U.S. INDIAN OCEAN TSUNAMI WARNING SYSTEM (IOTWS) PROGRAM

CONCEPTS AND PRACTICES OF "RESILIENCE": A COMPILATION FROM VARIOUS SECONDARY SOURCES.

A Working paper prepared for Coastal Community Resilience (CCR) Program

May, 2006

Prepared for the United States Agency for International Development
By the IRG-Tetra Tech Joint Venture

U.S. INDIAN OCEAN TSUNAMI WARNING SYSTEM (IOTWS) PROGRAM

CONCEPTS AND PRACTICES OF "RESILIENCE": A COMPILATION FROM VARIOUS SECONDARY SOURCES.

A Working paper prepared for Coastal Community Resilience (CCR) Program

May, 2006
Bangkok, Thailand

Prepared by:

Atiq Kainan Ahmed, Social Scientist, US IOTWS Program (Email: atiq@iotws.org)

Reviewed by:

Alan T. White, Ph.D., Chief of Party, US IOTWS Program.
Program Integrator, US IOTWS, Bangkok, Thailand.

Prepared for U.S. Agency for International Development
by IRG-Tetra Tech Joint Venture under Contract No. EPP-I-02-04-00024-00

Integrated Water and Coastal Resources Management IQC
International Resources Group – Tetra Tech Joint Venture

US IOTWS Program Document No. 05-IOTWS-06.

DISCLAIMER

The views expressed in this document do not necessarily reflect the views of the United States Agency for International Development or the United States Government

CONCEPTS AND PRACTICES OF "RESILIENCE": A COMPILATION FROM VARIOUS SECONDARY SOURCES.

CONTENTS

Contents **5**

1.0 Introduction **7**
- 1.1 Background 7
- 1.2 Purpose of the document 7
- 1.3 Users of the document 8
- 1.4 Methodology of developing the document 8
- 1.5 Structure of the document 8

2.0 "Resilience" – the definitions by Scholars **9**
- 2.1 C.S Holling (1973) 9
- 2.2 Louis Lebel (2001) 9
- 2.3 Carl Folke et. al. (2002) 9
- 2.4 Godschalk (2003) 9
- 2.5 Walker et al. (2004) 10
- 2.6 Various contested definitions – a discussion 10

3.0 "Resilience" – the Definitions by Institutions **15**
- 3.1 Resilience alliance 15
- 3.2 UN/ISDR 15
- 3.3 Millennium Ecosystem Assessment 16
- 3.4 Intergovernmental Panel on Climate Change (IPCC: 2001) 16
- 3.5 International Federation of Red Cross and Red Crescent Societies (IFRC: 2004) 16
- 3.6 Encyclopedia of Wikipedia 16
- 3.7 Environmental Advisory Council, Swedish Government 17

4.0 Discourses on "Resilience" and Other Issues **19**
- 4.1 Coastal Hazards and Resilience 19
- 4.2 Resilience and Adaptive Capacity 20
- 4.3 A framework for analysis of resilience of socio-ecological systems 21
- 4.4 Social-ecological resilience, phase shifts, and the 2004 tsunami 22
- 4.5 Swedish Water House 23
- 4.6 P. H. Longstaff (2004) – Resilience and "New Surprises" 24

5.0 Building Resilience: Models, Practices & Experiences **25**
- 5.1 The Community Resilience Model (CED: 2000) 25
- 5.2 Community-Based Disaster Risk Management (ADPC: 2004) 26
- 5.3 Building resilience through "Sustainable Coastal Livelihoods" Framework: The SCL projects in South Asia 28
- 5.4 Building resilience through "coastal vegetation" 31
- 5.5 Integrated Coastal Management (ICM): a "young and growing" approach of building coastal resilience 34
- 5.6 Microfinance and MFIs: economic instrument to "bounce back" resiliency 35
- 5.7 Infrastructure Canada (2004) – core elements to design and develop a Disaster Resilient Community 36

1.0 INTRODUCTION

1.1 Background

Under the program area four of the ITOWS program: the **"Local Preparedness and Mitigation"** has been uniquely devised as one of the most significant area of work. The **Tsunami Resilient Communities (TRC)** has planned as the core initiative to this local preparedness and mitigation program component. The title of the program, however, has recently been changed from "Tsunami Resilient Communities" (TRC) to **Coastal Community Resilience (CCR**).

The main goal is to improve of public safety during tsunami emergencies and to build resilience to recurring coastal events. To meet this goal, the objectives of CCR are:

- to develop minimum standard guidelines for a community to follow to become a resilient community
- to encourage consistency in educational materials and response among communities and national emergency systems
- recognize communities that have adopted CCR guidelines
- Increase public awareness and understanding of the tsunami and other hazards
- Improve community pre-planning for tsunami and other disasters impacts.

However, in approaching towards devising the CCR activities it emerged that the concepts and practices relating to the term "resilience" are often loosely used. These are often used in various contested ways as well. In academic domain various paradigms are also there for defining and interpreting the term. On the other hand, in practice a great number of agencies have used the term with their respective interpretations adopting operational definitions. A multiplicity of conceptualization, uses and practice of the term resilience thereby remains as a fact.

Keeping this fact in mind a common understanding among the researchers, professionals and practitioners involved with CCR program of IOTWS (also others) is the central purpose of the present document. This document is a synoptic compilation of some of the existing concepts, discourses and practices surrounding the concept of resilience. The paper tried to look at both the academic debates as well as the practices (frameworks, models, experiences etc.) existing in relation to "building resilience" in various empirical domains.

The document by nature is a form of compilation and a collection from various relevant secondary sources. The existing works on which the sections are build or compiled on have been duly referenced after each of the sections. The readers and future users are suggested to refer the original references for any further detailed account on these issues.

1.2 Purpose of the document

There are several major purposes behind this document:

a) Have a greater understanding of the background work, literature, publications and debates on the concept of resilience persisting in various disciplines, and domains of research.

b) To share a document that provides an easy to find synoptic on these concepts and their uses to create a common understanding among the participants of the CCR workshop and for their follow up activities.

c) Develop a bibliography on this concept and its use during the IOTWS program period and beyond.

1.3 Users of the document

The potential users of this document are the researchers, program-project professionals, and practitioners involved and others interested to it.

1.4 Methodology of developing the document

The methodology of developing the document was based on primarily review of secondary literature through readings and reviewing state of art web portals. The sources of information include:

a) relevant journal sources,

b) relevant papers available books,

c) searching of various targeted electronic sources primarily the various journal websites, websites of research institutions, development agencies, and various other knowledge portals have been looked, and

d) Discussion within the members of the IOTWS team members and other resource professionals experienced in the field.

1.5 Structure of the document

The present document is divided into five Chapters. In the first Chapter the background, objectives and the nature of the document is pointed out. The second Chapter of the document draws into the major definitions of the tem “resilience” from various scholarly works of eminent scholars and academics. The third Chapter focuses on the agency definitions that have been put into operation within various major agencies involved in building resiliency at community level. The Chapter after that (Chapter four) outlines a discussion on the various discourses of resilience and its perspective of uses.

Besides these academic and agency perspectives and definition and major Chapter has been devised drawing from various encouraging experiences and models developed in the context of Community resilience. This chapter is primarily build on the models, practices and experiences developed over the period for building resilience in an empirical context. The Chapter has been detailed out with some of the promising and encouraging ecological and social forms of resilience that are needed for building sustainable resilience towards facing various types of hazards at the community level.

2.0 "RESILIENCE" – THE DEFINITIONS BY SCHOLARS

2.1 C.S Holling (1973)

The concept of **resilience** has been introduced by Holling (1973) in the field of ecology. According to Holling,

> *"resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb change of state variable, driving variables, and parameters, and still persist". (ibid, p.17)*

Source: Holling, C.S. (1973) Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics 4, 1-23.

2.2 Louis Lebel (2001)

According to a relatively recent work of Louis Lebel the term **resilience** is defined as

> *"the potential of a particular configuration of a system to maintain its structure/function in the face of disturbance, and the ability of the system to re-organize following disturbance-driven change and measured by size of stability domain".*

Source: Louis Lebel, 2001. Faculty of Social Sciences. Chiang Mai University. November 2001.

2.3 Carl Folke et. al. (2002)

According to **Cark Folke et al**,

> *"….resilience for social-ecological systems is often referred to as related to three different characteristics: (a) the magnitude of shock that the system can absorb and remain in within a given state; (b) the degree to which the system is capable of self-organization, and (c) the degree to which the system can build capacity for learning and adaptation. "*

Source: Folke, C., S. Carpenter, T. Elmqvist, L. Gunderson, C.S Holling and B. Walker (2002). Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Ambio, 31(5), pp. 437- 440.

2.4 Godschalk (2003)

According to Godschalk a series of characteristics of resilient systems that can be applied to physical and social systems to create disaster-resilient cities, including:

- ***redundancy*** - systems designed with multiple nodes to ensure that failure of one component does not cause the entire system to fail
- ***diversity*** - multiple components or nodes versus a central node, to protect against a site specific threat
- ***efficiency*** - positive ratio of energy supplied to energy delivered by a dynamic system

- ***autonomy*** - capability to operate independent of outside control
- ***strength*** - power to resist a hazard force or attack
- ***interdependence*** - integrated system components to support each other
- ***adaptability*** - capacity to learn from experience and the flexibility to change
- ***collaboration*** - multiple opportunities and incentives for broad stakeholder participation

Godschalk's model emphasizes resilience as a way to cope with uncertainty. Because we can rarely predict the frequency and magnitude of hazard agents, and because the vulnerability of community systems cannot be fully known before a hazard event, cities must be designed with the strength to resist hazards, the flexibility to accommodate extremes without failure and the robustness to rebound quickly from disaster impacts.

Source: Godschalk, David R. (2003). "Urban Hazard Mitigation: Creating Resilient Cities," Natural Hazards Review 4(3): 136-143.

2.5 Walker et al. (2004)

Resilience is defined as "the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks"

Source: Walker, B. H., C. S. Holling, S. Carpenter, and A. Kinzig. 2004. Resilience, adaptability, and transformability in social-ecological systems. Ecology and Society 9(2):5.

URL: http://www.ecologyandsociety.org/vol9/iss2/art5/

2.6 Various contested definitions – a discussion

It has been almost three decades since the term resilience as a concept distinct to other stability concepts was first established and defined by C.S. Holling in his influential paper Resilience and stability of ecological systems (Holling 1973). Etymologically, the term resilience was formed in English on the model of Latin *resilientem* (nominative *resiliēns*), present participle of *resilīre* which means to rebound or to recoil (Barnhart 1995).

Resilience in its original-ecological sense has been defined in two different ways in the ecological literature (cf. Holling 1986, Holling et al. 1995, Gunderson 2001, Gunderson & Holling 2002, Gunderson & Pritchard 2002). There is no right or wrong use of the term. Rather, the different usage emphasizes two distinct stability properties.

The first definition (1) concentrates on stability near an equilibrium steady state, where the rate and speed of return to pre-existing conditions after a disturbance event are used to measure the property (deAngelis 1980, Pimm 1984, Tilman & Downing 1994, WBGU 2000, Lugo et al. 2002). Resilience is then defined as the time required for a system to return to a steady state following a disturbance. This definition matches the etymological meaning of the term resilience.

The second definition (2) emphasizes conditions far from any equilibrium steady state, where instabilities can shift a system to another basin of attraction which is controlled by a different set of variables and characterized by a different structure (Holling 1973, 2001, Gunderson 2001, Gunderson & Pritchard Jr. 2002, Holling & Gunderson 2002, Walker et al. 2002, 2004). Resilience, understood in this way, is the "magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior" (Gunderson & Holling 2002, 4).

Note that both definitions of resilience use several concepts that are hotly contested among ecologists. For instance, the first definition implies an assumption of global stability, i.e. an ecosystem has only one

equilibrium or steady state and the focus of study is on slow dynamics near this stable equilibrium (Ludwig, Walker & Holling 1997). The second definition presupposes the existence of alternative stable regimes, i.e. ecological systems can exhibit a shift from one regime to another that is controlled by a different set of variables (Holling 1973, 1986, Carpenter 2001, Muradian 2001, Scheffer et al. 2001, Scheffer & Carpenter 2003, Walker & Meyers 2004). Focus of interest are slow dynamics in a region that separates two alternative stable basins. In order to understand the ecosystem resilience concept entirely we have to go into these concepts in a more profound way.

The terminology of Hansson & Helgeson (H&H) (2003) provides a good tool in order to distinguish the two stability properties which are associated with the term resilience. Definition corresponds to the property resilience which is defined as "tendency of a system to recover or return to (or close to) its original state after a perturbation". Definition matches the property "robustness" or the "tendency of a system to remain unchanged, or nearly unchanged, when exposed to perturbations". Hence, the two different definitions of the resilience concept reflect two different properties of ecological systems: resilience and robustness or persistence, respectively. Both definitions are contrastive aspects of the common qualifier "stability". Whether they are related to each other in a close or loose manner depends on the concrete situation (Grimm & Wissel 1997).

In the Dictionary of Ecology, Evolution and Systematics (Lincoln, Boxshall & Clark 1998) the suggested definitions for stability and resilience both reflect the different usage of resilience and the confusion of two or even more distinct stability properties. The authors define stability as "resistance to change; tendency to remain in, or return to, an equilibrium state; the ability of populations to withstand perturbations without marked changes in composition" and resilience as "the ability of a community to return to a former state after exogenous disturbance; the capacity to continue functioning after perturbation". In this connection, aspects of robustness and resilience [both sensu H&H] are intermixed. It is important to separate stability properties meticulously in order to be able to communicate clearly.

The distinction of the two definitions for resilience is also highlighted by the Resilience Alliance. The research group uses a different terminology and provides the term engineering resilience for the property resilience and the term ecosystem resilience or ecological resilience for the stability property robustness. The term vulnerability is used, in turn, as an antonym for ecosystem resilience, i.e. the "propensity of ecological systems to suffer harm from exposure to external stress and shocks" (Folke et al. 2002, 5).

These terms (see following table) get crucial within this thesis since the Resilience Alliance represents the main authority within resilience debate, which necessitates not to ignore their terminology entirely. In the following terms: engineering resilience and ecosystem resilience while referring also to the terminology of Grimm & Wissel (1997) and Hansson & Helgesson (2003). Note that the term vulnerability is important when one considers the concept of ecosystem resilience within the framework of sustainability science.

Table 1. Terminology used by the Resilience Alliance (according to Holling & Gunderson 2002)

Stability term	Definition
Ecosystem resilience	Magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior.
Engineering resilience	Rate and speed of return to pre-existing conditions after disturbance.

Both resilience definitions refer to the term disturbance. Disturbance represents an important and widespread phenomena in nature which is considered as an ecologically significant object for study in itself (Pickett & White 1985).

Ecosystems cannot be seen as static entities, rather, they represent always changing, fluctuating, dynamic systems (Reichholf 1998). There is no balance of nature, rather endless change and the ongoing creation of novelty are the rule (Carpenter & Turner 2001). In reference to Jax, Jones & Pickett (1998), Grimm (1998) speaks of intermediate self-identity since certain parts of ecosystems do always change whereas other parts do not.

Following White & Pickett (1985), Paine et al. (1998), Turner & Dale (1998) Dittmann & Grimm (1999) and Colding, Elmqvist & Olsson (2003) define disturbance, rather general, as “any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment” (quoted from White & Pickett 1985, 7).

The definition of White & Pickett includes environmental fluctuations and destructive events, whether or not these are perceived as “normal” for a particular system. However, a distinction between natural small-scale disturbances and human large-scale disturbances tries to delimit disturbances that are considered to be part of the system from others that are superimposed on the system. This distinction gets important when relatively small disturbances are conceived as being an integral part of the ecosystem dynamics. Small-scale disturbances as integral parts of ecosystems are fundamental for the generation of ecosystem resilience (Holling 1986).

Bengtsson et al. (2003) suggest that ecosystems are subject to pulse disturbances at various spatial and temporal scales. The point of interaction between the disturbance force and the ecosystem is termed biotic interface (Lugo et al. 2002). The organisms that occupy these interfaces are most exposed to the disturbance and absorb most of the impact. The term perturbation is used, if the parameters or behaviours that define a system have been explicitly defined, a given disturbance is known to be new to the system at hand (e.g. some kind of human disturbance), or the disturbance is under direct experimenter control (White & Pickett 1985).

From a system perspective several descriptors of disturbances can be considered that together constitute the disturbance regime: spatial distribution of the disturbance relative to environmental or community gradients, frequency as the mean number of events per time period, return interval, cycle or turnover time, rotation period as the mean time to disturb an area equivalent to the study area, predictability, area disturbed, magnitude of intensity and severity, and synergism as a measure of the effects on the occurrence of other disturbances. In each case disturbance statements have to be specified for both the spatial and temporal scale. In my view the ecological checklist proposed by Grimm & Wissel (1997) for stability statements could function analogously as an appropriate tool for disturbance statements. Key processes common to all disturbances are alterations of resource availability and system structure (Pickett & White 1985).

Another distinction is given by Peterson (2002) between contagious disturbances such as fire, insect outbreaks and grazing herbivores, and non-contagious disturbances. Contagious disturbances appear to be more relevant for the structure of landscapes.

Most disturbances produce heterogeneous and patchy effects, a phenomena for which White & Pickett (1985) suggest the term patch dynamics. The authors propose that, in general, biological systems, on some level expose a heterogeneous community structure and behaviour (White & Pickett 1985). Levin (1992) suggests that disturbance is relevant for the maintenance of the “character” of ecosystems as a structuring agent. Additionally, natural disturbances occur in a wide variety of biomes (coniferous, deciduous, evergreen and tropical forests, grasslands, shrub-lands, tundra and deserts) and impacts are observable at all levels of ecological organization (Pickett & White 1985).

This notion of disturbance provides a provisional concept only. In the proceeding examinations further insights will expand the notion of disturbance putting it into relation to other concepts, such as ecosystem resilience or the adaptive cycle. If ecosystem resilience – which represents the main topic of this thesis - is conceived from an operational perspective the disturbance regime provides the to what part of the ecosystem resilience analysis.

There is another important point with respect to the two distinct resilience definitions. Although being only a different aspect of “stability” the emphasis on one of the two distinct stability properties – ecosystem resilience or engineering resilience – can be decisive. It can result in different views of nature, different basic assumptions (e.g. the debate about alternate stable regimes, different views on stability itself and as an outcome of the whole to a different environmental management which is characterised by entirely

different methods. The Resilience Alliance considers ecosystem resilience to be the more valuable concept both theoretically as well as operationally.

Source: Fridolin Brand. 2005. Ecological Resilience and its Relevance within a Theory of Sustainable Development. UFZ Centre for Environmental Research Leipzig-Halle. Department of Ecological Modelling. ISSN 0948-9452.

3.0 "RESILIENCE" – THE DEFINITIONS BY INSTITUTIONS

3.1 Resilience alliance

The Resilience Alliance (www.resalliance.org) defines **resilience** as applied to integrated systems of people and nature as:

> *a) the amount of disturbance a system can absorb and still remain within the same state or domain of attraction,*
>
> *b) the degree to which the system is capable of self-organization (versus lack of organization, or organization forced by external factors), and*
>
> *c) the degree to which the system can build and increase the capacity for learning and adaptation.*

Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary.

Resilience in social systems has the added capacity of humans to anticipate and plan for the future. Humans are part of the natural world, depend on ecological systems for survival and continuously impact the ecosystems in which human live from the local to global scale. Resilience is a property of these linked social-ecological systems (SES).

Resilience as applied to ecosystems, or to integrated systems of people and the natural environment, has three defining characteristics:

- The amount of change the system can undergo and still retain the same controls on function and structure
- The degree to which the system is capable of self-organization
- The ability to build and increase the capacity for learning and adaptation.

Source: http://www.resalliance.org/576.php

3.2 UN/ISDR

UN/ISDR defines the terms **resilience/resilient** as,

> *"The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures."*

Source: http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm

3.3 Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment defines **resilience** as,

> *"The level of disturbance that an ecosystem can undergo without crossing a threshold to a situation with different structure or outputs. Resilience depends on ecological dynamics as well as the organizational and institutional capacity to understand, manage, and respond to these dynamics."*

Source: http://www.millenniumassessment.org/proxy/Document.767.aspx

3.4 Intergovernmental Panel on Climate Change (IPCC: 2001)

According to the Third Assessment Report (TAR) of IPCC the term **resilience** is defined as,

> *"amount of change a system can undergo without changing state."*

Source: http://www.ipcc.ch/pub/syrgloss.pdf

3.5 International Federation of Red Cross and Red Crescent Societies (IFRC: 2004)

The IFRC defines **resilience** as,

> *"the capacity to survive, adapt and recover from a natural disaster. Resilience relies on understanding the nature of possible natural disasters and taking steps to reduce risk before an event as well as providing for quick recovery when a natural disaster occurs. These activities necessitate institutionalized planning and response networks to minimize diminished productivity, devastating losses and decreased quality of life in the event of a disaster."*

Source: IFRC 2004. World Disaster Report.

3.6 Encyclopedia of Wikipedia

The Encyclopedia of Wilkipedia defines **resilience** as,

> *"means the ability to recover from (or to resist being affected by) some shock, insult, or disturbance."*

Source: http://en.wikipedia.org/wiki/Resilience

3.7 Environmental Advisory Council, Swedish Government

The Environmental Advisory Council to the Swedish Government in their scientific background paper on resilience for the process of The World Summit on Sustainable Development put forwarded a definitional discussion. This paper outlines the following useful conceptual discussion on resilience and vulnerability.

> *"**Resilience** provides the capacity to absorb shocks while maintaining function. When change occurs, resilience provides the components for renewal and reorganization (Gunderson and Holling 2002, Berkes et al. 2002). **Vulnerability** is the flip side of resilience: when a social or ecological system loses resilience it becomes vulnerable to change that previously could be absorbed (Kasperson and Kasperson 2001a). In a resilient system, change has the potential to create opportunity for development, novelty and innovation. In a vulnerable system even small changes may be devastating.*
>
> *The concept of resilience shifts policies from those that aspire to control change in systems assumed to be stable, to managing the capacity of social-ecological systems to cope with, adapt to, and shape change. Managing for resilience enhances the likelihood of sustaining development in changing environments where the future is unpredictable and surprise is likely.*
>
> *The antonym of resilience is often denoted vulnerability. Vulnerability refers to the propensity of social and ecological system to suffer harm from exposure to external stresses and shocks. It involves exposure to events and stresses, sensitivity to such exposures (which may result in adverse effects and consequences), and resilience owing to adaptive measures to anticipate and reduce future harm. Coping capacity is important, at all stages, to alter these major dimensions.*
>
> *The less resilient the system, the lower is the capacity of institutions and societies to adapt to and shape change. Managing for resilience is therefore not only an issue of sustaining capacity and options for development, now and in the future, but also an issue of environmental, social and economic security."*

Source: The Environmental Advisory Council to the Swedish Government. April 2002. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Scientific Background Paper on Resilience for the process of The World Summit on Sustainable Development.

4.0 DISCOURSES ON "RESILIENCE" AND OTHER ISSUES

4.1 Coastal Hazards and Resilience

Natural hazards are an ongoing part of human history, and coping with them is a critical element of how resource use and human settlement have evolved. Globally, 1.2 billion people (23% of the world's population) live within 100 km of the coast, and 50% are likely to do so by 2030. These populations are exposed to specific hazards such as coastal flooding, tsunamis, hurricanes, and transmission of marine-related infectious diseases. For example, today an estimated 10 million people experience coastal flooding each year due to storm surges and landfall typhoons, and 50 million could be at risk by 2080 because of climate change and increasing population densities. More and more, adaptive responses will be required in coastal zones to cope with a plethora of similar hazards arising as a result of global environmental change.

Hazards in coastal areas often become disasters through the erosion of resilience, driven by environmental change and by human action . For example, when Hurricane Andrew, a powerful category 5 storm, struck Florida in 1992, it caused devastation valued at $26.5 billion and 23 people lost their lives. An equivalent tropical typhoon that ravaged Bangladesh in 1991 resulted in over 100,000 deaths and the displacement of millions of individuals from widespread flooding. In Florida, social resilience from strong institutions, early warning systems, and a high capacity to deal with the crisis confined the impact to manageable proportions, whereas social vulnerability in affected areas of Bangladesh caused a human disaster of a far greater scale. Yet adaptive capacity can be increased through purposeful action. Consequently, Bangladesh has reduced mortality associated with typhoons and flooding in the past decade through careful planning focused on the most vulnerable sectors of society.

The resilience (or conversely, the vulnerability) of coastal societies is more tightly linked to larger-scale processes today than in the past. For example, economic linkages and the globalization of trade in commodities and ecological goods and services tie regions much more closely together than before. In coastal regions, this is often evident in the vulnerabilities created by global tourism (an ecosystem service), where the growing demands of visitors impact previously undeveloped coastal areas. Similarly, increased mobility of people has spread infectious diseases such as human immunodeficiency virus–acquired immune deficiency syndrome (which have high prevalence in some coastal fishing communities), whereas global-scale environmental change is certain to exacerbate vulnerability to vector-borne diseases (e.g., malaria and cholera). Conversely, greater mobility, improved communications and awareness, and the growth of national and international NGOs that link societies can all strengthen resilience to crises and improve responses when they occur.

During periods of gradual or incremental change, many important sources of resilience may be unrecognized or dismissed as inefficient or irrelevant. Typically, therefore, components of resilience are allowed to decline or are deliberately eliminated because their importance is not appreciated until a crisis occurs. For example, chronic overfishing and declining water quality around coral reefs have made them more vulnerable to cyclones and global warming. Instead of absorbing recurrent disturbances as they have done for millennia, many overfished and polluted reefs have recently undergone radical regime shifts, where coral populations fail to rebuild after external shocks and have instead been replaced by fleshy seaweeds. Rebuilding resilience, by improving water quality and maintaining adequate stocks of herbivores, can promote the regenerative capacity of corals after recurrent disturbances. Thus, loss of ecological and social resilience is often cryptic, and resilience can be eroded or bolstered accidentally or deliberately through human action.

Resilient social-ecological systems incorporate diverse mechanisms for coping with change and crisis. In ecosystems, biodiversity, functional redundancy, and spatial pattern can all influence resilience. Biodiversity enhances resilience if species or functional groups respond differently to environmental fluctuations, so that declines in one group are compensated by increases in another. Spatial heterogeneity can also confer resilience, as when refuge areas provide sources of colonists to repopulate

disturbed regions. Similarly, in social systems, governance and management frameworks can spread risk by diversifying patterns of resource use and by encouraging alternate activities and lifestyles. Such practices sustain ecosystem services, analogous to the way that management of a diverse portfolio sustains the growth of investments in financial markets.

After catastrophic change, remnants ("memory") of the former system become growth points for renewal and reorganization of the social-ecological system. Ecological memory is conferred by biological legacies that persist after disturbance, including mobile species and propagules that colonize and reorganize disturbed sites and refuges that support such legacies and mobile links. Social memory comes from the diversity of individuals and institutions that draw on reservoirs of practices, knowledge, values, and worldviews and is crucial for preparing the system for change, building resilience, and for coping with surprises.

Source: W. Neil Adger, Terry P. Hughes, Carl Folke, Stephen R. Carpenter, Johan Rockström. 2005. Social-Ecological Resilience to Coastal Disasters. Science 12 August 2005: Vol. 309. no. 5737, pp. 1036-1039.

4.2 Resilience and Adaptive Capacity

The literature on systems dynamics is bedeviled with loose terminology and multiple definitions. We concur with the assessment of Grimm et al. (1992), and their checklist of features to be considered in discussing stability concepts in a particular situation. A more detailed account of our interpretation is given in Carpenter et al. (2001). To minimize confusion in what follows it is necessary to clarify here our use of the terms “state” and “resilience.”

The “state” of a system at a particular instant in time is the collection of values of the state variables at that time. The term is often used without reference to its fundamental dependence on time. In complex systems whose description requires many state variables, the term “state” is loosely used to describe a characteristic of the system, rather than its state. For example, the lake is in a eutrophic “state”, or the rangeland is in a shrub-dominated “state.” Such a loose definition is acceptable in everyday situations, but not when we want to analyze a system more carefully (cf. Grimm et al. 1992).

Often what we describe as a state in a dynamical system is actually a collection of states, the mathematical expression for which is an attractor. That is, the system visits the same states over and over again. The system may be stochastic, in which case future states are drawn from the same probability distribution, or sequence of probability distributions. In the case of a social-ecological system, we are usually interested in preserving a particular set of general criteria. The system can be in many different states and still meet this set of criteria. It does not make sense to describe a system that meets these criteria as being in a desirable “state” and we adopt the term “configuration” to describe a collection of states (usually an attractor or attractors, which may be stochastic) that meet a certain set of criteria. It then makes sense to refer to a system as being in a desirable or undesirable configuration (i.e., the behavior of the system is confined to a collection of (usually infinitely many) states that, taken together, produce a desirable or undesirable outcome.

The terms “resilience” and “adaptive capacity” are sometimes used interchangeably. For resilience, we adopt Holling's (1973) original meaning, as opposed to the notion of “engineering resilience” (Holling 1996); in this sense, **resilience** has three defining characteristics:

- The amount of change a system can undergo (and, therefore, the amount of stress it can sustain) and still retain the same controls on function and structure (still be in the same configuration—within the same domain of attraction).

- The degree to which the system is capable of self-organization. When managers control certain variables in a system, they create inter-variable feedbacks that would not be there without their

intervention. The more "self-organizing" the system, the fewer feedbacks need to be introduced by managers. Furthermore, if the system is strongly self-organizing, those feedbacks that do need to be built in by managers are not “delicate” or “sensitive,” in that there can be significant error in the feedback induced by the manager without the system deviating from the desired behavior. (Note that, in this discussion of management, managers could be regarded as being either “in” or “out” of the system. We regard them as being “in,” or as part of the system).

- The degree to which the system expresses capacity for learning and adaptation.

Resilience, therefore, is the potential of a system to remain in a particular configuration and to maintain its feedbacks and functions, and involves the ability of the system to reorganize following disturbance-driven change. In an operational sense, resilience needs to be considered in a specific context. As discussed by Carpenter et al. (2001), it requires defining the resilience of what to what?

Adaptive capacity is an aspect of resilience that reflects learning, flexibility to experiment and adopt novel solutions, and development of generalized responses to broad classes of challenges. Can SESs become generally resilient to a range of disturbances, including novel conditions? It is this type of behavior that we regard as being the adaptive capacity of a system. We recognize that the definition of adaptive capacity is relatively vague and requires further development. Despite this vagueness, it is useful to have a term for a broad class of flexible learning responses, which often turn out to be crucial when an SES is exposed to completely novel challenges.

Resilience is not necessarily desirable. System configurations that decrease social welfare, such as polluted water supplies or dictatorships, can be highly resistant to change. Some (social) systems may be resistant, yet not resilient (i.e., they do not allow for self-organization and learning), but some undesired ecological configurations may indeed be both resistant and resilient. Sustainability, in contrast, is an overarching goal that generally includes assumptions or preferences about which system configurations are desirable. Building resilience of a desired system configuration requires enhancing the structures and processes (social, ecological, economic) that enable it to reorganize following a disturbance. It also requires reducing those that tend to undermine it.

Source: Walker, B., S. Carpenter, J. Anderies, N. Abel, G. S. Cumming, M. Janssen, L. Lebel, J. Norberg, G. D. Peterson, and R. Pritchard. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. Conservation Ecology 6(1): 14.

URL: http://www.consecol.org/vol6/iss1/art14/

4.3 A framework for analysis of resilience of socio-ecological systems

Approaches to natural resource management are often based on a presumed ability to predict probabilistic responses to management and external drivers such as climate. They also tend to assume that the manager is outside the system being managed. However, where the objectives include long-term sustainability, linked social-ecological systems (SESs) behave as complex adaptive systems, with the managers as integral components of the system. Moreover, uncertainties are large and it may be difficult to reduce them as fast as the system changes.

Sustainability involves maintaining the functionality of a system when it is perturbed, or maintaining the elements needed to renew or reorganize if a large perturbation radically alters structure and function. The ability to do this is termed "resilience."

The recently proposed resilience management analysis framework (2002) has outlined an assessment framework for analyzing the resilience of the socio-ecological systems.

The resilience management analysis framework highlights on the close involvement of SES stakeholders. It comprises of following four major steps (also shown in following diagram).

Step 1 begins with a stakeholder-led development of a conceptual model of the system, including its historical profile (how it got to be what it is) and preliminary assessments of the drivers of the supply of key ecosystem goods and services.

Step 2 deals with identifying the range of unpredictable and uncontrollable drivers, stakeholder visions for the future, and contrasting possible future policies, weaving these three factors into a limited set of future scenarios.

Step 3 uses the outputs from steps 1 and 2 to explore the SES for resilience in an iterative way. It generally includes the development of simple models of the system's dynamics for exploring attributes that affect resilience.

Step 4 is a stakeholder evaluation of the process and outcomes in terms of policy and management implications. This approach to resilience analysis is illustrated using two stylized examples.

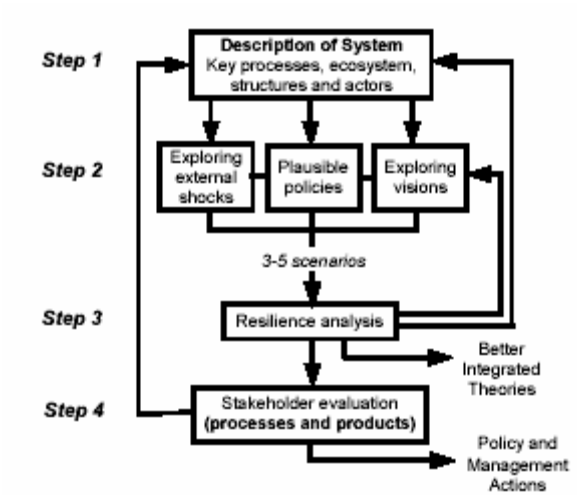

Figure 1. Steps of resilience management analysis framework.

Source: Walker, B., S. Carpenter, J. Anderies, N. Abel, G. Cumming, M. Janssen, L. Lebel, J. Norberg, G. D. Peterson, and R. Pritchard. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. Conservation Ecology 6(1): 14.

URL: http://www.consecol.org/vol6/iss1/art14

4.4 Social-ecological resilience, phase shifts, and the 2004 tsunami

The tragic human toll of the Boxing Day tsunami provides a stark example of the linkages between society and ecology, and of their entwined resilience in the face of rare catastrophes. In many developing countries, poverty is a key constraint on management options for sustaining resource use and attaining conservation goals. For example, coastal mangroves in many highly populated areas have been reduced to small remnants, harvested and cleared to create living space for crowded coastal settlements, to provide easier access to beaches for the tourism industry, and to generate new sites for prawn farming. The decline in mangroves has greatly diminished the supply of the ecosystem services that they once provided, such as timber, firewood and the provision of nurseries and habitat for numerous fisheries. Furthermore, clearing has largely removed an important mechanical buffer against modest wave energy and run-off of land-based pollutants. Similarly, fish stocks in south Asia are critically depleted by subsistence fishing and industrial-scale extraction. Nearshore coral reefs, seagrass beds and associated habitats have been degraded to varying extents throughout the region. From a social perspective, the financial capital and infrastructure (schools, hospitals, transport systems, communication) of the region is

under-developed. Furthermore, in Tsunami devastated Aceh and Sri Lanka, ongoing civil unrest erodes social capital and precludes collective action. All of these characteristics undermine resilience and make for a vulnerable social–ecological system.

The tsunami can be viewed as an external disturbance that has the potential to move a complex social–ecological system to a new SES state that is either more or less desirable than the one existing before. The local, regional and global response to the tsunami will determine whether the system has the potential to develop alternative paths and new trajectories. Beneficial outcomes could include reform of civil liberties, land use and property rights, improved governance, reduction of poverty and restoration of coastal ecosystems. Key components of resilience are likely to include leadership and insight, sustained mobilization of national and international aid, cultural and ecological diversity, development of multi-scale social networks, and the resolution of local civil unrest. It is clear that a narrow focus solely on restoration of coastal ecosystems is doomed to failure, unless the social costs and benefits of conservation efforts are addressed simultaneously.

Source: Hughes, T P; Bellwood, DR;.Folke,C; Steneck,RS: and Wilson,J. 2005. New paradigms for supporting the resilience of marine ecosystems. TRENDS in Ecology and Evolution Vol.20 No.7. July 2005.

4.5 Swedish Water House

What is resilience? Ecosystem resilience is the capacity of an ecosystem to cope with change and perturbation, such as storms, fire and pollution. Loss of resilience leads to more vulnerable systems, and possible ecosystem shifts to undesired states that provide fewer ecosystem goods (like fish and crops) and services (like flood control and water purification). Such loss of resilience can be caused by, for example, pollution, climate change, loss of biodiversity or altered freshwater flows. With decreased resilience, clear lakes can suddenly turn into murky, oxygen-depleted pools, grasslands into shrub-deserts, and coral reefs into algae-covered rubble. Resilience is the capacity of a system both to withstand pressures and to rebuild and renew itself if degraded.

Resilience as the "Immune System" of Ecosystems: Stressed, sleep-deprived and/or poorly nourished people are more susceptible to illness and recover more slowly afterwards. Likewise, studies of rangeland, forest and ocean ecosystems show that human-induced stress and overexploitation of species reduce their resilience to storms, fires or other events which they coped with before. Just as a person might seem unaffected by his or her destructive lifestyle, an ecosystem with low resilience often seems unaffected until a disturbance causes it to exceed a critical threshold. When resilience is lowered, even minor disturbances can cause a shift to a state that is difficult, expensive or even impossible to reverse.

Social Resilience is a measure of a community's ability to cope with change (for example in its environment) without losing its core functions as a community, including its economic and management possibilities. Human societies depend on ecosystems for survival but also continuously impact them from local to global scales. For such intertwined social-ecological systems, resilience is the capacity to absorb, or even benefit from, perturbations and changes that affect them, and so to persist without a qualitative change in the system's structure and function. Notably, social resilience differs fundamentally from eco-system resilience by having the added capacity of humans to anticipate and plan for the future.

Source: Swedish Water House. 200?. Swedish Water House Policy Briefs Number. 3.

4.6 P. H. Longstaff (2004) – Resilience and "New Surprises"

The term "resilience" has slightly different meanings in the various disciplines where it has been used, but it always includes some concept of an ability by an individual, group, or organization to continue its existence (or remain more or less stable) in the face of some sort of surprise, either a deprivation of resources or a physical threat. Unpredictable systems with low resilience have high vulnerability to surprise. This surprise may be partly predictable and come from a long-term trend (climate change), or a Black Swan locally (hurricanes in the Caribbean).

In the first case resilience strategies can be specifically planned for (adaptable artificial climates in buildings) but in the case of a reoccurring surprise of unprecedented magnitude, resilience will be an ability to move appropriate resources quickly (emergency services and stockpiles of emergency supplies).

A New Surprise (that was not predictable by looking at trends or historical occurrences) will challenge localities that were highly prepared for particular surprises because they will have set up very efficient responses for what they knew about but without much adaptability for things they did not plan for (their resilience strategy lacked robustness). For New Surprises, resilience will be found in systems that are highly adaptable (not locked into specific strategies) and have diverse resources.

Source: P. H. Longstaff. 2004. Security, Resilience, and Communication in Unpredictable Environments Such as Terrorism, Natural Disasters and Complex Technology.

5.0 BUILDING RESILIENCE: MODELS, PRACTICES & EXPERIENCES

5.1 The Community Resilience Model (CED: 2000)

The Center for Community Enterprise (CED) has developed a model of community resilience. This model of resilience is based on what people know about how communities work successfully.

It is made up of two levels of information. At the center are what is called four *dimensions* of resilience (see the Figure below). Each dimension is also expressed in terms of several, more detailed *characteristics* of resilience. Both the dimensions and the characteristics are based on the ideal – on the state or action that ideally exists in the most resilient communities. No community fits the following descriptions completely.

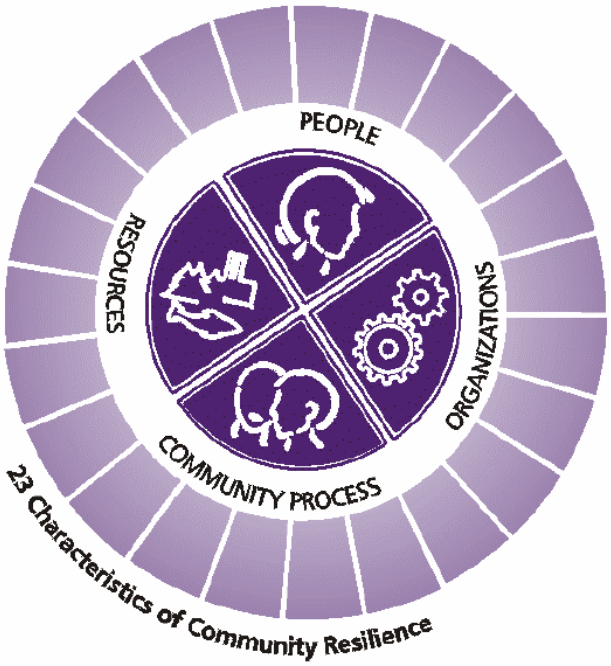

Figure 2. The Community Resilience Model of CED.

The four *dimensions* of resilience

The dimensions state, in a general way, the core component of the community from the perspective of resilience.

- people
- organizations in the community
- resources in the community
- community process

All four dimensions are linked, reflecting the reality that the parts of community are all related and independent. The first three describe the nature and variety of resources available to a community for development. The fourth dimension, community process, describes the approaches and structures available to a community for organizing and using these resources in a productive way. The four dimensions are explained below.

People in your Community: Attitude and Behaviors

Strongly held beliefs and attitudes, and the resulting behavior of individuals and groups create community norms that can either promote resilience, or hinder it. This dimension will help you to explore attitudes and behavior related to leadership, initiative, education, and optimism. Resilient communities exhibit a sense of pride and openness to new ideas and alternatives. They value education and demonstrate an awareness of the economic impact of social issues. Their leadership base is diversified and works to involve and mobilize the public around a common vision. The people in resilient communities have a “can do” attitude that is visible in their proactive response to change.

Organizations in your Community: Attitude and Behaviors

The scope of public and private organizations, institutions, agencies and networks in your community can be an asset in times of social and economic change. Resilient communities work to ensure they have sufficient organizational capacity of influence within each of the five functions (access to equity and to credit, human resource development, research and planning, and advocacy) to provide leadership and resources necessary to get things done. Social and economic development organizations in resilient communities work to inform and engage the public and demonstrate high levels of collaboration with each other.

Resource in your Community: Awareness and Use

Obviously, individuals and organizations require additional resources in order to effect change in their community. The presence of resources alone however, is not enough to ensure resilience. Moe important, is the way in which resources are viewed and utilized by the community. This dimension will assist your community in identifying the existing balance between internal and external reliance. Resilient communities are aware of and build on their local resource strengths while also seeking appropriate external resources to achieve their goals. They take steps to reduce their dependency on outside ownership and spend their money with a view to the long-term future of the community.

Community Process: Strategic Thinking, Participation and Action

The dimension examines the local process for planning, participation in, and implementation. Resilient communities take the time to research, analyze and plan for their future. The plan becomes integrated into the work of those organizations involved in and contains strategies that merge social and economic issue and solution. Resilient communities have a widely shared vision for their future, involve key sectors in the implementation of the goals, and measures results on a regular basis.

The Characteristics of Resilience

Each dimension breaks down into a series of more detailed "characteristics of resilience". These characteristics are the specific factors that are examined in a community to assess the level of resilience. They can be researched and analyzed to provide portrait of a community's resilience.

The characteristics in the model are not exhaustive. There are many other characteristics that might relate to or describe a community's resilience. However, those in the model have been the strongest relationship to resilience, given current knowledge about how successful communities work.

Each community is unique. Communities will experience a different level of resilience in each characteristic and these levels may change over time. Therefore, the characteristics are not black and white, but rather multiple shades of grey. The shades or levels that exist are what local people, not outsiders, assess them to be. Also, certain characteristics will play a more significant role in determining resilience in some communities, depending on the degree and nature of local stresses, and community history and values. This is important because the approach attempts to assess resilience in unique, very complex communities.

Source: CED 2000. The Community Resilience Manual: A Resource for Rural Recovery and Renewal. ISBN: 1-895818-40-0. The Center for Community Enterprise, British Columbia, Canada.
URL: http://www.cedworks.com/files/pdf/free/P200_Guide.pdf

5.2 Community-Based Disaster Risk Management (ADPC: 2004)

The Community-Based Disaster Risk Management (CBDRM) framework promoted by Asian Disaster Preparedness Center (ADPC) aims to reduce vulnerabilities and to strengthen peoples' capacity to cope with the disaster risks they face. The process of CBDRM puts the community in undertaking local level risk reduction measures as a central focus. Community takes responsibility for all stages of the program including both planning and implementation in this process. Experiences in the implementation of CBDRM point to the following essential features:

Centrality of the role of community in disaster risk management. The focus of attention in disaster risk management is the local community. The CBDRM approach recognizes that the local people are capable of initiating and sustaining their own development. Responsibility for change rests with those living in the local community.

Disaster risk reduction is the aim. The main strategy is to enhance capacities and resources of most vulnerable groups and to reduce their vulnerability in order to avoid the occurrence of disasters in future.

Recognition of the link between disaster risk management and the development process. CBDRM should lead to general improvement in people's quality of life and the natural environment. The approach assumes that addressing the root causes of disasters, e.g. poverty, discrimination and marginalization, poor governance and bad political and economic management, would contribute towards the overall improvement in the quality of life and environment.

Community is the key resource in disaster risk management. The community is the key actor as well as the primary beneficiary of the disaster risk management process.

Application of multi-sectoral and multi-disciplinary approaches. CBDRM brings together the many local community and even national stakeholders for disaster risk management to expand its resource base.

CBDRM as an evolving and dynamic framework. Lessons learned from practice continue to build into the theory of CBDRM. The sharing of experiences, methodologies and tools by communities and CBDRM practitioners continues to enrich practice.

CBDRM recognizes that different people have different perceptions of risk. Specifically, men and women who may have different understanding and experience in coping with risk also may have a different perception of risk and therefore may have different views on how to reduce the risks. It is important to recognize these differences.

Figure 3: The Seven-Step Process of CBDRM.

Various community members and groups in the community have different vulnerabilities and capacities. Different individuals, families and groups in the community have different vulnerabilities and capacities. These are determined by age, gender, class, occupation (sources of livelihoods), ethnicity, language, religion and physical location.

The CBDRM process

The CBDRM process has seven sequential stages, which can be executed before the occurrence of a disaster, or after one has happened, to reduce future risks. Each stage grows out of the preceding stage and leads to further action. Together, the sequence can build up a planning and implementation system, which can become a powerful disaster risk management tool. The following are the seven steps in the disaster risk management process.

1. Selecting the Community: This is the process of choosing the most vulnerable communities for possible assistance on risk reduction using a set of criteria.

2. Rapport Building and Understanding the Community: This is basically building the relationship and trust with the local people. As relationship is established, general position of the community in terms of social, economic, political and economic aspects is understood. Deeper appreciation of the community dynamics will happen later, when participatory risk assessment is undertaken.

3. Participatory Disaster Risk Assessment (PDRA): This is a diagnostic process to identify the risks that the community faces and how people overcome those risks. The process involves hazard assessment, vulnerability assessment and capacity assessment. In doing the assessments, people's perception of risk is considered.

4. Participatory Disaster Risk Management Planning: This follows after the analysis of the results of participatory risk assessment. People themselves identify risk reduction measures that will reduce vulnerabilities and enhance capacities. These risk reduction measures are then translated into a community disaster risk management plan.

5. Building and Training a Community Disaster Risk Management Organization (CDRMO): Disaster risks are better managed by a community organization that will ensure that risks are reduced through implementation of the plan. Therefore it is imperative to build a community organization, if there is none yet or strengthen the current one, if there is any. Training the leaders and members of the organization to build their capacity is important.

6. Community-Managed Implementation: The CDRMO should lead to the implementation of the community plan and motivate the other members of the community to support the activities in part one.

7. Participatory Monitoring and Evaluation: This is a communication system in which information flows amongst all the people involved in the project: the community, the implementing staff and the support agency, concerned government agencies and donors.

Source: ADPC 2004. CBDRM Field Practitioners' Handbook. Asian Disaster Preparedness Center, Thailand.

5.3 Building resilience through "Sustainable Coastal Livelihoods" Framework: The SCL projects in South Asia

The South Asia region has very high percentages of poor in the population, particularly in India and Bangladesh. The diversity of the natural resources found along the coast, and the open-access nature of many of them, means that barriers to entry are low, attracting the poor to the coast in search of livelihood opportunities. However, while the coast presents many opportunities for the poor, it also exposes them to many forms of shocks that increase their vulnerability. Floods, cyclones and inundation by sea water are all common in coastal areas of the region and the livelihoods of many of the coastal poor have suffered in the past due to natural disasters. Ownership of key livelihood resources, such as land, is limited and this affects people's access to stable livelihood opportunities. Many are fisher folk and these have been specifically identified as one of the poorer groups in South Asia. Others are farmers trying to make a living from soil which is often poor quality or is degraded and over which they often have little formal control. Some people make a living from harvesting forest or other common pool resources where access rights are often unclear, disputed or insecure.

The situation in which these people live is very dynamic and subject to a wide range of human pressures. Locally the population pressures mean that limited resources are spread between more people. In most places there are few alternatives to dependence on natural resources as the basis for economic use and subsistence. From further a field, human activities such as industrial development, urbanization, mining, intensive agriculture, industrial forestry, intensive fishing pressure and commercial aquaculture often result in downstream environmental degradation which further reduces the options for the poor coastal

dweller. At a global level there are fears that climate change and sea level rise will threaten the long-term survival of low lying coastal communities.

The support that the poor in coastal areas receive to deal with this situation is frequently limited due to a number of factors. Coastal areas are often remote and living conditions are difficult, discouraging the presence of government staff and NGOs. The costs of providing services in coastal areas can be high as transport is difficult. The situation of coastal communities is made worse by the low social status they often hold and their lack of political influence.

The coastal zone is also characterized by overlapping institutional and political responsibilities. Agricultural, forestry, fisheries, urban and industrial activities both in upstream catchments and in the coastal area itself can all have impacts on the lives of the poor in coastal zones, and marine environments are open to a wide variety of pressures from both near and far. The policies developed for these different sectors, by the various institutions and agencies responsible for them, often overlap and conflict with each other and with the strategies developed by the poor to sustain their livelihoods and with their needs and aspirations for improvement. The complexity of the coastal area often results in decision-making structures being inadequate or inappropriate to deal with the problems of the poor in ways which are co-ordinates and which actively involve the poor.

The causes and consequences of the problems facing the poor in coastal areas of South Asia are complex and changing and, from what limited detailed information is available, it is clear that the numbers of people living below or close to the poverty line in coastal areas in the region is increasing. Their vulnerability to the effects of natural disasters, environmental degradation and economic shocks means that large numbers of coastal dwellers risk increased poverty if appropriate measures are not taken to ensure that their livelihoods are more sustainable and more resilient.

DFID has provided support to alleviate the adverse consequences of cyclones in both India and Bangladesh, and the work in India has started to demonstrate that innovative approaches to support planning and partnership building can provide the basis for building on the capacity of communities to recover from severe shocks and to lessen the impact of future ones.

DFID has also worked closely with poor fish processors in coastal communities in the Western Bay of Bengal (through both the Bay of Bengal Post-Harvest Fisheries Project and the RNRKS Post-Harvest Fisheries Research Programme) to identify their needs and how they can be catered for. DFID-funded research under the Policy Research Programme identified that in fishing communities generally many of the problems faced by poor communities had their roots in, or were added to by, conflicts of policy between sectors and between different participants in the policy process.

All these interventions have indicated the need to approach the problems of the poor in coastal areas from a holistic perspective which is inclusive of the poor. The **Sustainable Livelihoods Approach (SLA),** an approach to dealing with and responding to the complexity of poor people's lives, provides a strong framework for doing this. The SLA takes the poor, the resources at their disposal and the social, economic, technical and institutional context in which they live as a starting point. It differs markedly from approaches that take resource management as their central and immediate aim by taking the poor as its main focus. The concentration of the SL approach on people and their means of combining the resources at their disposal to create a

The core objectives of the SLA

- More secure access to, and better management of, natural resources.
- Improved access to high quality education, information, technologies and training and better nutrition and health.
- A more supportive and cohesive social environment.
- Better access to basic and facilitating infrastructure.
- More secure access to financial resources.
- A policy and institutional environment that supports multiple and promotes equitable access to competitive markets for all.

livelihood allows an understanding of the way in which the poor draw on and are affected by a wide range of resources, sectors, social and institutional structures and processes.

The **"Sustainable Coastal Livelihoods" (SCL)** project has aimed to turn the understanding provided by the SLA into more appropriate policy and planning processes. It did this by researching conflicts in the policy process applied to a complex multi-sectoral situation which was very representative of the lives and needs of the poor and it identified ways in which a more enabling environment could be created for poverty reduction.

It builds on the experiences gained from previous research into participatory and integrated policy processes and assess their application to the sustainable livelihoods approach.

The issues covered by the project are as follows:

- Factors supporting and constraining the achievement of, sustainable livelihoods of poor coastal people in the Western Bay of Bengal, and the influence of policy processes on achieving those livelihoods, identified.

- The role of policy structures and processes in the livelihoods of the poor in selected coastal communities in Andhra Pradesh identified.

- Measures for improving the policy structures and processes to support poor coastal communities in their efforts to achieve sustainable livelihoods, identified and tested in Andhra Pradesh.

- Guidelines for improving policy structures and processes needed to facilitate and support the achievement of sustainable coastal livelihoods for the poor developed and their application to the Western Bay of Bengal region developed and promoted.

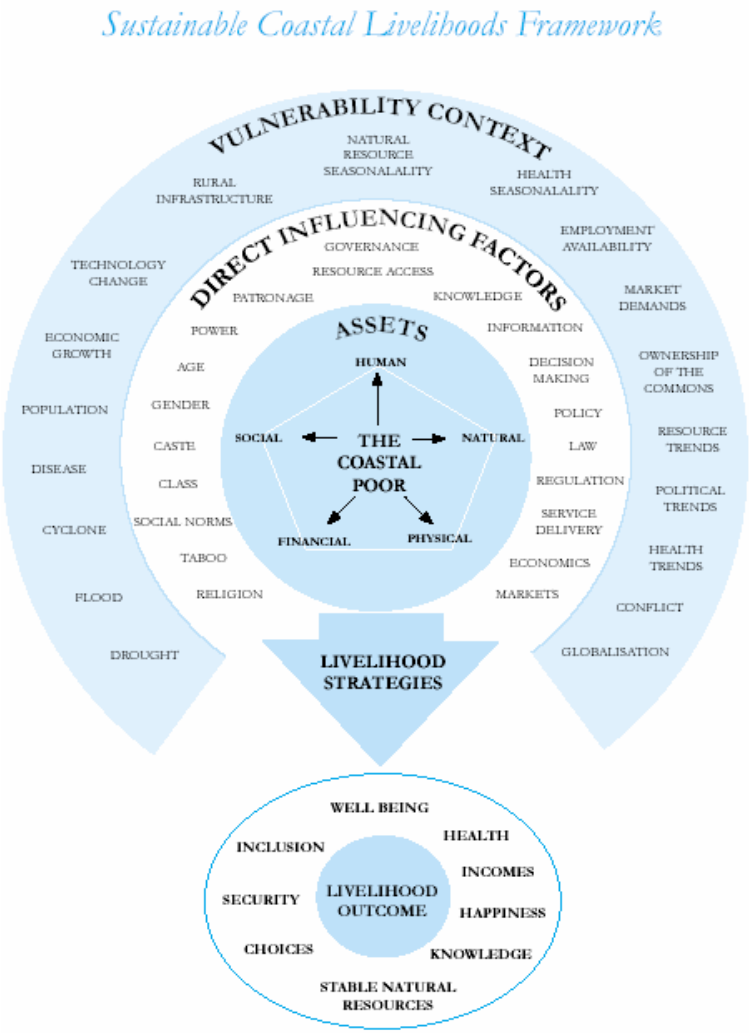

Figure 4. Sustainable Livelihoods Framework as of SCL.

Source: IMM's Sustainable Coastal Livelihoods website: http://www.innovation.ex.ac.uk/imm/SCL.htm .

5.4 Building resilience through "coastal vegetation"

Coastal mangroves as "bio-shield"

The recent scientific writings, the role of mangroves in reducing the sea-waves has gradually been highlighted. A debate seems to be prevailing relating to the efficacy and inefficacy of the mangroves in reducing the coastal hazards (e.g. tsunami). For instance, some suggest that a six-year-old mangrove forests of 1.5 km width will reduce 1 m high waves at the open sea and 0.05 m at the coast. On the other hand others suggested that this can mitigate but only a short period wave attenuation and this cannot be directly extrapolated to tsunami which has long wave period. So, a debate relating this 'pros and cons' of coastal mangrove vegetation is existing in the literature.

However, there is clear evidence that mangroves played a protective role in reducing the energy of the tsunami. Some mangrove areas on Sumatra, Indonesia were almost totally destroyed as they absorbed much of the tsunami energy. Along the coastlines of India and Sri Lanka, there are reports of villages that were spared the full force of the tsunami by their protective mangroves and coastal forests. Fishing boats and other debris were caught in the trees, and thus did not smash into houses behind them; moreover people were able to climb the trees to avoid being washed out to sea.

The evidence gathered by UNEP GRID was that, while mangroves tend to grow in more sheltered waters such as estuaries, these mangroves absorbed much of the tsunami surge up rivers. Similarly, intact coastal forests of hibiscus and casuarina growing on coastal dunes also absorbed much of the wave energy, thus protecting nearby coastal infrastructure. This was evident in most of the affected countries. In addition some coastal forests were extensively damaged as they absorbed the energy of the waves.

Some of the strong pro quotes of the well known scientists remained as below:

> *"Tsunami is a rare phenomenon. Though we cannot prevent the occurrence of such natural calamities, we should certainly prepare ourselves to mitigate the impact of the natural fury on the population inhabiting the coastal ecosystems. Our anticipatory research work to preserve mangrove ecosystems as the first line of defense against devastating tidal waves on the eastern coastline has proved very relevant today. The dense mangrove forests stood like a wall to save coastal communities living behind them,"*
>
> - M.S. Swaminathan, M.S. Swaminathan Research Foundation (MSSRF), Chennai, India. 2004.

Some of the cases that indicated the positive role of coastal mangroves as "bio-shield" in mitigating coastal hazards are shown in the following images. These are primarily drawn from two examples first one on from a Tamil Nadu experience and the second one from the more affected areas of Banda Aceh in Sumatra, Indonesia. Both are taken from the publication referred at the end of section titled "In the Front Line" (UNEP-WCMC: 2006).

Figure 5. Many parts pf the coast of Tamil Nadu in India were severely hit by the tsunami. Three villages behind the mangroves in Pitchavaram Sanctuary survived whereas the two in front were lost.

Figure 6. The once extensive mangrove around Banda Aceh in Sumatra, Indonesia, an area which suffered devastating damage and loss of life in the tsunami, had been largely replaced by shrimp firms. Although loss of mangroves could have contributed to the destruction, the area was also very close to the epicenter of the tsunami and thus vulnerable to substantial impact.

Mangroves and Regulatory Ecosystem Services – the case of the Sundarbans forest

The Sundarbans, lying at the southern end of the Ganges River and straddling the border between India and Bangladesh, is the largest continuous area of mangrove in the world. The area provides a livelihood for more than 300 000 people, protects them from cyclones and tidal waves and is an important source of revenue for both countries through commercial timber which is harvested on a 20-year felling cycle. The total extent – some 6,050 km^2 – has not changed significantly in the last 25 years, although there are concerns that forest quality may be declining.

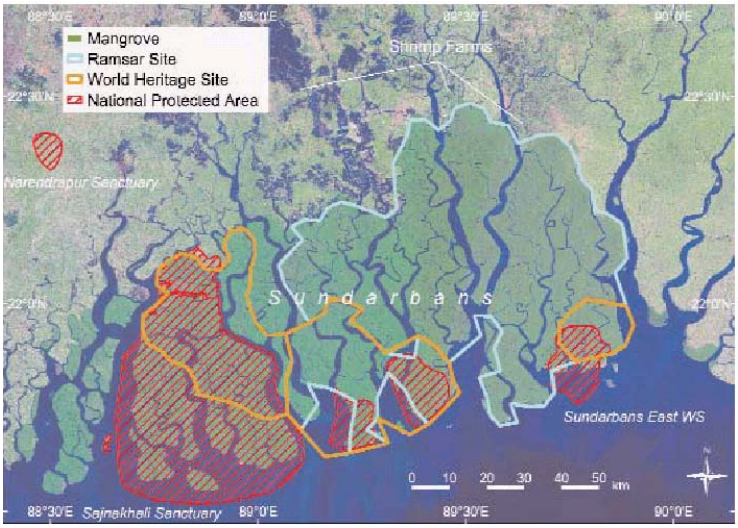

Figure 7. Reserved mangrove areas of the Sundarbans.

The relative success of the Sundarbans is largely due to its management which has been aimed at taking advantage of the mangroves' provisioning and regulatory ecosystem services. It has been managed as a commercially exploited reserved forest since 1875; wildlife sanctuaries and national parks protect key biodiversity areas, and the area is both a World Heritage and a Ramsar site. Since the 1970s, the Sundarbans has also been managed as a protective belt against storm damage.

Coral reefs as protections

Coral reefs can play a major role in protecting adjacent shorelines from wave erosion, especially in reducing the effect of tropical storm waves and surges. This is clearly evident on tropical islands, where there are sandy beaches, seagrass beds and mangrove forests behind the reefs. This protective function are particularly important as increases in the incidence and severity of tropical cyclonic storms are predicted.

Evidence gathered after the December 2004 tsunamis showed that large waves, often more than 10 m high, passed relatively unimpeded over the coral reefs. A preliminary analysis by UNEP GRID scientists detected little protection of the land immediately behind the coral reefs in Indonesia, Thailand and Srilanka. However, there was apparently greater damage behind reef flats which had been lowered by mining corals from the reefs (e.g. Sri Lanka and possibly the Maldives), than in areas that had not been mined. Some coral reefs sustained damage, especially those in channels between islands and passes between coral reefs. Here the tsunami energy was concentrated by the island topography to create strong surges and currents. Many corals in these areas suffered considerable damage with large coral heads weighing several tonnes and many branching and table corals being either shattered or overturned, thereby absorbing some of the wave energy.

Figure 8. Section of a healthy coral reef shown in the picture.

The consensus appears to be that coral reefs are particularly important in protecting shorelines from storm surges; this function will be more important in the future. The height of the waves generated on 26 December far exceeded most tropical storms, overwhelming much of the capacity of the reefs to protect the land.

Sources:

- Kandasamy Kathiresan and Narayanasamy Rajendran,. 2005. Coastal Mangrove Forests Mitigated Tsunami. Estuarine, Coastal and Shelf Science. Vol 65 (2005).

- UNEP-WCMC (2006). In the Front Line: Shoreline Protection and other Ecosystem Services from Mangroves and Coral Reefs. UNEP-WCMC, Cambridge, UK.

- Clive Wilkinson, David Souter and Jeremy Goldberg. 2005. Status of Coral Reefs in Tsunami Affected Countries: 2005. Global Coral Reef Monitoring Network (GCRMN) and partners. URL: http://www.aims.gov.au/pages/research/coral-bleaching/scr-tac2005/pdf/scr-tac2005-all.pdf

- Kim Stewart, 2005. Tsunami Disaster: Opportunity for Change in land use in coastal zones? http://www.melbourne.indymedia.org/news/2005/02/88318.php

5.5 Integrated Coastal Management (ICM): a "young and growing" approach of building coastal resilience

Coastal management activities are now expanding in the South Asian and South East Asian region because of both the devastating recent tsunami impacts and the urgent need to manage and protect the valuable coastal resources that occur along their extensive and diverse coastlines. Several countries in the region have adopted the Integrated Coastal Management (ICM) framework in recent years and came up with a wealth of "rich" experiences and lessons learned.

Integrated coastal management (ICM) is increasingly an accepted management framework to address coastal and marine environmental problems, conflicts and management needs. A primary goal of most ICM and related projects is to achieve sustainable use of coastal resources. This has also greater implications for devising sustainable coastal disaster risks management and building community resilience to mitigate and prepare for coastal disasters.

In recent time this has been widely accepted that the lessons of the integrated coastal management practices can bring good and can be immensely useful for devising coastal community resiliency which is a precondition for sustainable coastal hazard management. Hence, Alan T. White points out the scopes of ICM for building coastal resilience as,

> *"ICM is still young and growing but its potential to build coastal resilience both human and ecological is substantial. Let's learn from the emerging lessons and apply them!"*
> *(A.T. White: 2006)*

Some of the experiences and lessons learned in other parts of the region have some encouraging implications for developing further resilience and in particular for developing a sustainable coastal resilience in the Indian Ocean region.

One of the most encouraging instances of gradual coastal Management is the case of Philippines. The history and progression of ICM has been influenced through programmatic experiences and various projects that have tested and refined the practice of coastal management in the Philippines. The evolution of coastal management programs in the Philippines has approximated a pattern of five stages usually identified as a) incipient awareness (1970s and 1980s), b) growing awareness (1980s and early 1990s), c) national study (1990s to present), d) new program creation (late 1990s to present), and program development, implementation and evaluation (started to occur in 2002 and 2003).

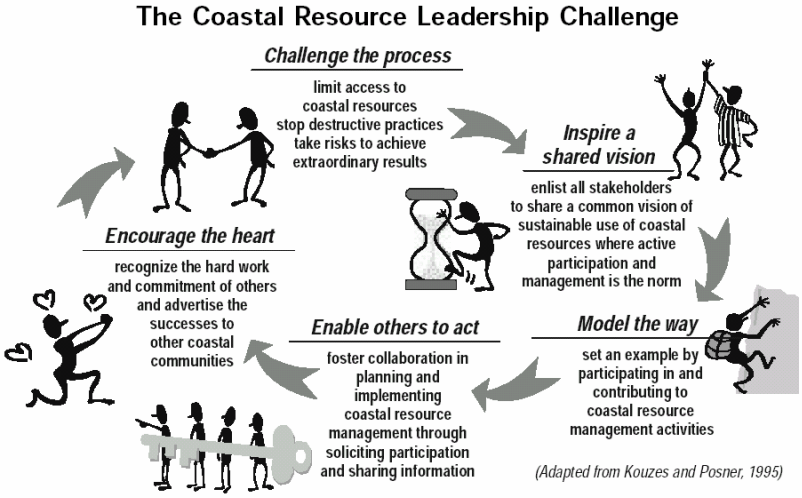

Figure 9. CRMP developed an innovative example of the community based "Coastal resource leadership challenge".

The coastal CRMP (1996-2003) project in Philippines has though a participatory coastal resource management process has **encouraged the coastal resource leadership challenge to build resiliency** among the various stakeholders of the coast. This includes local government units, NGOs, national government agencies, people's organization, community and others. The core approach adopted to build coastal resource leadership is shown in the above diagram.

Beside this the CRMP program has also developed some good instances of **"Coastal and marine zoning practices"** and practices of **"Marine Protected Areas (MPA)"** in a vary participatory way that can be identified as quite new blends of approach for building coastal resiliency under the generic approach of ICM.

Some work in this line of ICM has started to develop in other parts of the region. Countries such as Srilanka, Indonesia, Bangladesh and so forth have started to adopt the ICM framework in a varied way.

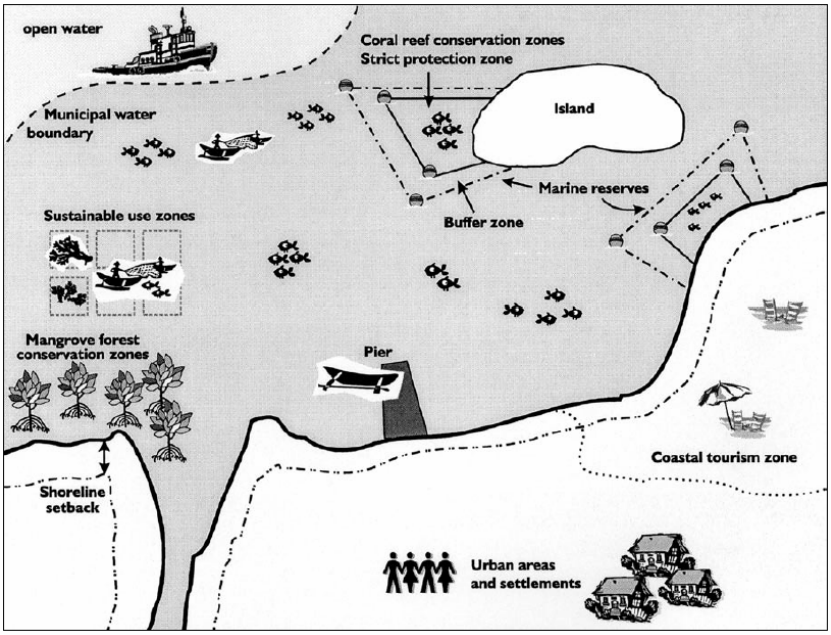

Figure 10. Planning and zoning of municipal water use in atypical Philippines bay of coastal area.

In post Tsunami period, these ICM practices if ICM can be more closely analyzed to devise lessons learned and at the same time make future provisions for including dimensions and measures needed to incorporate the coastal resiliency factors in a more strategic manner. In this young and growing stage this could be an opportunity to build on greater coastal resilience of the communities to face the future hazards.

Sources:

- A.T. White 2006. Presentation on Coastal Resilience through Integrated Coastal Management. In Presented in the Workshop on Learned in Recovery: Post-Tsunami Relief and Rehabilitation for Sustainable Coastal Development: Bangkok, February 15-17, 2006. Indian Ocean Tsunami Warning System Program, USAID-Asia, Bangkok. Thailand.

- CRMP 2004. Completion Report. Coastal Resource Management Project - Philippines 1996-2004. Coastal Resource Management Project of the Department of Environment and Natural Resources. Cebu City. Philippines.

- Walters, J.S., J. Maragos, S. Siar and A.T. White. 1998. Participatory Coastal Resource Assessment: A Handbook for Community Workers and Coastal Resources Managers. Coastal Resource Management Project and Silliman University. Cebu City. Philippines. URL: http://www.oneocean.org

5.6 Microfinance and MFIs: economic instrument to "bounce back" resiliency

Many research indicates that access to microfinance services including credit, often savings, and less typically housing loans and microinsurance, increases poor households' prospects of escaping poverty and at minimum stops them from falling further down the poverty line. Experiences of several Microfinance Institutions in disaster-prone areas have demonstrated that access to microfinance services can support disaster preparedness and risk reduction by decreasing client vulnerability. When clients have access to needed financial services during crisis situations, the impact of the disaster may considerably lessen.

Many of the poor and the near poor, who are the typical microfinance clients, suffer from both a higher disaster risk exposure and a lower risk bearing capacity than other population groups. The poor cannot usually avoid disaster risk given their limited choices when deciding where to live. By delivering services to clients under these conditions, MFIs link disaster risk to their portfolio, while exposing directly to it their staff, facilities and equipment.

On the other hand, the effectiveness of MFIs in helping clients manage disaster risk is limited by the nature of this type of risk. Disaster risk is collective in its origin and remains mainly a 'public,' shared risk that makes finding individual, and often community solutions, difficult. A disaster is said to take place precisely because the loss originated by a given event overwhelm the capacity of a population (local, regional or national) to respond and recover from it. Often, the poorer households are the most affected in relative terms.

In these critical premise of disasters the microfinance and the MFI can play a big role in bouncing back from the hazards and reduce the effect of disaster on one side and play a role in long term rehabilitation on the other. For overall steps towards building up resilience at community level these MFIs with their grass-root level presence could be useful and effective.

Sources:

- Enrique Pantoja, 2002. Microfinance and Disaster Risk Management Experiences and Lessons Learned. The World Bank. July 2002. Washington DC, USA.

- Miamidian, E; Arnold, M; Burritt, K; and Jacquand, M. 2005. Surviving Disasters and Supporting Recovery: A Guidebook for Microfinance Institutions. Disaster Risk Management Working Paper Series No-10. Hazard Management Unit, The Word Bank, Washington DC, USA. URL: http://www.worldbank.org/hazards

5.7 Infrastructure Canada (2004) – core elements to design and develop a Disaster Resilient Community

In the Background Paper on Disaster Resilient Cities prepared for Infrastructure Canada the agency have identified some core elements to design and develop a disaster resilient community. Infrastructure Canada identifies these core elements extracting from models and concepts build by others. It identifies following set of core elements that could be used to design and develop a disaster resilient community.

- Cultural attitudes must accommodate resilience
- Disaster resilience is a philosophy, a process and a condition
- Resilience requires an all-hazards approach
- Resilience requires an all-vulnerabilities approach
- Communities require greater resistance to hazard stresses
- Community system s must be flexible
- Recovery capacity must be enhanced
- Communities must develop an adaptive capacity

Source: Henestra, D., Kovacs, P., McBean, G. and Sweeting, R. 2004. Background Paper on Disaster Resilient Cities. Toronto: Institute for Catastrophic Loss Reduction. URL: http://www.dmrg.org/resources/Henstra.et.al-Background%20paper%20on%20disaster%20resilient%20cities.pdf