

# Hydrological Effects of Dams

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(Excerpted from **Silenced Rivers: The Ecology and Politics of Large Dams** by Patrick McCully)

Riverine ecosystems and human societies have evolved with, and often become dependent upon, seasonal changes in river flows. All storage dams alter to some extent these seasonal patterns, in most cases ironing out hydrological extremes by storing floods and increasing dry period flows. The exact nature of the impacts, however, will depend on the design, purpose and operating regime of the dam and the size of the reservoir.

Dams and barrages used to divert water, especially for irrigation, reduce, sometimes calamitously, the downstream flow. Undoubtedly the biggest ecological disaster caused by river diversion is the shrinking of the Aral Sea in Central Asia. Evaporation from the sea used to be matched by inflows of water from the Amu Darya and Syr Darya rivers (the Oxus and Jaxartes of classical times). Since the 1960s, however, the building of an extensive network of dams and canals for cotton irrigation has virtually eliminated the flow of water into the sea. In 1995, the area of the Aral Sea was only 30,000 square kilometres, compared to some 64,500 square kilometres in 1960. Its volume has dropped by more than three-quarters. A commercial fishing industry which once supported 60,000 workers ground to a halt in 1982 with what was left of the once freshwater lake now more saline than the oceans. By the early 1990s, 20 of the 24 fish species once caught in the sea had disappeared; the number of bird species found in the Amu Darya Delta had declined from 319 to 168, the delta forests had died, and only 30 out of 70 species of mammals remained.

The salt-encrusted, dried up bed of the lake is now known as the Akum Desert. Wind-blown dust from the new desert, laden with heavy metals and other toxins from fertilizers and pesticides used upstream, has been detected as far away as Alaska, and together with the heavily contaminated water supply has had a catastrophic effect on the health of the 3.5 million people living near the sea. The republic of Karakalpakia which surrounds the southern end of the sea has the highest rates of infant and maternal mortality in the former Soviet Union. The incidence of typhoid fever, hepatitis, kidney disease and chronic gastritis have rocketed as much as 60-fold. In the town of Muynak, nearly 70 per cent of the remaining population of 2,000 had 'pre-cancerous conditions' in 1994, according to the town's medical research centre. Life expectancy in Muynak tumbled from 64 years in 1987 to 57 in 1991. More than 80 per cent of women in the area suffer from anaemia and twelve kinds of pesticides have been found in their breast milk.

The USSR Ministry of Water Management wanted to increase the area of cotton in Central Asia so that they could justify building more canals and thus secure their share of government spending: the inevitable decline in the Aral Sea was not only predicted but justified by the planners. A map issued by the USSR Academy of Sciences in 1981 showed the estimated area of

dried up Aral Sea bed in the year 2000 being used to grow rice. In 1987, government water planners proclaimed in a magazine article: 'May the Aral Sea die in a beautiful manner. It is useless.'

## **Estuarine Impacts**

Some 80 per cent of the world's fish catch comes from continental shelves. Many of these fisheries are dependent on the volume and timing of the nutrients and freshwater discharged by rivers as well as on estuary habitats. Almost all the fish and shellfish caught along the US coast of the Gulf of Mexico, for example, live in estuaries for at least part of their lifecycle. The productivity of the Grand Banks of Newfoundland, one of the world's greatest fishing grounds, is directly related to the amount and seasonality of freshwater and nutrients flowing out the mouth of the St. Lawrence. The alteration of estuarine flows by dams and diversions is therefore, together with overfishing, a major cause of the precipitous decline in many sea fisheries.

Dams and diversions have done to the commercial fisheries of the saltwater Black, Azov and Caspian seas almost as much damage as they did to those of the freshwater Aral Sea. The discharge of the Volga into the Caspian Sea has been reduced by almost 70 per cent; that of the Dniester, Dnieper and Don into the Black and Azov seas by around half. The salinity in the estuaries of these rivers has increased by up to four-fold and that in their deltas up to ten-fold. The most valuable commercial fisheries in the seas have now been reduced by 90 to 98 per cent. Sturgeon catches in the Caspian Sea are only one to two per cent of historical levels and have been totally eradicated in the northwestern Black Sea and Sea of Azov (a northeastern appendage of the Black Sea). Michael Rozengurt, a Russian oceanographer now living in the US, estimates the combined economic losses to the fishing industries of the Black, Azov and Caspian in the decade between 1977 and 1987 at \$35 billion dollars.

Nutrients carried to sea during the flood season once caused a huge bloom of plankton at the mouth of the Nile. This plankton was grazed by great shoals of sardines which accounted for 30-40 per cent of the annual Egyptian sea catch. After the closure of the Aswan High Dam and the elimination of the annual flood, however, the sardine catch fell from 18,000 tonnes to less than a thousand tonnes in the late 1960s. The catch has since risen to a few thousand tonnes but this is attributed to improvements in fishing technology and greater numbers of boats. Shrimp catches at the mouth of the Nile decreased by two-thirds after the nutrient supplies were cut off. Landings of other fish in 1970 were 77 per cent below pre-dam levels.

Estuarine mangrove forests are valuable nurseries for fish and shrimps as they provide cover and also food when they shed leaves, flowers, fruit and twigs. Nearshore fish catches in several tropical areas are proportional to the mangrove cover of the adjacent coast. Mangroves are also directly used by people for fuel, animal fodder and fibre. The 80 per cent reduction in the discharge through the Indus Delta because of dams and barrages in Pakistan and India has killed off almost all the delta's mangrove forests which once covered a quarter of a million hectares (although mangroves can tolerate salinity much better than other plant species they still require freshwater to thrive).

## **River Plumbing**

*"The unregulated Colorado was a son of a bitch. It wasn't any good. It was either in flood or in trickle."*

**Floyd Dominy**

*US Bureau of Reclamation Commissioner, 1969*

The major hydrological impact of hydro dams is to impose on the river an unnatural pattern of flow variations. As Wallace Stegner puts it, 'a dammed river is not only stoppered like a bathtub, but it is turned on and off like a tap.' In Quebec, peak electricity consumption occurs during winter when river flows are naturally at their lowest because water is locked up in snow and ice. To meet the demand for electricity during cold weather, dams and diversions have increased the winter flow on the La Grande River by eight times (from 500 to 4000 cubic metres per second) and in order to store water for the following winter have eradicated the spring flood (flow reduced from 5000 to 1500 cubic metres per second). Interbasin diversions compound the effects of dam operation on rivers: redirecting water from the Eastmain River into the La Grande to increase generation has doubled the La Grande's total average annual discharge into James Bay, while reducing by 90 per cent flows to the Eastmain estuary.

Superimposed upon the seasonal post-dam pattern of downstream flows are short-term daily or even hourly fluctuations in river levels, sometimes of as much as several metres, due to releases to meet peak demands for power. The link between water releases and power demand means that river levels downstream of Glen Canyon now change not according to rainfall in the Colorado Basin but because of factors like the drop in electricity use on Sundays and public holidays. Releases from Glen Canyon Dam cause daily river level fluctuations of one-and-a-half metres compared to natural daily changes of a few tens of centimetres. Increases in demand for power from Kariba Dam on the Zambezi River can cause the downstream water level to rise by five metres in just half an hour.

Flow alterations on this scale have numerous ecological consequences. Rapid water level fluctuations speed up erosion downstream and can wash away the trees, shrubs and grasses along its banks. Without the riparian vegetation to hold it in place, the bank then erodes even faster. Riparian vegetation provides food and shelter for riverside creatures and branches on which birds such as kingfishers can wait for their prey to swim by. It also prevents the river becoming dangerously hot during the summer by providing shade. Furthermore, leaves and twigs falling into the river are an important source of food for insects and other aquatic fauna.

Varying releases through dams also effect reservoir levels. Rapid reservoir fluctuations can prevent fish spawning by alternately exposing and submerging the favoured nesting areas in shallow waters. Nests of waterfowl may be similarly affected. The fluctuations also prevent riparian and marsh vegetation from growing along the reservoir shore and so renders lifeless the nearshore shallows — usually the most biologically prolific areas of natural lakes and ponds. The six hydro-reservoirs on the La Grande river have submerged some 83,000 kilometres of natural shorelines with their fringing woods and shrubs; the shores of the reservoirs, meanwhile are broad, lifeless banks of mud, rock and dead trees.

## **Cutting off the Floodplain**

*"In my view, nature is awful and what we do is cure it."*  
**Camille Dagenais**, former head of Canadian  
dam engineering firm SNC, 1985

Even if flood control is not an intended consequence of a project, a storage dam will almost always delay floods downstream and reduce the size of average flood peaks, commonly by more than a quarter (even a flood control dam, however, may have little effect upon extremely large and infrequent floods — making the 'flood control' offered by dams often dangerously deceptive for people who move onto the downstream floodplain). The Warragamba Dam in Australia, for example, reduced the 'mean annual flood' (a flood likely to recur on average every 2.3 years) by more than half, while the size of the flood likely to recur every 50 years barely changed.

River and floodplain ecosystems are closely adapted to the annual cycle of flooding and drying. Many species depend on seasonal droughts or pulses of nutrients or water to give the signals to start reproduction, hatching, migration or other important lifecycle stages. Annual floods replenish wetlands not only with water but also with nutrients, while flooded manure from both domestic and wild animals on the floodplain enriches the river. Floods sweep fish eggs and fry into floodplain backwaters and lakes where they hatch and grow before joining the river again after the next annual floods. Adult fish and other aquatic animals such as turtles also follow the flood to take advantage of the new food sources offered in the submerged shrubs and woods.

For large floodplain rivers the floodplain is just as much a part of the river as the main channel itself. Most fish in the Amazon basin, for example, spend much of their lifecycle in the várzea, the tens of thousands of square kilometres of seasonally flooded forests and grasslands along Amazonian rivers. Some of the várzea forests are flooded for ten months or more each year and some fish and other aquatic species may never make direct use of the main channel. Many Amazonian fish eat the fruits of the flooded plants and play an important role in dispersing plant seeds. The renowned biodiversity of the Amazon rainforest is mainly in the várzea — the much greater area of dry forest is relatively unproductive and poor in species.

What ecologist Peter Bayley terms the 'flood pulse advantage' is the main reason for the astonishing diversity and productivity of rivers and floodplains — on a per unit area basis the diversity of fauna in rivers is 65 times greater than in the seas. Annual floods on tropical rivers are estimated to produce fish yields one hundred times higher than in rivers without floodplains, and, on a per hectare basis, around four times more than in tropical lakes or reservoirs. Most freshwater fish species are found in rivers and floodplains: few are adapted only to life in lakes.

It is generally recognised by biologists that dams and other flood control schemes are the most destructive of the many abuses which are causing the rapid disappearance of riverine and riparian species. Around 20 per cent of the world's 8,000 recognized freshwater fish species are threatened with extinction. Out of the 170 fish species endemic to the heavily dammed Western US, 105 are officially listed as threatened or endangered or are being considered for such a listing. A further 17 Western fish species have been exterminated during this century. The situation of some non-fish freshwater species is even worse: around two-thirds of the several hundred crayfish and freshwater mussel species in North America are on the danger list. In the little studied rivers of the tropics many species which have yet to be discovered by science have

almost certainly been extinguished, or are about to be extinguished, by the building of dams (there are three times more known species in the Mekong than in the Mississippi, yet there have been 10,000 times more scientific articles published on Mississippi fauna).

The plants and animals of the river bank and floodplain also suffer when the plain no longer floods — or when the river is in spate at the wrong time. Unseasonably high discharges from dams on the Savannah River in Georgia, for example, killed almost all the bald cypress seedlings along the river banks. Studies on the floodplains of the Missouri and the Pongolo River in South Africa have both shown a reduction in the diversity of forest species after dam construction upstream. The forest on the floodplain of Kenya's Tana River appears to be slowly dying out as it loses its ability to regenerate because of the reduction in high floods due to a series of dams upstream.

The 6,000 square kilometre floodplain of the Kafue River in Zambia, known as the Kafue Flats, was once one of the richest wildlife habitats in the world. The Kafue, a main tributary of the Zambezi, was impounded in the 1970s by the Gorge Dam which permanently flooded much of the Flats and then by the Itezhitezhi Dam upstream, which eradicated the seasonal floods over the remaining part of the plain. Biologist Walter A. Sheppe visited the flats before and after the dams. On his first visit in May 1967, 'the extensive annual floods were largely hidden by a dense growth of emergent grasses reaching to the horizon.' Large herds of antelope grazed the edges of the flooded area and zebra and wildebeest fed on the higher ground. The water and shore were dense with birds. Sixteen years later Sheppe returned to the same spot. This time the lowest part of the plain was covered by Gorge Reservoir and the rest was dry. The productive grasses that had depended on the seasonal floods had been replaced by aquatic plants on the open water, and on the dry former floodplain by a sparse cover of low grasses and scrub. There were few birds, relatively few antelope, and no zebra or wildebeest.

*Read the next section in this chapter, [The Mitigation Game](#)*

## The Mitigation Game

From *Silenced Rivers: The Ecology and Politics of Large Dams* by Patrick McCully

Dam builders and operators have been forced over the years to take a number of steps to mitigate the impact of their projects. Some mitigation measures can reduce some of the harmful impacts of a dam, others may be worse than useless. Mitigation is especially dangerous when it misleads the public into believing that dam builders can recreate the characteristics of wild rivers and fisheries and so allows more dams to be built. Mitigation measures generally reduce the amount of electricity and water which can be provided by dams and increases their construction and running costs. Regulations, such as those in the US, which insist that dams include mitigation measures can therefore render many projects uneconomic (especially as the economic viability of most dam projects at present is marginal at best). The effect of mitigation costs on project economics is an illustration of how many, probably most, dams would not be built were they to have to pay the cost of even a small part of the environmental damage they cause.

The most common mitigation measure taken in the US is to release more water from the reservoir than would be the case if the dam were operated only to maximize power or water storage. These 'instream flows' are usually spilled for the benefit of fish downstream but can sometimes be released in large 'flushing flows' intended to wash away harmful accumulations of boulders and gravel. The US Federal Energy Regulatory Commission now requires the operators of many privately owned hydrodams in the US to release instream flows as a condition of renewing their federal dam licenses. The average loss in power generation for relicensed dams having to guarantee instream flows is around eight per cent and in one case was almost a third. The drop in revenues due to lowered power production have forced some dam operators to close down their hydro plants and to give up plans for new projects.

While instream flows can generally be assumed to be beneficial they can also be little more than a palliative. In most countries instream flows are defined according to arbitrary criteria without any ecological basis. In Spain, for example, dams are supposed to release an 'ecological flow' which is ten per cent of the average annual flow — an amount which would in most cases be totally insufficient to retain the ecological characteristics of the regulated rivers. Instream flow requirements usually give little consideration to the importance of natural seasonal flow variations: releases which raise levels during normally dry spells can even do more harm than good. Instream flow requirements also rarely allow for the releases of the occasional exceptionally large flood flows which are an essential part of most fluvial ecosystems. In general, instream flows can mitigate the effects of dams but cannot recreate the essential variability and dynamism of a wild river.

One of the advantages of spilling extra water is that it will tend to increase downstream dissolved oxygen levels. Other measures can also be taken which increase oxygenation such as artificially aerating the water passing through turbines. Increasing dissolved oxygen is generally the cheapest form of mitigation and appears to generally be effective although as with instream flows there are problems in deciding exactly what dissolved oxygen level is the most beneficial and how to trade-off its costs and benefits.

Another form of mitigating the effects of a dam on downstream water quality is to regulate the temperature of releases by fitting the dam with intakes which can withdraw water from different levels of the reservoir. Around a hundred federal dams in the US are able to make so-called 'selective withdrawals'. In 1995, BuRec began work on a 35-storey-high steel selective withdrawal tower in the reservoir behind California's huge Shasta Dam at a projected cost of \$80 million. Shasta was built in the 1940s with just one outlet which when the reservoir is low releases water so warm that it is lethal to the few wild salmon remaining downstream. While selective withdrawal can improve thermal conditions below a dam they can rarely replicate the original seasonal variations in river temperatures as at times the reservoir will not have sufficient water at the right temperature.

## **The Hatchery Debacle**

Probably the most controversial form of environmental 'mitigation' is the use of hatcheries for artificially rearing fish whose natural habitat has been destroyed by dams. Since the late 1940s the US government has spent hundreds of millions of dollars on hatcheries to mitigate the

impacts of dams on Pacific salmon. The Bonneville Power Authority, which operates most of the big dams on the Colombia, now spends some \$350 million annually on 'fish and wildlife investments' — mainly hatcheries. Yet not only has the number of adult salmon plummeted, but hatchery fish are degrading the genetic diversity of the remaining wild salmon and helping push them toward extinction.

The hatchery programme has failed because dams are continuing to destroy salmon habitat, and also because of the inherent limitations of hatcheries. The genetically homogenous hatchery fish mate with their wild relatives and thereby reduce their genetic fitness: the effects on the natural stock include 'decreased survival and stock size, poor stamina and disease resistance, inappropriate territorial and hiding behavior and other poor performance.' The overcrowding in fish farms, furthermore, means they are highly prone to diseases which are then spread to wild populations. A 1995 report by the prestigious US National Research Council warned that current hatchery policies in the Pacific Northwest were 'based on deep ignorance'. 'It isn't enough to focus only on the abundance of salmon', the NRC concluded. 'The long-term survival of salmon depends crucially on a diverse and rich store of genetic variation.' Some fish biologists in the Northwest now believe that all the hatcheries should be shut down.

Despite the expensive failure of hatcheries in the Pacific Northwest and elsewhere in North America, hatcheries are regularly promoted by government fisheries departments and environmental consultants as a means of mitigating the destruction of natural fisheries by dams in other parts of the world. Part of the 'mitigation' for the Pak Mun Dam in Thailand, for example, is the hatchery rearing of some two dozen species of local fish — only around ten per cent of the species found in the undammed river. Mekong fisheries specialist Walter Rainboth of the University of California believes that the hatcheries at Pak Mun are merely 'public relations gimmicks'.

The backers of the Sardar Sarovar Dam claim they will 'mitigate' the loss of the hilsa fishery by stocking the reservoir and ponds in the estuary with hatchery-bred fish. But fisheries scientists have not yet been able to breed hilsa artificially. In fact the rearing of hilsa currently depends on obtaining spawn from wild adults, which would in all probability be eliminated by the desiccation of the river.

## **Down the River . . .**

Aiding smolts on their danger-filled voyage toward the sea is a cornerstone of the authorities' costly but so far largely fruitless plan to restore the Colombia River salmon. One part of this plan is the installation and improvement of screens and bypass systems which prevent young fish from being sucked down turbine intakes. The Army Corps of Engineers is spending \$345 million on upgrading fish facilities at its eight dams on the Columbia and lower Snake. The bypass systems, however, do not help the smolts negotiate the warm, predator-infested reservoirs. The preferred technofix for this is 'barging' — in a striking illustration of how far the Columbia has been transformed from a wild into a managed river, smolts are trapped, crammed into barges and motored through reservoirs and dams. While the survival rate of barged smolts is higher than for those left to negotiate the reservoir on their own, mortality due to stress and exposure to diseases in the barges is still high.

Salmon advocates on the Colombia claim that drawing down the reservoirs during the spring and summer migration is the key to helping the fish stocks to recover. The hydropower and navigation interests on the river, however, are strongly resisting pressure to make the dam operators spill water. The drawdowns would certainly not come cheap: the Corps of Engineers estimates that the necessary structural modifications to the eight relevant dams on the Colombia and Snake would cost up to \$4.9 billion — and this sum does not include the huge cost to the dam operators of lost revenues from foregone power production and barge fees.

### **. . . And Back Up Again**

While salmon are by far the best known of migratory fish there are many hundreds of other species with very different migration patterns, especially on large floodplain rivers in the tropics. 'Catadromous' fish live most of their lives in rivers but spawn in estuaries or in the sea, the opposite to salmon; 'amphidromous' species spawn and mature in both salt and fresh water; 'potamodromous' fish migrate entirely within freshwaters. Because these fish do not follow the classic anadromous migratory pattern and have mostly been very little studied they are sometimes not even regarded as migratory and so dam builders have often assumed that they do not need to bother building fishpass facilities in rivers without salmon.

Yet even where fishways have been built they are invariably based on the salmon fishpass model and have been impassable for many native species. In southeastern Australia, where many dams were fitted with fishways modelled on those on European and North American rivers, native potamodromous silver perch have declined by more than 90 per cent since the 1940s and are now listed as a threatened species. Dams have totally eradicated migratory grayling and bass from some coastal rivers in the region.

In the tropics there only a small number of examples of fish ladders being successfully used by native species. 'Experiences with such structures as fish ladders in Africa,' says UN Food and Agriculture Organization fishery biologist, G.M. Bernacsek, 'have been few and unsatisfactory'. In South America, Yacyretá Dam on the Paraná River has been fitted with fish elevators costing \$30 million which, according to the World Bank, were designed 'based upon the consultants' knowledge and experience with fish migrations on the Columbia River'. While only a few of the more than 250 species in the Paraná are well studied, it is known that at least some of its species migrate up and down the river several times during their lives. 'This aspect,' a internal World Bank evaluation of its loans for Yacyretá dryly notes, 'was not considered.' And so the Yacyretá elevators, based on salmon migrations, only transport fish upriver.

World Bank and Thai government officials for years refuted the claims of independent Mekong fisheries experts and local fishing communities that the fish ladder planned for the highly controversial Pak Mun Dam would be largely useless and that the dam would have a devastating impact on the Mun River's highly diverse and productive fishery. Thai electricity utility EGAT even produced a video for national television promoting the experimental ladder as 'helping to conserve biodiversity.' Well before the dam was completed in 1994, however, fish catches in the Mun, the largest tributary of the Mekong, had dropped disastrously. In 1995, the Thai Department of Fisheries admitted that the experimental fish ladder was not working and EGAT



agreed that local fisherpeople should be compensated for the loss of their fishery (although the World Bank still claimed that 'there has been no evidence to suggest that the dam will adversely affect fish stocks'). When a journalist from the Wall Street Journal visited Pak Mun in March 1996, 'two, small, dead fish [were] the only signs of life' in the ladder.

Furthermore, there are no bypass facilities at the dam, which is just upstream from the mouth of the Mun, to allow the scores of migratory fish species in the river to descend the river without a potentially lethal trip through the dam's turbines. Plodprasop Suraswadi, director of Thailand's Department of Fisheries, admitted to the Bangkok Nation newspaper in 1995 that there was a problem for fish migrating down the Mun but claimed that this would in fact be a good thing. 'This will pose no severe consequences,' Plodprasop said, 'as it would be beneficial for Thailand not to lose this group of fish to other downstream countries.'

## **Mitigating for the Cameras**

To alleviate public concern over the massive numbers of animals drowned when a large reservoir is filled, dam authorities often plan highly publicised rescue operations. Despite decades of experience that these rescues are of extremely little benefit and repeated criticism from wildlife conservationists, dam builders still insist on mounting them, mostly because, as William Partridge, a senior World Bank environmental employee has cynically remarked about the Yacyretá rescue effort, they make 'good TV.'

Wildlife rescue plans fail to capture all but a tiny proportion of the affected animals, most of which drown or starve to death after being stranded on small islands or at the tops of partly flooded trees. The rescue operation at Thailand's Chiew Larn Dam, for example, captured only an estimated five per cent of the animals in the submergence zone. Furthermore, once the animals which have been captured are released they are often lethally stressed, frequently injured, and usually have no replacement habitat in which to live — if a suitable habitat is available it will already be inhabited by competitor animals. Rogério Gribel of the Amazonian research institute INPA says that 'saved' or not, 'all the animals from the flooded area should be considered dead.'

## **The EIA Industry**

*Our experience with environmental impact assessment is that when you predict major environmental impacts, the likelihood is that you will get major environmental impacts. The only problem is that you don't ever get quite the impacts you expect.*

***Professor Frank Grad***

*Columbia University Law School, 1992*

Since the end of the 1960s a growing number of countries and international development agencies have followed the lead of the US in insisting that an environmental impact assessment (EIA) be written before any major infrastructure project be built. A thorough assessment of a proposed dam's possible environmental impacts should indeed be required before any project goes ahead. Unfortunately, governments and dam builders have invariably turned the EIA

process into a bureaucratic formality, merely another regulatory hurdle which developers must jump before they can get their project approved. Governments and funders rarely treat EIAs as objective studies to be used to inform an open debate on whether or not a project is desirable, but as rubber stamps for projects they have already decided to build.

International environmental consulting is now a big and very profitable business. According to the British Consultants Bureau, UK consultants earned \$2.5 billion on overseas contracts in 1994 — and the second biggest sector of the market after project management was writing EIAs. The environmental assessments for large internationally funded dam projects are invariably written by consultants from a relatively small number of companies, some of which, such as German consultants Lahmeyer International, are also directly involved in dam building. Others, such as Norwegian firm Norconsult, are subsidiaries of dam builders. There is an obvious conflict of interest when the company assessing the environmental viability of a project is also likely to get the contract to build it.

Even apparently independent environmental consultancies with no direct link to dam builders also have a strong self-interest in underplaying the environmental impacts of projects and exaggerating their benefits. If their conclusions are not favourable to the dam funders or builders then the consultants will be less likely to get contracts from those agencies or companies in future (the World Bank's guidelines on environmental assessment specify that consultants must be 'acceptable to both the World Bank and the local contracting agencies'). Consultancies, funders and builders often have warm and mutually rewarding relationships. British consultancy Environmental Resources Limited, for example, was awarded more than 11 contracts on World Bank development projects and eight with the UK government's Overseas Development Administration between 1985 and 1992 in South Asia alone.

Furthermore, there is no quality control on the consultants' reports — they are usually not peer reviewed as they would be were they to be published in an academic journal, and much worse they are often treated as state or commercial secrets and hidden from public scrutiny. This inbuilt bias for consultants writing EIAs to conclude what their clients want to hear means that the conclusions of an EIA for a large dam can often be guessed before reading the report: the dam's environmental impacts can be accurately predicted, will be relatively minor, and can be relatively cheaply and easily mitigated. In one form or another these seem to be the conclusions of almost every EIA for an international dam project.

Even when individual sections of an EIA are critical or raise concerns that some effects cannot be predicted these points are invariably toned down in the report's overall conclusions (and criticisms in drafts frequently disappear when they appear in final form). The 1994 feasibility study for a cascade of dams on the Mekong written by Canadian engineering and environmental consultants Acres International and French dam agency Compagnie Internationale de Rhône, for example, states that 'not enough is known' about fisheries ecology in the river 'to predict the effects' of the dams. Yet the consultants predict that the 'environmental impacts of the proposed projects are expected to be . . . not severe'.

One of the clearest examples of a corrupting relationship between a dam building agency and an environmental consultancy is that between Thai utility EGAT and TEAM Consulting

Engineering Company, a link which goes back for three decades. In 1978, EGAT commissioned TEAM Consulting to write the EIA for the Nam Choan Dam. Their final report was never publicly released but was used by EGAT to claim that the project would not have serious impacts on the two wildlife sanctuaries that it would partially flood. The Wildlife Ecology section of the EIA, however, was obtained by Belinda Stewart Cox, a British biologist doing research on the birdlife in the sanctuaries.

The TEAM consultants were unable to enter the submergence zone because it was held by Communist insurgents so they surveyed an area downstream which they presumed had similar habitats and then extrapolated this to the reservoir. Although the study contained no maps or location description Stewart Cox concluded from the species listed and omitted that TEAM had probably not studied riverine forest at all. TEAM's report failed to mention the ecologically valuable nature of the sanctuary areas which would be flooded; the effect of the reservoir on fragmenting animal populations; and the effect on aquatic species of converting a river to a reservoir. TEAM claimed that only six of the mammals it listed were classified as rare; Stewart Cox says that 35 were protected under Thai law.

TEAM also said that the reservoir would 'create favourable conditions for most bird species' because 'water birds find it easier to catch fish'. Yet according to Stewart Cox, only two out of 113 listed bird species would be likely to catch fish in the reservoir. Similarly TEAM stated that otters — which favour shallow, shady rivers — would benefit from the reservoir. Stewart Cox concluded that overall the TEAM report was 'inadequate, inaccurate, sloppy, misleading and, in some instances, apparently fraudulent. It is, in every respect, an inadmissible and unprofessional document.'

The storm of protest which Nam Choan provoked among environmentalists and local people forced EGAT to suspend the project. But EGAT did not blame for misleading them as to Nam Choan's possible impact. Instead they rewarded them with another EIA contract, this time for the World Bank-funded Chiew Larn Dam. Here TEAM's 'experts' found 122 wildlife species in the reservoir area — while the Royal Forestry Department's largely futile animal rescue operation found 338 species. Undaunted by TEAM's incompetence, EGAT then contracted them to do an environmental assessment for Pak Mun. TEAM claimed there were 80 fish species in the Mun — later surveys found more than 230 species. Mekong fisheries specialist Walter Rainboth reviewed a leaked copy of the Pak Mun EIA. 'Based on the importance of the project and the capacity for irreversible damage,' Rainboth concluded, 'the report is criminal. If something like this were submitted to Congress in order to solicit funds, its fraudulent nature would deserve criminal indictment.'

The extent to which the original purposes of environmental assessments have been subverted can clearly be seen at the Sardar Sarovar Project. In this case the World Bank and Indian authorities agreed that environmental studies for the world's biggest dam and irrigation project should be done parallel with, rather than before, work on the dam. Repeated criticisms of this approach were defended with the assertion that any environmental impacts would necessarily be less than the project benefits (although the authorities did not know what the environmental conditions prior to construction were, what the scale of the impacts would be, nor how much project benefits might be curtailed by environmental factors such as unsuitable soils in the areas slated

for irrigation). The independent commission set up by the World Bank to review Sardar Sarovar concluded that this approach 'subverts any acceptable notion of ecological planning'.

Sardar Sarovar's backers have also claimed that continued monitoring will enable any serious environmental problems to be identified and mitigated. But this attitude fails totally to allow for the fact that many environmental impacts cannot be mitigated once the project is built (and that many others only can be by substantially redesigning the project). It is in fact depressingly common to find the assumption in EIAs that 'monitoring' is the same as mitigation, and that recording environmental damage will somehow stop it.

Consultants invariably write EIAs as if the projects were being built in a world without pressure to maximize profits and cut costs on environmental mitigation. EIAs very rarely discuss whether the mitigation measures they recommend have been implemented — and if implemented effective — for past projects. Nor do they tend to mention what the environmental impacts of other projects have been and whether they were accurately predicted. Even if consultants did wish to discuss the success or otherwise of environmental mitigation, however, their ability to do so would be restrained by the fact that environmental studies usually end before construction is finished. More than 60 per cent of 31 national dam agencies surveyed by the industry journal *Water Power & Dam Construction* in 1991 stated that they had no formal system for monitoring the impacts of dams in operation — despite the claim in almost every EIA that environmental monitoring will be a key part of mitigation.

The secrecy which frequently surrounds EIAs is the most indefensible part of the EIA industry. The environmental impacts of dams are extremely complex and difficult to predict. Putting a price tag on possible environmental costs and then comparing these with supposed economic benefits is a process fraught with difficulty, assumptions and personal bias. Coming to a decision on whether or not the environmental damage done by a dam will outweigh its benefits is ultimately a subjective and political decision which should be made after an informed debate by the affected people and the general public. Weighing up the cost of the extinction of a species or the desiccation of an estuary against the benefit provided by increased electricity generation should not be the sole remit of a firm of consultants with a vested interest in ensuring that more dams are planned and built.

An argument often used by dam builders and backers in developing countries to defend incomplete and biased environmental surveys is that concern for the environment is a 'first world luxury' which they cannot afford. In fact the opposite is the case. The majority of people in developing countries depend directly on their environment to provide them with subsistence. The environmental destruction caused by dams in developing countries (and to a lesser extent elsewhere) thus carries a major human cost, which falls most heavily on the poorest sections of society. People in developing countries, in fact, can least afford the environmental impacts of large dams.