Resilience Assessment: International Best Practice Principles

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International Best Practice Principles

Resilience Assessment

PURPOSE
This document sets out international best-practice principles for resilience assessment being undertaken within an impact assessment (IA) of some project, plan, program, or policy (in this context, its function may be different to that of a self-standing resilience assessment). Resilience assessment can contribute to impact assessment by defining specific disturbances that can lead to failure of natural, social, and engineered systems. The disturbance can be caused either by the proposed action, factors beyond the influence of proposed action, or combination of both. The resilience assessment can consider all these factors within one coherent framework. It can identify synergies and knock-on effects that can cause potential system failures, and advise on interventions that avoid failures in the critical functions of the system.

BACKGROUND
Resilience assessment evaluates the structure and function of a system of focus (hereafter "focal system") and, in the context of an impact assessment, addresses the effects of the proposed action on the resilience of that focal system. The focal system can include: socio-ecological, biophysical, engineering, technological, or other components. Resilience assessment should ideally examine the consequences of the proposed action in combination with internal or external factors that may collectively influence the resilience of the focal system (e.g., biophysical system change caused by global warming on engineered structures).

Resilience is a cross-cutting theme relevant to all fields of impact assessment. Where applicable, these principles should therefore be used in conjunction with other principles of best practice provided by IAIA (https:// www.iaia.org/best-practice.php). The IAIA Resilience Assessment International Best Practice Principles were drafted by the authors listed below under the guiding hand of the Emerging Technology Section of IAIA.

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Introduction

The resilience of any complex system is its "ability to withstand a disturbance or recover from disturbance without significant deterioration of its structure or functions." Resilience is a fundamental property of the viability and function of a system, i.e., its ability to recover from disturbances without fundamental change. Resilience assessment determines the extent to which this capability exists within a system, the thresholds of specific disturbances for maintaining functions, and, in the context of impact assessment, the extent to which this ability of the focal system can be undermined or strengthened by the proposed action (which could change the structure or function the focal system).

Aspects of a resilience assessment that need to be considered prior to application of the best practice principles include:

a) For the focal system being subjected to resilience assessment there is a need to consider larger and smaller scales. This includes considering the focal system as a component part of another larger system (functioning at higher spatial or temporal scales) beyond its boundaries. It also includes considering smaller systems (at lower spatial or temporal scales) contained within the system being assessed. These need to be defined and described as background to any consideration of resilience.

b) A resilience assessment must consider baseline conditions, ongoing trends, and the desired state of the system resilience.

c) A resilience assessment examines how the functioning of a system responds to the existing and expected disturbances (and risks of disturbances) and their potential synergies with the changes caused by the proposed action. This involves identifying potential failure pathways due to disturbances, the critical variables defining these pathways, and the thresholds of these critical variables in relation to system failure.

d) A resilience assessment could identify changes that could enhance or threaten the resilience of a focal system.

e) If a focal system changes in response to a disturbance so that its structure or functional performance fundamentally changes, it essentially becomes a new system—and the resilience of the new system may need to be evaluated separately.

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The need for resilience assessment within impact assessment

Existing forms of assessment have a different focus or approach that do not address the functions of the system and the inter-relationships between the system's components. For example, Risk Assessment considers the "probability" of adverse effects and their seriousness, and ranks these. Technology Assessment focuses on the potential sensitivity of technology systems to external influences and enhancing the adaptive capacity of those systems to cope with unexpected situations. Impact Assessment processes typically examine change from the perspective of significance and equity but not resilience. Therefore, Impact Assessment could potentially underpin trade-off decisions that ultimately lead to the exceedance of resilience thresholds of a system.

Resilience assessment focuses on the potential exceedance of thresholds that may cause some level of system failure that may have far-reaching consequences (also known as domino effects or cascading failures). A resilience assessment can identify the causes of potential changes or failures in the system's structure or functional performance and describe and evaluate those changes. The resilience assessment should contribute to the development of mitigation and enhancement measures by identifying possible interventions that would maintain the desired system structure and functions, through reducing system vulnerability and/or enhancing its adaptive capacity.

Resilience assessment best practice: key international principles

a) **The focal system whose resilience is being assessed must be described in detail.** The description should include the actual and (where appropriate) intended structure and function of the system. The description should also identify the components of the system and, particularly, the system's vulnerability and adaptive capacity, the adaptive agents that are within the system scope, and hence the system capability to prevent or withstand the disturbance and recover from it.

b) **The boundaries for resilience assessment need to be clearly defined.** The boundaries should cover the potential for cascading effects to scales above and below the system that is the focus of the assessment.

c) **The objectives of the resilience assessment should be explicit.** These should include *what* the focus is, *where* the focal system is located (including boundaries), the time periods (*when*) considered in the resilience assessment, for *whom* the resilience matters, and *why* the assessment is needed (i.e., the possible consequences). Different methodologies will apply depending on the answers to these questions.

d) **The resilience assessment methodology should be clearly explained.** The methodology should be focused on delivering the objectives of the resilience assessment. The methodology should cover the system dynamics within the focal system. This includes the structure and function, mechanisms for change, connectedness, and thresholds that can trigger transition to alternative states.

e) **Significant assumptions about system structure and functions should be stated.** Assessment findings will be contingent on implicit and/or explicit assumptions. Therefore, these need to be very clearly stated given that the decisions will differ when based on a different set of assumptions.

f) **The connectedness of interconnected/nested systems should be described.** The number of connections between different components of the system defines the connectedness of elements within a system. Resilience varies with connectedness. Systems within which all or most of the components are connected to each other are vulnerable to shocks that can be rapidly transmitted across the whole system. Subsystem interdependencies should be identified, and it must be acknowledged that many complex systems are nested and interconnected at smaller and larger scales.

g) **Evaluations of the significance of changes to the focal system state involve comparisons of critical variables with system thresholds to potential system failure pathways.** The aim should be to identify as many failure pathways as possible, not just disturbances directly attributed to the proposed action. For all systems, this analysis can be extended to assessments of a system's vulnerability and adaptive capacity, and tolerable ranges for critical variables.

h) **The consequences of critical variables exceeding system thresholds should be defined.** This explains what happens if the proposed action exceeds a system threshold—which could be far greater than the significance of the environmental, economic, or social impacts identified in an impact assessment. The alternative states that could result, once the threshold has been exceeded, should be described.

i) **The levels of adaptive capacity within the system scope must be defined.** The functionality of the focal system will change if adaptive agents are able to respond to the proposed action. The ability of the focal system to respond to changes caused by a proposed action (the adaptive capacity of the system) must therefore be noted through identification of its internal adaptive agents. If the adaptive agents can change the system function and configuration, these must be noted as in-system contributors to resilience and differentiated from external agents.

Glossary

Adaptation. These are changes to a focal system, caused from within the focal system. Adaptation ranges from genetic adaptation (e.g., Darwinian selection of advantageous mutations), habitat adaptation (e.g., modification of food sources due to scarcity), technology adaptation (e.g., development of self-learning systems) and onwards to reconfigurations by adaptive agents that are within the focal system.

Adaptive agent. Any system may include within its boundaries, "adaptive agents" having degrees of capability for internal learning/reorganization. These may include pre-programmed algorithmic responses to failure, responses to environmental changes, adaptive behavior through to human agents applying abstract problem-solving approaches (e.g. re-purposing components and subsystem re-configurations).

Adaptive capacity. Resilience is defined in terms of a focal system's capability to withstand disturbances and recover from disturbances. The adaptive capacity of a system is a measure of its ability to respond to a disturbance.

Disturbance. The terms "perturbation" or "disturbance" are used broadly to describe significant changes to the values of critical variables— whether this is a change to the flow of an input substance, the impact of an external event (e.g., a tsunami), or the wear-and-tear failure of a subsystem process. Resilience is assessed for a particular type of disturbance. In the context of IA, the disturbance is often the proposed action (i.e., development policy, plan, program, or project).

System threshold. The point at which a focal system, when exposed to a disturbance, will experience a degree of significant change to its structure and functions. This may or may not result in the categorization of a "new system."

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