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Maximizing benefits for biodiversity: the potential of enhancement strategies in impact assessment

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Our demands on natural systems outweigh the capacity of those systems to support us. This paper calls for an approach to development that consistently delivers 'net benefit' for biodiversity or 'ecological enhancement'. Examples of enhancement are presented through four case studies in India undertaken between 2005 and 2010. Actions focus on improving the overall ecological structure, composition and functions of sites; strengthening ecological networks by creating new habitats and buffer areas; and improving the services provided by the ecosystems, without jeopardizing biodiversity. While recognizing the importance of quantitative metrics of impacts and mitigation measures to determine outcomes, such measures were not available in these cases; enhancement is evaluated primarily in relation to pre-project conditions. The paper emphasizes the importance of considering alternatives that satisfy the mitigation hierarchy, and proposes a number of criteria for evaluating ecological enhancement.

Keywords: ecological enhancement, biodiversity, conservation, case studies, ecosystem services, biological diversity, ecological impact assessment, environmental impact assessment

THE 1992 INTERNATIONAL convention on biological diversity (CBD) defines biodiversity as the 'variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (cited by Glowka *et al*, 1994: 16). Ecosystems are thus an integral component of biodiversity.

The rapid depletion of biodiversity prompted the CBD in 2002 to set a target of achieving a significant reduction of the current rate of biodiversity loss at the global, regional and national levels by 2010. This target, however, could not be met. We continue to lose biodiversity at an unprecedented rate and the principal drivers of loss continue, or are increasing (CBD, 2010). The net result is that we are in 'ecological deficit': our ecological footprint far exceeds the capacity of our environment to support us (e.g. Wackernagel and Rees, 1996).

Our lives and livelihoods depend on a healthy, functioning, natural environment, which in turn depends on the conservation of the biodiversity. In

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Special issue on enhancing positive impacts: lessons from SEA, EIA, SIA and HIA

addition, biodiversity plays a key role in mitigating and enabling our adaptation to climate change. It is widely recognized that the consequences of biodiversity loss will be severe on many fronts (e.g. TEEB, 2010; CBD, 2010). The costs of providing substitutes for lost and deteriorating ecosystem services are undoubtedly always high. Investing in natural capital can thus make both economic and policy sense (Salzman, 2005).

The biodiversity-related Conventions are based on the premise that further loss of biodiversity is unacceptable: 'biodiversity must be conserved to continue to provide services, values and benefits for current and future generations' (Slootweg, 2010: 23). Provisions of article 14 of the CBD and recommendations of the Ramsar Convention have called for ensuring consideration of biodiversity in planning, impact assessment and decision-making.

The reviews of impact assessment studies to date suggest that biodiversity considerations are inadequately addressed in impact assessment (e.g. Treweek, 2001; Slootweg *et al*, 2010). In addition, reviews note that the failure to recognize biodiversity conservation as a key development issue leads to a failure of impact assessment in delivering win–win outcomes for conservation and human wellbeing (e.g. Rajvanshi *et al*, 2010). In many (if not most) instances, some reduction of negative impacts on biodiversity has been seen as sufficient mitigation effort; residual negative impacts are seldom compensated or offset (e.g. Brownlie *et al*, 2006), leading to a cumulative loss of biodiversity over time.

Applying the full mitigation hierarchy is fundamental to achieving 'no net loss' of biodiversity as a consequence of development. The hierarchy is aimed at avoiding or preventing impacts where they are likely to result in irreplaceable or irreversible loss of biodiversity; reducing and minimizing other impacts; restoring or repairing damage; compensating or offsetting residual negative impacts remaining after all of the measures have been implemented; and enhancing benefits to achieve no net loss or net benefit or gain. Enhancement thus provides an additional measure to go beyond no net loss and try to rebuild natural capital. There may be overlap between biodiversity offsets and enhancement measures, depending on whether or not the offsets achieve a 'net gain'. Environmental enhancement of positive impacts, particularly in the context of biodiversity and habitat loss, represents one of the main objectives of sustainable development (CBD, 2002).

Published literature suggests a general paucity of examples of enhancement of biodiversity benefits, explaining the reasons for very few documented examples of enhancement to date. The portrayal of enhancement in impact assessment reports seldom considers the overall 'area of influence' of a project, often constitutes financial contributions rather than assured on the ground outcomes, and, in many instances, the loss or damage to the natural heritage is greater than any benefits of the enhancement proposed; that is, neither no net loss nor net gain (or true enhancement) is achieved.

The purpose of this paper is to define the scope of enhancement and identify a range of criteria for evaluating the successful implementation of enhancement measures

The purpose of this paper is to define the scope of enhancement and identify a range of criteria for evaluating the successful implementation of enhancement measures. The paper also presents four case studies demonstrating application of enhancement measures and analyses these cases in the light of their actual contributions to enhancing biodiversity values, leading to conservation gains or increases in ecosystem service benefits.

Approaches to enhancement

Enhancement has been defined in several ways. Dictionary meanings tend to define enhancement along the lines of to enrich, increase, strengthen, improve, augment, boost or otherwise add to the value, worth, beauty or other desirable quality of something. In the specific context of impact assessment, enhancement means to look for ways of optimizing environmental benefits (e.g. UNEP, 2006) or going beyond mitigation in order to make a net positive contribution of development to the environment.

In the context of natural areas, enhancement refers to genuine improvement of the natural heritage interest of a site or area through better management, or the addition of new or better habitats or features than currently present. The outcome of natural area enhancement would be a net or new benefit to the natural heritage (e.g. Scottish Natural Heritage, undated). Similarly, for biodiversity, enhancement means to provide additional, net and/or new benefits, or increases in existing benefits, through improved management, better conservation practices and/or a higher level of protection (Rajvanshi *et al*, 2010).

Enhancement measures can be incorporated in the following three ways during the planning, impact assessment and implementation process:

- **Proactively by continually seeking opportunities** to improve upon, and make a positive difference to the receiving environment iteratively through the design and implementation of the proposed activity. This approach emphasizes consideration of biodiversity at the earliest possible stage

of conceptualizing and designing development and throughout the planning process. It can facilitate strict application of the mitigation hierarchy, helping to shape the proposed development for a net benefit outcome. Measures to enhance biodiversity can be incorporated from strategic to project level.

- **Reactively by going beyond full compensation or no net loss offsets** to achieve net gain or net benefit for biodiversity. The reactive approach makes a particular effort to apply the full mitigation hierarchy rather than stopping at impact minimization. It recommends going beyond compensation or offsets designed to achieve no net loss to transform the residual impacts from net negative to net positive territory. Reactive actions to enhance biodiversity share many of the characteristics of actions intended to deliver biodiversity offsets which are defined as 'measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground' (BBOP, 2009a: 6).
- **Actively through effective monitoring and evaluation of implementation**, and corrective and adaptive management to get the most out of planned enhancement. In these rapidly changing times, exacerbated by climate change, it is essential at strategic and project levels to 'plan to learn, design for surprise, and manage for adaptation' (Gibson, 2006: 271) and apply caution where there may be irreversible impacts or irreplaceable loss (Croal *et al*, 2010; Slootweg and Jones, forthcoming December 2011). To have a lasting effect, it is important that enhancement measures are tied to assurance in the long term that they will endure. Sufficient capacity and funds to ensure success are crucial in this regard, as is the checking and adaptive changing of management. In addition, it is essential that the human side of any interventions is addressed: without the support of, and preferably tangible benefit to, local communities, efforts to enhance biodiversity may fail.

Criteria for reviewing enhancement benefits

With the prominence now given to the new agenda for positive planning (IEEM, 2010), where the emphasis is on proactive consideration of biodiversity and ecosystem services in development planning, together with a preferred net gain outcome for conservation, the need to understand what should constitute enhancement has emerged strongly. This paper proposes that the potential benefits and opportunities linked to ecological enhancement are of three main types:

(a) Socio-economic development
- Poverty alleviation
- Improved quality of life
- Greater food security
- Improved water security
- Improved livelihood security and opportunities
- Improved health care and sanitation
- Value addition in ecosystem goods or services
- Welfare benefits (reduced resource conflicts, improved amenities).

(b) Human capital development
- Improving opportunities for education, skill enhancement, networking in biodiversity conservation and applied fields
- More jobs to support biodiversity conservation and management
- Better media coverage of biodiversity and ecosystem services issues.

(c) Technological development
- Development of green technologies to 'produce more using less' and reduce impacts on natural systems
- Advances in technology for revitalization of polluted ecosystems.

While some guidance is already available (IEEM, 2006; ITRC, 2004, 2006; BBOP, 2009b; Slootweg, 2010), the authors have used their experience of conducting impact assessments in refining and further defining criteria for ecological enhancement (see Table 1), considering the potential benefits and opportunities linked to ecological enhancement listed above.

Case studies

The paper evaluates four case studies covering estuarine, freshwater, forested and arid environments in different states of India which reflect use of different enhancement approaches (see Table 2). Three of these case studies reflect the developments in irrigation sector and explored the benefits of considering specific enhancement approaches. The fourth case presents the options of enhancing conservation benefits in a mining area. One of the reasons for selecting these cases was to include areas rich in biodiversity that command high conservation status and global importance. The enhancement approaches implemented in case of Naraj Barrage Project targeted the biodiversity conservation of Chilika Lake, a Ramsar site. The proposed Madhya Ganga Canal was included to review measures for enhancing the wildlife values of a protected area (Hastinapur Wildlife Sanctuary), which is a unique habitat for swamp deer. The Keran Limestone Mining Project was selected as an example of applying enhancement measures that could help in building up the conservation status of a protected forest. The case of the Narmada Canal Project provides an interesting example of tackling conservation issues of wetland species in an arid

Table 1. Proposed criteria for ecological enhancement

Enhancement measures should:

- Be applied in parallel with other compensation and enhancement measures to encourage opportunities for synergy and limit duplication of effort;
- Be incorporated into a project as an integral part of the design process;
- Demonstrate clear net improvement or gains over pre-development or baseline conditions;
- Contribute to benefits over and above actions that would have happened anyway;
- Deliver verifiable biodiversity benefits based on accepted indicators of biodiversity (e.g. structure, function and composition, valued ecosystems, communities or species, the social, cultural or economic value of biodiversity) that last beyond the project's life; and
- Ensure that enhancement targets specific areas in which negative impacts are experienced.

Enhancement actions should achieve one or more of the following outcomes:

1. Better ecosystem management

- Better ecological management of existing natural areas.
- Increase in functionality of the existing site and resultant increase in species and/or diversity of communities.
- Manipulation of a site to improve a specific ecosystem service, without jeopardizing existing biodiversity or other ecosystem services.
- Restoration of degraded areas as natural habitat.
- Active eradication of invasive alien species.

2. Improved protection

- Creation of new protected areas.
- Upgrading legal protection in existing habitats for improving conservation prospects.

3. Enhanced areas for biodiversity conservation

- Establishment of dispersal corridors for better interlinking of habitats to enhance ecological or evolutionary processes.
- Establishment of habitat 'stepping stones' across the landscape to link previously isolated fragments.
- Increase in buffer area to minimize negative 'edge effects' and improve functionality.
- Establishment of supplementary or transitional habitats where nature conservation is not the primary concern (e.g. maintaining agricultural ecosystems as edges for bird diversity).
- Addition of new habitats.
- Addition of similar habitats.
- Addition of varied habitats.

4. Improved ecosystem services

- Improved protection, effective management and restoration (where relevant) of key natural areas that deliver regulating and/or supporting services.
- Improved protection of areas of cultural and natural heritage value.
- More or better ecosystem benefits through improved management and conservation.
- Increased biological productivity through better management, not jeopardizing the functioning and diversity of the ecosystem.
- Reduction in pressure on provisioning services through introduction of more sustainable ways of using existing natural resources and/or finding substitutes that better meet needs.
- Increasing ecosystem resilience and ability to adapt to climate change through conserving and restoring key ecosystems**,** and providing ecological corridors across climate and landscape gradients to enable ongoing adaptation.

ecosystem that is not a part of the protected area network of India.

The information presented for each case study is based on the first-hand experience from studies conducted by the authors and through a follow-up of the decision-making made in respect of each of these. In none of the four cases were the size of negative impacts or the anticipated benefit to ecosystems and biodiversity measured. For this reason, enhancement was evaluated mainly in comparison to the before project situation on qualitative grounds. Despite this potential limitation, all of these cases should help in building experience that can be applicable to other projects in India and even elsewhere.

Case Study I. Construction of Naraj Barrage in the Mahanadi Delta, Orissa, India: positive impact on Chilika Lake

Mahanadi is Orissa's largest river that flows for nearly 858 km before it drains into the Bay of Bengal. Kathjuri, a major branch of Mahanadi, further branches into Bhargavi, Daya and other small rivers that feed Chilika Lake (see Figure 1). During the monsoon, extensive flooding and waterlogging occurs along the downstream branches of the Kathjuri in the Delta Stage II irrigation scheme, resulting in serious damage to infrastructure and social distress for thousands of inhabitants. The Stage I area was brought under irrigation about 120 years ago with the Mahanadi, Birupa and Naraj weirs. The Stage II area was developed subsequent to completion of the Hirakud dam by construction of Mundali weir on the undivided Mahanadi at Mundali.

Under the World Bank-funded Orissa Water Resources Consolidation Project, several weirs have been replaced by barrages. Since barrages are gate-controlled weirs, they offer better control of the river outflow and facilitate sediment-free water into the off-taking canal. One old weir near the village of Naraj, which was in existence for more than a century, was replaced by a gated Naraj Barrage. This barrage was constructed in 2003 at the head of the delta to provide irrigation in the upstream regions of the Mahanadi Delta, and to control flooding and waterlogging in the downstream area.

Table 2. Overview of the four case studies

Case study	Short description	Location within India	Type of ecosystem	Time period construction
I. Naraj Barrage Project: flood control and diversion of water for extending irrigation benefits	Flood control structure and diversion of water for extending irrigation benefits	Orissa (Eastern India)	Estuarine	The gated barrage constructed in 2003 is still functional
II. Madhya Ganga Canal through Hastinapur Wildlife Sanctuary	Extension of an existing canal network to provide irrigation benefit in a larger command area	Uttar Pradesh (Northern India)	Gangetic Grassland biome	The canal has been under construction since 2009
III. Keran Limestone Mining Project: extraction of limestone for cement plant	A captive mine to provide raw material for a cement plant	Himachal Pradesh (Northern India)	Mountain forest ecosystem	Approval for mining was granted in 2009 with specified mitigation conditions imposed based on a WII study (WII, 2008)
IV. Narmada Canal Project: provision of irrigation and drinking water facilities	Introduction of irrigation benefits to agro-ecosystems through a network of major and minor canals in an arid area	Rajasthan (Western India)	Desert ecosystem	The canal is under construction since 1993–94. The project proponents have agreed to adopt the enhancement measures proposed in WII's study (WII, 2010)

Key: WII — Wildlife Institute of India

Apart from diverting water for irrigation during low flow conditions, the Naraj Barrage opened the possibility to divert monsoon floodwaters from the lower-lying Kathjuri branch into the wider Mahanadi, thus reducing flood damage in the Stage II irrigation scheme.

The environmental screening procedure did not reveal any negative impacts of the new barrage as it was considered a replacement of an already existing structure. The appraisal process also failed to recognize the potential positive effects of the construction of a barrage on Chilika Lake, a unique wetland ecosystem (Government of Orissa, 1995).

Importance of Lake Chilika Chilika Lake, with a surface area of approximately 1,000 km^2, is the largest coastal lagoon along the east coast of India that is fed by monsoonal floodwaters of Mahanadi through Bhargavi and Daya branches. Freshwater runoff from the drainage basin combined with saline water inflows from the ocean results in a unique assemblage of marine, brackish and freshwater ecosystems. Chilika is a biodiversity hotspot, sheltering a number of species listed in IUCN's Red List of endangered species. It was designated as a Ramsar site in 1981 and is a well-known wintering site for migrating birds, many of which are intercontinental

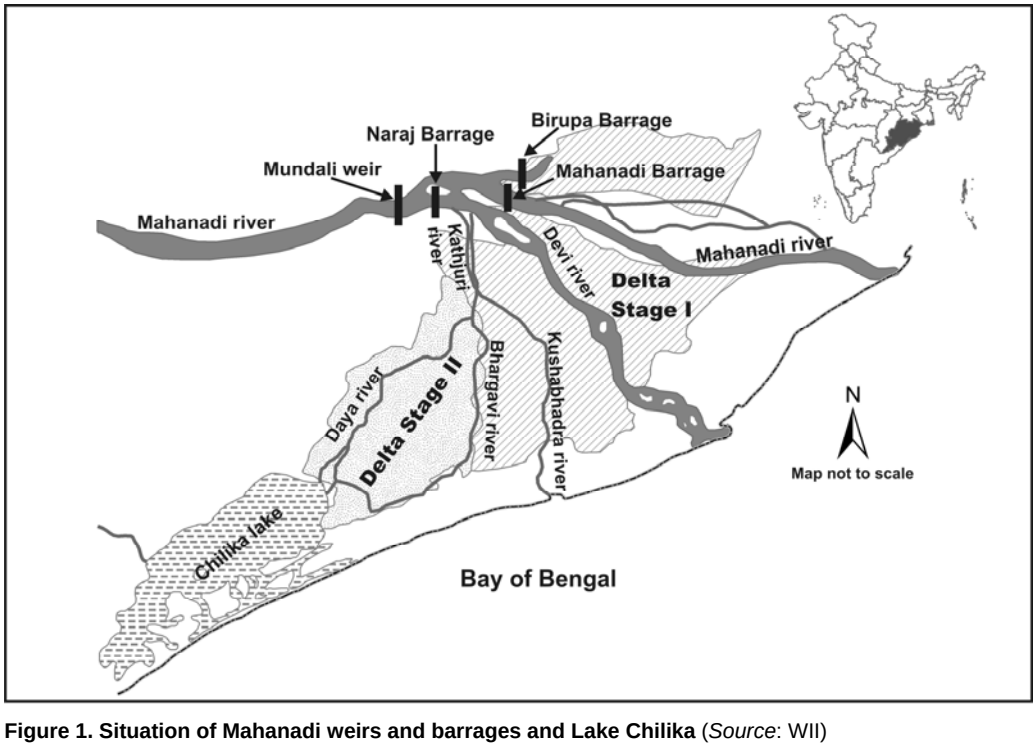

Figure 1. Situation of Mahanadi weirs and barrages and Lake Chilika (*Source*: WII)

migrants from the Caspian Sea, Lake Baikal and Siberia. The lake is one of only two lagoons in the world that is home to the Irrawady dolphin, *Orcaella brevirostris* (Ghosh *et al*, 2005). This highly productive lagoon with its rich fishery resources sustains livelihoods of more than 200,000 fishers and 800,000 farmers.

Negative impacts on the unique and fragile ecosystem of Chilika Lake comprised a decreasing salinity gradient due to the choking of the outlet to the sea, increased sedimentation due to increased soil erosion, and uncontrolled weed growth. During high floods in the monsoon season, two branches of the Kathjuri, the Daya and Bhargavi Rivers, discharge floodwater from the Mahanadi catchment area into Lake Chilika and transport large amounts of sediments into this brackish water lagoon. Its status as a Ramsar site was put in jeopardy because of its degraded state, leading to inclusion of Chilika Lake in the Montreux Record[1] in 1993 (Ramsar, 2001).

Enhancement measures of Case Study I The World Bank, which financed the project, initially recognized the benefits of the new Naraj Barrage to guarantee irrigation water flows to Delta Stage I and control floods and waterlogged conditions in Delta Stage II. Several additional potential benefits of construction of the Naraj Barrage were subsequently realized (World Bank, 1998; Braga, 1999; Hirji and Davies, 2009). Some of these benefits included a positive effect on the lagoon's hydrology by way of management of inflows into different branches of the delta, and the regulation of sediment discharge into Lake Chilika. To maintain the lagoon's ecological integrity, the Orissa State Department of Water Resources made a commitment to develop an environmentally sensitive operating rule for the Naraj Barrage (ILEC, 2005).

Due to the construction of the Hirakud dam and its hydro-electric power plant in the upstream reaches of the Mahanadi, the seasonal flow pattern was drastically altered, affecting spawning behaviour of fish such as the Indian carp that live in the delta and that are totally dependent on monsoon floods for spawning. The operating rules state that operation of the barrage must be regulated to maximize these spawning activities as knowledge of flow-biology relationships grows, subject to the requirement that irrigation needs are also to be met. The new Naraj Barrage is also useful to increase early monsoon floods in the Mahanadi branch which help to maintain certain minimum flows in the Kathjuri branch the first three months after the monsoon in view of upstream prawn migration.

Draft environmental flow rules developed for the Naraj Barrage will lead to the incorporation of environmental flows as a priority water use in the state water policy (Hirji and Davis, 2009). The barrage influenced freshwater flow to the lagoon, resulting in net gains to communities while maintaining the environmental quality of Chilika. It was estimated that by maintaining the present levels of freshwater flows and reducing high intensity floods, an overall annual incremental benefit of €8.4 million would be realized through enhanced agricultural and fish productivity of the local community (Ramsar, 2005).

Case Study II. Madhya Ganga Canal Project

The construction of the main Madhya Ganga Canal Project was completed in 1986 with the objective of providing irrigation to the western part of Uttar Pradesh (UP) state, commonly called the Ganga–Yamuna–Doab. Construction and operation of a 66-km-long irrigation canal, Madhya Ganga Canal (Stage II), was subsequently proposed to divert the monsoon discharge of river Ganga through an already constructed head regulator on the left bank of Madhya Ganga Barrage located in the Bijnor district. Of the 66-km-long proposed canal, 44 km is planned to be routed through Hastinapur Wildlife Sanctuary (see Figure 2).

This sanctuary covers an area of 2,073 km^2 and is the sole protected area for conserving the endangered Gangetic grassland biome in India. The integrity of this area is highly affected by unauthorized industries, human settlements and cultivation; these activities practically transform the protected area into a small township. Only a small part of the sanctuary, representing the Reserved Forest, provides the optimum wildlife habitat for the many ungulate species. Despite the various activities and land transformation within the sanctuary, large populations of blue bull and wild pigs and small populations of endangered species such as swamp deer, blackbuck and hog deer inhabit this area. The people living in the area have also reported sightings of the rare leopard, golden jackal jungle cat and fishing cat.

The project proponents (UP Irrigation Department) filed the project feasibility report of Madhya Ganga Canal Stage II before the Central Empowered Committee (CEC), seeking permission to route a section of the main canal through Hastinapur Wildlife Sanctuary. The CEC approved the use of the sanctuary area for construction of the canal subject to mitigation in the form of several animal-friendly bridges to facilitate wild animal movement across the canal and their wider dispersal within the sanctuary. The task of providing suitable design and location for construction of bridges across the proposed canal was assigned to the Wildlife Institute of India (WII, 2009), a premier conservation agency in the country.

Based on the understanding of the landscape features and the land use of the area surrounding the sanctuary, it was realized that the construction of bridges across the canal would pose two new challenges, namely: (i) crop raiding by animals and consequent increase in human–wildlife conflict in stretches where the canal is aligned between the sanctuary and the villages; and (ii) animal mortality

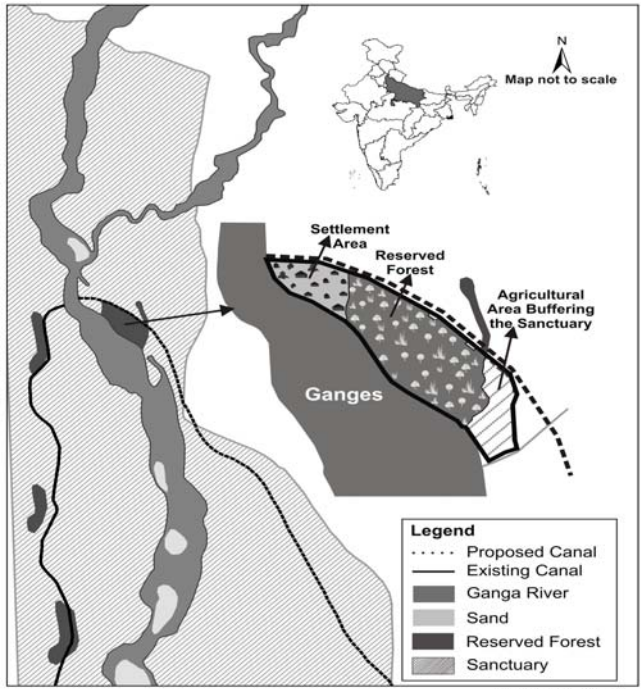

Figure 2. Proposed canal alignment through Hastinapur Wildlife Sanctuary (*Source*: WII, 2009)

in sections of the canal routed along the road bordering the sanctuary. Moreover, these bridges would also fail to serve the purpose of maintaining habitat contiguity as the sanctuary consists of only a mosaic of suitable habitats and no two such habitats are being separated due to the canal. In view of these challenges, it was felt that construction of bridges would bring new impacts without any significant gain in conservation prospects for the endangered species of the sanctuary.

Enhancement measures of Case Study II As a result of the study, WII (2009) recommended that the plan for construction of bridges be dropped as a mitigation measure. Instead, WII proposed measures to improve the conservation values of the sanctuary by building upon the existing habitat value through reconstruction of habitats. These measures would involve acquiring land presently under unauthorized settlements on the floodplains of the Ganges River and agricultural area buffering the Sanctuary on the south side and managing this area as one contiguous, extended habitat for wildlife species found in the area. The financial costs earmarked for construction of bridges far exceeded the amount needed for land acquisition and habitat improvement within the sanctuary.

Instead of the bridges, part of this cost would be utilized for establishing an eco-development programme to be jointly implemented with local people. This way the proposed conservation measures were inclusive and this helped ensure and sustain the long-term resource security for the local people.

The proposed measures would lead to enhancement of biodiversity and ecosystem services because of:

- Better prospects for conservation of animals in the existing wildlife sanctuary through improved management of habitats;
- Improved and expanded management of the acquired area to create larger and more integrated habitats within the sanctuary for wild animals, with better opportunities to satisfy their habitat requirements and sustain them within the wildlife sanctuary;
- Reduced risk of animals moving out of the wildlife sanctuary to surrounding areas to raid crops, with associated reduction in negative impacts on local community livelihoods;
- Reduced risk of entrapment or drowning of animals in the canal because of improved water and fodder availability within the protected area; and
- Greater economic benefits to local people who will sell their lands (i.e. higher prices).

Case Study III. Keran Limestone Mining Project: benefiting conservation from conversion

The Keran Mining Project involves the proposed extraction of limestone from the mine lease area that extends over 726 ha area in the Mandi district of Himachal Pradesh state of India (see Figure 3). The northern edge of the proposed mining lease is part of the Tarambri Demarcated Protected Forest (DPF), spread over 377 ha. Approximately 205 ha of the Tarambri DPF was fenced-off by the Himachal Pradesh Forest Department many years ago, with an objective to improve the protection of wildlife habitats within the somewhat degraded forests, in order to strengthen the conservation of several endangered species. The fenced area, referred to as Tarambri DPF Closed Area, today stands as a testament to the

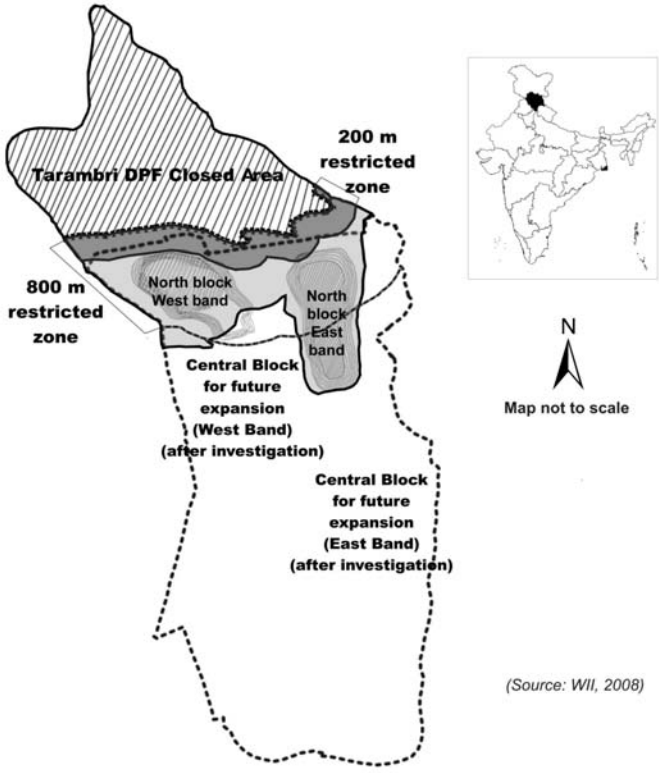

Figure 3. Mining area in relation to Tarambri DPF Closed Area
(Source: WII 2008)

combined efforts of the state forest agency and the local communities in restoring the habitat value of these degraded forest habitats: wild animals such as leopard, leopard cat, Himalayan palm civet, Himalayan throated marten and the goat antelope or 'goral' have staged a comeback in this area. From the ecosystem service perspective, the Tarambri DPF Closed Area is considered an isolated, yet important forest ecosystem that provides essential ecosystem services such as conservation of soil, recharging of the water table and producing biomass for sustained and regulated utilization of the energy and fodder resources by the communities residing in that area. This area is contiguous with a larger area outside the Tarambri DPF Closed Area that meets most of the resource needs of the local people.

An impact assessment study (WII, 2005) was undertaken to identify the biodiversity values of the mine lease area and the likely impacts of mining on these values. The study confirmed that the two northern blocks of limestone, North block-East and north block-West that hold the high quality grade limestone are located in the southern part of the Tarambri DPF Closed Area. Considering the significance of Tarambri DPF Closed Area for conservation of threatened species in restricted and specialized habitats, the environmental impact assessment (EIA) study highlighted the need to safeguard the buffer value of the forest area in the northern edge of the mine lease. The EIA study recommended that an 800-m-wide belt at the interface of Tarambri DPF Closed Area and the mine lease be excluded from the proposed mining area to avoid any direct impacts of mining operations and to avoid the likely secondary impacts of resettlements of people on the physical and ecological functions of the forest that buffer the Tarambri DPF Closed Area. Other negative impacts on biodiversity and ecosystem services were negligible as the remaining area under the mine lease was a non-forested area and comprised grazing lands and transformed private lands.

The project authorities reviewed the implications of no mining within the 800-m-wide belt outside the Tarambri Closed Area and indicated the likely reduction in available limestone reserves of nearly 80%, making the project economically unviable. In view of the economic impact of restricted mining, the project authorities requested the decision-makers to reconsider the option of a roll-back to 200 m below the Tarambri Closed Area as opposed to the earlier decision of restricting mining up to 800 m below the boundary. The project authorities also expressed their commitment to adopt offset measures to compensate for the impacts if the area under no mining was reduced.

This response catalysed a subsequent study to evaluate the optimum area to be designated as no mining zone below the Tarambri DPF Closed Area. The study (WII, 2008) recommended that the roll-back of the mining zone to 200 m was possible without compromising the conservation values of the site if the status of the Tarambri DPF Closed Area was elevated to that of a conservation reserve.

Enhancement measures of Case Study III The elevation of status of the area to a conservation reserve should benefit the two prime stakeholders, namely the conservation agency and the developer. The

creation of this conservation reserve would provide an opportunity to secure conservation at the scale of the wider landscape by inclusion of important habitats, biodiversity and ecosystem values within the proposed reserve. The reserve would be the first of its kind in the state of Himachal Pradesh. By linking the development initiative to this conservation initiative, the project authorities would be able to generate the necessary funds to secure the investments needed to establish and manage the proposed conservation reserve for the next ten years, and to compensate local communities either in-kind or financially for their foregone benefits (e.g. fuel, fodder, timber, thatch). The perceived win–win situation became an important consideration for the granting of approval to the project. The partnership between the conservation agency and the developer for promoting conservation initiatives is seen to provide reputation benefits for the mining company, which has already taken a lead in transferring funds to the state forest agency for expediting the process of establishing the reserve. The State Forest Department has already initiated efforts for the development of a habitat management plan for the proposed conservation reserve and an eco-development plan for ensuring the security of fuel and fodder for the people who have been dependent on Tarambri DPF Closed Area for these resources.

Case Study IV. Creative management of 'escape areas' as wetland habitats under the Narmada Canal Project

The Government of India constituted a Narmada Water Disputes Tribunal (NWDT) to ensure that utilizable flow of Narmada water is shared by four co-basin states: Madhya Pradesh, Gujarat, Maharashtra and Rajasthan. The Rajasthan state would receive its share of water for irrigation and drinking water facilities from the Sardar Sarovar dam in Gujarat via the 74-km-long Narmada main canal routed through villages in Barmer and Jalore districts.

As a part of the construction plan for the canal, escape structures to divert excess water from the canal in order to avoid flooding of nearby areas were provided in the project design at two locations: one at 52 km along the main canal and another at 65 km. These structures are meant to release excess water from the canal to a river to prevent the canal from overtopping when the water level of the canal exceeds its crest level. The locations for providing escapes are often determined on the availability of suitable drains, depressions or rivers with their bed level at or below the canal bed level so that any surplus water may be released quickly through natural outlets.

Experience from past canal development projects indicates that water released from canals at escape points may also cause problems of waterlogging, salinity in the surrounding areas and suboptimal crop production. The area affected by the project represents elements of the Thar Desert ecosystem, characterized by thorn forests, interspersed grasslands and temporary wetlands created because of water accumulation in low-lying agricultural areas. During the avifaunal survey conducted as part of the impact assessment studies, many winter migratory bird species and water birds, which are not generally found in semi-arid/arid regions, were observed in huge numbers. In addition to typical wetland birds, the Indian black ibis and painted stork, both belonging to the 'Near Threatened'[2] category, were noted. The functional value of such temporary wetlands is limited as it is dependent on the period of water retention in the agricultural fields.

Enhancement measures of Case Study IV A number of measures to mitigate the potential negative impacts of canal development on human wellbeing, affected habitat and species of high conservation importance (e.g. Indian gazelle, Indian desert gerbils) were incorporated into the design and management plans for the canal project. Planning of measures to mitigate the impacts of the canal route alignment on birdlife was premised on the argument that avoiding impacts on the temporary wetlands for bird species would result in no residual negative impacts.

However, the canal also offered an opportunity to enhance wetland habitat for the benefit of migratory birds. One of the recommended enhancement options was to retain excess water from the canal at the Escape site 2 and manage that site as a dedicated wetland to provide wintering habitat for many of the water birds that visit the affected area (Figure 4). As the location of Escape site 1 is located within irrigation lands, only Escape site 2 is encouraged for constructing a wetland habitat.

Although creation of a wetland in the escape area could be perceived as habitat conversion of the arid area, the minimal loss of converted habitat would have negligible effect on its overall conservation status. The objective of wetland creation was to provide a wintering habitat for several migrant species that have started visiting the area ever since the water regime has improved after the construction of the main canal. To prevent the ingress of saline water and formation of saline wastelands around the wetland, salt-tolerant species were recommended for planting.

Analysis and discussion

Evaluation of the extent to which environmental enhancement measures are considered in impact assessment and their effectiveness in making positive contributions can yield a good insight into the potential merit of impact assessment as a planning and decision support tool. Reviews of EIA and strategic environmental assessment (SEA) (ITRC, 2006) and McCluskey and João (2011) have emphasized the need to make the most out of these tools by exploiting

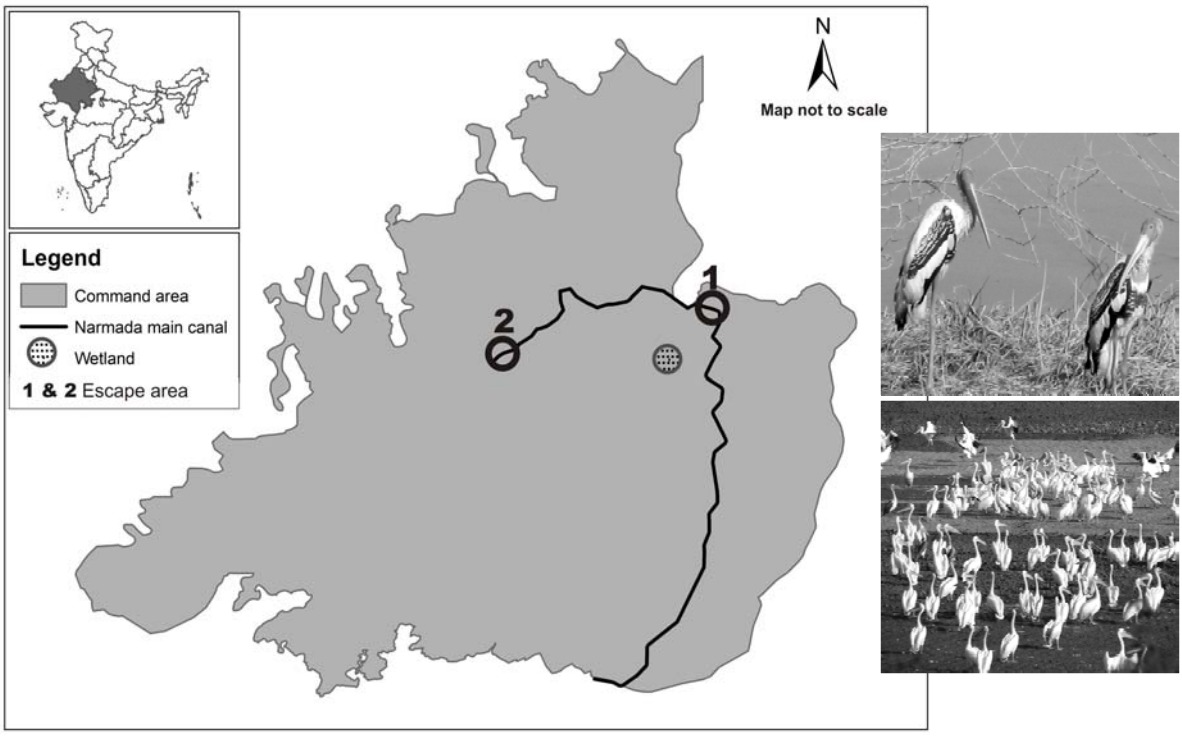

Figure 4. Painted storks and great white pelicans in a temporary wetland located within the Narmada Canal command area (*Source*: WII, 2010)

potential enhancement opportunities, in addition to considering mitigation measures for negative environmental impacts. With similar objectives, Table 3 summarizes the different case studies discussed in this paper.

For the analysis of the four case studies presented in this paper, an attempt was made to evaluate the extent to which the various criteria for enhancement (listed in Table 1) were applicable in each of the cases. It is obvious that not all of the criteria were found to be applicable in each of the cases. Only some specific criteria (such as enhanced areas for biodiversity conservation, improved ecosystem services and better ecosystem management) were found to be applicable in almost all cases and have been highlighted in Table 3.

In the case of the Naraj Barrage Project, ecological enhancement of a brackish water wetland of global recognition was a new and unintended positive benefit associated with hydrological intervention. Improving the ecological functions for sustaining wildlife populations within the existing Hastinapur Wildlife Sanctuary was a principal objective of proposing land acquisition for improving management of wildlife associated with the canal construction along the River Ganges. The proposal for the creation of a conservation reserve in a mining project represents a mutually supportive option for conservation and development. The EIA of the Narmada Canal Project offered an option of creating 'stepping stones' (interlinked islands of natural habitat) to help wetland birds migrate through environments disrupted by human-dominated landscapes in a desert ecosystem.

A critical aspect of this paper is that the review is based on snapshots of current project conditions in most cases except in the case of Naraj Barrage Project. The implementation of mitigation and enhancement measures has not progressed sufficiently far in time to allow rigorous evaluation of the sustainability and viability of the enhancement benefits in the long term. However, the existing legal processes, regulatory reforms and public awareness in India are likely to ensure timely enforcement of the proposed enhancement measures.

Conclusion and recommendations

With our natural world getting poorer in resources and more fragile in its ecological condition, mutually supportive approaches for conservation and development make the case for enhancement to be promoted both actively and proactively. The experience and guidance presented in this paper should provide a relevant resource to improve the use of impact assessment to ensure that biodiversity emerges as a beneficiary of development.

Broadly speaking, ecological enhancement should lead to restored biodiversity, improved ecosystem services, increased security of that biodiversity and/or ecosystem services and/or enhanced areas for conservation. These outcomes can be linked to four main criteria for the evaluation of ecological enhancement in impact assessment identified in the paper, namely better ecosystem management, improved protection, enhanced areas for biodiversity conservation and improved ecosystem services. Enhancement effort should target those components of biodiversity directly linked to, associated with or affected by a particular project.

Table 3. Review of cases to evaluate their enhancement potential and efficacy

Case study	Proposed mitigation measures	Criteria to evaluate enhancement	Effectiveness of enhancement
I. Naraj Barrage Project: flood control and diversion of water for extending irrigation benefits	Replacement of a solid weir with a gated barrage to regulate flow, with the following benefits: • Improved hydrological conditions due to regulation of fresh water entering the Chilika Lake • Improved ecological values of the unique and fragile ecosystem of Chilika Lake • Incremental benefit of enhanced agricultural and fish productivity	No negative impacts were identified; i.e. the case represents a 'no net loss' situation; any benefits from additional intervention represent enhancement. **Enhanced areas for biodiversity conservation; improved ecosystem services; and better ecosystem management** • Improved ecosystem functions of wetland • Improved biological productivity and habitat quality for promoting conservation of several species	Construction of Naraj Barrage and the opening of the mouth for exchange of fresh water and seawater improved the wetland quality of Chilika Lake. Chilika Lake, a Ramsar site, was included in the Montreux Record in 1993 because of its degraded state. Subsequent to the Naraj Barrage, it was removed from the Montreux List and its status as a Ramsar site was restored in 2001 (Ramsar, 2001)
II. Madhya Ganga Canal through Hastinapur Wildlife Sanctuary	• Development of animal-friendly bridges proposed across the canal to mitigate fully the predicted negative impacts of the project and enable movement within the wildlife sanctuary. The bridges could bring new impacts without benefit for conservation. • An alternative mitigation strategy was proposed — the acquisition of land to create a large buffer around degraded forest, and improved management of the larger habitat	The alternative mitigation measures would deliver net benefits relative to the baseline condition. **Enhanced areas for biodiversity conservation; better ecosystem management** • Net expansion in the effective area of wildlife habitat within the Reserved Forest area of the sanctuary • Improvement in functionality and integration of different habitats • Addition of supplementary habitats to serve as buffer	Central Empowered Committee and National Board for Wildlife would monitor compliance of proposed actions. The action will eliminate the risk of human–animal conflict and lead to better retention and dispersal of animals within the protected habitat
III. Keran Limestone Mining Project: extraction of limestone for cement plant	• Proposed establishment of an 800 m belt as buffer between mining area and Tarambri Closed Area to mitigate fully the negative impacts of mining • Negotiated reduction in buffer to a 200-m-wide zone, on condition that the status of Tarambri Closed Area was elevated to a conservation reserve	The elevation of the protection status and management effectiveness of the Tarambri Closed Area was deemed to deliver net benefit for biodiversity conservation compared with the establishment of an 800 m buffer. **Improved protection; better ecosystem management** within the Tarambri Closed Area for improving its management and conservation prospects in the long term	Fencing off the Tarambri Closed Area led to a revival of habitat values for many endangered species. Upgrading this area to a conservation reserve is predicted to improve the long-term security of the area and thus wildlife conservation prospects. Project authorities have transferred funds to the State Forest Department to set up the conservation reserve and provide for its effective management
IV. Narmada Canal Project: provision of irrigation and drinking water facilities	• Avoid wetland habitat for migratory birds, among other measures to mitigate fully the impacts of the canal on biodiversity • Convert escape points for surplus flow from the canal into additional wetland habitat and plant salt-tolerant species to avoid salination	Net increase in available wetland habitat for migratory birds compared with pre-project conditions. **Enhanced areas for biodiversity conservation; better ecosystem management** • Increase the functionality of the escape area for migratory birds, including 'Near Threatened' species. • Develop new habitats for migrating water birds	Follow-up mechanisms are in place as the Narmada Control Authority is responsible for compliance monitoring and enforcement

Importantly, ecological enhancement can contribute to improving the resilience[3] not only of the ecosystem or biodiversity affected by development but, more importantly, of the affected social–ecological system as a whole; particularly where enhancement measures are designed to respond to the questions 'resilience of what and to what' as posed by Carpenter *et al* (2001). That is, by improving the capacity of the ecosystem to absorb change and external pressure, and by reducing the risks of regime shifts that may in turn change the ecosystem services delivered by that ecosystem, the overall resilience of the social-ecological system may benefit. This factor is of growing importance in the face of climate change.

The four case studies presented all communicate an important lesson — that it may not be feasible to achieve enhancement of each and every component of affected biodiversity. The goal should be to ensure that none is left worse off through development, and that one or more component achieves a net gain relative to the before project situation.

For achieving the best conservation outcomes, it is important that all of the basic and some of the contextually more relevant and robust criteria

The four case studies presented all communicate an important lesson — that it may not be feasible to achieve enhancement of each and every component of affected biodiversity

become applicable for achieving significant positive benefits. For example, all the following were intended to ensure net positive gain in the post-project scenario:

- Approaches aimed at securing better ecological management of existing natural areas of Tarambri Closed Forest and proposals for upgrading the status of the area to a conservation reserve in the case of the Keran Limestone Mining Project.
- Restoration of degraded areas within the Hastinapur Wildlife Sanctuary to improve the habitat potential for wildlife, as in the case of the Madhya Ganga Canal Project.
- More or better ecosystem benefits through improved management and conservation of wetlands impacted by the Naraj Barrage and increase in functionality of the escape area intended to result in increased species and/or diversity of communities as in the case of the Narmada Canal Project.

It is important to note that in each of the four cases, neither the residual negative impacts nor the mitigation measures were quantified. That is, enhancement was evaluated qualitatively in relation to the pre-project situation or baseline environmental characteristics. As has been emphasized in work on biodiversity offsets (e.g. BBOP, 2009a), it is important to use a consistent, scientifically credible and reliable way of measuring losses and gains to demonstrate true enhancement. Such an approach requires robust baseline data and/or reference sites against which to evaluate the outcome of interventions for biodiversity conservation.

Another important realization from these case studies is that enhancement measures must progress sufficiently far in time to demonstrate sustainability and viability of the enhancement benefits in the long term to be able to foster greater acceptance of the concept and positive outcomes for biodiversity.

One of the principal recommendations for designing enhancement is that the benefits resulting from biodiversity or ecological interventions should maximize societal benefits and, where possible, should induce cost savings to the developer. In all the cases that were analysed, enhancement benefits aimed to reduce stress on ecosystem services and enhance productive potential of both terrestrial and aquatic ecosystems to improve resource security (e.g. fish, crops, fuel, fodder) for local communities, without jeopardizing existing biodiversity or other ecosystem services. A cost–benefit analysis, using total economic valuation, could help give a clear and realistic measure of anticipated benefits of the proposed development and those of enhancement measures. In addition, such valuation would help to discourage the practice of exaggerating the positive effects of proposed development. Therefore, the key lesson is that impact assessment must strongly encourage the integration of economic valuation in the assessment framework as an effective mainstreaming tool for biodiversity.

The case studies discussed in this paper certainly help to acknowledge that ecological enhancements can contribute effectively and efficiently to the success of many development projects. At the same time, the experience also suggests that ecological enhancement is not a static process and that the valuation of the success of enhancement actions must be based on rigorous monitoring, using established performance criteria. Such criteria are presently lacking, although urgently needed to verify the efficacy of these enhancement measures in delivering net biodiversity benefits.

Impact assessment professionals around the world must make a conscious effort to share best practices, experience and lessons for building stronger convincing arguments in support of promoting net gain options for biodiversity. Rigorous thinking about biodiversity and ecosystem services during the project design and assessment, identifying and fully exploring opportunities and options to achieve the biggest and best outcome for biodiversity and ecosystem services from proposed development should be the standard practice in EIA globally. This calls for greater levels of professionalism, enthusiasm, innovation and commitment among EIA professionals around the world to align impact assessment for maximizing biodiversity and ecosystem benefits alongside economic development for achieving societal wellbeing.

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Notes

1. The Montreux Record is a register of sites on the List of Wetlands of International Importance where changes in ecological character have occurred, are occurring, or are likely to occur because of technological developments, pollution or other human interference.

2. A taxon is 'Near Threatened' when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for, or is likely to qualify for, a threatened category in the near future (IUCN, 2001).
3. Resilience, as defined by Holling (1973) is the capacity of an ecological system to absorb internal and/or external change while exhibiting a similar set of structures and processes (i.e. remaining within a regime).

References

BBOP, Business and Biodiversity Offsets Programme 2009a. *Biodiversity Offset Design Handbook*. Washington, DC: BBOP.

BBOP, Business and Biodiversity Offsets Programme 2009b. *Compensatory Conservation Case Studies*. Washington, DC: BBOP.

Braga, M I 1999. *Integrating Freshwater Ecosystem Function and Services with Water Development Projects*. Workshop on Mainstreaming Freshwater Biodiversity in Water Development Projects, 5–9 February 1997, Yulee, Florida.

Brownlie, S, B Walmsley and P Tarr 2006. *Situation Assessment on the Integration of Biodiversity Issues in Impact Assessment and Decision Making in Southern Africa*. Dakota: IAIA's Capacity Building in Biodiversity and Impact Assessment project.

Carpenter, S, B Walker, J M Anderies and N Abel 2001. From metaphor to measurement: resilience of what to what? *Ecosystems*, **4**, 765–781.

CBD, Convention on Biological Diversity, 2002. CBD News Supplement 'Biodiversity and sustainable development'. Available at <http://www.cbd.int/doc/newsletters/news-sd-suplement-en.pdf>, last accessed 20 May 2011.

CBD, Secretariat of the Convention on Biological Diversity 2010. *Global Biodiversity Outlook 3, GBO-3*. Montréal.

Croal, P, R B Gibson, C Alton, S Brownlie and E Windibank 2010. A decision-maker's tool for sustainability-centred Strategic Environmental Assessment. *Journal of Environmental Assessment Policy and Management*, **12**(1), 1–27.

Ghosh, A K and A K Pattnaik 2005. *Chilika Lagoon. Experience and Lessons Learned. Brief Prepared for the GEF Lake Basin Management initiative*. Available at <http://www.iwlearn.net>, last accessed 8 March 2009.

Gibson, R B 2006. Beyond the pillars: sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision making. *Journal of Environmental Assessment Policy and Management*, **8**(3), 259–280.

Glowka, L, F Burhenne Guilmin and H Synge in collaboration with J A McNeely and L Gündling 1994. *A Guide to the Convention on Biological Diversity*. Environmental Policy and Law Paper No. 30. Gland and Cambridge: IUCN.

Government of Orissa 1995. *Operational Rules for the New Naraj Barrage for Supply of Irrigation Water and Flood Protection Control*. Department of Water Resources, Government of Orissa.

Hirji, R and R Davis 2009. *Water Resources Policies, Plans, and Projects: Findings and Recommendations*. Washington, DC: World Bank Publication.

Holling, C S 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, **4**, 1–23.

IEEM, Institute of Ecology and Environmental Management 2006. *Guidelines for Ecological Impact Assessment in the United Kingdom*. Winchester, UK: IEEM.

IEEM, Institute of Ecology and Environmental Management 2010. *Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal*, Final version 5 August 2010. Winchester, UK: IEEM.

ILEC, International Lake Environment Committee Foundation 2005. *Managing Lakes and their Basins for Sustainable Use: A Report for Lake Basin Managers and Stakeholders*. Kuatsu, Japan.

ITRC, Interstate Technology & Regulatory Council 2004. *Making the Case for Ecological Enhancements*. ECO-1. Washington, DC: Interstate Technology & Regulatory Council and the Wildlife Habitat Council.

ITRC, Interstate Technology & Regulatory Council 2006. *Planning and Promoting Ecological Reuse of Remediated Sites*. ECO-2. Washington, DC: Ecological Land Reuse Team, Interstate Technology & Regulatory Council.

IUCN, International Union for Conservation of Nature and Natural Resources 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. Gland and Cambridge: IUCN.

McCluskey, D and E João 2011. The promotion of environmental enhancement in strategic environmental assessment. *Environmental Impact Assessment Review*, **31**(3), 344–351.

Rajvanshi, A, V B Mathur and R Slootweg 2010. Biodiversity in environmental impact assessment. In *Biodiversity in Environmental Assessment: Enhancing Ecosystem Services for Human Wellbeing*, ed. R Slootweg, A Rajvanshi, V B Mathur and A Kolhoff, pp. 154–204. Cambridge: Cambridge University Press.

Ramsar 2001. *Ramsar Advisory Mission No. 50: India Removal of Chilika Lake Ramsar Site, India, from the Montreux Record 9–13 December 2001*. Available at <http://www.ramsar.org/cda/en/ramsar-documents-rams-ram50/main/ramsar/1-31-112%5E22934_4000_0>, last accessed 20 January 2011.

Ramsar 2005. *9th Meeting of the Conference of the Parties to the Convention on Wetlands,* COP9 DOC, 33. Kampala, Uganda, 8–15 November 2005.

Salzman, J 2005. The promises and perils of payment for ecosystem services. *International Journal for Innovation and Sustainable Development*, **1**(1/2), 5–20.

Slootweg, R 2010. Interpretation of biodiversity. In *Biodiversity in Environmental Assessment: Enhancing Ecosystem Services for Human Wellbeing*, eds R Slootweg, A Rajvanshi, V B Mathur and A Kolhoff, pp. 14–58. Cambridge: Cambridge University Press.

Slootweg, R and M. Jones (forthcoming December 2011). Resilience thinking improves SEA: a discussion paper. *Impact Assessment and Project Appraisal*, **29**(4), DOI: 10.3152/146155111X12959673795886.

Slootweg, R, A Rajvanshi, V B Mathur and A Kolhoff 2010. *Biodiversity in Environmental Assessment: Enhancing Ecosystem Services for Human Wellbeing*. Cambridge: Cambridge University Press.

SNH, Scottish Natural Heritage (undated). *Environmental Assessment Handbook: Guidance on the Environmental Impact Assessment Process*. Scottish Natural Heritage.

TEEB, The Economics of Ecosystems and Biodiversity 2010. *The Economics of Ecosystems and Biodiversity for Local and Regional Policy Makers*. Available at <http://www.teebweb.org>, last accessed 16 January 2011.

Treweek, J 2001. *Integrating Biodiversity with National Environmental Assessment Processes: A Review of Experiences and Methods*. UNDP/UNEP Biodiversity Planning Support Programme. Bristol: Komex Europe Ltd.

UNEP, United Nations Environment Programme 2006. *Voluntary Guidelines on Biodiversity-Inclusive Impact Assessment*. Curitiba: Conference of Parties to the Convention on Biological Diversity, eighth meeting, March 2006.

Wackernagel, M and W Rees 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC: New Society Press.

WII, Wildlife Institute of India 2005. *Ecological Impact Assessment of Cement Plant and Captive Limestone Mine, Sundernagar, Himachal Pradesh.* WII-EIA Technical Report 29. Dehradun, Uttaranchal: Wildlife Institute of India.

WII, Wildlife Institute of India 2008. *Environmental Clearance of Keran Limestone Mining Project, Sundernagar, Himachal Pradesh: A Review*. WII-EIA Technical Report 34. Dehradun, Uttarakhand: Wildlife Institute of India.

WII, Wildlife Institute of India 2009. *Development of Mitigative Measures for Wild Animal Movement across Madhya Ganga Canal Aligned through Hastinapur Wildlife Sanctuary, Uttar Pradesh*. WII-EIA Technical Report 25. Dehradun, Uttarakhand: Wildlife Institute of India.

WII, Wildlife Institute of India 2010. *Environmental Impact Assessment Study on Flora and Fauna in Narmada Canal Project, Rajasthan*. WII-EIA Technical Report 36. Dehradun, Uttarakhand: Wildlife Institute of India.

World Bank 1998. *Integrating Freshwater Biodiversity Conservation with Development: Some Emerging Lessons*. Environment Department Paper No. 61. Washington, DC.