Environmental and social impacts of dams in India

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SYNOPSIS It is reported that over the past 60 years the construction of some 4,300 large dams in India has displaced over 40 million people. India is now facing a severe shortage of water for agriculture, industrial and domestic use and this is largely brought about due to a lack of storage and poor water management. Recent trends in reduced reservoir capacity appear to have come as a result of environmental and social objection to projects and the need to limit resettlement. In order to ensure that the lessons of the past are learnt and mistakes avoided, or mitigated, the regulatory authorities are improving the processes to ensure that environmental and social impacts are properly evaluated and managed, whilst being designed to encourage growth.

WATER SCARCITY IN INDIA

> "There will be constant competition over water between farming, families and urban dwellers, environmental conservationists and industrialists, minorities living off natural resources and entrepreneurs seeking to commidify the resources base for commercial gain" (UNICEF report on Indian water. ref 1).

India's demand for water is growing at an alarming rate and population growth is forecast to peak at 1.6 billion by 2050. This will increase the strain on water resources as a rapidly growing economy and a large agricultural sector stretch India's supply of water even further. Climate change is expected to exacerbate the problem by causing erratic and unpredictable weather and could diminish the supply of water, especially that from glaciers. As demand for potable water starts to outstrip supply in coming years, India could face a number of linked problems such as food shortages and interstate and international water conflict.

India's water crisis is predominantly a man-made problem. The climate is not particularly dry, nor is it lacking in rivers and groundwater. Extremely poor management, unclear law, corruption and industrial and human waste have caused a water supply shortage and rendered the available water practically useless due to the high levels of pollution. In managing water

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resources the Indian Government must balance competing demands between urban and rural, rich and poor, the economy and the environment. And therein lies the problem. However because this problem has been triggered by people they also have the power to prevent water scarcity by changing their actions.

BALANCING DEVELOPMENT AND THE RIGHTS OF THE PEOPLE

In 2006 the domestic, agricultural and industrial sectors India combined used approximately 829 billion cubic metres of water (ref 2). By 2050 demand is expected to double.

Despite the recent rapid growth in the services and industrial production, agriculture is still a fundamental part of India's economy and society. Significant improvements in agricultural production have resulted in India becoming one of the world's biggest exporters of grain. The availability of canal water led farmers to adopt highly profitable but extremely water intensive crops such as sugar cane but India has now achieved its goal of obtaining food security. The rural economy sustains 2/3^{rds} of India's current 1.3 billion population, but the huge surge in agriculture requires significant water resources for irrigation and India's agricultural sector currently uses about 90% of the total water resources. Irrigated agriculture has been fundamental to economic development, but unfortunately this is now causing ground water depletion. At present, due to water pollution in rivers, India draws 80% of its irrigation water from groundwater.

Water is also an important resource for the many different fast-growing manufacturing and industrial sectors in India, but it relies on cheap water which can be pumped from underground aquifers. But these same industries are polluting the surface water sources by discharging untreated polluted water to the rivers. According to the Ministry of Water Resources industrial water demand stands at about 50 billion cubic metres or 6% of the total freshwater abstractions (ref 2).

The demand for drinking water in India is divided between the urban and rural populations and comprises about 5% of total water demand. As would be expected the increased wealth of the urban populations means that they lead more water-intensive lives. Currently 30% of the rural population now lacks access to drinking water and of the 35 states of India, only seven have availability of drinking water for all their rural inhabitants.

Table 1. Annual Surface and Ground Water Withdrawals (%)

	Surface Water	Ground Water
Agriculture	17%	73%
Industrial	1%	5%
Domestic	2%	2%

Table 1 shows the balance of surface and groundwater withdrawals across the agricultural, industrial and domestic sectors and clearly demonstrates the dominance of the agricultural sector and groundwater abstractions.

India has been successful in developing water infrastructure for many years and indeed it is this that allowed the rapid developmental growth in the first place. These projects enabled the expansion of the urban, agriculture and industrial sectors and increased availability of safe drinking water but as a result of poor management they have fallen into disrepair as they have not kept pace with development. India is now in the process of implementing a comprehensive management programme to increase supply and address adverse environmental impacts. India is also taking action immediately to start conserving water, by harvesting rainwater, treating human, agricultural and industrial waste effectively and regulating how much groundwater can be abstracted.

DAMS AND THEIR PLACE IN SOCIETY

The central government of India currently lacks the ability to store and deliver potable water to its citizens, partly because the main means for historic storage, such as temple tanks and huge step wells, have fallen into disrepair and are further compromised by the lowering groundwater levels. China, for example, is able to store five times as much water per person as India, making it clear that there are issues with India's approach to water management. Reservoir construction now forms the principal means of storing water but the pace of new development has fallen off in recent years.

India receives an average of 4,000 billion cubic metres of rainfall every year. Unfortunately only 48% of rainfall ends up in Indian rivers. Due to a lack of storage and crumbling infrastructure only 18% of that received can be utilised. Rainfall is largely confined to the monsoon season of June to September, when India receives on average 75% of its total annual precipitation. The current lack of storage means that the government is unable to store much of the surplus water for the dry season. Such uneven seasonal distribution of rainfall has now stimulated the development of better capturing and storing infrastructure, but there is a long way to go.

India possesses about 432 billion cubic metres of groundwater, replenished yearly from rain and river drainage, but only 395 billion cubic metres are utilisable. Of those 395 billion cubic metres 82% goes to irrigation and agriculture while only 18% is divided between domestic and industrial sectors (ref 3). Groundwater is increasingly being pumped from lower and lower levels, and at a much faster rate than rainfall is able to replenish it. The average groundwater recharge rates of India's river basins is currently only 260 billion cubic metres and the Delhi Jal Board estimates that water tables are dropping by an average of 0.4m a year, although many different figures are given.

The tragedy of India's water scarcity is that the crisis could have been largely avoided with better water management practice. There has been a distinct lack of attention to water legislation, water conservation, efficiency in water use, water recycling, water harvesting and infrastructure.

TRENDS IN DAM CONSTRUCTION

Up until the 1970s and 1980s dams and reservoirs in India were becoming larger and larger. In addition the environmental issues increased and the number of people affected grew likewise. In the 1980s the Sardar Sarova Dam was proposed on the Namarda River in central India. The main purpose of the dam was irrigation (18,000km²) but there was also a multi purpose element with water supply and hydropower (1,450MW). The ensuing environmental and social debate is well documented and although concessions were made the project is proceeding, albeit with major environmental consequences. The original 80m high dam was approved in 1988 with about 66,000 people affected. By 2006 the height had been raised to 122m and the number of people affected rose to about 300,000. The final scheme is to impound some 9,500Mm³ in a reservoir approximately 214km long. The Sardar Sarova project became the focus of national and international debate and is cited in the World Commission on Dams Report of 2000 (ref 4) as being of environmental and social concern, if not a disaster.

It is the backlash from projects such as Sardar Sarova and others in India that put in place a change in attitudes in the Indian Government. Steps were taken to strengthen the existing environmental and social approvals and new project authorisation processes to present an even-handed approach to development.

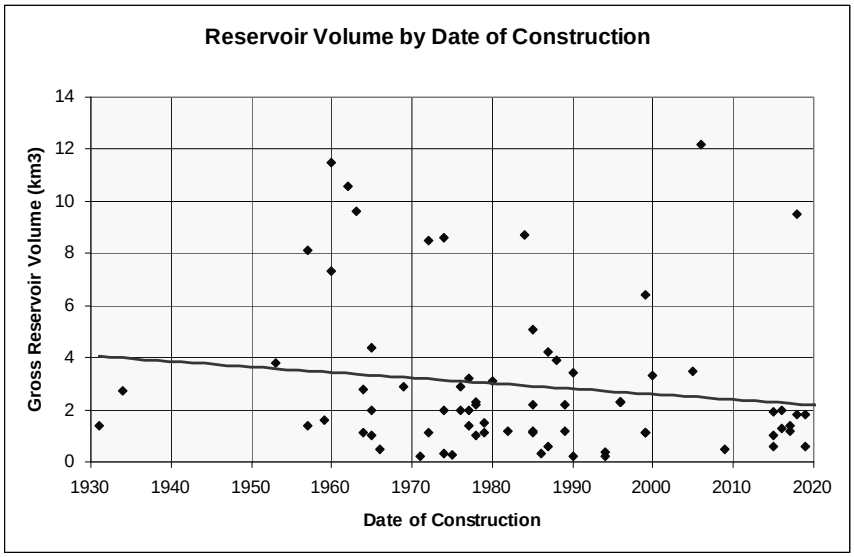

Figure 1. Trend in reservoir volume by date of construction - India

An analysis of dams over 10m high constructed over the past 80 years or under construction, as presented in the Indian National Register of Large Dams (ref 5), shows the trend of average reservoir volumes decreasing significantly, as shown in Figure 1. This appears to indicate that pressures on targeting sustainable reservoir development and limiting the environmental impact and social resettlement are beginning to be felt.

With time more dams have been built for hydropower as the need for power in the urban areas outstripped supply. Power shortages are a major problem now in urban areas and rural areas. With the growing affluence of the rural areas the fact that they have no power for many hours a day has become acute and is a political as well and social problem.

Figure 2 shows the trends in dam construction for all types of water resources including water supply, irrigation and hydropower by dam height and date of construction.

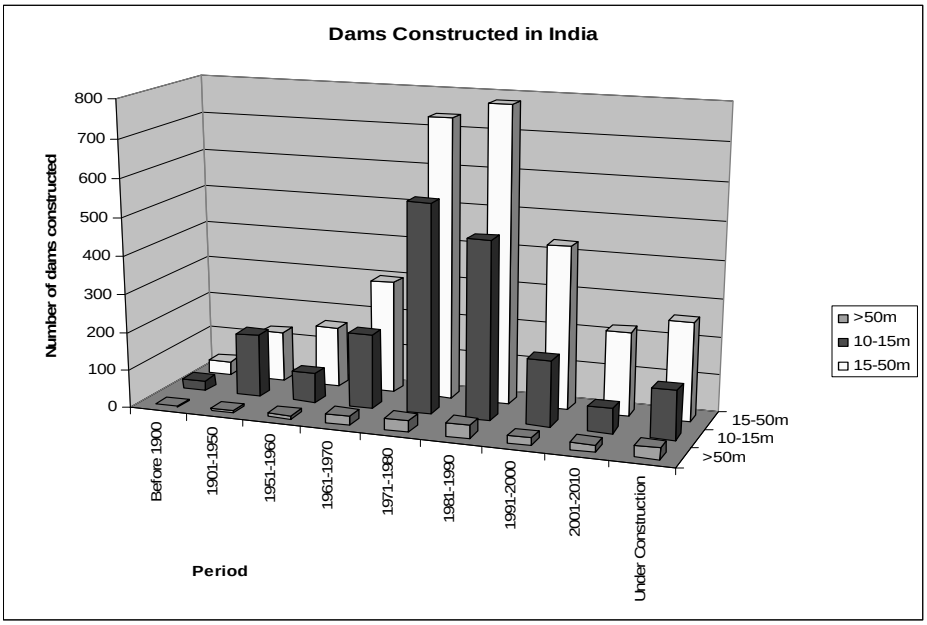

Figure 2. Dams constructed in India by height band

In general dams over 50m height represent only a small percentage (3%) of the dams constructed between 1900 and 2000. However, since 2000 this has risen to about 7%, showing an increased confidence in the construction of larger dams as technology is better understood and a move to building more dams in the mountainous regions is adopted. Assuming that most of the new reservoirs reported as being completed by 2020 are indeed completed by that date it would appear from Figure 2 that dam construction, of all dam heights, appears to be increasing again after a dip in the 2000s due to a reluctance to construct new dams in a changing environmental situation.

DAMS: ENGINEERING IN A SOCIAL & ENVIRONMENTAL CONTEXT

Since 1990 the average size of dams has been reducing despite the height of the highest dams increasing. These new large dams were mainly confined to the deep valleys of the Himalayan mountain regions where the environmental and social impacts could be reduced, if not eliminated. These large dams had little direct benefit in satisfying the needs of irrigation as they were too far from the agricultural areas. However, they suited hydropower development well, offering sufficient storage to provide peaking power generation. In addition they regulated floods and provided discharge for downstream irrigation and water supply in the dry months. However it is recognised that these large dams frequently prevent fish passage and impact the flow regime in the river by trapping silt.

WHAT SAFEGUARDS IS THE GOVERNMENT PUTTING IN PLACE?

So, with a well documented shortage of water storage and a lack of regulation on water usage and pollution why is the construction of new storage becoming more heavily regulated when there is a clear need for more water storage and established benefits? Under the current legislation any new water storage in the form of a reservoir - be it for water supply, irrigation, hydropower or multi-use - is required to go through a rigorous environmental and socio-economic evaluation and closely controlled mitigation measures are put in place.

India needs the irrigation water, the water supply and the hydropower but not the controversy associated with some schemes. Recognising that their environmental and social safeguards were not all that they could be, India set in place tighter regulatory controls for new dams and resources.

New water resources schemes are required to go through a Detailed Project Report stage which investigates the techno/economic aspects of the reservoir but in parallel the environmental and social impacts must be studied in detail before clearance is given. Environmental and social impact assessments must be carried out for all schemes over a full annual cycle and the Environmental Impact Assessment and Environmental Management Plan, as well as Social Impact Assessment, must be scrutinised by the Ministry of Environment and Forests on behalf of the Government. Only once the environmental and social ‘no objection’ certificate is issued can a developer proceed to implementation. In order to allow for potential changes to the environmental and social situation these Environmental Certificates are only valid for five years. If construction has not started within that period these then expire and new studies must be undertaken and the process repeated with new assessments.

The primary responsibility for the administration of environmental and social aspects of new reservoirs rests with the Ministry of Environment and Forests (MoEF) with respect to conservation, ecologically sustainable development and pollution control. The MoEF is responsible for enforcing

the regulations established pursuant to the National Conservation Strategy; National Forest Policy; Policy for Abatement of Pollution (1992) and the Environmental (Protection) Act 1986, revised in 1994 and amended subsequently in 1997 and again in 2006. Any project developer has to submit Terms of Reference (TOR) followed by a Feasibility report along with an application form to the MoEF/ State Environmental Impact Assessment Authority (SEIAA) according to present notification. This application is extensive and runs to about 50 pages of defined questions, supported by studies and investigations. The MoEF/ SEIAA committee subsequently asks the project promoter to make a formal presentation and then finalises the detailed TOR for conducting an EIA within 60 days of the submission of the documents. The committee generally requires a considerable number of environmental and social queries to be addressed and makes recommendations that require additional studies and work before the committee is satisfied.

As per the new Government of India Notification, water storage projects are now categorised in two categories, covering irrigation and hydropower projects depending upon their command area or installed capacity. The category A projects are then reviewed and approved by MoEF at national level whereas Category B projects are dealt with by State Pollution Control Boards, as the relevant authorities entitled to grant clearances under the Environmental Protection Act.

Category A: i) ≥ 50 MW hydroelectric power generation;

ii) ≥ 10,000 ha of cultivable command area

Category B: i) < 50 MW ≥ 25 MW hydroelectric power project;

ii) < 10,000 ha of cultivable command area.

Some environmental mitigation is governed at national level whilst some is governed at State level. Requirements to minimise forest land take and catchment management are driven by national legislation as is the requirement for new planting. The regulations relating to maintaining environmental flows in the river downstream of any dam are regulated at state level and in this case the requirements for each state vary significantly, with no consistency of approach. For example Arunchal Pradesh requires that an environmental flow of 10% of the minimum average monthly for the year to be maintained, whilst Sikkim sets the bar at 10% of the average flow through the dry months (December to March) and another state as 25% of the average dry season flow.

There is currently little environmental legislation on dealing with silt in the rivers or reservoirs - neither in relation to trapping silts nor flushing sediment downstream.

The need for fish passes has not been applied under environmental legislation for historical schemes but is now being considered under environmental impacts. To date this is being considered only for low dams and weirs and is not being applied for large dams because it is perceived as too difficult. One of the reasons cited by the regulatory bodies for not requiring fish passes is that previous schemes in a cascade have not been constructed with fish passes and so requiring one at the new scheme would not benefit the environment. Currently, there are no legislative means by which the environmental authorities can require an owner to retrofit a fish pass on a reservoir.

ENVIRONMENTAL AND SOCIAL SAFEGUARDS

When seeking Environmental Clearance developers are required to illustrate the baseline environmental features of the project environment as well as providing a clear evaluation of the environmental and social impacts and mitigations based on the detailed Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA).

A Forest Clearance certificate must be obtained from the Ministry of Environment and Forests which identifies forest lands to be acquired, including the reservoir area and any area of potential flooding or wave action (normally taken as 5m above top water level). Usually the approving authority will seek to limit the requirement for forest lands as much as possible and this can be a problem when trying to develop accesses and working areas, workshops and other temporary facilities as well as imposing space constraints on the permanent works. It is also one of the reasons why a growing number of hydropower developments are being guided to place their powerhouses underground to reduce the environmental impact.

For the Byunderganga hydropower project, which shared a narrow valley with an important pilgrim route in the mountains, the approving authority imposed strict environmental limitations on access to the dam and intake. Hence access roads were not allowed through the site area and all materials and plant have to be transported by a 4km cableway from a nearby highway.

A typical EIA considers three stages in the development of any water resources development scheme. These are the base line as existing initially; the construction phase and the operational phase. The EIA will consider a wide range of aspects relating to the project, including the following:

- Description of the works and the project area
- Geography and geology
- Climatically conditions
- Water Resources and Quality
- Assessment of agriculture, livestock and animal husbandry in catchment area

- Forests and ecology
- Fisheries
- Socio-economic profile and land use
- Archaeological aspects

Detailed Environmental Management Plans are to be developed for all new reservoirs and they are expected to cover the following aspects

- Solid waste management
- Sanitation facilities
- Provision of free fuel distribution
- Landscaping restitution
- Compensatory afforestation (usually adopted as double the area deforested for the project)
- Maintenance of water quality
- Biodiversity conservation plan
- Public health delivery system
- Control of air pollution
- Fish management
- Greenbelt development
- Establishment and funding of an Environmental Management Cell and an Environmental Monitoring programme.

The final point is of particular interest and possibly one of the most far-reaching of the environmental management requirements. Developers of new reservoirs are required to set up and fund a group to undertake the day-to-day management and monitoring of environmental issues. In practice the developer will general opt to pay the State Environmental Group to undertake this role, in order to avoid generating divided loyalties within a new environmental management group employed by the developer and reporting to the state.

Developers are also required to prepare a detailed Disaster Management Plan for the reservoir under the banner of the environmental and social impact assessments and mitigation plans. These tend to cover the following aspects:

- Dam break analysis and inundation mapping
- Emergency Action Plan and evacuation plans
- Administrative and procedural aspects
- Preventive actions and surveillance
- Communication systems and public awareness plan
- Notification procedures
- Management after flood water recession

In considering the environmental aspects of the watershed a developer must develop a Catchment Area Treatment Plan. This will cover the whole catchment to review current watershed management practices and consider possible catchment treatment measures not only to limit the environmental impact of the planned reservoir but also to improve the general condition of the catchment. The plan will also consider catchment areas prone to high soil erosion rates, assess silt yields across the whole catchment and investigate siltation modelling with respect to sediments entering the reservoir and their planned or unintended release. For most reservoirs a rim stability assessment will be undertaken to consider the risk of landslides into the reservoir either as a result of seismic events or from inundation of the toe of the slope.

The SIA assessment will consider the changes brought about by the project to the local population both directly for people living or making a living, such as farming, from within the project area but also those within the region who may be expected to be affected by the project directly or indirectly. If any of the population are to be considered for relocation it is necessary to seek legislative approval by undertaking a Resettlement Assessment and preparing a Resettlement Action Plan. State and central government regulations control the implementation of any Resettlement Plans, setting standards for consultation and levels for compensation and provision of alternative land and opportunities for livelihood. The levels of compensation do not always appear generous, but in most recent cases compensation is negotiated successfully. In many cases the local population may benefit through dam construction or operational employment or skills training for alternative livelihoods. This problem is far more acute in the plains areas where even modest height dams can impound large areas and displace multiple villages, resulting in the loss of extensive farmland. Balancing the socio-economic benefits of the population as a whole against the dis-benefits of those living in the area is difficult but this is improving.

IS IT WORKING?

Is it working? The answer must be yes. The central and state governments are balancing sustainable development against the needs for growth. Both levels of government are tightening their legislative control by better adherence to the environmental and social rules. They are keen to seek solutions to enable development to take place, but not at any cost. We are unlikely to see another Sardar Sarova in India and the authorities are encouraging responsible development to meet the shortages in water storage both now and for the future. The main question now is whether this development has been delayed too long to prevent major water shortages to come.

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