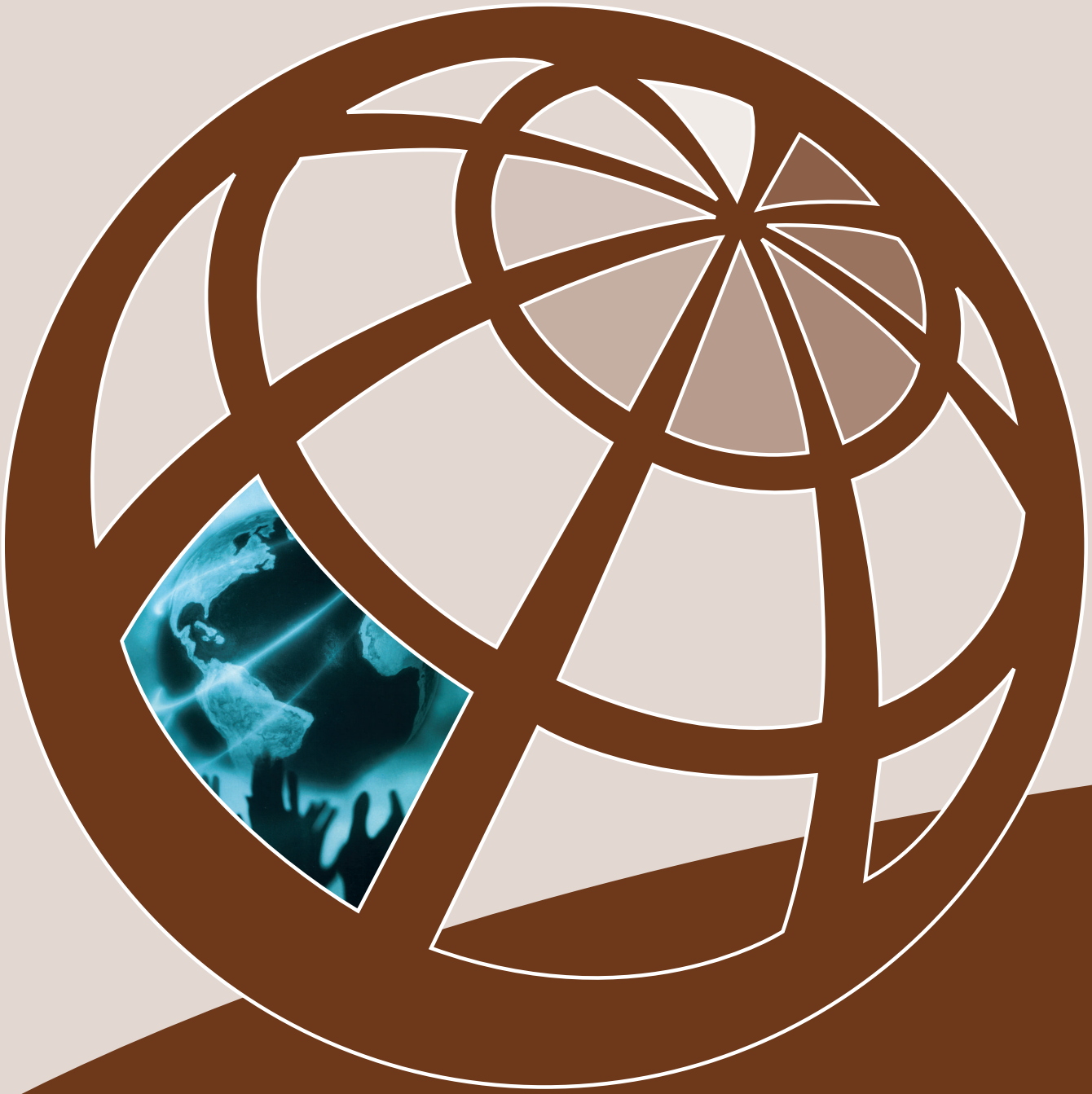

*Integrated Environmental Management Information Series*

# *Cumulative Effects Assessment*

7

Department of
Environmental Affairs and Tourism

*Other topics in the series of overview information documents on the concepts of, and approaches to, integrated environmental management are listed below. Further titles in this series are being prepared and will be made available periodically. Sequence of release and titles are subject to change.*

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*ISSUED BY*

Department of Environmental Affairs and Tourism
Private Bag X447
Pretoria
0001 South Africa

*This document is available on the DEAT web site: http://www.deat.gov.za*



ENQUIRIES AND COMMENTS

All enquiries and comments should be addressed to:
The Director: Environmental Impact Management
Department of Environmental Affairs and Tourism
Private Bag X447
Pretoria
0001 South Africa

REFERENCING

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PREFACE

This document is one of a series of overview information documents on the concepts of, and approaches to, Integrated Environmental Management (IEM). IEM is a key instrument of South Africa's National Environmental Management Act (NEMA). South Africa's NEMA promotes the integrated environmental management of activities that may have a significant effect (positive and negative) on the environment. IEM provides the overarching framework for the integration of environmental assessment and management principles into environmental decision-making. It includes the use of several environmental assessment and management tools that are appropriate for the various levels of decision-making.

The aim of this document series is to provide general information on techniques, tools and processes for environmental assessment and management. The material in this document draws upon experience and knowledge from South African practitioners and authorities, and published literature on international best practice. This document is aimed at a broad

readership, which includes government authorities (who are responsible for reviewing and commenting on environmental reports and interacting in environmental processes), environmental professionals (who undertake or are involved in environmental assessments as part of their professional practice), academics (who are interested in and active in the environmental assessment field from a research, teaching and training perspective), non-government organisations (NGOs) and interested persons. It is hoped that this document will also be of interest to practitioners, government authorities and academics from around the world.

This document has been designed for use in South Africa and it cannot reflect all the specific requirements, practice and procedures of environmental assessment in other countries.

This series of documents is not meant to encompass every possible concept, consideration, issue or process in the range of environmental assessment and management tools. Proper use of this series of documents is as a generic reference, with the understanding that it will be revised and supplemented by detailed guideline documents.

The opinions expressed and conclusions drawn are those of the author's and are not necessarily the official view of the publisher, the Department of Environmental Affairs and Tourism. The author and publisher make no representation or warranty, expressed or implied, as to the completeness, correctness or utility of the information in this publication. Whilst every effort has been made to ensure that the information contained herein is accurate, the author and publisher assume no liability of any kind whatsoever resulting from the use or reliance upon the contents of this publication.

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| Departmental Review | Mark Gordon (DEAT) |

## SUMMARY

Cumulative effects assessment (CEA) represents an emerging process within the broader field of integrated environmental management. As the scope of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) processes has been expanded to include sustainable development considerations, CEA has been identified as the tool to provide direction in understanding impacts on future generations. CEA broadens the spatial and temporal focus of EIA and SEA. There appears to be consensus that CEA should be integrated into existing EIA and SEA processes. Cumulative effects are commonly understood as the impacts which combine from different projects and which result in significant change, which is larger than the sum of all the impacts. The complicating factor is that the projects that need to be considered are from past, present and reasonably foreseeable future development. CEA therefore requires a holistic view, interpretation and analysis of the biophysical, social and economic systems. CEA is limited and constrained by the current methods used for identifying and analysing cumulative effects. Cumulative effects can be characterised according to the pathway it follows. One pathway could be the persistent additions from one process. Another pathway could be the compounding effect from one or more processes.

Cumulative effects can therefore occur when impacts are: (1) additive (incremental); (2) interactive; (3) sequential; or (4) synergistic. Impacts also occur when thresholds are passed or when interaction is antagonistic. Planning to address cumulative effects involves delineating spatial and temporal boundaries, determining future development and determining the significance of cumulative impacts.

Priority should be given to the development of guidelines to facilitate the incorporation of cumulative effects into EIA and SEA processes. Special consideration and attention needs to be focused on how developing countries deal with the issue of cumulative effects. Data requirements, the lack of infrastructure and expertise and cost implications militate against the widespread application of CEA in developing countries. Research is needed to further develop the concepts and methods in carrying capacity analysis and limits of acceptable change. Because of the complexity involved in identifying and analysing cumulative effects, initiatives should be established to promote shared learning, research and training.

# CONTENTS

*Summary* 3

*Contents* 4

1. INTRODUCTION 5
2. PURPOSE OF THIS DOCUMENT 5
3. DEFINING CUMULATIVE EFFECTS ASSESSMENT 5
4. INCORPORATING CUMULATIVE EFFECTS ASSESSMENT INTO EIA AND SEA 8
   - *4.1 Addressing cumulative effects in EIA* 8
   - *4.2 Addressing cumulative effects in SEA* 14
5. CONCLUSIONS 16
6. REFERENCES 16
7. GLOSSARY 18

TABLES

*Table 1: Types and characteristics of cumulative effects (adapted from the Council on Environmental Quality, 1997).* 6

*Table 2: Principles of cumulative effects assessment (adapted from the Council on Environmental Quality, 1997).* 6

*Table 3: Selection of methods that can be used to identify and assess cumulative effects (adapted from Sadler and Verheem, 1996; Council on Environmental Quality, 1997; Canter, 1999)* 7

*Table 4: Summary of steps to be addressed in evaluating cumulative effects in the EIA process (Council on Environmental Quality, 1997; Canter and Sadler, 1997).* 9

FIGURES

*Figure 1: Different approaches for assessing cumulative effects (adapted from Dubé, 2003).* 8

*Figure 2: Model of negative cumulative effects and linkages (Rossouw,et al. 1997)* 13

## 1. INTRODUCTION

Concerns are often raised about the long term changes, not only as result of a single action or development, but the combined effects of many actions over time on the environment. Environmental Impact Assessment (EIA) has traditionally focussed primarily on examining the direct environmental effects of a single development. Each individual development, when assessed on its own, may produce impacts that are socially acceptable. However, when the effects of the numerous single developments are combined, these impacts may become cumulatively significant. In recent years there has been a growing realisation that the process of evaluating the negative environmental impacts of individual developments, which may be unobjectionable in themselves, do not adequately take into account the accumulative nature of some effects (Court et al., 1994). This has led to the development of procedures, known as Cumulative Effects Assessment (CEA), for evaluating the consequences, sources and pathways of cumulative impacts of multiple activities (Canter, 1999).

There is a sustainable development imperative for decision-makers to consider projects within the spatial context of other known and planned developments (i.e. analysing the known cumulative effects). Direct effects will continue to be important, because they are easily identified and quantified. However, the need to understand local, regional and global linkages and environmental change has driven efforts to undertake and improve the analysis of cumulative effects. In this document the terms "cumulative effects" and "cumulative impacts" are used synonymously

## 2. PURPOSE OF THIS DOCUMENT

As a result of growing global concern of the cumulative environmental effects of human activities, there is a need to promote shared learning, conduct research and provide guidance and information.

This document provides background information on the principles for CEA and highlights potential approaches for incorporating cumulative effects into EIA and SEA. Issues and criteria for carrying out CEA are highlighted, drawing strongly on international experience and lessons learnt. This document has been written for a wide audience. Its objective is to serve as an initial reference text. The aim is to provide an introductory information source to government authorities, environmental practitioners, non-governmental organisations (NGOs), industry, project proponents, academics, students and other interested and affected parties (I&APs). This document does not prescribe or recommend specific methods, but rather provides an overview of the key criteria to consider in addressing cumulative effects.

## 3. DEFINING CUMULATIVE EFFECTS ASSESSMENT

A guide prepared for the Canadian Environmental Assessment Agency (CEAA) (Hegmann et al. 1999) defined cumulative effects as:

*"...changes to the environment that are caused by an action in combination with other past, present and future human actions."*

CEA is the process of systematically analysing and assessing cumulative environmental change. The purpose of CEA is to ensure that the full range of consequences of actions is considered.

According to the Council on Environmental Quality (1997) cumulative effects occur when:

* Impacts on the environment take place so frequently in time or so densely in space that the effects of individual impacts cannot be assimilated; or
* The impacts of one activity combine with those of another in a synergistic manner.

Cumulative impacts can occur over different temporal and spatial scales by interacting, combining and compounding so that the overall effect often exceeds the simple sum of previous effects.

The spatial scale can be local, regional or global, whilst the frequency or temporal scale includes past, present and future impacts on a specific environment or region. Cumulative effects can simply be defined as the total impact that a series of developments, either present, past or future, will have on the environment within a specific region over a particular period of time.

Eccles et al. (1994) summarises the essence of cumulative environmental change as follows:

*"Where the intensity of development remains low, the impacts can be assimilated by the environment over time, and cumulative effects do not become a significant issue. However, when development reaches a high level of intensity, impacts cannot be assimilated rapidly enough by the environment to prevent an incremental build-up of these impacts over time. Changes over time and space accumulate and compound so that in aggregate the effect exceeds the simple sum of previous changes. This temporal and spatial accumulation gradually alters the structure and functioning of environmental systems, and subsequently affects human activities."*

Examples of the different types of cumulative effects and the associated characteristics are described in Table 1.

The aim of CEA is to avoid what has been described by Odum (1982) as the "tyranny of small decisions". CEA also aims to address the total impact on the environment by highlighting externalities that affect public goods or resources. Hardin (1968) referred to this as the "tragedy of the commons".

The concept of cumulative effects has existed in legislation and guidelines since the global inception of environmental assessments systems in the 1970s. Table 2 sets out the main principles of assessing CEA.

*Table 1: Types and characteristics of cumulative effects (adapted from the Council on Environmental Quality, 1997).*

| Type | Characteristic | Example |
|---|---|---|
| Time crowding | Frequent and repetitive effects. | Forest harvesting rate exceeds regrowth. |
| Time lags | Delayed effects. | Bioaccumulation of mercury. |
| Space crowding | High spatial density of effects. | Pollution discharge into stream from non-point sources. |
| Cross-boundary | Effects occur away from the source. | Atmospheric pollution and acid rain. |
| Fragmentation | Change in landscape pattern. | Fragmentation of indigenous habitats. |
| Compounding effects. | Effects arising from multiple sources or pathways. | Synergism amongst pesticides. |
| Indirect effects | Secondary effects. | Developments following construction of new highway. |
| Triggers and thresholds | Fundamental changes in system functioning and structure. | Climatic change |

*Table 2: Principles of cumulative effects assessment (adapted from the Council on Environmental Quality, 1997).*

| |
|---|
| *Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions*<br>The effects of a proposed action on a given resource include the present and future effects added to the effects that have taken place in the past. If an environment is already degraded the effects of new plans or programmes on this environment may be more serious. Consideration of quality of the environment before the project, plan or programme is implemented is vital to predict what the quality of the environment will be after the project, plan or programme is implemented. |
| *Cumulative effects are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who has taken the action*<br>Individual effects from disparate activities may add up to or interact to cause additional effects not apparent when looking at the individual effects one at a time. The practicalities of this are complicated in terms of whose responsibility the assessment is. |
| *It is not practical to analyse the cumulative effects of an action on every environmental receptor, the list of environmental effects must focus on those that are truly meaningful*<br>For cumulative effects analysis to help the decision-maker and inform interested parties, it must be limited to effects that can be evaluated meaningfully. Boundaries must be set so analysts are not attempting to measure effects on everything. The significant effects of the action should be chosen through careful scoping. |
| *Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries*<br>Cumulative effects analysis on natural systems must use natural ecological boundaries and analysis of human communities must use actual socio-cultural boundaries to ensure all effects are included. Analysis of effects cannot stop at an administrative boundary. However, this causes problems with mitigation and monitoring of effects if the plan / programme makers have no jurisdiction to implement mitigation outside of their administrative area. |
| *Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects*<br>Repeated actions may cause effects to build up through simple addition (more and more of the same type of effect), and the same or different actions may produce effects that interact to produce cumulative effects greater than the sum of the effects. |
| *Cumulative effects may last for years beyond the life of the action that caused the effects*<br>Some actions cause damage lasting far longer than the life of the action itself (e.g., acid mine drainage, radioactive waste contamination, species extinction). Cumulative effects analysis needs to apply the best science and forecasting techniques to assess potential catastrophic consequences in the future. |
| *Each affected resource, ecosystem, and human community must be analysed in terms of its capacity to accommodate additional effects, based on its own time and space parameters*<br>Analysts tend to think in terms of how the resource, ecosystem, and human community will be modified given the actions development needs. The most effective cumulative effects analysis focuses on what is needed to ensure long-term productivity or sustainability of the resource. |

Stakhiv (1988) suggests that CEA reflects an assessment philosophy, by encompassing not only the consequences of actions, but also the causes, as well as possible management interventions. CEA needs to contend with the difficulty of balancing social needs and biophysical constraints within an incomplete and limited knowledge environment.

The study of possible cumulative effects is necessary in order to determine whether changes have been set in motion that are detrimental to the long-term health of the environment and the people who rely on it. In addition, such a study would assess the severity of the expected changes, possible policy responses and the implication of future development.

There are two ways in which cumulative effects can be assessed. These are:

* The application of CEA as an independent and stand-alone process; or
* the assessment of cumulative effects could be incorporated as part of existing environmental assessments (e.g. as part of the EIA or SEA process).

This first method of applying CEA as a stand alone approach is not the ideal manner of addressing cumulative effects within a developing country context. This is because of the realities of limited resources and capacity. It would be preferable to assess cumulative effects within existing tools (such as the EIA and SEA processes) where support and capacity already exist. An emerging approach within the South African context is to address cumulative effects within the SEA framework. The South African SEA Guideline document (DEAT and CSIR, 2000) mentions the improved consideration of cumulative effects as one of the main benefits of SEA. Concepts such as “limits of acceptable change”, “thresholds of significance” and “assimilative capacity” are inherent in this approach”. If this is used as a framework to guide decisions, the consideration of cumulative effects then becomes explicit.

A common reason given to explain the lack of attention to cumulative effects is the absence of appropriate methods (Canter, 1999). However, numerous existing methods can be adapted and modified to address cumulative effects (Table 3).

*Table 3: Selection of methods that can be used to identify and assess cumulative effects (adapted from Sadler and Verheem, 1996; Council on Environmental Quality, 1997; Canter, 1999)*

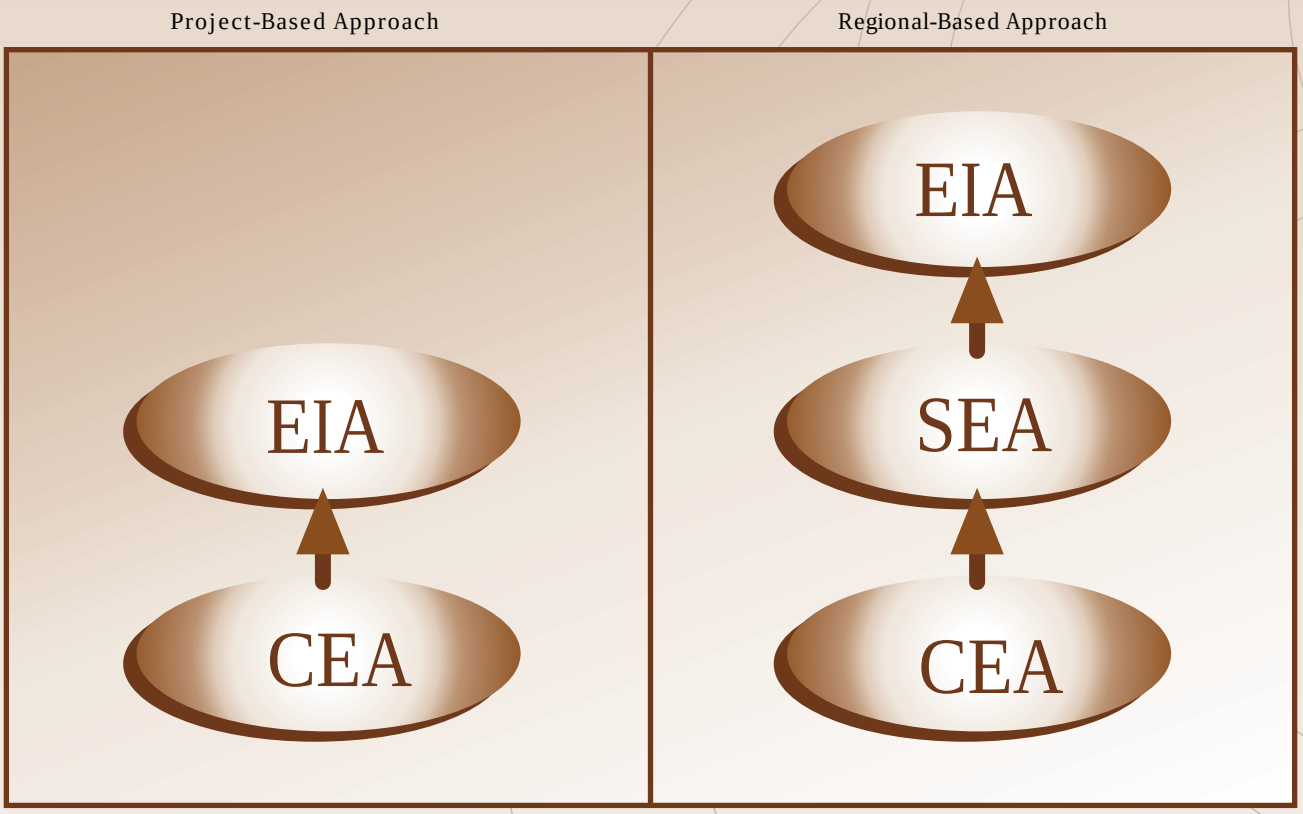
| Method | Comment |
|---|---|
| Geographic Information Systems (GIS) | Powerful mapping and spatial information computer tool for capturing, displaying and analysing digital data. Map overlays can be used to identify areas where effects are likely to be greatest. |
| Network analysis | Networks and system diagrams are useful for mapping and identifying cause-and-effect relationships, which result in cumulative effects. |
| Bio-geographical analysis | Landscape analysis, which emphasise pattern, structure and ecological process within a defined spatial unit. |
| Interactive matrices | Analysis of the additive and interactive effects of various configurations of multiple projects. |
| Ecological modelling | Computer modelling of ecosystems for which the structure and processes are fairly well understood. |
| Land suitability evaluation | Planning tool to evaluate environmental quality of land and establish thresholds for land use. |
| Questionnaires | Interviews with knowledgeable individuals are used to gather information on cumulative effects. |
| Checklists | Potential cumulative impacts can be identified by using a list of common or likely effects. |
| Trend analysis | Identifies historical, current and future trends for a resource. |
| Carrying capacity analysis | Identifies thresholds as constraints to development. In the ecological context, carrying capacity is defined as the threshold below which ecosystem functions can be sustained. |

## 4. INCORPORATING CUMULATIVE EFFECTS ASSESSMENT INTO EIA AND SEA

It is desirable to assess cumulative effects within the EIA process because project specific EIAs can then be placed into a broader spatial and temporal perspective. Lawrence (1994) and Sadler and Verheem (1996) believe that the scope of SEA is more appropriate to the time and space scales at which cumulative effects are expressed.

It is important to make the distinction between *project-based approaches* to the assessment and management of cumulative effects, as opposed to *regional-based approaches* (see Figure 1 below).

*Figure 1: Different approaches for assessing cumulative effects. (adapted from Dubé, 2003).*




The first approach would be to incorporate the assessment of cumulative effects into the EIA process. The second approach assesses cumulative effects as part of the SEA process, and then uses the outcomes of this process to inform future EIA process.

The SEA approach offers opportunities to address cumulative effects at the strategic level. The regional based approach is closely linked to concepts of 'limits of acceptable change' and 'thresholds of significance', which appear to be strongly emerging tools in SEA.

### *4.1 Addressing cumulative effects in EIA*

In response to the shortcomings of EIA, the scientific basis and institutional context of EIA has shifted internationally to incorporate considerations of cumulative effects (Canter, 1999). Analytical shifts include expanding spatial boundaries, extension of existing methods for assessment and monitoring of cumulative effects. Administrative shifts include the regulatory need to explicitly address cumulative effects in EIA.

These shifts and expansion of EIA have been adopted in countries like the United States and Canada (Droiun and Leblanc, 1994). Views differ as to whether these shifts or adaptations in EIA are sufficient to identify and assess cumulative effects. One perception is that these adaptations represent the maturing of EIA. This may require occasional scientific or institutional adjustments, but the conceptual and methodological bases are not considered to have developed sufficiently to address cumulative effects. Canter and Sadler (1997) describe a three step process for addressing cumulative effects in EIA:

* delineating potential sources of cumulative change;
* identifying the pathways of possible change (direct, indirect, nonlinear or synergistic processes); and
* classification of resultant cumulative changes.

South African research revealed that cumulative affects are not well addressed in EIAs (CSIR, 1998). The general feeling among South African practitioners is that cumulative impacts are not adequately determined or characterised. Many practitioners feel that they are restricted by the terms of reference for the site-specific project. Terms of reference to specialist scientists did

not explicitly communicate the importance of "thinking cumulatively". Other reasons why cumulative effects assessments are not adequately incorporated in EIAs include:

* the inability of EIA regulations to provide clarity on the criteria for identifying and assessing cumulative effects;
* the difficulty to conceptualise cause-and-effect relationships;
* data deficiencies make it difficult to conduct a reasonable assessment of secondary and further impacts;
* individual project proponents do not consider addressing cumulative impacts as their concern;
* spatial and temporal boundaries are not adequately defined; and
* EIAs have a site-specific focus.

According to the Council on Environmental Quality (1997) conceptual frameworks for addressing cumulative effects typically include the following three elements:

* a cause or source of change;
* the process of change as reflected by the relevant system structure and processes; and
* the result of change (or effect).

The source of change, refer to naturally occurring events, or human-induced actions, which occur over time and space and contribute to cumulative environmental change. The system structure and processes include the ecological, economic and social systems, which are affected by spatial and temporal processes. Lastly, the results of such change means that there will be an effect on a system's structure and function over time and space.

The Council on Environmental Quality (1997) identified eleven steps (see Table 4) that can be followed in accordance with the three main components of the EIA process, namely:

* the scoping phase,
* describing the affected environment, and
* determining the environmental consequences.

*Table 4: Summary of steps to be addressed in evaluating cumulative effects in the EIA process (Council on Environmental Quality, 1997; Canter and Sadler, 1997).*

| EIA Components | CEA Steps |
|---|---|
| Scoping | 1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.<br>2. Establish the geographic scope for the analysis.<br>3. Establish the time frame for the analysis<br>4. Identify other actions affecting the resources, ecosystems, and human communities of concern. |
| Describing the affected environment | 5. Characterise the resources, ecosystems, and human communities identified in scoping in terms of their response to changes and capacity to withstand stresses.<br>6. Characterise the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds.<br>7. Develop baseline conditions for the resources, ecosystems, and human communities. |
| Determining the environmental consequences | 8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.<br>9. Determine the magnitude and significance of cumulative effects.<br>10. Modify and add alternatives to avoid, minimise, or mitigate significant cumulative effects.<br>11. Monitor the cumulative effects of the selected alternative and adapt management |

Scoping for cumulative effects

Scoping is the first of the three broad phases of the EIA process. The purpose of the scoping phase for cumulative effects is to determine:

* whether the resources, ecosystems, and human communities of concern have already been affected by past or present activities; and
* whether other agencies or public have plans that may affect the resources in the future.

Incorporating criteria for addressing cumulative effects in the scoping phase are described in steps 1 – 4 below.

Step 1: Identify significant cumulative effects issues

Identify significant cumulative effects issues (resource-stress linkages) associated with a proposed action and define the assessment goals. The method of identifying the major cumulative effects issues of a project involves defining the following:

* the direct and indirect effects of the proposed action;

* which resources, ecosystems, and human communities, are affected; and
* what effects on these resources are important from a cumulative effects perspective.

The role of the environmental practitioner is to narrow the focus of cumulative effects analysis to important issues of national, regional, or local significance. This narrowing can only occur after thorough scoping. The practitioner should ask basic questions such as whether the proposed action will have effects similar to other actions in the area and whether the resources have been historically affected by cumulative actions.

The following key questions provide a generic list for determining what type of cumulative effect could be occurring within a study area.

i. Is the proposed action one of several similar past, present or future actions in the same geographic area?
ii. Do other activities (whether state or private) in the region have environmental effects similar to those of the proposed action?
iii. Will the proposed action (in combination with other planned activities) affect any natural resources, cultural resources, socio or economic units, or ecosystems of local, regional or national concern?
iv. Have any recent environmental studies of similar actions identified important adverse or beneficial cumulative effects issues?
v. Has the impact been historically significant, such that the importance of the resource is defined by past loss, gain or investments to restore resources?
vi. Does the proposed action involve any of the following?
    * Long range transport of air pollution;
    * Air emissions resulting in the degradation of regional air quality;
    * Loading large water bodies with discharges of sediment, thermal or toxic pollutants;
    * Contamination of ground water supplies;
    * Changes in hydrological regimes of major rivers and estuaries;
    * Long-term disposal of hazardous wastes;
    * Mobilisation of persistent bioaccumulated substances through the food chain;
    * Decreases in quantity and quality of soils;
    * Loss of natural habitats or historic character through residential, commercial and industrial development;
    * Social, economic or cultural effects on marginalised communities resulting from ongoing development; and
    * Loss of biological diversity.

Step 2: Establish the geographical scope for the analysis

Analysing cumulative effects differs from the traditional EIA approach in that there is a need to expand the geographic boundary and extend the time frame to encompass additional effects. Cumulative effects studies should be conducted at the scale of human communities, landscapes, catchments or airsheds. When identifying potential cumulative effects issues related to a proposed action, it is important to consider the value of the affected resource. Is it:

* protected by legislation or planning goals?
* ecologically important?
* culturally important?
* economically important?
* important to the well-being of a human community?

Key points to address would be to:

* determine the area that will be affected by the proposed action (i.e. the project impact zone);
* make a list of resources within that zone that could be affected by the proposed action; and
* determine geographic areas occupied by those resources outside of the project impact zone.

Geographic boundaries can generally be determined by establishing the distance an effect can travel.

Step 3: Establish the timeframe for the analysis

Cumulative effects is often defined as the incremental effect of the action when added to past, present and foreseeable future actions. The practitioner should determine the project timeframe and whether the predicted duration of the effects is sufficient for assessing the potential cumulative effects.

Step 4: Identify other actions affecting the resources or human communities of concern

Identifying past, present and future actions is critical to establishing the appropriate geographic and time boundaries. Information on past conditions are scarce, therefore the analysis of past effects is often qualitative. When identifying present actions, close co-operation is required with other agencies, government departments and private industries. Future plans must be obtained in order to determine what the possible future actions will be. The practitioner should develop a guideline as to what constitutes “reasonably foreseeable future actions” based on the planning process. Available

information should be used to develop scenarios that predict which future actions might reasonably be expected. Information on future development can be obtained from structure plans, local zoning requirements, water supply plans, economic development plans and various permitting records, which will help to identify reasonably foreseeable private actions. However, it is important that where speculative projections are made, assumptions should be explicitly described.

At the end of the scoping process, there should be a list of cumulative effects issues, a geographic boundary (spatial scale) and time frame (temporal scale) assigned for each key question.

### Describing the affected environment

Special attention needs to be paid to defining baseline conditions, as this provides the context for evaluating environmental consequences. This description of the affected environment provides a bridge between the identification, during scoping, of the cumulative effects that are likely to be important and the analysis of the magnitude and significance of these cumulative effects.

The description of the affected environment should contain the following types of information:

* data on the status of important natural, cultural, social and economic resources and systems;
* data that characterise important stress factors;
* a description of regulations, standards and development plans; and
* data on environmental and socio-economic trends.

### Step 5: Characterise baseline conditions.

Determining the status of the affected environment depends on obtaining data about the resources, ecosystems, and human communities.

Key issues identified during scoping must be reviewed in terms of the expanded geographic boundaries and time frames.

### Step 6: Characterise stresses affecting resources.

The next step in describing the affected environment is to compile data on stress factors pertaining to each resource. For each activity anticipated cumulative effects are identified for each resource. The primary locations of the expected effects are also listed and this information can then be used to summarise the overall net (adverse or beneficial) effect on the environment. Two types of information should be used to describe stress factors contributing to cumulative effects. Firstly the types, distribution and intensity of key social and economic activities within the region should be identified. Data on these socio-economic "driving variables" may identify cumulative effects problems in the project area. Secondly, individual indicators of stress on specific resources should be identified. Indicators of environmental stress can either be exposure-orientated (e.g. contamination levels) or effects-orientated (e.g. loss or degradation of soil resources). The goal of characterising stresses is to determine whether the resources are approaching conditions where additional stresses will have an important cumulative effect.

Government regulations and administrative standards (e.g. air and water quality guidelines) can play an important role in characterising the regional landscape. They often influence development activity and the resultant cumulative stress on resources.

### Step 7: Define a baseline condition for the resources

Cumulative effects occur through the accumulation of impacts over varying periods of time. For this reason, an understanding of the historical context of impacts is critical to assessing the direct, indirect and cumulative effects of proposed actions. Trend analysis can be used in three ways: (1) to establish the baseline for the affected environment more accurately (i.e. by incorporating variation over time); (2) to evaluate the significance of effects relative to historical degradation (i.e. by helping to estimate how close the resource is to a threshold of degradation); and (3) to predict the effects of the action (i.e. by using the model of cause-and-effect established by past actions). However, the ability to identify trends in conditions of resources or in human activities depends on available data. Remote sensing data is often a very valuable tool to use to collect recent historical data.

### Determining the environmental consequences of cumulative effects

Having determined the geographic extent and time frame for the project and gathered the appropriate data, the practitioner must then ensure that the issues identified during scoping encompass all those needed for an analysis of cumulative effects. The relevant past, present and reasonably foreseeable future actions also have to be identified. This is an iterative process. In addition to this process, the following steps (8-11) can be followed to determine the environmental consequences of the cumulative effects.

### Step 8: Identify important cause-effect relationships.

At this stage it is necessary to gather information about the cause and effect relationships between stresses and resources. In order to determine the consequences of a proposed action it is necessary to determine what cumulative environmental changes will result from the proposed action and other actions.

Using the information gathered to describe the affected environment, the factors that affect resources (i.e. the causes) can be identified and a conceptual cause–effect model developed. Network and systems diagrams (Figure 2) are the preferred methods of conceptualising cause-effect relationships, as these models can be developed without knowing precisely the response to environmental change (i.e. the mechanism of the cause-effect relationship). The complexity of the model depends on whether all the pathways are identified. The more complex models can seldom be fully analysed because of a lack of data to sufficiently quantify each pathway. Therefore, the models are simplified to include only important relationships that can be supported by data.

The cause-effect model can aid in the identification of past, present and future actions that should be considered in the analysis.

It should also be determined if there are other projects in the area that would affect any of the cause-effect pathways, and that would not have been included in the project specific analysis. Thus analysing the consequences of cumulative effects requires broader thinking about the interactions among different activities and resources that affect environmental change.

The cause-effect relationship for each resource is used to determine the magnitude of the cumulative effect resulting from all the actions included in the analysis. These relationships can be simple or complex. A wide variety of technical evaluation techniques are described in the literature e.g. habitat suitability index models, wetland evaluation technique etc. Nonlinear cause-effect relationships pose an additional challenge. Synergistic effects are even more complex to understand and explain. Trend analysis can be used to model the effects of linear facilities over time and extrapolate the effects of a project into the future. In many cases, these relationships cannot be quantified as the relationships are poorly understood, because of a lack of data.

Step 9: Determine the magnitude and significance of cumulative effects.

The primary goal is to determine the magnitude and significance of the effects of the proposed action in the context of other past, present and future actions. To accomplish this, a conceptual model of the important resources and their cause-effect relationships can be used. The critical element in this conceptual model is defining the appropriate baseline or threshold condition of the resource beyond which adverse or beneficial change would cause significant effects. The concept of a baseline against which to compare predictions of the effects of the proposed action and reasonable alternatives is critical to the process. The potential for the resource to sustain itself in the future must be determined. The baseline condition of the resource should include a description of how conditions have changed over time and how they are likely to change in the future without the proposed action. The potential for a resource to sustain its structure and function depends on its resistance to stress and its ability to recover. Determining whether the condition of the resource is within the range of natural variability or is vulnerable to rapid degradation is frequently problematic. Identifying a threshold beyond which change in a resource condition is detrimental is advised. This is achieved by reviewing the history of the resource and evaluating whether past degradation may place it near such a threshold. The baseline condition should also include other present (ongoing) actions.

When determining magnitude, the practitioner will usually determine the separate effects of past, present and future actions. Once each group of effects is determined, cumulative effects can be calculated. The cumulative effects on a specific resource, however, will not necessarily be the sum of the effects of all actions. Knowing how a particular resource responds to environmental change (i.e. the cause-effect relationship) is essential to determining the cumulative effect of multiple actions.

Once effects are identified, a table can be used to itemise effects into categories of past, present, proposed and future actions. Such tables are useful tools for putting the effects of the proposed action and alternatives into context.

A series of such tables for each alternative enables meaningful comparison of alternatives. The separation of effects into those attributable to the proposed action or reasonable alternatives versus those attributable to past and future actions allows for determining the incremental contribution of each alternative. Situations can arise where the incremental effect that exceeds the threshold of concern results, not from the proposed action, but from reasonably foreseeable but still uncertain future actions. The decision-maker is then faced with determining whether to forego or modify the proposed action or permit other future actions. Identifying incremental effects is an important part of informing the decision-maker. Most cumulative effects analyses will identify varying levels of beneficial or adverse effects depending on the resource and individual action.

Step 10: Develop mitigation measures.

The historical trends in resource condition and its potential for sustained structure and function are an essential frame of reference for developing mitigation measures.

Step 11: Monitor and evaluate the cumulative effects and adapt management.

Determining the full integrated consequences of cumulative effects involves the following actions:

* identify the key cause-and-effect relationships between human activities and resources using a network or systems diagram;
* adjust the geographic and time boundaries of the analysis based on cumulative cause-effect relationships;
* incorporate additional past, present and reasonably foreseeable actions into the analysis;
* determine the magnitude and significance of cumulative effects;
* determine cumulative effects of selected alternatives with mitigation and enhancement measures.

Explicitly address uncertainty in communicating predictions to decision-makers and the public, and reduce uncertainty as much as possible through monitoring and adaptive management.

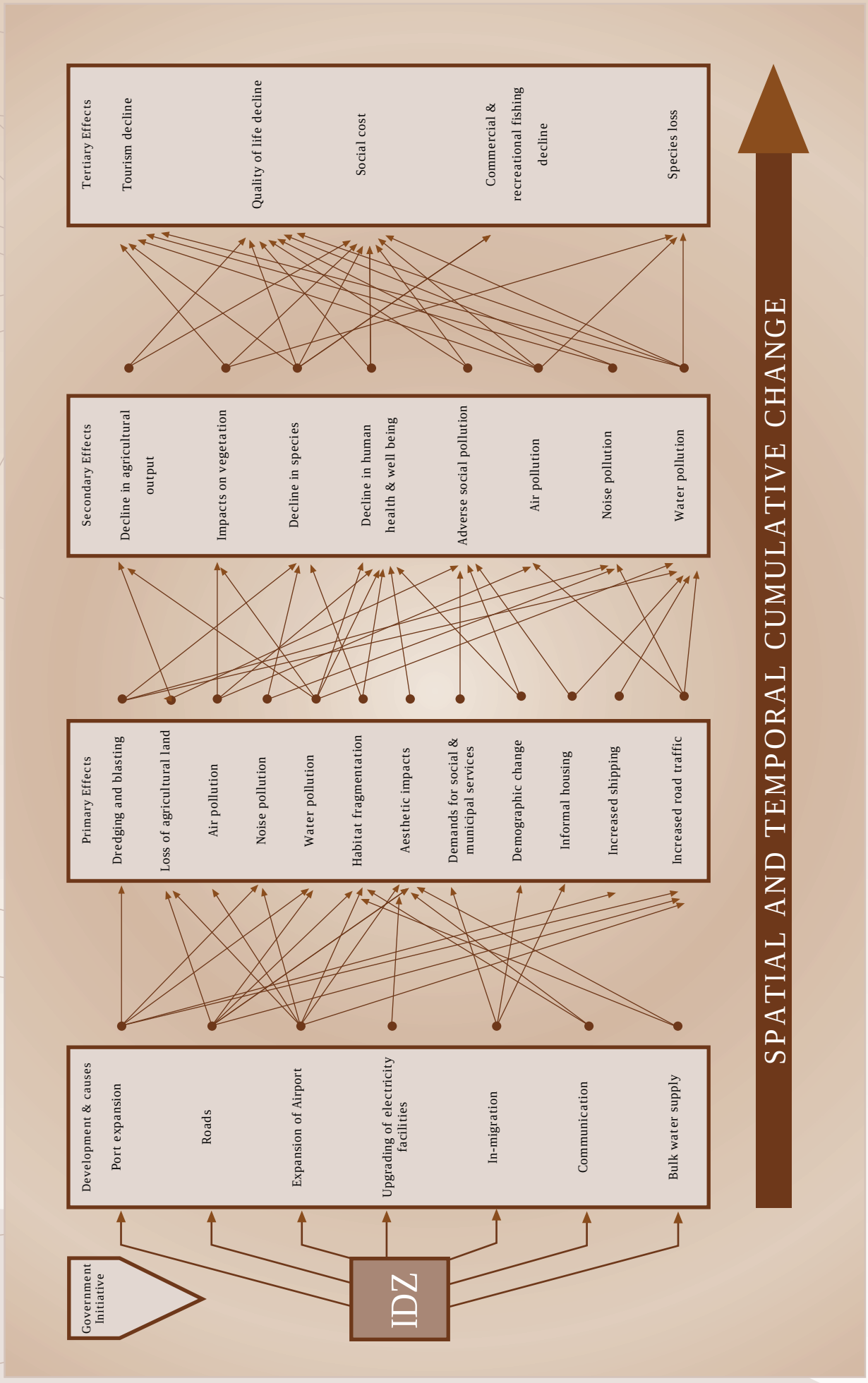



*Figure 2: Model of negative cumulative effects and linkages (Rossouw et al., 1997)*

*4.2 Addressing cumulative effects in SEA*

Cumulative effects are best considered at the policy, plan and programme level (Clarke, 1994). The temporal and geographical scales of analysis used at the project level are insufficient to comprehensively assess cumulative effects. There are numerous data, jurisdictional and methodological obstacles that inhibit CEA at the project level (Canter and Kamath, 1995).

SEA can facilitate the analysis of cumulative effects (Sadler, 1996; Court et al., 1994). Where policies, plans and programmes lead to projects and activities, SEA permits an early, overall look at their potential relationships and effects. Compared to EIA, the scope of SEA is more appropriate to the time and space scales at which cumulative effects are expressed. Addressing cumulative effects in SEA can serve as an early warning system, sign-posting further requirements for project specific EIA, environmental monitoring and other forms of review (Sadler, 1996).

The most common approach to evaluating cumulative effects involve analysing the collective impact of numerous probable development activities in a geographical area (regional assessments). Another approach involves the assessment of an entire programme of similar developments (sectoral assessments). These kinds of assessment fall within the SEA framework.

The information presented below has been sourced and summarised from a UK study on incorporating cumulative effects issues into SEA (TRL, 2003).

It is helpful to distinguish between different types of plans and programmes as the contribution of an assessment of cumulative effects will differ according to the plan or programme type. Fry et al (2002) identified three types of elements that can characterise plans or programmes. These are:

Policy-orientated – overarching plan for considering proposals that are not location-specific;
Area-wide plans (regional) - broad characterisation of the entire study area to consider location-specific proposals within a wide geographic extent (e.g. Tourism plans);
Specific Zones (sectoral) – where more detailed assessment may be required to consider local proposals (e.g. industrial development zones (IDZ), corridors within local transport plans).

In practice, most plans and programmes tend to be a combination of these different elements. The exact form an assessment of cumulative effects will take for different plans or programmes is likely to be different for each type of plan or programme.

Screening

Screening involves determining whether there is a requirement to undertake an SEA of a plan or programme and whether the assessment of cumulative effects is required as a part of this. Where certain plans or programmes are likely to give rise to significant effects then they are to be subject to a SEA. Such effects should include consideration of their cumulative effects. The cumulative nature of effects becomes important as this is one criteria that can be used to judge their significance and whether the plan or programme should be subject to the requirements of a SEA.

Scoping

Scoping has two purposes. Firstly it helps identify appropriate boundaries and issues of concern on which to focus an assessment. Secondly it ensures that data collection and assessment is limited to only the key issues (Kingsley, 1997). The key activities identified by Davies (1996) and Kingsley (1997) to be carried out as part of scoping in SEA are described below:

*1. Identification of potential issues and problems*
Kingsley (1997) suggests that identifying potential cumulative impacts of plans and programmes requires taking account of the dynamics and the current state of a natural system. Canter and Kamath (1995) propose a questionnaire checklist for identifying which issues are important and documenting how they are selected forfurther technical analysis. It is important within an assessment of cumulative effects to identify problems in terms of those environmental components that are in decline and are near to their threshold.

*2. Selection of valued environmental and community resources and future objectives*
An examination of cumulative impacts requires the considerations of impacts on both valued environment and community resources. It is not possible to assess the plan or programme's impact on every receptor. Therefore, it is necessary to define those resources that are particularly valued by the community or vital to the healthy functioning of the environment. The SEA process may develop sustainability objectives. The choice of objectives used in assessing cumulative effects will depend on whether locally defined objectives exist.

*3. Establish spatial boundaries*
The setting of spatial boundaries involves finding a balance between data availability, and the need to address effects that could extend for considerable distances away. Establishing spatial boundaries includes both an examination of the effects resulting from the plan or programme and spatial boundaries of the valued resources.

*4. Establish temporal boundaries*
Cumulative effects need to be considered in terms of a specified time period. How far back in time and how far ahead in time the assessment considers is dependent upon the specific environmental and community resource. Different actions within a plan or programme may be implemented over different time scales. This needs to be addressed within scoping whilst recognising that uncertainties increase with projections further into the future.

*5. Identification of past, present and reasonably foreseeable future actions*
To identify cumulative effects, there is a need to consider the state of the environment, past and likely future environmental trends. Identifying past, present and

future activities can often be difficult, as empirical evidence can be difficult to obtain. The classification of future actions can be considered in the following ways:

*Hypothetically:* There is a considerable uncertainty whether the action will ever proceed;
*Reasonably foreseeable:* The action may proceed but there is some uncertainty;
*Certain:* The action will proceed or there is a high probability the action will proceed.

The selection of the most appropriate analysis tools can be based on consideration of the following:

* ability to organise, analyse and present information;
* stage of the assessment (e.g. scoping, baseline data collection, analysis, reporting);
* types of issues;
* types of disturbances and effects;
* types of valued resources being examined;
* quality and extent of baseline data;
* level of expertise available; and
* resources available to meet the needs of decision-makers.

Uncertainty in predicting effects and determining significance can arise because of the variation in natural systems, lack of information regarding cause-effect relationships, or the inability of predictive models to accurately represent complex systems. However, the level of risk and uncertainty associated with cumulative effects increases at the planning level because, scales are broader and issues are more complex.

Mitigation and continual improvement

Mitigation is difficult for assessing cumulative effects, especially if the assessment addresses past, present and future plans or programmes of other organisations or national or provincial departments. In this situation there may be an absence of clear and precise allocation of responsibilities regarding the implementation of mitigation and monitoring measures. It is also probable that some mitigation measures may only be capable of being delivered by parties other than the proponent of the plan or programme. Several administrative jurisdictions and stakeholders may have to co-operate to ensure that the mitigation or enhancement measure is successfully implemented.

Monitoring of Cumulative Effects

Monitoring helps to ensure that impact predictions are checked and that mitigation methods are implemented. At this stage, monitoring should focus on the effects of the implementation of plans and programmes to identify unforeseen effects at an early stage and to be able to undertake appropriate remedial action. Monitoring should be carried out using the indicators that the plan or programme was measured against and that this should take account of cumulative effects as well as direct effects. However, some of the difficulties to overcome in this regard are that an in depth knowledge of cause and effect pathways is required in order to determine the elements of the plan or programme that are having an undesirable effect. The plan or programme may also be operating against a background of general environmental degradation or may be producing unforeseen interactions with other plans and programmes (both key issues in CEA). Therefore, it is difficult to separate out the effects of one plan or programme with another and the effects of background environmental trends.

Key components of a monitoring programme should include the objective or target set out in the SEA. Key components for monitoring cumulative effects include the use of measurable indicators of the magnitude and direction of change; appropriate temporal and spatial scales; appropriate measurement methods; and cost effectiveness.

Reporting and Consultation

A consistent, specified format for assessing cumulative effects should be used. The reporting of the assessment of cumulative effects should provide a traceable record of the identification and management of these effects, in a form suitable for distribution to stakeholders. Criteria for reporting cumulative effects include:

* describing various forms of cumulative effects and identifing those that are most likely to occur in the plan or programme;
* identifing various limitations such as inadequacy of available data, non-availability of proven methods and other limiting factors;
* describing in sufficient detail selected impact prediction methods and the proposed mitigation and monitoring measures;
    * presenting and justifying the criteria used for determining the relative significance of the cumulative effects upon valued resources;
    * reporting linkages between the bio-physical and socio-economic systems; and
    * describing appropriate mitigation measures and plans for monitoring.

## 5. CONCLUSIONS

There are still a number of scientific challenges inherent in cumulative effects identification, prediction and evaluation. For many environments the scientific understanding of the pathways by which impacts are manifested are extremely limited. The processes for the transfer of impacts are poorly understood. These issues pose limitations in analysing cumulative effects.

Another issue relates to the institutional co-ordination, and statutory requirements for the assessment of cumulative effects. The assessment of cumulative effects should be integrated into existing legislation and processes, in order to enhance current practice. The use of evaluation criteria for cumulative effects could provide a useful framework for integration into EIA and SEA processes.

The assessment of cumulative environmental effects is essential to support sustainable development. There are a myriad of complex interactions and processes in the natural, social and economic environments, which must be considered when evaluating cumulative impacts. CEA is only possible as long as the objectives are modest, the science robust and defendable and uncertainty levels specified.

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## 7. GLOSSARY

Definitions

*Affected environment*
Those parts of the socio-economic and biophysical environment impacted on by the development.

*Affected public*
Groups, organizations, and/or individuals who believe that an action might affect them.

*Alternative proposal*
A possible course of action, in place of another, that would meet the same purpose and need. Alternative proposals can refer to any of the following but are not necessarily limited thereto:
* alternative sites for development
* alternative projects for a particular site
* alternative site layouts
* alternative designs
* alternative processes
* alternative materials

In IEM the so-called "no-go" alternative also requires investigation.

*Authorities*
The national, provincial or local authorities, which have a decision-making role or interest in the proposal or activity. The term includes the lead authority as well as other authorities.

*Baseline*
Conditions that currently exist. Also called "existing conditions."

*Baseline information*
Information derived from data which:
* Records the existing elements and trends in the environment; and
* Records the characteristics of a given project proposal

*Decision-maker*
The person(s) entrusted with the responsibility for allocating resources or granting approval to a proposal.

*Decision-making*
The sequence of steps, actions or procedures that result in decisions, at any stage of a proposal.

*Environment*
The surroundings within which humans exist and that are made up of -
i. the land, water and atmosphere of the earth;
ii. micro-organisms, plant and animal life;
iii. any part or combination of (i) and (ii) and the interrelationships among and between them; and
iv. the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being. This includes the economic, cultural, historical, and political circumstances, conditions and objects that affect the existence and development of an individual, organism or group.

*Environmental Assessment (EA)*
The generic term for all forms of environmental assessment for projects, plans, programmes or policies. This includes methods/tools such as EIA, strategic environmental assessment, sustainability assessment and risk assessment.

*Environmental consultant*
Individuals or firms who act in an independent and unbiased manner to provide information for decision-making.

*Environmental Impact Assessment (EIA)*
A public process, which is used to identify, predict and assess the potential environmental impacts of a proposed project on the environment. The EIA is used to inform decision-making.

*Fatal flaw*
Any problem, issue or conflict (real or perceived) that could result in proposals being rejected or stopped.

*Impact*
The positive or negative effects on human well-being and/or on the environment.

*Integrated Environmental Management (IEM)*
A philosophy which prescribes a code of practice for ensuring that environmental considerations are fully integrated into all stages of the development and decision-making process. The IEM philosophy (and principles) is interpreted as applying to the planning, assessment, implementation and management of any proposal (project, plan, programme or policy) or activity - at the local, national and international level - that has a potentially significant effect on the environment. Implementation of this philosophy relies on the selection and application of appropriate tools to a particular proposal or activity. These may include environmental assessment tools (such as Strategic Environmental Assessment and Risk Assessment); environmental management tools (such as monitoring, auditing and reporting) and decision-making tools (such as multi-criteria decision-support systems or advisory councils).

*Interested and affected parties (I&APs)*
Individuals, communities or groups, other than the proponent or the authorities, whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. These may include local communities, investors, business associations, trade unions, customers, consumers and environmental interest groups. The principle that environmental consultants and stakeholder engagement practitioners should be independent and unbiased excludes these groups from being considered stakeholders.

*Lead authority*
The environmental authority at the national, provincial or local level entrusted in terms of legislation, with the responsibility for granting approval to a proposal or allocating resources and for directing or coordinating the assessment of a proposal that affects a number of authorities.

*Mitigate*
The implementation of practical measures to reduce adverse impacts.

*Non-governmental organizations (NGOs)*
Voluntary environmental, social, labour or community organisations, charities or pressure groups.

*Proponent*
Any individual, government department, authority, industry or association proposing an activity (e.g. project, programme or policy).

*Proposal*
The development of a project, plan, programme or policy. Proposals can refer to new initiatives or extensions and revisions to existing ones.

*Public*
Ordinary citizens who have diverse cultural, educational, political and socio-economic characteristics. The public is not a homogeneous and unified group of people with a set of agreed common interests and aims. There is no single public. There are a number of publics, some of whom may emerge at any time during the process depending on their particular concerns and the issues involved.

*Role-players*
The stakeholders who play a role in the environmental decision-making process. This role is determined by the level of engagement and the objectives set at the outset of the process.

*Scoping*
The process of determining the spatial and temporal boundaries (i.e. extent) and key issues to be addressed in an environmental assessment. The main purpose of scoping is to focus the environmental assessment on a manageable number of important questions. Scoping should also ensure that only significant issues and reasonable alternatives are examined.

*Screening*
A decision-making process to determine whether or not a development proposal requires environmental assessment, and if so, what level of assessment is appropriate. Screening is initiated during the early stages of the development of a proposal.

*Significant/significance*
Significance can be differentiated into impact magnitude and impact significance. Impact magnitude is the measurable change (i.e. intensity, duration and likelihood). Impact significance is the value placed on the change by different affected parties (i.e. level of significance and acceptability). It is an anthropocentric concept, which makes use of value judgements and science-based criteria (i.e. biophysical, social and economic). Such judgement reflects the political reality of impact assessment in which significance is translated into public acceptability of impacts.

*Stakeholders*

A sub-group of the public whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. The term therefore includes the proponent, authorities (both the lead authority and other authorities) and all interested and affected parties (I&APs). The principle that environmental consultants and stakeholder engagement practitioners should be independent and unbiased excludes these groups from being considered stakeholders.

*Stakeholder engagement*

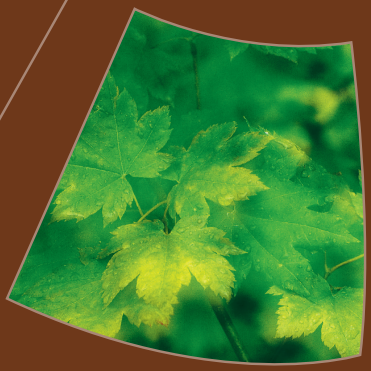
The process of engagement between stakeholders (the proponent, authorities and I&APs) during the planning, assessment, implementation and/or management of proposals or activities. The level of stakeholder engagement varies depending on the nature of the proposal or activity as well as the level of commitment by stakeholders to the process. Stakeholder engagement can therefore be described by a spectrum or continuum of increasing levels of engagement in the decision-making process. The term is considered to be more appropriate than the term "public participation".

*Stakeholder engagement practitioner*

Individuals or firms whose role it is to act as independent, objective facilitators, mediators, conciliators or arbitrators in the stakeholder engagement process. The principle of independence and objectivity excludes stakeholder engagement practitioners from being considered stakeholders.

## *ABBREVIATIONS*

| | |
|---|---|
| CBO | Community-based Organization |
| EA | Environmental Assessment |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Management Plan |
| EMS | Environmental Management Systems |
| I&AP | Interested and Affected Party |
| IEM | Integrated Environmental Management |
| NGO | Non-governmental Organization |
| SEA | Strategic Environmental Assessment |



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**Department of**
**Environmental Affairs and Tourism**

Private Bag X447, Pretoria, 0001, South Africa, www.deat.gov.za