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Protected Areas in Pandemonium: Will optimisation of different values lead to sustainability?



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Source for Picture 1: Anonymous; Picture 2: Authors; Picture 3: San Diego Zoo.
The pictures depicts sustainability through 'mother and child', reflecting our concern for current and future generations.

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1.0 Introduction

The balance of nature in any strict sense has been upset long ago…The only option we have is to create a new balance objectively determined for each area in accordance with the intended use of that area[1]

Conservation of biodiversity through the creation of protected areas comes with several benefits, such as maintenance of gene pool, environmental services, scientific research and education, eco-tourism and recreation, and people's cultural and spiritual traditions. Directly or indirectly, these benefits have many values, which are important for the survival of human life.

This is also endorsed by the World Conservation Union (IUCN), which defines protected area as 'an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources'. As evident from this definition, a protected area has multiple values, which may be categorized as ecological, economic, and socio-cultural.

The ecological value of a protected area accrues from ecosystem goods and services it confers to the society. These may range from the conservation of biodiversity at ecosystem, species and genetic levels, to the maintenance of life supporting systems, such as watershed protection, carbon sequestration and evolution. The ecological value of protected areas is measured and monitored through indicators, such as species richness, ecosystem integrity, and ecosystem resiliency. These values are sine que non for human well being.

In contrast, the economic value of a protected area accrues from utility, which protected area goods and services provide to human beings. These values are a combination of use and non-use values. The use value of a protected area comprise of direct and indirect use values. While the former are derived from protected area goods, such as timber and non-timber forest products, the latter are derived from protected area services, such as watershed protection and nutrient recycling. They play an important role in maintaining the productivity of economic systems. On the other hand, the non-use values of a protected area comprise of existence and bequest values, and they encompass ethical and moral reasons for the conservation of biodiversity. Both use and non-use values can be measured through a variety of economic valuation techniques, such as hedonic pricing, travel cost, and contingent valuation. However, the measurement of indirect use values and non-use economic values still remains a challenge for the economists.

The socio-cultural value of a protected area accrues from religious, ethical, and cultural practices of human beings. These values are expressed through designation of species and forest patches as sacred, and development of social rules concerning their use. For many people, socio-cultural identity is also constituted by the ecosystems in which they live and on which they depend. Though socio-cultural values transcend utilitarian preferences and are often difficult to measure, they are nonetheless important.

[1] Aldo Leopold, 1927, in a letter to the Superintendent of Glacier National Park.

The multiple values of protected areas have a common denomination, which is rooted in ecosystem services. These services are indispensable for human society; without them, other values of protected areas will simply cease to exist. Despite this fact, the multiple values of protected areas are often believed to be conflicting and competing in nature. It is generally believed that enhancement of one-value leads to loss of another value. For example, strict conservation enforcement approach applied in managing the core of a protected area implies enhancement in its ecological value, but subsequent decline in its corresponding direct economic and socio-cultural value.

One may question, how did this view evolve? The insular and disciplinary approaches adopted in the 20th century for the creation and management of protected areas led to the emergence of conflicting and competing value concepts. The early conservationists, who were mainly biologists, believed that the sole purpose of protected areas was to conserve biodiversity. Consequently, protected areas were treated as exclusive zones where human activity, except for eco-tourism and scientific research, was not allowed. This insular interpretation, which was based on the inclusion of ecological values but exclusion of economic and socio-cultural values, resulted in the creation of protected areas as ecological islands amidst human dominated landscapes. It also often engendered people-protected area conflict.

The strict conservation approach, now mocked by some modern conservationists as 'colonialism of conservation', led to a gradual erosion of economic and socio-cultural values, and became opportunity costs for those who were adversely affected by this process. In late 1970s it began to emerge that the strict conservation approach failed even to maintain the ecological value of protected areas. Inadequate representation of ecosystems, small size of protected areas, and protected area isolation, resulted in the degradation of ecological values. This was further aggravated by poaching, pollution, and deforestation, pushing protected areas into a state of pandemonium.

However, over the fast few years, conservationists have changed their tone. It is now a well-established fact that multiple values of a protected area are interlinked and co-evolutionary in nature. This understanding has led to new developments in the conceptualization of protected areas. Consequently, the focus has now shifted from an emphasis on one value system to optimization of multiple values, such that all values are maintained and enhanced, pulling protected areas out from pandemonium to sustainability!

This paper is mainly an outcome of our limited experience in the field of protected area management. It reflects our perspectives on the selection of protected area optimization principles and the development of a framework, which links problems with optimization and different elements of protected area sustainability.

The paper is organized into four sections. Section one deals with the introduction and objectives of the term paper. Section two deals with multiple values of a protected area and problems resulting from the disintegration of these values. This is followed by section three, which includes different approaches and tools used in the optimization of protected area values. The fourth and the final section links optimization with protected area sustainability.

1.1 Aims and Objectives

This paper aims to identify different concepts of protected area values and different approaches used to optimize them. It also examines the larger question of whether optimization of different values leads to sustainability. Therefore, the objectives of this paper are multi-fold:

1. To analyze the main reasons behind the disintegration of protected area values leading to poor performance of protected areas.
2. To identify different concepts of values of protected areas and the use of these values in the designation and management of protected areas.
3. To identify different approaches and tools used in the optimization of different values of protected areas.
4. To analyze if optimization will lead to sustainable protected areas.

The main focus of this paper is on the problems related to the management of protected area values. Therefore, it does not take into consideration problems, such as institutional, international influences, education, training and capacity building of the park staff and so forth.

1.2 Methodology

The research paper is based on the review of publications available in the libraries and on the Internet, with additional and supporting inputs from interdisciplinary discussions.

Interdisciplinary discussions reflective of disciplinary background in environmental economics and conservation planning were used to ensure that various concepts of protected area values are taken into consideration. This divergence of interest was useful in identifying optimization approaches and in bringing in the strengths of the disciplinary backgrounds in a holistic manner.

1.2.3 Limitations

The study suffers from a few limitations, of note being:

1.There exist a wide variety of optimization approaches and tools. However, due to time constraints and page limit, only four optimization approaches and two tools are discussed in the paper.

2. An attempt has been made to develop optimization-sustainability framework. Given the fact that sustainability is a complex and evolving concept, the framework may not reflect all dimensions involved.

2.0 Protected Area Values and Value-Conflicts

This section discusses in detail different concept of protected area values and co-evolutionary nature of these values. It also analyses problems accruing from disciplinary approaches used in the past to manage protected areas, which resulted in the disintegration of these values.

2.1 The Concept of Value

There exist a variety of definitions and concepts of values, tailored by several disciplines for their individual needs. Some of these are given in the box below:

In *anthropology*, the concept of value is a social construct and is defined by the culture using the concept.

In sociology, value is concerned with personal values which are popularly held by a community. It is subject to change under particular conditions. Different groups of people may hold or prioritise different kinds of values influencing social behaviour.

In psychology, value refers to the study of the way in which human beings develop, assert and believe in certain values, and act or fail to act on them.

In economics, value arises from scarecity of goods and services, resulting in prioritising of different alternatives which are perceived to be possible for the individual.

Source: Wikipedia, 2005.

Based on these definitions, it may be concluded that value expresses the concept of worth in general, and induces individuals to act to gain or keep. It is connected to reasons for certain practices, policies, or actions. Hence, 'contribution of an action or object to user-specified goals, objectives, or conditions, may be defined as a value'. [WRI, 2003 cited in IUCN, 2004; Wikipedia, 2005].

2.2 Multiple Values of Protected Areas

IUCN defines protected areas as '*An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*'[2].

As evident from the above definition, protected areas have multiple values, ranging from ecological and economical, to socio-cultural and even intrinsic. Based on their utility to human beings, these values can be grouped into two broad categories, which may bear a different set of names, as, homocentric and ecocentric, or anthropocentric and non-anthropocentric values, or Instrumental and Intrinsic, or utilitarian and non-utilitarian values.

[2] This definition was subsequently expanded in 1998 by the IUCN World Commission on Protected Areas (WCPA) to give greater coherence to the role and scope of protected areas. The WCPA has now developed six modified categories of protected area, which are discussed in detail in section 3.2.

While the first term in each category denotes the value of protected area to human beings, the second terms denotes the value of the protected area in itself. For the sake of simplicity, this paper adopts the use of terminology: utilitarian and non-utilitarian to describe these values.

Utilitarian values: protected areas and the services they provide have value to human societies because people derive utility from their use, either directly or indirectly (use values). People also value ecosystem services that they are not currently using (non-use values). It is based on human preference or human well-being.

Non-utilitarian values: accrue from a variety of ethical, cultural, religious, and philosophical bases. Notable among these are ecological, socio-cultural, and intrinsic values. Non-utilitarian values complement or counter-balance utilitarian values.

There exist arguments in the way these categories are structured. Some scientists argue that all protected area values are human based, for anything we care about is in reference to our roles as human beings, even if these values include recognizing the equal rights of all animals and plants to coexist. Others argue that protected areas have a status beyond or outside human-based values, such as those reflected by the newly emerging discipline of Deep Ecology [Gregory, 1999].

This paper takes into consideration both the utilitarian and non-utilitarian values of protected areas, with a special emphasis on ecological, economical and socio-cultural values. These values are briefly discussed with a corresponding example.

2.2.1 Ecological Value

The ecological value of a protected area arises from ecosystem goods and services. These range from the conservation of biodiversity at all levels to the maintenance of life supporting systems, as watershed protection, carbon sequestration and evolution. All species provide some kind of function to an ecosystem. They can, inter alia, capture and store energy, produce and decompose organic material, help cycle water and nutrients, control erosion or pests, fix atmospheric gases, or help regulate climate. Ecosystems also provide support to production processes, which are important for human survival.

The magnitude of the ecological value is expressed through indicators such as species diversity, rarity, ecosystem integrity, and resilience. The determination of safe minimum standards regarding sustainable use of ecosystem services is based in part on the ecological value.

Example of Ecological Value: Khao Yai National Park, Thailand

Khao Yai national park is a mosaic of ecosystems, comprising of tropical rain forest, dry evergreen forest, hill evergreen forest, and mixed deciduous forest. This ecosystem diversity allows for a high plant genetic diversity. The park contains as many as 120 species of orchids and is the only protected area in Thailand, which is considered as a plant conservation priority site.

The ecosystem diversity of the park also harbors a rich diversity of faunal life, with more than 60 mammal species inhabiting the park. Some of these include, tiger, gaur, serow, white handed gibbon and pileated gibbon. The park also contains 295 species of birds, 18 species of amphibians and 35 species of reptiles. It is the only protected area in the world where the ranges of two rare apes, pileated gibbon and white hand gibbon overlap.

Besides supporting conservation of biodiversity, Khao Yai also plays an important role in regulating the water resources of the surrounding region. The park contains the water head of four main rivers, which provide clear water to settlement downstream. The clean quality of water is assured by the high percentage of forest cover in the park. Being located at a altitude of over 500 meters, the park is also crucial in the maintenance of watershed protection benefits. [Dixon and Sherman, 1991]

2.2.2 Economic Value

The economic value of a protected area accrues from the utility, which protected area goods and services provide to human beings. The economic value of a protected area is usually measured using a Total economic value (TEV) approach, which has the following components:

TEV = UV [DUV (CU + NCU) + IUV + OV] + NUV [BV + EV]

Use value (UV): can be split into three main categories: Direct use (DUV), Indirect use (IUV), and Option value (OV).

The direct use values of protected areas are of twp types: Consumptive use (CU) and Non-consumptive use (NCU). The consumptive use value is derived from goods, which can be directly consumed, such as timber, fuel wood, and bush meat, while the non-consumptive use value is derived from goods, which are not consumed, such as ecotourism. Direct use values are often the easiest to measure.

The indirect use value of protected areas, also known as functional value, accrues from ecosystem services provided by protected areas. For example: nutrient cycling, watershed protection, and carbon sequestration. These values are complex in nature and often difficult to measure. They are also the most significant economic value of protected areas and often their monetary worth exceeds direct use value by several times.

Finally, the option value of protected area accrues from maintaining the resources of the protected areas for future potential use. It is a special case of use value.

Non-use value (NUV): can be split into two categories: Existence value (EV) and Bequest value (BV). The existence value of a protected area is the value, which people derive from the knowledge that something exists, even if they never plan to use it. On the other hand, the bequest value is the value derived from the desire to pass on these values to future generations. The non-use values of protected areas are the toughest to measure and there exist many controversies on the reliability of the valuation techniques used to measure them.

Economic values are among the most studied values of protected areas. There exist several techniques, which can be used to capture them. Some of these include: Contingent valuation method, Travel cost method, Hedonic pricing, and Opportunity cost method.

Economic Value of Protected Area in Uganda

The use values of a protected area in protected area system in Uganda were estimated as:

Direct use value of timber (US$ 40 million), tourism revenues (US$ 16.3 million), non marketed community use of natural resources (US$ 33 million) and game utilization (US $ 0.7 million)

Indirect use value of watershed protection (US$ 13.8 million) and carbon sequestration and influence on local climate (US$ 17.4 million)

Option value of biodiversity for pharmaceutical industry and wild coffee genetic material (US$ 2.3)

Source: Peter Howard (1995, cited in IUCN, 1998)

2.2.3 Socio-cultural Value

People value protected area elements based on different conceptions of nature and society that are ethical, religious, cultural, and philosophical. These values are expressed through, for example, designation of sacred species or places, development of social rules concerning ecosystem use, and inspirational experiences.

For many people, socio-cultural identity is also constituted by the ecosystems in which they live and on which they depend – 'these help determine not only how they live, but who they are'. To some extent, this kind of value is captured in the concept of "cultural". To the extent ecosystems are tied up with the very identity of a community, the socio-cultural value of ecosystems transcends utilitarian preference satisfaction.

Socio-cultural Value of a Protected Area in Australia

Kakadu is Australia's largest national park and covers nearly 2 million ha. Half of Kakadu is owned by Indigenous people and most of the remaining area is land under Aboriginal land claim.

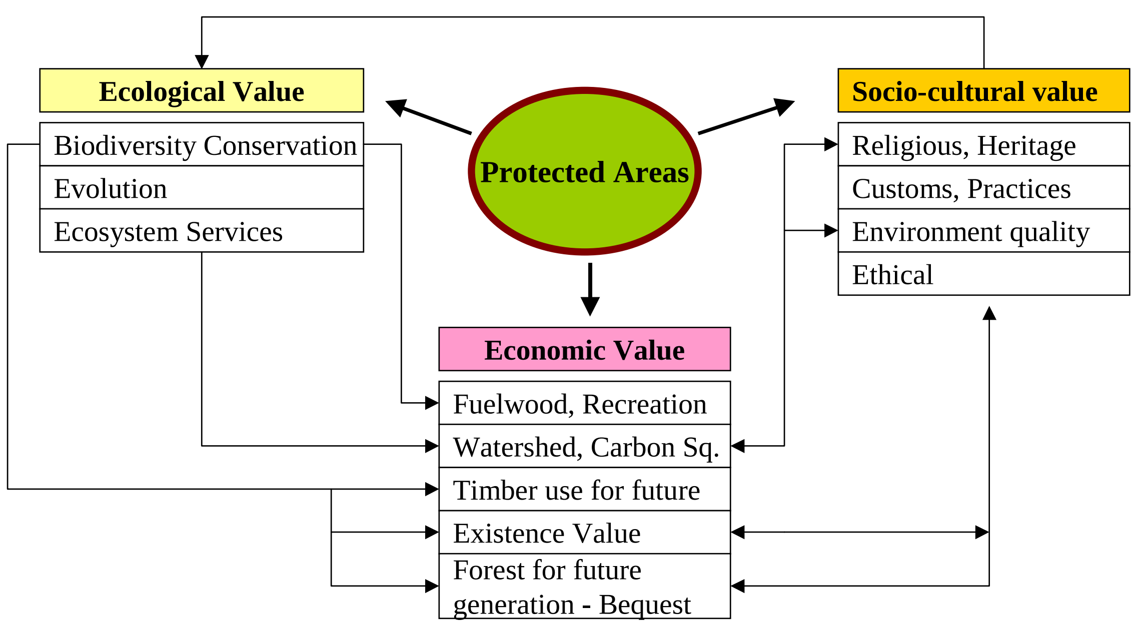
The park is an Aboriginal cultural landscape and is managed as such. It is also listed as a World Heritage area under natural and cultural criteria. Traditional owners are active partners in managing the park, and there are several language groups and a diverse and complex Aboriginal society in the park. The Park includes evidence that Aboriginal people have lived continuously in the region for over 50, 000 years.

Source: Department of Foreign Affairs and Trade. 2005. Indigenous Australians: Management of national parks and protected areas, Australian Government.

2.3 Interaction between Multiple Values of Protected Areas

As evident from Fig 1, the multiple values of protected areas are not confined into strict compartments but are often interlinked and co-evolutionary in nature. In most cases, enhancement in one value is often accompanied by enhancement in another value, though the degree of enhancement for each value might differ.

Fig 1: Interactions between multiple values of protected areas.



Source: Self construct, 2005

For example, ecosystem services provided by protected areas are important in the maintenance of watershed protection benefits, nutrient cycling, and soil fertility, which are important for the maintenance of the productivity of economic systems, such as agriculture. Ecosystem services provided by protected areas are also important in maintaining the environmental quality of human settlements. In return, socio-cultural values manifested as heritage and customs may contribute in maintaining the productivity of the ecosystem.

The co-evolutionary nature of protected area values is well illustrated through the case study of wildlife management by the Bishnoi community in the Thar Desert of Rajasthan, India. As part of its traditional and historical conviction, the community regards every life as sacred. This conviction is observed through the staunch protection of indigenous tree and animal species found in the region. Consequently, centuries of wildlife protection have resulted in the maintenance of ‘acacia green belt’ around the settlements.

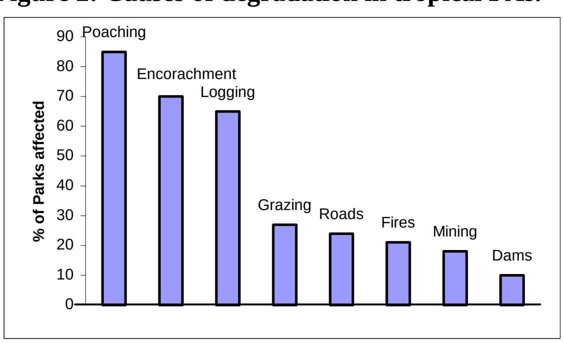
Despite the fact that the community lives in a desert area, their conservation practices have ensured them regular supply of water even at the height of the dry season. This helps the community to maintain agricultural production even during the dry season. In addition, the water bodies attract several species of migratory birds, as demoiselle cranes, and assist in the of the conservation of two endangered antelope species found in India, Black buck and Chinkara, both listed on Schedule I of the Wildlife Protection Act of India. Consequently, the socio-cultural conviction of the Bishnois has resulted in the appreciation of the ecological and economic values in the region.

2.4 The Problem

There exist more than 44,000 protected areas all over the world, which cover approximately 10% of the earth’s surface (Phillips 2000, WCMC 2002[3]), more than the area of India and China put together! However, a large percentage of these areas, mostly confined to the tropics of the world, remain as ‘paper parks’. They are not managed adequately or not managed at all, beyond being established on paper.

In a survey of 201 parks from 16 tropical countries, it was found that more than 80 % of these parks have problems due to poaching, 70 % have encroachment and logging problems, and over 25 % have problems due to overgrazing, road construction, and fire [Terborgh and van Shaik, 2002]. In a subsequent survey of 10 protected areas conducted by WWF in 1999[4], it was found that only one percent of forest protected areas are considered secure, and a quarter are suffering from degradation. A similar study across 93 protected areas in the tropics found that at least 20 % had experienced degradations in the past [WWF, 2001]. Consequently, it may be argued that protected areas in the tropics are in a state of pandemonium

Figure 2: Causes of degradation in tropical PAs.



Source: Terborgh and van Shaik, 2002

A look at Fig 2 reveals that most causes behind the degradation of protected areas are actually a result of interaction between protected areas and local communities. It may be questioned, why is this interaction leading to negative results? The answer lies in the disassociation and disintegration of the otherwise co-evolutionary values of protected areas, as a result of disciplinary management approach, which had its basis in the inclusion of ecological values and exclusion of direct economic and socio-cultural values [See Fig 3].

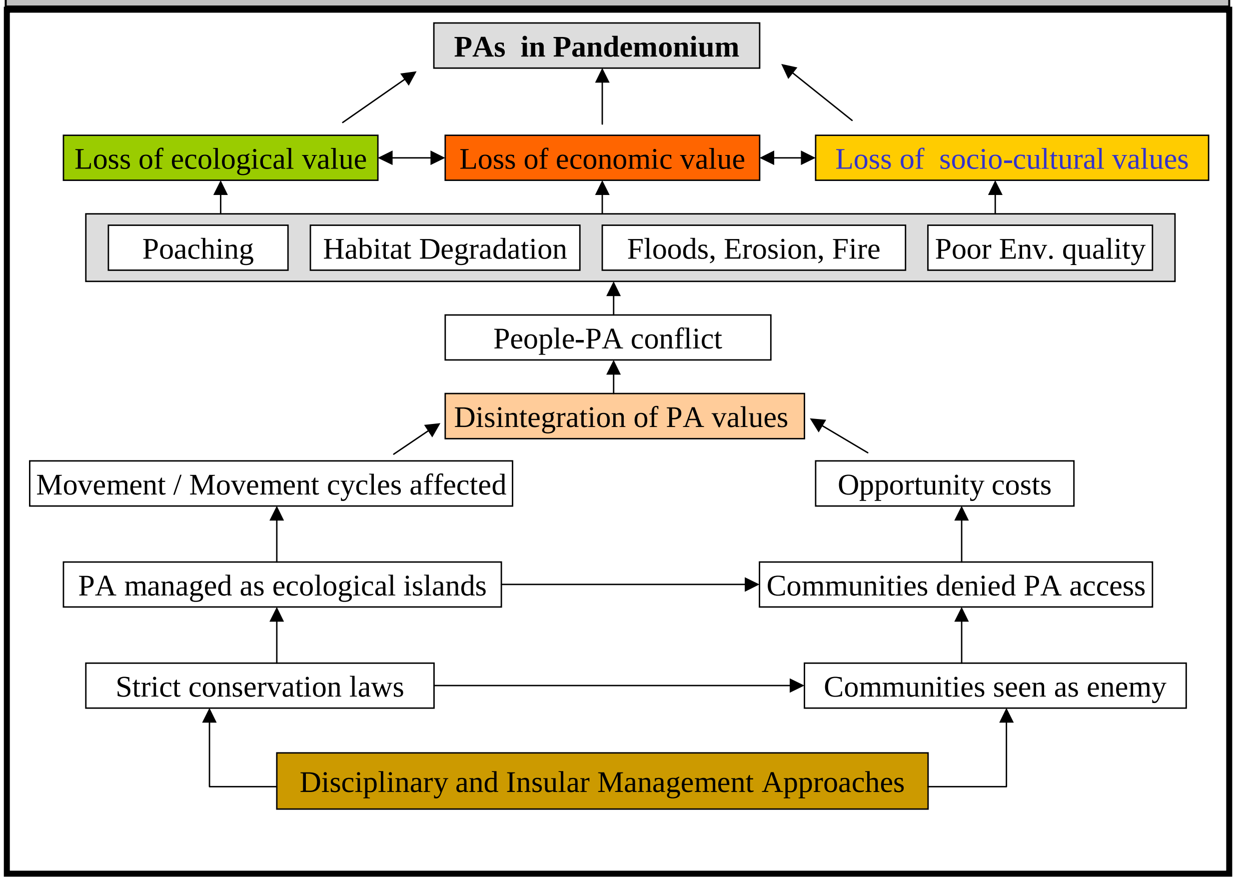
The initial effort to secure biodiversity conservation through the creation of protected areas was launched by biologists. Their understanding of the concept, role and scope of protected area was solely driven by the ecological paradigm, so much so, that it was seen as an end in itself. Consequently, a strict enforcement approach was adopted for the management of protected areas, which perceived local communities as enemies rather than as partners in the conservation process. The exclusion of the local communities from the conservation process resulted in the transformation of what was once direct economic and socio-cultural value to opportunity costs in the terms of opportunities forgone.

Traditionally, local communities use protected areas for their basic needs as food, fuel wood, and other non-timber forest products. But once the area is declared as protected, the locals lose access to the park. This is because the traditional management approach restricts any alteration of the protected area resources for human use and occupation. This restriction is kept on the ground by setting up boundaries of a protected area often marked by pillars, fences and other physical means. These barriers are to deter human beings and their livestock from entering the protected area. Any attempt to collect resources beyond the protected area boundary is treated as ‘poaching’ and is counted as an offence punishable under law. This insular approach to secure outright protection of biodiversity by taking control of resource management away from people who are most directly concerned about using these resources and on whom their survival depends has led to an emergence and growth of people-protected area conflict over the years, manifested in the form of illegal logging, hunting, and grazing.

The disciplinary approach to protected area management, led not only to the gradual erosion of direct economic and socio-cultural value, it subsequently led to a decline in the ecological value of the protected area. The pure enforcement approach led to the separation of the protected areas from human dominated landscapes, resulting in the development of protected areas as ecological islands. This had a major impact on the wide-ranging species, such as elephants and wolves, which traditionally require large areas for successful reproduction. The reduction in size of the protected areas also restricted movement of wild animals across the protected area boundary resulting in the isolation of the genetic pool. In addition, the movement of wildlife outside the protected areas often resulted in people-wildlife conflict. The erosion of ecological value has wider repercussions, because it implies loss of the total economic value as well as the loss of socio-cultural value, all of which have their denomination in the ecological values of protected areas.

Consequently there is a need to balance the different values of protected areas through an interdisciplinary focus. This can be achieved by optimization of protected area values.

Fig 3: The Problem Tree



Source: Self construct, 2005.

3.0 Optimization of Different Values of Protected Areas

Knowledge of hydrogen and oxygen does not give the whole story on water. Knowing the alphabet does not imply understanding of words, sentences or Shakespeare (Bingham, 2005).

Optimization is defined as maximum returns on investment. In the context of a protected area, it implies, biodiversity gains and socio-economic upliftment, ie, achievements of biodiversity targets while minimizing socio-cultural and economic opportunity costs. Therefore, optimization works at ecological, economic, and socio-cultural levels [World Bank/ GEF][5].

Optimization serves as an important step in the integration of multiple values of protected areas, structured around a core set of mutually agreed upon principles. It allows for dialogue between multiple perspectives, leading to a holistic approach to the management of protected area values. It helps to reestablish balance.

[5] cited in Berliner, 2000

3.1 Principles for Optimization of Protected Areas Values

Optimization of protected area values is guided by several principles, such as precautionary, stakeholder participation and distributive equity. Since optimization aims to balance different values of protected areas through a trade off between these values, it is important that the process of optimization is precautionary so as not to undermine a critical value, ignorance of which may lead to a disaster in the future. Likewise, it is important to have participation from different stakeholders to reflect their opinions before such a trade off is undertaken. Distributional equity is of special importance in the optimization process; to make sure that all values and all stakeholders are equally considered.

3.1.1 Precautionary Principle

The precautionary principle guides us to a response, be it justifying action or proscribing inaction, to a potential threat to human health and environment, before it happens. It involves taking action to prevent serious and irreversible threats, despite scientific uncertainty about the likelihood, magnitude or causation of that threat. It is based on the belief: "When in doubt, err on the side of caution." [Cooney, 2005].

Precautionary principle is currently being used to enhance the management of protected areas by integrating science with uncertainty, communities, and conservation. For example, it was adopted as one of the principles in the conservation of Rare Rocks Marine Protected Area in Victoria, Canada. In this case, the responsibility to demonstrate that there will be no damage to the marine ecosystem from proposed activity was shared with any individual, organization or government agency conducting activities within the park.

Since ignorance of one or the other form of value of protected areas often generates conflicts and threats which endanger the very existence of protected areas, the precautionary principles guises policy makers and protected area managers towards taking integrative actions in advance before the disaster strikes.

3.1.2 Stakeholders Participation

Multiple values of protected area imply multiple stakeholders, which may range from ecologists and anthropologists to economists and animal rights organizations. To optimize different values of protected areas, it is important to have each stakeholder opinion represented through a participatory process. This not only leads to the inclusion of divergent and conflicting values, but also accounts for values, which as explained in Fig. 2 are interdependent and co-evolutionary.

Though, participation encourages management decisions that contribute to the long-term well-being of different stakeholders and hence the natural environment, which protected areas, intend to conserve, identification of all stakeholders is not always an easy task. This is especially true when the protected area in consideration is large, diverse, and transnational.

Even though, encouraging participation of multiple stakeholders in the identification, planning and management of protected areas is often time consuming and difficult, it is one of the key principles in the optimization of protected areas.

3.1.3 Distributional Equity

Ecosystem values are only one of the bases on which decisions on ecosystem management are and should be made. Many other factors, including notions of intrinsic value and other objectives that society might have, such as equity among different groups or generations, will also feed into the decision framework.

As evident from the above quote, the principle of distributional equity calls for taking into consideration the manner in which resources and property rights are distributed among (a) different social groups in the same generation – Intra-generational equity, (b) groups in different generations - Intergenerational equity, and (c) between humans and nonhumans - Interspecies equity.

The focus of distributional equity stands in contrast to the utilitarian focus. Since utilitarianism ignores how benefits and costs are distributed among individuals and groups, it is possible for a set of actions to be economically efficient but inequitable from an intra-generational, intergenerational and interspecies viewpoint. In contrast, distributional equity, which may be pursued using an intrinsic rights approach, accords all living objects the same rights regardless of their benefits to humans.

Therefore, distributional equity aims to accord equal status to all values of protected areas and serves as an important principle in the optimization of multiple values of protected areas. Though this principle acts as a guiding principle in the optimization of protected area values, a trade off eventually involves marginal gains and losses in one or the other value to compensate for the relative importance of multiple protected area values.

3.2 PA Optimization Approaches

There exist a range of optimization approaches, which can be used to balance different values of protected areas. Most of these approaches involve trade off between different values, and thus help reduce the severity of conflicts and opportunity costs imposed by different stakeholders on each other. Some of these approaches are discussed below:

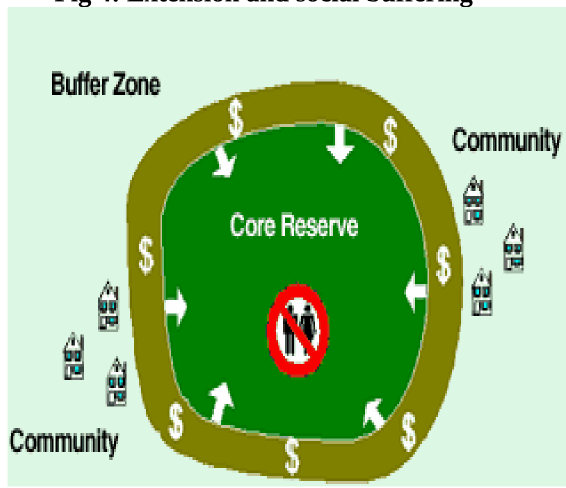
3.2.1 Buffer Zone Approach: creation of buffer zone around protected areas assists in the optimization of the ecological, economic and socio-cultural values of protected area, through extension and social buffering of the protected area. These are given in the box below:

Extension buffering: extending the area of habitats protected in the protected area into the buffer zone, allowing larger breeding populations of plant and animal species.

Socio-buffering: wildlife management is aimed primarily at providing products of use or cash value to local people as long as this does not conflict with the objective of the protected area itself. [See Fig 4]

[Paudel, 2002; Heinen and Mehta, 2000]

Fig 4: Extension and social buffering



Source: BCP, 1999.

Ecological Values

The ecological or biological benefits of buffer zones occur mainly from the territorial expansion of the protected area that keeps human impact further away. The territorial expansion is particularly important for the conservation of species with wide-ranging habitats and high mobility [Barzetti, 1993]. In addition, buffer zones also play an important role in increasing the population of rare and common species by soft edge effect [Shaffer, 1999]. They also provide breeding grounds and corridors for the migration of several wild species. Some of the ecological benefits accruing from buffer zones are listed below:

a. Filter or barrier against human access and undesirable use of core zone of the protected area.
b. Protecting core zone from invasion by exotic species of plants and animals.
c. Providing extra protection against storm damage, erosion, drought and other forms of damage.
d. Extension habitat and increasing the population of large wide-ranging species in the protected areas.
e. Enhancing environmental services provided by the reserve, such as watershed protection benefits, nutrient recycling and carbon sequestration.

[Barzetti, 1993; Shafe, 1999; Ebregt and Greve, 2000]

Socio-cultural Value

One of the main objectives for the creation of buffer zones is to provide socio-economic benefits to the local communities living on the fringe of the buffer zone. Consequently, buffer zones target conservation with recognition of the legitimate needs of the people. In general, buffer zones provide following social benefits:

a. Providing flexible mechanism for resolving conflicts between local communities and conservation.
b. Improving earning potential of the local communities.

c. Improving the quality of the environment of local people.
d. Building local and regional and local support for conservation program
e. Safeguarding traditional land rights and culture of local people.
f. Providing a reserve for plant and animal species for human use and for restoring species, population and ecological protection in degraded areas.

[Ebregt and Greve, 2000]

Economic Value

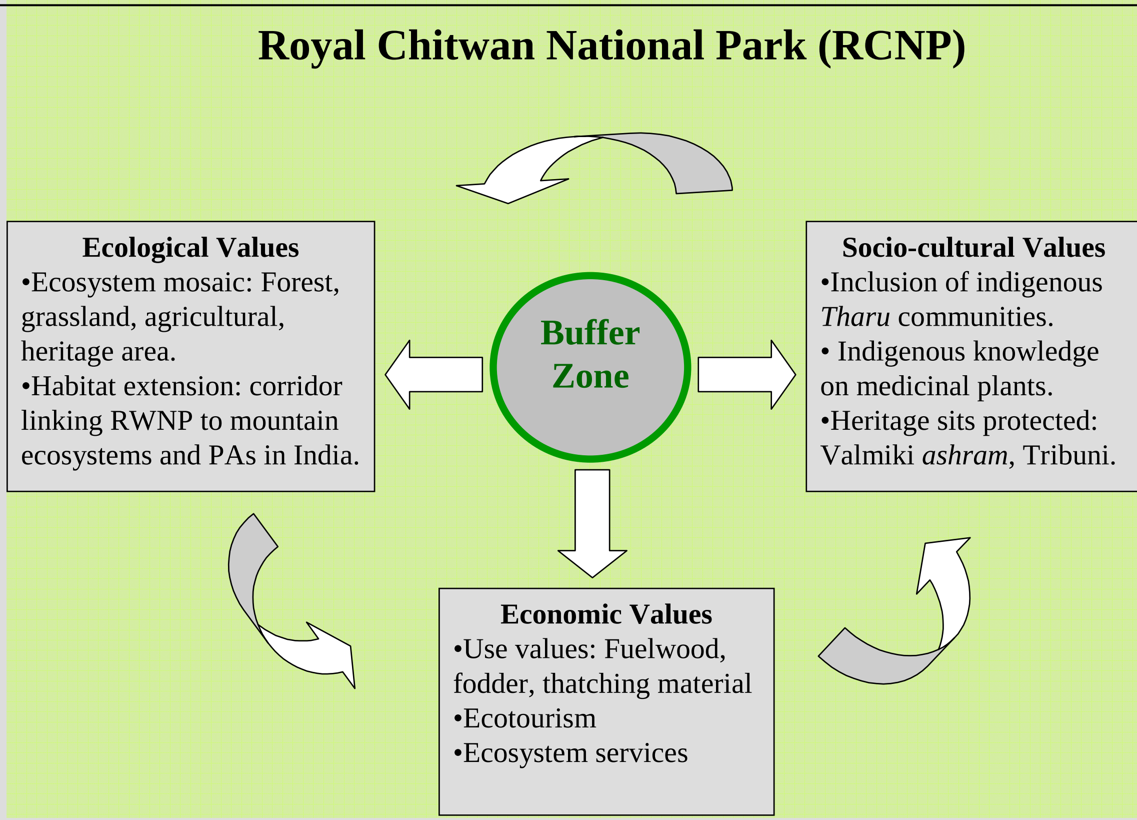
The economic benefits accruing from the establishment of buffer zones have both ecological and social components covered in it. For instance the economic value accruing from the maintenance of watershed protection benefits is essentially ecological in nature, whereas the economic value accruing from consumptive use benefits is more community specific and hence has a social characteristics attached to it. The economic benefits mainly include:

a. Compensation to people for loss of access.
b. Increasing benefits from protected areas for direct users such as, income from tourism, resource permit fee from scientists, income of locals employed in the area.
c. Increasing value of protected areas from indirect use, such as protection of the buffer zone and watershed protection.
d. Increasing the value of protected areas for non-users, such as existence value and bequest value.
e. Increasing the value of direct use benefits such as consumptive use benefits

[Ebregt and Greve, 2000]

The role of buffer zone approach in the optimization of different values of protected areas is well illustrated by the case of Royal Chitwan National Park (RCNP) in Nepal [See Fig 5]. A buffer zone on the periphery of RCNP supports a mosaic of ecosystems, ranging from forests and grasslands to agricultural lands to heritage areas. This mosaic of ecosystems provides an important animal refuge and corridor for linking RWCP with wider mountain ecosystems to the north of the park and wildlife sanctuaries in India on the south. In addition, the buffer zone provides local communities with NTFP, as fuel wood and fodder. It is also an excellent mosaic of various ethnic tribes, both indigenous as well as hill migrants. The cultural values associated with them are impressive and an expression of good blend of values. The local communities possess wealth of knowledge on the use and management of biodiversity. The indigenous *Tharu* communities use more than 150 species of plants for various medical purposes. Besides, park and buffer zone areas are also known for various cultural and historical sites. Among them *Bikram Baba* temple, Balmiki Ashram, and Tribani are most popular and are visited annually by thousands of Nepalese and Indian pilgrims [Paudel, 2002].

Fig 5: Role of Buffer Zone in Optimizing RCNP Values



Source: Self construct, 2005

Though successful in some cases, the buffer zone approach has met with limited success in several parts of the world. This is mainly because the approach requires considerable cooperation among different stakeholders and active participation of the local communities. Other challenges include decentralization and empowerment of local communities to carry forward the process.

3.2.2 Bioregional Approach through PA Classification: In explicit recognition of the multiple values of protected areas, the IUCN came out with six different categories in 1998. The classification aims to make maximum use of forest products, while ensuring persistence of biodiversity. The six categories are given in the box below:

IUCN Protected Area Categories and key Selection Criteria

Category I a: Strict nature reserve/wilderness protection area managed mainly for science or wilderness protection - an area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring;

Category Ib: Wilderness area: protected area managed mainly for wilderness protection - large area of unmodified or slightly modified land and/or sea, retaining its natural characteristics and influence, without permanent or significant habitation, which is protected and managed to preserve its natural condition.

Category II: National park: protected area managed mainly for ecosystem protection and recreation - natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Category III: Natural monument: protected area managed mainly for conservation of specific natural features - area containing specific natural or natural/cultural feature(s) of outstanding or unique value because of their inherent rarity, representative ness or aesthetic qualities or cultural significance.

Category IV: Habitat/Species Management Area: protected area managed mainly for conservation through management intervention - area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats to meet the requirements of specific species;

Category V: Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation or recreation - area of land, with coast or sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

Category VI: Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural resources - area containing predominantly unmodified natural systems, managed to ensure long-term protection and maintenance of biological diversity, while also providing a sustainable flow of natural products and services to meet community needs.

Source: Nigel and Dudley, 1998.

Table 1: IUCN Protected Area Categories and key Selection Criteria

IUCN Category	Name	Strict Protection	Level of Use	Conservation Value	Livelihood value
1a	Scientific reserve	High	Low	+++	0
1b	Wilderness area	↑	↓	++	0
II	National park			+++	Low
III	Natural monument			+	?
IV	Habitat species management			++	Low
V	Protected area landscape			+	High
VI	Multiple resource area	Low	High	+	Very high ↓

Source: Berliner et al, 2000.

As evident from the Table 1, the bioregional approach aims to optimize protected area values is either through prioritizing most important values of a protected area or through linking several categories of protected areas to represent a bioregion or landscape. For example, in case of a protected area, which harbors critically endangered species, such as tiger or the giant panda, the highest importance is assigned to the ecological value of the area. The opportunities for the development of direct economic and socio-cultural values are constrained to provide maximum protection to the species; indirect economic values, such as carbon sequestration are nonetheless maintained, and if the species is considered as a part of heritage in a certain culture, its socio-cultural value may also be maintained, for instance, tiger in Hinduism.

Likewise, some protected areas are developed for the fulfillment of mainly socio-cultural values. For example, the creation of protected area along the Inca road in Peru gives primary importance to the maintenance and enhancement of socio-cultural values, though needless to say, other values are automatically maintained or enhanced.

Though comprehensive, the IUCN's protected area categorization approach suffers from several limitations. It is not always possible to segregate protected areas on the basis of priority values. In some case a protected area with high ecological priority may also offer high economic and socio-cultural values. For instance, in the densely populated Terai region of India and Nepal, the protected areas have high ecological, economic and socio-cultural values. By the virtue of the fact that these areas represent highly endangered Terai ecosystem of the world, they acquire high ecological value. At the same time their location at the foothills of the Himalayas makes them critical in the maintenance of watershed protection function, vital for the agricultural productivity of the region. The region is also inhabited by several indigenous communities, who view protected areas as part of their heritage. In such a case, it may become difficult to apply the IUCN categorization approach. But, this limitation can be tackled through the creation of two or more categories of protected areas, which are likely to work as multiple resource areas.

This is best observed in the bioregional map of protected areas in southern Tanzania, which together covers an area greater than the size of the Netherlands [See Map1]. The map shows how different categories of protected area permit multiple uses in correspondence with the multiple values of protected areas. The protected areas interconnected in this bioregion include:

1. <u>Selous Game Reserve</u>: It combines ecotourism in the Northern Sector, game hunting in the other sectors, scientific research and education and biodiversity conservation, with a special focus on elephants, rhinoceros and wild dogs.

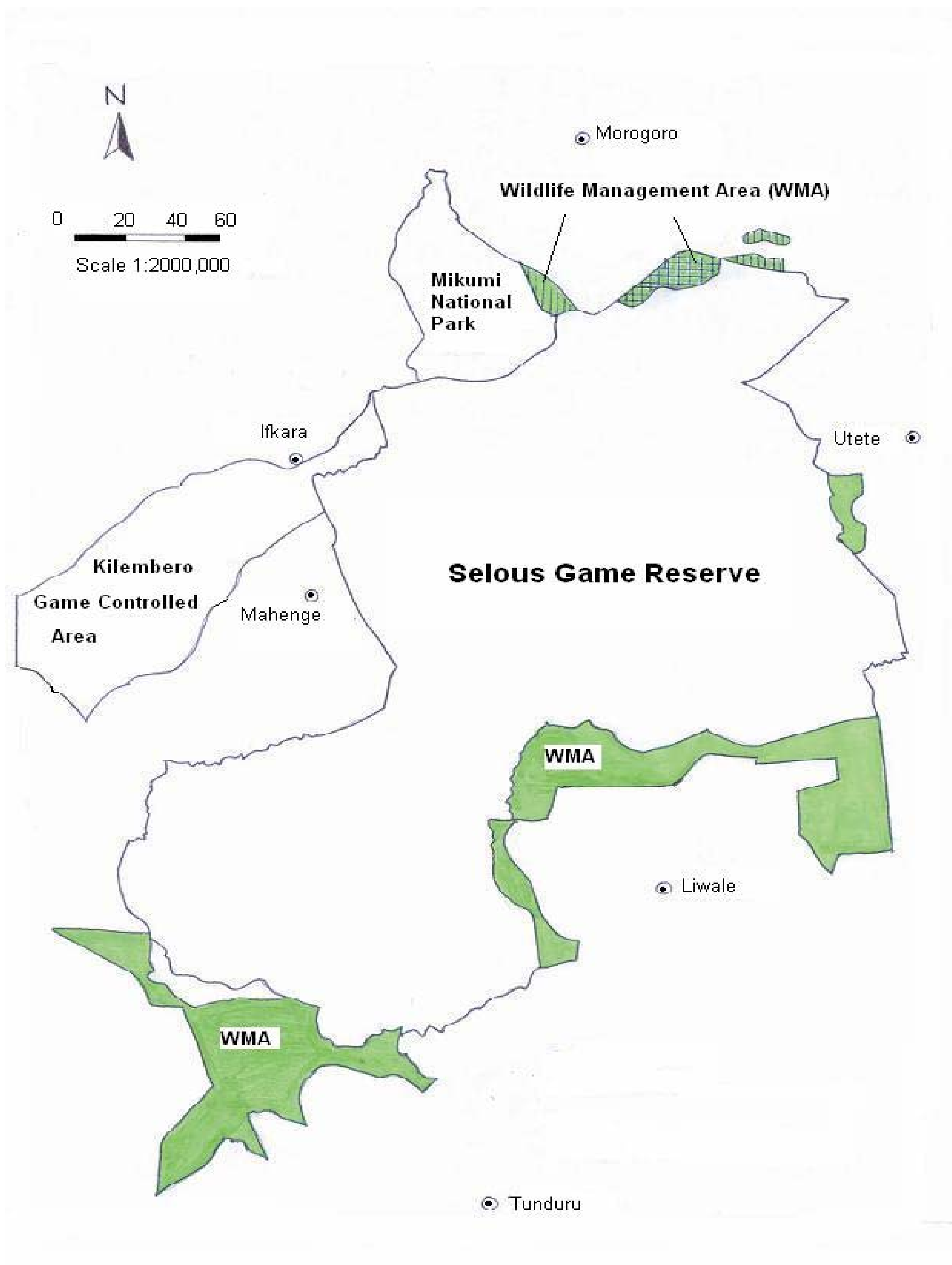
2. <u>Mikumi National Park</u>: It combines scientific research and education with ecotourism and biodiversity conservation.

3. <u>Kilembero Game Controlled Area</u>: As its name suggests, it provides opportunities mainly for game hunting and biodiversity conservation, with limited opportunities for eco-tourism.

4. <u>Wildlife Management Areas</u>: they provide for the needs of the local communities, through the provision of bush meat, thatching material and fodder. There also exist at times opportunities for ecotourism.

The interconnection of the protected areas also provides large habitat areas for wide ranging species, as elephants, wildebeest, zebra, wild dogs, and buffaloes, for which the Selous game reserve is well known.

Map 1: Different Categories of Protected Areas in Tanzania



Source: Based on map prepared by A. Cauldwell, 2000.

3.2.3 Adaptive Management Approach

Adaptive management is a technique in which policymaking is designed through an interactive process, which may be an experiment created on purpose or monitoring of a policy for its intended and unintended effects. Accordingly, there are two types of adaptive management techniques: passive and active.

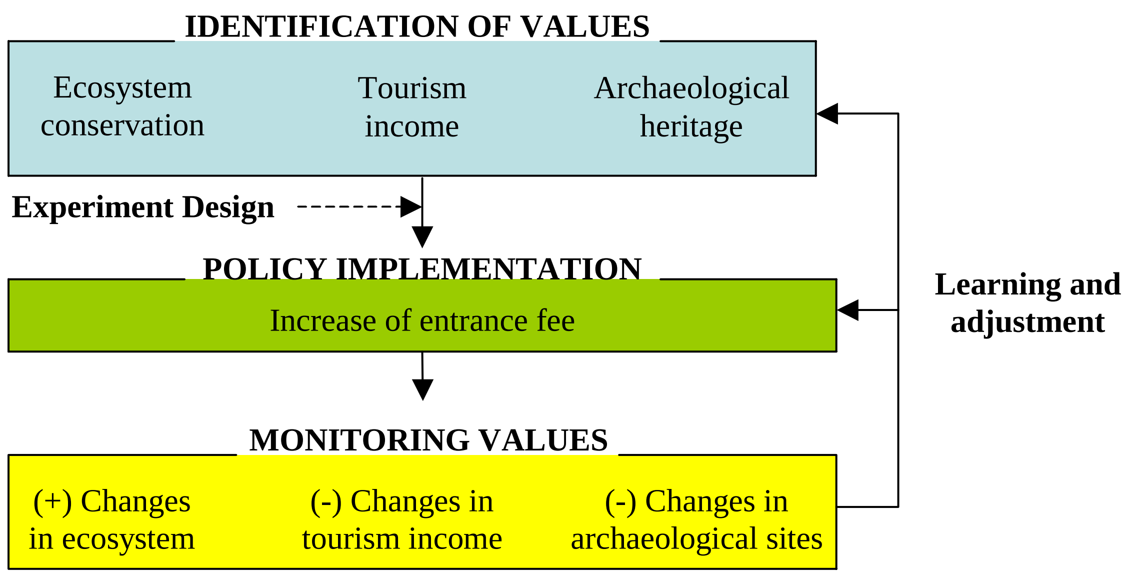
Passive adaptive management involves use of models to predict ecosystem response to management actions, take management decision based on these models, and continuously update such models on the basis of ecosystem responses. Though, it is easier and less expensive to apply than active adaptive management, it lacks statistical validity.

Active adaptive management uses statistically designed experiments to test assumptions or hypotheses about ecosystem response to management actions. Experimental results are used to determine whether a particular management action achieves a desired outcome, for example, recovery of an endangered species. Active adaptive management is best carried out by a collaborative working group that identifies desirable outcomes for a protected area ecosystem; determines feasible management actions for achieving those outcomes; compares the social, economic, and ecological consequences of management actions based on experimental results and other information, and selects preferred management actions.

The use of adaptive management approach, whether active or passive, in the optimization of protected area values, requires identifying different values, incorporating them into decisions, managing strategically to optimize the values, monitoring the values, and adjusting management actions according to the monitoring results. Consequently, in the adaptive management approach, policies are appropriately abandoned, adjusted, or fine-tuned in an ongoing effort to develop an effective and efficient system in an ever-changing world. This is especially relevant in the case of protected area management, because the latter is often associated with some level of uncertainty, at both ecosystem response to human actions and change in human behavior and attitude over a period of time. In this situation, the use of adaptive management approach assists protected area managers and decision-makers to continuously gather and integrate appropriate ecological, economic, and socio-cultural values.

As evident from Figure 6, three main values of protected area are identified by the stakeholders. Under an active adaptive management scheme, an experiment is designed, and a new fee policy is implemented which involves the increase in the entrance fee amount. The expected outputs are a substantial decrease in the number of tourists with positive changes in ecosystem conservation, negative changes in tourism income in local communities (restaurants and hotels) and negative changes in archaeological sites due to less central governmental investment in their restoration. The continuous monitoring of the change in values provides the information to adjust the policy to minimize the negative changes and account for unexpected results (for example: no significant positive changes in the ecosystems in different time periods). New values could also be identified due to they were overlooked during the first evaluation or they could emerge during the policy implementation.

Fig 6: The process of adaptive management



Source: Self construct, 2005.

Adaptive management was used in optimizing multiple values of the Banff National Park in Alberta, Canada. The technique is being used to provide high–quality experiences to visitors in the Park, without increasing stress on ecological integrity of the Park. This plan is being developed using a passive adaptive management approach, where the monitoring phase is guided by an advisory committee comprising of multidisciplinary experts [Prato and Fagre, 2005].

Although adaptive management approach offers an advantage in optimization of protected area values under conditions of uncertainty, it suffers from several limitations. Some of these include: long term time needed to capture the relatively slow response to human interventions, need to balance between risk of adverse consequences with maximizing the information value of experiments, lack of politician support due to potential adverse public reaction to failed experiments, and high costs related to experiments.

3.2.4 Holistic/ Ecosystem Management Approach

Holistic management again reflects the view that different values of the protected area are interconnected and co-evolutionary in nature. Therefore, ecosystem, including human economic activity cannot be studied or managed on a piecemeal basis. It intends to fill the void and gap in the past research, policy and management approaches which have focused on isolated practices, such as laws to protect a particular endangered species or research on the productivity of a particular plant [Bingham, 2005].

The holistic management approach was developed by non-profit Allan Savory Center for Holistic Management. It rests on four axioms:

a) The condition of the resource reflects the management and there are no excuses for it.
b) Management means management of ‘wholes’, which have characteristics, not present in, or in predictable from, their constituent parts being studied in isolation.
c) In complex, self-organizing systems and processes, the relationship patterns of ‘wholes’ are the only constants and therefore are the focus of research and management.
d) Management, being a human endeavor, must have a goal, such as an assumption of a better state. [Bingham, 2005]

An example of holistic management includes the management of federal lands in the U.S. which has shifted from focus on individual resources like timber, minerals, forage for livestock, and scenery to holistic management of multiple resources [Franklin, 1993, cited in Prato and Fagre, 2005].

Holistic management may be criticized for ignoring important issues or not going deeply enough into specific themes. Our particular disciplinary and professional perspectives often focus attention on certain issues and blind us to others. Interdisciplinarity is in itself difficult to achieve given the resources available. Interdisciplinarity poses serious financial constraints on a program because of the necessity to fund individuals representing the number of disciplines required for adequate problem identification and sufficient exchange of ideas and perspectives. Furthermore, there is a need for greater flexibility in financial management of projects working to empower local populations. The iterative process of bringing all stakeholders to consensus does not follow a set schedule [More et al, 2005].

Holistic/ecosystem management encourages practices that enable human beings to obtain necessary economic and socio-cultural values using methods that protect ecological values. In the commercial shrimp trawling industry, for example, holistic/ecosystem management techniques protect loggerhead sea turtles.

When scientists learned that commercial shrimp trawling nets were trapping and killing between 5000 and 50,000 loggerhead sea turtles a year, they developed a large metal grid called a Turtle Excluder Device (TED) that fits into the trawl net, preventing 97 percent of trawl-related loggerhead turtle deaths while only minimally reducing the commercial shrimp harvest. In 1992 the National Marine Fisheries Service (NMFS) implemented regulations requiring commercial shrimp trawlers to use TEDs, effectively balancing the commercial demand for shrimp with the health and vitality of the loggerhead sea turtle population.

[Encarta®. “Ecosystem Management]

3.2.5 Mix of Adaptive and Holistic Management - Participatory Landscape/ Lifescape Appraisal (PLLA)

Another manner to optimize protected area values is to joint adaptive and holistic management principles into a new approach, such as PLLA. PLLA is a method for participatory rural appraisal that was developed by the United States Agency for International Development (USAID) as part of the six-year program Sustainable Agriculture and Natural Resource Management (SANREM). The main highlight of this method was that it went beyond the traditional village level to more inclusive landscape level. It was initially used to gain an understanding of resource conflict facing the farmers and herders in Madiama Commune, of the Mopti Region in the Republic of Male.

PLLA is based on four main tenets: Firstly, it has a ‘research for development’ approach, whereby, stakeholders participate in full spectrum of research process, encompassing problem identification and diagnosis, identification and testing of potential solutions, and evaluation and adoption of practices or policies based on research findings.

Secondly, it requires an interdisciplinary approach that transcends traditional boundaries of ecology, economics and sociology. It also encompasses a variety of conceptual and methodological tools to produce an integrated understanding of landscape ecology and the systemic relationships between its components.

Thirdly, PLLA requires inter-institutional collaboration. By virtue of the crosscutting nature and breadth of environmental and agricultural sustainability issues, PLLA incorporates diverse institutions implicated in them.

Finally, it is based landscape/lifescape approach, which relies on the premise that in understanding sustainability and tin developing strategies to achieve it, the relationships and linkages within a landscape must be understood [Earl and Kodio, 2005]

For example, in an area outside the protected area, a PLLA was conducted, whereby farmers identified soil fertility and water retention capacity as primary constraints to sustainable livelihoods. The SANREM researchers identified various combinations of crop rotations and soil amendments that were refined by adaptive management incorporating farmer’s perceptions and preferences. In this process interdisciplinary researchers participated using a holistic management approach [Earl and Kodio, 2005].

3.3 Tools for Optimization of Different Protected Areas Values

The different approaches to the optimization of protected area values use a variety of tools to facilitate the optimization process, which range from economic valuation tools to multi-criteria, agent based and GIS models. This paper focuses on two such tools, namely, multi-criteria and agent based models. They are discussed in individual sections below:

3.3.1 Multi – Criteria Models

Given the fact that protected areas have multiple values, some of which cannot be captured by techniques currently used in the economic valuation of costs and benefits accruing from the creation of protected areas, multi-criteria techniques appear as appropriate modeling tool for the optimization of protected areas.

Multi-criteria models allow ranking of alternative futures based on their ecological, economic and socio-cultural values, as perceived by different stakeholders. The application of multi-criteria models usually involves six steps:

a) Selecting values of alternative futures
b) Quantifying/qualifying those values
c) Identifying alternative futures providing efficient combination of values
d) Eliminating unsustainable alternative futures
e) Accounting for stakeholder preferences for values
f) Ranking alternative futures based on a multiple attribute utility function

The most important steps in this model are accounting for stakeholder preferences and ranking alternative futures based on multiple attribute utility function. Value weights for each stakeholder are estimated, using techniques such as fixed-point scoring. The fixed-point scoring requires a member to allocate 100 percentage points among the values. Value weights are set equal to the percentage point. This forces the stakeholder to consider trade-off among values because it is not possible to assign a higher weight to one value without reducing the weight assigned to one or more of the remaining values. The weight results are substituted into a multiple attribute utility function and the scores are then used to rank alternative futures from highest to lowest [cited in Prato and Fagre, 2005].

For example, a multi-criteria model was used to determine the suitability of various marine protected areas for different uses and levels of protection in the Asinara Island National Marine Reserve. In particular, a spatial multi-criteria model was used to create maps of concordance scores that indicate the agreement between values for a particular zone inside the protected area. Additional feedback from stakeholders was used to develop a final zoning proposal [Prato and Fagre, 2005].

Some of the merits of this model include: a) it is based on public participation; b) it permits the inclusion of ethical values, c) it does not require values to be expressed in a common unit such as monetary terms, and d) it promotes transparent decision – making.

However, the models also suffers from several limitations: a) in public decision making a single point-value solutions often tends to deadlocks in a decision process because it imposes rigid conditions to reach a compromise; b) there are difficulties in selecting the relevant number of evaluation criteria; c) there exist problems in identifying ethical criteria; and d) the tool is static in nature as evaluation is based on fixed periods of time.

3.3.2 Agent-Based Models (ABM)

ABM is a numerical tool to study interactions among adaptive heterogeneous agents, on the basis of internalized social norms, mental models, internal behavioral rules, cognitive abilities, and social learning. It is a holistic tool, which assists in understanding political and economic systems.

It is used to predict the outcome of interaction among different agents with varying attributes and behavioral rules to obtain potential consequences of agent actions on the different values of protected area. In this way, it helps to analyze if the current or hypothetical behavior of different agents would lead to optimization of protected areas values.

Three types of agents can be distinguished in an ABM [Janssen, 2004]:

- Humans, who differ in mental gaps, goals, locations, and abilities, as well as scales from individuals, households, organizations and nations;
- Non -humans, such as flora and fauna;
- Passive agents, such as non-living entities.

These agents may continually adapt their behavior in response to agent -agent and agent-environment interactions in an attempt to optimize individual values of the protected area.

Most ABMs consists of two elements: cellular automata and agents. Of these, the cellular automata was popularized in a game called 'The Game of Life', which was invented by John Conway in 1970. This game consists of cells on a checkerboard, which can have two states, 'alive' or 'dead'. According to some deterministic rules, which are the same for each cell, the state of a cell in the future depends on its own present state and the status of all the surrounding cells in the present period. [Janssen, 2004].

These cells can be used to produce a dynamic Geographical Information System (GIS). The different cells may together represent a map of a protected area, with each group of cells representing a possible land use. Due to ecological restrictions, cells on some locations may be restricted to a limited number of states for example a secondary forest cannot turn back to a primary forest. Social agents can also be represented as cells. Based on their information on the protected area, agents feed the perception they have about the protected area values. Decisions about what actions to perform are then made on the basis of respective goals and attributes.

ABM was successfully used to resolve value conflicts between rice production (economic value) and water offerings for goods to Temples (socio-cultural value) in the case of Bali irrigation system [Lansing, 1991, cited in Jansen, 2004]. Lansing built an ABM of the interaction of groups of *subaks* (rice farmers having adjacent fields) management strategies and the ecosystem, and the local adaptation of *subaks* to strategies of neighboring *subaks*, and showed how to maximize the production of rice and how the coordination have been evolved as a result of local interactions.

The limitations of ABM are that the number of possible states, which an agent can take, might be too large to be efficiently represented. It is also challenging to verify and validate these models, including understanding the behavior of non-linear models, and comparing model outcomes to real-world data.

4.0 Will Optimization Lead to Sustainability?

4.1 Protected Area Optimization and Sustainability

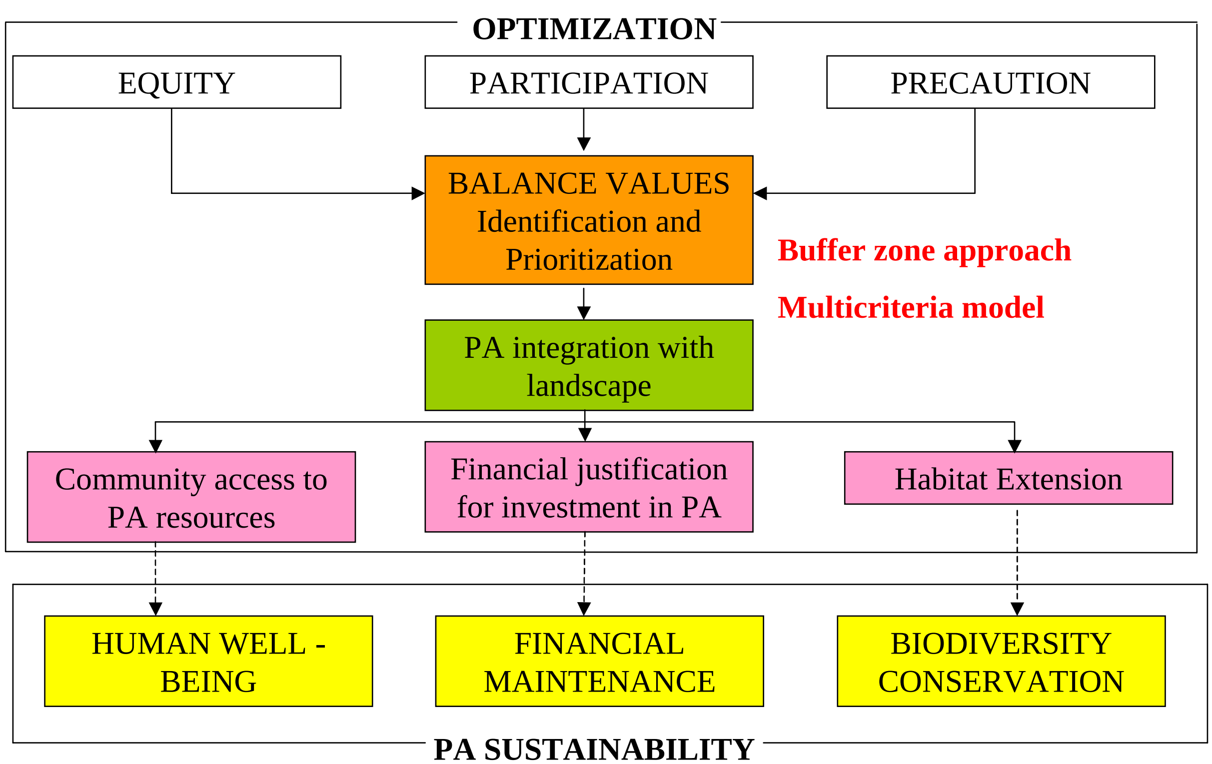
Sustainable development is commonly defined by the Brundtland report as 'meeting the needs of the present generation without compromising on the needs of the future generation'. The definition of sustainable development, therefore, implicitly assumes a need to maintain yields over long periods of time.

In the context of protected areas, sustainability implies maintaining multiple value of protected area for both present and future generations. Thus, a protected area is likely to be sustainable if it is able to offer, inter alia, ecological, economical, and socio-cultural values to the present as well as the future generations.

As illustrated in the Figure 7, the optimization of protected area value through the application of one of the approaches and tools, in this case buffer zone and multi-criteria, would result in the integration of the protected area with the greater human dominated landscape. The integration would not only provide community members with access to the protected area but also extend the habitat available for wild species inside the park, thus simultaneously enhancing the values. This is likely to have a positive effect on the use and non-use economic values of the area, which may be calculated using valuation techniques. The monetary values can be further used as financial justification for public spending and investment in the protected area.

Therefore, the notion of protected area sustainability embraces ecological, economic and socio-cultural values. Erosion of one value is likely to raise opportunity costs of conservation and destabilize the system. Since optimization aims at balancing different values of a protected area, which reflect the interests of different stakeholders, it has a positive impact on protected area sustainability.

Fig 7: Protected Area Optimization and Sustainability



Source: Self construct, 2005.

4.2 Constraints in achieving sustainability

Despite the fact that optimization helps in making protected areas as sustainable entities, it is constrained by a variety of factors, such as dynamics, scale problems and uncertainty. It is tough to incorporate these factors in to approaches and tools available for optimization. These factors are briefly discussed below:

4.2.1 Dynamics

Ecosystems are dynamic entities, which change over time and space in response to natural and human disturbances. This dynamic behavior of ecosystems can be explained in terms of an adaptive cycle that has phases for exploitation, conservation, creative destruction and reorganization, and anarchy. [Prato and Fagre, 2005].

Likewise, culture and human attitude and behavior also vary over space and time. In most cases, land management and environmental policy co-evolve with the change in human attitudes, awareness, and understanding regarding the impacts of economic development on natural resources. This can be well noticed in the three dominant periods of land management in the US: public land disposition from 1862-1891, public land reservation from 1892-1934, and public land retention and management from 1935 to present. [Prato and Fagre, 2005].

However, at times there is lack of understanding of the dynamics within and among systems, especially ecological and human systems, which may not co-evolve simultaneously. This causes many policy decisions to have unintended, potentially negative consequences [Van den Belt, 2004].

Approaches such as adaptive management are able to manage ecosystem and human dynamics but only to an extent.

4.2.2 Scale Problems

The presence of multi-scale phenomena in both protected areas and human institutions inhibits the process of optimization of different values of protected areas and hence sustainability.

Scale problems primarily occur because information and measurements are generally collected on relatively small scales (e.g. small plots in ecology, single firms in economics, sample size in sociological studies), but the information collected is subsequently used to build models at radically different scales, which may be at regional, national or global levels. Since, large systems are not “small systems grown large”, aggregation of information is problematic. In ecological and economic systems, which are characterized by complexity, non-linearity, and discontinuity, aggregation is a major problem. (Costanza et al, 2001).

Examples scale problems are given below:

a) Temporal scale problem: In most cases, policymakers serve short terms compared with the time scale on which environmental changes occur, it becomes difficult to maintain the continuity of initiatives taken in the past.

b) Spatial scale problem: Protected areas, which are small and disconnected, fail to provide sufficient habitat for wide-ranging species, such as grizzly bears, wolves, and cougars. Attaining a larger scale for all protected areas is not always an option, and is constrained by many factors, such as land.

Therefore, multi-scale factors are difficult to incorporate in PA optimization approaches, limiting their contribution to sustainability.

4.2.3 Uncertainty and Limited Information

A key constraint in protected area sustainability is the role played by uncertainty in natural systems. Uncertainty increases unpredictability. In such an instance, stochastic and fuzzy nature present in the information available to the policy makers may lead to high costs and failures. (Costanza et al, 2001).

The sustainability of a protected area can only be known after sufficient time has passed to observe whether the optimization process has led to holistic benefits. Uncertainty associated with estimating the maintenance/enhancement of ecological and socio-cultural values makes a simple prediction difficult.

Therefore, optimization approaches must have as much variety in its response capabilities as variety exists in the environment itself. In such events, adaptive management approach to protected area value optimization may help counter the high costs and failures, which may accrue due to uncertainty.

5.0 Conclusions

1. Protected areas have many values, which are interlinked and co-evolutionary in nature. However, due to disciplinary and insular management approaches adapted to protected area management in the past have led to disintegration and subsequent erosion of these values.

2. To prevent this further degradation of protected area values, there is a need to balance multiple values through optimization process, which calls for biodiversity gains and minimizing socio-economic costs. This can be achieved through a number of approaches, such as buffer zone approach, adaptive management, bioregional approach and holistic/ ecosystem management. These approaches may be used either in isolation or in combination.

3. It is likely that optimization of protected area values will lead to protected area sustainability, which may be defined as maintaining multiple values of protected areas for the present as well as future generations. Since optimization involves balancing different values of protected areas, it involves compromising on one value to gain on another value, however this does not imply complete loss of one value. Protected area sustainability through optimization process, however, is constrained by a number of factors, such as uncertainty and limited information, time and spatial scale dimensions, and complex system dynamics.

The problems in protected areas are difficult because their complexity, interrelatedness, and dynamic behavior are beyond the cognitive capacity of humans to fully understand and manage.

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