Environmental Management

New Concepts

Dr Murtaza Ali
Editor

ENVIRONMENTAL MANAGEMENT
New Concepts

Editor
Dr Murtaza Ali
Center for Advanced Studies in Engineering
Islamabad

KOROS PRESS

KOROS PRESS LIMITED
London, UK

Environmental Management: New Concepts

Revised Edition 2014

Published by
Koros Press Limited
3 The Pines, Rubery B45 9FF, Rednal,
Birmingham, United Kingdom

Tel.: +44-7826-930152
Email: info@korospress.com
www.korospress.com

ISBN: 978-1-78163-287-1

Editor: Dr Murtaza Ali

Printed in UK

10 9 8 7 6 5 4 3 2 1

British Library Cataloguing in Publication Data
A CIP record for this book is available from the British Library

ENVIRONMENTAL MANAGEMENT

New Concepts

Preface

Environment Management Planning includes the identification of mitigation and compensation measures for all the identified significant impacts. It also involves the physical planning including work programmed, time schedule and locations for putting mitigation and compensation systems in place, delineation of financial plan for implementing the mitigation measures in the form of budgetary estimates and demonstration of its inclusion in the project budget estimates. Environmental resource management can be viewed from a variety of perspectives. Environmental resource management involves the management of all components of the biophysical environment, both living (biotic) and non-living (abiotic). This is due to the interconnected and network of relationships amongst all living species and their habitats. The environment also involves the relationships of the human environment, such as the social, cultural and economic environment with the biophysical environment. The essential aspects of environmental resource management are ethical, economical, social, and technological. These underlie principles and help make decisions. Environmental resource management strategies are intrinsically driven by conceptions of human-nature relationships. Ethical aspects involve the cultural and social issues relating to the environment, and dealing with changes to it. "All human activities take place in the context of certain types of relationships between society and the bio-physical world (the rest of nature)," and so, there is a great significance in understanding the ethical values of different groups around the world. Broadly speaking, two schools of thought exist in environmental ethics: Anthropocentrism and Ecocentrism each influencing a broad spectrum of environmental resource management styles along a continuum. These styles perceive "...different evidence, imperatives, and problems, and prescribe different solutions, strategies, technologies, roles for economic sectors, culture, governments, and ethics, etc."

Ecocentrists believe in the intrinsic value of nature while maintaining that human beings must use and even exploit nature to survive and live. It is this fine ethical line that ecocentrists navigate between fair use and abuse. At an extreme end of the ethical scale, ecocentrism includes philosophies such as ecofeminism and deep ecology, which evolved as a reaction to dominant anthropocentric paradigms. "In its current form, it is an attempt to synthesize many old and some new philosophical attitudes about the relationship between nature and human activity, with particular emphasis on ethical, social, and spiritual aspects that have been downplayed in the dominant economic worldview. The pairing of significant uncertainty about the behaviour and response of ecological systems with urgent calls for near-term action constitutes a difficult reality, and a common lament" for many environmental resource managers. Scientific analysis of the environment deals with several dimensions of ecological uncertainty. These include: *structural uncertainty* resulting from the misidentification, or lack of information pertaining to the relationships between ecological variables; *parameter uncertainty* referring to "uncertainty associated with parameter values that are not known precisely but can be assessed and reported in terms of the likelihood...of experiencing a defined range of outcomes"; and *stochastic uncertainty* stemming from chance or unrelated factors. Adaptive management is considered a useful framework for dealing with situations of high levels of uncertainty though it is not without its detractors. A common scientific concept and impetus behind environmental resource management is carrying capacity. Simply put, carrying capacity refers to the maximum number of organisms a particular resource can sustain. The concept of carrying capacity, whilst understood by many cultures over history, has its roots in Malthusian theory. An example is visible in the EU Water Framework Directive. However, "it is argued that Western scientific knowledge ... is often insufficient to deal with the full complexity of the interplay of variables in environmental resource management. These concerns have been recently addressed by a shift in environmental resource management approaches to incorporate different knowledge systems including traditional knowledge, reflected in approaches such as adaptive co-management community-based natural resource management and transitions management.

The primary aim of this book is to present a succinct account of the essential features of this subject. It is being prepared by keeping in view the requirements of the students and academic professionals.

—*Editor*

Contents

Chapter 1

Ecological Disturbance and Nature

The purpose of this chapter is to consider the role of disturbance as a crucial ecological consideration in landuse planning for nature tourism. Incorporation of ecological insights into the environmental-planning process offers hope for rational and sustainable development. Nature tourism has been proposed in recent years as a solution to the dilemma that developing countries face in conserving their biological heritage and concurrently improving the economies of local human settlements. In Mexico, nature tourism has become a favoured mechanism for development, especially on the Yucatan peninsula. Recognising the immense value of its coastal natural communities, Mexico has recently established several large biosphere reserves to preserve natural resources and to accommodate and support human settlements.

The experience of sprawling, high-impact Cancun, with more than one million visitors annually, has encouraged the government to reassess its development goals. One example of Mexican openness to sustainable conservation-development projects is the innovative, cooperative effort of Mexico, Belize, Guatemala, El Salvador, and Honduras to establish Ruta Maya, a low-impact design to promote tourism based on natural and archaeological treasures (Garrett 1989).

In the Yucatan, two long, relatively pristine barrier peninsulas, Rio Lagartos and Celestun, are being identified as opportune sites for nature tourism. Both have high conservation value and were designated special biosphere reserves by the government in 1979 because of their floral and faunal diversity. Both have small human settlements based on fishing and salt extraction. The protection concept known as the

Mexican modality, in which local villages can coexist with both conservation and tourism, is an ambitious development plan.

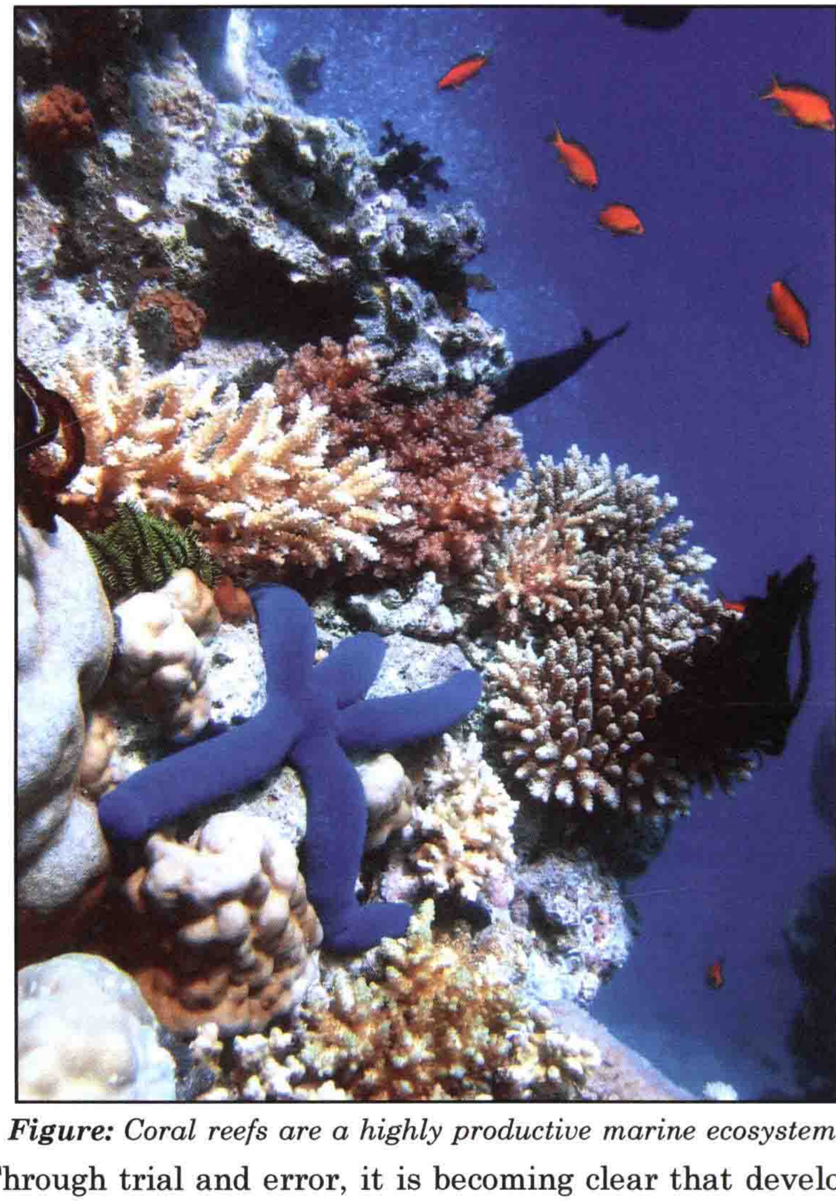

Figure: *Coral reefs are a highly productive marine ecosystem.*

Through trial and error, it is becoming clear that development must be guided by ecological understanding if degradation of natural systems is to be avoided. Sites worth visiting are often those that cannot endure heavy human use, and if irreversible environmental degradation results from nature tourism, both conservation of biological diversity and sustainable tourism will fail. Although political and economic considerations usually far overshadow ecological concerns, conservation of natural resources will not succeed if ecological insights are ignored in planning for nature tourism.

To retain the integrity of ecosystems, ecologists must convey the most useful information about the dynamic physical and biological contexts of natural communities, including information about the effects of human change on natural disturbance regimes. Important shifts in ecological theory in the past several decades could change perspectives on planning decisions. Fundamental models of community organisation throughout the history of ecological thought were rooted in the idea of equilibrium, and most principles applied to managing natural areas have been based on the notion of stability. Many recent empirical studies offer evidence that the natural world is not static, that natural disturbances are common to many environments, and that most landscapes are not in equilibrium, at least for the short term. Planners and developers of tourist facilities, along coastlines, for example, have mistakenly assumed that the physical context for hotels and roads was a stable place.

Recent Ecological Thought

From its beginnings, ecology has been the study of nature as a stable, orderly system. Natural communities that were undisturbed by people were generally thought of as pristine and immutable, composed of interdependent and harmoniously arranged species assemblages (Botkin 1990). This idea was based on a long tradition in Western culture that envisioned nature as orderly and was embodied in the phrase "balance of nature" (Glacken 1967). Largely through the writings of Frederick E. Clements (1916) early in the twentieth century, the notion of natural communities as naturally occurring assemblages of species in harmony with local climatic regimes became ecological dogma. If a community was disturbed, damage would be repaired along a predictable continuum towards the climax community. Later, equilibrium became an explicit assumption for most ecosystems, a steady state to which a system returned if a disturbance altered its balance (Connell 1978).

Dissenting voices proposed that species act independently of one another and that perturbation is a common event in many natural communities. Strong evidence for the commonness of disorder in nature has come from a large body of literature documenting the profound and pervasive effects of a multitude of disturbances—fires, floods, windstorms, alluvial erosion, landslides, grasing, insects, and invasion of exotics. It is now believed that all ecosystems are somewhat dynamic and that, in some, severe or even catastrophic disturbance is a regular occurrence. Natural disturbances were once assumed to retard the orderly progression of species replacement to a stable endpoint, a process known as succession; with sufficient time, it was argued, the climax assemblage would be reconstituted.

Natural systems are now regarded as influenced by factors such as variation in background climate and stochastic processes of seed availability, dispersal, and establishment, which can permit multiple pathways of succession on the same site (White 1979). In a nonequilibrium or kinetic model of community functioning, turmoil is the rule. To the extent that landuse planning has attempted to incorporate ecological principles into development plans, the effort has largely been based on equilibrium models. Planners and managers have sought to incorporate ecological principles in an effort to design and manage natural reserves and parks such that the preservation of natural processes and biodiversity would be maximised. The premier theoretical contribution of ecology to planning thus far has been island-biogeography theory.

This theory, which predicts the stability of numbers of species by rates of colonisation and extinction on islands, is a useful analog in designing nature reserves in areas of human settlement. Seeking to predict an equilibrium state of species numbers by size and distance from colonisation sources, the theory minimises the long-term effect of recurrent disturbance on species assemblages or the ability of disturbance to move the system to new equilibria. Recent attention to the role of disturbance in the context of the theory has not surmounted the problem that island-biogeography theory treats all species alike, simply as units of the system.

Similarly, inventories of biological systems for planning and preservation have relied on a one-time, descriptive inventory of species assemblages that assumes static, not dynamic conditions. Environmental-impact assessments, the usual forum for incorporating ecological concerns into planning, lack an explicit consideration of ecosystem change with time. A new branch of ecology, called landscape ecology because of its focus on interactions and functioning at a regional level, expands interest in change of spatial scale, not change with time. Rarely is the potential effect of humans on the system an explicit object of study in landuse planning. Where studies of disturbance in relation to natural-park management have been done, incorporating research findings into management or design schemes has not proved to be an easy task.

Human activities can alter natural-disturbance regimes or initiate novel disturbances that are often little investigated and poorly understood. Human activities are cumulative and interactive. If predicting and controlling human influences on natural-disturbance regimes in nature reserves have been minimal, there has been virtually no attention to the issue in planning for development, even where the explicit goal is preservation of nature.

Yucatan Biosphere Reserves

The relevance of a nonequilibrium ecological model in pragmatic strategies for environmental planning is illustrated by development trends on two coastal beaches on the Yucatan Peninsula. These coasts, fringed by biologically rich but fragile barrier beaches, are ideal and beautiful places for nature tourism. Two of the longest barriers are Celestun, on the northwestern coast, and Rio Lagartos, on the northern coast. Celestun encompasses 46,000 hectares and Rio Lagartos 58,000 hectares. The barriers extend along much of the peninsular coastline and protect shallow, brackish lagoons that connect to the sea through narrow channels. Precipitation ranges from 45 to 80 centimetres annually, but the porous calcareous soils derived from limestone give the region a semiarid character.

Temperatures are relatively stable year-round, ranging between 23 |degrees~ and 28 |degrees~ C. Gentle waves ordinarily lap the shores, because the tides have an amplitude of less than one metre in the Gulf of Mexico at Celestun and only slightly more towards the Caribbean Sea at Rio Lagartos (Spivey 1981). Both barriers were designated as reserves because of the exceptional habitat the resource-rich lagoons provide in winter for migrating aquatic birds. Rio Lagartos is the only site in Mexico designated on the List of the Convention of Wetlands of International Importance. Celestun, the fourth-most-important winter migration site in the Gulf of Mexico, hosts up to half a million overwintering waterfowl (Quiroz 1992).

More than two hundred thirty species use the site; among them are a great variety of ducks, geese, frigatebirds, cormorants, woodstorks, and night herons, as well as an endemic cactus wren and the Yucatan jay. Among the two hundred sixty species found at Rio Lagartos are the roseate spoonbill, the white ibis, egrets and herons, the Jabiru stork, the peregrine falcon, and an endemic turkey. Of special interest is the crucial habitat provided by the islands to a large population of Caribbean flamingos. The hypersaline lagoon at Rio Lagartos is the only permanent site in Mexico where flamingos breed, and from there they disperse along the coasts of the Yucatan.

Celestun attracts the majority of the flamingo population during the nonbreeding season; as many as twenty thousand birds feed on the rich waters of the lagoon during winter. These warm, protected waters also are a haven to a wide variety of coastal marine species. The threatened manatee and saltwater crocodile inhabit the lagoons. Hawksbill and green sea turtles, seriously threatened globally, nest on the sandy outer beaches in numbers considered important on a worldwide scale. Felids such as jaguars and ocelots have been sighted on land, while robust populations of fish and crustaceans such as shrimps, lobsters, and crabs feed in the extensive lagoon systems.

Conditions are harsher for vegetation communities on the barriers. Groundwater salinity and a shortage of surface freshwater create extreme conditions that mainland species do not tolerate well. The beaches have a great diversity of habitats: cattail beds, low-lying flooded cienegas, dunes, dry deciduous forests in the interior, and lagoon-fringing mangrove forests. Sand-dune communities are highly xeromorphic, halophytic, rich in endemics, and generally composed of pantropical and pioneer species typical of the Caribbean region (Sauer 1967). The protected inner dunes provide a habitat for palms and low broad-leaved trees, including rare Thrinax palmettos, cacti, and epiphytes. In the interior are groves of low deciduous forests with xeromorphic shrubs.

A crucial constraint of the physical environment is the distinctive hydrological regime of the peninsula. There is an absence of surface rivers on this coast, owing to the porosity of the limestone shelf that forms the peninsula. In the absence of freshwater rivers, the most important source of freshwater in the northernmost part of the Yucatan is a lens that slips northward towards the sea on a thin, nearly impenetrable layer of calcium carbonate about 0.5 to 1.4 metres thick. This aquifer, which is virtually the only source of freshwater for coastal communities, is thus confined to a layer about 0.5 metre above sea level and depressed to the seawater interface about 18 metres below mean coastal sea level.

The caliche-like layer retards the flow of freshwater into the sea and impounds as much as one-half of the aquifer (Perry and others 1989). This structure creates unusual and complex water relationships for the biotic communities of the coast. Generally, zones of water availability and salinity are arranged in narrow distributional patterns parallel to the beaches. A transect from the sea, across the barrier beach and lagoon into the mainland communities, crosses a fluctuating gradient of salinity. The beaches are exposed to periodic inundation of seawater during storms and salt spray, but dunes behind the beach are drier and less subject to spray because wind forces are ordinarily low. Interior low- and medium-height deciduous forests experience saltwater inundation only during storms.

The lagoon edges, both on the interior edge of the barrier islands and the mainland, are fringed with halophytic vegetation, primarily mangrove and salt-marsh communities, and the waters of the shallow lagoons are highly saline. The special hydrologic relationships of these barrier islands create a relatively delicate balance between biotic communities and physical constraints.

Disturbance

Storms are the preeminent natural disturbance influencing the biotic communities of these coasts. Two climatic disturbances are endemic: wintertime northern storms and rarer but more severe tropical hurricanes. About one dozen northerly storms with winds of at least moderate gale force penetrate to the southern gulf coast every year between November and April. The effect of these storms is relatively mild, but they can raise the gulf level by as much as a metre, knock down trees, and cause wave erosion in mangroves (Thom 1967). The impact of hurricanes can be much more severe, and they have long been recognised as a major agent in shaping vegetation communities in the Caribbean. They cross the Yucatan with relatively high frequency and can be expected to cross some part of the gulf coast of Mexico almost every year (Sauer 1967).

There is a gradient of hurricane damage—from most intense near the centre of a storm, where beaches retreat and vegetation is stripped from the littoral or killed, to the edges of the storm track, where mild defoliation and sediment erosion or deposition occur. Damage and death of plants can result from the physical beating by high winds, inundation, effect of boulders and debris moved by the storm, removal of substrate and exposure of roots, burying by sand or other substrate, uprooting, snapping, and effects of wind-driven seawater (Stoddard 1963). Killed trees are vulnerable to fire, and widespread burning can result, which slows community recovery. For animal populations, which can seek shelter, severe storms are less damaging. Damage is patchy and mostly takes the form of altered or lost food supplies and reduced sites for nesting, roosting, and foraging. Populations may be reduced, especially those of juveniles, but they tend to recover fairly quickly. If there are fires, slow vegetation recovery can cause a shift to animal populations that prefer open sites. Biological communities that evolve in the storm paths are evolutionarily adapted to respond to these periodic natural disturbances.

Mangrove communities, for example, are resistant to permanent damage; branches bend in high winds, and defoliated mangroves releaf rapidly. Palms, too, have flexible trunks and protected buds; even if defoliated, they display high survival rates. The short stature of all the vegetation is a reflection of periodic wind disturbance. Besides direct biotic effects, hurricanes can have important geomorphic effects, such as the potential for sediment erosion or deposition. Hydrologic effects, such as saltwater intrusion into the brackish lagoons, have consequences throughout the system. Ecosystem damage can result from altered salinity in lagoons and saltwater intrusion into the soils of the island interiors. Even small shifts in the distribution of saline water and freshwater can have large, if short-term, effects on the distribution of both plants and animal communities.

Recognition of the importance of hurricanes as a patterning agent of biological communities of the Yucatan was a consequence of Hurricane Gilbert in September 1988. The most powerful storm of the twentieth century in this region, Gilbert passed directly over the northern edge of the Yucatan, with gusts as high as 315 to 325 kilometres an hour. The mainland forests suffered heavy structural damage not only directly from the storm but also from extensive fires in the wake of the dry season. Still, many trees resprouted, and nutrients released from fallen leaves caused robust growth in the next wet season (Whigham and others 1991). In the natural state, these ecosystems have evolved a high degree of either resistance to destruction or resilience in recovery.

Human Interaction with Disturbance

Humans can have surprising and profound effects on how natural disturbances affect biotic communities. Human activities can change the scale of natural-disturbance events, increasing or decreasing the frequency or magnitude of some, and can create a directional rather than cyclic community change. By altering the scale of disturbance or intensifying the severity, humans can homogenise the landscape by reducing the number and variety of biotic elements. Even without the interaction of storms, inhabitants of small villages on Rio Lagartos and Celestun have adverse effects on plant communities, primarily mediated through the hydrological balance.

Early salt-gathering, which probably predated the Spanish conquest, required alteration of the barrier beaches and impoundment of waters of the lagoon. But water impoundment for salt gathering is currently intensifying for growing populations. On Rio Lagartos, this has already resulted in forest mortality from the unintentional flooding of inner-island forests with saltwater. Likewise, the construction of a new bridge from the mainland to Celestun has altered tidal patterns and created a zone of dead mangrove forest. Any human alteration of the terrain is likely to have an effect on the hydological balance. But the adverse effects of these changes are likely to be greatly exacerbated during severe storms.

A second bridge, built to connect Rio Lagartos with the mainland, illustrates the potential for destruction and unforeseen interaction of human structures with disturbance. The bridge trapped the storm surge forced into the lagoon by Hurricane Gilbert, which flooded and drowned large numbers of flamingo fledglings in their nests, although conservation of the species was a high priority. A series of potential changes for the barrier beaches can be expected with extensive development for tourism. Tourism can entail not only bridges but also buildings with foundations, roads, dikes, and buried pipes and sewer systems. The hydrological balance between saline water and freshwater is the component of the barrier-island system most vulnerable to this type of construction. The confined aquifer is the primary source of freshwater for the barrier-beach communities. If the confining layer is breached, a dramatic decrease in the thickness of the freshwater lens could result, with serious alteration of conditions for ecosystems.

Destructive effects of construction would be greatly intensified in the event of a major storm. Channels and construction would accelerate penetration of storm surges through and across the barrier peninsulas. Seawater would be forced into the freshwater lens through access created by construction. Precipitation runoff from roads and parking areas could increase the severity of flooding. Alteration of vegetation communities would lead to further changes in a kind of positive feedback. For example, removal of mangrove forests fringing the coast and lagoon eliminates a physical barrier buffering interior natural communities and exposes them to increased wind and salt disturbance. Direct effects of human use of plant communities, even walking on dunes and beaches, would accelerate plant diminishment. With reduced plant cover that follows extended human use of a landscape, depauperate communities would be further decimated with each subsequent storm (Linhart 1980).

The first step in integrating an awareness of natural disturbance into planning for development is a description of the nature and the