Contributing Paper

Downstream Impacts of Dams

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Prepared for Thematic Review I.1:
Social Impacts of Large Dams Equity and Distributional Issues

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Contents

1. Introduction

There has been increasing recognition by both dam proponents and dam opponents that the social impacts of dams are complex, and can be far-reaching. Social impacts can be positive (e.g. improved welfare resulting from new access to irrigation water) or negative (e.g. resettlement, decline of a downstream fishery due to flood control). Social impacts can be direct (e.g. the cultural trauma of involuntary resettlement), or the result of a cascade, where environmental impacts generate economic impacts, and these in turn cause social impacts (for example the impacts of changes in a river's flooding patterns reducing fish populations downstream of a dam, affecting the economic return form fishing and causing increased levels of out-migration of male fish catchers). Social impacts can be local to the dam site (e.g. the negative impacts associated with resettlement), or in places that are far from the dam, where water or electricity are consumed (see Thematic Review 1.1.a, *Social Impacts of Dams: Equity and Distributional Issues*).

Some social impacts of large dams have been extensively documented, especially those negative impacts associated with involuntary resettlement and population displacement (see In particular the World Commission on Dams (WCD) Thematic Reviews on *Displacement, Resettlement, Rehabilitation, Reparation and Development*, and on *Dams, Indigenous People and Vulnerable Ethnic Minorities*). However, the impacts of dams on environments downstream of dams is relatively little understood. Dams impact in particular communities dependent on agriculture and fishing in channels, floodplains and delta/inshore marine environments. In these areas, ecological, economic and social impacts tend to be closely linked.

This review aims

1. to address critical knowledge gaps about the positive and negative impacts of dam projects in downstream environments.
2. to review state of knowledge about the distribution of those impacts in space (down-river), across the economy, and socially (by wealth, gender, ethnicity etc.).
3. to review available planning approaches and deliberative procedures used to identify and minimise downstream impacts.

Traditional assessments of dams has focused on their economic direct costs (the investment to build it and the annual costs of operating it, and sought to compare this with the direct benefits expected from the stream of services (water, power, flood protection. etc.) that the dam will provide). However, most economic assessments tend to overestimate benefits and underestimate costs. Particularly, they argue that economic assessments tend to overlook indirect and opportunity costs to riparian environments and people (e.g. floodplain environmental impacts, loss of natural resources, loss of production opportunities, forced resettlement, social dislocation, etc.), and they fail to deal adequately with non-quantifiable socio-cultural costs. To a lesser degree, economic assessments may also fail to account for some indirect benefits (e.g. local jobs, improved services, local economic growth, the benefits of lower food prices, reduced flood damage, or reduced impacts from alternative development options, e.g. pollution from coal power stations).

The impacts of dam construction include quantifiable economic impacts, in the form of the changed flow of economic costs and benefits resultant of the construction of the dam. These can (in theory at least) be measured quantitatively. They would include reduced or enhanced streams of existing benefits from the river or economic systems supported by the river's water (for example losses from agriculture in the floodplain, or gains in terms of reduced flood damage downstream). However, the impacts of a dam also include intangible socio-cultural impacts. These are much harder to measure, and may in some cases be impossible to capture in economic terms. These include culture; political identity, freedom, mobility, the impacts of 'modernity', and knowledge (both knowledge made redundant and knowledge gained).

Downstream communities suffer in non-material as well as material ways. Such communities (e.g. along the Narmada River) often define their existence in terms of their natural surroundings of the river and the valley (Mehta and Srinivasan 1999). Vulnerable communities, and particularly women, children and the elderly, tend to be impacted by dams in ways that require an evaluation that goes beyond the economic impacts of loss of land or other resources, property or livelihoods (Mehta and Srinivasan 1999).

Mainstream approaches to the measurement of the distribution and costs and benefits of dams systematically de-emphasise the non-monetary, the non-quantifiable, and the interests of the powerless. They therefore legitimise existing inequalities (for example between genders) in the distribution of resources, and entrench dominant forms of social relations (Mehta and Srinivasan 1999).

Many impacts are experienced differentially by gender. Economists conventionally treat 'the household' as the fundamental unit within which resources are shared and allocated, but there can be significant structuring within the household, particularly by gender. The planning of dams and the analysis of their impacts has tended to ignore gender, as if differences between men and women in the household, community or nation simply do not exist (Mehta and Srinivasan 1999, see Thematic Review I1b):

- People affected by dams are not conventionally distinguished by gender;
- The household is treated as a single unit, and not understood in terms of gender;
- The family is often treated as an undifferentiated unit with convergent interests.
- the community earmarked for either compensation or benefits, is viewed as homogenous with male members usually being targeted by dam planners.
- Women’s needs and interests require a specific priority focus in policy if development is to yield truly gender-justice (Mehta and Srinivasan 1999).

2. The Downstream Impacts of Dams

2.1 General

The social impacts of dams in downstream environments tend to result from complex interactions between environmental impacts and economic impacts. Whereas in the case of resettlement, the environmental impact is simple (if drastic), downstream the impacts of a dam on people depends on a rather complex set of impacts on the amount and timing of water flowing in the river and on the hydrological links between river and floodplain. Where dependence of downstream communities on economic activities dependent on river flows, social impacts reflect ecological impacts closely. The links between social impacts, floodplain economy and the dam's environmental impacts are not widely understood. The discussion in this section therefore attempts to explain these linkages, making clear not only the nature and significance of downstream social impacts, but also their enormous complexity.

In order to avoid excessive discussion of river and floodplain hydrology and ecology, the broad linkages between environmental and economic impacts in the river channel, floodplains and deltas are set out in Table 2.1 below. This table does not offer an exhaustive classification, but indicates the diversity of impacts and the interactions between them.

Table 2.1 Downstream environmental and economic impacts of dams

Environment	Environmental Impact	Economic Impact	Social Impact and Interested/Affected Party
Channel	water turbidity (clear water erosion downstream of dams, channel scour, infrastructure damage, channel movement) and associated channel evolution (changes in patterns of erosion/deposition and channels; winter floods, woody debris, ice) and associated pools and wetlands	Impacts on any economic activities carried out on existing banks or ecosystems linked to present channel patterns, pools etc. Negative impacts if bank stability increases Negative or positive impact if bank stability increases	On all floodplain households needing access to the river bank (e.g. fish catchers, people washing; uncertainty, economic disruption, out-migration)
	water chemistry (Hydrogen sulphide; mercury) and aquatic biology	Negative impacts of fish food supply cut, and hence fish populations and fish catches; increased incidence of human parasites and disease	On fish catchers and their dependents; out-migration; changed gender roles; ill-health, especially children, elderly and women
	timing of flood flows and impact on lateral and longitudinal fish migration to breed and hence recruitment rate and fish ecology; risks of unpredictable high flows due to reservoir drawdown	Negative impacts of reduced productivity of downstream river fishery; safety of downstream communities	On all floodplain households (poverty; out-migration; changed gender roles; uncertainty; reduced nutrition status especially of women, children, elderly)
Floodplains and inland deltas/swamps	flood volumes and timing (extent and duration of flood flows)	Negative impacts on all aspects of riparian ecology including flood-recession agriculture	On all floodplain households (reduced food production and crops for sale; reduced trade; poverty and debt; poorer nutrition (children, women); out-migration)
	groundwater level and temporal and spatial dynamics of flooding	Negative flood-related agriculture, shallow-groundwater irrigation, human drinking and livestock water supply	On all floodplain households (poverty, Poor health, increased labour, gender divisions of labour, out-migration)

	reduced silt deposition and floodplain ecological productivity; enhanced dry season water tables	Negative impacts on agricultural productivity; increased waterlogging/salinity	On all floodplain households (reduced yields and incomes; poverty, health, especially vulnerable people)
	changes in form and functioning of wetland ecosystems (especially riparian forests that depend on 50 yr+ flood events for regeneration)	Negative impact on flows of economic benefits (e.g. timber and wood supply and non-timber forest products). See also fish (under 'channel' above).	On all floodplain households (poverty, health, out-migration etc.)
	changes in stable channel patterns, and implications for infrastructure (see under 'channel' above)	Negative impacts (loss of property etc.)	On all floodplain households (poverty)
	flood control	Positive impact from reduced risk to infrastructure, particularly urban	On urban households, business owners and employees
	insect or mollusc disease vector abundance	Negative impact from increased incidence of disease (e.g. schistosomiasis, malaria)	On all floodplain households, especially children and women (poor health)
Downstream water bodies, coastal deltas and inshore/marine environments	seasonal dynamics of saline/freshwater boundary breeding of crustacea, shellfish and finfish	Negative impact from reduced productivity of fisheries	On all delta resource using households (nutrition, health, out-migration, cultural change)
	mangrove ecology	Negative impact from changes to flows of economic benefits (e.g. loss of fishing)	On all delta resource using households (nutrition, health, out-migration, cultural change)
	fish reproduction	offshore finfish and shrimp	On all coastal resource using households (nutrition, health, out-migration, cultural change); On fisheries business owners and their employees

2.2 The Complexity of Downstream Impacts

Downstream impacts have been the Cinderella of debates about dams: unrecognised, misunderstood and underestimated by planners. One reason for this is that they occur in remote areas, far from the dam site, and are all too easily ignored. Even when recognised, downstream impacts are daunting in their complexity in space and time.

Downstream impacts involve a change in a dynamic element of the environment (variable river flows within and between years) rather than a gross change (a lake where there used to be dry land). A critical problem, therefore is the issue of uncertainty. There is inevitably a high degree of uncertainty in predicting the nature of the downstream environmental impacts of dams at any given point in space and time. A key challenge is how to convey the fact of this uncertainty to stakeholders and decision makers, and how to devise planning frameworks that take it into account.

Significant impacts are often remote geographically from the dam, beyond the boundary of planning, and therefore are unperceived by project developers. Such problems are compounded if, as in the case of downstream floodplain wetland environments, the places where impacts occur are also physically remote from centres of planning and decision making, difficult of access and of marginal importance politically. The spatial and temporal boundaries within which environmental impacts are assessed can have significant effects on the outcome of an assessment. If projects that are dependent on each other are appraised separately, relevant costs or benefits may be missed. For example, the Sardar Sarovar Dam on the Narmada River is designed to operate with the Narmada Sagar dam upstream (to control inflows) and the smaller Omkareshwar and Maheshwar dams (Rich 1994). Without Narmada Sagar, the hydro-power generation of Sardar Sarovar would be reduced by 25 per cent, and irrigation by 30 per cent. However, Narmada Sagar was expensive, would flood a large area of tropical forest, and would force resettlement of an additional 100,000 people. The World Bank appraised Sardar Sarovar as a discrete project out of the context of its links with the other schemes (Rich 1994). Wider costs were therefore excluded from consideration. Dam projects are particularly vulnerable to artificially narrow assessment in this way: for example, assessment of the viability of the Bakolori Dam and irrigation scheme in Nigeria specifically excluded any consideration of the considerable downstream impacts (Adams 1985), and assessment of the Pangue Dam on the Bio-Bío River in Chile in the early 1990's ignored its dependence on other dam projects (Usher 1997).

There are difficulties with the concept of 'downstream' impacts in the case of river basins where flights of dams, or linked sets of dams have been built. There are also conceptual difficulties where these upstream and downstream dams are linked, and are dependent on each other for their functioning (e.g. using headwater storage and release to a downstream dam). Examples of this include the Bio-Bío River in Chile or the Paraná (Ferradas 1999).

3. Impacts in downstream river channels and river-margin communities

3.1 The complexity of floodplains

Aquatic and riparian (floodplain) ecosystems are enormously complex. Freshwater habitats associated with river systems include both static water bodies (such as floodplain pools and meander cut-offs) and flowing water environments. Floodplain environments range from dry-land environments (often most distant from the river itself) to low-lying wetland areas. Both aquatic and floodplain ecosystems are subject to the dynamic flow patterns of the river, both in terms of the annual discharge regime, and the size and longevity of shorter-term flood events, and the groundwater regime the distribution of groundwater in space and time that these river flows support. Changes in river flow regimes can therefore obviously have very large potential effects on river and floodplain environments, and hence on the people depending on the resources of these ecosystems.

The nature of hydrological effects varies with the purpose of the dam and the seasonal regime of the river. Dams come in many different shapes and sizes. A critical distinction between types of dams reflects their purpose. Dams for flood-control exacerbate peak flow moderation effects, particularly in such seasonally torrential rivers. Hydroelectric dams are designed to create a constant flow through turbines, and therefore tend to have a similar effect on discharge patterns. However, if the intention is to provide power at peak periods, variations in discharge of considerable magnitude can occur over short timescales, creating artificial freshets or floods downstream. Dams for irrigation cause moderate variations in flow regime on a longer timescale, storing water at seasons of high flow for use at times of low flow. Discharge beyond storage capacity is usually spilled, allowing some flood flows to pass downstream, albeit in a routed and hence attenuated form. Dams are often designed to have multiple functions, in which case their impacts will be a combination of the above forms. It should be noted that other hydrological structures such as barrages and weirs can have similar impacts to dams, and that there can be significant downstream ecological and socio-economic impacts from other hydrological projects such as water diversion or inter-basin transfer projects.

The critical point is that most dams moderate and delay the incoming flood peak because of the flood-routing effect of the storage impoundment. Such effects can be particularly significant where river regime is flashy and such peaks are common, for example in rivers in the semi-arid tropics.

The downstream impacts of dams are complex, and have knock-on secondary and tertiary impacts on aquatic and floodplain ecosystems. These often go unrecorded, except by those left coping with them. There are relatively few studies of downstream degradation following dam construction in the Third World. Downstream impacts can extend for many hundreds of kilometres downstream, and well beyond the confines of the river channel. Transformation or modification of discharge patterns and stream environments have a range of significant effects on those ecosystems.

3.2 The Economic Importance of River Wetlands

The social impacts of dams on downstream environments are particularly significant in extensive floodplain wetlands, for example those of arid or semi-arid Africa. Economically important wetlands in Africa include river floodplains (on all scales from 1-2 Km across to the vast floodplains of the major rivers), freshwater swamps (sometimes occurring in conjunction with these floodplains), lakes, and coastal and estuarine environments (including mangroves). In the Sahel, there are major wetlands in the Delta Intérieure of the River Niger in Mali and Lake Chad (on the border between Niger, Chad, Cameroon and Nigeria). These have counterparts elsewhere in semi-arid Africa, notably the Sudd in Sudan and the Okavango Delta in Botswana, and in humid areas, such as the swamps of eastern Zaire. There are also countless smaller wetlands along seasonally flooded rivers (for example in West Africa the Senegal, those flowing into Lake Chad such as the Logone-Chari and the Hadejia-Jama'are, and the Niger), around lakes (notably those of eastern Africa) and in coastal environments (for example the delta of the Senegal in West Africa). Some of these wetlands are vast. The fringing floodplain of the Senegal River covers some 5000Km2 in flood, and shrinks to 500 Km2 in the dry season. The fringing floodplain of the Niger covers about 6000 Km2 in the flood season, shrinking to about half that at low water, while the Niger Inland Delta extends to 20,000-30,000 Km2 in the flood season, shrinking to

4000 Km2 at low water. In the Logone-Chari system, flooding covers some 90,000 Km2, of which only 7% remains wet at low water.

Tropical wetlands are among the most ecologically productive of global ecosystems and in the drier Tropics in particular they can be of enormous socio-economic importance. If development projects have impacts on their ecology, these can have serious socio-economic significance. Tropical floodplain wetlands are used for agriculture, hunting, fishing, grazing, and gathering. Their economic importance can be very great. These economic functions may overlap in time and space, or may be used by different communities in different ways through a year. Hunting, gathering and grazing and fishing activities closely linked to the seasonal cycle of river discharge. The economic values of rivers are dependent on the interconnection of geomorphological, hydrological and ecological processes. Wetlands are also important in other ways, for example in sustaining regional groundwater levels.

3.3 Impacts on Downstream Farming Communities

Floodplain agriculture embraces a number of distinct practices, including farming on the rising flood (planting before the flood arrives, rice often germinating with the arrival of the rains, and harvesting either after the flood has fallen, or from boats) or on the falling flood (involving the use of residual soil moisture left by retreating floods). Floodplain soils often contain clay and hold water well. Water is usually trapped in backswamp areas and pools long after the river level has fallen. These can be enhanced by human-made banks to retain water. Farmers become adept at judging the likely duration of water and soil moisture in these areas, and plant suitable crops as the water makes this possible.

Flood cultivation is a high-risk activity that offers the chance of high returns. Floodplain wetlands are highly productive in ecological terms compared to the drylands which surround them, partly because floodwaters allow plant growth for a longer period. Floodplain wetlands are also relatively fertile. Annual inundation involves the deposition of silt and other solid material carried by rivers, which with the dissolved load of the floodwater can support continuous cropping in such wetland environments, without the fallowing which is so widely necessary in drylands.

Floodplain farmers deal with risk in several ways. First, they are often skilled in crop and variety selection. Different crops have different flood tolerance, and varieties of the same crop (e.g. rice or sorghum) can also have different ecological requirements. It is common to find crops with different requirements planted together in the same field as a way to minimise risk. In the Sokoto valley, for example, it is not uncommon to see rice varieties which need a lot of flooding mixed with a kind of red-seeded sorghum which can tolerate fairly prolonged flooding but does best on a little. The farmer increases the chance of a reasonable harvest whatever the flood level and duration.

Second, floodplain farmers often have a detailed appreciation of the variation in land types in the floodplain and experience of past patterns of flooding. The Marba of the middle Logone valley in Cameroon, for example, have a system of land classification that uses both soils and natural vegetation cover to distinguish unflooded land, unfallowed garden plots and more distant fallow plots, unflooded but seasonally damp land, and nine different named types of flooded land. Land types have recognised characteristics of soil colour or texture or vegetation cover and each land type has a distinct flood regime and particular requirements in terms of crops and fallow periods.

Third, flood farmers spread risk by exploiting environments outside as well as inside wetlands. Richards (1986) shows the importance to rice farmers in Sierra Leone of a 'rolling adjustment' to nature, an ability to move up and down slope to find sites with different soil moisture, fertility and drainage characteristics, and a knowledge of appropriate rice varieties. Short-duration rices are planted on river terraces and lower slope soils which retain water, using residual soil moisture and wet season runoff. Medium-duration rices are grown under rainfall on well-drained upland soils, and long-duration varieties are grown in valley swamps or water courses growing (if they survive) in deeper water. Straddling ecological boundaries, yet knowing the risks and opportunities in each, rice farmers innovate and survive with skill in environments both hazardous and potentially productive.

Fourth, floodplain farmers spread their options into different economic activities. Often, floodplain 'farmers' are also fish catchers, herders or dryland cultivators; sometimes all three. Just as the wetland provides an additional option for dryland farmers in times of drought, dryland agriculture can provide an important fall-back for wetland farmers in times of flood. Indeed, the balance between the two options, and others, can be very variable even within one region or ethnic group. Once again, flexibility is a key ingredient of success in indigenous production systems.

Floodwater farming is found in most major West African floodplains, for example the *firki* clay plains around Lake Chad, the Chari-Logone system in Cameroon or the Sokoto and Hadejin floodplains of Nigeria. The links between economic activities are particularly well best developed in the floodplain of the River Senegal. The River Senegal runs in a broad floodplain up to 30 Km wide for 600 Km downstream of Bakel. The total area of floodplain land is about 1 million ha, of which the amount actually cultivated in any one year is very variable. In the 1960s (when rainfall was good) about 150-200,000 ha were cultivated. With the drought of the 1970s the area fell to perhaps a tenth of that.

The economic value of floodplain agriculture can be significant, although there are few formal studies. Barbier *et al.* (1998) calculate that the net benefits from agriculture in the Hadejia-Jama'are floodplain in Nigeria to be 239 Naira per ha per year (US$1 = 7.5 Naira).

The impacts of dam construction on downstream agriculture can be significant. One case study is the Bakolori Dam on the Sokoto River, completed in 1978 (Adams 1985). In subsequent years it caused a significant reduction in peak flows and reduced the depth, duration and extent of inundation in the floodplain for 120 km downstream before the next major confluence with the River Rima (Adams 1985). In three survey villages, flooding was reduced by an average reduction of 50 per cent. The area cropped fell (from 82 per cent to 53 per cent of plots in one village), and a particularly marked fall in the area under rice (from about 60 per cent of fields to 14 per cent in one survey village) and in the amount of dry-season farming. The proportion of households undertaking dry season cultivation fell from 100 per cent to 27 per cent in one village (Adams 1985). It was estimated that of a total of 19,000 hectares of floodplain land, the dam caused the loss of 7,000 hectares of rice and 5,000 hectares of dry season crops. To an extent these losses were compensated for by increases in the area under millet and sorghum, but the new uncertainty about flooding patterns and the intolerance of millet to waterlogging following rain on heavy soils meant that farmers were not able to adapt wholly to the new conditions. Furthermore, although irrigation was a known and tested technology in the Sokoto Valley, the costs of well digging and the labour demands of water lifting were both increased because reduced floods were accompanied by increased depth to water table. As a result irrigation became a more specialised technique, only accessible to larger producers (Adams 1992). More recently, the Sokoto valley has shared with other parts of northern Nigeria in a boom in small petrol pumps for irrigation (Kimmage 1991), and it is possible that the economies of production have changed. Nonetheless, the initial impacts of the dam itself remain clear.

The magnitude of lost production in the Sokoto floodplain needs to be seen against predictions that the flood-control effects of the dam would allow increased production of rice from downstream areas. The value of lost downstream production can be estimated, and compared with the economic benefits in the command area. They have a significant negative effect on the benefit/cost ratio of the Bakolori Project as a whole (Adams 1985), although the vast costs of lost downstream construction are in this instance dwarfed by the economic failure of the dam and irrigation scheme themselves (Adams 1991).

Adrian Adams (1999) reports that in 1989 OMVS (Organisation pour la Mise en Valeur du Fleuve Sénégal) inflicted heavy losses on farmers in the lower Senegal Valley through a double-peaked flood. The initial natural flood, due to the unregulated tributaries of the River, receded fairly rapidly, and farmers had begun sowing flood-recession crops, when a second, artificial flood, released ‘for technical reasons’, drowned the seedlings in low-lying areas. Many farmers, for want of seed or labour, were unable to make a second sowing (Horowitz & Salem-Murdock, 1993). In 1990, although it was a drought year and most rain-fed crops in the Valley failed, OMVS wished to test the reservoir’s storage capacity, and decided not to release any water at all (A. Adams 1999).

3.4 Impacts on Downstream Fishing Communities

Dams can have significant effects on fishing communities for many hundreds of kilometres downstream. There is no doubt about a) the economic importance of freshwater river and floodplain fisheries, and b) their dependence on existing patterns of river flow (Welcomme 1979). Fish production is a basic element in the economy of many riverine communities, particularly inland lakes (such as the Tonle Sap in Cambodia) and various kinds of floodplains. Such capture fisheries can be very productive, and can provide important sources of protein across wide areas (e.g. the Sahel, Cambodia). The FAO estimate that there are over 60,000 fishermen on the Niger River (50,000 fishermen in the Niger Inland Delta, plus another 6000 on the River Niger in Niger and Nigeria, and 5000 on the Benue), and that together they produce 120,000 tonnes of fish per year, of which 75% comes from the Niger Inland Delta. Barbier *et al.* (1998) calculate the net benefits from fishing in the Hadejia-Jama'are floodplain in Nigeria to be 179 Naira per ha per year (US$1 = 7.5 Naira). Much remains to be learned about fish biology and ecology, and about floodplain fisheries, but the high productivity of floodplain wetlands is obvious, as are the close links between that productivity and the flood regime.

Dams impact fish in three ways. Firstly, dams can affect the physical stability of river channels. River bed degradation downstream of dams can also lead to the loss of important in-stream spawning grounds for fish. Rivers drop sediment in reservoirs, and as well as slowly filling up the 'dead storage' of the reservoir, the water released at the dam is clear, and is able to erode more material from the river banks and bed below the dam. This can cause serious damage to infrastructure at the dam (e.g. to strengthen the spillway of the Tarbela Dam in Pakistan, which helped double the cost of the dam, McCully 1996) and further downstream where river banks erode, threatening infrastructure such as bridge abutments and bankside villages, although more often channels stabilise. There is extensive knowledge in temperate rivers of ways to improve in-stream spawning of fish, such as provision of artificial substrates and artificial 'flood' releases. Research and expenditure on dam management reflects the economic importance of game fishing, and the power of the fishing industry.

Secondly, dams can affect fisheries through impacts on water quality. Declines in water quality can have significance for human health, and for the economies dependent on the natural resources of the river. Water released from low outlets in a dam (e.g. turbines) tends to be cold and may be deoxygenated, or rich in hydrogen sulphide. In Arctic areas dam releases can in Winter can be unnaturally warm. Such water may not mix with surface releases for long distances downstream, and if toxic can cause local fish kills. High mercury levels have been reported in fish in Arctic rivers downstream of dams.

Thirdly, and most importantly, dams affect fishing communities by changing natural flooding patterns. In temperate rivers there is a relatively detailed understanding of the impacts of dams on migratory game fish, and the development of responses in dam design (e.g. fish ladders), dam operation (the release of artificial floods) and downstream river management (e.g. in-stream, flow diversion structures) to minimise adverse impacts of control on fish stocks. Knowledge of the impacts of dams on fisheries in tropical rivers is less complete.

In tropical floodplain rivers, the impacts of dams on natural flood regimes can drastically reduce fish populations in both river channel and floodplain. Many floodplain fish are stimulated by rising seasonal flood flows to move into the floodplain to breed in the warm organically rich water. As the flood subsides, fish move back to the river channel, and in many cases eventually to the small and deoxygenated pools of largely dry river beds. If a dam reduces flood peaks fish fail to move or breed, reducing the population size and the economic return to the fish catchers. This has been reported from many rivers, for example:

- in the Yaérés, the extensive floodplain of the Logone River systems above Lake Chad in Cameroon (Benech 1992),
- in the Pongolo floodplain in South Africa (Jubb 1972),
- on the Niger in West Africa below the Kainji Dam (Lowe-McConnell 1985);
- below the Bakolori dam on the Sokoto River in Nigeria, where both fish catches and fishing effort fell (Adams 1985)
- along the Lower Sinu River in Columbia, where 60,000 fishing families were affected by reduced fish populations due to poor water quality as a result of the Urrá Dam on the Upper Sinu River in Columbia (Müller-Platenberg, pers.comm).
- on the lower Volta, where the *Egeria* clam fishery of was affected by construction of the Akosombo Dam because the critical salinity conditions for breeding moved 30-50 km inland due to reduced river flow; once operating the constant flows pushed the fishery down to within 10 km of the river mouth (Adams 1992).

3.5 Impacts on Downstream Grazing Communities

Floodplain wetlands provide important pastoral resources in many areas, particularly in Africa, often providing key areas of dry-season grazing and hence sustaining dryland grazing systems over large areas of surrounding drylands (Scoones, 1991). In the Niger Inland Delta in Mali there are about half a million people, including farmers, fishing people and two groups of pastoralists (Moorehead 1994). The productivity of the Niger Inland Delta depends on the fact that the period of high flood is different from that of the local rains because the Niger draws water from the Futa Jallon far to the southwest. The rains fall on the Delta between June and September. During this period the floods rise, peaking after the end of the rains, between October and December. The floods fall between January and March, and the Delta is dry between April and June. The Delta is extensively used for grazing between December and July. It supports over 1 million head of cattle and 2 million sheep and goats, 20% of the total numbers in Mali. Fulani pastoralists are resident in the Delta, and Tamasheq move in during the dry season. The Fulani leave the floodplain as the rains begin to graze livestock in rainfed savanna grasslands away from the flood. As grazing resources and surface water supplies run out, they move progressively back into the floodplains of the Delta and graze livestock on the pastures emerging from the floodwaters. In February/March their stock are grazing the dry lake beds in the North of the Delta, particularly on *bourgou*, (*Echinochloa stagnina*). The Tuareg are allowed onto the floodplain pastures later than the Fulani (Moorhead, 1984). The use of the Delta grasslands allows a remarkably constant supply of grazing resources. Elsewhere in Mali milk supply is episodic within the year. In the Niger Inland Delta, the availability of forage allows maintenance of milk supply through the year.

Similar patterns of seasonal use of the grazing available exist in other floodplain wetlands in Africa. In the middle Senegal valley, for example, floodplain resources are shared between different people in space and time. Herders' stock come into the clay basins of the floodplain late in the dry season, around mid-April, after the *décrue* sorghum is harvested, this agriculture itself following use by fishermen in the flood season. In the rains, herders move away from the river to graze their herds in the surrounding bushland. This annual cycle is both symbiotic (with cattle consuming crop residues and leaving dung) and also interdependent economically (with trade in livestock products and grain), not simply within the floodplain itself but also with the drylands outside.

Of course, this picture is rather idealised. Furthermore, in as much as such an ideal existed, it is now in flux, with increasing competition for resources and significant external pressure changing the terms of access to the floodplain. In the Senegal Valley, existing production systems are threatened by the construction of the Manantali Dam upstream, and associated irrigation development has led to conflict between farmers and herders, and to serious ethnic violence between Senegal and Mauritania (A. Adams 1999).

A decrease in flooding will lead to a reduction of the productivity of floodplain grassland (Acreman *et al.* 1999).

- reducing the area of “normal” flooding, decreasing livestock carrying capacity in the floodplain
- reducing the value of hinterland grazing, as the total carrying capacity of the dry season/wet season system is reduced
- reducing the fertility and hence primary productivity of floodplains, as sediment loads are reduced
- replacing nutritious floodplain grass species with less nutritious dryland species
- increasing the risk of overgrazing in the floodplain as the loss of seasonal flooding no longer forces livestock owners to move their animals to the hinterland on a seasonal basis.

3.6 Impacts on delta and coastal communities

The physical impacts of dam construction extend downstream into delta and estuary environments. The impacts on these environments are complex, remote from dam sites, and in areas often little studied and un-monitored. The impacts of upstream dams on deltas such as that of the Paraná are insufficiently studies (Ferradas 1999).

The significance of such effects has been argued in a number of cases, notably that of the Nile Delta following the closure of the Aswan High Dam, completed in 1969. There were problems of reduced soil fertility in the Nile Valley because of the lack of sediment in floodwaters and consequent erosion of the delta, and reduced flows which led to saline penetration of coastal aquifers. Nonetheless, various studies suggest that erosion in the Nile Delta caused ultimately by the restriction of sediment supply by the High Dam is a serious problem, particularly for fishing villages and highly productive coastal lagoon fisheries (Kassas 1973).

The impacts of the Urrá Dam on the Sinu River in Columbia was felt most severely in the lagoon fishery of the river mouth. Changed river flows had significant impacts on the aquatic ecology of mangroves in the delta, anmd the lucrative fishery based around them (Müller-Platenberg, pers.comm).

The impacts of dams can also stretch into the shallow marine environment. George (1973) identified links between marine fisheries in the eastern Mediterranean and the construction of the Aswan Dam. Patterns of sediment movement seem to have changed off the delta (Murray *et al.* 1981). It is argued by some analysts that downstream impacts of Aswan are small, over-estimated and 'under control' (Shenouda 1999)

The closure of the Cahora Bassa Dam on the Zambezi in Mozambique changed the seasonal flow regime of the river, and the associated supply of nutrients to the shallow coastal waters. This has had a significant (and negative) impact on the recruitment of shrimps on the Sofala Bank and the lucrative inshore shrimp fishery (Gammelsrød 1996). Shrimp landings from this fishery have ranged from 7-10,000 tonnes. Catch per unit effort is closely correlated with river discharge from 1975-1988. Catch per unit effort in the fishery is improved by high wet season flows, and reduced by high dry season flows. Shrimp larvae use mangrove areas as nurseries in the dry season, and are taken offshore in the wet season. Increased runoff in the dry season may prevent larvae coming in-shore, while reduced wet season runoff may reduce recruitment offshore. River regulation, and smoothing out of river flow peaks, therefore has a direct impact on offshore fish catches Gammelsrød 1996).

3.7 The Economic Impacts of Dam Construction, Hadejia-Jama'are Wetlands, Nigeria

In the north east of Nigeria, the Hadejia and Jama'are rivers join, forming the Komadugu Yobe, and drain towards Lake Chad. Around their junction is an extensive floodplain complex of seasonal wetlands and pools, fed by the seasonal flood flows. This area is of enormous economic and ecological importance, supporting a large human community engaged in extensive rice farming, grazing, fishing. The combination of upstream dams (to supply rather unsuccessful large scale irrigation schemes) and low rainfall through the 1970s and 1980s has caused significantly reduced flooding in the wetland. This in turn has had considerable impact on flood-recession farming, fishing and grazing and has had measurable economic costs (Hollis *et al.* 1994, Polet and Thompson 1996, Barbier *et al.* 1998).

A analysis of the value of agriculture, fishing and fuelwood in the Hadejia-Jama'are Wetlands (Barbier *et al.* 1998) suggests the present worth of these benefits to be between N850 and N1280 per ha (N7.5 = US$1, 1989-90). In terms of water availability, the present net economic value of economic benefits is calculated as between 256 and 389 N/1000m^3. However, this figure includes wheat production, which may not be environmentally sustainable - if this is excluded, the benefits are between 242 and 366 N/000m^3. These figures exclude a wide range of other economic benefits, such as groundwater recharge, livestock and grazing, non-timber forest products and wildlife tourism (Barbier *et al.* 1998).

The calculated benefits (and those not calculated) are dependent on river inflows, and increase and decline in proportion to the extent of flooding, although this variation in economic productivity is not linear. There is also a complex spatial component to the dynamics in the agricultural economy, since spatial patterns of flooding are variable between years. Furthermore, the availability of small petrol pumps has allowed the expansion of irrigation in some villages and households, and to some extent mitigated the impacts of desiccation and allowed some floodplain people to improve their economic position in the face of environmental degradation (Kimmage 1991, Thomas and Adams 1999).

3.8 The Impacts of Dams Downstream due to Urban Development

A major positive economic impact of dam construction is the creation of new economic activities in rural and urban areas. If poorly serviced and regulated, however, these can themselves cause significant impacts on downstream environments. For example, in Paraguay and Brazil, the growth of the cities of Ciudad del Este and Foz do Iguaçu was greatly stimulated by the construction of the Itaipú Dam (Ferradas 1999). Because of the speed of the urban growth and the lack of adequate planning and investment in infrastructure, the cities lack sewage and garbage disposal systems. Most of the cities' waste is therefore thrown into the rivers without treatment, with significant impacts on downstream water quality. These impacts are combined with changes in river flows and have had serious impacts on the fish population and those people downstream whose subsistence was based either on agriculture or on fishing. Neither the Argentine government, nor the Paraguayan government, nor the provincial governments from the two countries have conducted studies to assess these effects downstream. Toxic materials from rural production (mainly pesticides) are also drained into the River Paraná (Ferradas 1999).

3.9 Impacts of Dams on Assets

There is a limited amount of research that documents the impacts of dams on the livelihoods of downstream communities. One framework for assessing these impacts is the idea of 'sustainable livelihoods' (Chambers 1988, Carney 1998, Acreman *et al* (1999). Carney (1998) identifies five forms of capital that underpin the *assets* of the poor: natural capital, financial capital, physical capital, human capital and social capital. They use this framework to review the impacts of large dams on assets, strategies and outcomes.

The downstream impacts of dams is on natural capital (on natural resources viewed as an asset for building livelihoods) have been extensively reviewed above. Impacts on other forms of capital include:

- Partial erosion of traditional patterns of social cohesion on the Tana river, based on age-groups and communal work groups since the interruption of floods.
- Increase in disputes between herders and farmers (e.g. Hadejia-Jama'are Nigeria, Tana River, Kenya).
- Impacts on land values in Mauritania following creation of the Manantali dam, and resulting conflict (Horowitz and Salem-Murdock 1991, A. Adams 1999).
- Farmers downstream of the Bakolori dam have been alienated by their inability to communicate with irrigation authorities over the threats to their livelihoods (Adams 1992).

Direct and indirect impacts on other forms of capital. are summarised in Table 3.1 (Acreman *et al.* 1999)

Table 3.1 Direct and indirect impacts of dams on capital

Type of capital and definition	Downstream impact of dams
Natural capital: the natural resource stocks from which resource flows useful for livelihoods are derived	Cessation of floods causes reduction in flood recession cultivation (Senegal, Sudan), dry-season grazing (Zambia, Nigeria) and fisheries (Nigeria, Thailand*). Reduction in availability of fuelwood, wildlife*
Financial capital: the financial resources which are available to people and which provide them with different livelihood options	*Indirect impacts through reduced access to natural capital.* If livestock are considered to constitute financial capital, profound impacts through disruption of seasonal grazing (Botswana)
Physical capital: the basic infrastructure and the production equipment and means which enable people to pursue their livelihoods	*Promises of improved public infrastructure, including power, for downstream populations may not be kept. Household physical capital may be indirectly effected through reduced access to natural capital and reduced income*
Human capital: the skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies	Health. *Indirect impacts on education. Loss of human capital when indigenous knowledge of the environment becomes irrelevant.*
Social capital: the social resources (networks, social claims, social relations, affiliations, associations) upon which people draw when pursuing different livelihood strategies requiring co-ordinated actions	Traditional patterns of collaboration within and between ethnic groups (stock loans, work groups, feasting, access agreements) eroded by irrelevance to new environment and dependence on state services (Kenya, Sudan). Conflict over access to resources (Mauritania)

Source: Acreman *et al*. 1999

Notes: Significant and demonstrable impacts are in ordinary type, with a river basin or country name appended. Minor or hypothesised impacts are in italics.

Dams have complex impacts on livelihood strategies (Table 3.2). There have been few studies of the impacts of dams on non-natural resource-based strategies and migration.

Table 3.2 The impacts of dams on livelihood strategies and impacts

Livelihood strategy	**Impact of dams**
NR-based	Profound changes of strategy, away from flood recession agriculture and livestock production and towards more input-intensive small irrigation. Either reduction or increase in wood collection, charcoal production
Non-NR-based in Situ	Diversification, often on unfavourable terms, into petty trade, handicrafts, wage labour. Where NR-based strategies are seriously disrupted, there may be secondary negative effects on existing rural and small-town employment.
Migration	Demonstrable increase in out-migration to towns. Changes in seasonal and permanent settlement patterns of fisherfolk

Examples of the impacts of dams on livelihood strategies include the following (Acreman *et al.* 1999):

- Downstream of Khashm el Girba dam in Sudan, the percentage of households involved in agriculture as a primary occupation fell from 92% to 81%. Manual labour and trade increased in importance. About 5% of the settled population left the area, and some villages completely disappeared, while others were severely depopulated.
- The Pongolapoort dam was partly responsible for high labour migration out of the Phongolo floodplain from the 1950s onwards.
- Farmers on the Tana river have had to diversify into activities such as casual labour, small-scale trading and charcoal burning, as well as long-term dependence on food aid.
- Literature on the Senegal Valley projects profound secondary negative effects on rural non-farm and small town employment from the large-scale decline in agricultural income.
- In various parts of the world, floodplain fisherfolk have had to move to new fishing grounds, often in the reservoirs created by the dams.

There are few studies of the impacts of dams on livelihood outcomes, even at the most simplistic level of incomes (Acreman *et al.* 1999, Table 3.3).

Table 3.3 The impacts of dams on livelihood outcomes

Livelihood Outcome	**Impact**
Income	Declines in income for cultivators due to decline in areas cultivated and increases in real costs of production. Secondary negative effects on rural non-farm and small-town incomes. Assumed decline in fishing and livestock incomes
Well-being	Decline in social capital and disruption of culturally important seasonal cycles
Vulner-ability	Apparent control of floods may lead to increased vulnerability to flooding through riskier settlement patterns
Environ-mental sustain-ability	Reduced availability of grazing, fuelwood, fisheries in floodplain may lead to overexploitation of resources elsewhere

4. Dam Planning and Downstream Impacts

Dams are designed to have a specific impact on downstream environments by changing the distribution of water in space and time (e.g. through water storage or flood control), and will inevitably have impacts of society and economy, on cultures, individuals and groups and classes of people. The problem is that because of the complexity of the linkages between different features and functions of the environment, and because of the limitations of technical planning (particularly where good long-running data sets are lacking), downstream impacts may be poorly predicted and understood.

The case studies reveal a wide range of experiences with downstream effects. In many past dams, planning at this time made no formal attempt to consider downstream environmental, social and cultural impacts. In the case of the Pangue Dam on the Bio-Bío River in Chile, the environmental assessment did not consider downstream impacts and water release patterns of Pangue, and failed to provide a full picture of Pangue and Ralco dams on the environment of the Bio-Bío valley (Silva 1997). Usher and Ryder (1997) argue that such failures on environmental assessment are characteristic of dam projects. The impact of the Theun Hinboun Dam in Laos (a tributary of the Mekong) on subsistence fisheries and the food security of floodplain communities were systematically ignored or underplayed in environmental impact assessments, with the result that the project's costs were not recognised (Usher and Ryder 1997).

Planning for downstream effects is some decades behind that of upstream (resettlement) effects. Downstream impacts are just as likely to be ignored or underplayed in dam design as upstream impacts, but in addition they are considerably less well understood by dam designers. There are a variety of reasons for this.

Technical assessment of the nature and extent of downstream impacts requires extensive environmental, social and economic data, preferably including long time-series. Such resources are unusual. Assessment of downstream impacts also demands a high degree of knowledge of ecosystem dynamics, and an ability to be able to make realistic predictions about their response to stresses of various kinds, and above all an understanding of the society and culture of potentially affected people. Knowledge of local languages is as important to effective dam design as knowledge of computer models, and much more relevant to the task of avoiding unforeseen and unwelcome impacts. Many river valleys are remote, and formal knowledge of their people and their livelihoods and culture (derived from in-depth or long-term study) is quite likely not to exist. Without such knowledge, dam planners can only rush to acquire such knowledge, or guess. Neither strategy is likely to deliver good policy.

The established response to the lack of indigenous expertise is to bring in outside 'experts' in the form of consultants. Foreign experts may command a legitimacy derived from their technology, expertise and experience, but they often lack local knowledge. Their planning therefore often involves the adaptation of off-the-shelf standardised blueprints, rather than engagement with problems from scratch. If appointed for a short contract, or late in the planning process, it is likely that their work will be rushed.

Disciplinary bias inherent in the dam planning process has significance for downstream impacts. Project appraisal is dominated by the 'hard' technical disciplines such as engineering, hydrology and agronomy, and only by the most technocratic of the social sciences, economics. Most project feasibility studies are undertaken by companies dominated by these disciplines, or by consortia typically dominated by engineering companies. The appraisal process concentrates on technical problems relevant to these disciplines. The characteristics of the population of downstream environments, their economy and society, are neither recognised or understood. Field investigations concentrate on the dam site, and not the downstream area. Engineering companies called in at each successive stage of project appraisal lack the skills necessary to comprehend resettlement planning problems. 'Soft' disciplines like ecology, geography, anthropology or sociology central to a holistic appraisal of impacts tend to be marginal to the planning process. Sociology and ecology are typically slotted in with perhaps a one or two person-month input on a project where the total planning input is several person-years and are often begun too late to influence project decisions in a significant way. Local people, who while untrained in formal knowledge may have a clear idea of the significance of impacts if they are told about the dam, are rarely considered as a source of knowledge or ideas.

The problem with effective planning for downstream impacts is their inherent complexity. To many observers, the hard part about building a dam would probably seem to be the geotechnical or engineering challenge, or the sheer logistics of building a massive artefact in an area remote from supplies of petrol, engineers and cement. In fact, social impact planning has often proved the Achilles heel of reservoir projects, seemingly straightforward but in practice fiendishly complicated. It typically involves a series of tasks, including population and socio-economic survey before the scale of the problem be assessed. Knowledge of the costs of negative impacts is of course a vital element in the assessment of the practicability and acceptability of the project as a whole. Without it, all the technical planning and design may prove useless. However, data on impacts are rarely available in a suitable form in sufficient time to influence decision-making about dam construction. Downstream impacts are regarded as a secondary problem, to be addressed once the technical feasibility of the project is known. The sunk costs of technical engineering appraisal are such that it can be hard to stop a project once the full social costs are finally factored in.

The full assessment of impacts can represent a considerable element in the costs of project appraisal, particularly if taken seriously. Impact appraisal costs are sunk before it is known whether the project is technically, environmentally and economically viable, and will not be recouped if the project does not go ahead. They also take time, and might be seen therefore to hold back the project appraisal process, and delay the moment when economic benefits can be realised. There can be strong financial incentives to truncate or speed up assessment procedures, or even omit them altogether. On the other hand, it is clear that tight project development schedules can prevent effective assessment of social impacts procedures.

If the assessment and mitigation of impacts is important, it needs time and money. Furthermore, if the results of such studies show that the costs of dam construction are unacceptable, it must be possible to stop the project. If impact assessment is simply seen as a bureaucratic hurdle of no great importance, it will be unsurprising if dams continue to have serious downstream social impacts.

Downstream impacts do represent real economic costs. They are often seen as somehow an added extra, additional to the costs of construction. It is as if they were in some way optional. Failure to specify a clear approach to equity and lack of data on the affected population can lead to serious underestimation of costs. If social impacts are a significant element in total project costs, it is vital that they are addressed seriously and early, because they will alter the cost/benefit calculations of the dam irrevocably.

4.1.1 Pre-project Surveys

It is suggested as a principle that 'analysis of the impacts of dams impacts should be holistic, in spatial, social and economic senses' (**Principle** 1, Chapter 6). In downstream areas, there need to be:
1) detailed hydrological studies to predict spatial and temporal changes in flooding patterns (with specific attention to groundwater);
2) studies of existing economic activities (especially fishing and agriculture), and costed assessments of economic impacts;
3) surveys of property, resource-use rights (formal and informal), and cultural engagements with place that are likely to be impacted by the dam;
4) careful baseline studies of health, formal and informal economy, gender divisions of labour, social and cultural practices.

It is suggested as a principle that 'a programme to monitor the impacts of dam development (particularly in downstream communities) should be an integral element of the planning process, and should be matched by resources to mitigate impacts not addressed fully by the planning process' (**Principle 2**, Chapter 6).

Human rights and key socio-economic parameters need to be monitored, at least along the river valley in the early years of dam operation. These parameters should be disaggregated enough in order to capture and address imbalances in the distribution of socio-economic costs and benefits of dams. It is important to generate gender-specific indicators that take into account the varied locations of men and women at all levels of society. Special financial resources, human and institutional resources should be built-in the dam project design to address unanticipated social and economic problems emerging from the monitoring activities. Affected people who feel they are experiencing negative impacts should be entitled to request quick appraisals, inspections, and specific research to document the seriousness and scope of the problems and to find solutions.

> There is therefore a pressing need for careful monitoring of impacts. There is little knowledge about socio-economic impacts of dams due to lack of knowledge of and monitoring of downstream economic activities. The remoteness of downstream areas and the complexity of impacts downstream and across the floodplain are major constraints on such work, but it is important. New dams should include a formal environmental and socio-economic monitoring programme, specifically designed to provide the data for post-hoc analyses of distribution, and hence to aid the learning of dam designers in this dimension of their work. Established dams should be subject to careful audit, with particular regard being paid to their downstream impacts.

Monitoring must be designed in the light of the way in which impacts change at different stages of the dam project. It should also distinguish between short term and long term affected groups at project preparation (design and evaluation) stage.

Monitoring is also vital to the good management of dams, and should include the establishment of a survey baseline to allow tracking the evolution of formal income and informal livelihoods, the income of identified target groups in relation to the project resource distribution and prices, or one or more key indicators (e.g. health, education, migration). This survey/tracking needs to take specific account of gender.

However. it should be noted that monitoring of itself is of little value unless it is linked directly and clearly to explicit procedures for ensuring accountability for negative impacts, and to procedures for addressing them. This issue is discussed further in Adams (2000).

As Adrian Adams points out in her paper (1999), even where downstream effects are explicitly considered as part of the development planning associated with a dam (as in the case of the irrigation of the lower Senegal River following the construction of the Manantali Dam and the Diama Barrage), the result may not be to the benefit of downstream users. The integration of a dam and downstream water users than simply a proposal to transform the face of floodplain agriculture wholesale from flood-cropping to irrigation. To the impacts of the dam itself there need to be added the impacts of an unsustainable blueprint for 'development' downstream. It is possible for the 'solution' to downstream impacts to become a problem of its own.

5. Integrating Dams and Downstream Users

5.1 The Need to Re-integrate Dams and their Floodplains

Downstream impacts of dams occur because of a dislocation between the capacity of the dam to provide the resources necessary to sustain downstream economy and society (either because it reduces available resources such as water, or fails to provide an adequate alternative). A critical element of planning for distribution and equity is therefore the need to re-connect dams and downstream users. Adrian Adams (1999) suggests the need in the Senegal Valley to refocus valley agriculture around 'renewed complementarity between flood-recession, rain-fed and irrigated farming'. She describes the possibility of using the Manantali Dam to release a flood to support floodplain agriculture and grazing, although she is also cautious about the prospects of making this work in the light of the persistent disregard for downstream users needs and an overwhelming interest in electricity generation on the part of the dam's managers (Box 1)

The idea of integrating the releases of water from upstream dams and the needs of people and ecosystems in downstream floodplains is being widely discussed (e.g. Scudder 1980, 1991, Scudder and Acreman 1996). Such planning is not simply a technical task. The diversity of downstream needs makes it effectively impossible to devise a single solution that automatically takes account of all interests. The possibility of community based management of water releases from dams has been tried in the Phongolo floodplain in South Africa. Here some 70,000 people depend on wetland resources sustained by the flooding of the river (Bruwer *et al*. 1996). The Phongolo was dammed in the 1950s, but the Pongolapoort Dam was only filled to 30 per cent of capacity to avoid inundation of part of Swaziland. Water was released from the dam to serve downstream communities, but the restructured floods up to 1984 were smaller and unpredictable in timing, and created a risky environment for floodplain resource use. In 1984 the reservoir was filled to capacity by floodwaters from cyclone Dominoa, and larger releases began to be possible. This enabled ecological conditions in the floodplain to be restored, but it did nothing to reduce uncertainty for floodplain people. From 1983 downstream villages began to organise themselves to present their needs and interests, and gradually 'combined water committees' were set up. In 1988 a Liaison Committee met to hear the views of all stakeholders. There are now careful agreed procedures for Ward Water Committees to communicate their needs for floods to the Department of Water Affairs. The result is reported to be positive local attitudes to the possibility of managing floodplain water effectively, and a move towards sustainable utilisation of the floodplain (Bruwer *et al.* 1996).

5.2 An Example: the River Senegal (Adrian Adams 1999)

Maintenance of an artificial flood is an officially stated objective for the Senegal Valley. In 1996, the Institut de Recherche pour le Développement (IRD, formerly ORSTOM) was entrusted by OMVS with the task of conducting research on the optimisation of reservoir management. The Manantali Dam is built on the Bafing, the main tributary of the Senegal River, which is responsible for over half the flow measured at Bakel; the two other major tributaries, the Bakoye and the Falémé, are unregulated. The artificial flood thus has two components: the natural flow of the Bakoye and Falémé, and an additional release of water from the Manantali reservoir. In practice, the artificial flood is the result of releases from Manantali, calibrated on the basis of the rate of flow of the unregulated tributaries, in such a way as to achieve the desired rate of flow at Bakel. Its volume will increase if the rate of flow of the Bakoye and Falémé is weak. Ever since Manantali became operational, the River’s rate of flow has been weak or average, so that releases from Manantali have been the essential component of the flood.

When research began, digital simulation of dam management, based on data available for 1950-1993 on the River’s natural rate of flow, showed how the dam would have functioned had it been in existence since 1950. Three possible management scenarios were considered:

- Scenario 1: priority to the needs of agriculture (both irrigated and flood-recession),
- Scenario 2: priority to the production of electricity and the needs of irrigation (no flood support),
- Scenario 3: taking into account all three of the major uses of the dam (water for irrigation, production of electricity, and flood support for flood-recession farming).

Comparison involved the quantity of electrical energy produced, and the area available for flood-recession farming.

Scenario 3 would yield the results shown in Table 5.1, where they are compared, for the sake of comparison, with the results of the River's unregulated natural flow.

Table 1: Flood Recession under Scenario 3

Multi-use dam management	***Unregulated river***
50,000 hectares of flood-recession crops one year out of 10, 40,000 hectares one year out of two	50,000 hectares of flood-recession crops one year out of three
Yearly average of 30,000 hectares during the period under consideration.	Yearly average of 57,000 hectares
No flood-recession crops at all one year out of three	Fewer years when flood-recession farming is possible

Scenario 2 would allow no flood-recession crops at all. As far as electricity production is concerned, of course it is Scenario 2 which gives the best results.

Scenario 1 yields results very close to 3, because when the river's rate of flow is weak (as during the period under consideration), there are few releases which cannot be used for energy production.

In 1997 IRD released an artificial flood close to the hydrograph used as a standard. Satellite images suggest that the area available for flood-recession farming is of the order of 70,000 hectares, 45,000 hectares on the left bank and 25,000 hectares on the right bank. A rapid survey of SAED agents and people living near major areas of flood-recession land suggests that this flood was generally satisfactory, although it was sometimes judged not to have lasted long enough for satisfactory flooding of low-lying land. It was much better than in 1996, when there was scarcely any flooding, but distinctly inferior to that of 1995. ' (IRD-OMVS, 1999). From 1998 , if the deficiencies of the 1997 flood are corrected, OMVS should have at its disposal the technical conditions required for flood support from Manantali.

The creation of an institutional framework for re-imagining dams as serving downstream communities directly, rather than simply treating them as potential losers to be compensated, is a challenging task. Adrian Adams (1999) points out that in the case of the Senegal River, this is quite separate from the technical considerations. In order for 'flood support' to be carried out, 1) there must also be the political will to provide such support, and 2) the private operator of the Manantali dam must have received explicit and binding instructions to that effect. While the possible technical merits of an artificial flood for downstream farmers is recognised, there remains uncertainty about the will of the associated countries to maintain it, a suspicion confirmed by OMVS's pursuit of the navigation component of its programme, which will require a year-round level in excess of that required by irrigation.

There is a fundamental choice to be made in agricultural policy for the Senegal River Valley, between striving to make the dams generate revenue, or using them to ensure the survival of downstream family farming and related activities. This debate has not taken place, and if the debate does not take place now, the question will be resolved once and for all, and the losers from Manantali Dam will have lost out forever.

In the absence of any political will to enforce flood support from Manantali, the only hope would seem to be for pressure to be brought to bear on donors by an alliance of dam-affected people and advocacy groups, to ensure that the outcome of final negotiations on the Water Users' Charter and Management Handbook, guarantees regular flood support, calibrated to meet the needs of downstream farming and pastoralism while consolidating present levels of irrigated farming and safeguarding its future as a sphere of individual initiative open to peasant farmers and others. This would be an extremely difficult negotiation to achieve, because, as already said, it implies not minor adjustments, but a major shift of priorities: 'making the last first,' to borrow a phrase.

5.3 Other Experiences

These problems at Manantali reflect the more general analysis of Acreman *et al* (1999). They identify a series of problems relating to the ownership or control of the dam, and constraints on freedom to allocate water. They point out that even though dams are often multi-purpose, control may not reflect the full range of potential uses. For example, a dam for hydropower may be managed by the Ministry of Energy, who may be resistant to making flood releases which would reduce the amount of water available for hydro generation. A dam for irrigation, managed by a Ministry of Agriculture might also be resistant to releasing water for small–scale floodplain agriculture. Different levels of government have different priorities (e.g. conflict between the Federal and Provincial Agencies, as in Nigeria). The solution to this problem must involve all relevant government departments, for example in an inter-ministerial committee that can act as the decision-making body governing the operating principles of the dam.

Acreman *et al* (1999) describe the example of different organisations having different responsibilities can be seen in the case of the Mahaweli dam in Sri Lanka. This is the overall responsibility of the Mahaweli Authority of Sri Lanka (MASL), under the Ministry of Mahaweli, Lands and Irrigation: 'Various divisions within the Water Management Panel (WMP), a policy making body within MASL, are responsible for administration of watershed management, hydroelectric generation, water diversions and distribution, and environmental management concerns to achieve optimum benefits from the Mahaweli scheme. The WMP makes operational policy decisions and sets out the overall cultivation programmes for irrigated areas served by the Mahaweli system based on the advice received by the Water Management Secretariat (WMS) a unit of MASL. The WMS also co-ordinates and implements selected policies, including the diversion and distribution of water and the monitoring of the programme. Irrigation water management responsibilities at the project level rest with the Mahaweli Economic Agency (MEA) and the Irrigation Department (ID) closely co-ordinating with WMS to ensure adequate supplies. Operation of the hydroelectricity stations associated with the dams is under the direct control of the Ceylon Electricity Board (CEB). The board recognises the role of the WMS in monitoring compliance with overall policy and specifying weekly releases to meet the needs of irrigation users but has the ultimate goal of operating the electrical systems in the most economically and reliable manner.'

Acreman *et al* (1999) identify four main types of ownership:

- Single or primary authority ownership (e.g. a power utility);
- Committee of primary authorities (e.g. joint ownership by power and agriculture ministries)
- Independent authority (e.g. river basin authorities, Nigeria, Kenya)
- User committees (e.g. representatives of communities and stakeholder participation, Phongolo)

6. Principles for Taking Account of Downstream Impacts

Five principles are suggested below that indicate how downstream impacts could be taken into account by dam planners.

1. Analysis of the impacts of dams impacts should be holistic, in spatial, social and economic senses.
Discussion: Dams should not be considered as projects isolated from their broader basin contexts. Assessments of the impacts of dams must include specific consideration of all affected people, including those living downstream whose subsistence depends on the natural flow of the river and its associated natural resources. These assessments must take specific account of gender.

2. A programme to monitor and periodically re-examine the impacts of dam development in downstream communities should be an integral element of the planning process, and should be matched by resources to mitigate impacts not addressed fully by the planning process.
Discussion: Human rights and key socio-economic parameters need to be monitored, at least along the river valley in the early years of dam operation. These parameters should be disaggregated enough in order to capture and address imbalances in the distribution of socio-economic costs and benefits of dams. I t is important to generate gender-specific indicators that take into account the varied locations of men and women at all levels of society. Special financial resources, human and institutional resources should be built-in the dam project design to address unanticipated social and economic problems emerging from the monitoring activities. Affected people who feel they are experiencing negative impacts should be entitled to request quick appraisals, inspections, and specific research to document the seriousness and scope of the problems and to find solutions.

3. All people who depend on the natural flow of the river and its associated natural resources for their subsistence should be adequately compensated for losses resulting from dam construction, or be among the primary recipients of benefits generated.
Discussion: The existence of an overall balance between positive and negative impacts should not be taken as the only criteria of a project's acceptability. The distribution of costs and benefits is also important, and heavily impacted groups (especially those downstream) should not bear uncompensated costs without balancing benefits.

4. The existing individual and community rights of riverine populations to natural resources to be affected by planned dams should be recognised in assessing potential losses and in devising mitigation measures, whether these rights are codified or informal, whether they relate to ownership or usufruct rights,
Discussion: Often ignorance of customary law and local use understandings of access to and control over resources can undermine the existing rights that women or indigenous people or other traditionally marginalised groups have over resources, in particular common property resources. Cost benefit analysis should be broadened to include intangible social, cultural impacts.

5. Project planning should allow for the participation of people affected by project development in downstream areas.
Discussion: This is the clear implication of agreements at the Rio Summit and the Copenhagen Summit. It is a challenge for two reasons, first because of the technical complexity (and cost) of dam design, and secondly because of the large and diverse communities affected by dams. However, while the principle of participation may require new approaches to planning, this needs to happen. Authentic and effective participation must take place in a way and at a time when decisions about the project and mitigation of its impacts can be influenced. Cost/benefit analyses should be balanced by participatory forms of planning involving all actors where all have a say in determining and assessing the nature of the costs and benefits and their effects on their lives, livelihoods and environment, and the nature of mitigation. The rights of those directly affected by large dams must include the right to be heard, and the right to information in a complete and culturally appropriate form. Gender-sensitive policies are needed to ensure that women can articulate their fears and apprehensions without intimidation from state, community or agencies.

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