A INTRODUCTION TO INDICATORS

A1 INDICATORS

The Namibian Government is committed to improving the living standards/quality of life of all its people and to sustainable use of the Nation's natural resources. Meeting this challenge requires an understanding of the factors governing the distribution and abundance of national natural resources, the patterns of resource use, a programme to monitor resource condition to guide management and policy decisions and the requirements of sustainable development. Without this adaptive approach to natural resource management, there is little hope for ensuring sustainable resource use and the long-term wellbeing of Namibia's citizens.

Policy makers and decision makers require current information to be proactive rather than reactive in response to environmental problems. An efficient and effective monitoring and information dissemination network could provide this information. Hence, some means of measuring the status and usage patterns of environmental resources such as water is needed. In the case of the industrialised environment, resources include not only those naturally occurring but also resources imported and used within the country such as petroleum products and electricity. Their use often has a direct or indirect impact on the natural environment or, as in the case of manufacturing, may require inputs from the natural environment.

An indicator is a measure of some variable of interest, whether it be related to the natural environment (pollution of groundwater by manufacturing), the economic environment (contribution to foreign exchange from mining), or the social environment (access to vehicles). As the name suggests, indicators are measures that are symptomatic of particular situations. The current numerical value of an indicator may be determined by a simple measurement (kilometres of road and rail in Namibia) or derived from an equation that incorporates measurements of several variables.

A2 WHY DO WE NEED INDICATORS?

The value of indicators to the management of natural resources in Namibia becomes clear when viewed in the context of Namibia's "Information and Communication Service for Sustainable Development in Namibia" programme, of which this report is a part. This programme is managed from the Directorate of Environmental Affairs, Ministry of Environment and Tourism and funded by the Government of Finland. If this programme is to be effective, it must:

- determine the status of resources
- discern changes and trends
- provide an understanding of processes

- provide early warning of emerging problems
- measure the effectiveness of environmental and sustainable development policies

The measurement and interpretation of key indicators are central to the success of such a programme. Indicators used in a national programme for monitoring environmental resources must address the fundamental questions of:

- Is the environment (natural, social, economic) getting better, worse or holding steady?
- Why (what are the causes of change)?
- What can we do about it (do we understand the stressors involved)?

While the measurement and interpretation of indicators is clearly crucial, which ones should we use and how should we use them? Two general types of indicators can be defined: core and developmental. Core indicators are those in which the data collection and evaluation methodologies are well defined, and existing data series provide a historic record in support of future analyses. Developmental indicators are those in which further testing of sampling and evaluation methods is still needed, and historic data series do not exist. Both types of indicators are important components of a long-term monitoring program for Namibia's industrialised environment. However, in the industrialised environment there are few long term data sets available in that data prior to the past ten years are very sparse. Means of calculation of indicators is, in some instances, well defined. Once indicators are selected, the overall health of Namibia's industrialised sector may be determined through a critical evaluation of indicator scores relative to reference conditions.

A3 DETECTING POLICY-RELEVANT TRENDS

A primary goal of this report is to identify key indicators that are relevant for assessing trends at the national level. These trends may affect policy or be affected by policy at the national, regional or local level. Indicators of trends must have a direct and easily-recognised relationship to socio-economic or environmental well-being, and have the social and political impact to catch the attention of and demand action from policy-makers. The development of appropriate indicators is a key step in addressing questions about the existence or magnitude of trends in natural resources. What constitutes a policy-relevant trend and how well can we measure or detect it?

While a trend may be defined as a long-term change in the mean value of a series of measurements, an equally or more important trend may be a shift in the variance. Traffic accidents per capita provide an example, wherein a small change in the mean over time could be associated with a significant increase in the variance. The relevant indicator in this case would not be the mean itself, but rather the variance, as an increase in traffic accidents per capita could reflect changes in regulation and control of licensing or of traffic flow, the age of vehicles or quality of tyres imported. Large

variance in such an indicator would suggest the need for further investigation of the causes of the variance.

Although the concepts of trend and change are familiar to many, the issues associated with their analysis, and accurate and timely detection, are more subtle. First, the term "trend" is difficult to define precisely and objectively. The term trend describes the continuing directional change in the value of an indicator over time, generally upwards or downwards. Effective trend detection is entirely dependent on the availability of data collected over a period of time in a consistent and reliable manner. Monotonic trends, continual increases or decreases, are commonly detected in the evaluation of long-term data series. Such trends may occur gradually over time, or in abrupt "steps." Step trends may occur in a data series in direct response to a specific event, such as the introduction of a contaminant to a water source, resulting in a sudden change in the variable of interest (Hirsch et al. 1991).

What constitutes long-term, when considering a trend, is subjective and depends upon the dynamics associated with the system under study. A basic understanding of the variability of Namibia's climate only begins to emerge after many decades of study. Long-term data are essential for detecting environmental trends and for putting the present into perspective (Magnuson 1990). Data from a single year, such as income from diamond production, reveal little information. Similarly, only a few years of measurements of energy generation at Ruacana tell us little regarding hydropower as a proportion of the total power used in Namibia through time.

In the same way that variation from one year to the next may complicate our recognition of trends, so too may high levels of variation from one site to another during any given year. This spatial variation, which typifies Namibia's environment, adds another complexity to our definition of trend. What constitutes the appropriate coverage in a given space, such as a particular region within the country? While facilities for disposal of hazardous waste may be present in and used by one municipality, we cannot assume that that site is representative of all municipalities. Identification of regional or national trends in terms of hazardous waste distribution and disposal will probably require more complete data, sampled across a range of sites. Thus our definition of trends must include both change over time as well as change over space in target regions. It should thus be immediately clear that data sets of short duration and limited spatial coverage are not adequate to recognize trends accurately.

A4 HOW OFTEN DO WE MONITOR?

Determining the optimal frequency and distribution of surveys is a key issue in effectively monitoring the status of Namibia's resources. Given the limited resources for monitoring, the longest survey cycle which still meets the needs of early and accurate detection must be identified. The main goal in achieving this optimal frequency is avoiding both unnecessary cost and regulation, while preventing the development of any serious environmental problem. Mining's contribution to foreign

exchange provides a useful example. The diamond production per year is a simple and useful indicator that is responsive to a number of factors. However, discovery and development of new deposits occurs infrequently and are associated with intensity of exploration. What is the optimal frequency for measurement?

A5 MOVING FROM DETECTION TO CAUSATION

Once detected, determining the cause of a trend is important so that appropriate policy changes and management can be instituted. Assigning causality is a key challenge in environmental monitoring programmes. While our chosen indicator may be a reliable measure of a given resource, in the absence of any measurements of change in suspected stressors, we may be unable to assign causality and determine whether the trends are "natural" or caused by human activities. Natural resource monitoring programmes commonly emphasize effects-oriented monitoring, which provides a direct measure of a resource. However, early detection of changes in resources through stressor-oriented monitoring (e.g., environmental contract compliance) may be a more effective means of ensuring sustainable resource use. Monitoring changes in stressors is essential to successful adaptive management, and the prevention of serious resource degradation.

A major challenge associated with natural resource monitoring programs is to isolate the effect of interest from noise introduced by natural spatial and temporal variability. If the size of an impact from a human disturbance is small relative to natural variability, it will be difficult to detect with any degree of confidence (Osenberg et al. 1994). This challenge of distinguishing natural from anthropogenic variability is at the heart of Namibia's attempts to monitor and ensure the sustainable use and development of its resources. Namibia's arid climate is highly variable. For any data series, the ability to detect trends is a function of three characteristics: (1) the magnitude of the signal, (2) the variance of the data, and (3) the sample size. In an arid country like Namibia, where the variance of atmospheric quality may be very high, only a large change, for example, in lead emissions or green-house gas emissions is likely to be detected in the absence of a long-term data set.

This issue of separating natural from human-induced change is of particular significance in Namibia, given the high levels of variation, both over space and time, in many resources. Monitoring programmes are often piecemeal, intermittent, and short term. They generally have not provided the continuous long-term information about temporal and spatial variation necessary to distinguish natural from human-induced change. This distinction may be best made with a combination of stressor-oriented and effects-oriented monitoring. Ultimately, monitoring trends in both effects and stressors can improve the interpretability of observed changes. The status of an aquifer provides a simple example, in which a change in water quality may be in response to multiple stressors, such as changes in rate and types of water pollution, changes in draw-down and changes in rates of recharge. In such cases, the choice of appropriate response variables (indicators) is dependent upon our knowledge of the dynamics of the system.

A6 WHAT ARE THE CHARACTERISTICS OF A GOOD INDICATOR?

To be effective, an indicator must be:

- efficient (i.e., easily measured and analyzed using existing data)
- effective (i.e., sensitive to change and clearly linked to causative factors)
- economically and logistically feasible (e.g., already being measured)
- reliable (i.e., accurate and continuous)

An issue in the development and application of indicators is the feasibility, technical, financial and environmental, of gathering the information required. While an indicator may have great potential for monitoring policy-relevant trends, the logistical, technical, and economic realities of collecting and analyzing the information required for its determination will dictate its use. While some indicators may have great utility, technical and financial constraints may preclude their use.