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Construction of Big Dams and its Impact on Socio-Cultural & Ecological Diversity

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Abstract

Dams are constructed for variety of purposes such as hydroelectric power generation, increase the water supply for irrigation, provide recreational opportunities and flood control etc. Dam construction causes adverse environmental and sociological impacts. However, dam projects are ultimately beneficial to either the environment or surrounding human populations. This paper describes the environmental as well as socio-economic impacts due to construction of a dam.Changes in moisture percentage, temperature and air movements caused by the water bodies differentiate the climatic conditions related to topography. Regional scaled climatic changes can be observed by these effects. Biological life of the river changes fast both in the reservoir and in downstream. The parts of the bio-system that are affected by the dam are the watered parts of the shore.

keywords: Dams, environmental impacts, social impacts, Territorial biological system,Aquatic ecosystem.

1. Introduction

Water from rainfall or snowmelt naturally runs downhill into a stream valley and then into larger streams or other bodies of water. The "watershed system" refers to the drainage process through which rainfall or snowmelt is collected into a particular stream valley during natural runoff (directed by gravity). Dams constructed across such a valley then impound the runoff water and release it at a controlled rate. During periods of high runoff, water stored in the reservoir typically increases, and overflow through a spillway may occur. During periods of low runoff, reservoir levels usually decrease. The owner can normally control the reservoir level to some degree by adjusting the quantity of water released. Downstream from the dam, the stream continues to exist, but because the quantity of water flowing is normally controlled, very high runoffs (floods) and very low runoffs (drought periods) are avoided.

Dams alter aquatic ecology and river hydrology upstream and downstream, affecting water quality, quantity and breeding grounds (Helland-Hansen *et al.*, 1995). They create novel and artificial types of aquatic environment for the life span of the dam.The complex inter-relationship between dams and their environment make it extremely difficult to predict all the consequences that dam construction will have for any particular river ecosystem. The impact of each dam is unique and dependent not only on the dam structure, but also local sedimentsupplies, geomorphic constraints, climate and the key attributes of the local biota.

Dams have impacts on both upstream and downstream ecosystems. They constitute obstacles for longitudinal exchange along rivers and disrupt many natural environmental processes. Flooding upstream of dams results in the permanent destruction of terrestrial ecosystems through inundation. All terrestrial plants and animals disappear from the submerged area. Reservoirs trap waterborne materials including sediment and obstruct migration pathways for some aquatic species. Downstreamthere are changes in flow regime, sediment transport, and water temperature and quality. Many ofthese changes are immediate and obvious. However, others are gradual subtle and more difficult topredict. For example, changes in thermal regime, water quality and land-water interactions result inchanges in primary production, which in turn has long-term implications for fish and other fauna higherup the food chain. Dams may cause changes in ecosystems at great distances from the dam. Forexample, changes in sediment transport result in changes in river, floodplain and even coastal delta

morphology sometimes many hundreds of kilometres from the site of the dam.(M.P. McCartney*et* al., 2001).

2. Importance of Dam Construction

Dams provide a range of economic, environmental, and social benefits, including recreation, flood control, water supply, hydroelectric power, waste management, river navigation, and wildlife habitat. In addition to helping farmers, dams help prevent the loss of life and property caused by flooding. Flood control dams impound floodwaters and then either release them under control to the river below the dam or store or divert the water for other uses. For centuries, people have built dams to help control devastating floods. In some instances, dams provide enhanced environmental protection, such as the retention of hazardous materials and detrimental sedimentation. Dams and locks provide for a stable system of inland river transportation throughout the heartland of the Nation. Several examples of these benefits are as follows:

(a) Flood control in China

Flooding is one of the most serious problems that China faces, with about 70% of the land area vulnerable, and it also accounts for 40% of the total economic loss from all disasters. The Chinese government has made great achievements in controlling flooding (ranging from 20-year return periods to 100-year floods) with the construction of over 86 000 reservoirs reaching a total capacity of 450 billion m^3 71% of which belongs to the large reservoirs. The total length of dikes amounts to 251 000 km, and the area of land protected by dikes reaches 34 million hectares.(Source: Nanfang Zhoumou, August 8, 1998.)

(b) Irrigation in Sri Lanka

A major option for assisting project-affected people to become beneficiaries of dam construction is to incorporate them within irrigation schemes, such as during earlier phases of the Mahaweli Project, Sri Lanka, where resettlers and downstream hosts were given priority over all other categories. The economic welfare of the landless poor and small farmers in the Dry Zone in Sri Lanka was highly dependent on rainfall patterns. The timing and intensity of seasonal rainfall determine the degree and success of paddy cultivation, the mainstay of domestic agriculture. In parts of the Dry Zone where there were no major irrigation systems, paddy cultivation was limited to the main rainy season but even within this season, crops may not succeed unless water can be stored for later use during the crop period. Mahaweli Project, which was completed in the early 1980s, has contributed significantly to increased production and higher living standards for these farmers, with a reliable and streamlined irrigation network. By 1999, 142 329 hectares of lands were irrigated under Mahaweli Project and a further 195 328 hectares of land were fed by diverted Mahaweli irrigation systems. It is expected that a further 29 600 hectares will come under irrigation within the next few years with the implementation of the proposed Moragahakanda project. (Source: *Daily News*, January 9, 1999.)

(c) Hydropower generation in the US—a clean and cheap source of energy

It is estimated that about 10% of US electricity is generated from hydropower, with approximately 77 000 MW of conventional capacity and 18 000 MW of pumped storage, producing over 300 billion kWh annually with further undeveloped capacity of about 30 000 MW. The equivalent of this to fossil-fueled generated power fired by oil, coal, or natural gas would be 520 million barrels of oil, 129 million tons of coal, or 3.16 trillion cubic feet of gas. Thus, if hydropower generation were completelyreplaced with coal-fired generation, there would be an increase of pollutants emitted to the atmosphere, including 7.7 million tons of particulates and 296 million tons of CO2. That is, if the energy produced by hydropower were generated instead by coal, pollutants from coal would increase by 16%. In the US, only 0.6 cents per kWh is needed to finance the operation and maintenance of a hydropower plant and conversely 2.2 and 2.1 cents per kWh is required for nuclear and coal power plants, respectively. (Sources: USCOLD Newsletter, July 1996; EIA Annual Energy Review 1999, Energy Information Administration, US Dept. of Energy).

2. Impacts of Dam

Rivers are central elements in many landscapes. They are important natural corridors for the flows of energy, matter and species, and are often key elements in the regulation and maintenance of landscape biodiversity (Nilsson and Jansson, 1995). Large dams are those having height of 15 m. or more from foundation to crest. Another criteria of large dam include the dams having height 10 to 15 m. and crest length is over 500 m. or spillway discharge over 2000 m^3 /s or reservoir capacity is more than one million cubic meters. Dams constitute obstacles for longitudinal exchanges along fluvial systems. The most obvious effect of storage reservoirs is the permanent destruction of terrestrial ecosystems through inundation. Upstream of dams, submerged terrestrial biotopes are completelydestroyed.

The most common downstream effect of large dams is that variability in water discharge over the year is reduced. Total discharge may be reduced in instances where evaporation rates arehigh and/or water is removed directly from the reservoir. Reduction of flood peaks reduces the frequency, extent and duration of floodplain inundation. Truncated sediment transport results in complex changes in degradation and aggregation below the dam. Reservoirs act as thermal regulators so that seasonal and short-term fluctuations in temperature, that are characteristic of many natural rivers, are regulated.

The chemical composition of water released from reservoirs can be significantly different to that of inflows. Changes occur in pH and salinity as well as in the concentration of nutrients (e.g. phosphorous), carbon-dioxide, oxygen, hydrogen sulphide, iron, manganese and even heavy metals (e.g. mercury).The changes caused by dams directly and indirectly influence a myriad of dynamic factors that affect habitat heterogeneity and successional trajectories and, ultimately the ecological integrity of river ecosystems (Ward and Stanford, 1995).

3. Socioeconomic Impacts

Social impact assessment is the process of analysing (predicting, evaluating and reflecting) and managing the intended and unintended consequences on the human environment of planned interventions (policies, programs, plans, projects) and any social change processes invoked by these interventions so as to bring about a more sustainable and equitable biophysical and human environment.(Vanclay,2002).

As might be expected, many of the most challenging socioeconomic impacts of dam construction relate to the migration and resettlement of people near the dam site or in the catchment area (Bartolome et al., 2000). This primary impact results in a wide array of subsequent social impacts, including changes in household size and structure (Lerer andScudder, 1999), changes in employment and income-generatingopportunities, alteration of access and use of land and water resources, changes in social networks and community integrity (Fuggle and Smith, 2000); changes in the nature and magnitudeof various health risks (Lerer and Scudder, 1999; McMillan, 1995); and often a disruption of the psycho-social wellbeing of displaced individuals (Scudder, 2005; World Commission on Dams, 2000). Managing and mitigating the socioeconomic impacts of dam construction is an important task since, as the WCD noted in its seminal report, these effects are ‘‘spatially significant, locally

disruptive, lasting, and often irreversible’’ (World Commission on Dams, 2000, page no.102).

3.1. Displacement

One of the major problems of dams is the displacement of people from the submerged area. The policy of government generally includes compensation in the form of land and homes. For example, The Tehri Dam project will submerge Tehri town and 112 villages, 69 of these partially. Some villages have been or will also be acquired for new Tehri Township and for other project related purposes. In all some 9290 rural and 455 I urban families are going to be affected. The Narmada Valley Project will displace about one million people, 126 villages will be submerged in Maharashtra, Madhya Pradesh and Gujarat and other 365 villages will be partially submerged.

Displacement of People by Narmada Sagar and Sardar Sarovar Projects:

Displacement	Narmada Sagar	Sardar Sarovar	Total
No. of villages to be fully submerge	**89**	**37**	**126**
No. of villages to be partially submerge	**165**	**200**	**365**
No. of families to be affected	**10,758**	**-**	**-**
No. of people to be affected	I ,29,000	67,000	1,96,000

The Tehri Dam will displace a large chunk of hill people. It will uproot and disturb atleast 1 .25 lakhs people. There is no concern and provision for the rehabilitation of these people.

Locality	No. of families	No. of villages
Rural	9220	112
Urban	4551	-
Total	14,841	112

Out of these only 1800 have been so far been rehabilitated. The villagers have been settled in Doon Valley and Pathari near Haridwar on marginal land. These people are mostly hill people. In their previous location, they used to collect fuel, fodder, sile roots, timber and vegetables from the forests. They irrigated their fields with natural springs but in the new settlements, they have been denied of these facilities.

3.2. Resettlement

According to the World Bank, forced population displacement caused by dam construction is the single most serious counter developmental social consequence of water resources development. With extensive comparative analysis of resettlement issues related to dam construction, Cernea (1990) has identified eight risks that lead to social impoverishment: landlessness, joblessness, homelessness, marginalization, increased morbidity, food insecurity, the loss of access to common property, and social disarticulation. Scudder (1997) has added a ninth risk, which is the loss of resiliency.

However, resettlement can have positive impacts if well planned, but this takes time. Usually the second generation of the displaced community can realize the benefits of a successful resettlement with better utilization of the resources available to them. Provided that such communities are relocated with adequate compensation, new economic opportunities, and social benefits, they can exploit the new circumstances as a chance to strengthen their income-earning capacity and thus their living standards. The new settlement may provide upgraded infrastructure facilities and reduced exposure to natural hazards.

3.3. Impacts on Human Life

There are changes in the employment and production systems starting before the construction of the dam including expropriation of the land, employment of construction workers and the transport of construction material with the machines to the site. Unqualified workers are employed from the site, however the technicians and experts come from other places. Moreover, the social life becomes active, trade increases, cultural activities arise. Important

alterations are observed in the transportation system. The ways lying under water and their surrounding area are important from this point of view. The new roads that were constructed to prevent any breakdown in the transportation services result in additional expenses and additional environmental costs. At the same time dams decrease the pollution effect considerably in the down-stream part by lowering the pollution load coming from the source, thanks to their big storing reservoirs. In addition, they decrease the pollution load again by containing water continuously in their beds during dry periods. It is difficult to consider the relations between these effects beforehand and determine which positive and negative effects will come up.

4. Environmental Impacts

There is a growing concern that dam projects cause irreversible environment change,which are often complex, multiple, and essentially negative. Artificial lakes profoundly alter the natural functioning of the entire ecosystem associated with them, ranging from altering flow regimes, changing water temperature and chemistry, modifying algal and macroinvertebrate communities, disrupting resident and migratory fish communities, altering channel geomorphology and sediment transport, and impacting the abundance and diversity of physical habitats.

4.1. Effect on Aquatic Ecosystem

The microorganisms that decomposes organic matters in water body cause on increase in the nutrient substance in water body. Therefore, bio-chemical Oxygen demand of water rises. In deep reservoirs, the oxygen cannot penetrate deep inside the water body, so in the bottom portion of such reservoir, anaerobic decomposition takes place which results dark colour, smelling badly besides the phytoplankton and microflora grow up on the water surface. These events can be harmful for both the lives of lake &also for the people fishing, taking a boat trip & even from the dam gates & turbine propellers. Sometimes macroflora created here acts like a source for disease vectors. A dam that will be built on this way will interrupt the life cycle of these creatures and cause deaths in a mass. It has seen the by-pass flows are designed for this purpose.

4.2. Effect on Territorial Biological System

Biological life of the river changes fast both in the reservoir and in downstream. The parts of the bio-system that are affected by the dam are the watered parts of the shore. During the filling works of the dam, while the lands remain under water the land part of the region decreases. However, the water-land boundary extends. Thus plant, animals or human being livelihood changes. Forests, agricultural areas may come under water. Water-soil-nutrient relations, which were settled after flood in the downstream of the dam, change in a long period of time. Moreover, changes occur in flora, fauna and the agricultural traditions of people in the region. This effect can extend for kilometres.

4.3.Effect on Atmospheric System

Changes in moisture percentage, temperature and air movements caused by the water bodies differentiate the climatic conditions related to topography. Regional scaled climatic changes can be observed by these effects. These alterations don't affect human health directly, but they are notable from many plants and animals. Their secondary effects influence human being.

Reservoirs may contribute to changes in the Earth's climate. Warm climate reservoirs generate methane, a greenhouse gas when the reservoirs are stratified, in which the bottom layers are anoxic (i.e. they lack oxygen), leading to degradation of biomass through anaerobic processes. At a dam in Brazil, where the flooded basin is wide and the biomass volume is high the methane produced results in a pollution potential 3.5 times more than an oil-fired power plant would be. A theoretical study has indicated that globally hydroelectric reservoirs may emit 104 million metric tonnes of methane gas annually. Methane gas is a significant contributor to global climate change.

The following table indicates reservoir emissions in milligrams per square meter per day for different bodies of water.

Location	Carbon di Oxide	Methane
Lake	700	9
Temperate Reservoirs	1500	20
Tropical reservoirs	3000	100

4.4. Reservoir sedimentation

Rivers carry sediment down their riverbeds, allowing for the formation of depositional features such as river deltas, alluvial fans, braided rivers, oxbow lakes, levees and coastal shores. The construction of a dam blocks the flow of sediment downstream, leading to downstream erosion of these sedimentary depositional environments, and increased sediment build-up in the reservoir. While the rate of sedimentation varies for each dam and each river, eventually all reservoirs develop a reduced water-storage capacity due to the exchange of storage space for sediment. Diminished storage capacity results in decreased ability to produce hydroelectric power, reduced availability of water for irrigation, and if left unaddressed, may ultimately result in the expiration of the dam and river.

5. Conclusion

Dam construction involves negative impacts as well as positive impacts also. Water- soil-nutrient relations, which come into existence, are related to the floods occurring from time to time in a long period of time. Changes come into existence in the agricultural habits of the people living in this region and also in the flora and fauna. Dams may cause increases in water sourced illnesses like typhus. typhoid fever, malaria and cholera. Dams affect the social, cultural and economical structure of the region considerably.

Dams are not only important in economic growth, but also in overall economical and moral development. Dams, which contribute to the national economy from many aspects like irrigation, drinking water supply, flood control electricity generation, fishing, tourism, are also effective in increasing the standards of living. It decreases and minimizes the flood effects.

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