Reviewing the Devastated Ecosystem Services of Chotiari Reservoir to Formulate a Restoration Scheme

Muhammad Husnain; Environmental Assessment and Planning Group, Berlin University of Technology, Str. des 17 Juni 145 D-10623 Berlin, Germany; husnain@mailbox.tu-berlin.de

Robert E Whale (a.k.a. Rab Nawaz) PMU WWF-Pakistan Karachi; jejeel3@gmail.com

Abstract: This paper provides a review and proposal to recover the devastated ecosystem services of Chotiari Reservoir site area. The reservoir, located in the Province Sindh of Pakistan, was constructed in 2003 with funding from the World Bank. The reservoir altered the hydrological and ecological settings of the site area. The EIA for the project failed to identify and mitigate the reservoir impacts, which resulted in degradation of local biodiversity habitats and deprivation of locals of resources needed for their livelihood. In this paper, the reservoir site's ecosystem and habitat services were analyzed and assessed. The goal of this assessment is to establish a basis for improving the income of the poor local communities and restoring the site ecologically. The dependency of the locals for income generation and survival of key species of the reservoir site were estimated to identify the key *ecosystem services* of the site. Based on these investigations, a proposal is formulated to restore the degraded natural livelihood resources and to rehabilitate the biodiversity by providing alternative habitats. The proposal concept is based on 'payments for water services' and 'environmental impact offsets'. It is the opinion of the authors that incorporating ecosystem services early in the EIA process would improve the quality of the scoping outcomes and result in a more focused EIA. It would also aid in preparing and designing better impact mitigation measures including offset plans.

Introduction:

Pakistan, an agriculture based economy, fosters expansion of cultivation areas through the construction and expansion of irrigation infrastructure. Building such an extensive infrastructure, while beneficial economically, also generates consequences in the form of negative environmental impacts such as loss of biodiversity habitats, ground water logging, and salinization of fertile lands due to high water tables. Although authorities are well aware of these issues and major efforts have been made to address impacts but long term sustainable solutions have been elusive. Current unsustainable irrigation practices have become one of the major causes of direct and indirect land degradation and are a major threat to the wetlands and biodiversity (U Alam, P Sahota, and P Jeffery 2007).

Construction of the Chotiari reservoir is a typical example of unsustainable irrigation planning in Pakistan. The Chotiari is an off-canal storage reservoir and covers an area of 45,000 acres, which was constructed mainly with the World Bank funding. It is located on the left Bank of Nara canal and on the western flanks of Thar Desert in the Sanghar district of the Sindh province. It supports a complex mosaic of interconnected naturally occurring lakes, swampy wetlands, grasslands, riverine forest and agricultural lands. This intermixing of diverse habitats makes this site regionally rare and unique both ecologically and aesthetically and supports a wide range of internationally important species.

The reservoir has damaged its aesthetic quality, habitats and livelihoods providing natural resources. The site is facing rapid loss of mammalian and reptilian species and decline in the resident and visiting birds count due to habitat loss. The site is home to poor communities that have lost natural resources formerly used for their livelihood and they are facing difficulties in shifting to other occupations (WWF-Pak 2008a). These environmental issues prompted a situational analysis of the major causes of loss of biodiversity and traditional occupation of the locals. A multipurpose scheme for restoring species and habitat biodiversity and resources of traditional income is formulated and discussed.

Reservoir Project Impacts:

Chotiari reservoir expanded and merged a number of lakes into a single large lake of 45,000 acres. This expansion tripled the site's water storage capacity and doubled its water surface footprint (GoP 1993). This major expansion, in an area of rich ecological diversity and a source of ecological services for poor local communities, caused extensive negative impacts not only on biological diversity but also on the socio-economic setting of the area. The EIA studies and reports were prepared by Sir M MacDonald and Partners in association with National Engineering Services Pakistan (Private) Limited and Associated Consulting Engineers (Private) Limited (GoP 1998; GoP 1993). The report was effective in establishing the site baseline conditions but it faced shortcomings in identifying and estimating the scale of negative impacts (Husnain, Wende, and Bruns 2010). Checklists and matrices were used to identify and estimate the degree of impacts at the scoping stage of the EIA (GoP 1998). Discrepancies at this stage however led to an EIS with unclear focus that negatively affected impact monitoring, management and mitigation plans. As a result, massive losses in the local biodiversity and livelihoods of locals were observed. These impacts were not indicated in the EIA or expected by project stakeholders. This prompted the World Bank to commission a team to visit and review the site issues (Nauman, 2003).

Pakistan, to fulfil its eminent freshwater needs, is planning and building dozens of dams and reservoirs (GoP 2013). To avoid situation like described above EIA system, process and methods are required to be strengthened in the country. An Ecosystem Services concept and methods are used in this study to review the lost / impaired Ecosystem Services of the site and estimate the ecological and economic impacts.

Assessing the Project Impacts:

For this case study an impact assessment process is implemented that identifies and highlights the affected ecosystem services in the scoping stage. These services would then need to be addressed in the later stages of the EIA (Table 1). The approach identifies the main actions of the project that could cause impacts on the major ecosystem services. The potentially impaired services are then linked with the impacted resources, impacted species and livelihoods (Table 1). Table 1 summarizes the major project actions that could impair the site's services and result in ecological and socio-economic consequences. The table scopes out what needs to be addressed and managed in the later stages of the EIA.

Table 1: Scoping major actions of the project and main environmental and socio-economic issues to be addressed and managed

Driver of Change	**Effected Services**	**Impacted resources**	**Impacted Biodiversity / Livelihood resources**
Inundation under water of most of the Site Area	- Habitats services lost - Primary production declined - Food provisioning services and food chains disrupted - Nesting, shelter and reproduction sites of species lost	Habitats lost including Riverine Forest, Rangelands, Reed Beds, cultivated lands and semi-marsh areas	Hog Deer Chinkara Jungle Cat Smooth-Coated-Otter Fishing Cat Resident Birds
		Food chains were disrupted due to loss of lake edge vegetation	Hydrophytes, invertebrates, insects, Juvenile fish and crocodile, amphibians, resident and visiting birds

		Loss of nesting sites due to submergence of forest Reduced dry area for crocodile eggs hatching	Resident Birds Jungle Cat Crocodile
		Trapping of animals at temporary islands of low storage levels and submergence their barrow pits due seasonal filling	Hog Deer Cats Foxes Hedgehog Etc
Shift in the Ground Water Balance	- Water regulation disrupted which raised the groundwater table in surrounding area of the reservoir..	Vast amount of agricultural land was devastated and agriculture production lost due to waterlogging and land salinization. The effect reflected in shifting the pressure of exploitation on fishing and rangelands for livelihoods.	Feeding grounds for wild animals are reduced. Hog Deer, Chinkara, Birds, Mongoose
			Submergence of rangelands and agriculture lands and waterlogging of surround land has ravaged the income resources of the locals

Table 1 highlights the issues that need to be focussed on to estimate and predict the significance of impacts. This in turn will facilitate effective impact management, mitigation and offset plans, allowing the development to comply with legal requirements and meet the objectives of sustainable development as outlined in national environmental legislation (GoP 1997; GoP, WWF-Pak, and IUCN 2000; GoP 2005).

Table 2; Scale and significance of Project impacts on species.

Impact Type	**Impacted species**	***A*- Magnitude of Damage 1= Little 2= Medium 3= High**	***B*- Availability of Alternative 1= Abundant 2= Not Enough 3= No**	***C*- Scale of Impact (C=A*B)**	***D*-Species Importance 2=Least Concern 3=Near Threatened 4=Vulnerable 5=Endangered 6=Critically Endangered**	***S*- Significance score of the Impact (S=C*D)**
Damage to habitat and/or Nesting Sites and/or Breeding and/or Refuge sites	Hog Deer	3	3	9	5	45
	Fishing Cat*	2	3	6	5	30
	Jungle Cat	3	3	9	2	18
	Chinkara	3	3	9	2	18
	Smooth-Coated Otter	3	3	9	4	36
	Marbled Teal	2	2	4	4	16
	Palla's Fish Eagle	2	2	4	4	16
	Houbara Bustard	2	2	4	4	16
	Ferruginous Duck	2	2	4	3	12
	Glossy Ibis	2	2	4	2	8
	At least 15 more species of birds	2	2	4	2	8 (15)

	Crocodile	3	3	9	5	45
Destruction to feeding site and/or Food Sources	All Species of Birds	3	2	6	2	12
	Hog Deer	3	3	9	5	45

Matrices were developed to: 1) assess the magnitude and scale of ecological and economic impacts; 2) to score and assess impact significance; and 3) to prioritize the site's livelihood resources and/or species to be compensated and/or protected (Tables 2 and 3). The species significance score determination is based on three criteria including: 1) *magnitude of the damage to the habitat;2) availability of alternative habitats; and 3 species importance.* Due to the loss of habitats as a result of project interventions in the area vertebrate wildlife species have declined over the years (WWF-Pak 2007; WWF-Pak 2008b; Husnain, Wende, and Bruns 2010).

The level of dependence of locals on a resource for livelihood and the scale of impact of the project on the resources (Table 3) determines the significance score for the particular livelihood service. Due to the loss of agriculture lands and rangelands the locals were forced to shift their occupation to fishing from farming and herding and they are facing difficulties in generating enough income for their survival (WWF-Pak, 2010; Husnain, 2013).

Table 3; Scoring of impact significance based on ecosystem services that provide food and income.

Ecosystem/site Function	**Ecosystem Service**	(A)=Level of dependence of local people for food and/or livelihood on ecosystem service No = 0 Little = 1 Medium= 2 High = 3	(B)=Degree of impact of the Project- based on level of enhancement(+)/reduction (-)		Significance of the Impact on locals **(C)= (A)*(B)** '-' indicates negative impact
			Large = +4 Medium = +3 Little = +2	Large= -4 Medium= -3 Little= -2	
			No change = 1		
Agriculture Land	Food Production	3	-4		-12
	Income Resource – Cash Crops	3	-4		-12
Lakes & Wetlands	Fish Catch – Food Production	2	2		4
	Fish Catch – Income Source	2	4		8
	Water Regulation	2	-4		-8
	Irrigation water	1	4		4
	Mat Making	1	-2		-2
	Recreational	0	1		0
Range Lands	Food Production	2	-3		-6
	Source of Income	2	-3		-6

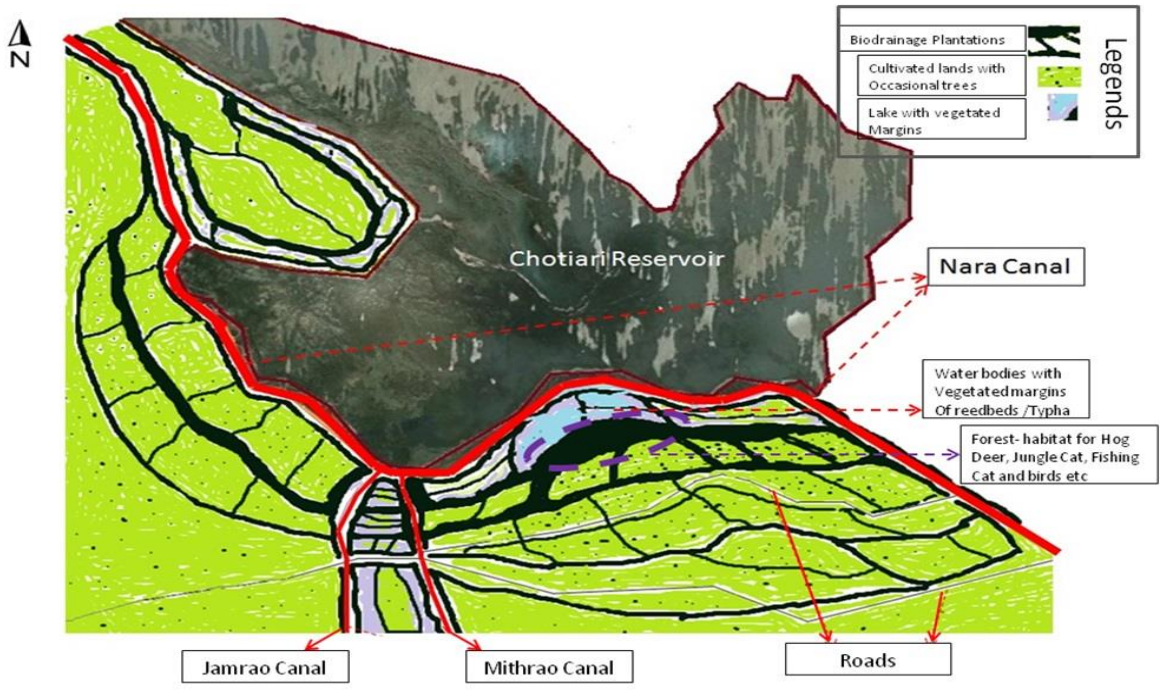
Riverine Forest	Food Production	1	-4	-4
	Source of Income	1	-4	-4

Restoring Important Ecosystem Services of the Site:

Habitat for wildlife species, shelter, water regulation, water balance, food and livelihood provision are the major services which are deteriorated by the reservoir project. These result primarily from inundation of resources inside the reservoir and logging of the water table in the surrounding lands. The inundation impacts could not be avoided and therefore impact offsetting should have been planned for these losses. Waterlogging in the surrounding land could have been tackled by taking appropriate mitigation measures.

A multipurpose scheme was designed to provide habitat services to most of the site's important (priority) species identified in table 2, which include Hog Deer, Chinkara, Jungle Cat, Fishing Cat, Crocodile, Smooth Coated Otter and numerous species of resident and migratory birds and to recover fertile lands surrounding the reservoir. The scheme is based on the concept of biodrainage and involves planting forests and promoting agro-forestry around and along the embankments of the reservoir. The land area of forest required to balance the seepage from the reservoir is determine by estimating the seepage loss and rate of transpiration of local tree species. A large lake embedded within the forest plantations is also designed (Figure 1) to fulfil habitat needs for the site priority species. It is proposed that the restoration scheme would be financed by charging payments for reservoir water services from downstream farmers benefitting from it and that can be useful in improving the irrigation water use efficiency.

Figure 1; Proposed restoration schematic of the Chotiari reservoir site.



Conclusions and Recommendations;

- The EIA for the construction of the Chotiari reservoir was ineffective in scoping out the major issues of the project and hence failed in managing, mitigating and offsetting the major impacts.

- The site's ecosystems and livelihood resources have been devastated as a result of the project. These impacts which could have been managed by scoping, mitigating and reducing them and by offsetting the unavoidable losses.

- Simple scoping and scoring approaches such as used in this study can serve to generate well focussed, compact and comprehensive impact assessments and result in more focussed impact management and mitigations including offset plans to achieve no-net-loss in ecosystem services.

- Waterlogging and related salinization is one of the major causes of fertile land loss in the province of Sindh. Biodrainage approaches with agro-forestry should be promoted to counter this problem.

- Charging payments for irrigation water services in Pakistan is recommended to improve the agriculture water use efficiency and reduce consumption.

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