

Ecosystem Resilience System in Silent Crisis

Case Study: Bushehr As a Coastal Area in Iran

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1. Introduction

It is a global justice concern that those who suffer most from climate change have done the least to cause it. According to the Silent Crisis Forum 2009 manifest, developing countries bear over nine-tenths of the climate change burden, 98 percent of the seriously affected and 99 percent of all deaths from weather-related disasters, along with over 90 percent of the total economic losses. The 50 Least Developed Countries contribute less than 1 percent of global carbon emissions. (Silent Crisis Forum Manifest, 2009) The poorest are hardest hit, but the human impact of climate change is a global issue. Climate change increases the risks of climate-related disasters, which cause the loss of lives and livelihoods, and weaken the resilience of vulnerable ecosystems and societies.

Iran is among those developing countries that suffer problems with air and water pollution with the ecology in the Caspian Sea and Persian Gulf significantly threatened. This is while due to the Carbon Dioxide Information Analysis Center (CDIAC), although Iran has shown remarkable growth in total fossil-fuel CO₂ emissions since 1954 -averaging 6.3% per year- but still is globally ranked 54th based on their 7.4 metric tonnes of carbon dioxide emissions per capita according to the World Bank data.

Bushehr is a coastal city near Persian Gulf that her vulnerable ecosystems have largely affected by such ecological issues and hence have selected as a case study for our research. In this paper Bushehr ecological vulnerabilities have been studied and several recommendations to increase her ecological resilience have been suggested.

2. Resilience and Vulnerability Definition

Firstly we should introduce the concepts of resilience and also the ecological *resilience* that we mean in this paper. Although the term of resilience is most commonly used in the study of ecosystem dynamics (Holling 1973), it can also be applied to social systems (Adger, 2000 and Adger et al. 2001), social-ecological systems (Gunderson et al., 1995; Berkes and Folke, 1998 and Gunderson and Holling 2001), and the study of global change (Holling 1997). The concept of *resilience* as applied to integrated socio-ecological systems –which is used in this paper- may be defined as “the amount of disturbance a system can absorb and still remain within the same state or domain of attraction, the degree to which the system is capable of self-organization (versus lack of organization or organization forced by external factors), and the degree to which the system can build and increase its capacity for learning and adaptation” (Carpenter et al. 2001). Socio-ecological systems are complex adaptive systems that are constantly changing, and the resilience of such systems represents the capacity to absorb shocks while maintaining function (Holling, 1995 & 2001; Gunderson and Holling 2002; Berkes et al. 2002).

Due to *Resilience Alliance* (2001) we can assess change in terms of the organizing concept of resilience, which has three defining characteristics. It is a measure of:

- (1) The amount of change the system can undergo and still retain the same controls on function and structure;
- (2) The degree to which the system is capable of *self-organization*, and
- (3) The community's ability to build and increase its capacity for *learning* and *adaptation*.

The terms “self-organization,” “learning,” and “adaptation,” which are important for our arguments, is those defined by the Resilience Alliance (Diagram 1).

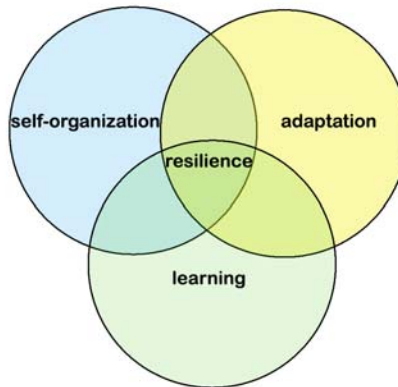


Diagram 1: Resilience Alliance

When a human or ecological system loses resilience, it becomes *vulnerable* to change that previously could be absorbed (Kasperson and Kasperson 2001). At a global level, various efforts over the past several decades have defined vulnerable indexes. It is obvious from the notion of *vulnerability* that three major dimensions are involved:

- Exposure to stresses, concern, and shocks;
- The sensitivity of people, places, and ecosystems to stress or concern, including their capacity to anticipate and cope with the stress;
- The resilience of exposed people, places, and ecosystems in terms of their capacity to absorb shocks and concern while maintaining function. (UNDP, 2007)

The most vulnerable people are those whose livelihoods directly depend on nature and on the ecosystem services that nature provides and Bushehr citizens are not an exception.



Figure 1: Bushehr city from top

3. How Can Social Movements Affect Ecological Resilience?

As population sizes, technologies, incentives, values, and social, economic and political conditions change over time, these transformations can cause ecological damage unless people respond to ecological feedback and modify their management institutions. Resilience

depends on decisions made by people using their cultural norms and institutions at different scales. Effective governance requires good cross scale links in order to harmonize decisions made at local, national and international levels. When different cultural norms exist at different scales, conflicting management decisions are made at different scales.

Ecological resilience therefore springs from biological communities but depends on the evolving institutions that govern people and their use of natural resources (Alcorn and Royo, 2000). When a resilient ecosystem is disturbed, it retains the ability to reorganize and renew itself without loss of function or diversity. The natural processes of evolution, competition and succession in communities of diverse species form the foundation for ecosystem resilience, but human management must keep disturbance within certain bounds so that this foundation is not lost. Social movements can prevent ecological degradation if they successfully challenge the dominant system to accommodate marginal voices concerned about ecological feedback. Consequently, the term “Socio-ecological Resilient” have been used to show such resilience in our ecosystems which we believe is quite important for Bushehr case.

4. Socio-ecological Resilient Systems

Resilient social-ecological systems are systems that are able to absorb larger shocks without changing in fundamental ways. When massive transformation is inevitable, resilient systems contain the components needed for renewal and reorganization. In other words, they can cope, adapt, or reorganize without sacrificing the provision of ecosystem services. Ecological Resilience is often associated with diversity – of species and ecosystems– that maintains and encourages both adaptation and learning. In general, ecological resilience derives from ecosystems that can be restored only slowly, such as reservoirs of soil nutrients, heterogeneity of ecosystems on a landscape, or variety of genotypes and species (Folke and Carpenter, 2002).

Ecological resilience typically depends on slowly changing variables such as land use, nutrient stocks, soil properties, and biomass of long-lived organisms (Gunderson and Pritchard, 2002), which are in turn altered by human activities and socio-economic driving forces (Lambin et al., 2001). The increase in social and economic vulnerability as a consequence of reduced resilience through land degradation and drought may cause losses of livelihood and trigger tension and conflict over critical resources such as fresh water or food (Homer-Dixon and Blitt 1998).

5. Constructing Socio-ecological Resilience

Resilience-building increases the capacity of a social-ecological system to cope with surprise. A changing, uncertain world in transformation demands action to build the resilience of the socio-ecological systems which embrace all of humanity. The need to account for resilience in a world of transformations is a perspective that should become embedded in strategies and policy of the World Summit on Sustainable Development has recognized in the next phases for implementation of Agenda 21 (Folke and Carpenter, 2002).

Building social-ecological resilience requires understanding of ecosystems that incorporates the knowledge of local users. Thus the ecological ignorance of some contemporary societies undermines resilience. The outdated perception of humanity as *decoupled from, and in control of, nature* is an underlying cause of society's vulnerability. Technological developments and economic activities based on this perception further contribute to the erosion of resilience. It can be counteracted by understanding the complex connections between people and nature, which create opportunity for technological innovations and

economic policies aimed at building resilience. Two useful tools for resilience-building in social-ecological systems are *structured scenarios* and *active adaptive management*.

(a) *Structured scenario*: People use scenarios to envision alternative futures and the pathways by which they might be reached. By envisioning multiple alternative futures and actions that might attain or avoid particular outcomes, we can identify and choose resilience-building policies.

(b)

(c) *Active adaptive management*: Active adaptive management views policy as a set of experiments designed to reveal processes that build or sustain resilience. It requires, and facilitates, a social context with flexible and open institutions and multi-level governance systems that allow for learning and increase adaptive capacity without foreclosing future development options. (Berkes, and Jolly, 2001)

Improved dialogue and coordinating mechanisms between Sustainable development and human systems will achieve greater balance between ecosystems and ecological Resilient. Our research shows that at least three general policy recommendations can be drawn from the synthesis of resilience in the context of sustainable development. The first level emphasizes the importance of policy that highlights interrelationships between the biosphere and the prosperous development of society. The second stresses the necessity of policy to create space for flexible and innovative collaboration towards sustainability, and the third suggests a few policy directions for how to operationalize sustainability in the context of socio-ecological resilience. Our research reveals that among several factors that have impacts on socio-ecological resilience, *management* if directed properly can better play its role to enhance our ecosystems resilience.

This is mostly because management that builds resilience can sustain social-ecological systems in the face of surprise, unpredictability, and complexity. Resilience-building management is flexible and open to learning. It attends to slowly-changing, fundamental variables that create memory, legacy, diversity, and the capacity to innovate in both social and ecological components of the system. It also conserves and nurtures the diverse elements that are necessary to reorganize and adapt to novel, unexpected, and transformative circumstances. Thus, it increases the range of surprises with which a socio-economic system can cope. (Folke, Holling, 1996)

6. Socio-ecological Resilience Management

Management can destroy or build resilience, depending on how the socio-ecological system organizes itself in response to management actions (Carpenter et al., 2001 and Holling, 2001). There are many examples of management suppressing natural disturbance regimes or altering slowly changing ecological variables, leading to disastrous changes in soils, waters, landscape configurations, or biodiversity that did not appear until long after the ecosystems were first managed (Holling and Meffe, 1996). Similarly, governance can disrupt social memory or remove mechanisms for creative, adaptive response by people in ways that lead to the breakdown of socio-ecological systems (McIntosh et al., 2000 and Redman, 1999). Successful ecosystem management for human well-being requires monitoring and institutional and organizational capacity to respond to environmental feedback and surprises (Berkes and Folke, 1998; Danter et al., 2000).

Managing resilience of desired ecosystem states is the most pragmatic and effective ways to manage ecosystems in the face of increasing environmental change (Scheffer et al., 2001). Resilience measures differ from most existing sustainability indicators. Resilience focuses on variables that underlie the capacity of social-ecological systems to provide ecosystem services, whereas other indicators tend to concentrate on the current state of the system or service. Management that monitors, clarifies, and redirects underlying; fundamental variables may succeed in building resilience, and thereby adaptive capacity.

By responding to and managing feedbacks from complex adaptive ecosystem, instead of blocking them out, adaptive management has the potential to avoid the pathology of natural resource management that threatens the existence of many social and economic activities (Holling and Meffe, 1996).

7. Bushehr as Case Study

The coastal region can be defined as the meeting point of land and sea. Each one of these – land and sea – possesses a distinct and different eco-system, cohabiting side by side. The environment of the coastal region has developed naturally through the ages, and is one of the most complex and rich ecosystems found on earth. Bushehr city in south of Iran usually is referred to as a “transfer and vulnerable ecological area”, since it is at this point, that pollution from the Persian Gulf effects the ecological environment of the land, and vice versa. Thus, the polluting factors of one or the other – land and sea – can create potential threats to the entire ecosystem of that region. (Nouri, 2007) research has focused on the importance of increasing Bushehr ecological resilience as one of the main "ecological sensitive areas" of Iran (figure 2).

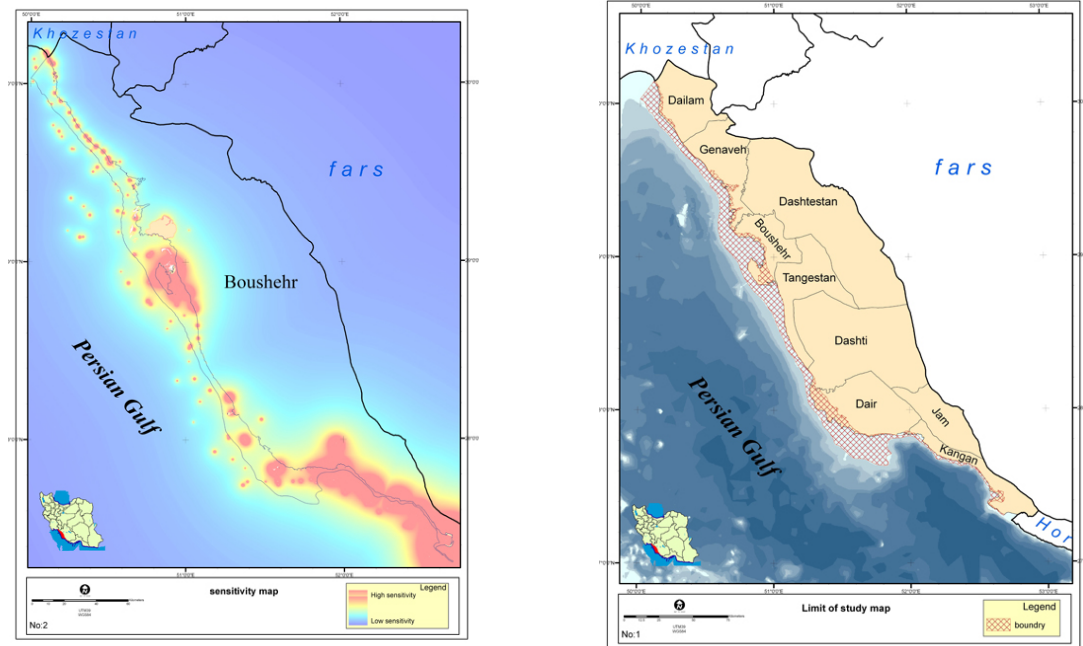


Figure 2: Sensitivity map of the northern coastal area Bushehr Province, (Nouri, 2007)

Generally “ecological sensitive areas” are known or defined as vital or critical ecological regions thus stressing their extreme importance, as well as their natural vulnerability. The value of these areas should be recognized as independent or as supporting factors of other habitats or species. This point of view has been influenced by, Grim Kalhor and Richard Chington’s (1992) opinions about sensitive habitats. Therefore, following sections of our paper aims to suggest several recommendations to enhance her ecological resilience through social management processes.

8. Bushehr Ecological Vulnerabilities

Our study revealed that the patterns and dynamics that shape the vulnerability of coupled socio-ecological systems in Bushehr are composed of a multitude of linkages and processes. As such, assessments of vulnerability need to be analyzed comprehensively in advance. Hence a number of observations relevant to attempts to assess and reduce vulnerability and to build resilience have been offered.

Human alterations of ecosystems and ecosystem services shape both the threats to which people and places are exposed and their vulnerabilities to the threats. Consequently, the same alterations of environment can have very different consequences, depending on the differential vulnerability of the receptor systems. Therefore, in the following, the driving conditions of vulnerability issues for Bushehr have been well characterized at least at a general level (figure 3).



Figure 3: Bushehr city in 1935 (Left), Current (Mid.) and prospectus Socio-ecological Resilient Bushehr (Rendered Image)

The main challenge for coastal cities such as Bushehr is to balance the requirement to achieve growth with the need to retain the existing character. This includes consideration for scale of development relative to the existing environmental context, views, access, transport and amenity. Currently many larger development applications before coastal councils in Bushehr do not consider their likely impact on the surrounding natural and urban context, infrastructure and sense of place. This leads to a number of issues including:

- Development inappropriate to the settlement's present and future demographic mix
- A lack of housing and business accommodation choice
- Inadequate services and provision for older people retiring to the coast
- limiting the city's long-term economic opportunities
- erasing the qualities that give the place its beauty, livability, lifestyle choices and make it a desirable place to visit
- Impacts on water quality
- Poor infrastructure integration and planning
- Unsafe and degraded pedestrian environments
- Privatization of streets, open spaces and the foreshores
- Lack of quality building construction and design
- Building inappropriate in scale, bulk and character with the city's streets, open spaces and existing buildings
- Buildings that are not energy efficient
- Locating buildings and infrastructure in areas subject to natural hazards.

9. Present Opportunities for Bushehr

We believe Bushehr city should offer a diversity of opportunities for growth and best practice, place-based planning that considers:

- protecting the qualities that attract people to coastal cities and set them apart from other locations along the coast
- Economic growth without compromising the city's amenity
- revitalizing city centers
- optimizing the efficient use of land and improving lifestyle choices
- improving public access and a diversity of uses along the coastal edge
- encouraging development in the main centers and suburban centers where it provides economic stimulus and allows for the efficient use of public transport, services and social infrastructure and cycle networks
- consolidating public facilities within the city centre
- complementing uses within neighboring settlements
- protecting and enhancing natural areas within the city
- improving building design and construction
- designing energy efficient and environmentally sound buildings
- providing a wide range of tourist accommodation types.

10. Desired Future Opportunities for Bushehr

We suggest Bushehr city to:

- grow and accommodate a larger working, residential and retirement population whilst maintaining the coastal virtues that make the place sought after.
- plan for urban opportunities whilst not creating continuous linear development along the coast. --optimize the efficient use of land, services and infrastructure to minimize impacts on the surrounding environment.
- reduce the pressure for expansion in more sensitive locations.

To achieve such goals and hence enhance its Socio-ecological resilient, it should consider 3 main issues:

- i) Relationship to the environment
- ii) Diversity as insurance
- iii) Edges to the water and natural areas

In the following section each factor has been detailed and some recommendations are suggested:

i) Relationship to the environment

The relationship of Bushehr city to the coast is improved by:

- planning to minimize expansion of city edges;
- extending, connecting and improving the open-space network and the public domain throughout the whole city for conservation, recreation, access and water management;
- protecting cultural places and relics and allowing interpretation, where appropriate;
- maintaining the pattern of settlement relating to the original geography, the foreshore and other natural features;
- Ecological links between the coast and the hinterland - negligible impacts on water quality in water bodies and sustainable water and waste water systems;
- ensuring soil areas on sites and within public land are maintained for water percolation and mature tree growth;
- Protecting existing areas of indigenous vegetation within the city for environmental, education and recreational purposes;
- enhancing micro-climatic conditions through landscaping and street trees.

ii) Diversity as insurance

Diversity plays a significant role in sustaining the resilience of ecosystems (Perrings et al. 1995, Peterson et al. 1998, Chapin et al. 2000, Loreau et al. 2001, Diaz and Cabido 2001, Kinzig et al. 2002). This role is related to the diversity of functional groups of species in a

system, like organisms that pollinate, graze, predate, fix nitrogen, spread seeds, decompose, generate soils, modify water flows, open up patches for reorganization and contribute to the colonization of such patches.

Resilience does not only depend on the diversity of functional groups in ecosystems. It is also related to the number of species within a functional group and the overlapping functions among groups. Species within the same functional group appear to respond differently to environmental change, a property we call response diversity (Walker 1989, Walker 1997, Ives et al. 1999).

Hence, a resilient ecosystem contains functional groups with several species that perform a similar function, but respond in different ways to environmental changes. In areas like Bushehr, where humans reduce response diversity by decreasing biodiversity and favoring monocultures, the capacity of ecosystems to sustain society with goods and services becomes more vulnerable to disturbances and environmental, social or political change.

iii) Edges to the water and natural areas

A variety of edge conditions exist between the city and the coastline that should be properly considered to reduce ecological disturbances:

- Access to and along the coast and the foreshore is optimized and designed to allow cultural and social opportunities
- Watershed management should be considered; (Kasperson, Dow, 2007)

A technical plan for the watershed in Bushehr district should be drawn up, be aimed at land treatment and drainage line treatment measures. Land treatment measures sought to reduce the loss of topsoil and to augment rainwater retention and biomass production. Measures such as embankments, earthen gully (channel) plugs, and agro forestry were to be deemed applicable to cultivated land, while it was deemed to be applicable to uncultivated lands.

- Drainage treatments should be suggested by the plan included mechanical measures such as the construction of dams and surface water storage tanks.

11. Conclusion

Many of the regions and peoples who will be affected are highly vulnerable and poorly equipped to cope with the major changes in ecosystems that may occur. Further, many people and places are already under severe stress arising from panoply of environmental and socioeconomic forces, including those emanating from globalization processes. Involved are such diverse drivers of change as population growth, increasing concentrations of populations in megacities, poverty, accumulating contamination of the atmosphere as well as of land and water, a growing dependence on distant global markets, growing gender and class inequalities.

In carrying out place-specific research in Bushehr, we have tried to develop an approach that involves (1) observing and analyzing the actual response of the community to the ecological changes, (2) evaluating these observations in the light of the adaptive strategies known to exist in that society, and (3) using these two streams of thought to generate insights about the resilience of the social-ecological system (the community and its resources) and further response options. One of the insights from this study is the key importance of participatory research in the production of knowledge that is based on social understanding. This example highlights one important reason why individual regions such as Bushehr, need to increase attention to resilience: to provide a buffering against effects of climate change.

Key attributes of resilience in complex adaptive systems of Bushehr include:

- Ecological resilience can be assessed by the amount of variability that can be accepted without patterns changing and controls shifting to another set of keystone processes.
- In an ecosystem keystone processes interact in an overlapping, apparently redundant manner. They should not be evaluated by the efficiency with which any one process

functions.

- Resilience within a system is generated through major changes and renewal of systems at smaller, faster scales.
- Essential sources of resilience lie in the variety of functional groups and the accumulated experience and memory that provides for reorganization following disturbances.
- Resilience also resides in slowly-changing variables such as soils, biological legacies, and landscape processes, which provide ecological memory and context for critical life processes.

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