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ABSTRACT

Large dams are one of the largest regional development projects, which aim at redistributing the benefits of large multiple use natural resources such as rivers. In these projects, costs are borne by some people whereas other sections of the society bear the benefits. Recently, large dams have been the focus of many environmental and non-governmental groups. While many studies are being done to mitigate the impacts of dams, large dams are still being constructed all across the world.

Large dams are accused of often having negative social and environmental impacts; in some cases, both of these impacts are interrelated. The focus of this study is to understand these interrelations, and that's why the researcher looks at five case studies of dams and analyzes environmental impacts that have led to social impacts in each. The case studies are selected based on their displacement index, which the researcher defines as the number of people displaced per one hectare of reservoir surface area.

After selecting the five case studies, the researcher identifies social and environmental impacts that have occurred in each of the case studies based on literature review using content analysis tool. The researcher then identifies environmental impacts that have led to social impacts in each of the case study. Based on the research and findings trends are observed and recommendations for future studies are made. This study has identified that elimination of flora and fauna which is an environmental impact leads to many social impacts like lowered standard of living, negative health impacts and other kinds of social impacts. It has also been observed that the same environmental impact leads to different social impact in different case studies.

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CHAPTER 1: INTRODUCTION

Thou shall safeguard thy fields from soil erosion, thy waters from drying up, thy forests from desolation and thy hills from over grazing. If thou shall fail in this duty, thy fruitful fields shall become sterile, stony grounds and wasting gullies and thy children shall live in poverty (Goonetilleke 94)

This is an old rendering from an ancient Sanskrit[1] verse, which is equally apt today. Man is dependent on the environment, and, if he fails to save it, he will be at a loss. Large scale regional development projects such as dams tend to alter the existing ecosystems. Altering existing ecosystems has negative impacts, not only on the environment, but also on the people who are depended on it. This report is aimed at identifying environmental impacts that lead to social impacts in large dams. Large dams in this report are defined as dams taller than 15 meters or dams with a height between 5 and 15 meters which also have a reservoir capacity of $3*10^6 M^3$. (Mc Cully 2001, 15)

1.1 Purpose of the Report: The World Commission on Dams (WCD) is acclaimed by many critics as having prepared the most comprehensive study on dams done to date (Glieck 1998, 110). In its study, the WCD suggested seven strategic priorities, which would set a stage for sustainable and equitable development of water resources. One of the seven priorities is 'sustaining rivers and livelihood'. In its key message for this strategic priority (WCD 2000, 234) the World Bank suggests that "A basin wide understanding of the eco system's functions, values and requirements, and how community livelihoods depend on and influence them is required before decisions on development options are made." Many other studies also acknowledge the fact that social impacts are caused due to environmental impacts (MCCully , 2001 , Hildyard and Goldsmith, 1984). A base line study of interactions occuring can be a useful resource for future studies addressing the concept of interactions.

1.2 Context and Scope: This study identifies environmental impacts that have led to social impacts in large Dams. Large Dams have been accused time and again of often having high negative social and environmental impacts (WCD 2000, McCully 2001, Hildyard and Goldsmith). Many of the studies identify and discuss social and environmental impacts independently of each other. Only some of the authors (Mc

[1] Sanskrit is one of the world's oldest language.

Cully, Hildyard and Goldsmith) have addressed their interrelations. The researcher was neither able to identify any reports which have addressed the interrelations directly nor found any documentation of interrelations among social and environmental impacts for a specific dam. The main objectives of this study are to:

- Study dams with high social and environmental impacts in order to identify environmental impacts which have led to social impacts.
- Identify further research questions which have to be addressed in order to identify interrelations prior to construction of the Dam.

Research Questions:

1. **Which environmental impacts lead to social impacts?**
2. **Are the interrelations the same irrespective of technical and locational aspects of Dam?**
3. **Do the Interrelations follow any trend?**

The number of case studies will be limited based on available data and the time limitations for the study. Since the aim is to understand whether the impacts occur irrespective of locational and technical aspects, Dams will be selected based on their social and environmental impacts, and dams with the highest social and environmental impacts will be selected. The aim is not to prove the existence of interrelations, since many studies acknowledge the existence of interrelations among impacts (WCD, 235 Mc Cully, Goldsmith and Hildyard, R.Goodland). Instead is to see what interrelations have occurred in the selected case studies and observe any trends (if existing). For example has the same environmental impact caused a similar social impact in all the five case studies?

1.3 Structure of the Report:

One way to understand social and environmental interactions within impacts of large dams is to look at what has already occurred. The second chapter of this report explains both the methodology followed to identify case studies and identifying interactions between social and environmental impacts in the selected case studies. This chapter also looks at the various problems associated with large dams. The World Commission on Dams prepared a report on large dams which is acclaimed as the most comprehensive

study on large dams, ever conducted (Glieck, 1998 110). The next step is to look at the development of the movement against dams. Large dams were acclaimed as engineering marvels in their early years and the movement against large dams started only in 1960's when the US government announced plans to construct dams in the Grand Canyon. Since then the movement grew stronger, and today the fight against large dams is much more wide spread. *Social and Environmental Impacts of Large Dams* published in 1984 is the first book that not only brought the environmental and social impacts of dams to the forefront, but also insisted that the impacts caused by large dams are not peculiar to one dam but were largely inherent to the technology itself (McCully, 2001, Pg 306).

The third chapter, which is the literature review, gives a brief description of distribution of water resources in the world. It briefly describes the dynamics that have led to the current state of understanding of dams. The chapter also lists the state of the art studies done on large dams, and impact of those studies on the dam industry. This section also describes research methods used in the study such as content analysis.

The fourth chapter is research on a number of identified case studies. This chapter has five sections with each section addressing one of the five identified case studies. These sections also identify environmental impacts that have led to social impacts in the five selected case studies. The fifth chapter of the study summarizes the findings by using interaction matrices and identifying trends. The last chapter identifies trends and lists recommendations for future studies.

1.4 Study Limitations:

This study is limited to identifying environmental impacts that lead to social impacts. The other limitation is that the researcher's choice of dams is limited to literature review. However in order to complete the study, he researcher needs comprehensive and reliable documentation of existing dams. This is rather a tough limitation since the selection of case studies is very much dependent on the available studies and their quality.

CHAPTER 2: METHODOLOGY

The main objective of this thesis is to identify the environmental impacts that have led to social impacts in the selected case studies. Documentation of past interactions among social and environmental impacts of dams, would aid in better understanding of the problem (refer to Box1 for an example of social and environmental interrelations).

BOX1: Social impacts due to environmental impacts

Blight of Colorado

The Colorado river has been Dammed and diverted so many times since 1922 that the Colorado delta is a delta no more.

Since 1960's Colorado has only reached the sea during rare flood years. More usually it ends somewhere just south of the US border in a few stagnant pools of pesticide and salt laced agricultural run-off. Besides decimating the waterfowl and mammals of the delta, the loss of the fresh water and nutrients flushing into the Colorado estuary has contributed to the near collapse of a once highly productive fishery and the virtual extinction of the Vaquita, the world's smallest porpoise.

The human communities of the delta are as blighted as the eco- system that once supported them. Fishing villages are suffering deep economic recession. The indigenous people Cucapa, or 'people of the river,' who once fished farmed and hunted the delta, have been reduced from a population of 1200 a century ago to just 40 or 50 families barely subsisting on a diet of beans and junk food.

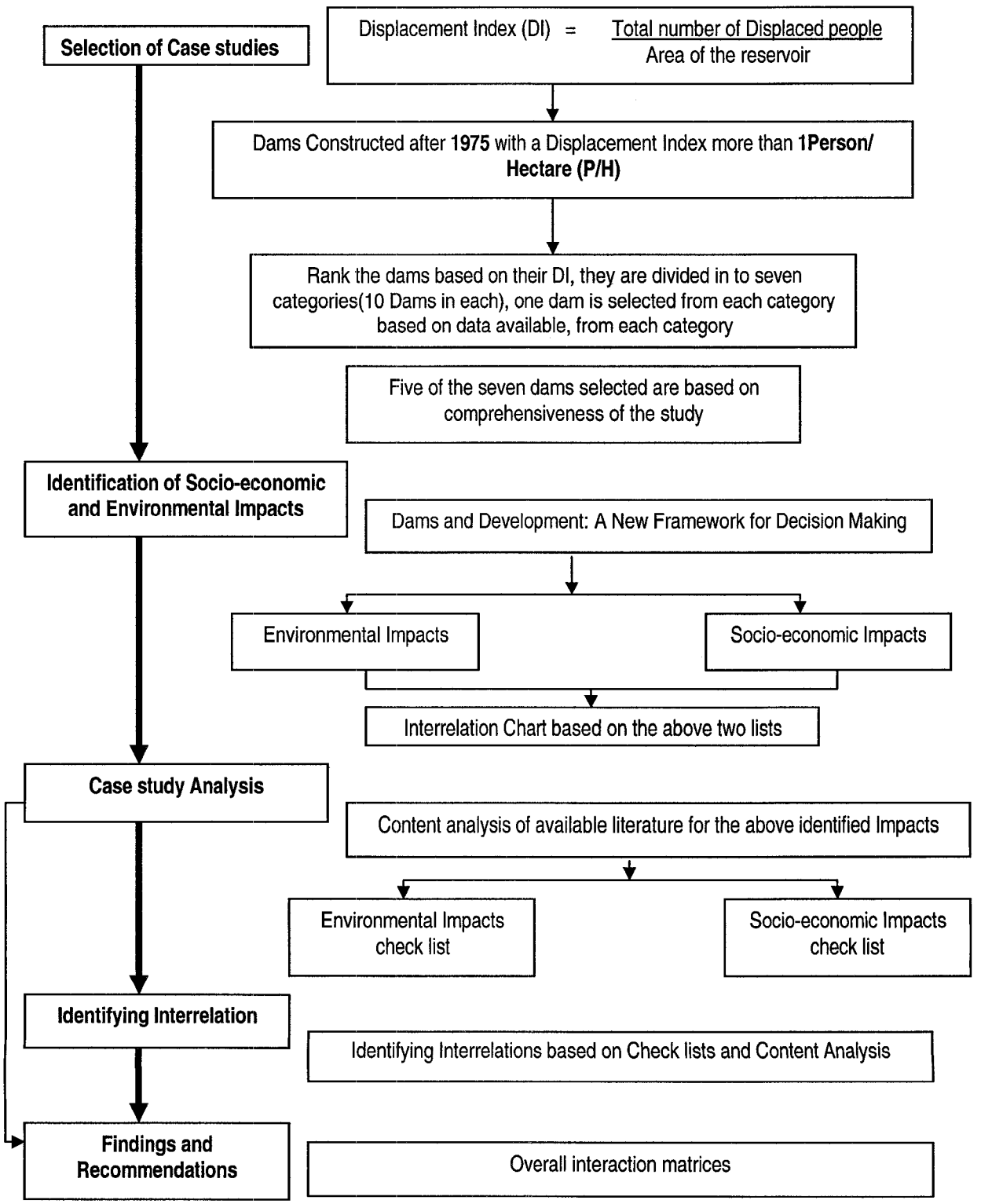
Source: Excerpt from McCully, 2001,29-30.

This chapter explains the methodology followed to identify the potential interrelations among environmental and social impacts of large dams. There are four steps in the methodology. They are

1. Selection of case studies
2. Identification of socio-economic and environmental Impacts
3. Content analysis of case studies
4. Identifying interrelations

These steps are further explained in the following chart

Figure 2.1: Steps Involved in identifying interrelations among environmental and socio-economic impacts of dams



2.1 Selection of Case Studies

As seen in figure 2.1, the first step in the process of identifying interrelations is selecting case studies. There are two main objectives in identifying case studies. The first is to identify cases with relatively high social and environmental impacts and the other is to choose cases with adequate and available data.

In order to recognize dams with a higher magnitude of environmental impacts, this study uses the displacement index (DI). Defined as number of people displaced per one hectare of reservoir surface area (reservoir area in the rest of the document means reservoir surface area), which has been chosen because reservoir surface area is considered a strong proxy for many environmental and social impacts. A large reservoir area implies the loss of much natural habitat and wildlife, or the displacement of many people or both (Cartney, C. Sullivan and M.C. Acreman, 2000, 20). This index is an indication of the magnitude of impacts because it gives the number of people who were dependent on the land prior to construction of the dams (refer to Box 2).

BOX 2: Srisailam Hydroelectric Project, displacement index of 1.650

Loss of Fertile land, Srisailam Project, India

The Srisailam Hydroelectric Scheme near Hyderabad flooded some 107,000 acres of farmland, land which until the Dam was closed, had provided a livelihood for some 100,000 people. Fact finding committee of Srisailam Project noted that the agricultural economy of the region was considered to be highly prosperous. The lands, both dry and wet, situated along the Tungabhadra and Krishna rivers were highly fertile and the cropping patterns adopted by the farmers were both remunerative and profitable. Not only food crops such as paddy, wheat and redgram, but also commercial crops such as groundnut, tobacco, chillies, and cotton were grown extensively in the areas which have been submerged.

Source: Excerpt from Goldsmith and Hildyard, 1984 51-52.

Mc Cully in his phenomenal book *Silenced Rivers* lists details of 334 dams which involved forced displacement (identified by Patrick McCully based on various other reports , 2001 Appendix-3). Data needed for calculating the displacement index available for 269 dams. The displacement index varied from 0.001 to 102.857 (i.e., .001 to 102.857 people were displaced per 1 hectare of reservoir area). The list was further shortened by using two further criteria (Appendix 1) as follows.

1. Dams constructed before 1975 were removed from the list since environmental impact assessment was not mandatory for dams constructed before that year. Hence data is not readily available for those dams.
2. Dams with a displacement index of less than 1person/ hectare are assumed to have low environmental and social impacts.

Seventy of the Two hundred and sixty nine dams met the above criteria. They were then ranked based on their DI. At this stage the researcher had also identified studies that were conducted on individual dams. The studies identified by the researcher are.

1. Eight case studies by the World Commission on Dams:
    a. Tuccuri Dam, Brazil
    b. Glomma and Lagen River Basin, Norway
    c. Tarbela Dam, Pakistan
    d. Pak Mun Dam, Thailand
    e. Aslantas Dam, Turkey
    f. Grand Coulee Dam, USA
    g. Kariba Dam and Zambezi River Basin, Zambia/ Zimbabwe
2. Technical Reports by International Rivers Network, conducted by different researchers
    a. Lesotho Highlands water project, Lesotho
    b. Three Gorges Dam
    c. Chixoy Dam
    d. Pak Mun Dam
3. Involuntary Resettlement in Africa: Selected Papers from Conference on Environment and Settlement Issues in Africa:
    a. Akosombo Dam, Ghana
    b. Kariba Dam, Zambia
    c. Kiambere Dam, Kenya

d. Kainji Dam, Nigeria

e. Lesotho Highlands Water Project

4. Technical Reports Available on the World Bank Website:

    a. Xiolangdi Dam

5. Development Disasters: Japanese Funded Dam Projects in Asia:

    a. Lam Takhong, Thailand

    b. Koto Panjang Dam, Indonesia

    c. San Roque Dam, Philippines

6. Development Dilema: Displacement in India (Parasuraman 1999):

    a. Maharashtra Irrigation Project

    b. Upper Krishna Irrigation Project

    c. Sardar Sarovar Project

7. Development Projects and Impoverishment Risks (Mathur and Marsdan, 1998):

    a. Rengali Dam

    b. Upper Indravati

Based on these reports one dam was picked up for every ten Dams. The list of the selected dams is given in Table 2.1. After the initial selection of dams, the literature of the selected case studies was further studied. During this initial study the following observations were made:

1. Studies conducted by the World Commission on Dams are very comprehensive.
2. The study on the Kiambere Dam, which was selected, was not comprehensive. The study by the World Bank was more concentrated on the physical displacement.
3. Construction of Xiolangdi was completed in 2000, and none of the available studies addressed the post dam impacts.

Based on the above observations the Xiolangdi and Kiambere case studies had to be discarded. Since the researcher was limited in scope just to a literature review inorder to do the analysis, a comprehensive analysis of Xiolangdi and Kiambere was not feasible.

Table 2.1: Selected Dams and their Details

	Aslantas	Pak Mun	Chixoy	Kiambere	Tarbela	Katse Dam	Xiolangdi
River	Ceyhan	Mun	Rio Chixoy		Indus		Yellow River
Country	Turkey	Thailand	Guatemala	Kenya	Pakistan	Lesotho	China
Reservoir Size	4900	6000	1,400	2500	26000	3,600	27200
Installed Capacity	138	136		150	3478		1800
Type of Dam	Earth fill dam	Roller Compacted Concrete	Rock Fill dam and spill way		Earth fill dam		Earth and Rock filled dam
Operation	Storage	run-of-river			Storage		Storage
Function	Multi purpose	Hydro Power	Hydro Power	Hydro Power	Multi purpose	Water Supply	Multi Purpose
Number of People Displaced	5000	7000	3,400	7500	96000	21,700	181600
Displacement Index	1.02	1.17	2.43	3.00	3.69	6.03	6.68
Number of Environmental Impacts	8	6	11		10	8	
Number of Social Impacts	4	8	10		9	19	
Number of Interrelations	0	6	3		6	6	
Important Aspect	Living conditions of the displaced people improved after resettlement	The gates of the dam are opened for four months. Studies are being conducted and based on the studies the dam may be decommissioned	376 people of the Maya'Achi Community were masacred for the construction of dam	World bank agrees that resettlement is unsuccessful	Largest Earth Fill dam of its time	Largest dam in South Africa 183mt	Second Largest dam and had extensive rehabilation program
Data Source	WCD Case Study	WCD Case Study	Reports by IRN and Friends of Earth	Report by World Bank	WCD Case Study	Report by IRN	Reports by World Bank
Year	1984	1994	1985	1988	1976	1996	2001

Dam selected for further study
Dams not considered for the study

Source: Compiled by Author

2.2 Environmental and Social Impact Checklists

The second part of the study includes identification of environmental and social impacts of dams, The environmental and Social impacts of large dams were identified by various studies (Goldsmith and Hildyard 1984, McCully, 2001, WCD 2000). Impacts identified by the World Commission on Dams will be used to analyze the social and environmental impacts of dams in the above selected case studies. The World Commission on Dams identifies various environmental and social impacts based on eight case studies and various other reports (WCD had 938 submissions; they also had a large dam cross check survey, and details about the procedures are given in Literature Review). A total of 22 environmental impacts are identified. The impacts are listed inthe Table 2. The same table will be used as a checklist to recognize the impacts that have occurred in the above selected case studies.

Social impacts of dams are defined by the World Commission on Dams as "impacts on the lives of individual people or groups or categories of people, or forms of social organization (Adams, 2000 1)." Table 3 lists the various impacts recognized by the World Commission on Dams in their study.

Table 2.2 : Environmental Impacts of Large Dams identified by World Commission on Dams

	Categories of Environmental Impacts based on WCD Study	
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**	
	a	Loss of forests due to inundation (WCD 2000, 75)
	b	Loss of habitats for animals (WCD 2000, 75)
	c	Elimination of Flora and Fauna (WCD 2000, 75)
	d	Land degradation (WCD 2000, 75)
	e	Increased sedimentation due to loss of vegetative cover (WCD 2000, 75)
	f	Decreased water Quality (WCD 2000, 75)
	g	Variable changes in the seasonal timing of water yield (WCD 2000, 75)
2	**Emission of green house gases associated with large dam projects and their reservoirs**	
3	**Impacts of altered downstream flows on aquatic eco systems and bio diversity**	
	a	Introduction of Non-native species (WCD 2000, 78)
	b	Loss of system dynamics (WCD 2000, 79)
	c	Loss of ability to maintain continuity of an eco system (WCD 2000, 78)
	d	blocking migration of aquatic organisms (WCD 2000, 78)
4	**Impacts of altering the natural flood cycle on downstream floodplains**	
	a	Altered water temperature and chemistry (WCD 2000, 78)
	b	Loss of aquatic species due to fluctuations in water level (WCD 2000, 79)
	c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80)
	d	Impacts of loss of access to river on wildlife in riparian forests (WCD 2000, 80)
	e	Impacts of channel, floodplain and coastal delta morphology (WCD 2000, 83)
	f	Degradation of river channel below the reservoir (WCD 2000, 81)
	g	Reduction/ Elimination of riparian vegetation (WCD 2000, 81)
	h	Erosion of Coastline (WCD 2000, 81)
	i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment (WCD 2000, 83)
	j	Diminished recharge of groundwater in flood plains due to loss of floods (WCD 2000, 85)
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas (WCD 2000, 85)**	
6	**Enhancement of ecosystem through reservoir creation and other means**	
	a	Creation of productive wetlands (WCD 2000, 87)
	b	Habitat for birds (WCD 2000, 86)
7	**Cumulative impact of a series of dams on a river system**	
		Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity (WCD 2000, 88)

Source: WCD 2000 75-88.

Description of environmental impacts:

1. Impacts of reservoir on terrestrial ecosystem and bio diversity: The most obvious ecological effect of a dam is the permanent inundation of forests, wetlands, and wildlife (McCully 2001, 32). The inundation of forests causes impacts that in turn cause secondary impacts like increased sedimentation due to loss of vegetative cover (WCD,2000 75). Seven different impacts are listed under this section, which are direct impacts caused in most of the dams. In some cases, like in the Lesotho Highlands Water Project, trees grow only in the riparian areas. In such cases, inundation of riparian vegetation has disastrous effects on the local eco system and social structure (Bond 1999, 3).
2. Emission of green house gases associated with large dam projects and their reservoirs: Green house gas emissions in reservoirs due to rotten vegetation are a proven eco system impact of dams (WCD, 2000 75). However, none of the case studies reported emission of greenhouse gases.
3. Impacts of altered downstream flows on aquatic eco systems and bio diversity: Every river is different from the other. The downstream ecosystems of any river evolve based on its dynamics much as the amount of sediment transported, flow of the river, etc (McCully, 2001 44). Storage dams alter the flow of the river and thus adversely affect the ecosystem in the downstream (WCD 2000, 77). Some fish species can only sustain in rapids and thus the loss of the existing system dynamics such as loss of rapids in Pak Mun Dam, has led to a decrease in fish species diversity (Amornakchai and Associates, 2000 90).
4. Impacts of altering natural flood cycle on downstream flood plains: Even if flood control is not an intended consequence of a dam project any storage dam affects the natural flood cycle (McCully, 2001, 47). Altering of flooding patterns adversely affects the natural productivity of riparian areas, flood plains and deltas (WCD 2000, 83). The impacts of altered flows result in a multitude of impacts and sometimes in coastline erosion. Many of these secondary impacts are listed in Table 2.2.

5. Impacts of dams on fisheries in the upstream, reservoir and downstream areas: All the above impacts adversely affect the fisheries both up and downstream. For example, altered downstream flows adversely affect fish population upstream of dams by blocking migratory route of aquatic organisms (WCD 2000, 84).
6. Enhancement of eco system through reservoir creation and other means: WCD case studies show instances of eco system enhancement due to dams. In the Tarbela Dam case study, the reservoir is a staging point for migratory birds (Asiantics, 2000 148).
7. Cumulative impacts of a series of dams on a river system: Many river basins in the world have been dammed more than once, although the cumulative impacts of dams are much worse than the impact of one single dam. In the Tarbela case study the Indus River Basin in Pakistan was dammed more than once and which resulted in increased coastal erosion and loss of the productive mangrove eco system (Asiantics, 2000 148).

In each case study this list of impacts was used as a check list. The advantage of using a checklist is that it is easier to compare the number of impacts that have occurred in each case study. While checklist is not helpful to measure the magnitude of the impacts, it gives an indication of the multitude of impacts that have occurred in each case study.

The researcher conducted a content analysis of the five case studies to identify the impacts that have occurred in the respective case studies. The next section briefly gives a description of the social impact check list used in the study.

Table 2.3: Social Impacts of Dams, as identified by World Commission on Dams

Categories of Social Impacts based on WCD Study		
1		**Socio economic impacts through planning and project cycles**
	a	lack of development and welfare projects during the time lag that generally occurs between planning and onset of construction of a large dam (WCD 2000, 99)
	b	Infrastructure (especially roads) exposes indigenous and vulnerable groups to national economy, threatening their lives and livelihood (WCD 2000, 100)
	c	Loss of social cohesion with large influx of outsiders (like construction workers) (WCD 2000, 100)
	d	Health problems due to increased population (in migration of construction workers) (WCD 2000, 100)
2		**Displacement of people and livelihoods**
	a	Physical displacement (WCD 2000, 102)
	b	Loss of livelihood (WCD 2000, 102)
	c	Loss of commons (WCD 2000, 105)
3		**Indigenous people**
	a	Cultural alienation (Colchester 2000, 16)
	b	Disposesion, both from their land and other resources (Colchester 2000, 16)
	c	Lack of compensation or inadequate compensation (Colchester 2000, 16)
	d	Human rights abuse (Colchester 2000, 16)
	e	Lowering of living standards (Colchester 2000, 16)
4		**Downstream livelihoods**
	a	Impact on flood plain house hold due to loss of access to river and river banks (Adams 2000, 4)
	b	Impacts on fisherman (out migration and ill health) (Adams 2000,4)
	c	Loss of Delta resources (Adams 2000,4)
	d	Loss of Coastal resources (Adams 2000, 4)
5		**Widened Gender disparities**
	a	imposing a disproportionate share of social costs on women (WCD 2000, 114)
	b	inequitable allocation of the benefits generated (WCD 2000, 114)
6		**Loss of Cultural heritage**
	a	loss of culturally important sites (temples, archaelogical sites etc) (WCD 2000, 116)
7		**Adverse health impacts**
	a	Adverse health impacts caused due to lowered nutrition (WCD 2000, 118)
	b	Spread of diseases due to dam (various vector born diseases) (WCD 2000, 118)

Sources:

WCD 2000, 99-118.

Colchester 2000, 16

Adams 2000, 4

Description of Social Impacts

1. Socio-economic impacts through planning and project cycle: One of the most important impacts during the planning cycle is the delay between the decision to build a dam and the onset of construction (WCD, 2000 99). Before the construction of the dam starts, government agencies and other private firms are reluctant to begin any kind of development, welfare or rehabilitation programs at the identified site. The other impact is the fear felt by the people living in the reservoir area. Other kinds of impacts occur due to the influx of construction workers. Large development projects like dams require a high number of both skilled and unskilled labor (WCD 2000, 99) and this high influx of outsiders leads to various problems ranging from loss of social cohesion to spread of diseases.
2. Displacement of people and livelihoods: "A large, multi functional resource base like a river and its surroundings is characterized by a complex web of diverse, interconnected, implicit and explicit functional roles, dependencies and interactions (WCD 2000 102)." Hence large dams lead to the displacement of people in more than one way. However, this section looks at people, who are directly displaced due to loss of their houses or loss of their livelihood.
3. Indigenous people: In various developing countries, like India and the Philippines, indigenous people are the most highly affected groups of all (WCD, 2000 111). Most of the indigenous people lack titles to lands and hence receive low compensation (WCD, 2000 111). Other impacts are the loss of access to resources.
4. Downstream livelihoods: As has been mentioned earlier, many groups of people depend on the regular flows of river and ecosystems downstream have accustomed themselves to the high and low flows of the river (McCully 2001). This group is the most affected of the stakeholders, and yet it lacks social, economic and political power to seek mitigation (WCD 2000 112)
5. Widened gender disparities: dams are accused of gender disparities on two counts. The first is that they impose social costs on women, and the second is the inequitable allocation of benefits (WCD 2000 114).

6. Loss of cultural heritage: Dams sometimes inundate cultural sites like temples, burial sites. In some cases, these temples or other sites are of prominent importance to the community. Hence the loss of these sites affects the local communities more than any thing else (WCD 2000, 116).
7. Adverse health impacts: Environmental change and social disruption adversely affect the human health of the local people (WCD 2000 118). Health effects can occur in more than one way. They can occur due to decreased nutrition, or spread of vector born diseases, which are very common in tropical and subtropical areas (WCD 2000, 118).

After recognizing both the social and environmental impacts by using the check lists, the next step is recognizing the environmental impacts which have caused to social impacts. An interrelation chart, is used here to identify environmental impacts that lead to social impacts. In this chart, social impacts are listed vertically and environmental impacts are listed horizontally. Then a second 'content analysis' of the case studies is conducted to identify environmental impacts that have caused social impacts.

The researcher then looks at the findings of the study, and her conclusions will be based on patterns (if any) identified. Since this study looks at case studies, which are different from each other, none of the analysis is conclusive and further research should be done to identify more clearly if any patterns emerge from the study.

CHAPTER 3: LITERATURE REVIEW

3.1 Distribution of water resources in the world

Water is one of the few resources, which is very essential for the existence of life on this planet, but, with the exception of oxygen it is also the most exploited resource. Earth is called the water planet, since most of the planet is covered with water. However, fresh water resources form a very tiny part of the water available on Earth. Total annual withdrawals in the year 2001 were 3800 cubic kilometers- twice as much as were withdrawn in 1950.

A lot of research has been done on fresh water resources available on the planet, and the results are not very encouraging. Mankind has drained out much of the available fresh water resources and has also exploited much of the groundwater. Scientists have found that the groundwater table in many parts of the world are going below satisfactory levels. How much water does one person need per day? The answer to this question depends on various factors, such as the current physical condition of a person, geographical location etc... Based on the work done in this area recently, a recommendation for a "Basic Water Requirement" (BWR) has been made by Peter. H. Gleick. According to him, just considering drinking water and sanitation needs, a BWR of 25 liters per capita per day (l/p/d) would be sufficient. This level is also in line with the recommended standards of the United Nations International Drinking Water Supply and Sanitation Decade and Agenda 21 of Earth Summit. If we add the water required for bathing and cooking is added, the minimum level BWR would rise to 50 l/p/d from 20 l/p/d. Calculations of BWR do not consider climatic, technological and cultural constraints (Glieck, 1998 9).

There are fifty-five countries whose reported domestic per capita water withdrawals fail to provide 50 l/p/d. Large countries like China and India report that their average domestic water use slightly exceeds this figure, but these figures hide significantly large regional variations. Some parts of the country might be receiving a larger share of the water resources, whereas other parts might not be adequately supplied. The scenario in developed countries is very different from that in the developing countries. Domestic water use in developed countries far exceeds the BWR, Moreover, the quality of this water varies widely. A BWR of

50 l/p/d forms less than 25% of total domestic water use in Western Europe, whereas it forms less than 10% of total domestic water use in the United States and Canada (Glieck, 1998 10).

Successfully meeting human demands for water in the next century will increasingly depend on non-structural solutions and a completely new approach to planning and management. Non structural solutions are those which do not involve construction of new structures. This new paradigm is to think of water use with the objective of increasing the productive use of water. Two approaches are needed. One is increasing the efficiency with which current needs are met, and the second is increasing the efficiency with which water is allocated among different uses (Gleick 1998 11)

3.2 Dams and Water Resources

One of the reasons industrialized countries have fared well in their basic water requirement is that they were successful in tapping all their surface and ground water resources (Petts, 1978 4). G.E. Petts in his book "*Impounded Rivers*" tells us that rivers', which have been manipulated with the use of dams, diversions and other structures for human needs. In industrialized countries become man made waterways almost from the headwaters to the mouth. "Its headwaters are impounded and its flows are determined by the controlled releases from the dam; the quality of the water released is determined by the processes that are operative with in the impounded reservoir it may yet prove to our cost that technology has advanced far more quickly than our knowledge of the environmental consequences of such impoundment" (Petts, 1978 1). Dams have contributed highly to the control of nature.

The first dam built can be traced back to 2850 BC, and it was built by Egyptians. Since then, many dams have been built, but, before 1900, the growth rate of dam construction was low. Between 1900 and 1945, there was a period of moderate building activity separated by troughs associated with wars and economic depression. And between 1945 and 1971, there was a period of accelerated impoundment world wide with the completion of 8140 large dams. More than 35,000 large dams were constructed between 1950 and 2001. The disease of constructing large dams spread fast across the world, and soon developing

countries were following the trend in the developed world and started constructing large dams. China has the highest number of large dams, followed by US and India (Petts, 1978 6).

Until late the 1970's and early 1980's, water planning and management rarely took into account the environmental consequences of major water projects or the water required to maintain natural environmental resources and values (Glieck 1998, pg 12). Environmental movements against dams first started in late 1960's and early 1970's. Following is a list of land mark environmental movements against large dams.

3.3 Large Dams and controversies

1960's Grand Canyon USA

The US government announced plans to build a series of massive dams in the Grand Canyon, one of the most important national symbols of America. These dams provoked such an enormous outcry of dismay from environmental groups and the American public that the plans were halted; the first time such a major project has been stopped (Mc Cully, 2001 285)

1970's Siberian Rivers Old USSR

In the old Soviet Union, the central government's decision to divert the flow of Siberian rivers away from the arctic stimulated unprecedented open opposition from the public and academic communities normally not able or willing to criticize the government. This opposition on both environmental and economic grounds- played a major role in halting development on the Siberian River.(Glieck 1998, Pg 80)

Three Gorges Dam, China

The idea of building the Three Gorges Dam was proposed more than seventy years ago. In the spring of 1992, the National People's Congress officially approved the construction of the project, and in December 1994 the Chinese government began construction. The dam will stretch 2 KM across the Yangtzee river, will be 185 KM tall and will create a 600 KM long reservoir with a total storage capacity approaching forty billion cubic meters. The project has generated enormous international controversy because of its magnitude, the impacts it will have on the environment and ecology of the region, and

massive human resettlements. The reservoir would permanently submerge tens of thousands of hectares of farmland and forests, as well as 160 towns, 1500 factories and hundreds of archaeological sites (Glieck, 1998, pg 84). Official estimates are that 1.3 million people will need to be resettled- the largest population displacement in the history of dam construction and recently some sources have suggested that the number may be as high as 1.9 million (Glieck 1998, Pg 93).

Narmada Valley Development, India

Narmada is the fifth largest river in India, and a master plan for developing the Narmada River Basin was conceptualized in the 1960's. The Narmada Valley Development Authority was formed with the sole objective of implementing those developments. The plan includes 30 major dams, 135 medium and 3000 minor projects. Six of the major projects are completed. Narmada Bachao Andolan (NBA)[2], an internationally supported anti-Dam movement in the valley, opposes the construction of five major Dams. Two of these Dams (Maheshwar Dam and Man Dam) are in the final stages of construction. Maheshwar Dam is publicized as a run-of-river dam and displaces 20,000 families. Construction of the Sardar Sarovar Project is continuing despite huge protests. This controversial project would displace half a million people. The Japanese Government and the World Bank withdrew their aid loan to the project in 1990 and 1993 respectively. NBA is trying to stop the construction of "The Upper Veda" and "The Lower Gol" dams (Website of Friends of Narmada, www.narmada.org).

As was discussed earlier, the movement against dams was strengthening during the 1960's, when conservationists were questioning the need for large dams. During the same period, scientists began to find that irreparable changes could be caused by river impoundment. Since about 1970, a general desecration of the landscape by dams has attracted the attention of the public; before this time, awareness was confined to academics or the most esoteric government research laboratories (Petts, 84 9).

Formation of International Rivers Network (IRN), 1985

[2] NBA has been fighting the construction of large Dams in the Narmada River Basin since 1985. It has gained the support of many international NGO's including the International Rivers Network.

The first issue of International dams Newsletter was published in late 1985. This issue included critiques of the Three Gorges and Narmada projects, which are still a focus of international campaigns more than a decade later. In mid 1987, the group's title became the International Rivers Network, and its newsletter was renamed "World Rivers Review." (McCully, 2001 290)

San Francisco Declaration, 1988

This declaration was signed by 60 anti-dam activists, who met each other at the IRN organized conference in San Francisco in 1988. The declaration demanded a moratorium on all the new large dam projects, which fail to meet a list of conditions including the participation of affected people in the planning process, access to project information, environmental impacts, resettlement, safety, health impacts and economics. They also endorsed a 'Watershed Management Declaration' recommends alternatives to large dams (McCully, 2001 290)

3.4 World Commission on Dams

One of the studies that resulted from all the international criticism is the report by the World Commission on Dams (WCD). WCD was an independent international, multi-stakeholder commission, which addressed the controversial issues associated with large dams. After two years of research, the commission issued its report "Dams and Development: A New Framework for Decision- Making" in November, 2003. The report was co-sponsored by the World Bank. The Commissioners included the CEO of ABB (one of the multi national Dam construction firms) and an ex-president of the International Commission on Large Dams (ICOLD), a major trade group in the global big dams industry. The commission proposed a set of seven strategic priorities, which it considered crucial for sustainable and equitable water resource development. They are as shown in Table 1. The commission also proposed a series of 26 guidelines that describe in general terms how to assess options, as well as plan and implement dam projects that meet the commission's strategic priorities (Table 2).

Table 3.1: WCD's Strategic Priorities (framed as achieved outcomes)

Priority	Key Message
1. Gaining Public Acceptance	Public acceptance of key decisions is essential for equitable and sustainable water and energy resources development
2. Comprehensive Options Assessment	Alternatives to dams do often exist. One has to explore these alternatives, needs for water, food and energy are assessed and objectives clearly defined.
3. Addressing Existing Dams	Opportunities exist to optimize benefits from many existing dams, address outstanding social issues and strengthen environmental mitigation and restoration measures.
4. Sustaining Rivers and Livelihoods	Rivers, watersheds and aquatic ecosystems are the biological engines of the planet. They are the basis for life and livelihoods of local communities. Dams transform landscapes and create risks of irreversible impacts
5. Recognizing Entitlements and Sharing Benefits	Joint negotiations with adversely affected people result in mutually agreed and legally enforceable mitigation and development provisions.
6. Ensuring Compliance	Ensuring public trust and confidence requires that governments, developers, regulators and operators meet all commitments made for the planning, implementation and operation of dams
7. Sharing Rivers for Peace, Development and Security	Storage and diversion of water on transboundary rivers has been source of considerable tension between countries and within countries.

Source: Peter H. Gleick *The World's Water 2002-2003: 154*

Patrick McCully, in his book, *Silenced Rivers,* refers to the WCD report as the "most important single development in the past five years to impact the world of dam building and dam resisting." The report is the largest and most comprehensive study of large dams to date and proposed an equally broad ranging set of guidelines and recommendations to guide future decision making (Gleick 99 pg 171).

Table 3.2: WCD's "Good Practice" Guideline Topics

Stakeholder analysis
Negotiated decision-making process
Free, prior, and informed consent
Strategic impact assessment for environmental, social, health and cultural heritage issues
Project level impact assessment for environmental, social, health and cultural heritage issues
Multi-criteria analysis
Life cycle assessment
Greenhouse gas emissions
Distributional analysis of projects
Valuation of social and environmental impacts
Improving economic risk assessment
Ensuring operational rules reflect social and environmental concerns
Improving reservoir operations
Baseline ecosystems surveys
Environmental flow assessments
Maintaining productive fisheries
Baseline social conditions
Impoverishment risk analysis
Implementation of the mitigation, resettlement, and development action plan
Project benefit- sharing mechanisms
Compliance plans
Independent review panels for social and environmental matters
Performance bonds
Trust funds
Integrity pacts
Procedures for shared rivers

Source: Adapted from WCD 2000a:278

***3.5 Realities of Dams*:**

With the increasing criticisms against large Dams, some new facts about Dams have surfaced and the myths that were traditionally associated with Dams were proven wrong. Some of those myths are listed below:

Myth 1: Hydro electricity produced by dams is clean and does not have any negative impact.

Fact: Dams contribute significantly to greenhouse gases, and the forests that are submerged due to the dams effectively increase global warming (Fearnside, 2001)

Myth 2: Dams increase food productivity, by making more land arable.

Fact: So far 10% of 270 million hectares of land irrigated globally has been damaged by salinization and another 20% are showing symptoms of damage. The main contributors to salinization are dams (Joyce, 1997).

Myth 3: Dams are modern temples of development; they have significantly contributed to national development.

Fact: The World Commission on Dams has stated that so far dams have not given as many benefits as their engineers have promised. In addition, the environmental and social effects of dams have been largely ignored in the past. If the human and environmental impacts of dams were calculated, their benefits would have looked much smaller.

Other than the above stated myths, dams have significantly affected the natural environment, Scientists at the National Aeronautical Society of America (NASA) found that dam construction in temperate regions of the earth during the last 40 years is causing the earth to spin more rapidly(Gelt 1996). The consequences of this are yet unknown (Gelt 1996). dams are also accused of increasing the chances of earthquakes in the world.

The World Bank has faced many criticisms for funding large dams in developing countries. Hence now thinks twice before funding any large dam project (Mc Cully 2001, 306). The Indian Power Minister in 2001, N.K.P Salve told *International Water Power and Dam Construction* in late 1993. "We want run-of-river project and to have smaller dams, if they are necessary at all, which will not cause any impediment what so ever to the environmental needs." However Mr. Salve assumes all the run-of-river dams are not totally foolproof. Unfortunately they also have some environmental and social impacts, For example, Maheshwar Dam in the Narmada River Basin is a run-of-river dam but still displaced 20,000 families.

3.6 Dams and Sustainability: Sustainability is defined differently by different people. The Brundtland Commission defines sustainable development as, "Development that meets the needs of present generation without compromising the ability of future generations to meet their needs." Agenda 21, is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations, governments and major groups in every area in which human impact on the environment.[3] It calls for the protection of the quality and supply of freshwater resources through application of integrated approaches to the development, management and use of water resources (Chapter 18 Agenda 21). Jeremy Bird, who is

[3] http://www.un.org/esa/sustdev/documents/agenda21/index.htm

the interim co-ordinator of UNEP's dams and Development Project, describes the partnership's relation with Agenda 21's objectives as follows, "Nowhere are the difficulties posed by meeting targets of equitable and sustainable use and protection of the world's freshwater resources more visible than in dam projects (Dams and Development: Partnership Initiative Information Sheet)." Dams and Development project was formed three months after the disintegration of the World Commission of Dams (August, 2002 completion date: 2004 or beyond) to broaden awareness of the issues presented and recommendations made in the report and help show- how, where, why and in what ways they can be translated into action on the ground.

For ICOLD (International Commission on Large Dams), sustainable development is meant to bring water, food, energy and other essential elements to the people who need them. Without these, sustainable development becomes sustainable poverty. ICOLD believes that large dams can play an essential role in bringing those elements to the developing world[4]. WCD, a unique multi stakeholder program worked for two years and prepared a report. Based on the studies and findings, WCD developed seven strategic priorities and policy principles for future decision making. These seven strategic priorities would then set stage for an equitable and sustainable development of water and energy resources (WCD, 213-214). These are as follows:

1. Gaining Public Acceptance.
2. Comprehensive Options Assessment
3. Addressing Existing Dams.
4. Sustaining Rivers and Livelihoods
5. Recognising Entitlements and Sharing Benefits.
6. Ensuring Compliance
7. Sharing Rivers for Peace, Development and Security

Strategic Priority Four: Sustaining Rivers and Livelihoods directly addresses the aspect of sustainability in dams. The World Commission specifies the policy principles that would aid in meeting this priority. They are listed below (adapted from WCD 2000 234):

1. A basin wide understanding of the eco system's functions, values and requirements, and how community livelihoods depend on and influence them, is required before decisions on development options are made.

[4] http://icold-cigb.net/ICOLDiguassu_pressnote.htm

2. Decisions value eco systems, social and health issues as an integral part of project and river basin development and prioritize avoidance of impacts in accordance with a precautionary approach.
3. A national policy is developed for maintaining selected rivers with high ecosystem functions and values in their natural state. When reviewing alternative locations for Dams on undeveloped rivers, priority is given to locations on tributaries
4. Project options are selected that avoid significant impacts on threatened and endangered species. When impacts cannot be avoided viable compensations measures are put in place that will result in net gain for the species within the region
5. Large dams provide for releasing environmental flows to help maintain downstream ecosystem integrity and community livelihoods and are designed, modified and operated accordingly.

Reasoning: Dams disrupt the existing pattern of water use and reallocate water to new uses. Where water is abundant, or where few people depend on fish, floodplains or deltas for their livelihoods, this process can often proceed smoothly. Where water is scarce, heavily used or supports economically or socially important eco systems, this redistribution can lead to irreversible impacts, losses, inequities and conflicts Since mitigating all ecosystem impacts is rarely fully predictable, understanding the eco system complexity and prioritizing avoidance, especially in sensitive areas, is important (WCD, 235). The natural resources associated with rivers directly support natural habitats and the livelihoods and cultural values of millions of people worldwide (WCD, 235). Based on the above understanding, it can safely be concluded that riverine areas, which are ecologically as well as socially critical, should be given the highest priority.

3.7 Content Analysis: Content analysis is a research tool, it is used to determine the presence of certain words or concepts in a text or a set of texts[5]. This tool can be very technical looking for a set of words, however this tool can also be used to identify concepts. In the current study the researcher uses the tool not

[5] http://writing.colostate.edu/references/research/content/com2a1.cfm website accessed on 06/29/03

to count the number of occurrences rather she uses the tool to identify different kinds of impacts that have occurred in the case study.

CHAPTER 4: CASE STUDIES

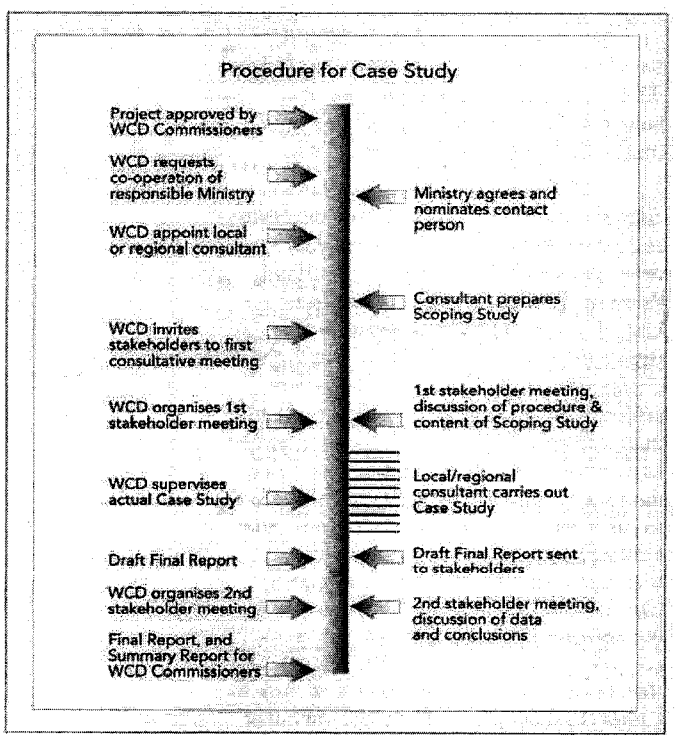
In this chapter the five selected case studies are revised in detail, as was mentioned earlier. Three of the selected case studies will be further evaluated using the study conducted by WCD. All the case studies of the World Commission on dams follow a similar methodology and this section briefly explains the methodology, as shown in Figure 4.1

Methodology of WCD Case Studies: All the WCD case studies follow the same methodology. Firstly, the study team for each case study is selected. Each team consists of:

1. Two Secretariat staff members and the in-country/regional team.
2. An additional study member, who will be the government or dam operator liaison individual.
3. A review panel established to provide input from key senior experts of prominence (if required)

Once engaged, the in- country study team follows the framework shown in Figure 4.1 to conduct their study

Figure 4.1: World Commission on Dams Case Study Procedure



Source: World Commission on Dams Official Website http://dams.org/commission/wp_ov_anx1.htm

4.1 Case Study 1: Aslantas Dam, Turkey

Context and Scope: Aslantas Dam was a part of the Ceyhan Aslantas Project (CAP) initially conceived in 1965 and completed in 1985. The main objectives of the project include (Agrin 2000, Vii):

1. Irrigation of 97,000 ha of land in the lower Ceyhan Basin.
2. Power generation.
3. Reduction in the occurrence of floods.

The final cost of the project was $884.9 million in 1998 dollars (Agrin 2000, Vii)

Technical Details

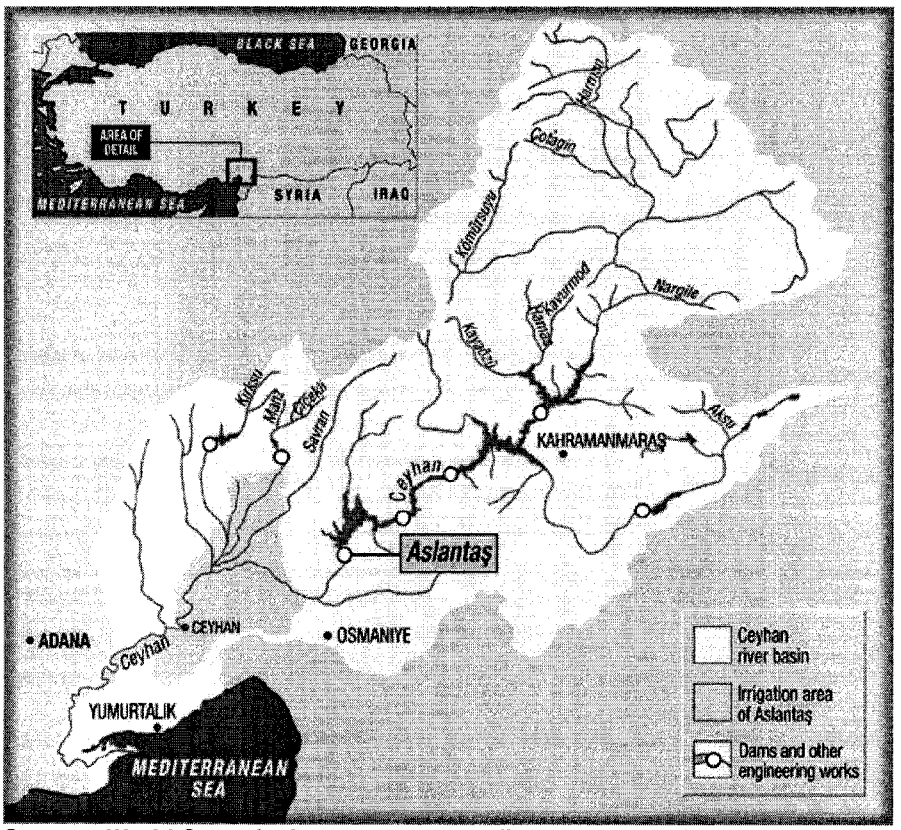
Name of the Project:	Aslantas Dam
River:	Ceyhan River
Owned by:	Government of Turkey
Operator:	
Dam Type:	Earth filled dam
Dam Height:	78 M
Reservoir Area:	4900 ha
Hydropower Capacity (MW):	138 MW
No of People Resettled:	5000 people
Total Land Acquired for the Project:	
Other Ecological Impacts:	Migration of eels was restricted
Resettlement:	Affected people with land titles were compensated (WCD, 2001, 105)
Critical aspect of the Dam:	No reported social impacts both upstream and downstream of the dam
Year Completed	1985

Case Study Procedure: This was one of the eight WCD case studies. The project primarily used existing data sources and reports to inform its assessment. Some additional studies were conducted in selected areas. Parallel to the study two consultation meetings were held. A detailed account of the case study analysis is provided in the introduction section of this chapter (Pg number 32).

Natural Conditions of the River: The Ceyhan River Basin is located in the eastern Mediterranean region of Turkey and drains into the Mediterranean Sea in the South. The river basin covers 20,670 KM ^{2} and includes mountains, three major provinces (Kahramanmaras, Osmaniye and Adana), the major towns of Ceyhan, Kadirli, Yumurtalik, Erzin and Dortyol and a potential of up to 590,000 ha irrigable land (Agrin 2000 Vii). Due to the fact that no environmental impact analysis was done, it is hard to find the data regarding any environmental impacts of the dam. Based on the data available, however, no serious environmental impacts are identified (Agrin VIII).

The social conditions of the displaced population have greatly improved after resettlement, which is partly due to urbanization of the region but also due to improved living conditions provided for resettlers. No social and environmental interactions were identified in this case study.

Figure 4.2: Map of Aslantas Dam



Source: World Commission on Dams http://www.dams.org/images/maps/map_aslantas.htm

Table 4.1 : Environmental Impacts of Aslantas Dam

	Categories of Environmental Impacts based on WCD Study		Environmental Impacts in Aslantas Dam
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**		
	a	Loss of forests due to inundation (WCD 2000, 75)	The land flooded by the dam reservoir is about 6 000ha and was mainly used for agricultural purposes and especially for cotton cultivation Within this area about 3 000ha consisted of forest and maquis vegetation. All the timber and firewood in reservoir area were clean cut under the control of forest authorities (Agrin 2000, 109)
	b	Loss of habitats for animals (WCD 2000, 75)	The habitats formed by the extension of forests to the river is now lost. (Agrin 2000, 109).
	c	Elimination of Flora and Fauna (WCD 2000, 75)	
	d	Land degradation (WCD 2000, 75)	
	e	Increased sedimentation due to loss of vegetative cover (WCD 2000, 75)	
	f	Decreased water Quality (WCD 2000, 75)	
	g	Variable changes in the seasonal timing of water yield (WCD 2000, 75)	
2	**Emission of green house gases associated with large dam projects and their reservoirs**		
3	**Impacts of altered downstream flows on aquatic eco systems and bio diversity**		
	a	Introduction of Non-native species (WCD 2000, 78)	
	b	Loss of system dynamics (WCD 2000, 79)	
	c	Loss of ability to maintain continuity of an eco system (WCD 2000, 78)	
	d	blocking migration of aquatic organisms (WCD 2000, 78)	The design of dam allows no passage for eel. Therefore, eel migration is disrupted. The fish traders have also indicated that the catch is considerably reduced in the downstream and the mouth of the river. (Agrin 2000, 110)
4	**Impacts of altering the natural flood cycle on downstream floodplains**		
	a	Altered water temperature and chemistry (WCD 2000, 78)	
	b	Loss of aquatic species due to fluctuations in water level (WCD 2000, 79)	The decrease in the rate of flow of the river especially in summer and alterations in the river bed have negative effects on the organisms living in stream eco system and adapted to flow (Agrin 2000, 113).
	c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80)	It is reported that the population of bleak (*Alburnus orontis),* which can adopt to lake conditions easily has reached the largest size in comparison with other native species. The same tendency is expected for the population of (*Silurus Glanis)* if over exploitation of this species is prevented (Agrin 2000,110)
	d	Impacts of loss of access to river on wildlife in riparian forests (WCD 2000, 80)	
	e	Impacts of channel, floodplain and coastal delta morphology (WCD 2000, 83)	
	f	Degradation of river channel below the reservoir (WCD 2000, 81)	
	g	Reduction/ Elimination of riparian vegetation (WCD 2000, 81)	Due to the decrease in the amount of sediments carried by the river, the growth of delta has been stopped and revised in some degree. This might be considered as a negative affect of the dam on the natural environment (Agrin 2000, 110)
	h	Erosion of Coastline (WCD 2000, 81)	
	i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment (WCD 2000, 83)	Due to control of flow regime, the seasonal wetlands and temporary habitats formed by floods at the downstream of Ceyhan river has decreased despite this habitat reduction, comparing the old and new topographical maps it is observed that there are no great changes in vegetation cover on the river banks (Agrin 2000, 110)
	j	Diminished recharge of groundwater in flood plains due to loss of floods (WCD 2000, 85)	
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas (WCD 2000, 85)**		
6	**Enhancement of ecosystem through reservoir creation and other means**		
	a	Creation of productive wetlands (WCD 2000, 87)	
	b	Habitat for birds (WCD 2000, 86)	The dam reservoir now serves as resting area for many migrating species and over wintering site for many other(Agrin 2000, 110)
7	**Cumulative impact of a series of dams on a river system**		
		Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity (WCD 2000, 88)	

Source: Compiled by Author

Table 4.2 : Social Impacts of Aslantas Dam

		Categories of Social Impacts based on WCD Study	Social Impacts of Aslantas Dam
1		**Socio economic impacts through planning and project cycles**	
	a	lack of development and welfare projects during the time lag that generally occurs between planning and onset of construction of a large dam (WCD 2000, 99)	
	b	Infrastructure (especially roads) exposes indigenous and vulnerable groups to national economy, threatening their lives and livelihood (WCD 2000, 100)	
	c	Loss of social cohesion with large influx of outsiders (like construction workers) (WCD 2000, 100)	
	d	Health problems due to increased population (in migration of construction workers) (WCD 2000, 100)	
2		**Displacement of people and livelihoods**	
	a	Physical displacement (WCD 2000, 102)	1000 families or 5000 people were displaced (Agrin 2000, 101)
	b	Loss of livelihood (WCD 2000, 102)	The study did not identify any person who earned a livelihood from fishing in pre dam context (Agrin 2000, 102)
	c	Loss of commons (WCD 2000, 105)	
3		**Indigenous people**	
	a	Cultural alienation (Colchester 2000, 16)	
	b	Disposesion, both from their land and other resources (Colchester 2000, 16)	
	c	Lack of compensation or inadequate compensation (Colchester 2000, 16)	
	d	Human rights abuse (Colchester 2000, 16)	
	e	Lowering of living standards (Colchester 2000, 16)	The social life of people in the basin has changed for better. Working and living conditions improved, birthrates have decreased. Illiteracy has almost been eradicated. The number of people who have a university degree is rapidly increasing (Agrin 2000, 102).
4		**Downstream livelihoods**	Experts have observed that there were no groups downstream of the dam whose livelihoods totally depended on the river and adjacent land use (Agrin 2000, 88)
	a	Impact on flood plain house hold due to loss of access to river and river banks (Adams 2000, 4)	
	b	Impacts on fisherman (out migration and ill health) (Adams 2000,4)	
	c	Loss of Delta resources (Adams 2000,4)	
	d	Loss of Coastal resources (Adams 2000, 4)	
5		**Widened Gender disparities**	
	a	imposing a disproportionate share of social costs on women (WCD 2000, 114)	
	b	inequitable allocation of the benefits generated (WCD 2000, 114)	
6		**Loss of Cultural heritage**	
	a	loss of culturally important sites (temples, archaelogical sites etc) (WCD 2000, 116)	
7		**Adverse health impacts**	
	a	Adverse health impacts caused due to lowered nutrition (WCD 2000, 118)	
	b	Spread of diseases due to dam (various vector born diseases) (WCD 2000, 118)	

Source: Compiled by Author

4.2 Case Study 2: Pak Mun Dam, Thailand

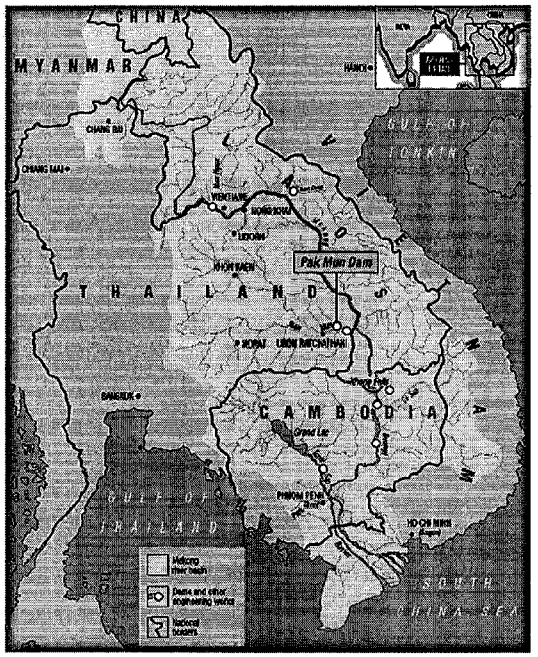
Context and Scope: Pak Mun is a run- of- river dam located near the confluence of the Mun and the Mekong Rivers in the Northeast region of Thailand. The total cost of the project was 264 million dollars

Case Study Procedure: This was one of the eight WCD case studies. The study primarily used existing data sources and reports to inform its assessment. Some additional studies were conducted in selected areas. Parallel to the study two consultation meetings were held. A detailed account of the case study analysis is provided in introduction of this chapter.

Technical Details

Name of the Project:	Pak Mun
River:	Mun River
Owned by:	Electricity Generating Authority of Thailand (EGAT)
Operator:	EGAT
Dam Type:	Roller Compacted Concrete
Dam Height:	17 M
Reservoir Area:	6000 ha
Hydropower Capacity (MW):	136 MW generating capacity
No of People Resettled:	7000
Total Land Acquired for the Project:	141 hectares of riparian corridors, along with 828 hectares of agricultural land were inundated
Other Ecological Impacts:	
Resettlement:	
Critical aspect of the Dam:	The gates of Pak Mun were opened in June 2001. After a decade of resistance by the villagers, the government opened the gates.
Year Completed	1994

Figure 4.3: Location of Pak Mun Dam

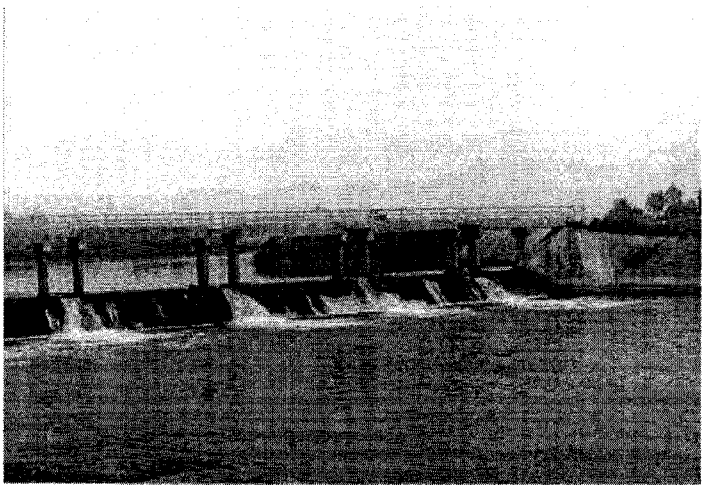


Source: http://www.dams.org/images/maps/map_mekong.htm

Environmental Impacts: The Mun River Basin has a very rich eco system with high bio diversity. More than 265 species of fish were reported in the waters. The dam was hence planned as a run-of-river dam to minimize environmental impacts, however the dam destroyed the eco system and the environmental impacts led to a multitude of social impacts.

Social Impacts: There are three densely populated communities located on the banks of Mun River : Warin Chamrab, Ubon Municipality and Philby Mangsahan. Inhabitants on both banks are dependent on the Mun River for domestic uses and for agriculture, livestock raising, fisheries, industries, transportation, recreation etc (Amornsakchai and Associates 2000, 60).

Figure 4.4: Pak Mun Dam



Source: International Rivers Network www.irn.org accessed on 05/30/03

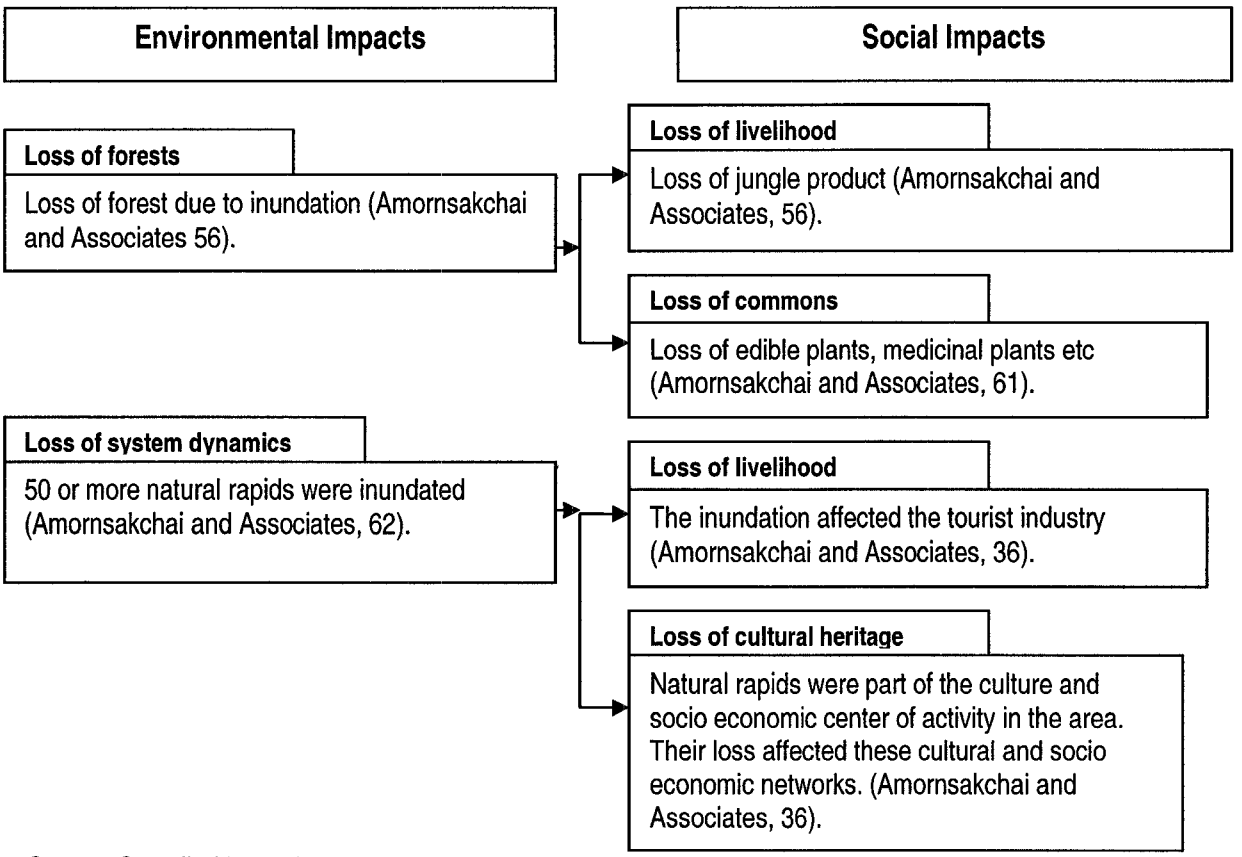
Table 4.3 : Environmental Impacts of Pak Mun Dam

		Categories of Environmental Impacts based on WCD Study	Environmental Impacts in Pak Mun Dam
1		**Impacts of reservoir on terrestial ecosystem and bio diversity**	141 Hectares of riparian area was inundated, along with 828 hectares of agricultural land (Amornsakchai and associates 67)
	a	Loss of forests due to inundation (WCD 2000, 75)	Along the Mun River, Pa Bung-Pa Tham, swamps and wetland forests, are parts of the riverine ecosystem. During the rainy seasons, these are flooding areas and places for fish to spawn. In the past, villagers used the area along the river to find bamboo shoots, mushrooms, native plants and vegetables that they depend on for their subsistence. During the dry seasons, they also developed narrow patches of land along the riverbanks for growing vegetables. In the upper part of the lower Mun, where banks were not steep, land along the river was developed as paddy fields or Na Rim Mun and Na Tham. After the dam was built, not only the rapids and "wang" were lost,lost, but also swamps, wetland forests, cultivation strips and paddy fields were submerged under the reservoir. (Amornsakchai and associates, 55)
	b	Loss of habitats for animals (WCD 2000, 75)	Forestland covering 20 hectares at the confluence of the Dome Noi and the Mun River was permanently submerged.(Amornsakchai and associates, 67)
	c	Elimination of Flora and Fauna (WCD 2000, 75)	A hundred or more medicinal plants were reportedly found near the Mun riverbanks (from the interview of this study, 1999). Loss of these plants due to inundation means significant loss of biodiversity
	d	Land degradation (WCD 2000, 75)	
	e	Increased sedimentation due to loss of vegetative cover (WCD 2000, 75)	
	f	Decreased water Quality (WCD 2000, 75)	
	g	Variable changes in the seasonal timing of water yield (WCD 2000, 75)	
2		**Emission of green house gases associated with large dam projects and their reservoirs**	
3		**Impacts of altered downstream flows on aquatic eco systems and bio diversity**	
	a	Introduction of Non-native species (WCD 2000, 78)	
	b	Loss of system dynamics (WCD 2000, 79)	From the field survey concluded by the Study team (in November 1999) it emerged form the statements of the people that more than 50 natural rapids were submerged due to water impoundment. (Amornsakchai and associates 2000, 62)
	c	Loss of ability to maintain continuity of an eco system (WCD 2000, 78)	
	d	blocking migration of aquatic organisms (WCD 2000, 78)	Of the 265 fish species recorded in the Mun-Chi watershed before 1994, 77 species are migratory and 35 species are dependent on rapid habitat.147 Available evidence does not indicate disappearance of any species before 1990, and nearly all species are very common ones to the region. Out of 265 species, about 10 were introduced species. The decline has been higher in the upstream region. The latest survey recorded 96 species in the upstream region. Out of 169 species not found in the present catch, 51 species have been caught less significantly since the completion of the project. At least another 50 species of rapid dependent fish have disappeared, and many species declined radically (Amornsakchai and associates 2000, 90)
4		**Impacts of altering the natural flood cycle on downstream floodplains**	
	a	Altered water temperature and chemistry (WCD 2000, 78)	
	b	Loss of aquatic species due to fluctuations in water level (WCD 2000, 79)	In the post dam period fishing communities located upstream and downstream of the dam reported 50-100% decline in fish catch (Amornsakchai and associates, 2000 60-61, Vii).
	c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80)	
	d	Impacts of loss of access to river on wildlife in riparian forests (WCD 2000, 80)	
	e	Impacts of channel, floodplain and coastal delta morphology (WCD 2000, 83)	
	f	Degradation of river channel below the reservoir (WCD 2000, 81)	
	g	Reduction/ Elimination of riparian vegetation (WCD 2000, 81)	
	h	Erosion of Coastline (WCD 2000, 81)	
	i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment (WCD 2000, 83)	
	j	Diminished recharge of groundwater in flood plains due to loss of floods (WCD 2000, 85)	
5		**Impacts of dams on fisheries in the upstream, reservoir and downstream areas (WCD 2000, 85)**	The fish catch directly upstream has declined by 60-80% after construction of dam (Amornsakchai and associates, Vii)
6		**Enhancement of ecosystem through reservoir creation and other means**	
	a	Creation of productive wetlands (WCD 2000, 87)	
	b	Habitat for birds (WCD 2000, 86)	
7		**Cumulative impact of a series of dams on a river system**	
		Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity (WCD 2000, 88)	Cumulative impacts of all dams on Mun river has led to disappearance of species (Amornsakchai and associates, 2000 Vii)

Table 4.4 : Social Impacts of Pak Mun Dam

		Categories of Social Impacts based on WCD Study	Social Impacts of Pak Mun Dam
1		**Socio economic impacts through planning and project cycles**	
	a	lack of development and welfare projects during the time lag that generally occurs between planning and onset of construction of a large dam (WCD 2000, 99)	
	b	Infrastructure (especially roads) exposes indigenous and vulnerable groups to national economy, threatening their lives and livelihood (WCD 2000, 100)	
	c	Loss of social cohesion with large influx of outsiders (like construction workers) (WCD 2000, 100)	
	d	Health problems due to increased population (in migration of construction workers) (WCD 2000, 100)	
2		**Displacement of people and livelihoods**	
	a	Physical displacement (WCD 2000, 102)	1700 families were displaced, rural families dependent on rice farming and fisheries income Cash compensation failed to provide livelihood regeneration.
	b	Loss of livelihood (WCD 2000, 102)	More than 6000 families of subsistence farmers and fisher folk suffered loss of livelihood from fisheries reduction
	c	Loss of commons (WCD 2000, 105)	The free access of local people to riparian areas was now underwater. they used to have harvested jungle produce in those inundated areas (Amornsakchai and associates 2000, 60-61).
3		**Indigenous people**	
	a	Cultural alienation (Colchester 2000, 16)	
	b	Disposesion, both from their land and other resources (Colchester 2000, 16)	
	c	Lack of compensation or inadequate compensation (Colchester 2000, 16)	Some households had to settle in forest reserve areas or on other common property as the compensation money was insufficient to buy alternative land.(Amornsakchai and associates 2000 Viii)
	d	Human rights abuse (Colchester 2000, 16)	
	e	Lowering of living standards (Colchester 2000, 16)	
4		**Downstream livelihoods**	
	a	Impact on flood plain house hold due to loss of access to river and river banks (Adams 2000, 4)	
	b	Impacts on fisherman (out migration and ill health) (Adams 2000,4)	Villagers below the dam also claim that they hardly catch any fish because their fishing gear is often damaged by the operation of generators, making the discharged water highly turbulent and dangerous to fish. They have to wait until midnight when the generators stop. Villagers of Ban Hua Heo located at the first rapids or the Łcapital of fishŁ cannot use their conventional fishing gears anymore because the blasting of rapids and rocks have destroyed fertile fishing ground (Amornsakchai and associates 2000, 54)
	c	Loss of Delta resources (Adams 2000,4)	
	d	Loss of Coastal resources (Adams 2000, 4)	
5		**Widened Gender disparities**	
	a	imposing a disproportionate share of social costs on women (WCD 2000, 114)	
	b	inequitable allocation of the benefits generated (WCD 2000, 114)	At least 40 different edible plants, 10 species of bamboo and 45 mushroom species were found to be freely harvested by the locals (mostly women) for domestic consumption (Kittisiri, 1997). Women and housewives also earned a small but sustainable daily income of at least 5-10 and sometimes even up to 50-60 Baht a day from selling the harvested vegetables at local markets (Amornsakchai and associates 2000, 61)
6		**Loss of Cultural heritage**	The natural rapids of the Mun were actually also local of cultural and socio-economic centres of activity in the area. People from various communities gathered here of there to catch fish and engage in formal and non-formal exchange of goods/services at the rapids. They come in a group or individually and relationships grew out of these interactions. This generated a feeling of community and cultural and social networks. The inundation of the rapids has at one stroke virtually destroyed (Amornsakchai and associates 2000, 65, 66)
	a	loss of culturally important sites (temples, archaelogical sites etc) (WCD 2000, 116)	
7		**Adverse health impacts**	
	a	Adverse health impacts caused due to lowered nutrition (WCD 2000, 118)	The abundance of fish pre dam ensured household subsistence and nutrition. The surplus income froom fishing supported rice farming (Amornsakchai and associates, 2000 60-61Viii)
	b	Spread of diseases due to dam (various vector born diseases) (WCD 2000, 118)	

Social and Environmental Interactions for the Pak Mun Dam



Source: Compiled by Author

Currently after a decade of resistance by the local villagers, the Government of Thailand opened the gates of the Pak Mun Dam in June 2001, for one year of commissioning studies. The preliminary studies show improved aquatic diversity. The riparian ecosystem along the river has started to recover in the last year following the dam removal[6].

[6]Website of Rivers Watch, East and South East Asia http://www.rwesa.org/pakmun2nd.html accessed on 05/30/03

4.3 Case Study 3: Chixoy Dam, Guatemala

Context and Scope

Chixoy Dam was built by the Guatemala National Electrification Institute (INDE) during the 1976-1985 period. It was financed with loans from the World Bank and Inter- American Development Bank (IDB) (Levy 2002, 7). The project's principal objective was

- To provide a reliable source of cheap and abundant energy to Guatemala (Stewart and Associates, 10).

The Chixoy hydro-electric project was built during the military dictatorship in Guatemala and in the midst of a violent civil war fought between the army and armed opposition groups, a war that caused about 200,000 victims among civilians between 1980 and 1984 (Coljacamo 2000, 1).

Case Study Procedure:

Three reports were used for this study, They are:

1. A People Dammed: This publication examines the Chixoy project as a case study in destructive World Bank lending, suggesting links between the project and the 1982 Rio Negro Masacres and demonstrating that the Chixoy was a socio economic failure (Stewart and Associates, 2). The first chapter of the publication explains the World Bank's involvement in the project while, the second chapter explains the current conditions of the project area. The second chapter of the report was very helpful for the study as it throws light on some facts.
2. Life Submerged: Technical, economic and social costs incurred during the course of construction of Chixoy Dam were well documented, while the environmental impacts of the dam have been largely ignored (Levy 2002, 3). The author uses a combination of document procurement analysis and key informants to do the study. This study was very helpful and proved valuable information for the researcher's case study. Since it used key informants, the social impacts caused due to environmental impacts were very clear.

3. The Maya Achi Genocide: The Story of Forced Resettlement: This paper mainly talks about the struggle that one indigenous group had to face due to the project. It has given useful insights as to social impacts of the dam.

Technical Details

Name of the Project:	Chixoy Hydroelectric Dam
Construction Year:	1976
River:	Rio Chixoy
Owned by:	INDE, Guatemala National Electrification Institute
Operator:	INDE
Dam Type:	Rock-fill dam and spillway
Dam Height:	
Reservoir Area:	1400 ha
Hydropower Capacity (MW):	300 MW generating capacity
No of People Resettled:	3400
Total Land Acquired for the Project:	1400 ha
Other Ecological Impacts:	
Resettlement:	Resettlement was provided
Critical Aspect of the Dam:	It included a series of four massacres, in which half of the *Maya Achi* Community (440 people) were murdered.
Year Completed:	1985

Environmental Impacts

High mountainous regions with rugged topography and steep slopes characterize the Rio Chixoy Basin, which has a catchment area of 6000 km^2. The major ecological impacts of the Chixoy Dam as research revealed are (broadly defined) (Stewart and Associates, 3) as:

1) Flooding of 14 km^2 of forested and cultivated lands (as well as several archaeological sites)

2) Dewatering of 56 km (35 mi) of riverbed channel downstream from the dam.

3) Alterations to the fish community, including local extinction of certain species, the introduction of exotic species, yearly fish die-offs, and the introduction of fish disease.

4) Local extinction of native wildlife population.

5) Increased incidence of malaria and dengue fever in the human population.

Social Impacts:

The project completely disregarded the people displaced by the dam, as there was a total lack of public participation in the planning phase of the program. The dam affectees were informed about their

displacement only after the construction of the dam had started. The Rio Negro population (Maya Achi tribe) was the only one of the community that was to be displaced by the dam. A total of 3440 people were displaced. Other communities in the affected area agreed to displacement (i.e., the Mestizo community of Chicruz). The Rio Negro population disagreed with relocation because, "The Rio Negro valley was the most fertile and well connected to the forests and their resources, the river and the upper Verapaz markets, where the people could trade hand crafts and food" (Coljacamo 2000, 3).

Table 4.5: Environmental Impacts of Chixoy Dam

	Categories of Environmental Impacts based on WCD Study		Chixoy Dam, Guatmela
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**		
	a	Loss of forests due to inundation (WCD 2000, 75)	14 Km^2 of forested and cultivated lands (as well as several archaelogical sites) were flodded (Stewart and associates 2000, 3)
	b	Loss of habitats for animals (WCD 2000, 75)	
	c	Elimination of Flora and Fauna (WCD 2000, 75)	The riparian areas along the river were flooded consisted of large fruit trees, smaller shrubs and herbs growing on the banks of the river (Stewart and associates 2000, 19)
	d	Land degradation (WCD 2000, 75)	
	e	Increased sedimentation due to loss of vegetative cover (WCD 2000, 75)	Despite warnings of high sedimentation rates and recommendations and plans to combat erosion through soil conservation and reforestration programs, the watershed still experiences a huge amount of erosion wuth sediments ending in the reservoir. (Stewart and associates 2000, 17)
	f	Decreased water Quality (WCD 2000, 75)	
	g	Variable changes in the seasonal timing of water yield (WCD 2000, 75)	
2	**Emission of green house gases associated with large dam projects and their reservoirs**		
3	**Impacts of altered downstream flows on aquatic eco systems and bio diversity**		
	a	Introduction of Non-native species (WCD 2000, 78)	When the reservoir was first filled, the lake was stocked with exotic fish species that out competed the native fish (Stewart and associates 2000, 19)
	b	Loss of system dynamics (WCD 2000, 79)	The reservoir has flooded the historic river channel 50 KM upstream of the dam, therefore turned a lotic system in to a 13.5 Km^2 lentic eco system (Stewart and associates 2000, 15)
	c	Loss of ability to maintain continuity of an eco system (WCD 2000, 78)	
	d	blocking migration of aquatic organisms (WCD 2000, 78)	
4	**Impacts of altering the natural flood cycle on downstream floodplains**		
	a	Altered water temperature and chemistry (WCD 2000, 78)	Villagers have noticed an increase in water temperature (Stewart and associates 2000,16)
	b	Loss of aquatic species due to fluctuations in water level (WCD 2000, 79)	The dam has led to a decrease in species richness of the aquatic eco system, although fish are still plentiful in the reservoir (Stewart and associates 2000, 19)
	c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80)	In downstream riparian areas an encroachment of fast growing (ephemeral) vegetation occurs during summer months, but the floods clean out the vegetation annually (Stewart and associates 2000, 24)
	d	Impacts of loss of access to river on wildlife in riparian forests (WCD 2000, 80)	
	e	Impacts of channel, floodplain and coastal delta morphology (WCD 2000, 83)	
	f	Degradation of river channel below the reservoir (WCD 2000, 81)	Dewatering of 56 KM of riverbed channel (Stewart and associates 2000, 3)
	g	Reduction/ Elimination of riparian vegetation (WCD 2000, 81)	There has been a loss of large trees along the riparian zone, likely caused by a combination of lack of ground water recharge during dry months and high volume flows released from the dam during wer months which do not allow seedlings to become established (Stewart and associates 2000, 24).
	h	Erosion of Coastline (WCD 2000, 81)	
	i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment (WCD 2000, 83)	
	j	Diminished recharge of groundwater in flood plains due to loss of floods (WCD 2000, 85)	
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas (WCD 2000, 85)**		
6	**Enhancement of ecosystem through reservoir creation and other means**		
	a	Creation of productive wetlands (WCD 2000, 87)	The reservoir has created habitat for several species of water fowls which previously that did not previously inhabit the riverine system (Stewart and associates 2000, 20)
	b	Habitat for birds (WCD 2000, 86)	
7	**Cumulative impact of a series of dams on a river system**		
		Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity (WCD 2000, 88)	

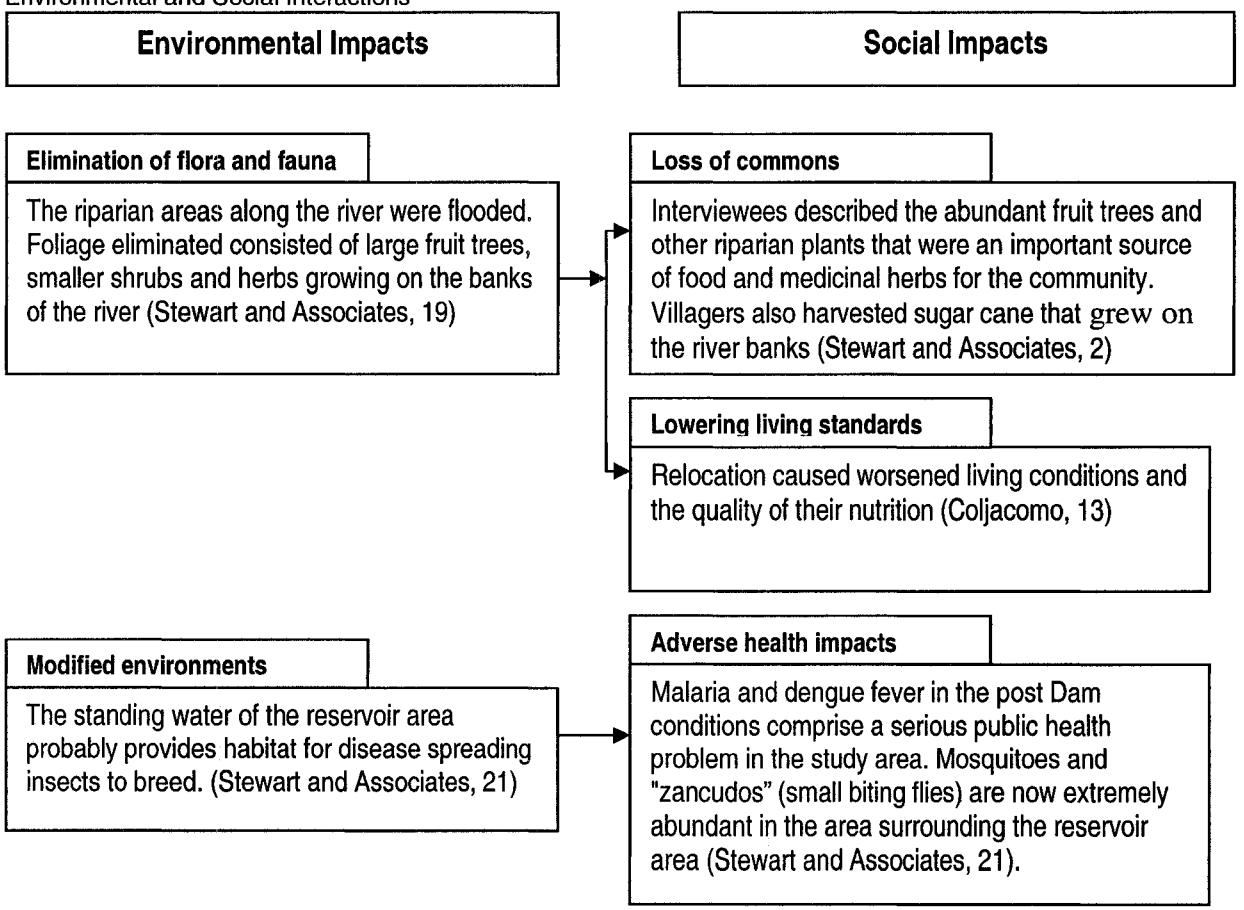
Source: Compiled by the author

Table 4.6: Social Impacts of Chixoy Dam

	Categories of Social Impacts based on WCD Study		Social Impacts of Chixoy Dam, Guatmela
1	**Socio economic impacts through planning and project cycles**		
	a	lack of development and welfare projects during the time lag that generally occurs between planning and onset of construction of a large dam (WCD 2000, 99)	
	b	Infrastructure (especially roads) exposes indigenous and vulnerable groups to national economy, threatening their lives and livelihood (WCD 2000, 100)	
	c	Loss of social cohesion with large influx of outsiders (like construction workers) (WCD 2000, 100)	
	d	Health problems due to increased population (in migration of construction workers) (WCD 2000, 100)	
2	**Displacement of people and livelihoods**		
	a	Physical displacement (WCD 2000, 102)	
	b	Loss of livelihood (WCD 2000, 102)	All the inhabitants depended on agriculture and fishing for their livelihood, most of the land provided in their new site is not cultivable (Stewart and associates 1995, 22)
	c	Loss of commons (WCD 2000, 105)	Interviewees described the abundant fruit trees and other riparian plants that were important source of food and medicinal herbs for the community. Villagers also harvested sugar cane that grew on the river banks(Stewart and associates 1995, 2)
3	**Indigenous people**		
	a	Cultural alienation (Colchester 2000, 16)	The attachment that INDE referred to is due to the fact that, since the classic Maya age (330 AC to 900 DC), the area around the Chixoy river was inhabited by indigenous people who built up various ceremonial religious centers. (Coljacomo 2000, 1)
	b	Disposesion, both from their land and other resources (Colchester 2000, 16)	
	c	Lack of compensation or inadequate compensation (Colchester 2000, 16)	The village(resettlement village) was inhospitable, housing badly built. Electricity and water supply were provided, but up to today the supply was at best sporadic (3-8) The Rio Negro people have so far obtained only 7 caballerias against the 22.5 caballerias of flooded land, that is, less than one third.(Coljacomo 2000 ,10)
	d	Human rights abuse (Colchester 2000, 16)	Half the population (376 including women and children) of Maya'Achi was masacred by soldiers and Xococ patrollers between Mar'04, 1980 and Sep 13, 1982
	e	Lowering of living standards (Colchester 2000, 16)	People used of have free access to water in pre dam conditions, now they have to pay for water supply (Stewart and associates1995, 23) People had to pay for resources which were previously available from the forest (Stewart and associates 1995, 24)
4	**Downstream livelihoods**		
	a	Impact on flood plain house hold due to loss of access to river and river banks (Adams 2000, 4)	
	b	Impacts on fisherman (out migration and ill health) (Adams 2000,4)	
	c	Loss of Delta resources (Adams 2000,4)	
	d	Loss of Coastal resources (Adams 2000, 4)	
5	**Widened Gender disparities**		
	a	imposing a disproportionate share of social costs on women (WCD 2000, 114)	
	b	inequitable allocation of the benefits generated (WCD 2000, 114)	
6	**Loss of Cultural heritage**		
	a	loss of culturally important sites (temples, archaelogical sites etc) (WCD 2000, 116)	Among the archeological losses were also the Cahuinal site in Cubulco, with its religious temples where communities went to pray, the Pelota playing field, more than 150 other buildings and other 16 Mayan ceremonial sites. (Coljacomo 2000,11)
7	**Adverse health impacts**		
	a	Adverse health impacts caused due to lowered nutrition (WCD 2000, 118)	Relocation has caused worsened living conditions for local communities and the quality of their nutrition. (Coljacomo, 13)
	b	Spread of diseases due to dam (various vector born diseases) (WCD 2000, 118)	Malaria and Denuge fever in the post dam conditions comprise a serious public health problem in the study area mosquitoes and *zancudos' (small biting flies) are now extreemely abundant in the area surrounding the reservoir area. The standing water of the reservoir area probably provides habitat for these insects to breed. (Stewart and associates 1995, 21)
		Other Important Social Impacts	In February 1999, the United Nations-sponsored Commission for Historical Clarification concluded that in certain regions of the country the Army planned and carried out genocide (according to article 11 of the Convention on Genocide), classified the violence that occurred in Río Negro as genocide, and included the forced resettlement among the causes of elimination of the Río Negro community. In the face of still remarkably horrific conditions, the survivors have been able to have their experience – in terms of genocide, violence, loss of traditional livelihoods, and the poverty and instability that these create – verified and corroborated at high levels. (Coljacomo 2000, 11)

Source: Compiled by the Author

Environmental and Social Interactions



Source: Compiled by Author

4.4 Case Study 4: Tarbela Dam, Pakistan

Context and Scope

Construction of the Tarbela Dam started in 1967, and the first four power units started generating in early 1977. The cost of the project, excluding power units and the cost of resettlement, is $1497 Million. The main objectives of the dam were (Asiantics 2000, 8):

- To provide 11.5 billion cubic meters storage dam on the River Indus.
- To increase food production and to achieve self sufficiency in food.
- To generate cheap hydropower through staged development of 2100 MW of capacity.

The dam affected about 33,200 hectares in 135 villages, and displaced about 96,000 people in 120 villages. None of those displaced downstream were resettled (Asiantics 2000, XV).

Case Study Procedure: Most of the information for this case study was acquired from the WCD Case Study Report. Tarbela Dam was one of the eight case studies conducted by the World Commission on dams. The WCD study team for Tarbela case study consisted of 11 members, and the team was headed by Dr. Amir Muhammed, from Asianics Agro-Dev International, Islamabad. Other members represented various sectors related to dam construction, while there was one person representing the hydro power sector, another person representing the irrigation sector. There were also two professors of sociology and two members representing the environment and ecology sectors (Asiantics 2000, 2).

The study used existing data sources and published reports. In addition, the team collected micro level information from stakeholders and affectees to supplement the socio-economic and environmental aspects of the project.

Technical Details

Name of the Project:	Tarbella Dam
River:	Indus
Owned by:	Government of Pakistan
Operator:	Indus River System Authority
Dam Type:	Earth fill dam

Dam Height:	143 M.
Reservoir Area:	260 KM^3
Hydropower Capacity (MW):	3478 MW
No of People Resettled:	96,000
Total Land Acquired for the Project:	33,221
Other Ecological Impacts:	Degraded mangroove areas, reduced fish.
Resettlement:	Those who had a minimum of 0.2 hectares of irrigated land or 0.8 hectares of non irrigated land were be eligible for alternate land.
Critical aspect of the Dam:	This dam was the largest earth fill dam of its time.
Completion Year	1976

Natural Environment of Indus River Basin: The Indus River Basin can be divided into four parts. They are

a. *The Mountain River Ecosystem:* These extend from the headwaters of the Indus (and its tributaries as they flow through the Himalayas) to the point where it emerges from the foothills at Tarbela. The dam at Tarbela, at an altitude of 471m, has created a reservoir of about 25,600ha. with a depth of 64m., backing up the river by 97 km (Asiantics, 105).

b. *The Upper Indus Ecosystems of the Punjab Plains:* There are three major barrages on this stretch of the Indus: Kalabagh, Chashma and Taunsa being the main offtakes for irrigation and re-distribution of water through link canals to the other Punjab rivers (Asiantics, 105).

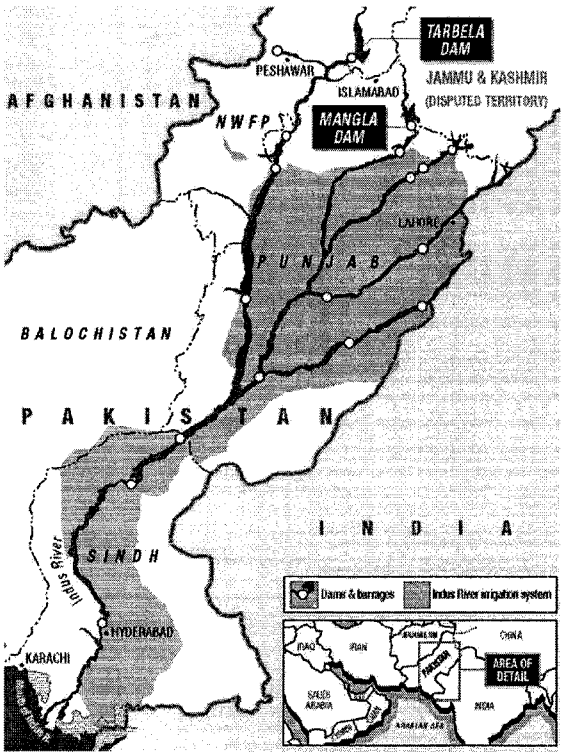
c. *Ecosystems of Lower Indus:* It meanders through a very wide flood plain (several kilometres wide). Flooding is common and results in accumulated silt being deposited. Due to confinement, the river bed is being gradually raised so that some riverine forests now lie high above the regular flooding levels (Asiantics, 106).

d. *The Indus Delta*: The Indus Delta is one of the largest areas of arid climate mangroves in the world and is the seventh largest delta (Asiantics, 107).

Impacts of Dam on the Existing Natural Environment: The Indus Basin Irrigation System is the largest continuous irrigation system in the world developed over the last 140 years (Asiantics, 4). A number of dams were constructed in the basin, Tarbela being the largest among them. The total storage capacity of dams in the basin is 19 Billion Cubic Meters (BCM), two thirds of which is provided by Tarbela reservoir (12

bcm). An environmental impact assessment was not required prior to construction of the dam, hence there is a lack of base line information of the pre existing environmental conditions.

Figure 4.6: Tarbela Dam Location



Source: World Commission on Dams http://www.dams.org/images/maps/map_tarbela.htm

Table 4.7: Environmental Impacts of Tarbela Dam

Tarbela Dam, Pakistan

Categories of Environmental Impacts based on WCD Study			
1		**Impacts of reservoir on terrestial ecosystem and bio diversity**	Tarbela Dam, Pakistan
	a	Loss of forests due to inundation (WCD 2000, 75)	
	b	Loss of habitats for animals (WCD 2000, 75)	1. The many forested islands in the river- the belas- used to be refuges for wildlife, but with reduced flooding in the river, access to these belas has been made easier with the result that many forests have been cleared and increasingly land on the belas is being used for agriculture (Asiantics 2000, 148) 2. Changes in habitat have resulted in losses of important wildlife species, for example, swamp deer and gharial have become extinct (Asiantics 2000,16)
	c	Elimination of Flora and Fauna (WCD 2000, 75)	The flora and fauna of the mountain river have been lost or pushed upstream, and over a period of time, a lacustrine flora and fauna has established (Asiantics 2000, 111)
	d	Land degradation (WCD 2000, 75)	
	e	Increased sedimentation due to loss of vegetative cover (WCD 2000, 75)	
	f	Decreased water Quality (WCD 2000, 75)	
	g	Variable changes in the seasonal timing of water yield (WCD 2000, 75)	In downstream riverine areas, those dependent on flood based recession agriculture and the natural resources of wetlands and forests were negatively affected by reduced flood flows, due in part to reduced flows and to the impact of flood embankment (Asiantics 2000, 17)
2		**Emission of green house gases associated with large dam projects and their reservoirs**	
3		**Impacts of altered downstream flows on aquatic eco systems and bio diversity**	
	a	Introduction of Non-native species (WCD 2000, 78)	
	b	Loss of system dynamics (WCD 2000, 79)	
	c	Loss of ability to maintain continuity of an eco system (WCD 2000, 78)	
	d	blocking migration of aquatic organisms (WCD 2000, 78)	The building of the dam has prevented the migration of mahseer in to the cooler waters upstream during summer (Asiantics 2000, 142)
4		**Impacts of altering the natural flood cycle on downstream floodplains**	
	a	Altered water temperature and chemistry (WCD 2000, 78)	
	b	Loss of aquatic species due to fluctuations in water level (WCD 2000, 79)	
	c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80)	Changes to the floodplain due in part to flood bunds has reduced the indigenous *Acacia Nilotica* and beds of *Typha,* and allowed the invasion of exotic species(*Prosopis*) with negative impacts on wildlife. (Asiantics 2000, 16)
	d	Impacts of loss of access to river on wildlife in riparian forests (WCD 2000, 80)	
	e	Impacts of channel, floodplain and coastal delta morphology (WCD 2000, 83)	1. The overall average sedimentation was 0.106 bcm during 1974-99. In 15 years 2057 meters of reservoir was filled with sediment (Asiantics 2000, 72) 2. The building of tarbela dam has changed the eco system of the mountain upstream, coverting it into a deep narrow oligotrophic lake. The productivity of this lake is low, and there is no emergent vegetation due to operational draw down (Asiantics 2000, 116). 3. Reduced sediment reaching the sea has stopped the growth of delta and it may even now be transgressing (Asiantics, 145)
	f	Degradation of river channel below the reservoir (WCD 2000, 81)	The most evident eco system changes resulting from changed flow patterns have occurred below kotri barrage, where the river can sometimes cease to flow for up to three months at a time. It has become severely braided and the channel can become blocked by sand bars. Saline intrusion has increased upstream has increased during rabi season, reaching approximately 25km upstream from delta (Asiantics 2000, 149)
	g	Reduction/ Elimination of riparian vegetation (WCD 2000, 81)	1. Decline of previously predominant species like Acacia Nilotica and Populus Euphrotica (Asiantics 2000, 146) 2. Increased intrusion of sea water has negatively affected the Mangrove forests (Asiantics 2000, 165) 3. Due to increased erosion, delta is expected to be inundated as high as several metres per year (Asiantics 2000, 114)
	h	Erosion of Coastline (WCD 2000, 81)	
	i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment (WCD 2000, 83)	Reduced sediment transport has reduced the alluvium deposited in the flood plain causing a reduction in nutrient status of soils (Asiantics 2000, 145)
	j	Diminished recharge of groundwater in flood plains due to loss of floods (WCD 2000, 85)	
5		**Impacts of dams on fisheries in the upstream, reservoir and downstream areas (WCD 2000, 85)**	
6		**Enhancement of ecosystem through reservoir creation and other means**	
	a	Creation of productive wetlands (WCD 2000, 87)	The wetlands in the river basin have remained more or less losses due to lower flooding being balanced by increases due to barrage reservoir and seepage from the canals (Asiantics 2000, 148)
	b	Habitat for birds (WCD 2000, 86)	The lake is staging point for migratory birds, but is not suitable for over wintering birds (Asiantics 2000, 148)
7		**Cumulative impact of a series of dams on a river system**	
		Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity (WCD 2000, 88)	

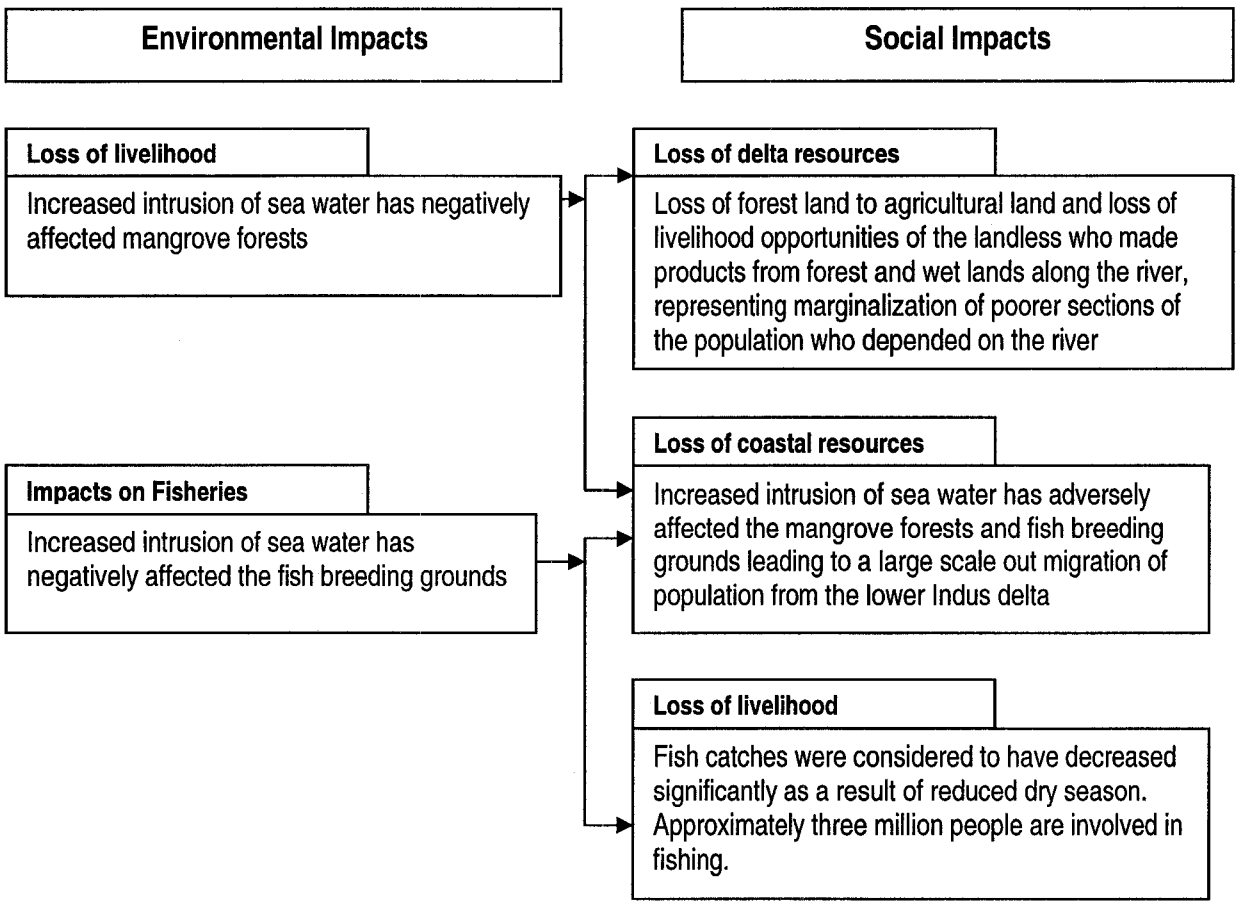
Source: Compiled by the Author

Table 4.8: Social Impacts of Tarbela Dam

		Categories of Social Impacts based on WCD Study	Social Impacts of Tarbela Dam
1		**Socio economic impacts through planning and project cycles**	
	a	lack of development and welfare projects during the time lag that generally occurs between planning and onset of construction of a large dam (WCD 2000, 99)	
	b	Infrastructure (especially roads) exposes indigenous and vulnerable groups to national economy, threatening their lives and livelihood (WCD 2000, 100)	
	c	Loss of social cohesion with large influx of outsiders (like construction workers) (WCD 2000, 100)	
	d	Health problems due to increased population (in migration of construction workers) (WCD 2000, 100)	
2		**Displacement of people and livelihoods**	
	a	Physical displacement (WCD 2000, 102)	1. 96,000 people from 120 villages were displaced (Asiantics 2000, XIV) 2. Only two thirds of affected people were eligible for land (Asiantics 2000, XIV)
	b	Loss of livelihood (WCD 2000, 102)	1. Livelihood of landless and ineligible affectees was adversely affected due to the resettlement process (Asiantics 2000, 83) 2. The fishing economy of the affectees was disrupted due to the reservoir, current fishing projects are awarded to contractors who bring fishermen from other parts of the country (Asiantics 2000, 84)
	c	Loss of commons (WCD 2000, 105)	Number of people affected by the project but not eligible for compensation has not been quantified, although assertion froms concerned groups place this number in the same order of magnitude as the number of those that are eligible (Asiantics 2000, XIV)
3		**Indigenous people**	
	a	Cultural alienation (Colchester 2000, 16)	
	b	Disposesion, both from their land and other resources (Colchester 2000, 16)	
	c	Lack of compensation or inadequate compensation (Colchester 2000, 16)	
	d	Human rights abuse (Colchester 2000, 16)	
	e	Lowering of living standards (Colchester 2000, 16)	
4		**Downstream livelihoods**	
	a	Impact on flood plain house hold due to loss of access to river and river banks (Adams 2000, 4)	Reduced flow of river water due to upstream dams has resulted in a reduced supply of fresh water for drinking purposes and for agriculture (Asiantics 2000 XIV)
	b	Impacts on fisherman (out migration and ill health) (Adams 2000,4)	Fish catches were considered to have decreased significantly as a result of reduced dry season approximately three million people are involved in fishing (Asiantics 2000, 96)
	c	Loss of Delta resources (Adams 2000,4)	[illegible] who made products from forest and wetlands along the river, representing marginalisation of poorer sections of the population who depended on the river (Asiantics2000, 99) 2. Grazing for domestic animals has become rare in the delta, camels have to be maintained with boat loads of water through out the year. The only remaining livelihood for people living in delta is fishing (Asiantics 2000, 146) 3. Riparian vegetations like Acacia Nilotica, which was important for grazing animals and fuel wood has deteriorated. Another timber species Populus Euphrotica which was used for lacquer work
	d	Loss of Coastal resources (Adams 2000, 4)	Increased intrusion of sea water has adversely affected the Mangroove forests and fish breeding grounds leading to a large scale out migration of population from lower indus delta (Asiantics 2000, XV)
5		**Widened Gender disparities**	
	a	imposing a disproportionate share of social costs on women (WCD 2000, 114)	1. Gender aspect has been totally neglected in the resettlement process, and women specifically have suffered as a result of the disruption of their social life due to migration (Asiantics 2000, XIV) 2. In the pre dam conditions, women had mobility since they lived with their close relatives, but after resettlement the neighbours are not relatives and they are confined to their houses.(Asiantics 2000, 88)
	b	Inequitable allocation of the benefits generated (WCD 2000, 114)	
6		**Loss of Cultural heritage**	1. Families have been divided and lost their identity (Asiantics 2000, 90) 2. Their emotional attachment to their fore fathers was severely damaged when their graveyards were submerged under water (Asiantics 2000, 91)
	a	loss of culturally important sites (temples, archaelogical sites etc) (WCD 2000, 116)	

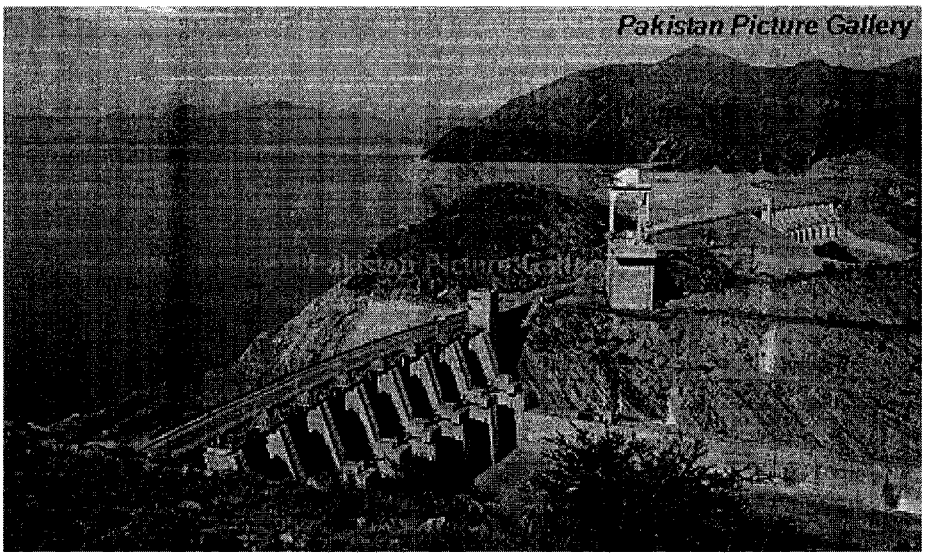
Source: Compiled by the Author

Figure1: Environmental Impacts leading to Social Impacts



Source: Compiled by Author

Figure 4.7: Tarbela Dam



Source: http://www.pakistanpage.net/gallery/main/misc/td.html

4.5 Case Study 5: Katse Dam, Lesotho

Context and Scope:

Lesotho is one of the smallest countries in the world. Approximately of the size of Belgium it is also one of the worlds poorest countries (Hoover 2001, 1). Lesotho is landlocked by its powerful neighbor South Africa. The country has one of the ten highest income disparities in the world (Hoover 2001, 1). The economic impact of the multi billion dollar Lesotho Highland Water Project (LHWP) is profound. In 1998 the project accounted for 13.6% of the value of Lesothos's Gross Domestic Product (GDP). Royalties from the project make up 27.8% of all government revenue. Some 4000 Basotho (citizens of Lesotho) got temporary jobs at the Katse Dam construction site, and hundreds flocked into the area to service the workers as food vendors, shopkeepers and prostitutes (Hoover 2001, 2).

LHWP is the most massive infrastructure project ever constructed on the African Continent (Hoover 2001, 1). The whole project has four phases. The first phase is again divided into phases 1A and 1B. Katse Dam, Muela Dam , Transfer tunnel, Delivery tunnel and Muela power station are completed under phase 1A construction (www.lhwp.org.ls/overview/concept). This case study discusses the impacts of Katse Dam constructed in Phase 1 A of the project. LHWP was prepared with professionals covering socio-economic and environmental issues resulting in a high quality environmental action plan (Hoover 2001 2).

Compared to other resettlement projects around the world, Katse Dam's resettlement program is very well funded. Each resettled household is provided with approximately $ 62,500 worth of benefits, which is the highest amount ever spent per resettled household in any World Bank funded project (Hoover 2001 17). Despite this grandiose plan which is acclaimed as "Africa's biggest ongoing success stories" "best plans" etc by the World Bank and other funding organizations (Hoover 2001 2), serious delays in resettlement and flawed implementation resulted in significant harm to the affected communities (Hoover 2001 2).

Case Study Procedure: This study uses the publication of International Rivers Network (Pipe Dreams). Though the report addresses the completed first phase of the LSWP, it refers to the Katse Dam and specific

impacts of the dam in various sections of the report. This source has proved to be very valuable, and its insights have been very useful for this study. The paper by Patrick Bond has a section on Katse Dam and has been useful in identifying certain social and environmental impact interrelations.

Technical Details

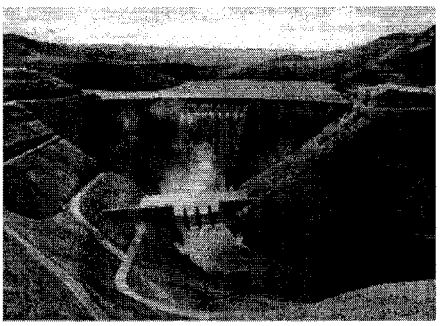
Name of the Project:	Katse Dam
River:	Orange River
Owned by:	Lesotho Highland Water Commission
Operator:	Lesotho Highlands Water Commission
Dam Type:	Double Curvature Concrete Arch
Dam Height:	185 M.
Reservoir Area:	3600 ha
Storage Capacity:	*1950* 10^6 M^3*
Hydropower Capacity (MW):	NA
No of People Resettled:	21,700
Total Land Acquired for the Project:	
Other Ecological Impacts:	Loss of riparian areas
Resettlement:	Best resettlement plan, but flawed implementation
Critical aspect of the Dam:	Tallest dam in Africa
Completion Year:	1996

Natural Environment of Orange River Basin: The Lesotho Highlands Water Project is the largest inter basin and transboundary water project in Sub Saharan Africa (Hoover 2001, 3). Lesotho's tourist industry often refers to the Maloti Mountains as the 'Rugged Mountain Range'. In addition to supporting the rural mountain communities in farming and herding their animals in the rugged mountain watersheds, this range also supports a fragile ecosystem (Hoover 2001, 2). The mountains are home to the threatened spiral aloe and scores of wild flower species (Hoover 3). Trees grow only in riparian areas (Hoover, 3). The Katse and Muela Dams affected these riparian areas directly and inundated the best land suitable for vegetation as well as common areas used by the community (Hoover, 7).

Social Structure Prior to the Dam: Villages are relatively small, consisting of perhaps 25 family compounds per village. Villagers in the LHWP area are very poor, according to a survey in 1993, which found nearly 80% of the villagers survived on less than $15 per month (Hoover 3). Most of them lived on far

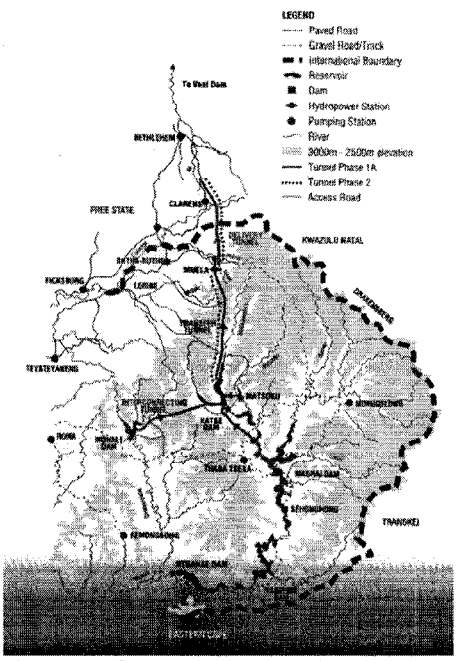
less. The Katse Dam has affected common natural resources which provided resources like the ingredients for a nutritious diet for the families (in the form of vegetables), grazing lands for their herds, building materials etc. Communities also have to search for an alternate fuel source worth $200 per year, thereby substantially increasing the cost of living of the communities (Hoover 2001, 6).

Figure 4.7: Katse Dam



Source: Lesotho Highlands Water Project Official Website http://www.lhwp.org.ls/ accessed on 05/30/03

Figure 4.8: Map of Lesotho Highlands Water Project



Source: Official website of Lesotho Highlands Water Project http://www.lhwp.org.ls/ accessed on 05/30/03

Table 4.9: Environmental Impacts of Katse Dam

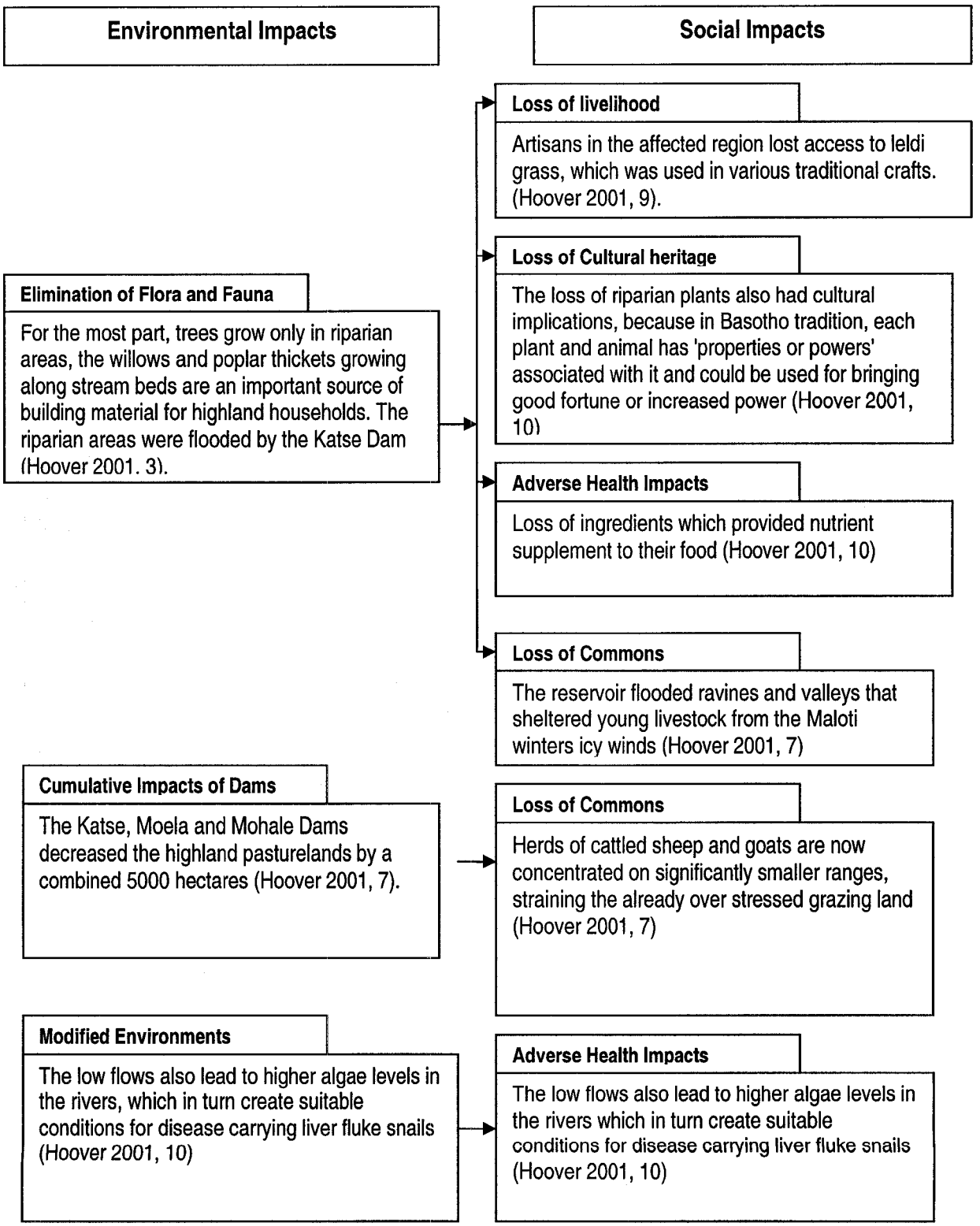
	Categories of Environmental Impacts based on WCD Study		Environmental Impacts in Katse Dam
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**		
	a	Loss of forests due to inundation (WCD 2000, 75)	
	b	Loss of habitats for animals (WCD 2000, 75)	
	c	Elimination of Flora and Fauna (WCD 2000, 75)	1. Over 175 species of medicinal plants grew in the flooded areas. Some species disappeared from the area completely. (Hoover 2000, 8) 2. The dams also destroy crucial habitats of the Maluti Minnow (an endangered species), bearded vulture and four other species considered "globally threatened." (Bond 1999) 3. For the most part trees grow only in riparian ares, the willows and poplar thickets growing along stream beds are an important source of building material for highland households (Hoover 2000, 3)
	d	Land degradation (WCD 2000, 75)	
	e	Increased sedimentation due to loss of vegetative cover (WCD 2000, 75)	
	f	Decreased water Quality (WCD 2000, 75)	Water below Katse dam is too contaminated to drink (Hoover 2000, 10)
	g	Variable changes in the seasonal timing of water yield (WCD 2000, 75)	
2	**Emission of green house gases associated with large dam projects and their reservoirs**		
3	**Impacts of altered downstream flows on aquatic eco systems and bio diversity**		
	a	Introduction of Non-native species (WCD 2000, 78)	
	b	Loss of system dynamics (WCD 2000, 79)	The reservoirs also flooded ravines and valleys that formerly held most palatable grass (Hoover 2000, 7)
	c	Loss of abilty to maintain continuity of an eco system (WCD 2000, 78)	
	d	blocking migration of aquatic organisms (WCD 2000, 78)	
4	**Impacts of altering the natural flood cycle on downstream floodplains**		
	a	Altered water temperature and chemistry (WCD 2000, 78)	
	b	Loss of aquatic species due to fluctuations in water level (WCD 2000, 79)	A decline in Fish stock downstream (Hoover 2000, 10)
	c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80)	The low flows also lead to higher algae levels in the rivers which in turn create suitable conditions for disease carrying liver fluke snails (Hoover 2000, 9)
	d	Impacts of loss of access to river on wildlife in riparian forests (WCD 2000, 80)	
	e	Impacts of channel, floodplain and coastal delta morphology (WCD 2000, 83)	
	f	Degradation of river channel below the reservoir (WCD 2000, 81)	
	g	Reduction/Elimination of riparian vegetation (WCD 2000, 81)	
	h	Erosion of Coastline (WCD 2000, 81)	
	i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment (WCD 2000, 83)	
	j	Diminished recharge of groundwater in flood plains due to loss of floods (WCD 2000, 85)	
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas (WCD 2000, 85)**		
6	**Enhancement of ecosystem through reservoir creation and other means**		
	a	Creation of productive wetlands (WCD 2000, 87)	
	b	Habitat for birds (WCD 2000, 86)	
7	**Cumulative impact of a series of dams on a river system**		
		Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity (WCD 2000, 88)	Katse, Muela and Mohale dams decreased the highlands pasture lands by a combined 5000 Hectares. Herds of cattle sheep and goats are now concentrated on a significantly smaller range straining already over stressed grazing land. (Hoover 2000, 7)

Source: Compiled by the Author

Table 4.10: Social Impacts of Katse Dam

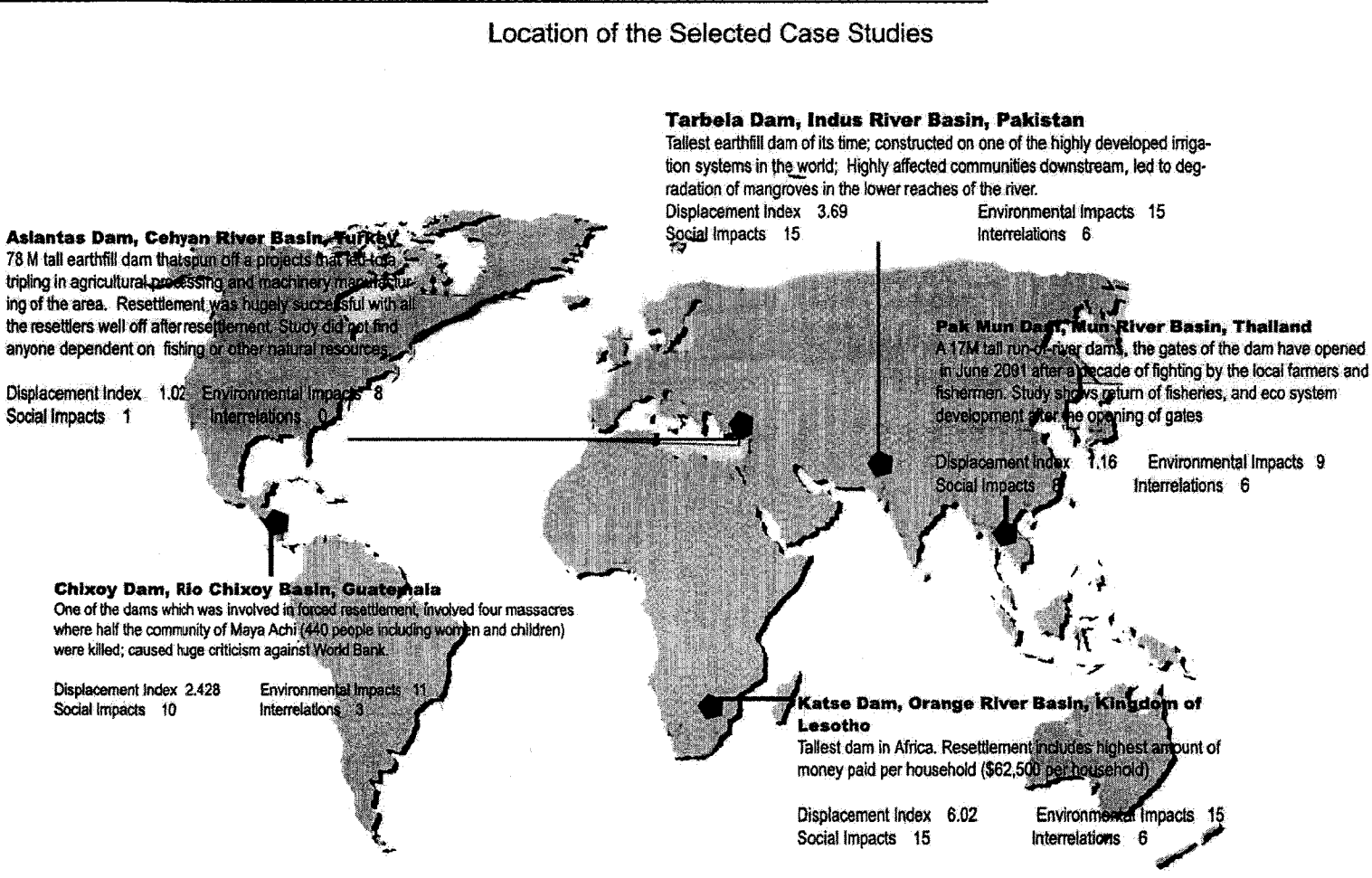
		Categories of Socio-economic Impacts based on WCD Study	Social Impacts of Katse Dam
1		**Socio economic impacts through planning and project cycles**	
	a	lack of development and welfare projects during the time lag that generally occurs between planning and onset of construction of a large dam (WCD 2000, 99)	
	b	Infrastructure (especially roads) exposes indigenous and vulnerable groups to national economy, threatening their lives and livelihood (WCD 2000, 100)	Project roads certainly allowed thieves easier access to the LHWP areas (Hoover, 13)
	c	Loss of social cohesion with large influx of outsiders (like construction workers) (WCD 2000, 100)	Huge influx of construction workers and job seekers was a large part of this social disruption. Families broke up when men from the labor camps initiated affairs and often set up house keeping with the wives of local unemployed men (Hoover 11)
	d	Health problems due to increased population (in migration of construction workers) (WCD 2000, 100)	
2		**Displacement of people and livelihoods**	
	a	Physical displacement (WCD 2000, 102)	Katse and Moela took approximately 1900 hectares of cropland out of use. Inundated land tends to be the best land for cultivation (Hoover, 7)
	b	Loss of livelihood (WCD 2000, 102)	Artisans in the affected region lost access to leldi grass, which was used in various traditional crafts. (Hoover, 9)
	c	Loss of commons (WCD 2000, 105)	1. Katse, Moela and Mohale dams decreased the highlands pasturelands by a combined 5000 hectares herds of cattled sheep and goats are now concentrated on a significantly small ranges, straining the already over stressed grazing land. (Hoover, 7) 2. Katse reservoir inundated 78 crossings that were used by the affected people to cross the river, isolating hundreds of villages between the reservoir branches and forcing many other villagers to pay significant fee for auto transport from one side of the dam to the other (Hoover , 9) 3. The reservoir flooded ravines and valleys that shelered young livestock from the Maloti winters icy winds (Hoover, 7)
3		**Indigenous people**	
	a	Cultural alienation (Colchester 2000, 16)	
	b	Disposesion, both from their land and other resources (Colchester 2000, 16)	
	c	Lack of compensation or inadequate compensation (Colchester 2000, 16)	
	d	Human rights abuse (Colchester 2000, 16)	
	e	Lowering of living standards (Colchester 2000, 16)	With submergence of the riparian zone, almost half the population must now locate over $200 worth of brush wood elsewhere or else substitute expensive alternate fuel. (Hoover, 9)
4		**Downstream livelihoods**	Aproximately 150,000 more people are affected by reduced river flows downstream of LHWP dams (Hoover, 10)
	a	Impact on flood plain house hold due to loss of access to river and river banks (Adams 2000, 4)	
	b	Impacts on fisherman (out migration and ill health) (Adams 2000,4)	
	c	Loss of Delta resources (Adams 2000,4)	1. Water below katse dam is too contaminated to drink 2. Each household within a 5KM corridor of katse was gathering an average of $146 worth of renewable resources from the submerged zone annually (The income of the majority of mountain households is less than $320/ year) (Hoover 9)
	d	Loss of Coastal resources (Adams 2000, 4)	
5		**Widened Gender disparities**	
	a	imposing a disproportionate share of social costs on women (WCD 2000, 114)	Other gender impacts included the disproportionate exposure of local women and girls to HIV/AIDS and other sexually transmitted diseases introduced to the area by LHWP construction workers. (14)
	b	inequitable allocation of the benefits generated (WCD 2000, 114)	LHWP dams added to women's already considerable workload, and made it even more taxing and time-consuming.First, because the reservoirs flooded springs and many areas where women would collect fuel and food, they were forced to travel greater distances to find these resources. (14)
6		**Loss of Cultural heritage**	
	a	loss of culturally important sites (temples, archaeological sites etc) (WCD 2000, 116)	1. Katse reservoir submerged hundreds of graves and many more were disinterred because they rested on th proposed access roads.(Hoover, 15) 2. The reservoir destroyed all of the sacred places where the Mapayana (local Priest) prayed for rain and an access road ruined the spring from which he collected water for use in healing ceremonies. (Hoover, 10) 3. The loss of riparian plants also had cultural implications, because in Basotho tradition, each plant and animal has 'properties or powers' associated with it and could be used for bringing good fortune or increased power to its possesor (Hoover, 9)
7		**Adverse health impacts**	
	a	Adverse health impacts caused due to lowered nutrition (WCD 2000, 118)	Almost the half the affected households gathered wild vegetables from the river valley to provide a valuable nutritional supplement to their maize based diet
	b	Spread of diseases due to dam (various vector born diseases) (WCD 2000, 118)	1. Project significantly increased the risk of sexually transmitted diseases. By 1992 HIV infection rates in the dams work camps were 20% higher (5.3%) than the villages around the dam. (Hoover, 10) 2. The low flows also lead to higher algae levels in the rivers which in turn create suitable conditions for disease carrying liver fluke snails

Source: Compiled by the Author



The figure in the next page shows all the five dams geographically. It also illustrates specific findings of the research till this point.

Figure 4.9: Location of case studies



Source: Compiled by Author

CHAPTER 5: FINDINGS

Based on the interrelations recognized in all the five case studies two overall interactions matrices are prepared. Interaction Matrices of all the five case studies are attached in the Appendix 2 of the report. The final findings of the study are represented using two matrixes. The first overall interaction matrix identifies environmental impacts which led to social impacts in most of the case studies; similarly it identifies social impacts that are most vulnerable to environmental impacts. The second matrix is the over all interaction matrix, this matrix illustrate which of the interactions were repeated in all the five case studies.

5.1 Overall Impacts Matrix: This matrix illustrates which environmental impact has caused to any kind of social impact in how many case studies. This kind of illustration gives us a broad idea of what kind of environmental impacts are critical and lead to social impacts. In the following part of this section we identify the results of the matrix and briefly explain the impacts that have been proved to be useful and important. Environmental impacts that have caused Social Impacts are ranked based on the number of times they have led to social impacts.

Table 5.1: Environmental Impacts that led to Social Impacts in all the five case studies

Environmental Impacts	No of Dams where it led to Social impacts
1. Elimination of Flora and Fauna	4
2. Modified Environments more conductive to Non native and exotic plant, fish snail, etc	3
3. Impact on Channel flood plain	2
4. Reduction or elimination of riparian vegetation	2
5. Gradual loss of fertility	2
6. Cumulative Impacts	1
7. Loss of forests due to Inundation	1
8. Increased Sedimentation	1
9. Loss of System Dynamics	1

Table 5.2: Overall Impact Analysis

Interactions in all the Five Dams

Social Impacts / Environmental Impacts		Impacts through planning and project cycles				Displacement of people and livelihoods			Indigenous people					Downstream livelihoods				Widened gender disparities		Loss of Cultural heritage	Adverse health impacts due to environmental change and social disruption		
		Planning blight	Impact due to infrastructure development	Impact due to influx of outsiders	Health problems due to increased population	Physical displacement	Loss of livelihood	Loss of commons	Cultural alienation	Dispossession both from their land and other resources	Lack of compensation or inadequate compensation	Human rights abuse	Lowering of living standards	Impact on flood plain /mouth holds	Impact on fishermen	Loss of delta resources	Loss of coastal resources	Disproportionate social cost on women	Inequitable allocation of benefits generated	Loss of culturally important sites	Impacts due to lowered nutrition	Spread of disease due to dam	
1	Impacts of reservoir on terrestial ecosystem and bio diversity																						
a	Loss of forests due to inundation (WCD, 75)																						1
b	Loss of habitats for animals (WCD, 75)																						
c	Elimination of Flora and Fauna (WCD, 75)																						4
d	Land degradation (WCD,75)																						
e	Increased sedimentation due to loss of vegetative cover (WCD, 75)																						
f	Decreased water Quality (WCD, 75)																						1
g	Variable changes in the seasonal timing of water yield (WCD, 75)																						
2	Emission of green house gases associated with large dam projects and their reservoirs																						
3	Impact of altered downstream flows on aquatic eco systems and bio diversity																						
a	Introduction of Non-native species (WCD, 78)																						
b	Loss of system dynamics leads to loss of habitat(WCD, 79)																						1
c	Loss of ability to maintain continuity of an eco system (WCD, 78)																						
d	blocking migration of aquatic organisms (WCD, 78)																						
4	Impacts of altering the natural flood cycle on downstream floodplains																						
a	Altered water temperature and chemistry (WCD, 78)																						
b	Loss of aquatic species due to fluctuations in water level (WCD, 79)																						
c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD, 80)																						3
d	Impacts on lateral biological linkages (WCD, 80)																						
	Impacts of trapping sediment and nutrients behind a dam																						
e	Impacts of channel, floodplain and coastal delta morphology																						2
f	Degradation of river channel below the reservoir																						
g	Reduction/ Elimination of riparian vegetation																						2
h	Erosion of Coastline																						
	Flood plain eco systems																						
i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment																						2
j	Diminished recharge of groundwater in flood plains due to loss of floods																						
5	Impacts of dams on fisheries in the upstream, reservoir and downstream areas																						
6	Enhancement of ecosystem through reservoir creation and other means																						
a	Creation of productive wetlands																						
b	Habitat for birds																						
7	Cumulative impact of a series of dams on a river system																						3
							3						2	1		3	2	1		3	3		

	One dam
	Two dams
	Three dams
	Four dams
	Five dams

Source: Compiled by the Author

As we have seen in the earlier section Elimination of Flora and Fauna and Modified environments are two impacts which have led to social impacts in more than 2 case studies. The following paragraphs look in to these two environmental impacts more deeply and list the social impacts they have caused in the selected case studies.

1. Elimination of Flora and Fauna: The construction of a storage dam and the subsequent inundation of the reservoir area effectively kill terrestrial plants and forests and displace animals. As many species prefer valley bottoms, large scale impoundment may eliminate unique wildlife habitats and affect populations of endangered species. Social impacts caused due to the environmental impacts of different dams are listed below

Pak Mun Dam: More than a 100 medicinal plants were found near the banks of the Mun River. The loss of these plants means a significant loss of bio diversity.

1. At least 40 different edible plants, 10 species of bamboo and 45 mushroom species were found to be freely harvested by the locals (mostly women) for domestic consumption. Women and housewives also earned a small but sustainable income of 5-10 and sometimes 50- 60 baht a day from selling the harvested vegetables. The loss of this resource not only meant a loss of income to women but also the loss of nutritional food to their families
2. A hundred or more medicinal plants were reportedly found near the Mun riverbanks (in the study here, 1999). Loss of these plants due to inundation means a significant loss of biodiversity as well as of local food and health security. The dietary, nutritional, medicinal and economic importance of local vegetation was overlooked and ignored by almost all studies and reports (Amornsakchai and Associates 2000, 61)

Chixoy Dam: The riparian areas along the river, which were flooded consisted of large fruit trees, smaller shrubs and herbs growing on the banks (Stewart and Associates, 19).

1. Interviewees described the abundant fruit trees and other riparian plants that were an important source of food and medicinal herbs for the community. Villagers also harvested sugar cane that grew on the river banks (Levy, 19)
2. Relocation has caused worsened living conditions for local communities and has lowered the quality of their nutrition (Coljacomo 2000, 13)

Tarbela Dam: The flora and fauna of the mountain river have been lost or pushed upstream, and over a period of time, lacustrine flora and fauna have established themselves (Asiantics, 111)

1. Landless people who pursued professions other than farming (fishermen, boatmen, basket makers, and weavers) were adversely affected, mainly because there used to be significant spill-over of the river before the dam were resulting in marshy areas and wild growth. These forests, natural vegetation and ponds provided a means of earning a living for people residing on the river banks. After the dam was constructed and water flow was controlled, the ponds, forests and wild vegetation diminished. The wild growth was used to weave baskets, mats, roof ceilings and handicrafts. These days this indigenous product is produced in much smaller quantities (Asiantics 2000, 124).

Katse Dam: For the most part, trees only grow in the riparian area in this watershed. Before the dam was built, the ecosystem near the river was healthy, and people depended on the riparian corridor for various things. Listed below are the impacts caused due to the inundation of the riparian area and subsequent loss of flora and fauna.

1. Artisans in the affected region lost access to leldi grass, which was used in various traditional crafts (Hoover 2001, 9).
2. With submergence of the riparian zone, almost half the population must now find over $200 worth of brush wood per year elsewhere or else substitute expensive alternate fuel (Hoover 2001, 6).

3. Almost half the affected households gathered wild vegetables from the river valley to provide a valuable nutritional supplement to their maize based diet (Hoover 2001, 7).
4. The loss of riparian plants also had cultural implications. According to basotho culture each plant had some cultural value. According to their belief some plants bought prosperity, and other bought good luck. Loss of these plants hurt their sentiments badly (Hoover, 2001 10)

2. Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD 2000, 80): These resulting non-native species often out-compete the natives and end up modifying eco systems that may become unstable, nurture disease vectors, or become no longer able to support the historical environmental and social components. Social impacts caused in different case studies due to modified environments are listed below

Chixoy Dam: In downstream riparian areas, an encroachment of fast growing (ephemeral) vegetation occurs during summer months, but the floods clean out the vegetation annually (Stewart and Associates, 24).

1. Malaria and dengue fever in the post dam conditions comprise a serious public health problem in the study area Mosquitoes and "zancudos' (small biting flies) are now extreemely abundant in the area surrounding the reservoir. The standing water of the reservoir area probably provides the habitat for these insects to breed (Levy, 21).

Tarbela Dam: Changes to the flood plain, due in part to flood gates has reduced the indigenous Acacia Nilotica and beds of Typha, and allowed the invasion of exotic species(Prosopis) with negative impacts on wildlife (Asiantics 2000, 16).

1. The riverine forests are as important for grazing and browsing animals, and for the provision of fuelwood for local communities, as they are for timber. With the general deterioration and change in predominant species from the more useful Acacia Nilotica to Prosopis, these values have been lost. Tarbela has contributed significantly to the decline in this resource.

Katse Dam: The low flows also lead to higher algae levels in the rivers, which in turn create suitable conditions for disease carrying liver fluke snails (Hoover 2001, 9).

1. Increased liver fluke disease among the natives (Hoover 20001, 9).

Some social impacts are more vulnerable to environmental impacts than others. Hence this section identifies social impacts that have resulted due to environmental impacts. The following sections briefly describe the impacts that have been identified

Table 5.3: Social Impacts that are vulnerable to environmental impacts

Social impacts as a result of environmental impacts	**No of Dams**
1. Loss of livelihood	3
2. Adverse health impacts due to low nutrition	3
3. Loss of cultural heritage	2
4. Lowered living standards	2
5. Loss of delta resources	2
6. Loss of coastal resources	1
7. Impact on flood plain household due to loss of access to river	1
8. Imposition disproportionate share of social cost on women	1

Source: Compiled by Author

1. Loss of livelihood

Many development interventions to transform natural resources, particularly large scale infrastructure projects, involve some form of displacement of people from their livelihoods and homes (WCD, 2000, 102)

Pak Mun Dam: The environmental change caused by the Pak Mun Dam has immensely altered the way of life of the Pak Mun villagers. This is because the riverine ecological system, which was suitable as a fish habitat and spawning ground, has been destroyed. Villagers, who had adapted to the ecological system and developed their knowledge on how to use its natural resources, now have no access to these resources. Abundant fish are no longer available for the people of Pak Mun (Amornsakchai and associates, 56).

Tarbela Dam: In downstream riverine areas, those dependent on flood based recession agriculture and the natural resources of wetlands and forests were negatively affected by reduced flood flows, due in part to reduced flows and to the impact of flood embankment (Asiantics 17).

Katse Dam: Artisans in the affected region lost access to leldi grass, which was used in various traditional crafts (Hoover, 9).

2. Adverse health Impacts due to low nutrition

Destruction of community productive bases in agriculture and fisheries can give rise to food shortages, leading to hunger and malnutrition.

Pak Mun: A hundred or more medicinal plants were reportedly found near the Mun riverbanks. The loss of these plants due to inundation means a significant loss of biodiversity as well as of local food and health security. The dietary, nutritional, medicinal and economic importance of local vegetation was overlooked and ignored by almost all studies and reports. (Amornsakchai and associates, 61)

Chixoy Dam: Relocation has caused worsened living conditions for local communities and has reduced the quality of their nutrition (Coljacomo, 13).

Katse Dam: Almost the half the affected households gathered wild vegetables from the river valley to provide a valuable nutritional supplement to their maize based diet (Hoover, 8).

3. Loss of cultural heritage:

Large dams have had significant adverse effects on this heritage through the loss of local cultural resources (temples, shrines and sacred elements of land scape, artifacts and buildings)

Pak Mun Dam: The natural rapids of the Mun were actually also local cultural and socio-economic centers of activity in the area. People from various communities gathered there to catch fish and engage in the formal and non-formal exchange of goods/services at the rapids. They came in groups or individually, and relationships grew out of these interactions. This generated a feeling of community and cultural and social networks. The inundation of the rapids has at one stroke virtually destroyed these cultural and socio-economic networks.

Katse Dam: The loss of riparian plants also had cultural implications, because in Basotho tradition, each plant and animal has "properties or powers" associated with it and could be used for bringing good fortune or increased power to its possesor (Hoover 2001, 9).

4. Lowered living standards

Indigenous people who have been dependent on natural resources for a long time, suffer a sharp reduction in their living standards, due to the loss of these resources.

Pak Mun Dam: At least 40 different edible plants, 10 species of bamboo and 45 mushroom species were found to be freely harvested by the locals (mostly women) for domestic consumption (Kittisiri, 1997). Women and housewives also earned a small but sustainable daily income of at least 5-10 and sometimes even up to 50-60 Baht a day from selling the harvested vegetables at local markets (Amornsakchai and Associates 2000, 61).

Katse Dam: With submergence of the riparian zone, almost half the population must now find over $200 worth of brush wood annualy elsewhere or else substitute expensive alternate fuel (Hoover 2001, 9).

5. Loss of delta resources

Delta resources that are available to people from flood plains, wetlands and forests that are maintained due to the flows from the river are affected due to the lower flows of the river (Adams 2000, 5).

Katse Dam: Water below Katse Dam is too contaminated to drink (Hoover 2001, 10).

Tarbela Dam:

1. In downstream riverine areas, those dependent on flood based recession agriculture and the natural resources of wetlands and forests were negatively affected by reduced flood flows, due in part to reduced flows and to the impact of flood embankments which curtailed the flooding (Asiantics 2000 17).
2. The riverine forests are as important for grazing and browsing animals, and for the provision of fuelwood for local communities, as they are for timber. With the general deterioration and

change in predominant species from the Acacia Nilotica to Prosopis, these values have been lost. Tarbela has contributed significantly to the decline in this resource (Asiantics 2000, 30). The last section of findings, which will follow will look at the number of times one particular interaction has occurred in all the dams.

5.2 Overall interaction matrix: This section briefly describes the interactions that have occurred more than once in all the five case studies. As is clear in table 5.2, there are very few interactions that have been repeated. The reason might be that the selected case studies are from different parts of the world.

Interactions	**No of Dams**
1. Elimination of flora and fauna ⟶ Lowering of living standards of Indigenous people	2
2. Elimination of flora fauna ⟶ Adverse Health Impacts due to low nutrition	2
3. Modified environments ⟶ Spread of diseases	2

Elimination of flora and fauna ⟶ lowering of living standards of indigenous people:

This interrelation was identified for the Pak Mun Dam and Katse Dam. In the Pak Mun case study 40, different kinds of edible plants were available to indigenous people, as were many other resources like bamboo for construction, fire wood etc. All these resources were lost due to the construction of the dam. The loss of these resources increased their living expenses thus lowering their living standards (Amornsakchai and Associates, 2000 60-61). In the Lesotho case, all the local people had to find $ 200 worth of firewood annualy (Hoover, 2001 9), when their income was as low as $ 15 per month (Hoover, 2001 3).

Table 5.4: Overall Interactions Matrix

	Social Impacts / Environmental Impacts	Impacts through planning and project cycles				Displacement of people and livelihoods			Indigenous people					Downstream livelihoods				Widened gender disparities		Loss of Cultural heritage	Adverse health impacts due to environmental change and social disruption	
		Planning blight	Impact due to infrastructure development	Impact due to influx of outsiders	Health problems due to increased population	Physical displacement	Loss of livelihood	Loss of commons	Cultural alienation	Disposession both from their land and other resources	Lack of compensation or inadequate compensation	Human rights abuse	Lowering of living standards	Impact on flood plain house holds	Impact on fishermen	Loss of delta resources	Loss of coastal resources	Disproportionate social cost on women	Inequitable allocation of benefits generated	Loss of culturally important sites	Impacts due to lowered nutrition	Spread of diseases due to dam
1	terrestial ecosystem and bio diversity																					
a	Loss of forests due to inundation (WCD, 75)																					
b	Loss of habitats for animals (WCD, 75)																					
c	Elimination of Flora and Fauna (WCD, 75)																					
d	Land degradation (WCD, 75)																					
e	Increased sedimentation due to loss of vegetative cover (WCD, 75)																					
f	Decreased water Quality (WCD, 75)																					
g	Variable changes in the seasonal timing of water yield (WCD, 75)																					
2	associated with large dam projects and their reservoirs																					
3	eco systems and bio diversity																					
a	Introduction of Non-native species (WCD, 78)																					
b	Loss of system dynamics leads to loss of habitat(WCD, 79)																					
c	Loss of ability to maintain continuity of an eco system (WCD, 78)																					
d	blocking migration of aquatic organisms (WCD, 78)																					
4	cycle on downstream floodplains																					
a	Altered water temperature and chemistry (WCD, 78)																					
b	Loss of aquatic species due to fluctuations in water level (WCD, 79)																					
c	exotic plant, fish, snail, insect and animal species (WCD, 80)																					
d	Impacts on lateral biological linkages (WCD, 80)																					
	Impacts of trapping sediment and nutrients behind a dam																					
e	Impacts of channel, floodplain and coastal delta morphology																					
f	Degradation of river channel below the reservoir																					
g	Reduction/ Elimination of riparian vegetation																					
h	Erosion of Coastline																					
	Flood plain eco systems																					
i	due to loss of annual silt and nutrient replenishment																					
j	to loss of floods																					
5	In the upstream, reservoir and downstream areas																					
6	through reservoir creation and other means																					
a	Creation of productive wetlands																					
b	Habitat for birds																					
7	Cumulative impact of a series of dams on a river system																					
	One dam																					
	Two dams																					
	Three dams																					
	Four dams																					
	Five dams																					

Source: Compiled by Author

CHAPTER 6: TRENDS AND RECOMMENDATIONS

6.1 Trends: Based on the above research and findings a few trends can be observed for the whole study. They concern the displacement index and the elimination of flora and fauna. Each is discussed below in turn.

1. Displacement Index: The displacement index, as has been defined in this thesis is the ratio of the number of people displaced per one hectare of reservoir surface area. As the displacement index increased in the case studies, an increase in the number of environmental and social impacts can be observed. Aslantas Dam, which has the lowest displacement index was constructed in 1976. There was no environmental impact analysis conducted for that dam and neither was there any other study done prior to its construction (Asiantics 2000 Vii). However, the study conducted by the WCD identified no social impacts, although eight environmental impacts were identified. In comparison Katse Dam construction of which started in 1998 after detailed studies had the highest displacement index and the study conducted by IRN reported 15 social and 8 environmental impacts.

2. Elimination of flora and fauna: This environmental impact has led to social impacts in four case studies. Webster defines flora and fauna as vegetation and animal life that are characteristic of a region (www.webster.com). In two of the selected case studies (Pak Mun and Katse) local people or indigenous tribes depended on the local flora for daily use as medicines. Hence the loss of flora affected their health indirectly. In some other cases the loss of riparian areas led to lowered living standards especially for the indigenous tribes (Katse and Cixoy Dams).

6.2 Recommendations: As seen in the above section, there are two strong trends that can be observed from the study. There are few recommendations which are based on the study its findings and trends and on the author's personal experience with the study. They are summarized below:

1. **Displacement Index**: While the index used for the study is a crude form, it has proved very useful. It helped in identifying case studies, which irrespective of their location and other criteria, have shown that with an increase in the value of the displacement index, there is an increase in the overall impact caused by a dam. Hence, this kind of index has the potential of being used earlier than at present in the process of dam construction to identify the final impacts of the dam.
2. **Impact Index:** To be of more importance, the development index should be further developed and more attributes added. Such attributes should cover social status of the people to be displaced, as well as other indicators which would identify the number of people directly and indirectly dependent on the region. The displacement index gives an indication of one of the impacts. Similarly other indexes should be identified to indicate various other impacts of dams. These indexes taken together can be called the Impact indices, which would identify different attributes of both dam characteristics and local characteristics that would more comprehensively specify the impacts caused by dams.
3. **Proxy Models of Dams**: The current study was intended to understand different kinds of social and environmental impact interrelations as the discussion of impact indices suggests further studies are needed to understand impacts that are particular to a geographical region or a particular dam design. This kind of study gives an indication of impacts when a dam with similar traits, or dam in a similar region, is proposed.

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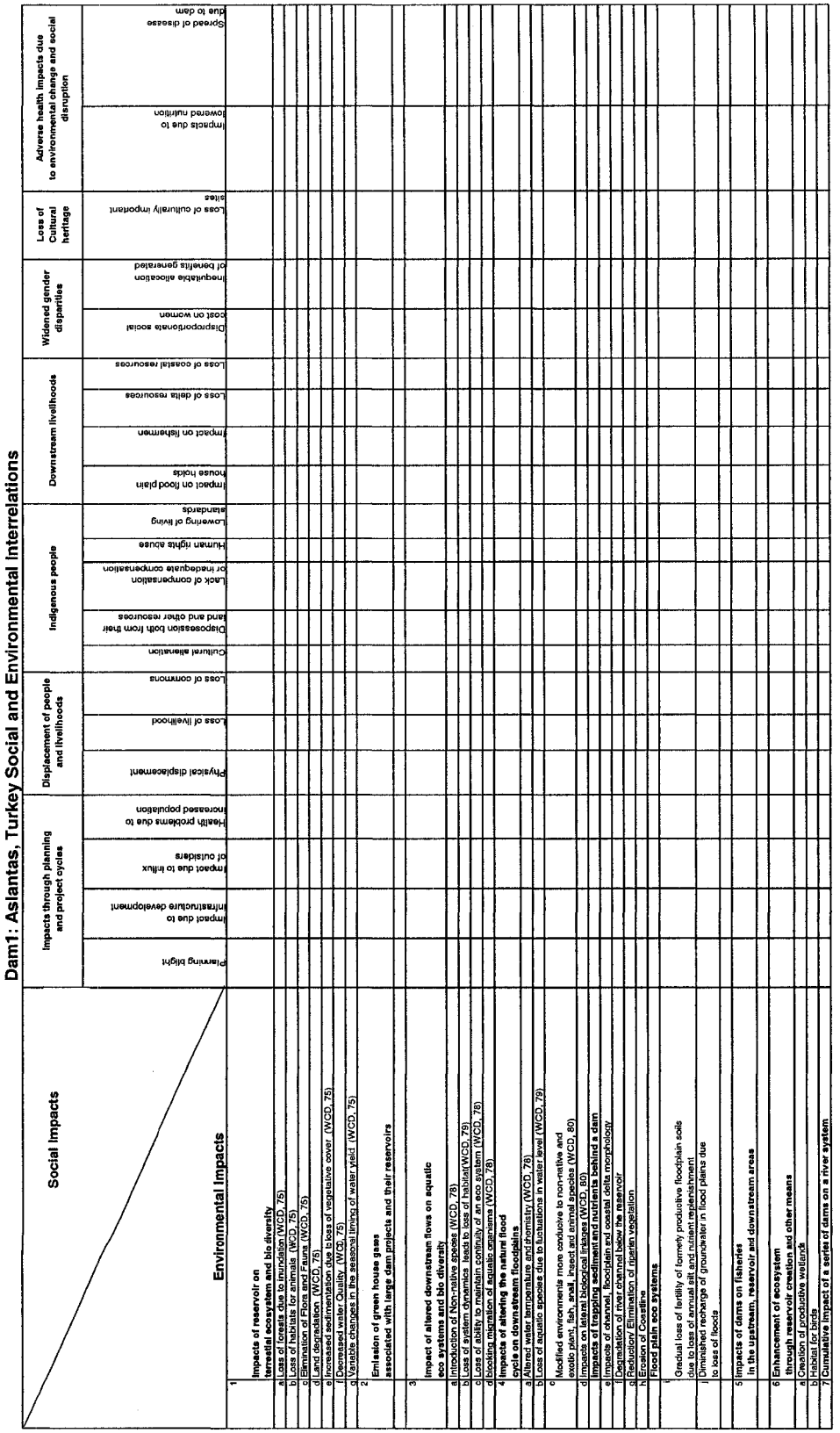
APPENDIX – I: SELECTED DAMS

Dams in grey color signify selected dams
Dams Constructed after 1975 with displacement index more than 1

S. No	Dam/ Project	River	Country	No. Displa	Res. Area	Dam Heig	Installed	Completio	Primary P	Displacem	Ranking
1	Tabqua		Syria	60000	60000	60	800	1976	Multi Purp	1	139
2	Thika		Kenya	500	500		2	1990	Multi Purp	1	137
3	Atatürk		Turkey	50000	49000	78	1338	1983	Multi Purp	1.020408	141
4	Urra I		Colombia	7300	7000			2000	Hydro Pow	1.042857	143
5	Zimapan		Mexico	2500	2300	207	292	1994	Hydro Pow	1.086957	144
6	Upper Wainganga	Wainganga	India	6400	5600	43		1990	Irrigation	1.142857	146
7	Ita		Brazil	12000	10300	125	1620	1999	Hydro Pow	1.165049	148
8	Rio Grande		Colombia	1200	1000			1993	Multi Purp	1.2	151
9	Sir		Turkey	4950	4100	120	315	1991	Hydro Pow	1.207317	152
10	Upper Kolab		India	15000	12400			1986	Multi Purp	1.209677	153
11	Bhima	Bhima	India	1400	1150	56		1980	Irrigation	1.217391	154
12	Chivor		Colombia	1500	1200			1982	Hydro Pow	1.25	156
13	Sri Rama Sagar		India	75100	56000			1985	Multi Purp	1.341071	160
14	Hemavathy	Hemavathy	India	11600	8500	59		1983	Irrigation	1.364706	161
15	Pak Mun		Thailand	9500	6000	17	136	1994	Hydro Pow	1.583333	164
16	Pantabangan		Phillippines	13000	8900	107		1977	Multi Purp	1.460674	166
17	kiri	Gongola	Nigeria	19000	13000	20		1982	Irrigation	1.461538	167
18	Karkaya		Turkey	45000	29800	178	1800	1989	Hydro Pow	1.510067	168
19	Riano	Esla	Spain	3100	2000	98		1987	Irrigation	1.55	171
20	Srisailam		India	100000	60600			1984	Multi Purp	1.650165	173
21	San Carlos		Colombia	520	300			1987	Hydro Pow	1.733333	176
22	Panam	Panam	India	16600	9200	56		1977	Irrigation	1.804348	178
23	Barna	Barna	India	15300	7700	48		1976	Irrigation	1.987013	181
24	Kpong		Ghana	7000	3500			1982	Hydro Pow	2	183
25	Upper Indravathi		India	26500	12800			2000	Multi Purp	2.070313	186
26	Daguangba		China	23800	9900			1995	Hydro Pow	2.40404	190
27	Salandi	Salandi	India	2900	1200	52		1976	Irrigation	2.416667	191
28	Chixoy		Guatmela	3400	1400			1983	Hydro Pow	2.428571	192
29	Aji III	Aji	India	3500	1440	25		1980	Irrigation	2.430556	193
30	Lupohlo		Swaziland	300	120	45	20	1984	Hydro Pow	2.5	194
31	Almatti		India	200000	79000	48	154	2001	Irrigation	2.531646	195
32	Dez		Iran	17000	6500	203	520	1978	Multi Purp	2.615385	198
33	Machhanala	Machhan	India	2100	800	32		1982	Irrigation	2.625	201
34	Chandoli (Warna)	Warna	India	11800	4400	91		1990	Irrigation	2.681818	202
35	Kadana		India	45200	16600			1978	Multi Purp	2.722892	204
36	Damanganga	Damangan	India	1100	400	59		1989	Irrigation	2.75	205
37	Chakra	Chakra	India	48500	17400	84		1985	Irrigation	2.787356	206
38	Uben	Uben	India	1400	500	19		1982	Irrigation	2.8	207
39	Saguling		Indonesia	16700	5600	99	700	1986	Hydro Pow	2.982143	209
40	Klambera		Kedva	7500	2500	112	160	1988	Hydro Pow	3	210
41	Jamrani		India	1500	500			1990	Multi Purp	3	210
42	Dongjiang		China	53000	16000			1989	Hydro Pow	3.3125	217
43	Uri		India	1000	300		480	1998	Hydro Pow	3.333333	218
44	Jiangya		China	12000	3580			1999	Multi Purp	3.351955	219
45	Ertan		China	35000	10100			1999	Hydro Pow	3.465347	220
46	Tarbela		Pakistan	96000	26000	143	3478	1976	Multi Purp	3.692308	224
47	Geheyan		China	26700	7200			1995	Hydro Pow	3.708333	225
48	Guavio		Colombia	5500	1440			1990	Hydro Pow	3.819444	226
49	Amli (Ver II)	Ver	India	2300	600	29		1984	Irrigation	3.833333	227
50	Sukhi	Sukhi	India	11200	2900	38		1980	Irrigation	3.862069	228
51	jhuj	Kabini	India	1100	272	97		1980	Irrigation	4.044118	229
52	Chung Ju		South Kore	38700	9500	98	412	1984	Multi Purp	4.073684	230
53	Hidkal	Ghataprab	India	31100	7100	62		1979	Irrigation	4.380282	232
54	Salvajina		Colombia	10000	2200			1985	Hydro Pow	4.545455	236
55	Wuqiangxi		China	84800	17000			1995	Hydro Pow	4.988235	238
56	Venu II	Venu	India	3300	625	13		1990	Irrigation	5.28	241
57	Cirata		Indonesia	34800	6100	125	500	1991	Hydro Pow	5.704918	244
58	Lubuge		China	2320	400			1984	Hydro Pow	5.8	245
59	Kedung Ombo		Indonesia	27000	4600	66	30	1993	Multi Purp	5.869565	246
60	Kaisa		Lesotho	21700	3600	185		1988	Water Sup	6.027778	248
61	Xiaolangdi		China	181600	27200	154	1800	2001	Multi Purp	6.676471	249
62	Shuikou		China	84000	9300			1996	Hydro Pow	9.032258	254
63	Lower Manair	Manair	India	78000	7900	42		1980	Irrigation	9.873418	256
64	Warna		India	29300	2900	89		1994	Multi Purp	10.10345	257
65	Cerro de Oro		Mexico	18000	1700	56		1989	Multi Purp	10.58824	258
66	Kamthi Kheri	Pench	India	28500	2300	44		1977	Irrigation	12.3913	259
67	Kulekhani		Nepal	2500	200	114	60	1982	Hydro Pow	12.5	260
68	Kotmale		Sri Lanka	13000	950	87	200	1988	Multi Purp	13.68421	261
69	Upper Jonk		India	15500	1100			1986	Multi Purp	14.09091	262
70	Victoria		Sri Lanka	45000	2300	122	210	1984	Hydro Pow	19.56522	266
71	Colorado (El Tapiro)	Cerro Colo	Mexico	13300	300	38		1982	Irrigation	44.33333	267

APPENDIX II
ENVIRONMENTAL AND SOCIAL IMPACT INTERACTIONS



Dam2: Pak Mun, Thailand Social and Environmental Interrelations

	Social Impacts / Environmental Impacts	Impacts through planning and project cycles				Displacement of people and livelihoods			Indigenous people					Downstream livelihoods				Widened gender disparities		Loss of Cultural heritage	Adverse health impacts due to environmental change and social disruption	
		Planning blight	Impact due to infrastructure development	Impact due to influx of outsiders	Health problems due to increased population	Physical displacement	Loss of livelihood	Loss of commons	Cultural alienation	Dispossession both from their land and other resources	Lack of compensation or inadequate compensation	Human rights abuse	Lowering of living standards	Impact on flood plain house holds	Impact on fishermen	Loss of delta resources	Loss of coastal resources	Disproportionate social cost on women	Inequitable allocation of benefits generated	Loss of culturally important sites	Impacts due to lowered nutrition	Spread of disease due to dam
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**																					
a	Loss of forests due to inundation (WCD, 75)						b												c			
b	Loss of habitats for animals (WCD, 75)																					
c	Elimination of Flora and Fauna (WCD, 75)												c								d	
d	Land degradation (WCD, 75)																					
e	Increased sedimentation due to loss of vegetative cover (WCD, 75)																					
f	Decreased water Quality (WCD, 75)																					
g	Variable changes in the seasonal timing of water yield (WCD, 75)																					
2	**Emission of green house gases associated with large dam projects and their reservoirs**																					
3	**Impact of altered downstream flows on aquatic eco systems and bio diversity**																					
a	Introduction of Non-native species (WCD, 78)																					
b	Loss of system dynamics leads to loss of habitat (WCD, 79)						a, f													e		
c	Loss of ability to maintain continuity of an eco system (WCD, 78)																					
d	blocking migration of aquatic organisms (WCD, 78)																					
4	**Impacts of altering the natural flood cycle on downstream floodplains**																					
a	Altered water temperature and chemistry (WCD, 78)																					
b	Loss of aquatic species due to fluctuations in water level (WCD, 79)																					
c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD, 80)																					
d	Impacts on lateral biological linkages (WCD, 80)																					
	Impacts of trapping sediment and nutrients behind a dam																					
e	Impacts of channel, floodplain and coastal delta morphology																					
f	Degradation of river channel below the reservoir																					
g	Reduction/ Elimination of riparian vegetation																					
h	Erosion of Coastline																					
	Flood plain eco systems																					
i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment																					
j	Diminished recharge of groundwater in flood plains due to loss of floods																					
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas**																					
6	**Enhancement of ecosystem through reservoir creation and other means**																					
a	Creation of productive wetlands																					
b	Habitat for birds																					
7	**Cumulative impact of a series of dams on a river system**																					

Interactions

a. The environmental change caused by the Pak Mun dam has immensely altered the way of life of the Pak Mun villagers. This is because the riverine ecological system which was suitable as a rich habitat and spawning ground has been destroyed. Villagers who had adapted to the ecological system and developed their knowledge on how to use its natural resources now have no access to these resources. Abundant fishes are no longer available to the people of Pak Mun. (60)

b. The free access of local people to areas now underwater where they harvested jungle produce was lost. The total lost area of 5,700 rai included the riverine or riparian area of 525 rai (84 hectares). The riverbed areas with a high capability for agriculture that were also used for growing vegetables during the annual dry season were also inundated. The assessment of actual losses particularly of the riverbed cultivated areas with definite implications for domestic food and income levels were not made in the previous environmental impact study (EIA, or 1982). Therefore the compensation did not in effect cover the actual losses. (60-61)

c. At least 40 different edible plants, 10 species of bamboo and 45 mushroom species were found to be freely harvested by the locals (mostly women) for domestic consumption (Kittiam, 1997). Women and housewives also earned a small but sustainable daily income of at least 5-10 and sometimes even up to 50-60 Baht a day from selling the harvested vegetables at local markets (61)

d. A hundred or more medicinal plants were reportedly found near the Mun riverbanks (from the interview of this study, 1989). Loss of these plants due to inundation means significant loss of biodiversity as well local food and health security. The dietary, nutritional, medicinal and economic importance of local vegetation was overlooked and ignored by almost all studies and reports (61)

e. The natural rapids of the Mun were actually also focal of cultural and socio-economic centers of activity in the area. People from various communities gathered here of there to catch fish and engage in formal and non-formal exchange of goods/services at the rapids. They come in a group or individually and relationships grew out of these interactions. This generated a feeling of community and cultural and social networks. The inundation of the rapids has at one stroke virtually destroyed these cultural and socio-economic networks

f. The natural rapids on the Mun River are among the popular tourist areas in Ubon Ratchathani Province. After the completion of the project and inundation of rapids, the number of tourists have decreased from the maximum of 242,616 in 1991 to 142,128 in 1997. The project was not able to compensate this loss through the creation of new tourism opportunities, although KTVP was promoted for this purpose. Further the impact on the incomes of local people dependent on the tourism industry was not assessed or compensated prior to project completion. The affected people are estimated to have suffered losses in income ranging from 4,800-6000 Baht/year (67-68)

Dam3: Chixoy, Guatemla Social and Environmental Interrelations

Social Impacts / Environmental Impacts		Impacts through planning and project cycles				Displacement of people and livelihoods			Indigenous people					Downstream livelihoods				Widened gender disparities		Loss of Cultural heritage	Adverse health impacts due to environmental change and social disruption	
		Planning blight	Impact due to infrastructure development	Impact due to influx of outsiders	Health problems due to increased population	Physical displacement	Loss of livelihood	Loss of commons	Cultural alienation	Dispossession both from their land and other resources	Lack of compensation or inadequate compensation	Human rights abuses	Lowering of living standards	Impact on flood plain house holds	Impact on fishermen	Loss of delta resources	Loss of coastal resources	Disproportionate social cost on women	Inequitable allocation of benefits generated	Loss of culturally important sites	Impacts due to lowered nutrition	Spread of disease due to dam
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**																					
a	Loss of forests due to inundation (WCD, 75)																					
b	Loss of habitats for animals (WCD, 75)																					
c	Elimination of Flora and Fauna (WCD, 75)							a												c		
d	Land degradation (WCD, 75)																					
e	Increased sedimentation due to loss of vegetative cover (WCD, 75)																					
f	Decreased water Quality (WCD,75)																					
g	Variable changes in the seasonal timing of water yield (WCD, 75)																					
2	**Emission of green house gases associated with large dam projects and their reservoirs**																					
3	**Impact of altered downstream flows on aquatic eco systems and bio diversity**																					
a	Introduction of Non-native species (WCD, 78)																					
b	Loss of system dynamics leads to loss of habitat(WCD, 79)																					
c	Loss of ability to maintain continuity of an eco system (WCD, 78)																					
d	blocking migration of aquatic organisms (WCD, 78)																					
4	**Impacts of altering the natural flood cycle on downstream floodplains**																					
a	Altered water temperature and chemistry (WCD, 78)																					
b	Loss of aquatic species due to fluctuations in water level (WCD, 79)																					
c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD, 80)																				b	
d	Impacts on lateral biological linkages (WCD, 80)																					
	Impacts of trapping sediment and nutrients behind a dam																					
e	Impacts of channel, floodplain and coastal delta morphology																					
f	Degradation of river channel below the reservoir																					
g	Reduction/ Elimination of riparian vegetation																					
h	Erosion of Coastline																					
	Flood plain eco systems																					
i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment																					
j	Diminished recharge of groundwater in flood plains due to loss of floods																					
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas**																					
6	**Enhancement of ecosystem through reservoir creation and other means**																					
a	Creation of productive wetlands																					
b	Habitat for birds																					
7	**Cumulative impact of a series of dams on a river system**																					

	Interactions
a	Interviewees described the abundant fruit trees and other riparian plants that were important source of food and medicinal herbs for the community. Villagers also harvested sugar cane that grew on the river banks (2- 19)
b	Malaria and Dengue fever in the post dam conditions comprise a serious public health problem in the study area. mosquitoes and 'zancudos' (small biting flies) are now extremely abundant in the area surrounding the reservoir area. The standing water of the reservoir area probably provides habitat for these insects to breed. (2- 21)
c	Relocation has caused worsened living conditions for rural communities and the quality of their nutrition. (3-13)

Dam4: Tarbela, Pakistan Social and Environmental Interrelations

Social Impacts / Environmental Impacts		Impacts through planning and project cycles				Displacement of people and livelihoods			Indigenous people					Downstream livelihoods				Widened gender disparities		Loss of Cultural heritage	Adverse health impacts due to environmental change and social disruption	
		Planning blight	Impact due to infrastructure development	Impact due to influx of outsiders	Health problems due to increased population	*Physical displacement*	Loss of livelihood	Loss of commons	Cultural alienation	Their claim of compensation for inadequate	Human rights abuse	Lowering of living standards		Impact on flood plain house holds	Impact on fishermen	Loss of delta resources	Loss of coastal resources	Disproportionate social bout on women	Inequitable allocation of benefits generated	Loss of culturally important sites	Impacts due to lowered nutrition	Spread of disease due to dam
1	**Impacts of reservoir on terrestial ecosystem and bio diversity**																					
a	Loss of forests due to inundation (WCD, 75)																					
b	Loss of habitats for animals (WCD, 75)																					
c	Elimination of Flora and Fauna (WCD, 75)														c							
d	Land degradation (WCD, 75)																					
e	Increased sedimentation due to loss of vegetative cover (WCD, 75)																					
f	Decreased water Quality (WCD, 75)																					
g	Variable changes in the seasonal timing of water yield (WCD, 75)															e	b					
2	**Emission of green house gases associated with large dam projects and their reservoirs**																					
3	**Impact of altered downstream flows on aquatic eco systems and bio diversity**																					
a	Introduction of Non-native species (WCD, 78)																					
b	Loss of system dynamics leads to loss of habitat(WCD, 79)																					
c	Loss of ability to maintain continuity of an eco system (WCD, 78)																					
d	blocking migration of aquatic organisms (WCD, 78)																					
4	**Impacts of altering the natural flood cycle on downstream floodplains**																					
a	Altered water temperature and chemistry (WCD, 78)																					
b	Lose of aquatic species due to fluctuations in water level (WCD, 79)																					
c	Modified environments more conducive to non-native and exotic plant, fish, snail, insect and animal species (WCD, 80)																					
d	Impacts on lateral biological linkages (WCD, 80)																					
	Impacts of trapping sediment and nutrients behind a dam																					
e	Impacts of channel, floodplain and coastal delta morphology													a,c			b,c					
f	Degradation of river channel below the reservoir																					
g	*Reduction/ Elimination of riparian vegetation*													b,c								
h	Erosion of Coastline																					
	Flood plain eco systems																					
i	Gradual loss of fertility of formerly productive floodplain soils due to loss of annual silt and nutrient replenishment															a,d						
j	Diminished recharge of groundwater in food plains due to loss of floods																					
5	**Impacts of dams on fisheries in the upstream, reservoir and downstream areas**																	a				
6	**Enhancement of ecosystem through reservoir creation and other means**																					
a	Creation of productive wetlands																					
b	Habitat for birds																					
7	**Cumulative impact of a series of dams on a river system**																					

Interactions	
a	In downstream riverine areas, those dependant on flood based recession agriculture and the natural resources of wetlands and forests were negatively affected by reduced flood flows due in part to reduced flows and to the impact of flood embankment (Asianics, 17)
b	In the coastal areas, the reduced dry season flows and the reduction in sediment flows, led to saline intrusion and a reduction in mangroves and forest areas and consequent lose of livelihoods.
c	Landless people who pursued professions other than farming (fishermen, boatmen, basket makers, and weavers). This segment of the community was adversely affected, mainly because there used to be annual spill over of the river before the dam, resulting in marshy areas and wild growth. These forests, natural vegetation and ponds provided a means of earning a living for people residing on the river bank. After the dam water flow was controlled, the jungle forests and wild vegetation diminished. The wild growth was used to weave baskets, mats, roof ceilings and handicrafts. These days this indigenous product is produced in much smaller quantities (Asianics, 104)
d	The local communities stated that in the coastal areas seawater is gradually increasing, and thereby causing irreversible salt deposition in the lands that are thereby rendered unsuitable for agricultural activity. (Asianics, 129)
e	Women currently have little work outside the household due to reduced fishing opportunities (Asianics, 130) (Coastal Areas)
f	The riverine forests are as important for grazing and browsing animals and for the provision of fuelwood for local communities, as they are for timber. With the general deterioration and change in predominant species from the more useful Acacia nilotica to Prosopis, so these values have been lost. Tarbela has contributed significantly to the decline in this resource.

Dam 5: Katse, Lesotho Social and Environmental Interrelations

Social Impacts / Environmental Impacts		Impacts through planning and project cycles				Displacement of people and livelihoods			Indigenous people					Downstream livelihoods				Widened gender disparities		Loss of Cultural heritage	Adverse health impacts due to environmental change and social disruption	
		Planning blight	Impact due to infrastructure development	Impact due to influx of outsiders	Health problems due to increased population	Physical displacement	Loss of livelihood	Loss of commons	Cultural alienation	Dispossession both from their land and other resources	Lack of compensation or inadequate compensation	Human rights abuse	Lowering of living standards	Impact on flood plain house holds	Impact on fishermen	Loss of delta resources	Loss of coastal resources	Disproportionate social cost on women	Inequitable allocation of benefits generated	Loss of culturally important sites	Impacts due to lowered nutrition	Spread of disease due to dam
1	**terrestial ecosystem and bio diversity**																					
a	Loss of forests due to inundation (WCD, 75)																					
b	Loss of habitats for animals (WCD, 75)																					
c	Elimination of Flora and Fauna (WCD, 75)						d						a							f	c	
d	Land degradation (WCD, 75)																					
e	Increased sedimentation due to loss of vegetative cover (WCD, 75)																					
f	Decreased water Quality (WCD, 75)															b						
g	Variable changes in the seasonal timing of water yield (WCD, 75)																					
2	**associated with large dam projects and their reservoirs**																					
3	**Impact of altered downstream flows on aquatic eco systems and bio diversity**																					
a	Introduction of Non-native species (WCD, 78)																					
b	Loss of system dynamics leads to loss of habitat(WCD, 79)																					
c	Loss of ability to maintain continuity of an eco system (WCD, 78)																					
d	blocking migration of aquatic organisms (WCD, 78)																					
4	**cycle on downstream floodplains**																					
a	Altered water temperature and chemistry (WCD, 78)																					
b	Loss of aquatic species due to fluctuations in water level (WCD, 79)																					
c	exotic plant, fish, snail, insect and animal species (WCD, 80)																					e
d	Impacts on lateral biological linkages (WCD, 80)																					
e	Impacts of channel, floodplain and coastal delta morphology																					
f	Degradation of river channel below the reservoir																					
g	Reduction/ Elimination of riparian vegetation																					
h	Erosion of Coastline																					
i	due to loss of annual silt and nutrient replenishment																					
j	to loss of floods																					
5	**in the upstream, reservoir and downstream areas**																					
6	**through reservoir creation and other means**																					
a	Creation of productive wetlands																					
b	Habitat for birds																					
7	**Cumulative impact of a series of dams on a river system**																					
	Increased and cumulative loss of natural resources, habitat quality, environmental sustainability and eco system integrity							g														

Interrelations

a	With submergence of the riparian zone, almost half the population must now locate over $200 worth of brush wood elsewhere or else substitute expensive alternate fuel. (Hoover, 9)
b	Water below Katse dam is too contaminated to drink (Hoover, 10)
c	Almost the half the affected households gathered wild vegetables from the river valley to provide a valuable nutritional supplement to their maize based diet (Hoover, 9)
d	Artisans in the affected region lost access to leidi grass, which was used in various traditional crafts. (Hoover, 9)
e	The low flows also lead to higher algae levels in the rivers which in turn create suitable conditions for disease carrying liver fluke snails (Hoover, 10)
f	The loss of riparian plants also had cultural implications, because in Basotho tradition, each plant and animal has 'properties of power' associated with it and could be used for bringing good fortune or increased power to its possessor (Hoover, 9)
g	Katse, Muela and Mohale dams decreased the highlands pasturelands by a combined 5000 hectares. herds of cattled sheep and goats are now concentrated on a significantly small ranges, straining the already over stressed grazing land. (Hoover, 7)