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Large dams and their geophysical effects

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Summary

The human being has struggled, since the beginning of its existence, to transform the ecosphere in the way it wanted. The period in which this attempt could be observed the most was the period of transit from the primitive, migratory society, whose main occupation was hunting, to the permanent, resident life, which begins to learn the secrets of agriculture. The most profound change of the environment against nature, which was made in the history of mankind, began during this period.

Even the development and decline of civilizations are correlated with this interaction between human beings and nature.

Dams have one of the most important roles in the use of water resources. Their construction began many years before the current information on hydrology and hydromechanics.

Dams also have negative consequences on the environment, in addition to the benefits they bring such as the control of water flows, therefore flood prevention, obtaining from stored water, domestic water and irrigation water and obtaining electricity.

Wherever the dams are positioned, their ecological impact is the same. The impact of dams on the environment can be classified according to different criteria into Long-term impact, Short-term impact, Impact on a restricted area, Impact on a region, Social impact, Beneficial impact, Harmful impact. These effects can be ordered in an intensive and complicated way as: Climate effect, Hydraulic effect, Biological effect, Social effect, Cultural effect, Archaeological effect. In addition to their important social and environmental benefits, it is important to minimize the negative effects that dams have on the sustainable development of the environment. The mentioned effects and their solutions were taken into account in the concept of environmental impact assessment.

1 Introduction

Large dams have enjoyed a very positive reputation as industrial powerhouses in comparison to fossil fuel equivalents. The dam lobby claims that they produce negligible greenhouse gases, little disturbance to river systems, and labels them ‘renewable and green technology’. In reality, studies have shown that dams can be more polluting, emit more greenhouse gases and be less sustainable than even fossil fuel alternatives.

The environmental consequences of large dams are numerous and varied, and includes direct impacts to the biological, chemical and physical properties of rivers and riparian (or "stream-side") environments.

The dam wall itself blocks fish migrations, which in some cases and with some species completely separate spawning habitats from rearing habitats. The dam also traps sediments, which are critical for maintaining physical processes and habitats downstream of the dam (include the maintenance of productive deltas, barrier islands, fertile floodplains and coastal wetlands).

Another significant and obvious impact is the transformation upstream of the dam from a free-flowing river ecosystem to an artificial slack-water reservoir habitat. Changes in temperature, chemical composition, dissolved oxygen levels and the physical properties of a reservoir are often not suitable to the aquatic plants and animals that evolved with a given river system. Indeed, reservoirs often host non-native and invasive species (e.g. snails, algae, predatory fish) that further undermine the river's natural communities of plants and animals.

The alteration of a river's flow and sediment transport downstream of a dam often causes the greatest sustained environmental impacts. Life in and around a river evolves and is conditioned on the timing and quantities of river flow. Disrupted and altered water flows can be as severe as completely de-watering river reaches and the life they contain. Yet even subtle changes in the quantity and timing of water flows impact aquatic and riparian life, which can unravel the ecological web of a river system.

2. Dams and people

2.1 The need for dams

throughout history , dams have been built to collect and store quantities of water for the purpose of controlling and augmenting water supplies that would otherwise be lost in seasonal floods of rivers and streams . traditionally, irrigation water has been extracted from river and lakes. Unfortunately maximum irrigation demands often coincide with period of low river flows . for more than 5000 years dams that impound reservoirs have enabled communities to flourish by assuring a dependable supply of water for domestic purposes and irrigation . in fact the loss of ability to construct, maintain and repair dams has been the demise of several civilizations . in addition we have succeeded in influencing the global water cycle through irrigation along arid river valleys by constructing networks of artificial waterways and modifying the vegetative cover through plowing and tree cutting .

2.2 Benefits and problems of dams

Dams contribute significantly toward fulfilling society's water supply requirements; at the same time, they provide a renewable, nonpolluting source of electric energy. Many dams also serve multipurpose uses; for example, dams contribute to irrigation, flood control, navigation, recreation and fishing. Storing water, however, calls for human intervention in the natural water cycle. Inevitably, this activity will not only lead to changes in surface and groundwater quality but it will also have major social impacts. In some developing countries, for example, problems have surfaced as dams in some areas have destroyed valuable and productive ecosystems or reduced deposition of fertile sediments in downstream flood plains. Often, groundwater aquifers are overexploited leading to higher pumping costs and/or salination of such aquifers. In the developed world, agriculture has caused water resource problems as a re- suit of nitrate pollution, pesticide residues in soil and eutrophication of lakes.

2.3 The need for water

The need for increased water supplies (and power generation) is particularly acute in developing nations. Water is needed to increase productivity people, develop industrial potential and improve the state of health (80 percent of all deaths among children in the third world are the result of water pollution). Water demand and consumption expected to continue to grow exponentially worldwide. The pressure on our water resources has increased dramatically over the past several decades as a result of:

- Unprecedented growth in world population (from 3 billion in 1960 to 5.2 billion in 1990). Exponentially growing urban populations make it extremely difficult to maintain infrastructure and services (e.g., Los Angeles, Mexico City, Lagos and Rio de Janeiro). By 2000, 50 percent of the population is expected to live in cities, with 10 cities having between lo and 15 million inhabitants each.

- Rising expectations for economic development and Improved standards of living. The limited availability and corresponding high price of water are constraints to socioeconomic development.

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- Vast expansion of irrigation agriculture and failure to address inefficiency in water application, inequity and unreliability of irrigation systems has caused major setbacks to food production in many developing countries.

- Discharge of waste products often requires large volumes of water for dilution. Synthetic chemical pollution is the main problem in highly developed countries (bacterial pollution and organic waste). In the less developed countries, water pollution by organic waste is the main water quality problem.

- physfca1 scarcities and pollution problems are growing in international river basins and groundwater aquifers.

2.4 Water availability

Enormous quantities of water exist on a global scale; however, not all fresh water is available or accessible and what is, varies greatly in terms of quality and distribution. More than 97 percent of the approximately 1.4 billion km3 of water on this earth is seawater or brackish water; only approximately 2.5 percent is fresh. Of all freshwater, approximately 77 percent is stored in polar ice and glaciers. Nearly 23 percent exists as groundwater and less than.01 percent (1,500 km3) appears, at any moment ,in rivers. Early civilizations developed along major rivers (Tigris /Euphrates, Nile, Ganges, and Yellow) because water was abundant and readily available for transportation, consumption, food production, and, later, industrial use. Today, 90 percent of the global population resides in river basins that cover 60 percent of the total landmass.

2.5 Water Shortages

Water supply deficiencies around the world are vastly underestimated and are rapidly becoming a major constraint to our sustainable environment.
Population has reached levels where water availability is critical not only to allow further development but also to simply sustain existing communities. Efforts to supply water have failed to keep Up with population growth. Some of the more alarming statistics include:

- Total global water use doubled between 1940 and 1980, and is expected to double again by the year 2000.
- Eighty countries, which account for 40 percent of the global population, face a serious scarcity of water.
- 65 percent of the world’s rural population and 35 percent of the urban population lack a reliable water supply system.
- 1.7 billion people are without sanitary facilities.
- Between 1980 and 1990, safe drinking water was brought to an additional 1.35 billion of the world’s 5.2 billion people (980 million rural and 369 million city dwellers). Yet 1.2 billion

people (989 million in rural areas and 243 million in urban areas) are still without safe water.

Many large urban centers around the world are facing deteriorated water quality in their supply systems.
A crisis in safe water supply is imminent, especially in the world's underdeveloped countries where population growth and urbanization are outstripping water supplies. In 1975, there were 19 countries that lacked adequate renewable water resources for domestic and irrigation uses. It is estimated that this number will grow to 29 countries by the year 2000 and 37 countries by 2025. If present trends continue, a target of clean water and adequate sanitation for the entire global population by the year 2000 will not be possible.

2.6 SOCIAL AND ECONOMIC IMPACTS

Socioeconomic Impacts - Generally

- resettlement
- health
- local economic impacts
- employment opportunities
- cultural landmarks and heritage resources
- tourism and recreation
- navigation
- downstream
- existing laws and policies
- internalization of environmental and social costs.

Socioeconomic Impacts – Generally

Effects of project construction and subsequent operating activities on local and regional economies include direct and secondary (or spin-off) Demands for labor and services, as well as effects on local resources, and thus on the very structure of the local economy. Such economic effects also cause significant social impacts. Also, various impacts stem directly from project activities and these also have economic implications. Overall, Socioeconomic impacts engender a complex dynamic which is not easy to predict accurately. impacts are most conveniently evaluated and managed when this dynamic is seen in terms of issues, but it is essential to remember that such issues are not discrete problems; mitigation, like the impact analysis and project planning, must take into account the interrelationships between the various social and economic considerations.

Because large dams are often seen as essential for national economic development, their macroeconomic benefits tend to be highlighted while their local economic and social impacts are less adequately evaluated. This is particularly true in underdeveloped or developing countries located in tropical zones where the attraction of inexpensive hydroelectric energy for Improving the conditions of the general population are self. evident. The socioeconomic impacts, however, are much more subtle and indirect.

Health

Water Borne Diseases. Some of the worst human diseases are of parasitic nature and are transmitted to man by vectors, such as mosquitoes and snails that breed in rivers, lakes and wetlands. Impoundments may expand these breeding areas increasing the density of vectors in a certain area and there by submitting local populations to higher risks of infestation. Malaria, schistosomiasis, filariasis and viral encephalitis are some of the most important considerations. Concentrated primarily in tropical and subtropical climates, their incidence may rise significantly with the creation of a large reservoir, especially when associated with irrigation projects. Long before impoundment, it is important to build a solid knowledge of the prevalence and seasonal incidence of diseases in exposed neighboring populations. Precise identification of the parasites and their vectors must be made. The quality and efficiency of the existing public health network must be evaluated and upgraded where necessary. The availability and quality of biological products and services, such as vaccines and screening tests, must be assessed and secured. A special prevention program must be prepared and publicized. This program should begin years before impoundment and continue for at least five years there after. Ideally, this program should aim to eliminate the " reservoir " of human carriers by treating each carrier before impoundment.

Great care must be taken during reservoir clearance operations to remove marginal vegetation relevant to an eradication campaign on mosquito breeding. Spraying the shores with appropriate insecticides during and for several months after impoundment is recommended. Reservoir level fluctuation at the opportune time should have a positive effect on insect control. The formation of stagnant pools along the shoreline should be prevented by providing drainage back into the reservoir during drawdown's or by construction of exclusion embankments. When the oncomelania snail is the target vector, the creation of shallow water areas must be avoided and molluscicides must be used.

Mitigation of Health Impacts. Health maintenance and sickness prevention planning should be secured during pre-project planning. An evaluation of the strengths and weaknesses of the local and regional health services will allow for plan fling of any necessary improvements. These may include a task force approach, on-going monitoring, preventive and supportive measures and emergency facilities. As with other types of impact, it is important to inform the population concerned so that they themselves can take particular care of their health. Committees representing a cross section of the affected population will help assure a sound project interface with the communities and will collaborate in the management of the various health and other social and economic impacts.

Local Economic Impacts While construction activities associated with a large dam project usually stimulate the local economy, the sequence of "boom and bust" may cause problems. In the boom phase, demand may be inflationary and create various infrastructure costs for local authorities, If their fiscal autonomy is large, local governments may receive tax revenues including property tax income from the value of the dam or from water rights, or perhaps share in power sales. However, the withdrawal from then local economy of agricultural land, pastures and woods required for project implementation may represent significant resource losses that warrant additional compensation. It is important that Local officials channel newly available funds to improve the rural areas. Undoubtedly the project Will have some positive effects on local economic resources. For instance, lost stream fishing potentials should be more than replaced by reservoir fishing. The establishment of small local businesses and restaurants is often initiated by dam projects to the general financial benefit of the entire local community. Enhanced property values that result from the economic upgrades may, however, lead to problems for those still following traditional life styles. Suitable tax offsets may be an appropriate in alleviation.

Employment Opportunities

A dam project will always result ‹n creating new jobs within the project's community. For the most part, these jobs are temporary in nature; but for a large project they may last up to a decade. A limited number of those who are employed during construction may be retained as operating staff members. Preferably, these operators should be local residents. However, most of the time, these people lack the necessary education and skills to perform in an optimal manner. One proven method to overcome this is through on-the-job training together with formal coursework during the implementation phase, and by close cooperation between the dam building entity and local authorities. In this manner, the transition from construction to operation may be as smooth as possible. Depending on the degree of success of local recruitment for construction, it may be necessary to import a number of skilled and semi-skilled laborers. Oftentimes, these imported Laborers come from a different background and culture, and care is needed to integrate them into the local community. Once the construction phase is complete, it may be possible to retain some of the individuals employed during that phase to tend to the needs of the operators and of tourists or vacationers, provided the site is or has the potential to become a recreational attraction.

Tourism and Recreation

The creation of a reservoir often enhances the development of tourism and recreation, thereby providing a source of additional income for the local community as well as an asset for a broad region of communities.

Navigation

Projects on larger rivers typically include shiplocks or other navigation installations to facilitate river traffic that may have been constrained by low river flows, rapids, or flood conditions in the natural river condition. The extra commerce created by increased navigation ‹s an advantage to the local and regional economies. Lock dues may generate income to the project, some of which may be allocated to local advantage. Provision of services to passing shipping provides another opportunity for generating local income, and reservoir shore development is further encouraged by the availability of inexpensive transport.

2.7 SUMMARY

Dam projects have always had as their initial consideration and ultimate objective meeting the needs of people. Defining these needs and incorporating the ideas, needs, and concerns of all of the people affected is a complex challenge. The Various social and economic consequences of any projects are being studied and addressed by project planners and engineers more rigorously now than at any previous time. Many of these activities involved with the planning and engineering of project go far beyond the physical and technical matters. By taking these steps, water resource professionals are meeting the challenge and are able to develop dam projects which result in the lasting economic and social improvement for the local community and the nation as a whole.

3 Dams and water supply

in many parts of the world, rain and snowfall are seasonal: the typical cycle includes a dry season and a wet season. Because of these seasonal discrepancies, civilizations, since the begging of time, have endeavored to store water for use during the dry times. To accommodate the in consistencies in our global water supply, reservoir are essential to store fresh water until the time of need. Today, operation of reservoirs by storing water during periods of high surface runoff and releasing it during dry periods provides water for human consumption, water for irrigation, for food and other crops, water for groundwater recharge, ‘water for hydroelectric energy generation, indusia1 processes, and cooling systems, as well as for recreation.
unfortunately, in a global sense, areas of ample supply are offset by scarcity elsewhere. Some countries face frequent flooding while others face recurring drought. In the Sahel of West Africa, severe droughts occurred from 1907 through 1915 and again from 1968 until 1973. In Russia, 80 percent of the stable river runoff occurs in the least populated regions. Thirty-eight of the poorest countries border regions of snow or desert. In these areas, poverty is often aggravated by flooding from meitwaerty runoff or by a shortage of water.

The purpose of this discussion provide both a historical and global perspective. The discussion describes how dams and their reservoirs provide the essential benefit of a reliable water supply to satisfy the needs of civilizations, particularly in an arid environment.

3.1 WATER DEMAND AND POPULATION GROWTH

The greatest need for water occurs in the arid regions of the world during the warm, dry seasons. Further, demands on water supplies worldwide are increasing rapidly due to unprecedented growth in population, increased economic development and higher standards of living prompted by industrialization. World population has soared from billion in 1960 to about 5.3 billion at the present time, and the demand for water has quadrupled A tremendous demand for water supply is created by vast increases in irrigated agriculture necessary to support the population with food, and a desire for improved living standards through economic development.
Enormous amounts of fresh water exist on a global level; however, the availability of this water and uneven geographical distribution pose great difficulties. At the present time, 80 countries, most of which are underdeveloped, account for 40 percent of the world’s population. The majority of these countries are in arid regions and face a serious and rapidly increasing scarcity of water. Furthermore, 65 percent of the world’s rural population and 35 percent of the urban population have no fresh water supply systems. In addition, 1.7 billion people are without sanitary facilities. Over

the past decade, new safe drinking water supplies were provided to 1.35 billion people. However, 1.2 billion people remain without safe drinking water. According to the United Nations Development Fund, a crisis ‹n safe water supply is developing in the world's poor nations, where population growth and urbanization are outstripping water development.

3.2 AVAILABILITY AND USE OF WATER

Since the Precambrian era, the earth has held approximately 1.4 billion km^3 of water. Of that amount, however, only about 2.5 percent is fresh, trapped in polar ice and glaciers, groundwater, or part of the hydrologic cycle. Our primary source of fresh water supply is from precipitation; however, of the total annual precipitation over land of 1 19,000 km^3, only about one-third is recorded as river runoff; the rest is lost through evaporation or transpiration. And only 36 percent of the runoff, called the stable portion, is available for use. The rest is lost to the oceans during floods. To complicate matters more, great imbalances in water supply exist on a geographical basis: one-sixth of the Norld's supply is in the lightly populated Amazon region .Annual per capita usable runoff varies from 100,000 m^3 in Canada to 1,200 m^3 in Egypt.

while our global water supply has remained fairly constant since the beginning of time, over the last two centuries, water use from surface and ground water sources has increased from about loo km^3 to 3,500 km^3. Global water use doubled between 1940 and 1980 and is expected to double again by the year 2000. A comparison of the principal water withdrawals in 1980 and the projected principal water withdrawals for the year 2000 are shown in Table 1 and Table 2, respectively.

Table 1
Water consume in liters/day/capita in 1980

Continent	Population millions	Domestic municipal	Industrial	Irrigation	Total
Africa	589	51.2	30	558	639
Asia	2.932	82.2	110	1.215	1.407
Australia	26	432	148	1.686	2.266
Europe	496	265	1.006	608	1.879
North America	411	440	1960	2.200	4.600
South America	279	235.7	295	687	1.218
Russia	282	213.8	1.137	2.526	3.877
World	5.015	144	415	1.205	1.764

Table 2
Projected water consume in liters/day/capita in 2000

Continent	Population millions	Domestic municipal	Industrial	Irrigation	Total
Africa	853	96	106	514	716
Asia	3.612	152	250	1.138	1.540

Australia	30	502	301	1.827	2.630
Europe	512	300	1.338	669	2.307
North America	489	504	2.045	2.185	4.734
South America	367	299	784	672	1.755
Russia	310	309	1.282	2.652	4.243
World	6.173	203	546	1.147	1.896

To raise the standard of living, guarantee suffice food production, and create industries require about 1,400 liters/capita/day. Irrigation uses large amounts of water in comparison to domestic USE For example, in developing countries, 25 liters /capita/day is sufficient for domestic use. For a family of five, that is ‘1 25 liters/day. Therefore, one cubic meter provides enough water for a family a five for eight days. However, 200 m3 of water per day are needed to irrigate one hectare of land to depth of 2 cm. That amount would last the family of five for 1,600 days, or nearly 4.5 years.

3.3 HOW WATER IS SUPPLIED

Approaches to water supply vary around the world .in developed countries, water stored in reservoirs s used during dry periods of the year and aqueduct are used to transport water from remote areas to cities. In contrast, in some parts of rural Africa women walk as much as 15 km every day to fetch one pail of water. Integrated water manages necessary to assure water quality as well as quantity and to stimulate efficiency in water use the conjunctive development of surface to groundwater resources.

3.4 Management of water resources

Careful management of our global water resources iS a critical step toward meeting the water supply needs of both the present and projected global populations. Such a plan should consider the following measures:

- a Maximize use of renewable water resources from precipitation
- Limit use of nonrenewable groundwater aquifers and fossil water
- Counter the adverse effects of using water as a transport medium for sewage and other waste, which eventually turns water into a conduit for disease and poisonous materials
- Reduce flooding, which destroys life and property
- Control damage to riparian plants and wildlife resulting from development of wetlands
- Balance human needs and wildlife preservation .
- Place ecological sustainability at the core of investment policies and decisions .

Projects should be favored that lead to the least disruption of natural systems. Conservation, efficiency and reuse of available water supplies would enhance human welfare, better protect the environment and in special cases, enhance the prospects for peace. Several other measures are also suggested in the interest of maximizing the use of our available water supply:

- Conservation of water through improved management and appropriate pricing of water (not a free commodity) to discourage waste
- Improvements in efficiency of water use in industry
- Improvements in irrigation practices
- Reuse of water through recycling of waste water
- Increased pumping of renewable groundwater and recharging of suitable wells.

3.5 WATER STORAGE

An essential part of water resource management is the ability to store water during wet periods for use during dry seasons. In some parts of the world, water supply for human needs is provided by regular rainfall and constantly flowing rivers and streams. However, in much of the world, population centers are some distance from watersheds and water must be collected, stored and transported to populated areas. In many cases, the maximum need for irrigation coincides with periods of low rainfall. To deal with the uneven distribution of water and to meet future demands for water requires a reliable storage system. Reservoir operation allows for the capture, control and management of water resources. Surface reservoirs provide the most practical means of storing water for use during dry periods. At the present time, these facilities store some 3,600 km^3 of usable water, which adds about 25 percent to the stable portion (about 36 percent) of the global annual river runoff. Another option is the subsurface reservoir, which involves ground water recharge and storage. Both types of reservoirs require a structural solution: the surface reservoir needs a dam for impoundment and the groundwater reservoir needs a basin or surface structure to effectively recharge the subsurface aquifer. The subsurface reservoir also requires pumping system to retrieve the re charge water from under the ground.

3.6 Water for Irrigation

At Oros Dam in Brazil, in addition to the irrigated crops developed along the river downstream, important fish raising projects have been developed in the reservoir, increasing protein food provisions for area residents. Pedra do Cavalo dam on the paragucu river in bahia state , brazil, provides water supply and irrigation to a region where crop failures due to lack of water occurred every year before construction of water reservoir.

Pine Flat Dam in the Sierra foothills of central California has a storage capacity of 1,245 million m^3 providing seasonal water supplies for agriculture to the Kings River Water Association. Here, the major precipitation is snow falling on the high elevations of the Kings River watershed. In late spring and early summer, as the snowmelt runs Off the mountains, the water is stored in Pine Flat Reservoir for use in the fields of California’s Cenai Vatley in the summer and early autumn.
Roosevelt Dam on the Salt River in Arizona was completed in 191 1 to provide irrigation water for he Salt River Valley. While it still provides irrigation, it is the principal storage reservoir for the Salt river Project, which provides domestic and industrial water supply, as well as energy through hydrometric power plants for the rapidly growing operation of Phoenix and surrounding cities.

3.7 Water for Groundwater Recharge

Groundwater storage can provide the “carryover” required to manage water resources. The groundwater aquifer is recharged by seepage from river, reservoirs or water courses into the underlying strata through streambed sands and gravels. This process, however, is generally inefficient in the only a small percentage of the surface flow enters the aquifer unless the water is held or delayed in a basin or reservoir to provide the time needed for seepage (recharge) to occur. In general, this means that a structural solution is required. Also, to recover the groundwater, pumped wells are needed, which require the use of energy.

Water released from surface reservoirs is used for recharge of groundwater basins along rivers. In the Santa Clara Valley of California, falling ground- water tables resulting from excessive pumping for agricultural and domestic water supply has caused compression of the soft soil strata as a result of loss of buoyancy. In order to combat the sinking ground and the falling groundwater table, a series of dams was built with downstream channels and
ponds to enhance the recharge of groundwater over the entire year instead of only during the rainy season. The result has been a significant improvement in the groundwater levels and nearly a complete stop to the sinking ground.

3.8 Water for Industry

Much water supplied from dams is used for industrial needs. Surface reservoirs provide water for direct use in manufacturing and chemical and petroleum refining p processes. An 1mPortant Industrial use of water is as a coolant for conventional and nuclear power plants and manufacturing processes. For cooling, minimum flows are often required in dry periods. Additionally, minimum flows provided by releases from reservoirs are used to dilute discharged substances to maintain water quality within safe limits. Without dams and reservoirs, many industries could not operate.

3.9 Water for Industry Causes Pollution

Industrial water supply projects are often criticized returning polluted water to our river systems. The key to preserving clean river waterish to integrate the industrial water-use system with a treatment facility to maximize the reuse of industrial water, thereby eliminating pollutant discharges.

3.10 SUMMARY

The well-being of mankind is closely linked to sustainable water supplies. Our social and economic development potentials are increasingly determined by available water and energy. Both of these are even more necessary because of unprotected growth in population and a host of other aspects particular pollution and economic development with regard for the environment.

Water shortages are on the rise in many parts of The world. Enormous quantities of fresh water are available, however these supplies are distributed unevenly in terms of both time and place. A more effience and effective method of capture and storage f the renewable portion (flood runoff) is essential for subsequent distribution and low river flow augmentation.

Both surface and groundwater reservoirs store water in times of surplus and disperse water in times of scarcity. Recharge of groundwater and surface reservoirs, generally, require a structural solution. Surface reservoirs are somewhat more efficient than groundwater because extra time is required for recharge. In addition, a pumping system is required to retrieve the water from under the ground. Also, in some areas groundwater aquifers of sufficient capacity simply do not exist. Therefore, without reservoirs formed by dams, many people would be faced with years of water deprivation, hunger and drought, alternating with years of flooding.

4. Dams and flood control

One of the more outstanding benefits resulting from construction of a dam is the significant protection that dams provide against floods. Nevertheless, the relationship of a dam to flood events has been a topic of controversy with dam opponents. While there is some valid concern about the potential for flooding as a result of dam failure, that concern is far outweighed by the benefits that a dam offers in terms of flood control. The discus below describes these benefits in more detail and provides responses to several of the more reverent concerns of dam opponents with respect to the issue of dams and flood control.

4.1 Factors influencing flood control

Dams modify the natural flow of a river, transforming a river downstream of the dam. Therefore, the effect of dams and reservoirs on floods and inundation are influenced to a greaten or lesser Degree by several factors:

- Level of reservoir
- Modification of the hydrograph
- Sediment load
- hydrology of the river
- Floating objects
- Side effects
- Eventual failure
- Sediment Load

Reservoirs often retain transported suspended sediments. In many cases, useful reservoir volume is lost due to sediment deposits, in some cases entire reservoirs have been filled. Retention can be beneficial during floods because it prevents or reduces the inundation of downstream property with unwanted sediment. There is also evidence that silts carrying minerals, etc., when deposited down stream, can improve the agricultural capacity of Land.

Heavy sediments such as gravels are deposited primarily at the upstream end of the reservoir in the form of a delta, which causes a decrease in the Slope of the river at the entrance zone of the reservoir. The decreased slope causes a “backwater” effect that further increases the inundation of lands upstream and extends into the reaches of the river. where a dam is located in the upper or intermediate stretches of a river, this effect is usually minimal because of mountainous terrain.

4.2 Eventual Failures

Like any man-made structure, dams are subject to shortcomings and defects that can lead to failure. In fact, failures during floods have occurred historically in various parts of the world. In recent times, however, the strict regulatory environment in most countries combined with the strong influence of ICOLD has resulted in a set of very high standards for dam design and construction. Consequently, dam failures have become very rare.

The failure of a dam is such a grave accident that the official statutes that regulate or govern the design, construction and operation of dams are the most strict of all regulations in the world. In addition, adequate systems of monitoring the behavior of the structure, mechanisms of warning, emergency and alarm must be included, used and constantly maintained to help guard against unforeseen disasters.

4.3 SUMMARY

The benefits of dams and reservoirs to a community far outweigh any potential risk. Some of the more significant points to consider include: Dams have been proven to reduce the risk of floods downstream. However, what is obvious to the industry specialists is not always obvious to the general public. It is important to educate the public on the benefits of dams and reservoirs with respect to flood control as well as the consequences that
would be faced if the existing dams were not in place.

Dams typically suppress or even eliminate the occurrence of flooding, which has the unusual side effect of causing the public to forget about the Possibility of flooding in their community. Because of this effect, there is a tendency to occupy high risk flood zones such as river beds, which are subject to significant damage during flood events when water is released through spillways. Consequently, it is important to correctly define both the downstream and upstream river channels by dearly marking the water levels resulting from the range of flows during spillway operation.

Dams are subject to the most stringent statutes and regulations of anything in the world. This fact, combined with efforts to constantly improve dam safety through design improvements, construction practices and monitoring of performance through out life of the dam/reservoir structure, construes the best response that proprietors, designers and operators of dams can offer to those who a concerned about or opposed to dams.

5. Dams and safety

Damming of rivers is the only effective way of regulating variable natural stream flows in order to provide required water for the benefit and survival of mankind, and to decrease the threat to life and property from devastating natural floods. Water is mankind's most precious natural resource, and given the rapid increase in world population, the need for reliable water supplies is increasing rapidly.
The assumed useful life of dams, in current economic analyses, is typically 60-100 years. In reality, such structures will often have a useful life on the order of l00 years; some even much longer. The dams, therefore, constitute valuable public assets that will benefit mankind for many generations and provide economic benefits many times that assumed at the time of justifying their construction.
Approximately 39,000 dams over l5m in height exist in the World today. While a few are over 2,000 years old, more than 33,000 were built in the last 50 years. Large dams retain large volumes of water behind relatively slender, man-made structures and must, therefore, be assigned some risk with respect to the downstream public.
The general interest of the public in the safety of dams has grown significantly over the past several decades in many countries. As people continue to move into vulnerable flood plains below dams, the consequences of dam failure is taking on increasing importance. Recent dam failures have aroused the public and as a result, dam safety is no longer the exclusive domain of engineers, owners and government officials. Dam safety aspects have always been of prime Concern to dam engineers. What is new is the involvement of the general public. In addition, professionals have recognized in recent decades that many existing dams were aging to the point that material

deterioration and operational reliability were sources of concern. Also, new dams were being built in countries where no previous experience or tradition in dam engineering existed.
For all these reasons, in 1982, ICOLD felt it needed to address the topic by establishing a committee on dam safety to define a common safety philosophy, provide an integrated approach for all technical committees to follow for addressing safety issues, propose remedial action if omissions or Weaknesses in safety requirements are perceived, and develop general guidelines on dam safety for world wide use.
In 1987, the committee completed work on Bulletin 59, "Dam Safety Guidelines," which is a general reference on dam safety operations starting
at the initial dam planning stage and running through design, construction, operation, monitoring and deactivation phases.
As a result, the dam engineering profession has made major advances in recent years in developments that will enable dam owners to ensure that their dams can be maintained at the very highest level of safety demanded by society today.
Early dams were built based on experience only, that is, without adequate knowledge of hydrology, geology and seismicity. At that time, builders recognized the vulnerability of dams to natural forces. Historically, about 1 percent of dams of all types have failed.
With increased knowledge concerning these natural phenomena, better engineering, advancements in construction technology, as well as improved knowledge of dam behavior, lessons learned from failures and continued surveillance, a significant decrease in dam failures has been observed over
the past 40 years. Whereas the total number of failures of dams built prior to 1950 reached 2.2 percent, since 1951 the percentage is less than 0.5 percent.
The number of 2l6failures reported in ICOLD Bulletin 99, includes 54 dams which were completely abandoned, and 162 dams which were successfully repaired and placed back into operation. some dams were redesigned; others were completed with the same design.
Dam failures have resulted from a variety of causes unpredictability of extreme floods, uncertainties of geologic setting, seepage the rough foundations an embankments, design and construction defects and liquefaction under earthquake conditions.

6. Dams and environment

Mankind has affected its environment ever since agriculture was first introduced. For over 5,000 years, dams that impound reservoirs have enabled civilizations to flourish by assuring a dependable supply of water for domestic purposes and irrigation.
Many civilizations have come and faded away with the loss of the ability to construct, maintain and repair dams. For millennia humans have influenced the global water cycle through irrigation along arid river valleys, by networks of artificial waterways, and by modifying the vegetative cover
through plowing and tree cutting.
Mankind's needs have led to the development and exploitation of natural resources, and, as a consequence, nature could not and cannot be preserved in an unaltered state. After 1930, major transformations in water balance and in terrestrial and aquatic ecosystems occurred with the

harnessing of rivers due to changes in total volume and timing of stream flows resulting from urbanization, water withdrawal, and reservoir construction. After 1950, the number of reservoirs increased sevenfold, and their combined storage capacity increased tenfold.
Large-scale hydraulic development works completed over the last few decades have changed nature in a spectacular manner: rivers have been fully canalized over hundreds of kilometers; meadows,forests, and agricultural land have been sub-merged over considerable areas by the reservoirs of large dams; estuaries formerly subjected to tides have been transformed into fresh water or salt water lakes and polders; while marine gulfs, lakes and marshes have been drained and brought under cultivation.

The objectives of all these development schemes have been extremely varied: hydroelectricity; protection against floods (or tides); commercial navigation and pleasure boating; water distribution for irrigation, industry or drinking water supply, and agricultural development.

These structures, corresponding to the vital needs of each country, have often met the desired goals. They have produced favorable results in economic and social terms. However, the traditional land scape of many regions has been altered. in certain cases, the quality of life has been affected and adverse effects have appeared causing a reaction against dams in public opinion.
The need for increased water supplies (and power generation) ‹s particularly acute in developing countries. Water is needed to increase productivity of people, develop industrial potential, and 1mprove the state of health (eighty percent of all children that die in the third world die of water pollution). Water demand and consumption is expected to continue to grow exponentially world wide.
The developing countries are generally far more dependent on their water supplies than are many of the industrial countries. Problems in developing countries have arisen as dams in some cases have destroyed valuable and productive ecosystems or reduced deposition of fertile sediments in downstream flood plains. Often groundwater aquifers are overexploited leading to higher pumping costs and/or salination of such aquifers. All these
changes have major social impacts. in the developed world, agriculture has caused water resource problems as a result of nitrate pollution, pesticide residues in soil, and eutrophication of lakes and rivers.

The pressure on water resources in the world has increased dramatically in the last several decades as a result of: unprecedented growth in world population (from 3.0 billion in 1960 to 5.2 billion in 1990), rising expectations for economic development and improved standards of living, vast expansion of irrigation agriculture, increased use of nature resources requiring enormous quantities of water, discharge of waste products requiring large volumes of water for dilution and physical scarcities and pollution problems that are growing in river basins and groundwater aquifers.

6.1 Environmental Benefits

It has been observed that ‹n arid regions scarce in surface water an artificial lake is more acceptable. Lakes and rivers with the usual fringe of vegetation are normally regarded as positive elements that provide variation and "friendliness" to the landscape. The custom in some countries of creating artificial water bodies by digging ponds or filling gravel pits in an example. In this case, the surroundings are usually landscaped, the water stocked with fish, and paths constructed around the "lake" for recreational purposes. In addition, the formation of the aquatic and terrestrial habitats provides conditions conducive to supporting a variety of animals which can increase the aesthetic value of the habitat.

The same effects can be identified with water supply and hydropower reservoirs in "lake-less" regions of the world. Typically, these new areas are used for recreational purposes with various arrangements for watersports, fishing, lodging, etc. In these cases, the reservoir may be regarded as an important aesthetic addition to the existing land escape.

The acceptance of reservoir in "natural environments" for aesthetic reasons is closely linked to the degree of water level variations within the reservoir. Drastic seasonal variations in stage and discharge can result in both increased erosion of the shoreline or stream bed and drowning of vegetation along or near the shore. Each of these deleterious effects can substantially diminish the beauty of the reservoir.

Great seasonal variations, with their accompanying eroded areas along the shore or tree stumps sticking out of the water are not much appreciated Any where.

6.2 Environmental Concerns

To fill a valley with water or to turn a small lake into a more extensive artificial reservoir may not be regarded as an aesthetic improvement. The landscape may have been relatively unchanged for generations, and the loss of farmland, woods, picturesque natural lakes, wetlands, and running rivers with waterfalls is often hard to accept based on aesthetic reasons. Plants and animals with narrow ecological niches may no longer survive in the altered area. Loss of biotic diversity is often regarded as a loss of aesthetic value, especially if the species in question is particularly sensitive and extinction is possible.

The landscape may have been relatively unchanged for generations and may, in the eyes of the inhabitants, be the most beautiful place on earth.

Improper operation of reservoirs where insufficient water is released to the downstream river can negatively impact the downstream river's self cleansing mechanisms through either insufficient flushing or dilution. Without adequate flushing or dilution, the river will exhibit water quality and aesthetic problems in the form of eutrophication, clogging vegetation, vector infestation, and associatedodors.

Establishment of reservoirs with no or insufficient release of water into the river downstream has often led to reduced diluting capacity. Sewage or other harmful effluents entering the river do not only cause water quality problems, but often resuit in great numbers of algae, weeds, rats, other vermin, and associated with foul smells and a largely unappetizing look. The establishment of a reservoir can negatively impact the recreational use of the respective river. For example, for canoers or whitewater rafters, the establishment of a reservoir is not necessarily beneficial.

A "big picture" approach should be followed by reservoir planners in order to address both the benefits and concerns regarding reservoir establishment. This approach can be implemented by consulting with environmentalists, landscaping and conventional architects, and other relevant experts.

Through a balanced view, mitigating measures can be identified and evaluated at the start of the plan- fling process to provide acceptable solutions to all parties.

6.3 Reservoirs and Climatic Changes

The measurable effects, positive or negative, on the macro climate is considered to be insignificant. Synergistic effects such as changes in groundwater level resulting in changes in plant cover and the micro climate may occur. However, very little documentation of these effects is available.
In subarctic or arctic climates, large scale water bodies have been known to cause frost-fog which negatively affects plant growth. Farmers located close to reservoirs and along rivers claim that frost-fog phenomena reduce their crop growth rates and yields. Investigations carried out in Norway during the last decade were inconclusive regarding the long-term effect on plant growth. Results from the study showed that the probability associated with the frequency of occurrence of frost-fog events increased slightly under special meteorological and topographical conditions. Frost-fog conditions can be mitigated, e.g. in areas with subzero temperatures, submerged out
lets from power stations have been successfully demonstrated.
On the micro climate level, the establishment of large reservoirs especially in arid regions may influence the climate close to the shores of the reservoirs. Humidity close to the shore and some meters above the reservoir will increase. At the micro level, this increase in humidity may be beneficial in an arid environment; however, this benefit would be very species specific because the existing flora and fauna have adapted to the dry conditions.

6.4 Reservoir caused Water Quality Changes

All rivers carry suspended solids in greatly varying amounts. A high suspended solids content is a water quality problem thus limiting the use of the water or requiring additional treatment. Although the removal of solids in the reservoir can improve the downstream water quality, settling of solids in the reservoirs reduces the supply of sediment downstream. Without a sediment supply, increased erosion of the downstream stream bed will occur until a new equilibrium has been established. Downstream alluvial zones may be deprived of fertile deposits on a seasonal basis. Yearly floods and subsequent deposition of fertile sediments are known to be important for the regional/local agriculture. If the natural supply of nutrients is discontinued through the construction of flood control structures, nutrients will have to be supplied artificially. Artificial fertilization has two negative effects:

1) fertilizer ‹s more expensive than natural nutrient deposition,
2) fertilizer application can have a negative long-term effect, such as Europe's nitrified-laden groundwater.

Water released from deep in a reservoir behind a high dam is usually cooler in summer and warmer in winter than river water, while water from outlets near the top of a reservoir will tend to be warmer than river water all year round. Warming or cooling the natural river affects the amount of dissolved oxygen and suspended solids it contains and influences the chemical reactions which take place in it. . Altering natural seasonal changes in temperature can also disrupt the lifecycles of aquatic creatures — breeding, hatching and the metamorphosing of larvae, for example, often depend on thermal.

Relatively warm winter releases from reservoirs in cold climates will inhibit the formation of ice downstream. Reduced ice cover makes hazardous or impossible the use of frozen rivers as winter roads: in northern Scandinavia, for example, dams mean that the Sami people can no longer use many of their traditional winter reindeer herding routes which follow frozen rivers. Cold winter air passing over the relative warmth of some of the huge Russian and Canadian reservoirs can cause long spells of freezing fog.

In the same way as reservoirs trap river sediment, they also trap most of the nutrients carried by the river. During warm weather, algae are likely to proliferate near the surface of a highly nutrient-enriched, or eutrophic, reservoir. Through photosynthesis the algae consume the reservoir nutrients and produce large amounts of oxygen. Summer releases from the surface layer, or epilimnion, of a reservoir will thus tend to be warm, nutrient-depleted, high in dissolved oxygen, and may be thick with algae. High levels of algae can provide food for fish but also give water an unpleasant smell and taste, clog water supply intakes, coat gravel beds and restrict recreation. Massive algal blooms in the shallow, stagnant reservoirs of the ex-USSR have rendered their water unfit for either household or industrial use.

When algae in a reservoir die they sink to its bottom layer, or hypolimnion, where they decay and in doing so consume the already limited hypolimnion oxygen (there is usually not enough light for photosynthesis at the bottom of a reservoir). The acidity of this oxygen-depleted water often render it capable of dissolving minerals, such as iron and manganese, from the lake bed. Warm weather releases from a dam with low-level outlets will thus be cold, oxygen-poor, nutrient-rich and acidic, and may contain damagingly high mineral concentrations. The presence of an adequate level of dissolved oxygen in a river is one of the main indicators of good water quality. Water poor in dissolved oxygen can 'suffocate' aquatic organisms and make water unfit to drink. Dissolved oxygen, furthermore, is vital to enable bacteria to break down organic detritus and pollution.

Because they greatly multiply the surface area of water exposed to the rays of the sun, dams in hot climates can lead to the evaporation of huge amounts of water which is mainly lost to the river downstream. In the region of 170 cubic kilometers of water evaporates from the world's reservoirs every year, more than seven per cent of the total amount of freshwater consumed by all human activities. The annual average of 11.2 cubic kilometres of water evaporated from Nasser Reservoir behind the High Aswan Dam is around ten per cent of the water stored in the reservoir and is roughly equal to the total withdrawals of water for residential and commercial use throughout Africa.

The massive amounts of evaporation from the reservoirs behind Hoover and the other dams on the Colorado — one third of the river's flow is evaporated from reservoirs — is one of the reasons why the salinity of the river has risen to damaging and costly levels. High salt concentrations are poisonous to aquatic organisms and they corrode pipes and machinery: the increased Colorado River salinity costs Southern California's water users millions of dollars each year.

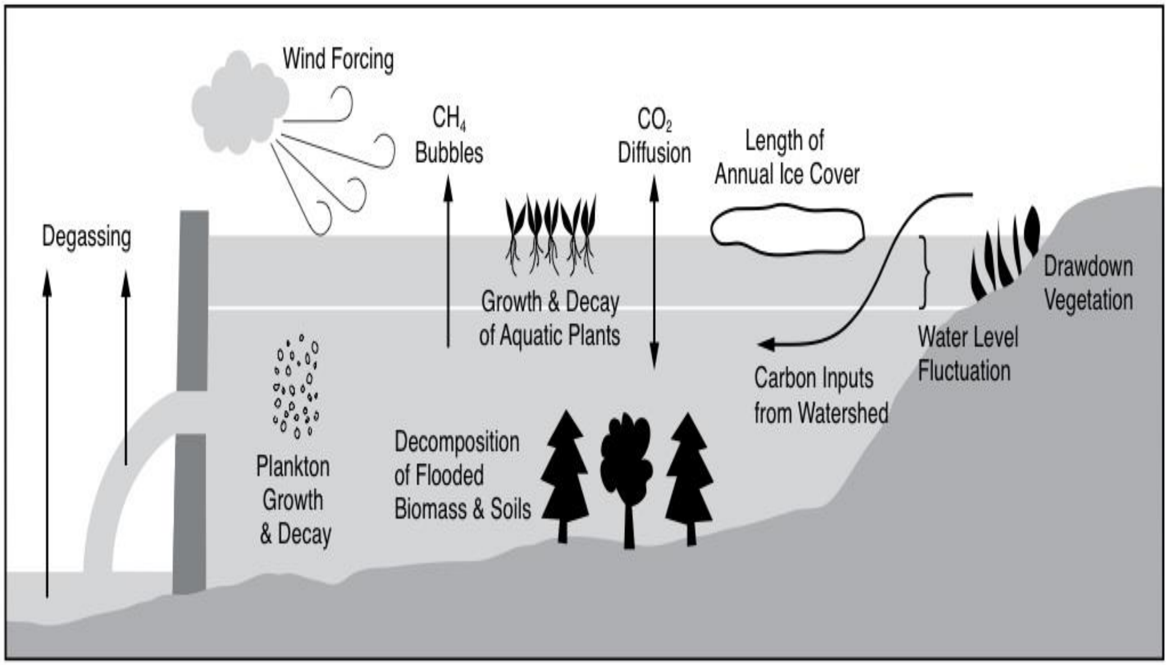
6.5 Contribution of dams to global warming

According to the most detailed estimate available, done by Ivan Lima and colleagues from Brazil's National Institute for Space Research (INPE), the world's large dams emit 104 million metric tones of methane annually from reservoir surfaces, turbines, spillways and rivers downstream . This implies that dam methane emissions are responsible for at least 4% of the total warming impact of human activities. No one has yet calculated the total climate impact of dams, which would include releases of carbon dioxide and nitrous oxide.

According to the estimates of the INPE researchers, dams are the largest single anthropogenic source of methane, being responsible for 23% of all methane emissions due to human activities. Methane is a much more potent heat-trapping gas than carbon dioxide, although it does not last as long in the atmosphere.

The most recent assessment of the Intergovernmental Panel on Climate Change states that methane has a warming impact 72 times higher than carbon dioxide if measured over 20 years, and 25 times higher measured over 100 years. Using these IPCC "global warming potential" (GWP) estimates means that one year's methane emissions from large dams, as estimated by Lima, have a global warming impact over 100 years equal to that of 2.6 billion tonnes of carbon dioxide. (Under the Kyoto Protocol, countries estimate their total warming impact using the 100 year GWPs). Over 20 years, the warming impact of annual large dam methane emissions is equivalent to 7.5 billion tonnes of carbon dioxide.

The "fuel" for the methane, carbon dioxide and nitrous oxide emitted by dams is the rotting of the vegetation and soils flooded by reservoirs, and of the organic matter (plants, plankton, algae, etc.) that flows into, and is produced in, reservoirs over their lifespan. The gases are released at the reservoir surface, at turbines and spillways, and downstream of the dam. Greenhouse gases are also produced by various other dam-related impacts including the fossil fuels and building materials used during dam construction; land clearing for resettlement sites, transmission lines and access roads; and the expansion of irrigated agriculture (an important cause of methane emissions). The trapping of sediments in reservoirs may act as a carbon sink; it may also indirectly increase the concentration of carbon dioxide in the atmosphere by reducing the amount of river-borne sediments available to fertilize oceanic plankton, which are important consumers of carbon dioxide.



Reservoir Emissions

6.6 SUMMARY

Water projects should result in benefits to human society, to the natural environment, and to the sociological factors of an area, especially when thoughtful, innovative and mitigating measures are planned ‹n concert with the overall needs of the area. In some cases, the benefits are directed toward a specific objective such as protecting migratory bird habitat. Other projects cover a wide range of issues. in such cases, both positive and negative effects may be present, and the total impact of the projects must be evaluated.

Consideration of all social, environmental, and economic effects, both positive and negative, is the most difficult issue to resolve in a manner which is acceptable to everyone. The economic need is often a strong driver; however, concerns for environmental and social values are now being incorporated into project development even in the most difficult situations.

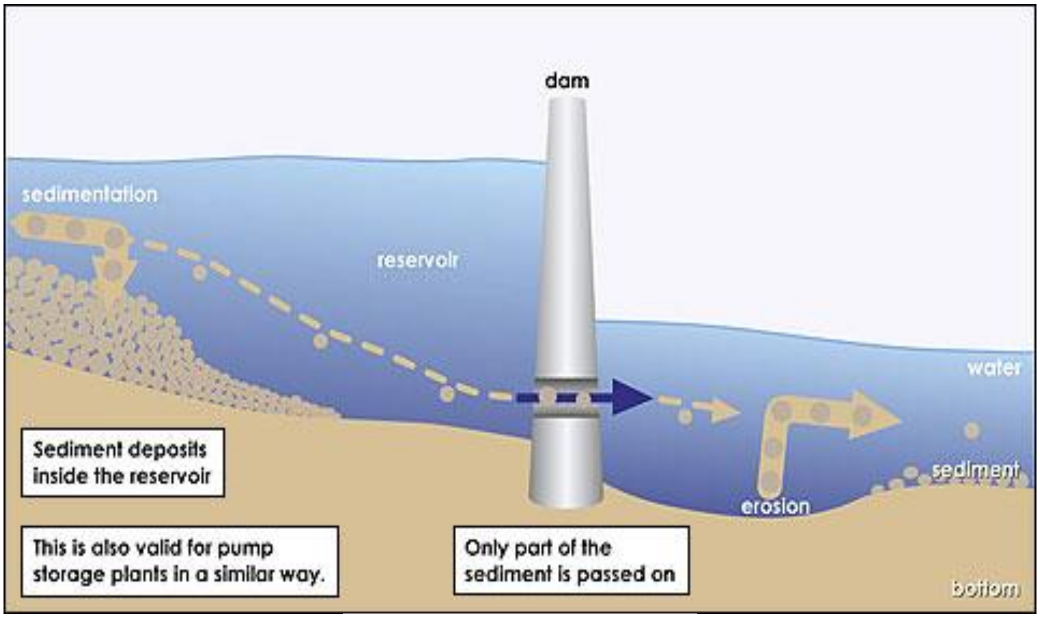
7. Dams and sedimentation

Dams and the resulting storage reservoirs are essential for supplying water from the natural hydrologic cycle to satisfy demands of the population. Reservoirs on natural water courses are subject to sediment inflow and deposition. As a stream enters a reservoir, the flow regime changes as the cross-sectional area increases and the velocity decreases. Consequently, at least a portion of the sediment load of the stream is deposited in the reservoir. This deposition, referred to as siltation, has dual negative impacts: it decreases the storage capacity of the reservoir and increases down stream erosion of the stream bed. Reservoirs lose storage capacity due to sediment deposition at a predictable rate which can average approximately 1 percent per year on a world wide basis. Methods available to mitigate reservoir sedimentation include: a) watershed management; b) reservoir By passing; c) sluicing; d) flushing; arid e) dredging. This section presents the role of dams, both positive and negative, in the process of siltation and discusses measures to mitigate the negative impacts of sediment deposition in reservoirs.

The creation of a reservoir changes the hydraulic and sediment transport characteristics of the river, with implications for sediment and erosion processes at the reservoir, in the downstream river system, and in cases in the estuarine/deltaic zone. The natural sediment load in a river is usually trapped within the storage and this material is deprived to the downstream river system. Sediment accumulation is a sustainability issue for some reservoirs and in cases can reduce the long-term viability of developments. Erosion issues in the reservoir itself can occur depending on the lake level operating regime, the retention of stabilizing vegetation, the control of recreational activities on the lake, and other factors such as wind-induced wave action or rapid drawn-downs. Impacts of a reduced sediment load to the river downstream of a power station may arise depending on the pre-existing sedimentation and erosion patterns, the nature of the regulated flow release and the altered flooding regimes, and the riparian vegetation condition. Where diversions out of river systems have occurred, and sediment inputs continue from the downstream catchment, channels can accumulate sediments, vegetative species may encroach on the river channel, and this can exacerbate the impacts of floods. Downstream of power stations, reduced sediment loads and in cases, higher than natural base flows, may lead to erosion of the existing channel sediments and destabilization of riparian vegetation through a range of mechanisms, e.g. rapidly fluctuating discharges, rapid water level draw-downs, or continuous discharges at a single flow.

All rivers contain sediments: a river, in effect, can be considered a body of flowing sediments as much as one of flowing water. When a river is stilled behind a dam, the sediments it contains sink to the bottom of the reservoir. The proportion of a river’s total sediment load captured by a dam – known as its "trap efficiency" – approaches 100 per cent for many projects, especially those with large reservoirs. As the sediments accumulate in the reservoir, so the dam gradually loses its ability to store water for the purposes for which it was built. Every reservoir loses storage to sedimentation although the rate at which this happens varies widely. Despite more than six decades of research, sedimentation is still probably the most serious technical problem faced by the dam industry.

The rate of reservoir sedimentation depends mainly on the size of a reservoir relative to the amount of sediment flowing into it: a small reservoir on an extremely muddy river will rapidly lose capacity; a large reservoir on a very clear river may take centuries to lose an appreciable amount of storage. Large reservoirs in the US lose storage capacity at an average rate of around 0.2 per cent per year, with regional variations ranging from 0.5 per cent per year in the Pacific states to just 0.1 per cent in reservoirs in the northeast. Major reservoirs in China lose capacity at an annual rate of 2.3 per cent.



Dams and sedimentation

A high dissolved oxygen content of water is very important to the aquatic life . if low oxygen concentrations are anticipated , in reservoirs with heavy metals in the sediments , these toxic substances may be release as a result of anoxic chemical reactions .
The dissolved oxygen content of a new reservoir largely depends on the decomposition of organic matter from the soil and from submerged vegetation . on chemical or biological demand for oxygen . the reservoirs reaeration capacity , the production of oxygen by aquatic plantlife . and the amount of material transported from upstream and of natural water mixing . the dissolved oxygen content of most new reservoirs is mostly low due to demand from submerged vegetation , but generally this vastly improves by the third year of impoundment .

The extent to which a reservoir is contaminated by nuisance and toxic compounds depends on several factors , including the submersion of land , the inflow , the balance between adsorp[tion and desorption of pollutants associated with sediment , and their deposition through these sediments.

The decomposion of the organic matter from the flooded soil and sedimentation of planktonic organisms may lead to the depletion of dissolved oxygen in the deep layers of the reservoir and to release of heavy concentration of highly toxic reduced substances such as sulphide ,ferrous and manganese , as well as organic mercury .

The main source of nutrients and minerals in an reservoir are carried by the river . these include stream , agricultural , domestic , and industrial contaminations . initially the flooding of a reservoir is often associated with substantial increase in nutrients and the level of minerals which cause , on the one hand beneficial effects such as a higher productivity , but also negative effect including the proliferation of plants , taste and adour problems . the decomposition of organic matter tends to increase the phosphours content available for the growth of algae.

7.1 Positive Impacts

The most significant positive impact of the reservoir sedimentation process is the increased clarity of the stored water due to the removal or settling of suspended solids in the reservoir. Water released from a reservoir will require much less treatment for use as a domestic or industrial water supply due to its increased clarity. The problem of sediment buildup in irrigation distribution networks and sprinkler systems is minimized or eliminated. By contrast, stream withdrawals of water can be heavily laden with sediment requiring further mechanical treatment.

Other benefits include: a) the high clarity, stored water also becomes a much more appealing recreational attraction than the turbid waters of a f lowing stream; b) the deposited sediments serve as a sink for capturing heavy metal ions and pesticides which would otherwise be carried via the flowing water as has been observed in many reservoirs; however, the trade-off is that the sediment material may now be contaminated; c) valuable sport fisheries have developed downstream of many dams where non e existed naturally, because the water released from the dam has a significantly reduced suspended solids load and, ‹n the case of deeper reservoirs, is most probably colder than the natural stream flow in temperate climates; d) the deposits in the entry zone of the reservoir, usually termed the “delta”, provide ideal biological growing condition, particularly for phreatophytes.

Although this vegetative growth increases the evapotranspiration from the reservoir water supply .it provides excellent riparian and wetland wild-life habitat.

7.2 Negative Impacts

One of the most serious impacts of sediment deposition on a water reservoir is the loss of storage capacity within the reservoir due to the deposited sediment. This loss of storage capacity can be matched to a direct loss of economic benefits once the active storage capacity is encroached upon. In addition, sediment deposits with I n the reservoir r may also encroach upon marinas, pumping plant intakes, and other facility appurtenances. One historical approach to mitigating this loss in storage was the building of an oversized reservoir (and a larger dam) to ensure that the required beneficial storage was not encroached upon during the economic life of the project. Currently, environmental concerns and ever increasing costs are combining to dictate more innovative approaches to providing sustainability of the water resource, i.e., to extend the life of new and existing reservoirs for much longer time periods. Another negative impact is the increased erosion in the downstream river channel due to “sediment- hungry” water releases from the dam. The clear water released from the dam is capable of transporting a prescribed load of sediment and will erode the existing channel bed and channel banks until this sediment load is provided. In order to redress this imbalance, erosion will continue until the flow velocities decline or the water has again attained a full sediment load. Increased bank erosion may occur downstream of a dam, depending upon the characteristics of the bank material. Valuable “real estate” may be eroded away, in-chanel or along-channel structures may be undermined, and water tables may be lowered. Both in stream and riparian habitat may be altered. How ever, channel erosion (degradation) has often proven to be negligible due to a natural “armoring” process which occurs as larger material remains as the smaller particles are eroded. Sediment deposition may extend some distance upstream of the reservoir and occurs during periods of high stage in the reservoir and stream. This deposition can result in increased surface flooding and raised water tables in the surrounding lands. Where deposits

have been exposed during long periods of reservoir drawdown, windblown dust has sometimes become a significant problem.
Much credit has been given in the past to the soil building and fertilization benefits of river flooding, particularly. In the term mal deltas of large rivers. The original formation of these lands was dependent upon the total upstream sediment load of the river floodwaters. However, the fertilizing effect of subsequent inundations has often been overrated, and the net effect is negative when soil losses due to floodwater erosion are considered.
It has been estimated that since the closure of the High Aswan Dam, the cost of imported fertilizer to replace natural fertilization from silt deposits are less than one-third of the costs of dredging and removal of sediment deposited in canals by floods. In some coastal areas, the elimination of naturally transported inland sediments has resulted in increased beach erosion. Consequently, in order to maintain a solids balance, sand for beaches must be replenished through the import of sand from other areas and deposition on the depleted beach areas.

7.3 Mitigating Measures

The history of dam construction includes many cases in which the economic and environmental damages due to the accumulation of sediment in reservoirs has been significant and difficult to remedy. Conversely, many reservoirs have been in existence for hundred s of years with only Limited diminishment in their beneficial uses. The degree to which deposition in a reservoir occurs is dependent upon many factors such as the sediment yield rate of the river, the size and shape of the reservoir, the design of the spillway and outlet structures of the dam, and plans for operation of the dam and reservoir. Therefore, it is extremely important that the planning, design, and construction of all dams be undertaken with the best available knowledge and tools to forecast and accommodate the eventual sediment inflow . Several mitigating measures can be incorporated into the plan fling, design, and operation of dams and reservoirs to offset the negative impacts of sedimentation and improve the sustainability of the resource.

7.4 Reservoir Bypassing

in case of bypassing, high flows having greater sediment concentrations are guided around the reservoir, while the storing of water having lower sediment concentrations occurs for the remainder of the time. The bypassing system usually consists of a channel or tunnel circumventing the reservoir. In arid areas the maximum inflows usually occur during the flood season. Since these flood flows occur with the largest sediment concentrations, the bypassing of sediment-laden water is in conflict with the purpose of conserving flow during high runoff periods.

7.5 Sluicing

Sluicing is an operational technique in which sediment laden inflows are allowed to pass through the reservoir and through the dam while the trans ported sediment remains ‹n suspension. This is generally accomplished by operating the reservoir at a low water level during the flood season and keeping low level outlets open to maintain maximum release. This method can have the same negative impact on water conservation as bypassing in which peak flows are not stored. Where sediment sizes are small, significant amounts of sediment can be sluiced even when the reservoir level is kept full or nearly full. Density currents can be generated which carry sediment concentrations along the bottom of the reservoir to the outlets.

7.6 Flushing

Sediment flushing is technique in which the flow velocities within a reservoir are increased so that previously deposited sediment is resuspended and then transported through low level outlets. Flushing operations are dependent upon excess capacity in the reservoir and are generally not nearly as efficient as sluicing operations, because the material removed is limited to a channel having a geometry similar to the original regime conditions of the river.

7.7 SUMMARY

Dams and reservoirs are essential to providing areliable water supply in most areas of the world, particularly in arid regions. Reservoirs collect water during the rainy season of the year and store it for use later in the dry periods.
Unfortunately, reservoirs entrap sediment thus jeopardizing the ability of the reservoir to retain sufficient runoff water to satisfy their purposes and reduce the value of this huge investment. How ever, special sediment handling measures and watershed management practices can and do permit reservoirs to avoid siltation (filling with sediment) thus ensuring their ability to fulfill their in tended purposes.

8. Dams and energy

As demonstrated ‹n other sections, the construction of dams and reservoirs brings multiple benefits to a community including water supply, irrigation, recreational opportunities, navigation, fish and wildlife habitat, flood control and energy generation. The focus of this discussion in on the use of a dam as an energy source. Energy is a primary requirement for economic development, as well as for civilizations to prosper. We depend on energy for a variety of purposes including lighting, cooking, heating, and industrial development, all of which are essential for stimulating long-term economic growth. In many developing countries, hydropower is the only natural energy resource.
Hydropower can play an important role in a nation’s industrial development because it offers low-cost energy to support the growth of many basic industries, thus providing regional economic benefits. It is essential to develop new projects in harmony with the environment by protecting ecological resources and by assuring social acceptability. Operation of existing reservoirs may have to be adjusted to meet similar requirements.
It is important to note that over the past three decades, the global population has soared from 3 billion to about 5.3 billion. It is anticipated that this figure will double within the next 50 years,

which provides ample reason to anticipate that water and energy requirements will increase dramatically as well.
Approximately three-quarters of our primary energy requirements today are satisfied by fossil fuels. However, due to the continuous and inevitable depletion of these resources, especially of oil and gas, there is a need to reduce the heavy usage of these resources. Another incentive to reduce our dependency on these fuels is their adverse impact to the environment. Fossil fuels contribute to the "Greenhouse Effect" and global warming by releasing CO_2 to the atmosphere and solid and liquid waste by-products to the environment.
Dam opponents point out that after first filling, the decomposition of submerged vegetation and soils can drastically deplete the levels of oxygen in the water. Rotting organic matter can also lead to releases of huge amounts of the greenhouse gases methane and carbon dioxide. Though reservoirs often mature within a decade or so, in the tropics It may take decades or more for most of the organic matter to decompose. Thorough cleaning of the reservoir is important, though this may be very costly.
One step toward reduction in our use of fossil fuels is to draw upon renewable energy sources. For the short- and medium-term, the three principal sources of renewable energy that will permit large-scale exploitation are wind, biomass and hydro power. Of these sources, hydropower is the most reliable, efficient and by far the most used. A 100 MW hydroelectric project, operating 50 percent of the time, saves the burning of 600,000 barrels of fuel oil annually and saves the release of 1.95 x 10^12 Btus into the atmosphere.

8.1 SUMMARY

Dams contribute significantly to supporting our global demands for water supply and, at the same time, are providing a clean, low cost source of electric energy.
Dams have many positive environmental effects; environmental conditions are improved when water management practices regulate and augment low flows of rivers and streams, decrease erosion, control floods, minimize water waste, cultivate deserts and improve health and sanitary standards.
It is likely that a very considerable demand for hydroelectric power plants, as a source of clean energy, will continue to grow. Consequently, dams and reservoirs are and will be essential for the development of the enormous available hydro power potential. Hydropower offers a unique solution to provide as much electricity as possible from a reliable, renewable and sustainable resource with no n polluting results.
Meanwhile, work continues to improve design, construction and operation of dams and hydro electric plants especially to improve efficiency by generating more energy for a given amount of water discharge. These efforts have as their goal to balance growth and prosperity with conserving and enhancing the environment. The ultimate purpose of dam building and hydropower generation is to serve and improve the welt-being of people.

9. Dams and Earthquakes

Earthquakes can be induced by dams. Globally, there are over 100 identified cases of earthquakes that scientists believe were triggered by reservoirs. The most serious case may be the 7.9-magnitude Sichuan earthquake in May 2008, which killed an estimated 80,000 people and has been linked to the construction of the Zipingpu Dam.

In a paper prepared for the World Commission on Dams, Dr. V. P Jauhari wrote the following about this phenomenon, known as Reservoir-Induced Seismicity (RIS): "The most widely accepted explanation of how dams cause earthquakes is related to the extra water pressure created in the micro-cracks and fissures in the ground under and near a reservoir. When the pressure of the water in the rocks increases, it acts to lubricate faults which are already under tectonic strain, but are prevented from slipping by the friction of the rock surfaces."

Given that every dam site has unique geological characteristics, it is not possible to accurately predict when and where earthquakes will occur. However, the International Commission on Large Dams recommends that RIS should be considered for reservoirs deeper than 100 meters.

Ground water plays a large part in earthquake activity. Fluid injection into wells in USA, Japan and elsewhere has triggered small earthquakes.

Water pore pressure reduces the normal stress within a rock while not changing the shear stress. Under any circumstances, an increase in water pore pressure means that a failure is more likely. The critical value of shearing stress may be made arbitrarily low by increasing the pore pressure.

Pore pressure can increase in two ways:

- Due to the decrease in pore volume caused by compaction under the weight of the reservoir. This occurs while the reservoir is being filled.
- Due to diffusion of reservoir water through permeable rock under the reservoir. The rate of flow depends on the permeability of the rock, so this effect is not instantaneous. The increase in pore pressure takes more time depending on the distance from the reservoir. It may take years for the pore pressure to increase at depths of kilometers beneath a reservoir.

Reservoir induced seismicity is a transitory phenomenon which will occur either immediately after filling of the reservoir, or after a delay of a few years. If there is a delay, this depends on the permeability of the rock beneath the reservoir.

Once stress and pore pressure fields have stabilised at new values, reservoir induced seismicity will cease. Earthquake hazard will then revert to similar levels that would have existed if the reservoir had not been filled.

Even for those reservoirs that show a correlation between earthquake activity and water level, reservoir induced seismicity does not continue indefinitely as it is limited by the available tectonic energy.

Depths of reservoir induced earthquakes, especially those occurring immediately after filling of the reservoir, are normally very shallow. If detailed seismograph coverage is available, then depths within one to three kilometres of the surface are common.

Induced earthquakes at reservoirs that have experienced delayed triggering may be much deeper, perhaps as deep as ten to twenty kilometres. These may occur ten to twenty years after filling of the reservoir.

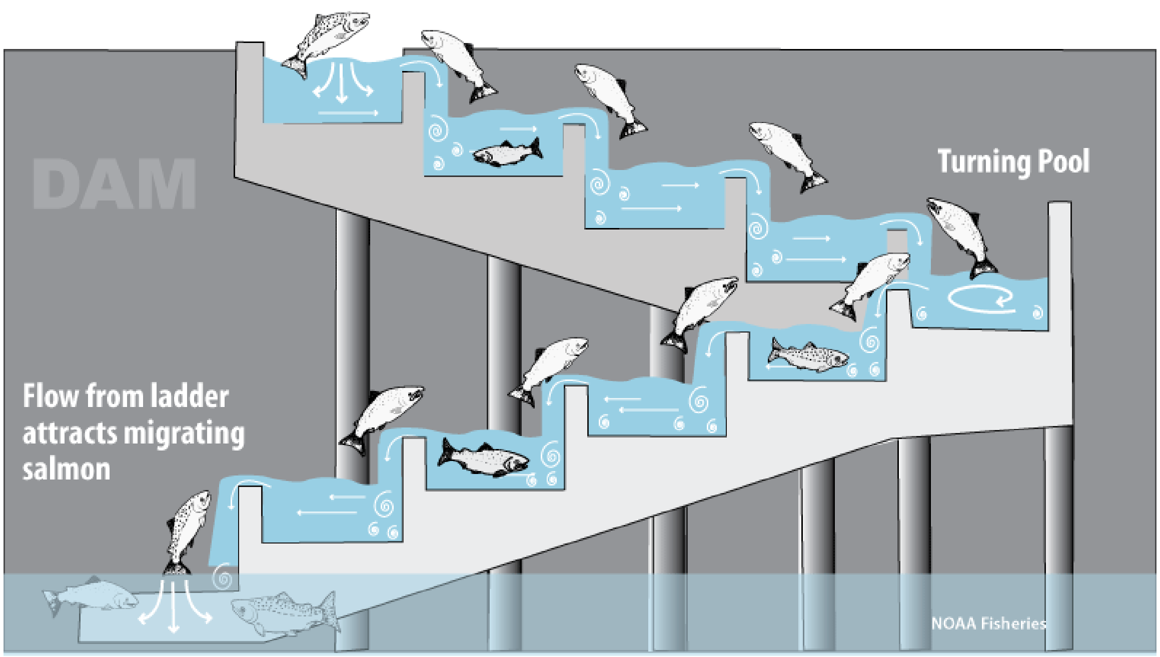
10 . Fish populations

Where water is scarce any body of water would be beneficial for aquatic , amphibious , or other water dependent organisms . The reservoir will provide necessary space and food for organisms while the boundary zone between high and low reservoir levels are the extend over which the groundwater level is influence by the reservoir may both benefit . increase population densities of species are common in connection with reservoir. Secondary effects such as increase number of herbivores and carnivores foraging on plans and animals respectively are also reported .

Fish populations and other biodiversity are seriously affected by dams. Salmon and other migrating fish cannot pass the dam to reach their spawning grounds. Andromous fish such as this return to the same breeding grounds each year, and cannot reproduce if their path is blocked. In the Columbia river lamprey and salmon were devastated to 1% of their previous population after a dam was built, ruining the fishing economy and biodiversity. Other fish may not be able to lay their eggs in the eroded beds of sediment deprived rivers, or tolerate the change in water quality.

The annual run of adult salmon and steelhead trout in the huge Columbia River basin — which covers an area larger than France — is estimated to have averaged between 10 and 16 million fish before non-native settlers first arrived in the 19th century. Today, after decades of decline due overwhelmingly to the 130 or so dams in the basin, only some 1.5 million salmon and steelhead enter the Columbia each year, and around three-quarters of these are hatchery-reared, rather than wild, river-spawned fish. The National Marine Fisheries Service have estimated the cost of salmon fishery losses due to dams in the Colombia Basin for the period between 1960 and 1980 alone at $6.5 billion.

Salmon and steelhead are anadromous fish, meaning that they are born in freshwater, migrate to the ocean to mature and then return to rivers to spawn, and, in the case of most salmon, die. Salmon always return to the same stretch of river or shallow lake bed where they hatched. Fish which return to different rivers at different times of the year are known as 'stocks'; different stocks are genetically distinct and generally only breed with other fish from the same stock. Out of the original 400 or so salmon and steelhead stocks of the US Pacific coast only 214 remain, out of which 169 are at high or moderate risk of extinction.



Fish ladder

Fish passage

11. Conclusion

1. large dams contribute in global warming . The "fuel" for the methane, carbon dioxide and nitrous oxide emitted by dams is the rotting of the vegetation and soils flooded by reservoirs, and of the organic matter . The gases are released at the reservoir surface, at turbines and spillways, and downstream of the dam.
2. large dams can induce earthquake by the extra water pressure created in the micro-cracks and fissures in the ground under and near a reservoir. When the pressure of the water in the rocks increases, it acts to lubricate faults which are already under tectonic strain .
3. The natural sediment load in a river is usually trapped within the storage and this material is deprived to the downstream river system. Sediment accumulation is a sustainability issue for some reservoirs and in cases can reduce the long-term viability of developments .
4. A high dissolved oxygen content of water is very important to the aquatic life . if low oxygen concentrations are anticipated , in reservoirs with heavy metals in the sediments , these toxic substances may be release as a result of anoxic chemical reactions .
5. The decomposing of the organic matter from the flooded soil and sedimentation of plank tonic organisms may lead to the depletion of dissolved oxygen in the deep layers of the reservoir and to release of heavy concentration of highly toxic reduced substances such as sulphide ,ferrous and manganese , as well as organic mercury .

6. Salmon and other migrating fish cannot pass the dam to reach their spawning grounds. Andromous fish such as this return to the same breeding grounds each year, and cannot reproduce if their path is blocked.
7. Water released from deep in a reservoir behind a high dam is usually cooler in summer and warmer in winter than river water, while water from outlets near the top of a reservoir will tend to be warmer than river water all year round. Warming or cooling the natural river affects the amount of dissolved oxygen and suspended solids it contains and influences the chemical reactions which take place in it.
8. the flooding of a reservoir is often associated with substantial increase in nutrients and the level of minerals which cause , on the one hand beneficial effects such as a higher productivity , but also negative effect including the proliferation of plants , taste and Adour problems .

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