Role of Dams for Irrigation, Drainage and Flood Control

— ICID Position Paper

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INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE

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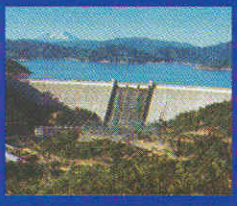

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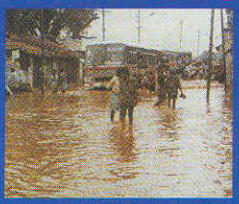

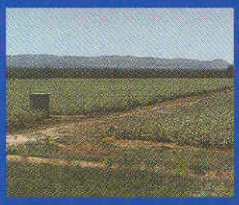

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Dams and stakeholders

Dams - large and small

Although dams have been built in the world since times immemorial, large dam construction was earlier not possible though needed, because of lack of adequate design knowledge, construction equipment, new materials like cement and concrete and technology of construction. Also, economic conditions and institutional capacity existing in countries that needed large dams, did not enable them to take them up. The large dam construction became possible during the 20th century mainly because of advances made in Science and Technology, which enabled mechanisation of construction processes and speedier construction. Improved design procedures and new construction materials enabled the design of larger dams and their components to take on much higher loads and stresses. Also, the needy countries had mobilised finances and built up their capacity by then. Large dams, distinct from smaller ones, enable larger storage of water at suitable places, thus saving on multiplicity of efforts which would be needed to construct several smaller ones. Larger water storages were also found to be necessary by the society in response to the needs of the growing urban and industrial centres, generation of hydropower or for agricultural support.

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Main stakeholders

The large dams enable harnessing of large water resources potentials, where and when available, to meet needs of fast growing societies round the world: food, fodder, fish production (aquaculture), drinking water, clothing fibres, sanitation, energy, industry, wildlife and others. After several decades of evolving dam construction activity, even today's needs are far from satisfied in many developing regions. These people of the world comprising, farmers who grow food; industries, municipal institutions who use water stored behind the dams, besides the governments who promote water resources development (WRD) are major stakeholders in dams which have been so far built. The need for more dams, especially in developing regions of the world, is still enormous. Societies for whom these dams are crucial for existence have therefore to be considered as the most important stakeholders.

Affected people

Plans and efforts have been made during the last 2 - 3 decades to see that the people that are adversely affected due to dams are involved in the development process and are treated as stakeholders. However, there are people and organisations who feel strongly that not enough is being done by governments and society while building dams to mitigate their hardships and conserve or improve the environment and ecology. The affected people, undoubtedly, have to be considered major stakeholders alongwith those who are benefited from the dams.

Dam builders, funding agencies and professionals

The planners and builders of dams, users of water, supported by sociologists, economists, politicians who promote dams form another group of stakeholders. There are several associations of these stakeholders. Three majors of such world bodies are :

* International Commission on Large Dams (ICOLD) established in 1928;
* International Commission on Irrigation and Drainage (ICID) established in 1950;
* International Hydropower Association (IHA) established in 1995.

There are some 10 similar world-wide associations of professionals dealing with some of the aspects of dams which can extend help in the matter, wherever required. Recently (1998) the World Commission on Dams (WCD) has been established.

ICID

Sustainable irrigated agriculture, drainage of rainfed crops and of irrigated land, and flood control and management - comprise the main action thrusts of the ICID. All these are directed to ensure continued food security through improvement and extension of irrigated and drained areas, increase in productivity and transformation of the rural development scenario throughout the world. A recent report from the

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International Water Management Institute (IWMI) indicates that even with best irrigation efficiency, the world needs an extension of irrigated areas by building more dams and storages. To achieve these objectives, ICID acts through its country membership, which at present includes 87 countries. Together they account for 95% of the total irrigated area which contributes about 40% of the world food production. It has more than 25 work bodies comprising international experts dealing with some of the issues related to the role of dams for irrigation, drainage and flood control. The themes covered by these bodies include Environmental Impacts of Irrigation, Drainage and Flood Control Projects, Socio-economic Impacts and Policy Issues, Research and Development, Irrigation and Drainage Performance, Sustainable Use of Natural Resources for Crop Production, etc. The ICID gathers world wide experience through these work bodies, draws lessons and builds them in its strategy for future action.

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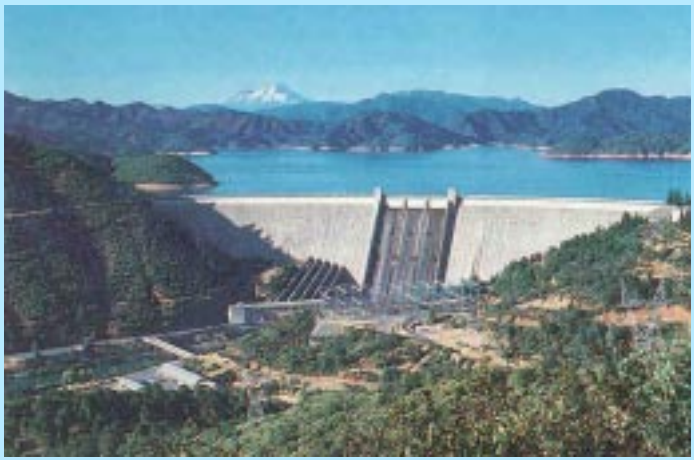
ICID aims to provide better management for the agricultural lands of the world through the application of science and techniques of irrigation, drainage and flood control measures. In pursuing its aims, ICID embraces the sound principles of socio-economic values and environmental management. The welfare of the people and preservation of nature are at the heart of it's concerns. Dams of all sizes - small, medium and large are an essential component of overall and integrated water management systems. They divert water, they retain it over long periods of time to use it effectively and they attenuate floods and alleviate impacts of droughts. They relieve drainage congestion, and they provide for the timely and continuous supply of irrigation water needed to meet the demands of crops and livestock. Existing and new dams will continue to play a major role in the management systems.



A Background on Dams

Storages provide insurance against uncertainty due to climatic variability, can help reduce variability in season's low flows in rivers and basically save societies from economic upheavals and losses due to flood and drought.

Large dams

Under what situations large storages are necessary and feasible for promoting irrigation, drainage or flood control vary according to agroclimatic setting. All dams store behind them flood-waters, primarily for the benefit of human beings. ICOLD defines large dams as those more than 15 m in height, while including smaller dams up to 10 m height as well, if they are otherwise significant with respect to storage volume, density of population, etc. The classification is notional. But because of the effects of scale the larger a dam is, the lower will be the cost of a unit of water stored.

Choice and size

The storage of water enables removal of mismatch between variable availability and supply, but usually more is demanded round the year. For this purpose, many reservoirs are designed to carry over storage to the next season as well. The variability, if not taken care of by such storages, results in droughts and/or floods. All dams - large and small and mega to micro, ameliorate such conditions and serve similar purposes. All dams facilitate transport of water to deficit areas by means of open canals, tunnels or closed pipelines. In a river basin, a judicious combination of large and small dams may be required to store water for facilitating withdrawal and use with minimum transport distance to demand regions. The choice of large or small dams and location for each dam depends on several factors including technical feasibility, location of water deficit regions that need to be serviced and alternatives available for the purpose. Besides, the balance of advantages and disadvantages due to a particular dam in socio-economic and environmental aspects helps in decision making.

Storage and quantities for beneficial uses

Not all the water stored behind dams is withdrawn for use. A top depth varying from 1 to 2 meters depending on local climate, is annually lost to atmosphere due to evaporation. At the bottom, some depth serves as a dead storage for accommodating sediment brought in

by inflow. Similarly some silt does accumulate in higher reaches where inflows merge into the reservoir periphery, gradually building up small deltas of sediment. Gated crests obviate this loss of storage to a significant extent by allowing opening of gates when inflows contain higher levels of sediment. The remaining volume minus the seepage from the bed of the reservoir and that across the dam foundation and body, is available for transport and supply for different beneficial uses. Dead storage size depends upon the catchment area characteristics but similar to evaporation losses, tends to be proportionately more in case of a smaller dam.

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Disadvantages

Every dam causes partly temporary and partly permanent submergence of land in the upstream and displacement of resident persons and their property generally, along-with submergence of plant life and disruption to animal life. As reservoir levels recede, the submerged land - rich with fertile soil and silt deposits can produce valuable crops. Also downstream of dams, such effects are caused by ancillary facilities on a similar but much smaller scale. The consequent social and economic loss is generally assessed and compared with benefits due to the dam. The downstream uses are met with mostly from flow by gravity or regulated releases into the river, whereas in the upstream, lifting of water is involved.

All these disadvantages have to be assessed in advance to plan ameliorative measures. During implementation of the plan and during operation, each disadvantage calls for careful management and monitoring.

Withdrawal for irrigation

A major portion of water stored behind dams in the world is withdrawn for irrigation which mostly comprises consumptive use, that is, evapotranspiration (ET) needs

All the disadvantages of dams have to be assessed in advance to plan ameliorative measures.

of irrigated crops and plantations. On the submerged land, there are often possibilities for seasonal irrigation. A majority of dams built in the world are multipurpose in nature, but irrigation is the largest user of the waters withdrawn. This does not necessarily mean that irrigation is also the biggest user of storage. The dams were responsible a few decades ago, for bringing under cropping, additional areas and ushering in the green revolution through high yielding crops and application of fertilisers, imparting food security in the face of ever-growing population. Water used in excess of ET needs, however appears in the system as surface or ground water, albeit with degradation in quality, mainly due to fertilisers and pesticides, besides minerals drawn from soils. Such waste has to be minimised. But for riparians dependent on lean season flows, the deficit has to be made good with supplies from upstream withdrawals.

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Non-irrigation withdrawals

A much smaller portion of storage is withdrawn from reservoirs and supplied for drinking, municipal and industrial purposes, hydropower generation, etc. Of this withdrawal, only a very small portion is consumed by evapotranspiration. A larger portion is not consumed and is returned to the system. Wastewater from municipal and industrial withdrawals is of degraded quality. Such wastewater has to be treated for quality improvement and reuse to increase availability for downstream uses. These uses are mounting with economic development round the world and are considered on priority while planning withdrawals for different uses from a limited storage. Even in ultimate stage, these uses will remain low and can be taken care of through recycling of waste waters. Drinking water requirement is given top priority by most of the countries in their policy documents. Similarly, use of stored or diverted waters for hydropower generation is considered most eco-friendly, because of its non-consumptive nature and because the resource is renewable and can be used again and again in the downstream for power generation.

Floods

The total quantum of flow and size and frequency of peak floods in the flood season reduce in the downstream

due to a dam, reducing flood hazard due to inundation of land, crop and property which might result into economic upheavals. It also reduces congestion of runoff in plains and coastal lands. Dams, reservoirs, flood levees, embankments, and river training works constitute structural measures for better flood management. However, non-structural measures like monitoring of precipitation, river and reservoir stages and flow measurements, forecasting, early warning, appropriate disaster warning and strategy, also are important in flood management. In the lean season, the river flow in the downstream reduces depending on withdrawals from dams through canals or pipelines, however, it can be augmented with supplies from upstream withdrawals. Reduced frequencies of floods and reduced peak flows reduce the agricultural and non-agricultural losses. On the other hand, if storage is used for generation of hydropower in the river bed, then seasonal flow is enhanced ameliorating several difficulties downstream. Intensive economic developments have been realised, for instance in the areas of Damodar, Mississippi, Missouri, Nile, and Tennessee rivers, only because of flood protection by the dams.

Standards

The various professional institutions/associations, Governments and the academic sector have, during the last century, developed criteria and guidelines for all aspects of decision making as related to dams. Present day standards are a result of continuous review and upgrading through experience and generated knowledge. The standards help assess availability, variability, statistical dependability, storage size, risk analysis about chances of hydrological failure, multipurpose sharing of reservoir space, sharing of costs, environmental checklists, monitoring of environmental effects, mitigation measures and effectiveness of development effort, in addition to the numerous Science and Technology based procedures, methods and design of structures and their components. All storage dams proposed to be built for identified purposes therefore aim to conform to the approved standards.

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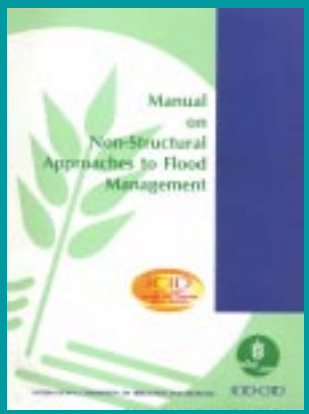

Decommissioning of dams

The question of decommissioning of dams built for irrigation purposes hardly arises because of continuing food requirements. On the other hand, in many situations, raising and strengthening of dams is called for, for improving the irrigation service. Dam builders have not sufficiently considered so far, 'decommissioning of dams' as a necessary step. Dams are complex and major structures involving large investments. Some dams can prove less effective than most, but efforts have been made to minimise the reasons for this and increase the effectiveness through modernisation and rehabilitation of such dams. At some places a larger dam has been built in the downstream of an existing dam incidentally submerging it. When a reservoir gets silted up over a period of time, the dam has been used to work as a diversion structure for run of the river withdrawals, sometimes for shorter period of time. The operation and maintenance costs for an older dam are often very low because of the sunken character of investment cost.

Sustainability of development due to dams

The subject of sustainability of development has been extensively debated over the last two decades. Dams have solved many problems of communities served and have provided basis for economic development that has sustained itself. Employment opportunities have been generated, incidence of poverty has been reduced, rural population including nomads has been stabilised locally and migration of rural unemployed population to urban centres has been reversed. Food security to ever growing population, protection from floods and droughts to chronically vulnerable areas and generation of the cleanest form of energy, namely hydropower, are some other benefits of water resources development. Many urban and industrial centres have been provided with water supply for consumption and transport of waste for treatment.

Gated reservoirs provide for less submergence in totality of long term sustainability of the irrigation service by avoiding excessive silting above the crest of the spillway. A substantial part of that storage quantity stands almost

perpetually guaranteed. Navigation, fishery, irrigated forestry, recreation and leisure are some other obvious benefits. The overall development due to dams is there for everybody to see. Benefits, costs and risks undoubtedly increase with size of a dam. Efforts are made by dam planners to maximise benefits, minimise costs and build in defensive measures in dam components to take care of risks by deploying appropriate technology and design features. Incidents involving dam failures are decreasing from decade to decade and the safety record is likely to be better than in many other sectors of infrastructural development. Dam safety concerns and policies have been incorporated in dam engineering from concept to O&M stage and this has shown positive effects on the performance of dams. Thus, structural safety of high dams is no longer a real concern.

Compensation for affected population

The adversely affected people due to a dam comprise those who are displaced due to inundation in the reservoir or due to ancillary structures. Some people dependent on those displaced are also incidentally affected. Some farms develop waterlogging due to canal waters and the concerned farmers are also affected. These people have to be rehabilitated and resettled with due compensation and recognition for their sacrifice. Such rehabilitation and resettlement (R&R) effected in their consultation and with their consent can also include partnership and ownership in the facilities and provide them economic benefits flowing from the water resources development. Very liberal R&R policies/guidelines have been framed by several developing countries which provide for appropriate compensation measures for the project affected population.

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The canals generally run along a contour and provide irrigation water by flow in a command area. For farmers who are on higher level than the canal, and similarly those on the fringe of reservoirs, lift irrigation facilities can be provided, if so desired by either affected people or those who are close to the facilities. While the supplies through the canal could be seasonal, those directly by lifts from the reservoir are more assured and

available almost round the year. The equity in supplies can thus be provided at local and regional level by applying some basic economic principles. However, it is often seen that social - more than economical - concerns, provide clues to bring equity to the project people.

Summing up

While large quantities of fresh water are yet flowing to seas through rivers, scarcity is engulfing many countries of the world. Thousands of dams are still to be built to store water and make it available, during the next century on a world wide basis, especially in the non-industrialised countries of Asia, Africa, Latin America and East Europe. The needs of growing populations, the pace of urbanisation and industrialisation, and the urgent need to improve the standard and quality of life of poorer strata of their societies calls for urgent steps to build these facilities. It is an enormous challenge to decision makers, developers and designers to develop economically required capacity in an environmentally sound and sustainable way.

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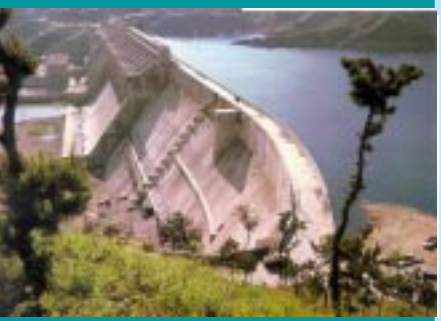
ICID's Position

The IWRDM has to address the needs of the ultimate stable size of global population.

Appropriate policies and guidelines on sustainability aspects of dams need to be fully developed, and where developed they need to be uniformly applied.



Effectiveness of dams for development

Large or small dams, if built without adequate preparatory work, can fail to deliver expected results. Any dam could thus prove less effective than planned. It is therefore necessary to select cases of success or failure of both large and small dams. Lessons are to be drawn from failures to guide future action. The owners of such dams have to be approached first for their assessments. If a new dam is identified, a bench-mark status if not available at the time of construction, might have to be ascertained to realistically assess its effectiveness. Where much depends on how the delivery system is operated, the dam is hardly the reason for any loss of efficiency. Greater attention is necessary in the irrigation sector to bring about and maintain perfection in the delivery systems.

Storages of various magnitudes are a requirement for practically whole of the developing world and dams of various sizes fulfill that necessity. It is therefore, imperative that such a development process is supported by effective procedures to minimise negative effects, if any, and enhance benefits. Large dams contribute significantly to the productive efficiency of irrigation, in addition to giving ancillary and intangible benefits. The large dams built in the past have provided water supplies to needy areas for growing food, for drinking water, for reducing flooding, and for generation of hydropower at lowest of costs from amongst various options. Smaller a dam, more is the cost per unit of water stored, but every size has its role in development of basin resources. They are complementary to each other. They cannot replace each other.

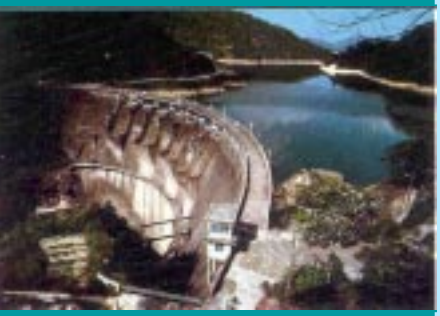
Assessment of options and decision making framework

Sustainability

Sustainability has become the touch-stone for development effort since Agenda 21 was adopted at the Rio Conference in 1992. Although its definition has had different connotations for various development sectors, it means that fruits of development ought to be of

sustained nature to meet needs of future generations as well, and should not be of transient nature to address only present day concerns. ICID fully underlines the recommendations of the Rio Conference and actively promotes their implementation. Recently, the Global Water Partnership has come up with the following definition of Integrated Water Resources Management, 'a process which aims to ensure the co-ordinated development and management of water, land and related resources to maximise social and economic welfare without compromising the sustainability of vital ecosystems'. For instance, in case of dams, the present decisions ought to result into outputs for a long enough time. It is possible only through integration of development and management of water resources (IWRDM) which is enshrined in Agenda 21. While achieving it, quality and quantity i.e. sustainability of natural resources themselves must not be affected. Dams have a finite life like any other man-made structure. The right combination of large and small dams in a river basin, which provides such sustained fruition throughout the structures' life, has to be ascertained by scientifically oriented specific studies. The IWRDM has to address the needs of the ultimate stable size of global population expected to be reached, hopefully, by the middle of the next century. Such needs can be met with from basin-wise availability, through the desired combination of dams to provide a model for sustainable development. Within a basin itself, conflict of interests often manifests due to perceived shortages regarding size of dams. Appropriate policies and guidelines are called for to resolve such conflicts.

Appropriate policies and guidelines also on sustainability aspects of dams need to be fully developed, and where developed they need to be uniformly applied. Basically dams store flood runoff of the rivers and make the storage available for withdrawal to meet with beneficial needs. Within the range of variability of availability, appropriate withdrawals are designed to import sustained supplies and hence sustained productivity. The waters of a basin thus get redistributed at minimum economic cost and hence ensure sustenance of the source as well as fruits for development.



Integration of options

The alternative to such discrete combination, as proposed by those who oppose large dams, is to go in for minor dams and micro river basin development schemes only. The minor dams have a definite role to play in a basin, along with major dams. Micro river basin development basically is useful in rainfed areas, which cannot be served by canals starting from dams or by groundwater facilities. About half of the sown area in the world is likely to remain dependent on rains. For such area, micro river basin development usefully provides protection from variability in rainfall in a rainy season. It ensures fair growth of one crop, by retaining soil moisture over a longer period and increases yield. Unfortunately due to agro-climatic factors such as: rainfall intensity, extent, frequency, duration and antecedent conditions of moisture availability in soils, the rainfed agriculture remains sustainable in a very narrow range of dependability. Also, evaporation rates in concerned areas restrict availability of supplemental moisture drastically.

Dams and micro river basin development are not alternatives, but are complementary to each other to increase food productivity of cropped land and to ensure food security in irrigable and rainfed lands.

The dams and the micro river basin development are thus not alternatives, but are complementary to each other to increase food productivity of cropped land and to ensure food security in irrigable and rainfed lands. The total amount of water remaining available in a basin with small size reservoirs is considerably lower due to relatively large scale evaporation, than that from a river basin with larger water storages.

It is ICID's position that micro-development schemes ought to be considered and conceptually developed for areas which will remain rainfed as part of an integrated evaluation process that progresses toward an optimised river basin development scheme. It is considered to be shortsightedness, as also inappropriate, to reject large dams, or any other component of a proposed river basin development scheme without even-handed and comprehensive analyses of overall relevant social, economic and environmental considerations.

Issues related with planning, implementation, socio-economic aspects

Decision support systems

Planning and implementation of different facilities created for land and water development have evolved over the last 100 years utilising advances made in science and technology. For micro river basin development also, sufficiently detailed criteria have been developed over the last two decades. Spatial decision support systems have been developed to take into account hydrologic, land use, bio-mass, energy and socio-economic components for river basins. In view of low food productivity of rainfed areas under various climatological and soil conditions, several countries have taken up such development. Appropriate decision support tools for analysing and, if favourable, implementing water resources schemes involving large dams, should be developed, with due regard to overall national interests, individual basin plans, safe designs and strict monitoring.

Economic analysis

Socio-economic impacts of large dams and alternatives of micro river basin development have been studied extensively. As mentioned earlier, the larger a facility, the benefits, costs, and risks are usually larger. But while planning a facility, effort is made for maximising benefits and minimising costs and risks. A view is taken, on the balance, of advantages to the community. The benefit cost (BC) analysis has to include social benefit- and cost streams to expand it to Social Benefit Cost Analysis (SBCA). It is difficult to accurately quantify secondary and incidental benefits and costs. The SBCA essentially helps a planner to prioritise projects for implementation besides improving dimensioning of a scheme and selection of the best alternative.

Prioritisation

For many countries of the world, all the planned storage facilities are required and still the level of water supply may remain short of their ultimate requirements. In such cases, the BC analysis does not help beyond prioritisation in face of resource crunch, because even the most

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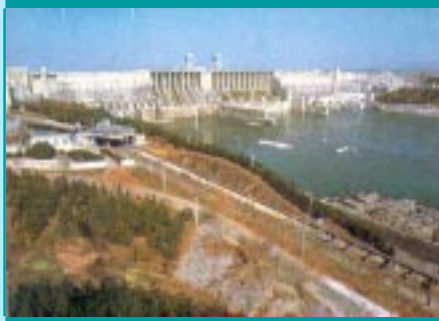

expensive facility may have to be put in place to meet the needs of society. Water resources development and utilisation in most of the developing countries is of utmost importance for their socio-economic upliftment, poverty alleviation programs and food security. A sovereign country no doubt will preserve its basic right of deciding its own priority of developmental needs and most suited options. Global criteria can at best indicate guidelines.

Environmental issues

Compensatory packages

Every human activity modifies the environment. Some changes are for the good, some are not, but the awareness in the society about size and scope of the adverse impacts plays an increasing role in decision making. Effort is made to mitigate and compensate such effects while increasing the positive impacts, so that sustainability of development is maintained and the natural resource base is not eroded. The challenge is to ensure that the positive effects on environment outweigh negative effects. Mitigation/enhancement measures have been evolved, over a period of time, by concerned professionals. ICOLD and ICID have prescribed detailed listings, criteria and guidelines for study of environmental impacts and their mitigation. Many countries have developed appropriate policies and measures for compensating negative impacts. While respecting the privilege of countries/governments to develop their water resources plans and priorities, it will be only fair to expect that adequate compensatory packages are provided by them to the adversely affected people and to ensure that such people are better off after the project implementation than before it.

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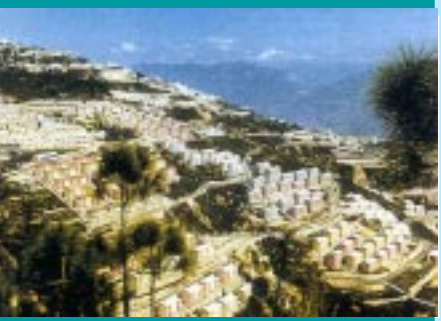

Adverse impacts with and without a dam

In the developing world, land and water development is required to take care of the population pressures and the poverty level of societies. As development reduces the poverty level and improves the standard of living mainly by providing employment generation, this in itself has positive effects. While adverse impacts of a dam can be taken care of, the availability of freshwater

on the other hand reduces environmental degradation. The positive impacts on environment are manifold. In absence of a dam or a water withdrawing facility, the environmental degradation continues unabated especially in less developed regions because of population pressures. Environmental impact studies therefore have to be carried out for both, with and without dam scenarios. The environmental cost of constructing a dam is normally smaller than that in a situation without the dam, if the continued degradation in absence of a dam due to poverty and population pressures during the life of the dam, is considered. It is often to be concluded that the environmental cost of building and using a dam in a developing country is smaller than that of not doing that dam project. The extent of submergence and evaporation loss from a large storage project is lesser than that from a series of equivalent small storage projects.

Apart from assessment of adverse impacts with and without a dam, it is sometimes required to carry out the assessment for situations before and after completion of a dam project as one time exercise. Both assessments are important as they provide important insight into the environmental concerns and their containment.

The checklists

The components of environmental impacts normally considered are: loss of land and biomass, forest etc. due to submergence, likely loss of land due to water-logging and salinization in irrigation command, deforestation in the command due to bringing of new areas under cultivation, loss of passage for fish and aquatic life, reduction of flow in the downstream river portion, and effects on flora and fauna in estuaries and mangroves regions. All these effects can be ameliorated by means of adoption of appropriate mitigation measures.

A checklist enables the planner to identify items of environmental concerns that are site specific. The ICID checklist encourages the authorities to embark upon studies to assess likely impacts on each of the identified aspects qualitatively and quantitatively. Such studies at project stage enable assessments of costs/benefits due to positive and negative impacts including measures to minimise, contain or compensate them.

The ICID checklist encourages the authorities to embark upon studies to assess likely impacts on each of the identified aspects qualitatively and quantitatively.

While only the general guidelines could be internationalised, much of the standardisation work has to be done by a particular country within the country to suit its prevailing conditions with due regard to the safety requirements and mandatory procedures.

Development of internationally acceptable criteria and guidelines

The development of dams in the world has not taken place in absence of knowledge. Large volume of experience is available. The ICID, ICOLD and IHA with the help of their participating member countries around the world, for instance, have developed a variety of standards and guidelines. They have been adopted in international and professional fora and fine-tuned especially during the last 50 years. Besides, most of the countries have their own standards which are statutory and hence adopted by dam professionals. The standards and criteria adopted by any one country for its conditions can not be made applicable to another country. Thus, while only the general guidelines could be internationalised, much of the standardisation work has to be done by a particular country within the country to suit its prevailing conditions with due regard to the safety requirements and mandatory procedures.

Institutional policy and financial arrangements for equitable sharing of benefits, costs and risks

One principle that ought to be followed is that all those who are benefited or who are adversely affected by dam projects are made stakeholders of the project so that they get a share in the benefits equitably. The standard of living and quality of life of those adversely affected due to a dam, should be brought up to a level higher than what it was prior to the dam project. Risks to the structure due to deficiency in planning, implementation or natural hazards have to be evaluated and integrated in the cost streams, which should include ample defensive and mitigation measures. They have to be appropriately worked out and provided in the overall planning of the area. Again in this case, ICID believes that the risks to the downstream society due to floods in absence of a dam are much higher, than the risks after construction of a dam. An appropriate assessment of the status of society with and without dams has therefore to be made, according to already well defined assessment procedures whose implementation has to be pursued by all responsible segments of society.

Large dam projects provide conducive environments for livelihood enhancement, sharing of benefits and empowerment of weaker sections, especially women farmers. But in each sector for which withdrawals are made, ICID encourages incorporation of the principles of equity, efficiency, and economy amongst water users. Participation of dam affected people, alongwith dam benefited people, is important according to ICID for planning of dam schemes and their size, coverage and area of influence.

As a conclusion, ICID stresses that dams have played and will continue to play an important role in the development of water resources, especially in developing countries. In order to develop and operate successful projects, a balance has to be struck between the requirements based on the needs of society, acceptable side effects and a sustainable environment.