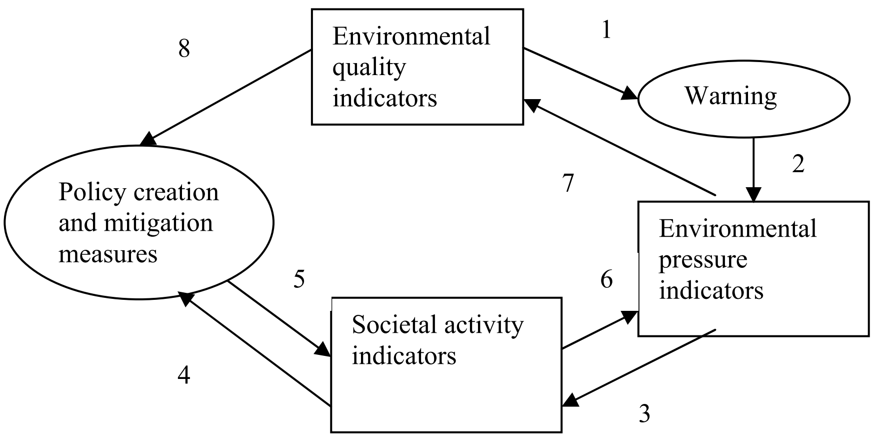


Fig 3.6: How the environmental quality, environmental pressure and societal activity indicators can serve as feedback loops for policy and decision making.

Following the feedback loop, in either direction, requires tracing of the causes and effects of societal impacts on nature. This can be complicated since, e.g., there can be several different sources giving rise to an environmental pressure (NO_x emissions can originate from traffic, industry agriculture etc) and one source can give rise to several environmental pressures (an industry can emit NO_x, SO_x, CO_2, chemical wastes etc) (see fig 3.7).

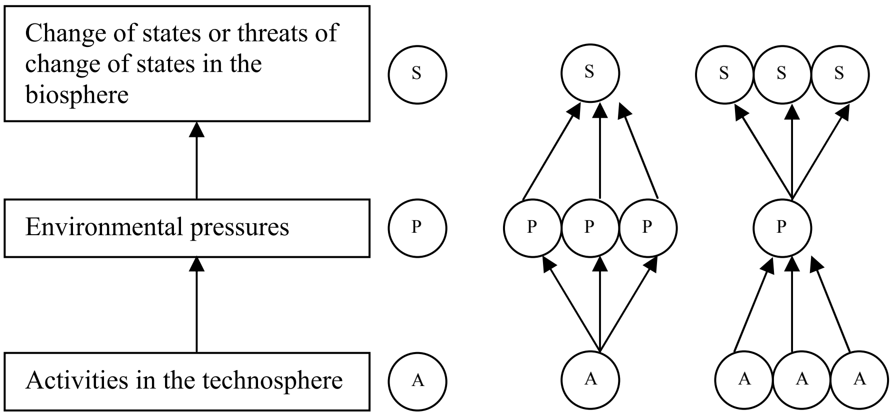


Fig 3.7: The various combinations of the number of causes (A and P) and number of effects (P and S) with regard to societal activities, environmental pressures and changes in the state of the environment (adapted from Carlson et al.[13], p. 6).

Although environmental quality indicators are a part of the feedback loop (see figure 3.6) and provide important information, goals do not have to mention environmental quality aspects explicitly since, if the goals focus on activities and pressures, they indirectly affect the state of the environment. Nevertheless, when producing the environmental indicators for a goal, at least one indicator from each group should be designed in order to complete the feedback loop (see fig 3.8). This was however not done for the case study due to lack of time. Instead, the focus of the goal (pressure or activity) determined if a pressure or activity indicator was developed. If more time had been permitted, all three types of indicators would have been developed for each goal to complete the feedback loops.

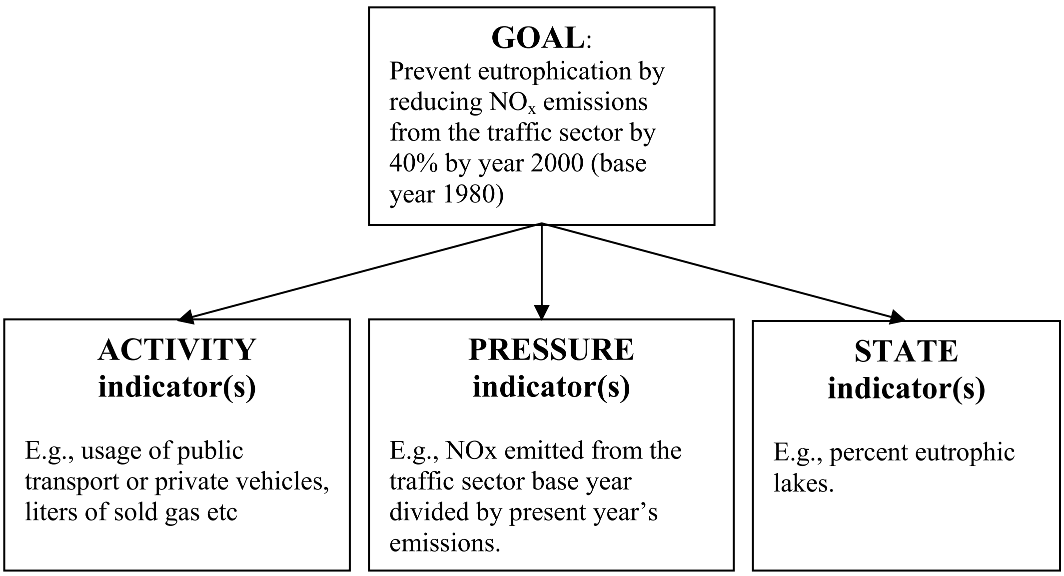


Fig 3.8: An example of how an indicator(s) from each group can be used to measure the success of one and the same environmental goal. With the knowledge gained from all three indicators rather than just one or two indicator types, policy and decision makers can make better and more informed choices.

3.2 How Should the Indicator Values be Presented?

Having decided that the indicators should have non-monetary and retrospective characteristics in collaboration with the environmental department and then individually that they should be grouped as societal activity, environmental pressure and environmental state indicators, the next step was to determine how the indicator values should be presented. These choices of presentation appearance were made prior to deciding how the indicators should be designed since the design can be altered depending on which appearance is preferred.

The first choice, regarded the number of indicators to be presented and this is determined by the user group of the indicator values. An environmental indicator, monitors a specific aspect or cause of degradation of nature. This results in the need of several indicators to cover all the aspects of an environmental problem. Take climate change as an example of an environmental problem. It is caused by the emission of various greenhouse gases from several different sources (industry, transport, forest clearing etc). There might be an indicator for each source and greenhouse gas, resulting in a large number of indicators which have to be studied in order to understand the trend in climate change. Natural scientists might find all the indicators interesting but for a policy or decision maker it is difficult to gain a general overview. The indicators, therefore, have to be designed with a specific target group in mind[3]. Based on quantity of information incorporated in the indicator, three types of target groups can be distinguished (see fig 3.9)[3].

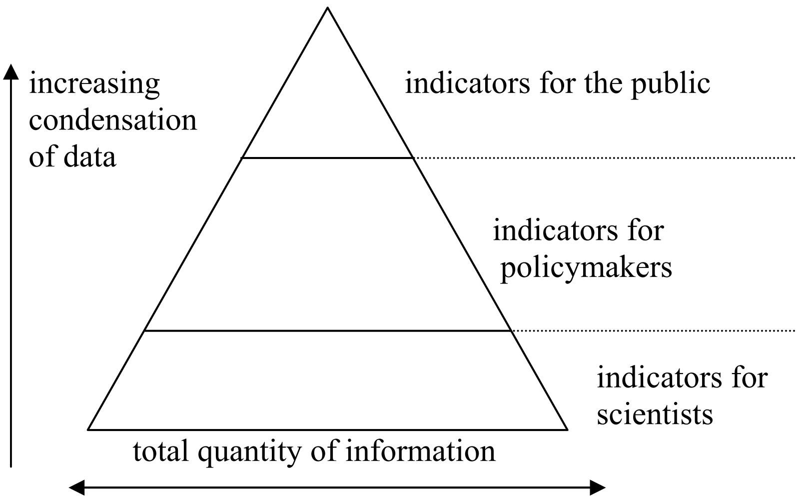


Fig 3.9: The relationships between indicators, data and information (Kuik &Verbruggen[3], p. 59).

Sets of indicators can be presented when the target group is in need of a larger number of indicators. Sets are more transparent than indices but all indicators have to be evaluated as a group and, therefore, gaining a general overview or comparing with other sets of indicators can be difficult[15].

If the number of indicators are to be kept as few as possible, there are two options. Aggregating the indicators into indices[1] (e.g., adding and weighting all the greenhouse gases into one indicator) or identifying representative indicators which mirror the behavior of a wider group of measures[11] (e.g., the global temperature which would reflect the amount of greenhouse gases in the atmosphere). The advantage of single aggregated indices is that there is only one numerical value for each environmental issue, but finding appropriate weight factors for the aggregation can be a problem[15]. Furthermore, single aggregated indices drastically reduce the number of presented indicators but the quality of the interpretations by policy and decision makers may also be reduced. For example, a physician will make a better diagnosis and prescribe a more appropriate treatment if he/she knows the location of pain, pulse rate, temperature etc rather than simply that the patient is ill[2]. However, if the assumptions, sources of data and the methodology for the aggregation are explicitly reported, the index can be disaggregated to the separate components[1]. Scientists may find this attractive but it would be considered tedious and time consuming by the policy and decision makers. Similarly, representative indicators, do not provide a complete picture of the environmental situation and is prone to bias when being chosen. Furthermore, representative indicators can not be broken down to access information as aggregated indices. By rejecting the other indicators which were not considered as representative as the one chosen, their information potential is lost.

Since the target group for the indicators is primarily the personnel at the environmental department of Svedala municipality, and the objective of the indicator development project is to monitor the progress in achieving the environmental goals, it was decided that every indicator should be presented. No aggregating into indices and the indicators would be presented in sets according to the environmental issues they monitor. The next step was to determine the appearance of the presented indicators.

In the literature, many variations of presentation forms were found depending on which issues were being monitored and the objectives of the indicator development program. However, since these indicators were developed to assess the progress in achieving environmental goals on a municipal level and the design of the indicators was based on the environmental goals, only two were of interest for the case study. They were the AMOEBA-approach[12] and the graph approach used by the Environmental Delegation in Lund municipality[14].

The great advantage with the AMOEBA-approach is its manner of grouping environmental indicators. All the relevant indicators are gathered into one diagram (see fig 3.10).

Fig 3.10: An example of an amoeba diagram. Target variables, i.e., aspects of an environmental issue, are listed along the reference circle and their indicator values are shown as peaks originating from the center of the circle. The reference circle represents threshold and target values. The distance between a variable's peak and the reference circle depicts the distance between the present value and the goal value (Gilbert, A.[12], p. 1743).

This single diagram not only saves space, but enhances the opportunity to gain a general overview in almost a single glance. However, there are certain disadvantages. First, there is no time dimension which could expose changes in the monitored aspects. If dotted lines were to be used for depicting past values, the diagram would quickly become cluttered and difficult to read. An option would be to include one AMOEBA diagram per year, but comparing the distance between the peak and the reference circle (depicting target and threshold values) between different years would be hard. Furthermore, the various environmental goals have different years by when the target values should be reached and these are depicted by one and the same circle. The remaining time for reaching the goal can not be interpreted from the diagram. Two aspects could have the same distance from the reference circle but one of the aspects, has a target year only one year away while the second aspect has ten years. The remaining time for reaching an environmental goal has great impact on the actions taken by policy and decision makers and must, therefore, be clearly portrayed in the presentation of indicators. This remaining time aspect is much clearer in the graph approach used for presenting Lund municipality's indicators.

The graph approach for presenting the indicator values, in contrast to the AMOEBA-approach, includes a time axis and in addition to the target value, the target year is depicted (see fig 3.11). The slope of the curve in the graph exposes the trend with regard to environmental degradation. Positive slopes depict positive trends for the environment while negative slopes expose negative trends for the environment (see fig 3.12).

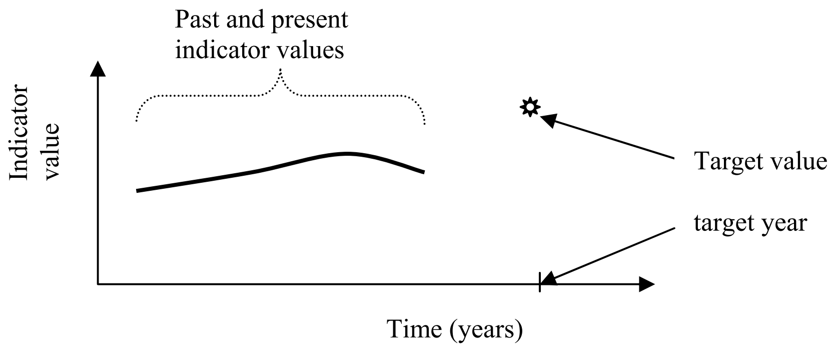
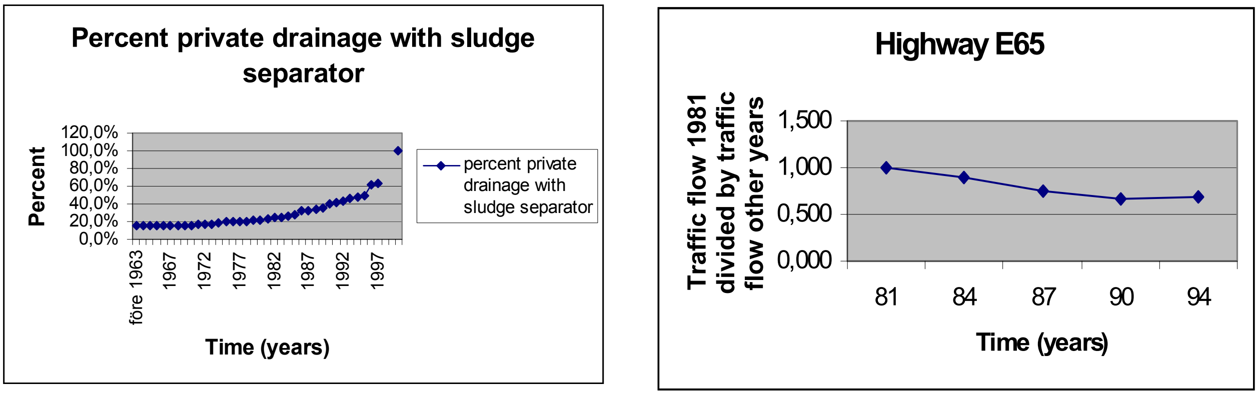


Fig 3.11: In each graph presenting the indicator values, the target value is included to aid policy and decision makers to understand the potential urgency of taking actions to reach the goal in time.



(a) An increase in the percentage of private drainage with sludge separator is positive for the environment, and thus depicted by a positively sloping curve.

(b) An increase in the traffic flow on highway E65 is negative for the environment, and thus depicted by a negatively sloping curve. (No target value nor target year has been formulated for traffic flow and thus not included in the graph.)

Fig 3.12: Examples of curves from the case study of Svedala municipality portraying the issue's positive or negative environmental impacts.

This latter format for presenting the indicators was found to be more appropriate even if several graphs would have to be presented per issue and each would have to be analyzed to obtain a general overview of the situation for that specific issue. However, since the slope of the curves in all graphs mean the same thing, a general overview can still be obtained quite easily. For example, if seven of the ten graphs for an environmental issue have negative slopes, it is quite obvious that the situation is not good. Furthermore, the advantages of including both the target value and the target year in the presentation outweigh and exceed the slight disadvantage of including several graphs. Aiding the policy and decision makers in determining the urgency of action is of uttermost importance and the amount of remaining time before a goal is to be achieved is much more clearly exposed in the graph approach than in the AMOEBA-approach.

3.3 How Should the Indicators be Designed?

Since the graph approach for presenting indicators is not excerpted from theoretical literature, but rather, simply included in an annual report, the designing of the indicators had to be done independently. The process for designing the indicators are, therefore, presented below.

While designing the indicators, the presentation format was kept in mind to ensure that the computed indicator values would according to their position in the trend, give rise to positive or negative sloping curves. To create such curves, raw data could be used. If CO_2 emissions were to be monitored for example, an increase in emissions would give rise to a positively sloping curve which depicts a trend in favor of the environment. However, increased CO_2 emissions have a negative impact on the environment. Therefore, ratios were necessary to invert such data (see fig 3.13). In the case of CO_2 emissions in a municipality, the ratio was amount CO_2 emitted in 1990 divided by the amount CO_2 emitted during the present year. If CO_2 emissions were reduced to a level below 1990's level, which is in favor of the environment, the ratio value would increase giving a positive slope.

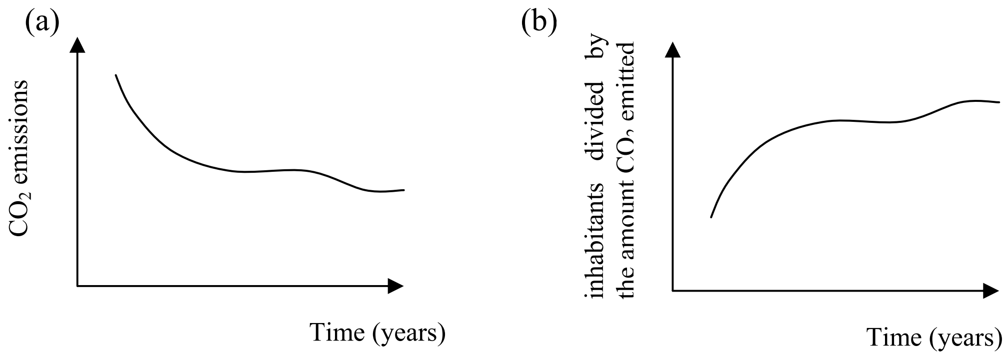
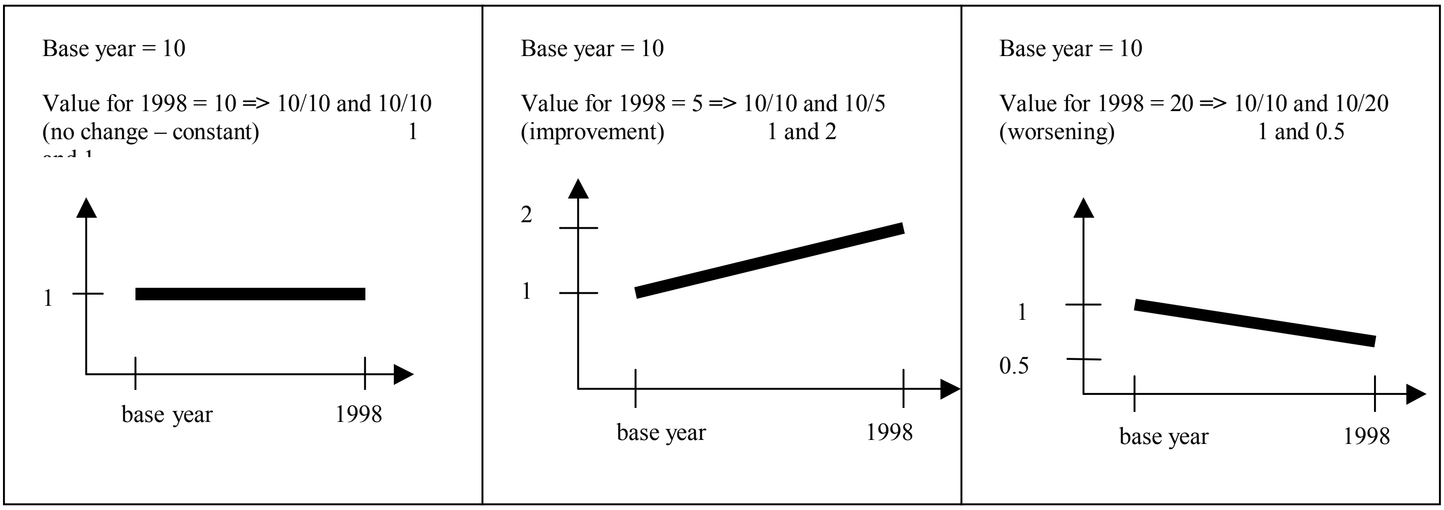


Fig 3.13: The difference in curve appearance if raw data is used or if data is transformed to allow a positive slope depict a trend in favor of the environment.

Since one indicator was developed for each environmental goal, and the objective of the indicator is to monitor the progress in achieving the values specified in the environmental goal, it was found appropriate to use these specified target values, threshold values or values for base years in creating the ratios. The next step in designing the indicator was determining which value was to be the numerator and which was to be the denominator. At this point, the meaning of positive and negative sloping curves had to be considered. For example, if the past few years' NO_x emissions were divided by NO_x emissions in 1980 (NO_x emissions have increased since 1980), the curve would have a positive slope (large numerator and small denominator) and would accordingly be interpreted as in favor of the environment. This is not true though – increased NO_x emissions is negative for the environment. Thus, if the ratio was inverted, 1980's value divided by past years' values (small numerator and large denominator) the curve would have a negative slope and accordingly would expose a trend not in favor of the environment.

In general, when determining which values to be assigned to the numerator or denominator, target values, threshold values and values for base years were placed in the numerator and present values in the denominator. At this point in time, since most present values are larger than the values aimed for in the goals, the curves will have negative slopes. Once the present values are curbed through mitigation actions, the denominator will become small relative to the numerator and the curve will turn and become positive exposing trends in favor of the environment (see box 3.1).

Box 3.1: How to interpret the slopes of the indicator curves



4. ENVIRONMENTAL INDICATORS DEVELOPED FOR SVEDALA MUNICIPALITY

The environmental department of Svedala's local government has grouped their 72 goals according to the following five environmental issues: (i) land, water and biodiversity, (ii) acidification and eutrophication, (iii) health threats – polluted air, noise and radon, (iv) disrupted ecocycles – metals and organic toxins, and (v) greenhouse effect and ozone depletion[9]. At least one indicator was developed for each environmental goal. The indicators are presented in tables 4.1 through 4.5 below to the right of their corresponding environmental goal and divided into their numerator and denominator components. The indicator type, based on its monitoring focal point (societal activity, environmental pressure or environmental state), is also presented in the column furthest to the right.

Despite the usage of the simple method for designing indicators described in chapter 3, in which the indicators are based on goals, several problems arose. First, some of the environmental goals were very vague and did not contain any specified values to be achieved that could be used in creating the ratios, e.g. groundwater should be protected and preserved. How is groundwater best protected and preserved? Second, there is a zero tolerance for certain issues, such as noise, and hence, mitigation measures are implemented immediately resulting in no aspect to be monitored, as was the case for goal numbers 38, 39 and 41. Third, there was not enough time to do the research necessary to understand what could have been monitored for the vaguely formulated goals. The 16 goals and their specific reasons for complicating indicator development are presented in table 4.6.

For approximately 50% of the indicators, data was found. Indicator values will be computed for these indicators and they will be presented in the report to be submitted to the environmental department.

According to the societal activity, environmental pressure and environmental quality definition of the causal chain, most of the indicators designed for Svedala municipality monitor societal activities or environmental pressures. Very few indicators measure the state of the environment. This is primarily due to the fact that the environmental goals formulated by the local government of Svedala were used in the procedure for designing the indicators. The environmental goals targeted the societal activities and the resulting environmental pressures. For example, there are many goals to reduce the emission of various substances (pressures) and several goals which require an alteration in human activities such as fertilizer and pesticide usage, recycling, energy usage etc (activities). In contrast, no goals explicitly state that the quality of the environment should be altered.

Table 4.1: The environmental goals for land, water and biodiversity with their respective environmental indicators and corresponding indicator groups.

Land, water and biodiversity		**Environmental indicators**		
	Environmental goals	**numerator**	**denominator**	**Activity, Pressure or State**
1	Implement the measures suggested in the water conservation plan by Segeåns Vattendrags förbund.	*No indicator**	*No indicator**	
2	Land and water areas with endangered plant and animal species, with special natural and cultural value, ecologically sensitive areas or larger undisturbed areas and beaches with public access should be exempted from exploitation.	Number of new nature reserves *No data***	Most valuable areas *No data***	A
		Area nature reserves *No data*	The municipality's total area	A
3	Groundwater should be protected and preserved.	*No indicator*	*No indicator*	
4	Cultivable land should be viewed as a resource and only in the case of exceptions, be exploited.	Total area cultivable land *No data*	Area cultivable land that has been exploited *No data*	A
5	New land should not be used for e.g. building or infrastructure if this can be conducted on land that is near land already in use.	Area land that has been exploited near already exploited land *No data*	Total area land that has been exploited *No data*	A
6	The municipality should attempt to replace land taken for exploitation with natural environment somewhere else.	Number of cases when replaced *No data*	Total number of cases of exploitation *No data*	A
7	Valuable landscape, cultural and nature areas should be protected by e.g. creation of nature reserves.	*See 2*	*See 2*	A
8	All naturally existing species should be able to thrive. Nationally and internationally endangered species, as well as those typical for Scania, should be prioritized.	*No indicator*	*No indicator*	
9	Publicly accessible land for recreation and outdoor life, even near populated areas, should be increased.	Area for recreational activities *No data*	Total exploited area *No data*	A
10	Green open space in populated areas should be preserved, protected and managed in such a way that biodiversity is favored.	Area park *No data*	Populated area	A
		Area park *No data*	Amount pesticide purchased *No data*	A
		Area park *No data*	Amount fertilizer purchased *No data*	A
11	Existing wetlands should be protected and establishing new wetlands and restoration should be encouraged.	Area wetlands (base year)	Area wetlands *No data*	A/S

* no indicator was designed for the environmental goal for reasons described previously in chapter 4.
** no data could be found for the indicator for reasons described in section 5.5.

12	The gravel plan for Scania should be abided. When constructing, e.g. roads, the percentage of "bergkross" should increase in relation to "naturgrus" so that 80% is reached by year 2000.	Amount bergkross *No data*	Amount bergkross plus naturgrus *No data*	A
13	The usage of fertilizer and chemical pesticides should gradually decrease. By year 2005, 10% of the agricultural land should be cultivated ecologically.	Area ecologically cultivated	Total agricultural land *No data*	A
		Total area agricultural land *No data*	Amount pesticide purchased *No data*	A
		Total area agricultural land *No data*	Amount fertilizer purchased *No data*	A
14	When planting forest on abandoned agricultural land, deciduous species should be prioritized.	ha planted deciduous forest *No data*	Ha abandoned agricultural land *No data*	A
		ha planted forest *No data*	ha abandoned agricultural land *No data*	A
15	The small biotopes in the agricultural landscape should be conserved and managed as well as natural elements which create important corridors between the biotopes. Farmers should have access to information regarding endangered biotopes in agricultural landscapes. The variations of ecosystems found in older agricultural landscapes should be conserved e.g. meadows and pastures should be prioritized.	ha meadow *No data*	Total municipal area	A/S
		ha pastures *No data*	Total municipal area	A/S

Table 4.2: The environmental goals for mitigating eutrophication and acidification with their respective environmental indicators and corresponding indicator groups.

Eutrophication and acidification		Environmental indicators		
Environmental goals		numerator	denominator	Activity, Pressure or State
16	N- and P-emissions to watercourses should decrease by 50% by 1995 base year 1985)	N-emissions 1985	N-emissions	P
		P-emissions 1985	P-emissions	P
17	N in the form of fertilizer should decrease by 20% from 1986 to 2000	Amount fertilizer purchased 1986 *No data*	Amount fertilizer purchased *No data*	A
18	carry on forestry in such a manner that N-leakage is limited	*No indicator*	*No indicator*	
19	ammonia emissions from agriculture should be reduced by half between 1990 and 2000	Ammonia emissions from agriculture 1990 *No data*	Ammonia emissions from agriculture *No data*	P
20	sewage treatment plants should cleanse 90-95% of P	P in minus P out	P in	P
21	sewage treatment plants should cleanse 70-80% of N	N in minus N out	N in	P

22	N- and P-emissions from sewage treatment plants should be minimized	Permitted P out	P out	P
		Permitted N out	N out	P
		Transported P base year	Transported P	P
		Transported N base year	Transported N	P
23	private drainage should have a sludge separator by year 2000	Number private drainage with sludge separator	Total number of private drainage	A
24	private drainage should have ground filters by year 2006	Number private drainage with ground filters	Total number of private drainage	A
25	NOx emissions from the traffic sector should be reduced by 40% by year 2000 (base year 1980)	NOx from traffic sector 1980	NOx from traffic sector	P
26	NOx emissions from the industrial and energy sectors should decrease by 50% by year 2000 (base year 1980)	NOx from industrial sector 1980	NOx from industrial sector	P
		NOx from energy sector 1980	NOx from energy sector	P
27	deposition of S compounds may not exceed 3 kg/ha/year	3 kg/ha/year	S-deposition	P
28	deposition of N compounds may not exceed 5 kg/ha/year	5 kg/ha/year	N-deposition	P

Table 4.3: The environmental goals for mitigating health threats (air, pollution, noise and radon) with their respective environmental indicators and corresponding indicator groups.

Health threats – air pollution, noise and radon		Environmental indicators		
	Environmental goals	**numerator**	**denominator**	**Activity, Pressure or State**
29	air pollution levels should not exceed present regulative threshold and target values	Present regulative threshold/target values *No data*	Actual emissions *No data*	P
30	levels of SO_2, soot/air borne particles, NO_2, CO_2 and ground level ozone should be reduced to background levels	SO_2 background level	SO2 emission	P
		Soot/air borne particle background level	Soot/air borne particle emission	P
		NO_2 background level	NO_2 emission	P
		CO_2 background level	CO_2 emission	P
		Ground level ozone background level	Ground level ozone	P
31	by year 2000, VOC emissions from traffic should be reduced by 70% (base year 1990)	VOC emissions from traffic 1990	VOC emissions from traffic	P
32	by year 2000, VOC emissions from other sources (including households) should be reduced by 50% (base year 1990)	VOC emissions from other sources 1990	VOC emissions from other sources	P
33	VOC most dangerous to health and the environment (alkenes, aromats, aldehydes etc) should be replaced or brought to an acceptable level through cleaning	VOC regulative threshold/target value	Amount VOC in air	P
34	the emission of carcinogens in populated areas should be reduced by 90% and 50% by 2005 (base year ?)	*No indicator*	*No indicator*	
35	CFC emissions should be reduced by 90% by year 2000 (base year 1990)	CFC emissions 1990	CFC emissions	P

36	planning and construction should include encouragement of minimizing traffic and enhancing public transport	Number of cases when this is true *No data*	Total number of cases *No data*	A
37	the burning of wood in households should not disturb the surroundings with odors or unhealthy levels of organic compounds	*No indicator*	*No indicator*	
38	by year 2000 sound quality should be as listed in the report	*No indicator*	*No indicator*	
39	in areas with outdoor recreation activities noise levels should be reduced to 40 dB(A) ekv. level and 50 dB(A) max level	*No indicator*	*No indicator*	
40	existing guidelines for external noise from industry, construction, shooting ranges and motor sport arenas should be followed and considered in planning and construction	Number of cases when guidelines are followed *No data*	Total number of cases *No data*	A
41	the guidelines in "Bättre plats för arbete" for protective distances regarding environmentally damaging activities should be followed	*No indicator*	*No indicator*	
42	no new construction or drawing of power lines giving rise to magnetic fields exceeding an annual average of 0,2 microtestla	Number of cases not exceeding *No data*	Total number of cases *No data*	A
43	the electromagnetic field strength from power lines should be decreased where exposure exceeds the normal value by a factor of 10, when this can be done at a reasonable cost	Number of mitigated cases *No data*	Total number of cases *No data*	A
44	before year 2005, all households and places of work with levels of radon gas exceeding 400 Bq/m^3 should be found and appropriate measure taken	Number of cases mitigated *No data*	Total number of cases exceeding 400 Bq/m^3 *No data*	A

Table 4.4: The environmental goals for mitigating disrupted ecocycles, metals and organic toxins with their respective environmental indicators and corresponding indicator groups.

Disrupted ecocycles, metals and organic toxins		**Environmental indicators**		
Environmental goals		**numerator**	**denominator**	**Activity, Pressure or State**
45	amounts of waste should be minimized	Total amount waste base year	Total amount waste	P
46	the waste's toxicity should be minimized	Amount chemical waste base year	Amount chemical waste	P
47	Recycled material should be reused (glass, paper, plastic and metal)	Amount reused (glass, paper, plastic and metal) *No data*	Amount recycled (glass, paper, plastic and metal)	A

48	materials from households and industries should be recycled	Amount of glass	Number of inhabitants or number of industries	A
		Amount of paper	Number of inhabitants or number of industries	A
		Amount of plastic	Number of inhabitants or number of industries	A
		Amount of metal	Number of inhabitants or number of industries	A
		Amount of chemical waste	Number of inhabitants or number of industries	A
49	biological material should be composted or decayed	Number of households or industries with composts *No data*	Total number of households or industries *No data*	A
50	energy should be extracted from waste	Amount energy from waste *No data*	Total energy production *No data*	A
		Amount waste for energy production *No data*	Total amount waste *No data*	A
51	waste not recycled should be deposited	Total amount waste not recycled	Amount waste deposited	P
52	sludge should be of the quality set by the limits for metal content	Amount permitted for lead, cadmium, copper, chrome, mercury, nickel or zinc	Content of lead, cadmium, copper, chrome, mercury, nickel or zinc	P
53	the content of stable and almost non-degradable compounds in sludge should be minimized	Total volume sludge	Content of stable and almost non-degradable compounds	P
54	sludge and other biological wastes from sewage treatment plants should be recycled, e.g. through agricultural use	Amount sludge recycled	Total amount sludge	A
55	the usage of chemical pesticides should be in such a manner that it doesn't cause health or environmental hazards	*No indicator*	*No indicator*	
56	pesticides may not be applied to land so that its biological function deteriorates	*No indicator*	*No indicator*	
57	the emission of stable organic compounds and toxins should be reduced so that by year 2000 it will have reached a level where the environment or humans' health is jeopardized	Emissions base year *No data*	Emissions *No data*	P
58	in the long run, no stable organic compounds or toxins should exist in the environment	*See 57*	*See 57*	P
59	discharge of mercury, cadmium and lead should be decreased by 80% by ? (base year 1985)	Discharge of mercury, cadmium, or lead 1985	Discharge of mercury, cadmium or lead	P
60	discharge of copper, zinc, chrome and arsenic should be reduced by 60% by ? (base year 1985)	Discharge of copper, zinc, chrome or arsenic 1985	Discharge of copper, zinc, chrome or arsenic	P
61	in the long run, the usage of mercury, cadmium and lead will cease while the usage of arsenic and chrome will be minimized	*No indicator*	*No indicator*	

Table 4.5: The environmental goals for mitigating greenhouse effect and ozone depletion with their respective environmental indicators and corresponding indicator groups.

Greenhouse Effect and Ozone Depletion		Environmental indicators		
	Environmental goals	**numerator**	**denominator**	**Activity, Pressure or State**
62	by year 2000, CO_2 emissions from use of fossil fuels should stabilize at 1990 levels and thereafter decrease	CO_2 emissions 1990	CO_2 emissions	P
63	by year 2050, CO_2 emissions should be reduced by 60% (base year 1990)	*See 62*	*See 62*	P
64	total energy usage should decrease according to the energy plan (5% reduction between 1996 and 2010)	Energy usage in households, transport sector or industrial sector 1996 *No data*	Energy usage in households, transport sector or industrial sector *No data*	A
65	the usage of renewable fuels and energy sources should increase	Renewable fuels *No data*	Total energy usage *No data*	A
66	by year 2010 the percentage of local renewable energy resources should be 25% excluding the transport sector	Amount local renewable energy resources *No data*	Total energy resources *No data*	A
67	by year 2002, 25% of the municipality's vehicles should be fueled with renewable fuels	Number of vehicles fueled with renewable fuels	Total number of vehicles	A
68	the phase-out of ozone depleting compounds should abide by the national plan	*No indicator*	*No indicator*	
69	the leakage of ozone depleting compounds from various equipment should be minimized, e.g. leakage of CFC and HCFC should not exceed 5% of the installed amount	Installed amount CFC *No data*	Amount CFC leaked *No data*	P
		Installed amount HCFC *No data*	Amount HCFC leaked *No data*	P
70	electricity usage should be reduced	Electricity usage base year *No data*	Electricity usage *No data*	A
71	the use of electricity for heating households and offices should be eliminated	Total number of households or offices *No data*	Households or offices with electric heating *No data*	A
72	the total electricity supply should be reduced by at least 12 GWh, corresponding to 7% of 1996 electricity supply, by year 2010	Total electricity supply 1996 *No data*	Total electricity supply *No data*	A

Table 4.6: The environmental goals for which no indicators were developed and why.

1	Implement the measures suggested in the water conservation plan by Segeåns Vattendrags Förbund.	No time to read the conservation plan in depth to be able extract the relevant measures.
3	Groundwater should be protected and preserved.	Not detailed enough. Research was required to find out how groundwater is best protected and preserved.
8	All naturally existing species should be able to thrive. Nationally and internationally endangered species, as well as those typical for Scania, should be prioritized.	Biodiversity is an issue which has proven to be the most problematic for designing indicators.
18	Carry on forestry in such a manner that leakage of nitrogen is limited.	Not detailed enough. Requires research on how leakage of nitrogen is best prevented.
34	The emission of carcinogens in populated areas should be reduced by 90% and 50% by 2005 (base year ?).	By what year should the 90% reduction be reached. Which is the base year? Which substances are considered carcinogens?
37	The burning of wood in households should not disturb the surroundings with odors or unhealthy levels of organic compounds.	How are odors monitored? What levels are considered unhealthy levels and which organic compounds?
38	By year 2000 sound quality should be listed as in the report.	No use in designing an indicator since, if the sound quality is below the standard, measures are taken immediately. Nothing to monitor.
39	In areas with outdoor recreation activities, noise levels should be reduced to 40 dB(A) ekv. level and 50 dB(A) max level.	No use in designing an indicator since, if the noise levels are above the standards, measures are taken immediately. Nothing to monitor.
41	The guidelines in “Bättre plats för arbete” for protective distances regarding environmentally damaging activities should be followed.	No use in designing an indicator since, if the protective distances are not followed, measures are taken immediately. Nothing to monitor.
55	The usage of chemical pesticides should be in such a manner that it doesn’t cause health or environmental hazards.	Not enough detail. How can chemical pesticides be used without causing health or environmental hazards?
56	Pesticides may not be applied to land so that its biological function deteriorates.	Not enough detail. How is pesticide applied without deteriorating the land’s biological functions?
61	In the long run, the usage of mercury, cadmium and lead will cease while the usage of arsenic and chrome will be minimized.	No year is given as a reference for the data transformation for mercury, cadmium and lead. What amounts of arsenic and chrome can be considered minimized?
68	The phase-out of ozone depleting compounds should abide by the national plan.	Not enough time to find the national plan and to extract the relevant measures.

5. EVALUATION OF THE ENVIRONMENTAL INDICATORS DEVELOPED FOR SVEDALA MUNICIPALITY

The final step in Mitchell's strategy for indicator development includes an evaluation of the indicators with regard to desirable indicator characteristics and program objectives[2]. This step is important since the aim of environmental indicators is to aid in the process of policy and decision making. They, therefore, have to be designed in such a manner that their format enables them to be useful to the policy and decision makers, and that their legitimacy as a representation of the progress in the abatement of environmental degradation is enhanced.

Due to the short time period for the case study, 20 weeks, the development of indicators for Svedala municipality was commenced prior to identifying desirable indicator characteristics. The indicators had to be developed at once so that enough time would remain for collecting the necessary data. Thus, a list of the most commonly found requirements in the literature was compiled after the indicators had been developed. Of all the literature studied, Kuik & Verbruggen, Mitchell and Liverman et al. had the most extensive lists of requirements. According to them the indicators should be:

- user-driven and give a general overview,
- built on appropriate data transformations and references,
- sensitive to time,
- sensitive to variations across space and social distribution,,
- based on easy accessible data,
- policy relevant and predictive,
- unbiased,
- monitor reversible or controllable issues, and
- representative of the system monitored

5.1 Be User-Driven and Give a General Overview

Professional analysts and scientists prefer raw data for statistical analysis and they are interested in many information bits per message conveyed[3]. In contrast, policy makers prefer information that is condensed to a few bits per message and that is related to policy objectives and target and threshold values[3]. The third group, the public, prefers messages in a single bit of information and that is unambiguous and free of redundancy[3]. Since the target group determines the number of indicators presented, a choice has to be made if the indicators should be presented in sets, as an index or if a representative indicator should be chosen.

Furthermore, the layout of the presented indicator has a great impact on the digestibility of the information revealed by the indicator[1]. Great care and afterthought is required in planning the presentation of the indicators so that the monitored trends can readily be viewed and interpreted by the target group.

The environmental indicators designed in the case study, were for the environmental department of Svedala's local government and therefore, they are relatively many in number. One indicator was designed for each environmental goal so that the environmental department could assess the progress of reaching the specific goals. The environmental department will later chose the relevant indicators for their contacts with the other departments within the local government and the regional departments outside the municipality. Similarly, a small number of indicators will be chosen for a pamphlet to be distributed to the households at the beginning of next year. In the pamphlet with the general public as a target group, indicators monitoring the sewage treatment plants' phosphor and nitrogen discharges will not be presented but rather issues which they themselves can influence such as recycling, electricity usage etc.

The graph approach with positive slopes depicting positive developments for the environment was chosen to be the presentation format of the indicators developed for Svedala municipality. From these graphs, it is easy for the target group to obtain a general overview of the environmental situation. Say that ten graphs are presented on the same page in a report, the reader could quickly pick out the issues where the mitigation measures have had an effect (graphs with positive slopes) and which issues that have not been improved (graphs with negative slopes). However, there is a possibility that economists find it easier to interpret these graphs than, for example, natural scientists or the general public. In economy, good things are always depicted by positive curves. In contrast, in the natural sciences, this rule does not exist. Curves are either positive or negative, depending on what they are measuring rather than the value associated with the result. Natural scientists, would interpret a negative curve as positive if, e.g., the CO_2 emissions were measured, and thus find it confusing when a positive curve is applauded. This confusion is understandable, but since the curves are mainly to be used by policy and decision makers who are used to the economists' manner of interpreting graphs, this manner of presentation should be continued. The general public on the other hand, need to be aided in inverting their interpretation of the curves. An option could be to provide both types of graphs in the pamphlets distributed to households. The two types of graphs would not be presented next to each other but perhaps divided between the first half and the second half of the pamphlet. This way, a general overview of the present environmental situation could be obtained from the indicator graphs while more specific numbers for recycling or electricity usage could be obtained from the graphs that the public is perhaps more used to.

Another problem with the graph approach which might limit the ability to gain a general overview of the information provided in the graph is the issue of adding a title to the graphs. Titles should in a clear manner expose what is presented in the graph but the ratios necessary to create the positive or negative curves, demolishes any sound units for the graph. Take the example of the highway graph shown previously in chapter 3 (fig 3.12). The average number of cars per 24-hours in 1981 are divided by the average number of cars per 24-hours during other years. The value is not a percentage of reduction or increase in traffic flow which it would of been if the ratio was inverted. What the graph is exposing, is a measurement of the increase in traffic flow, but it feels very strange to write "the increase in traffic flow between 1981 and 1998" when the curve has a negative slope.

5.2 Built on Appropriate Data Transformations and References

The data presented by indicators must be expressed in a manner which makes sense[2] and is meaningful to the policy and decision makers. Most often, raw data needs to be transformed to percentages, rates or per capita for the trends in attaining environmental sustainability to become more obvious[2]. For example, the area of forest in a region does not say much pertaining to the progress towards environmental sustainability and if mitigation actions are necessary[11]. In contrast, the ratio of forest loss per year in relation to original or existing forest area, exposes the trend in a clearer manner and could help determine if stricter policies need to be implemented[11].

Furthermore, if reference and threshold values are used, the progress towards or away from achieving environmental sustainability can be determined[3]. The indicator should be designed so that the present values are compared to the target or threshold values, which will give the distance from the desired goal. The target values represent desirable conditions and threshold values represent problem levels, both critical and irreversible[2].

The indicators developed for Svedala municipality clearly fulfill these two criteria. By using indicators that were based on ratios in the case study, data transformations occurred almost automatically. Using reference values in the indicator ratio also enabled the indicator to monitor the progress towards or away from the goals. Finding reference values was simple in most cases since they were specified in the environmental goals. For example, NO_x emissions from the traffic sector should be reduced by 40% between the years 1980 and 2000. The reference value is given by the target value, i.e., 40% of 1980's NO_x emissions from the traffic sector. The indicator was therefore, defined by the ratio between NO_x emissions during 1980 and the NO_x emissions during the present year. The result was then compared to 40% of 1980's emissions divided by 1980's emissions. The difference gives the distance from achieving or surpassing the goal.

Threshold values given in the goals, also served as reference values. Take the goal stating deposition of sulfur compounds may not exceed 3 kg/ha/year as an example. The reference value is 3 kg/ha/year and the indicator was defined by the ratio between 3 kg/ha/year and the number of deposited kilos of sulfur per hectare during the present year.

If no reference value was served on a silver platter, as in the cases above, a reference value was created by picking the first year of which there was data for (base year) and that value was used as a reference. By doing so, levels that were worse than the base year gave a value of less than one, and better values gave a ratio greater than one. This was in accordance with the idea of positive slopes depicting a reduction in society's negative impacts on the environment.

For some environmental goals with no specified goal values, no base years could be created either since no such data existed. Hence, the indicators were designed without a reference value. For example, goal 9 in table 4.1, states that publicly accessible land for recreation and outdoor life should be increased. To what extent is not specified and the indicator measures the area for recreational activities in relation to total exploited area. For a positive curve to be the result, the area for recreational activities has to increase. However, all exploited area cannot be turned into area for recreational activities. Space is needed for housing and infrastructure as well. The same applies to indicators for goals 2, 10 and 15 where the whole municipality cannot become one large nature reserve, meadow or pasture nor can the populated areas become one large park.

This can cause problems in the future when no more area for parks, recreational activities, meadows or nature reserves are desired. The decreasing amount of area for these land use types will be depicted by a curve which is slowly moving towards a horizontal line. Policy or decision maker casting a glance at these curves could misinterpret them as if no actions were taken. When in reality, there is no more space for such land use types.

5.3 Sensitivity to Time

An indicator must be sensitive to change in time. As discussed earlier in the paper, data must be collected frequently to detect significant trends and variations[11] and to prevent the situation with the “black box”. The frequency of data collection will of course depend on the environmental aspect that is monitored. It is sufficient to monitor the emission of greenhouse gases on a yearly basis, since climate change is a relatively slow and constant process, whereas the pH of a small lake, for instance, requires more frequent monitoring since the fluctuations could be greater during a year.

Time was incorporated into the indicators in a similar manner as the reference values to make the indicators sensitive to time. Either the numerator or denominator part of the ratio (most often denominator) allowed for a present value which could be compared to the reference value for every unit of time that was found suitable for the specific environmental issue. Time can always be incorporated into an indicator but this does not force the frequency of monitoring to increase. Unfortunately, even if the indicator was designed with the notion of having each year’s measured values compared to the reference values, the indicator will still fulfill its function if it were only every five years. However, drastic changes in the trend could occur within a five year period and therefore, it is recommended to keep the period between indicator value computations as short as possible.

Time was incorporated into the indicators for another reason as well. Since most environmental goals are to be reached by a certain point in time, a time axis must be included in the presentation of the indicator values to depict the deadline.

5.4 Sensitivity to Variations Across Space and Social Distribution

Indicators should be sensitive to variations across space[3] to enable comparisons between different regions. Circumstances can vary greatly between regions and they will affect their respective indicator values. For example, if indicators reflecting household heating were compared between the south and north of Sweden, the fact that the annual average temperature is much lower in the north than in the south, must be taken into consideration. Savings in household heating consumption could be drastically reduced in the south if the energy was not wasted by careless actions (e.g. leaving the heater on while airing the room). In contrast, in the north where the population is much more dependent on heating and would not open the windows for airing as often, drastic reductions might only be possible through technological innovations.

Indicators should also be sensitive to variations across social groups since the difference in behaviors and environmental impacts between, e.g., poor and rich, men and women, and ethnic groups could vary greatly.

The criterion of indicator sensitivity to variations across space is partially fulfilled by the indicators designed for Svedala municipality. The indicators contain specific target values and target years since they were developed on the basis of the environmental goals. Hence, comparing the indicator values with another municipality's indicator values, is only possible if the other municipality has the same target values and target years. Nevertheless, comparing indicators between municipalities is not of current importance since very few municipalities have developed environmental indicators. This criterion will, however, become more important if developing environmental indicators is adopted by a larger number of municipalities.

As for sensitivity to variations across social distribution, the indicators for Svedala municipality were not designed with this criterion in mind and thus, would not be able to expose the difference between the social groups.

5.5 Based on Easy Accessible Data

When designing the indicators, the accessibility to data should be considered. The data should be relatively easily accessible and available at a reasonable cost[4] for the indicator to be successful. Unfortunately, some of the most insightful environmental indicators are difficult and expensive to collect[11]. For example, the most obvious manner for monitoring biodiversity would be to count the number of individuals of each species in a region over time. However, the monetary cost and the time needed for such a project are unreasonable. A more appropriate indicator would perhaps be to monitor the area of nature reserves in the region.

When developing the indicators for Svedala municipality, the accessibility of the necessary data was taken under consideration so that they could be monitored frequently, to evade the "black box" scenario. However, several problems arose when trying to locate the sources of data. The primary barrier arose when the potential data source themselves, did not keep statistics on the issue depicted by the indicator. For example, the case with recycling. Several companies collect recycled material in Svedala municipality, but they also collect from the bordering municipalities resulting in a lack of data of what was collected in Svedala municipality specifically. The same problem arose when investigating the activities at sewage treatment plants. Svedala municipality has only one sewage treatment plant, thus, a percentage of the sewage is transported to a plant in Malmö. Svedala's plant had all the asked for statistics, but in Malmö, the statistics was for the whole plant rather than differentiated municipality-wise. Similarly, the electric company, could not produce data for Svedala municipality. Their electricity sales were registered client-wise and the clients were not grouped municipality-wise.

Competition between companies created another barrier. In the case of statistics regarding energy supply and usage, the gas company refused to surrender the statistics for Svedala municipality. Their excuse was competitive reasons.

A definite barrier to the work with indicator development was when an issue was not monitored at all. This was the case for land use and the purchase of fertilizer and pesticides.

In contrast, the most accessible data, was that of issues already monitored by a larger organization. The County Administrative Board of Malmöhus County, for example, had statistics on emissions and deposition of certain substances while the National Statistics Office of Sweden could provide data on the supply and usage of petroleum products.

Usually, if the data was not easily accessible, the indicator was substituted for another indicator which monitored another aspect of the same issue. For example, eutrophication where presently there are no measurements of how much nitrogen or phosphor is emitted to the major watercourses. On the other hand, the amount of nitrogen and phosphor transported from Sege å to the sea is monitored and was used instead.

Unfortunately, this substitution was not always possible, or the substitute indicator was not as good as the original indicator. If more time had been allotted to the thesis, the data source could have been contacted and a contract could have been negotiated to ensure that the necessary kind of data could be produced in the future. In many cases, it would not demand too much from the data source, e.g. the electricity company, to introduce minor alterations in their routines for data collection. If the list of clients and their addresses is registered in a computer, reorganizing the list according to the address instead of the last name, or whatever the present system is based on, is quite simple with modern computer programs. All in all though, data for approximately 50% of the indicators that were designed was possible to retrieve.

Although this criterion of using easy accessible data is sensible and would facilitate computing environmental indicator values, the data availability must not hinder the design of indicators. An indicator should not be refuted solely by the lack of data. If an aspect needs to be monitored, a process for the data collection will have to be created. Otherwise, data bases will stagnate and there would be no development nor progress in the field of monitoring. Even if a process for quantitative data collection is not possible, the aspect monitored should not be left unmonitored. Perhaps it could be studied qualitatively until a process for quantitative data has been created.

5.6 Policy Relevant and Predictive

For indicators to be useful in policy and decision making, the indicators must be pertinent to policy concerns[1] and have predictive meaning[3]. Indicators need to function as an early warning system to end the present method of management by accident where calamities are the main ground for policy making rather than scientists (see fig 5.1). Early warning systems are already in function in non-hard core environmental fields. For instance, defining and then monitoring the precursors of the economic deprivation and food shortages which result in famine (increases in urban food prices, cattle slaughter rates and population movements) has great predictive power, and policy and decision makers can take action before it is too late[11].

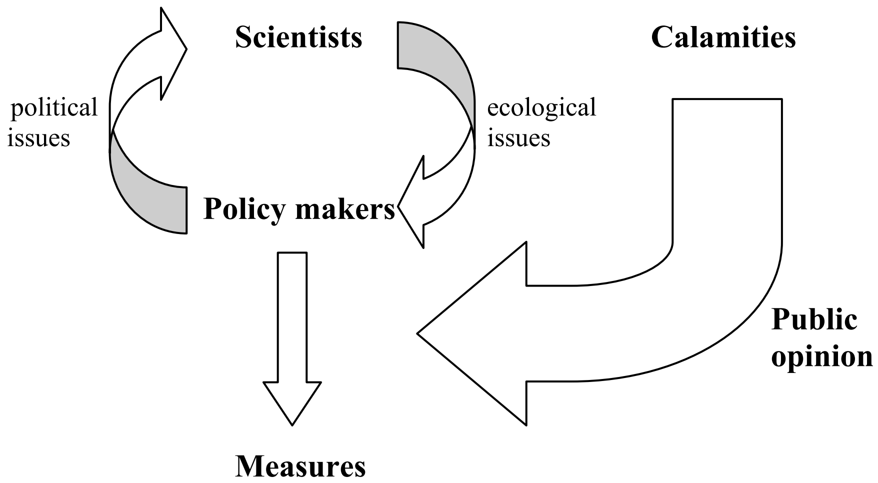


Fig 5.1: Model of management by accident (Kuik & Verbruggen[3], p.74).

The indicators designed for Svedala municipality are highly policy relevant since the environmental goals were used as the basis for the indicator design. Each indicator serves as a measure of the success of a specific environmental goal. However, the environmental department in Svedala must consider the policy relevance criterion when using the indicators in their collaboration with the other departments both within Svedala municipality and outside.

In contrast to the criterion that the indicators should be predictive, most of the indicators designed for Svedala municipality are retrospective regarding their information content. Yet, as discussed in section 3.1, retrospective indicators can serve as predictive indicators since they expose past trends of the impacts of past mitigation measures. Also, even though the final scenario of environmental degradation may not always be known since the situation has not arisen earlier, e.g., climate change, many final scenarios are known as in the case of eutrophication and acidification. By analyzing the sequence of events that took place in an eutrophic lake for example, warning signs can be distinguished and incorporated in the indicators used for the evaluation of other endangered lakes.

5.7 Unbiased

This requirement is very difficult to fulfil with regard to environmental indicators. For instance, politicians select a certain environmental issue and then drive an abatement campaign. Money is provided and the media and the public become very aware of the issue. It then becomes difficult to put such current drives into its proper perspective with regard to other environmental issues which might actually be more critical. It is, therefore, important to include a few lines of text with each presented indicator to explicitly state which assumptions have been made and the reasoning behind the designer's choices regarding the manner for data collection. Hence, the value judgements made throughout the process of designing the indicator as to where, what, how and when to measure as well as, how to weight and how to present the results[11] is explicit to the indicator user.

Therefore, while designing the indicators and collecting data for indicator values, this aspect was kept in mind and notes were taken that can be included in the presentation of the indicator curves. When delivering the indicator curves to Svedala municipality, a short text will be presented along with each curve explicitly stating the sources of bias.

5.8 Monitor Reversible or Controllable Issues

The requirement that indicators should only represent reversible and controllable processes is disputable[3]. Decision and policy makers argue that they only need to know which aspects of environmental degradation they can influence through policies and regulations[11]. Scientists on the other hand, argue that the indirect predictive meaning of some irreversible or unmanageable processes (e.g. extinct species or frequency of typhoons) can be useful[3]. Not much can be done if the situation has already become irreversible or unmanageable, but lessons can be learnt and similar disastrous courses of action can be prevented in the future.

All the indicators designed for Svedala municipality monitor reversible or controllable processes. The emission of substances, recycling of material, energy use, land use etc, are all susceptible to present or future mitigation measures. The main reason for most indicators monitoring reversible or controllable issues is that the indicators were designed with the environmental goals as a basis, and the goals, in turn, focus on revocable and governable issues. Even so, the local government of Svedala may not alone, have the complete control of an issue nor the possibility to reverse the situation by themselves. Issues such as NO_x and SO_x emissions are transboundary both nationally and internationally. A great deal of lobbying and cooperation might be necessary for attaining the goals for such issues.

5.9 Be Representative of the System Monitored

The indicator has to be designed so that it is representative of the chosen system[3]. It must accurately describe the system's behavior and structure[3]. Margins of uncertainty should also be explicitly included[3]. Often the quality of data needs to be mentioned since assumptions are made and discrepancies in the data exists. For example, emissions of a substance may not actually be measured so an estimated value is used instead. The estimated value is not completely representative of the system and should, therefore, be mentioned in the presentation of the indicator.

The indicators designed for Svedala municipality were based on the environmental goals formulated by the environmental department. Thus, the options of how the natural systems were to be represented, were limited. A number of goals were designed for each environmental issue so the main aspects of how to mitigate the specific issue were already chosen. A discussion whether the appropriate choices were made when formulating the goals would be interesting but beyond the scope of this thesis.

However, some questions arose regarding the degree to which the indicator is representative of what it is supposed to monitor. For example indicators developed for goal number 48 in table 4.4 where it is stated that materials from households should be recycled. At first, the approach of putting a base year value in the numerator and the present year in the denominator was used. However, with this ratio, a negative curve will result if the amount recycled is increased after the base year. Although increasing the amount recycling could be considered positive, it could also be interpreted as an increase in material usage which is negative for the environment. In an ideal system of recycling, a constant amount of material exists but if the recycled amount increases, new raw material must have entered the cycle. This raw material has most probably been extracted from nature or chemically produced and is an unnatural element to nature and potentially dangerous if released to nature.

Due to the problems of interpreting if what the indicator was monitoring was favorable or not to the environment, the indicator was substituted for amount of recycled material divided by the number of inhabitants. The problem with this ratio is that the number of inhabitants is not constant as in the case of a specified goal value and hence, it can be questioned which issue is actually being monitored by the indicator.

The ideal indicator for the environmental goal regarding recycling of material would be to have the amount recycled as the numerator and the amount purchased in the denominator. A direct correlation could be made between purchases and recycling, but data on purchases of material for households does not exist at present.

6. CONCLUSIONS AND DISCUSSION

The aim of the thesis was to develop and arrive at a conception of environmental indicators that can be utilized as a tool by the environmental department of Svedala's local government for monitoring their progress in achieving their environmental goals. The second aim was to analyze these indicators with regard to their adequacy as measurements of society's present impacts on the environment and as a tool for policy and decision making.

On my own initiative, the goals were used as a basis for the development of indicators. Of the 72 goals only16 remain without an indicator. Approximately 80 indicators were designed, of which, data was found for half of them. Data collection was the main problem for fulfilling the first aim of the thesis.

Through the analysis of the indicators designed for Svedala municipality with regard to the list of indicator requirements compiled from literature studies, the indicators only scored less on two points. They are not unbiased and they are not very sensitive to changes and variations across space. However, designing unbiased indicators is impossible. Furthermore, the indicators were designed for use within the municipality and not for comparisons with other municipalities. Thus, the indicators can still serve their purpose well.

The indicators do not completely fulfil the criterion of demanding easy accessible data. It should be noted though, the accessibility of data should not limit indicator development. Instead pressures should be placed on the potential data sources to provide the data in the future.

Otherwise, with regard to the other requirements; giving a general overview and being user-driven, appropriate data transformations and reference, sensitivity to time, policy relevant and predictive, monitoring reversible or controllable issues and representative of the system, the indicators fulfill them satisfactorily.

Having worked with environmental indicators that are physical and retrospective, my trust in their credibility as measurements of the environmental situation has increased. Some information is naturally lost when condensing the environmental situation into a few number of indicators. However, in general, they are still representative of the system if the development process is based on a framework model of that system and if time and care is spent on designing the indicator so they fulfill a majority of the criteria discussed in chapter 5.

The environmental department in Svedala municipality may have obtained a large number of environmental indicators with little effort, but a great deal of effort will have to be invested in the near future to keep these indicators "alive". Data has to be collected again within a year to compute the indicator values for 1999. Hopefully, by then, a number of deals may have been negotiated with data sources that were not able to provide statistics this year. The number of municipalities reaching the stage of designing environmental indicators is increasing and as a direct result, the demand for environmental statistics will increase. Industries and businesses should begin to perceive environmental statistics as a service rather than extra, trivial labor. These companies can actually gain a great deal from the demanded data compilation. They can use the statistics in their own environmental reporting and increase their competitive position on the market.

Another essential future development for environmental indicators is that they cannot be considered a goal in themselves much longer. The indicators have to be incorporated into the daily activities of the local government in order for them to have an impact on the course of action taken by the different departments of the local government. Unless the various departments are involved in the designing and usage of the indicators, there is a risk that the indicators will be perceived as something trivial and not pertinent to the daily routines. The time and effort put behind the indicator development will then be fruitless. On the other hand, if each department was responsible for designing environmental indicators reflecting their own activities and gathering the relevant data themselves, greater attention would be paid to the indicators and an interest for the indicators would grow. Furthermore, by working with indicators, greater knowledge of the respective department's effects on the environment would be gained, reducing the environmental department's time and efforts in producing information materials. The task for the environmental department would then shift to compiling the data from the various departments and show the trends for the municipality as a whole. In addition, each department has better knowledge of their respective activities and projects resulting in the production of a wider scope of indicators than having the environmental department first tracking down the types of activities and then trying to understand the environmental impacts of each department's activities. (The need for incorporating environmental issues into practice, are aspects currently discussed widely in a variety of research literature.)

However, the environmental department should be assigned the role of coordinating the development of indicators within all the local government's departments. Otherwise, there is a risk that very different types of indicators are developed and that they monitor dissimilar issues, inhibiting the possibility of compiling them later. A structure is needed but it should not prevent the development of unique indicators if they are needed.

Another interesting development would be if indicators were used for social and economic reporting as well. At present, the annual economic report and environmental report, are two separate reports. If the annual results were instead presented in the same manner, it would enhance the opportunity to combine the reports where environmental and economic consequences were presented next to each other, rather than separately. If this reporting manner was introduced, there could, for example, be a graph depicting the monetary investments in reducing carbon dioxide emissions and next to it, a graph depicting the actual carbon dioxide emissions. Policy and decision makers would then be able to see the effect of their mitigation measures much more clearly. Furthermore, by entwining environmental indicators together with economic indicators, environmental issues will be lifted from the background or an appendix, and placed at the same level as economic issues. For example, if the costs for carbon dioxide reductions have been high and there is no knowledge of the effects in carbon dioxide emissions, decision makers will most probably cut down on the budget for carbon dioxide emission reductions. In contrast, if the emission graph is right next to the economic graph, they could perhaps see that the emission curve is starting to turn upwards and they will realize that with a bit more money and a bit more time, the environmental goal will actually be reached.

If the environmental indicators are presented together with the economic and social indicators, dialogues need to be opened up between the indicator designers and the decision makers so the most useful indicators can be developed. These meetings would further enhance cooperation and exchange of ideas. Local governmental departments can no longer work separately since their respective activities affect the other departments' activities, maybe not directly, but at least indirectly through the environmental impacts.

More cooperation is also needed between municipalities. Pollution knows no boundaries and therefore, dialogues and joint projects are necessary to curb environmental degradation. At a meeting at the County Administrative Board in Malmö in November 1998, several local governmental representatives from the county's municipalities were present and the idea of municipalities cooperating in producing similar indicators to be published by the county administrative board was presented. Of course, the local governments prioritize the various environmental issues differently depending on the situation in the respective municipality, but they also have certain environmental issues in common. Through cooperation and defining certain indicators to be used by all municipalities in the county, a better overview of the county's situation is offered but a reference for the individual municipalities is also offered. Through comparisons with other municipalities, a local government has better knowledge of their own situation as part of a county in addition to their own environmental goals. Also, if one local government has difficulties in curbing their carbon dioxide emissions for example, they can turn to a neighboring local government who has had greater success and receive advice on how to carry out the mitigation measures. Mitigating environmental degradation is not a zero-sum game nor a competition with opposing teams, but rather, a team sport with no opposing team and where all players are winners.

It is believed that by monitoring the societal impacts on the environment, better policies can be created and the travelling speed on the road to environmental sustainability could be increased. This was true for certain environmental issues in Holland[1] but it would be very interesting to see if the same applies to the case study of Svedala municipality. Will these indicators be used efficiently and will they have an effect on their policy and decision making?

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