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## 1. ARTIFICIAL FLOOD RELEASE:

### 1.1 FLOOD RELEASE AND FLOODPLAIN MANAGEMENT

Acreman-M; Howard-G. 1996

The use of artificial floods for floodplain restoration and management in sub-Saharan Africa.

IUCN-Wetlands-Programme-Newsletter  
No. 12 January 1996, 20-25

#### *Summary:*

This article provides comprehensive overview of the issues surrounding the artificial release of flood waters from reservoirs as a sustainable method of floodplain management in sub-Saharan Africa.

The article provides summaries of a number of cases where artificial floods have been attempted and assesses the potential, limitations and implementation difficulties of creating artificial floods in sub-Saharan Africa.

**Note:** The text of this article is attached at the end of this Annex.

### 1.2 MANANTALI DAM, SENEGAL

#### 1.2.1 Summary

- Dam Purpose: Hydropower, river regulation, and barge transportation
- Major impacts on downstream agriculture and on wildlife
- Flood release allowed for but these were planned as a temporary measure only, and affect only 50,000 hectare compared with an estimated 250,000 ha prior to dam construction.

- Reservoir operation is being re-examined in order to attempt to provide a more substantial flood release at minimal expense of hydropower. In reality, during a great majority of years there is expected to be no reduction in hydropower generation capacity as a result of controlled flood release.
- Along the left bank of the Senegal River, most of which is in a low rainfall Sahelian zone, 800,000 people support themselves with a diversity of smallholder productive activities. They fish, rear livestock, cultivate rainfed millet, flood-recession sorghum, and irrigated rice. This diversified system, which is well adapted to the floodplain environment and depends on the annual flood, is threatened by the Manantali and Diama Dams, which may seriously alter basin ecology.
- The challenge to development planners is to devise a strategy minimizing the adverse affects of the dams while maximising their benefits through maintenance and enhancement of existing production systems, the improvement and possible expansion of irrigation, and the generation of hydroelectric power.

## 1.2.2 References

Drijver, C.A. & M. Marchand, 1985

The Middle Valley of the Senegal River, (Senegal).

Case Study in Taming of the Floods, edited by C.A. Drijver and M. Marchand, Commission of the European Communities Centre for Environmental Studies, State University of Leiden, December 1985.

### *Abstract:*

The middle valley of the Senegal River is an area of 10,000 km<sup>2</sup> between the border of Richard Toll and Bakel. The author describes the natural and human geography of the area, the population and land-use systems. About 550,000 people live here. They are involved in herding, fishing and agriculture. The fisheries have been traditionally very rich. The total harvest used to add up to 33,000 metric tons in a year of average rainfall - 48 million US\$ dollars (1977). Drought conditions in recent years have reduced the catch.

The author describes in detail the traditional system of crop culture in the floodplain known as 'Walo': "Directly after recession of the floods the culture starts. According to the different ecological zones, several types of 'Walo' - culture can be distinguished; the 'Falo', the 'Hollade' and the 'Fonde'."

- The 'Falo' is found on the relatively steep slopes of the riverbed. These soils are often well enriched with silt. They are of the utmost importance during the dry season for the culture of maize, beans, watermelons, tomatoes and potatoes. Their surface is limited (5,000-8,000 ha) but yields are significant (10,000 tons/yr.).
- The 'Hollade' form the largest areas of recession culture, they include vast depressions that are more or less regularly inundated. Mainly millet is

cultivated associated with beans and watermelons.

- The 'Fonde' are the higher grounds that are only inundated and cultivated after strong floods. Their irregular flooding makes them less valuable than the 'Falo' and 'Hollade'.

As a whole, the Fonde's and Hollade's area under cultivation varies between 40,000 - 180,000 ha resulting in total yields of 16,000 - 72,000 tons per year.

Since 1972 all this has been changing. Some 30,000 ha are now under irrigation, of which 25 per cent are for agro-industrial use, (large sugar cane plantations), 20 per cent are watered by small irrigation schemes and 50 per cent by large irrigation schemes.

In 1972 the Senegal Scheme (OMVS) was set up involving two dams, the Manantali dam and the Diama dam. Since then the droughts in combination with an increasing over-exploitation of pastures, forests and fish populations, has caused a frightening deterioration of the natural resources of the middle valley. Their future restoration is totally dependent on the return of wetter years. However, the proposed development of dams and irrigation schemes will affect all basic ecological conditions of the valley and will block such a return to the original natural state.

The authors sum up the consequences of the scheme as follows:

The upper basin near Manantali:

- loss of savanna, savanna forest and riverine forest as a living and production area for ca 16,000 people due to inundation of the reservoir site.
- loss of corresponding fauna,
- water quality problems and negative impact on fisheries after inundation of the present forests at Manantali,
- increased occurrence of water-related diseases.

The middle valley:

- loss of floodplain area, and corresponding production of recession culture (Walo),

- Loss of floodplain pastures, a grazing resource for semi-nomadic herding,
- loss of floodplain forests as a resource for fuelwood, timber and additional grazing,
- loss of floodplain aquatic environment and corresponding fish production,
- possible drying up of wells.

The middle valley and the delta:

- possible contamination of groundwater by agricultural wastes,
- increased occurrence of water-related diseases like malaria and schistosomiasis.
- increased occurrence of pests from mice and rats.

The delta:

- risk of salinisation of topsoils by the rising of the groundwater level,
- loss of estuarine environment and production of shrimps and estuarine fishes,
- partial deterioration of the Djoudj National Park, Senegal's most important bird sanctuary.
- acceleration of the threatened extinction of lamantines,
- loss of area under cultivation for vegetables,

The local people will lose 67,000 ha at present in recession culture and 179,000 ha of grazing land; but the remaining areas in the floodplain will be difficult to use, as according to them, they will be hampered by irrigation structures. This will put pressure on traditional herders, who are likely to exploit rain fed pastures that remain at their disposal more intensely, causing erosion and desertification.

The authors describe the nature of floodplain forests (Gonakie forests) which grow on river banks and depend on floods for reproduction and growth of seedlings. These have been severely depleted since 1972 and further losses are likely with the consequences of the Diama dam. The total elimination of flooding as projected by the year 2028 would lead to the total disappearance of the Gonakie forest. In the meantime, wood consumption by the

local inhabitants is increasing. Six hundred and seventy thousand metres a year is nine times more than the annual growth of the forest. At this rate all forests in the area will be destroyed in a matter of years.

The loss of 360,000 ha of floodplains after the construction of the Manantali dam is likely to lead to a reduction of 21,600 metric tons of fishing potential and put 12,800 fishermen out of work. Many of these fishermen are part-time cultivators using much of the best flood recession lands (Falo), but projected flow regulation will entirely destroy this land. The Diama dam will lead to an additional loss of 7,000 metric tons of fish. This will be compensated only partly by the fishing potential of the new lakes. The decreased floodplain inundation in the middle valley will cause the drying up of wells due to the destruction of groundwater resources whose major recharge is from such inundation.

The traditional Walo agriculture will be eliminated from an area of 87,510 ha. If successfully built, managed and maintained the projected irrigation schemes will be able to compensate this loss of production more than 4 to 5 times. Moreover their production is independent of the occurrence of dry years. However, the feasibility of the proposed development (224,000 ha of irrigated agricultural land) has to be questioned in the light of the problems discussed above.

#### **Drijver C.A. & M. Marchand, 1985**

Taming the Floods, Environmental Aspects of Floodplain Development in Africa.

Commission of the European Communities - Centre for Environmental Studies, State University of Leiden, edited by C.A. Drijver and M. Marchand, December 1985.

**Abstract:**

This is a valuable report of 27,000 words followed by seven case studies which make up 108 pages.

1. The Middle Valley of the River Senegal (Senegal).
2. The Internal Delta of the River Niger (Mali).
3. The floodplain of the Logone (Cameroon).
4. The floodplain of the Benoue (Cameroon).
5. The Sudd Jonglei Canal Case (Sudan).
6. The Tana Delta (Kenya).
7. The Kafue Flats (Zambia).

The report is based on the case studies. It "describes the patterns, ecological processes and human exploitation characteristics for African floodplains in general". It then proceeds "to analyse the ecological problems related to water management programmes," and then provides "a list of measures which may prevent or mitigate these problems" and describes the general ecological guidelines to be built into water management and design.

The book provides a wealth of valuable information on the social and ecological functions of floodplains in Africa. Their most salient features. "are their relatively undisturbed, natural character, their traditional cultures, their importance for cattle and fish and their international importance for migrating waterfowl" The flooding regime of most rivers in Europe, North America and to an increasing extent, in Asia is now tamed by embankments, reservoirs and dams. The floodplains are stripped of their original vegetation or modified completely by reclamation activities for agricultural, industrial and urban development. The floodplain of Africa enable us to learn how natural and cultural processes are inter-mingled as was once the case in the cradles of many a civilisation (cf. the Euphrates-Tigris floodplain, the Nile Delta etc.). Many societies in Africa are highly dependent on natural floodplain

resources. Nearly half of the 1.4 million tonnes of fish caught in 1975 was thought to originate from rivers. In addition many large cattle rearing societies in Africa depend on nearby floodplains for dry season grazing and water opportunities.

The authors describe in detail the way floodplains are used in a stable manner by traditional societies. "On the Kafue Flats" (Zambia) for example. "the Twa fishermen act as guides for the Ila herdsmen and their herds searching for good pastures on the plain. Fishing boats are often used for transport and people not only belonging to the fishermen themselves. This co-operation enables the population to benefit optimally from the total of natural resources the floodplain provides."

"Africa south of the Sahara forms the winter region for a multitude of Palearctic migrants breeding in Europe as far as Greenland. For these birds the green zones along the rivers are like oases in the Sahel. The Niger Internal Delta and the Senegal Delta, with the famous National Park in Djoudj, are but two examples of floodplains being indispensable for the existence of millions of migrating birds."

A section is devoted to the ecology of the floodplains, another to their potential for market uses such as agricultural produce and cattle rearing. A further section describes the changes brought to them by development, in particular by the ever-increasing number of large dams. Probably a hundred of varying sizes have been built in Africa. The authors point out that they provide between them 8,145 MW (1978), which is only 2.6 per cent of the energy provided by African Rivers. This is low compared with the standards of other continents, and explains the pressure to build more dams.

A further section deals with the environmental impact of these dams; the usual destruction of forests and agricultural land and the extermination of wildlife. These effects are considered in

greater detail in the individual case studies.

The final section deals with development options. It considers three. The first is "development excluding large-scale agriculture" which means leaving present traditional "recession culture" largely intact. The second is "restricted transformation towards large-scale irrigated agriculture." This involves a partial and slow change towards an export-oriented irrigated agricultural system. The third is "a nearly complete transformation towards large-scale irrigated agriculture". This involves "a nearly complete social and ecological transformation" with little scope for conservation. Its main components would be large dams and reservoirs, enabling "full control of the water regime, combined with irrigation schemes stretching out over practically the whole floodplain. Because loss of floodplain area and water extraction are maximal, possibilities for combining this scenario with conservation of the floodplain-ecosystem and adapted production systems are lacking".

The authors nevertheless consider the latter a possibility however, with a proviso that "an extensive and sophisticated central management" is set up "to rationally supervise irrigation and agricultural development on the entire floodplain." The past experience of large-scale irrigation in Africa. However, "shows great difficulties in realising" such programmes.

The suggests that it "does not seem academic to seriously question the feasibility of the almost complete transformation towards modern agriculture through a very large agro-hydrological culture and herding project." However since existing fisheries, traditional agriculture and herding would be totally destroyed by the project, its failure "would mean a catastrophe for both local people and the natural environment."

Mounier, F., 1986

The Senegal River Scheme: development for whom? In: The social and environmental effects of large dams. Volume 2: case studies [edited by Goldsmith, E.; Hildyard, N. OAE. Camelford, Cornwall, UK; Wadebridge Ecological Centre.
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**Abstract:**

The scheme was created by Senegal, Mali and Mauritania in 1972 and aims to oversee an 80-year plan to develop the Senegal river valley. Under the scheme, the flow of the river will be controlled for about 1,000 km with the aim of making the Senegal navigable; in addition over 300,000 ha of land will be irrigated; and a hydroelectric generating station is to be installed. To achieve this programme, two dams need to be built: the Diama Dam, near the coast, and the Manantali Dam in Mali. The adverse effects of the scheme are likely to be considerable: destruction of fisheries around Diama; social upheaval caused by splitting up of traditional farms and redistribution of land; escalating costs and alarming delays; loss of 50,000 ha of arable land which will no longer be flooded by the river; resettlement problems; loss of 242,000 ha of pastures; damage to fauna and destruction of forests. The benefits of improved food production and health are questionable.

**Summary:**

This is a valuable article on the Senegal River Project. "L'Organisation Pour La Mise en Valeur de la Vallee du Fleuve Senegal." (OMVS). Created in 1972 by three riparian countries-Senegal, Mali and Mauritania, its object was to develop the entire river valley over a span of eighty years. It is justified on the grounds that it would "halt the present desertification of the valley, put an end to malnutrition in the region, and raise the standard of living of the peasants - now living on an income of £40 a year if they are lucky."

The plan involves building two dams, the Diama Dam near the coast and the Manantali in Mali about 1,000 km inland. The cost of the project is estimated at 5 billion francs. The Senegal River basin covers over 290,000 km and carries a volume of 24 billion m<sup>3</sup> of water. It is capricious, its flow varying between 10 and 3,000 m<sup>3</sup> per second. During the rainy season between 15,000 and 150,000 hectares are flooded, while during the dry season the river becomes a mere trickle.

Local tribes have learnt to adapt their traditional agriculture to these conditions. They were highly sophisticated and highly sustainable. To quote Mounier "formerly, in good years, a peasant would fill several grain stores with enough millet to survive for several consecutive seasons. Cattle grazing was also operated according to the available pastures and water points so as to avoid over-grazing. In the villages, the chiefs were careful to establish long fallow periods to enable the soil to recover. All the condition for maintaining ecological stability were there: millet supplies, controlled herds and lengthy fallow periods."

All this has been disrupted by irresponsible economic development. As a result, malnutrition and famine are becoming endemic. Needless to say, this situation is seen as justifying further development. The OMVS solution is "messianic in its tone - Let us concrete over, irrigate, industrialise and we shall be saved." The author describes the way Diama was pushed by the French Minister for Co-operation and Development. As Mounier notes: "irrigation might be a failure, but it is a highly profitable failure for the French company involved".

The Manantali Super-Dam is supposed to provide irrigation land to small farms to begin with; but slowly these are to be replaced by big ones. In effect "the decision has been made to favour large-scale mechanised agriculture - with its imports of fertilisers and pesticides in order to produce crops for export-at the

expense of the independent, self-sufficient smallholder." Once again, the planners seem to have confused construction work with development, gigantism with progress. About 16,430 people will be displaced by the two dams, in all some 300,000 people will have to change their way of life. "Have they been consulted?" the answer is clearly no.

The author describes other consequences of the dam: the loss of traditional pastoral land (about 242,000 ha, by the year 2028), the destruction of fisheries, the spread of waterborne diseases, the annihilation of wildlife and the destruction of forests. Seventy-six thousand hectares of "Gonakie" forests that require flooding for their reproduction) are doomed, as are 42,900 ha of open forests. All in all, it seems clear, the entire population of the Senegal Valley is to be sacrificed for the short-term interests of a few politicians and industrial corporations.

#### Gopsill, T. 1988

Will Senegal farmers reap barrage benefits?
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World-Water. 1988, 11: 3, 17-25.
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#### *Abstract:*

Completion of the Manantali and Diama dams on the Senegal river, West Africa, brings an end to flood-recession agriculture. This article examines whether people will adapt easily to irrigated agriculture or whether the scheme will prove to be an expensive anachronism.

#### Brokensha DW; Koenig D; Horowitz MM; Chaiken MS (ed.); Fleuret AK (ed.), 1990

Involuntary settlement at Manantali, Mali.
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Social-change-and-applied-anthropology.- Essays-in-honor-of-David-W.-Brokensha. 1990, 69-83; Westview Special Studies in Applied Anthropology
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#### *Abstract:*

This paper reports on the relocation of some 10 000 persons in western Mali

whose former villages and productive lands have been flooded in the impoundment of waters by the Manantali Dam. Since the relocation began in 1986, and the dam was first closed in 1987, it is too early for a definitive evaluation of the impacts of resettlement on the ecology, society, and economy of the region. The chapter, however, offers some preliminary assessments of the process, and suggests some ways in which it might have been improved. The US Agency for International Development (USAID), which funded the resettlement does not have a formal relocation policy. Rejecting an earlier proposal to agglomerate relocatees in a few large towns whose size justified establishing schools and health facilities, the project sought to resettle villages as units, to involve the people in the choice of new locations, and to re-establish existing production systems. Despite its admirable intentions, the project suffers from (1) the lack of a coherent development plan for relocatees and host communities; (2) lack of adequate settler and host population participation in all phases of project planning and implementation; and (3) inadequate land over the long term to sustain local needs for fallowing and pasture.

**Horowitz, MM; Salem-Murdock, M. 1990**

The Senegal River Basin Monitoring Activity: A Phase One Synthesis".
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Institute for Development Anthropology. November 1990. 53 pp.
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**Summary:**

Until recently, the prevailing assumption among donors, governments, and the regional multistate Senegal River Basin Development Organisation was that after a transitional period the artificial flood from the Manantali dam would be terminated, and the Senegal River waters would be managed solely for hydropower, irrigation and navigation. This position was

supported by cost-benefit analyses that compared the values of hydropower and flood-recession agriculture. These analyses that favoured terminating the flood ignored the full range of costs: hydrologic, environmental, economic, social and political. In 1987, the Senegal River Basin Monitoring Activity (SRBMA) began to explore the hypothesis that a permanent controlled release from Manantali would be justified by environmentally sustainable increases in production, income, and employment. In 1989, the Government of Senegal identified itself with a more holistic approach to river basin management and a reconsideration of alternative management strategies for the dam.

The argument to terminate the artificial flood assumes a competition for scarce water. The principal hydropower consultant for the basin claimed that a controlled release would entail an annual power loss of more than twice the production value of 50,000 hectares of recession agriculture. These figures, which were maintained by the consortium responsible for drafting the Left Bank Master Development Plan until as late as December 1989, are now considered flawed on two points: (1) an overestimation of the losses in power resulting from artificial floods, and (2) an underestimation of the total economic returns from floodplain production.

Development initiatives in the Senegal River basin have remained largely focussed on irrigation despite its historical record of rarely having met with production or revenue objectives. This weak performance is attributable to (usually unspecified) labour and capital requirements that are too burdensome for many households that allocate most of their capital to food purchases and most of their labour to a risk-minimising diversified production repertory. A comparison of net returns to land, labour, and capital indicates that in years of adequate flood and rainfall, higher net



returns are achieved to the scarcer production factors - labour and capital - from recession farming than from irrigation. A sound development strategy must place irrigation in its proper perspective, as one, and only one, of the elements in a complex production system. On the floodplain, the calendric succession of fish, grain and livestock production already generates a greater rate of return than that hoped for on irrigated systems. The interaction of rivers with the lateral floodplain is critical for the reproduction of freshwater fish. Per hectare production of fish was approximately 70 kg, or about 35,000 FCFA @ 500 FCFA/kg (pre-drought years). When this figure is compared with the value of flood-recession sorghum of 34,000 FCFA/ha, it indicates the importance of fishing, both for household food consumption and for income. The floodplain also supports large herds of ruminant livestock during the dry season that browse trees, shrubs, grasses, and post harvest grain stubble, and that manure the fields. Flood reduction is likely to lead to a sharp decline in the carrying capacity of the plain. One estimate of this decline results in an annual loss of 17,500 FCFA/ha.

There is no clear understanding of the fertility value of manure on Senegalese cultivated fields, although for one area in Mali, there are estimates of increased yields of three to five times over unmanured, periodically fallowed fields (Grosenick et al 1990:115). The nitrogen content of the manure is highest when animals have browsed relatively fresh high-quality forage, such as still-green sorghum stalks on *waalo* fields that have just been harvested. This manuring is the only external fertilisation these fields receive. Livestock, both transhumant and locally owned agropastoral herds, probably contribute importantly to the productivity of flood-recession cultivation, although the magnitude needs to be documented with empirical study.

The herds also contribute to the productivity of floodplain fisheries. The dung dropped by cattle converts much of the dry season primary production into readily dissolved organic and mineral nutrients which have an important impact on the chemistry of the floodwaters.

*Acacia nilotica*, the dominant woodland species in the middle valley, depends for its growth and reproduction on periodic flooding. The woodlands seem already to have suffered from the droughts of the 1970's and 1980's, and permanent reduction of the flood might prove devastating. The tree contributes to soil stabilization and provides fuelwood, charcoal, livestock browse, and termite-resistant wood for construction.

Aquifer recharge depends on the flood. The shallow aquifer provides the middle valley and the extensive surrounding lands with ready access to water for household and livestock use and for irrigating small vegetable gardens, especially those managed by groups of women. A reduction of the flood will cause a lowering of water tables, and alternative methods will have to be introduced to assure continued access. Boreholes tapping the deep aquifer may be the only solution, and these are costly to install and to operate. Even then, a sustained fall in groundwater levels will raise pumping costs, necessitate borehole rehabilitation and may lead to the inland movement of saline water in the delta.

By narrowing opportunities for a diversified production system, reduction of the flood may foster intense competition among individuals and groups for access to a reduced and homogenised resource base. This narrowing may also adversely affect the burdens of women, children and the aged, who will remain in the valley while adult men seek remunerative employment elsewhere. As the rural exodus accelerates, the economic base of small towns in the region will deteriorate, since nongovernment employment in these urban centres is

sustained largely by cash purchases from the rural sector.

The hydrologic calculations of the engineering consultants to the regional river basin organization have informed the discussions on dam management, and they have fostered the notion of an incompatibility between power and controlled flooding. Their analysis asks what maximum amount of energy could have been produced continuously from 1904 to 1984 had there been a 50,000 hectare flood. SRBMA's alternative calculations assume that in the very driest years, such as 1983-84, there would be no artificial floods. The findings are that in 62 of 81 years there would have been sufficient water for both a 50,000 ha flood and a guaranteed power output of 86 megawatts. Furthermore, in many of the 19 deficit years, there was sufficient water in the reservoir to have supported a controlled flood of the required volume for 50,000 hectares.

**Keith, JE; Riley, P; Grenney, WJ; Campp, C; Andersen, JC; Sampath, RK. 1990**

Cost allocation in multipurpose, multicountry projects: the Senegal River Basin Project. Social, economic and institutional issues in Third World irrigation management [edited by Sampath, R.K.; Young, R.A.]. 1990, 289-317.

Studies in Water Policy and Management No. 15, Boulder, Colorado, USA; Westview Press.

**Abstract:**

The chapter explores the multi-country cost allocation problem in the context of the Senegal River Development Project, where some environmental data are available. The Senegal River Basin includes Mali, Mauritania and Senegal. The Project consists of the Diama Dam at the mouth of the Senegal River and the Manantali Dam on the Bafing River in Mali. The application of the separable cost

remaining benefit method (SCRB) to the Senegal River Basin Programme appears to be consistent with game-theoretic approaches, insofar as the data will show a comparison. However, cost allocation itself appears to be relatively sensitive to the assumption made with regard to rates of development and service use. This sensitivity could cause friction among the member states in the future as conditions change. There exists a relatively large degree of uncertainty with respect to the data that are used for the cost allocation procedures. For example, the rates of development for irrigated agriculture have been much lower than was projected during the late 1970s and early 1980s. Further, the projected mix of small and large perimeters has changed over that time, as problems have arisen with large-scale mechanized agriculture. Changes in projected dates for the delivery of energy and navigation services have been, and probably will continue to be frequent. These factors create the potential for instability in project development. The uncertainty of the data must be understood by all parties, and the countries themselves must be heavily involved in the on-going cost allocation process, in order to assure stability within the project.

**LeMarquand, DG. 1990**

International development of the Senegal River.

Water-International. 1990, 15: 4, 222-230;

**Abstract:**

This paper looks at the main political factors that were instrumental in design and implementation of the Diama and Manantali dams on the Senegal River. The rationale for making use of the valuable international resource is undermined by the political concessions, compromises, and accommodations the basin states and the donors who finance the projects need to make to sustain international cooperation among the three participating

basin states of Mali, Mauritania and Senegal. At best there is an over-investment in physical works and at worst the dam projects are unnecessary at this time and will be an economic and social disaster. Planning of the projects was backwards in that it was oriented towards justifying a political decision made as long ago as 1962. While the river programme is uneconomic, and a number of the funding agencies were dissatisfied with parts or even all of it, the basin states, nevertheless, succeeded in obtaining the necessary concessionary finance by playing one donor off against another, with limited effect by controlling the type of technical information produced, and more successfully by taking political initiatives to circumvent the technical funding process and exploiting the political sympathies of the donor country political leaders.

**Horowitz, MM. 1991**

Victims upstream and down. Journal-of-Refugee-Studies. 1991, 4: 2, 164-181
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**Abstract:**

This paper focuses on the millions of rural smallholders downstream from high dams in the Third World. They are selected for study because:

- (1) they are the most numerous of victims of development;
- (2) they are relatively ignored by social scientists as compared with the quite considerable attention paid to persons upstream from dams who are forced to resettle; and
- (3) the author has first-hand familiarity with the case of the middle Senegal River Valley, that exposes not only how victims are created by development, but also how that development can be modified so that the downstream residents might be allowed to benefit from the new infrastructure.

Persons living in the planned reservoir areas of large dams constitute classic instances of involuntary relocation, and the largest funding institution for these dams in the Third World, the World Bank, has elaborated guidelines for their resettlement. Guidelines are necessary but insufficient steps in confronting victimization from development actions, first, because they are often ignored, and second, because there are no guidelines to protect the often larger number of persons downstream from dams who experience environmental, economic, and political dislocations. The Senegal River Valley is a current case in which dam construction and water management policy will inflict hardships both upstream and downstream, but only upstream has there been any attempt to compensate people for their losses. A different management policy would contribute to mitigating many of the downstream hardships without causing losses in either hydropower or irrigation. Whether so enlightened a policy will be adopted, remains problematic.

**Horowitz, MM; Salem-Murdock, M. 1991**

Management of an African floodplain: a contribution to the anthropology of public policy. Landscape-and-Urban-Planning., 20: 1/3, 215-221
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**Abstract:**

Several hundred thousand smallholder households in Senegal and Mauritania are at risk from a large dam built at Manantali on the Bafing, the major tributary of the Senegal River. These households practise a complex set of production strategies sustaining a dense population in a Sahelian region. Despite low rainfall, in average years the area allows for two harvests, one dependent on summer rains on sandy upland soils and the other on post-summer floods on the alluvial plain. If the dam is managed as planned, it will adversely affect downstream production,

income, and employment. Designed for hydropower, large-scale irrigation, and barge transportation, the dam would restrict the natural flood, causing: drastic reduction of recession cultivation; heavy reliance on costly irrigated production; decline in the quality of riverine pasture and in the numbers of stock that can graze during the long dry season; reduction in fish capture; transformation of the natural floodplain, reducing its capacity to support migratory birds and other wildlife. A delayed installation of turbines and an agreed controlled release from Manantali for at least 10 years provide an opportunity to examine the impacts of that release and to measure them against a potential reduction in hydropower and irrigation water.

**Niasse, M. 1991**

Production systems in the Senegal Valley in a no-flood context.
Development-Anthropology-Network. 1991, 9: 2, 12-20.

**Abstract:**

During the two years following completion of the Manantali high dam on the Senegal River in 1987, releases from the reservoir generated 'artificial floods' and vast areas of the lateral plains in the Middle Valley were inundated. In 1990 and in 1991, however, when poor rainfall resulted in mediocre or non-existent dryland harvests the Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) unilaterally, and without alerting the farmers, herders and fishermen whose production system is flood dependent, decided to retain all waters stored in the reservoir. A discussion is presented of production systems in the Senegal Valley in a no-flood context, with reference to the 1990/91 agricultural year. Following an examination of farming restrictions imposed by the agricultural calendar, positive and negative experiences are considered with regard to jeeri (rainfed) and waalo (flood recession) lands. For

most households faced with a rather inflexible agro-pastoral calendar, migration remains the only hope of success in difficult years. Formal and informal interviews with villagers from Doumga, Rindiauw, Kaawel and Mbakhna yielded information on their realization of the hardships to be encountered, their apportioning of responsibility for their predicament, and their strategies for coping. No longer in receipt of assistance from the government or donors, most villagers turned to either irrigation, migration or herding strategies. The production strategies of agriculturalists, herders and fishermen living in the Valley and depending on the flood system have been greatly disrupted by the dam, at least for the moment.

**Salem-Murdock, M; Horowitz, MM. 1991**

Monitoring development in the Senegal River Basin.
Development-Anthropology-Network., 9: 1, 8-15

**Abstract:**

More than 100,000 households downstream from the Manantali high dam on the Bafing River in Mali, are rural smallholders who practise a complex set of economic activities. Since turbine and transmission lines are not yet installed, Manantali is supposed to be managed with a controlled release of reservoir waters every September. This release was initially planned as transitional; an opportunity for the riverine populations to continue their complex production system while slowly being weaned away from traditional agriculture to year-round irrigation as more schemes came on line. The hypothesis was tested that the net benefits to local, regional and national economies are greater under the 'artificial flood' than they would be under a water regime that markedly limited the flood to maximize hydropower and irrigation. The research, in three Middle Valley regions

of the Senegal River Basin, was generated by a desire to see the residents of the valley become beneficiaries rather than victims of development, while their urban compatriots also profit from more reliable and potentially cheaper electricity. Research with computer simulations focused on: (1) a comparison of the economic returns from village irrigated perimeters and flood-recession cultivation; (2) a comparison of smallholder production with and without an artificial flood, and to determine the potential costs of an artificial flood; and (3) an assessment of the water requirements of hydropower. The findings show a cost-benefit analysis that tips the balance away from a decision to terminate the artificial flood and toward a management policy that seeks to optimize the benefits of water control for the broadest range of constituents: electricity consumers, small-scale agricultural producers, irrigation farmers, herders and fishermen. The potential costs to power generation from providing an artificial flood to improve the livelihoods of hundreds and thousands of people living downstream from the dam are modest, indeed, as compared with the gains to power generation from not providing the flood.

**Thiel, RE. 1991.**

Senegal: water for the desert?
Development-and-Cooperation. 1991, No. 4, 10-12;

**Abstract:**

Development projects are often assessed on grounds of economic viability, involving cost-benefit analysis. This article uses the case of the Senegal River project to argue that economic viability does not necessarily indicate the worthiness of a development initiative. It is a well-known fact that the water of the Senegal River can help in the fight against desertification in Senegal and improve the lives of the Toukoulour people who

inhabit the region. The assessment of several irrigation projects in the region, however, has identified this role of the river as economically non-viable due to high project cost and several other reasons. In overlooking the ecological consequences of such a decision, it is worth noting that development objectives are defeated, even in the presence of economic viability. This example provides a strong case for including environmental costs and benefits in project appraisal in future.

**Horowitz, MM; Salem-Murdock, M. 1993**

Development-induced food insecurity in the Middle Senegal Valley.
Geojournal., 30: 2, 179-184.

**Abstract:**

The productivity and incomes of thousands of smallholder farmers, fishers, herders, traders and townspeople who live in the Middle Valley of the Senegal River in Mali, Mauritania and Senegal are threatened by the dam management strategy propounded by the Senegal Valley Development Authority (OMVS) Council of Ministers. Research conducted by the Institute for Development Anthropology in collaboration with the Government of Senegal's Cellule Apres-Barrages recommends that the proposed Manantali Dam on the Senegal River be managed with a controlled release, an 'artificial flood', that will maintain the productivity of the plain without massive capital investment. The purposes of the Manantali Dam are discussed. The damage caused to inhabitants' livelihoods is described. If the dam continues to be managed without taking account of downstream smallholder productivity, then irrigation on a massive scale will be the only recourse. The costs in ecological, social and economic terms will be enormous.

Albergel, J; Bader, JC; Lamagat, JP; Seguis, L., 1993

Floods and droughts in a major river of tropical West Africa: application to flood management in the Senegal River.

Secheresse. 1993, 4: 3, 143-152. ORSTOM, Centre de Hann, Dakar, Senegal.

**Abstract:**

The correct evaluation of water resources in large river basins of West Africa is complicated by the decrease in yields which has occurred since 1970. New data on droughts have to be taken into consideration. This paper shows the importance of the reference period chosen when analysing the performance of a multi-purpose dam. Rainfall and runoff variability was studied in Upper Senegal, and two possible scenarios for the management of the multi-purpose Manantali dam were tested by numerical simulation. Results are discussed.

Frankenberger, TR; Lynham, MB; Park, TK. 1993

Household food security and coping strategies along the Senegal river valley.

Risk and tenure in arid lands: the political ecology of development in the Senegal River Basin [edited by Park, T.K.], 1993, 51-86; Tucson, Arizona, USA; University of Arizona Press.

**Abstract:**

Households in the Senegal River Valley do not respond arbitrarily to variability in food supply; when faced with recurrent instability, they have developed self-insurance strategies to minimize the risks to their food security. This chapter describes the variable strategies pursued by farm families on both sides of the river, in maintaining household food security, and how some of these strategies relate to environmental degradation. The information presented by this chapter is

based on a number of reconnaissance surveys carried out by the University of Arizona between 1986 and 1987 in Mauritania and Senegal, West Africa. The chapter begins with a review of the literature on coping strategies in Africa, followed by a description of the methodology used in the surveys. A summary of the findings is then presented along with a section dealing with the environmental impact of some of these strategies. During drought years, relief efforts should target resource improvement and promote better resource management. Rather than simple food distribution, cash for work schemes should be adopted, allowing independent economic decision making to continue within the household.

### 1.3 BAKOLORI DAM, NIGERIA

#### 1.3.1 Summary

- The Bakolori Dam was built in the mid-1970s on the River Sokoto in Northwest Nigeria to supply a 30,000 ha irrigation scheme.
- Main Purpose: Irrigation
- Altered natural flooding patterns and disrupted the traditional cultivation over a wide area. Major impacts on downstream agriculture and fisheries
- Evidence of land degradation in flood plain areas downstream of the Bakolori dam where flood plain cultivation has been reduced by as much as 50 percent.
- Significant political repercussions
- Flood release appears to have been considered, some time after the dam was built, but status uncertain.

#### 1.3.2 References

Adams, WM. 1985

The downstream impacts of dam construction: a case study from Nigeria. Transactions, Institute of British

Geographers. 1985, 10: 3, 292-302.

**Abstract:**

The Bakolori Dam was built in the mid-1970s on the River Sokoto in Northwest Nigeria to supply a 30,000 ha irrigation scheme. The dam reduced the magnitude of the wet season floods which supported an extensive and sophisticated agricultural system and a fishery on which a population of some 50 000 people depended. Reduced flooding caused a shift from rice to lower value millet and sorghum crops in the wet season, and a significant reduction in the extent of dry season cultivation. Fish populations apparently declined, and fishing decreased. Estimates of the consequent loss of production show how a more complete economic appraisal of the scheme at Bakolori would have been less favourable than the calculation upon which it was approved. Downstream effects of dam projects are rarely considered in project appraisal. Some reasons for this are discussed, and opportunities for remedial development in the flood-plain are outlined.

**Beckman, B. 1985**

Bakolori. The menace of a dam.

Development, Seeds-of-Change, Village-Through-Global-Order. 1985, No. 3, 24-32

**Abstract:**

The paper was presented at the World Food Conference, Rome, in November 1984. In late April 1980, the Governor of Sokoto state in Northwestern Nigeria announced that he had ordered the police to take over the Bakolori Irrigation Project, where farmers had been rioting. The paper focuses on the grievances which resulted in the massive, organized and partly armed struggles waged by the peasantry against the project. It was a protracted struggle, a confluence of different grievances, which had built up since the Italian contractors first entered

the area in 1975. The article attempts to go beyond the immediate grievances and examines the nature of the contradictions built into the strategy of development which the state seeks to impose on the peasantry. Central to this strategy is the effort to subordinate peasant land and labour to the requirements on large-scale irrigation capital. It is argued that, despite the terrible price paid (14 farmers dead and 15 others and four policemen injured), the peasants successfully resisted subordination. It discusses the social forces, foreign and domestic, which back the strategy of subordination and the implication of their failure to achieve their ends. The first section outlines the context.

**Adams, WM. 1986**

Traditional agriculture and water use in the Sokoto Valley, Nigeria.

Geographical-Journal. 1986, 152: 1, 30-43.

**Abstract:**

This article describes the economics of traditional agricultural practices in the flood plain of the River Sokoto in northwestern Nigeria. The area lies in the Sudan savanna, and rain-fed agriculture is subject to periodic drought. Although river flow is also highly variable, both seasonally and between years, the flood plain represents a valuable agricultural resource. Flood plain hydrology is complicated, but surveys of flooding based on interviews with farmers, together with a study of cropping practices, reveal a complex and highly developed agriculture in the flood plain based on the cultivation of rice and sorghum varieties of known flood-tolerance. These wet-season crops are followed by vegetables grown in the dry season. Despite the sophistication and potential for development represented by the flood plain agriculture, official development has failed to capitalize upon it. Instead, Bakolori Dam, which supplies this

scheme, has altered natural flooding patterns and disrupted the traditional cultivation over a wide area.

**Beckman, B. 1986**

Bakolori: peasants versus state and industry in Nigeria.

The social and environmental effects of large dams. Volume 2. Case studies [edited by Goldsmith, E.; Hildyard, N.]. 1986, 140-155.

**Abstract**

Social problems arising from the construction of the Bakalori Dam are discussed.

**Pilon, PG; Howarth, PJ; Bullock, RA. 1988**

An enhanced classification approach to change detection in semi-arid environments.

Photogrammetric Engineering and Remote Sensing. 1988, 54: 12, 1709-1716.

**Abstract:**

The use of Landsat digital classification or enhancements to monitor change in semi-arid environments has generally met with limited success. This can be partially attributed to unique physical and human factors which complicate change detection in these environments. An enhanced classification approach which combines image enhancement to isolate change with multispectral classification to identify change dynamics has been developed. The technique has been applied in northwestern Nigeria to dry season Landsat MSS images acquired for dates before and after construction of the Bakolori dam and reservoir. These images span a nine-year period during which marked changes have occurred as a result of dam construction and stream regulation associated with the Bakolori project. The results show evidence of land degradation in flood plain areas downstream of the Bakolori dam where flood plain

cultivation has been reduced by as much as 50 percent. Comparisons with ground survey data confirm that the enhanced classification approach provides more accurate information on change by minimizing errors associated with misregistration and misclassification and by allowing the suppression of environmental factors through the separation of natural and human-induced change.

**Adams, WM. 1988**

Approaches to water resource development, Sokoto Valley, Nigeria: the problem of sustainability.

Conservation in Africa: people, policies and practice [edited by Anderson, D.; Grove, R.J.]. 1988, 307-325. Cambridge, UK; Cambridge University Press.

**Abstract:**

This chapter examines two different approaches to the development of the water resources of the Sokoto Valley in northwestern Nigeria. In the 1970s a large dam and extensive irrigation scheme were developed at Bakolori. Its problems, and the lessons which might be learned from its poor performance, are compared with a previous small-scale water conservation initiative in the valley during 1917-21. The two approaches to water resource development were very different, and yet neither was successful. The more recent scheme is typical of large-scale top-down development, and its poor performance is easily blamed on these characteristics. The earlier project, however, had many of the features of the alternative approach to development being advocated today.

**Adams, WM. 1993**

Development's deaf ear: downstream users and water releases from the Bakolori Dam, Nigeria.

World-Development-Oxford. 1993, 21: 9, 1405-1416



**Abstract:**

Construction of the Bakolori Dam on the Sokoto River, Nigeria, altered the pattern of wet season flooding, with consequential adverse impacts on downstream agriculture. Such impacts are not uncommon in tropical floodplain rivers, and one strategy proposed to offset them is the release of controlled flood flows from dams. Experience with such compensation floods is needed. On the Sokoto, both downstream farmers and the engineers responsible for the supply of water to Sokoto City sought to influence the operation of the Bakolori Dam to increase the amount of water available to them. This paper describes the debates between those managing the dam about the need for and proper nature of releases for downstream users. It considers the relative failure of the farmers and success of the engineers in the context of disciplinary bias and problems of communication.

**1.4 PONGOLAPOORT DAM, SOUTH AFRICA**

- Main Purpose: Irrigation
- Severe impact on fishing and recession agriculture

Plans for controlled flood release were drawn up to rehabilitate the floodplain. Initial releases were made at wrong time of year and crops either rotted or were washed away. Eventually, decisions on timing of flood release have been made by the local people - a scheme which has proved to be very successful.

**1.5 HADEJIA-NGURU WETLANDS, NIGERIA**

- Main Purpose: Irrigation
- Floodplain inundation decreased from about 200,000 ha to only 30,000 ha

Cost of irrigation development US\$ 3 billion (70,000 ha at US\$43,000 /ha). Total production from system decreased.

Yield from irrigated areas per 1000 m<sup>3</sup> of water was only US\$0.15, but \$35 from flooded wetlands. A meeting in 1993 agreed that artificial flooding must in future play a central role in water resource use and the operation of all dams will now be modified to provide artificial flood release.

**Kimmage, K; Adams, WM. 1992**

Wetland agricultural production and river basin development in the Hadejia-Jama'are valley, Nigeria.

Geographical-Journal. 1992, 158: 1, 1-12.

**Abstract:**

There are relatively few studies of the values associated with tropical wetlands. Lack of such knowledge is a significant contributor to the failure of river basin planning to take account of existing economic activities such as indigenous irrigation, herding or fishing. Development of formal projects such as dams and large-scale irrigation schemes can have serious adverse effects on existing activities and economic values in wetlands. Data on these values are vital if development planning is to consider them properly. This paper describes the nature and magnitude of agricultural production in the floodplain wetland of the Hadejia-Jama'are rivers in northern Nigeria, between Hadejia and Gashua. There is flood-rice and rainfed agriculture in the wet season, and in the dry season cropping by residual soil moisture, shadoof and (expanding rapidly through the 1980s) small petrol pumps. Most of this production is dependent on the annual flood. This has been reduced in magnitude by drought, and by dam construction and water Abstraction for irrigation upstream in Kano State. The gross value of agricultural production is large, somewhere between 250 and 850 million Naira (1989 prices). The economic importance of the floodplain is placed in the context of the performance of the

costly formal large-scale irrigation schemes upstream which have been favoured by the river basin planning process.

**Adams WM; Thomas DHL, 1993**

Mainstream sustainable development: the challenge of putting theory into practice.

Journal-of-International-Development. 1993, 5: 6, 591-604

**Abstract:**

This paper outlines the main features of the mainstream of sustainable development thinking and the documents from which it is drawn. It then explores these in the context of a conservation project, The Hadejia-Nguru Wetlands Conservation Project (HNWCP), established in 1987, in northern Nigeria. Issues of environment and development have been tackled in different ways, through protected area designation, development microprojects and concerns for river basin management. It is concluded that the practical implementation of 'sustainable development' projects is far more complex and problematic than might at first appear. In particular attention should be given to whether sustainability is about the right management of the environment or about people's welfare; whether the focus should be the poor or the economy as a whole; and lastly, whether sustainability is primarily local or global in focus.

**Hollis GE (ed.); Adams WM (ed.); Aminu-Kano M, 1993**

The Hadejia-Nguru wetlands: environment, economy and sustainable development of a Sahelian floodplain wetland.

International Union for Conservation of Nature and Natural Resources (IUCN); Gland; Switzerland. 244 pp.

**Abstract:**

This book on the Hadejia-Nguru Wetlands in Nigeria comprises an introduction and 3

parts: (1) the environment (natural resources of the Hadejia-Nguru Wetlands; hydrology of the river basin; hydrological model of the floodplain); (2) economy (economy of the floodplain; agriculture, grazing and forestry; fishing in the floodplain); and (3) conservation and development (management of the river basin and irrigation; water resource developments and their hydrological impacts; economic valuation of wetland benefits; the wetlands and nature conservation; land use, water management and conservation in the Komadugu-Yobe basin.

**Thompson JR, Hollis GE, 1995**

Hydrological modelling and the sustainable development of the Hadejia-Nguru wetlands, Nigeria.

Hydrological Sciences Journal-Journal des Sciences Hydrologiques 1995 Feb;40(1):97-116

**Abstract:**

The Hadejia-Nguru Wetlands produce agricultural, fishing and fuelwood benefits of upto 1,277 Naira ha<sup>-1</sup> (N1 = US\$22, October 1994), over five times the productivity of formal irrigation schemes. The wetlands play a vital role in aquifer recharge. The key is the annual wet season flooding of over 2,000 km<sup>2</sup> in the 1960s and around 1500 km<sup>2</sup> in the 1970s. A water balance model, utilizing monthly hydrological and meteorological data simulates flood extent and groundwater storage within the wetlands. The model was operated between 1964 and 1987 and was calibrated using observed flood extents ranging from 50 to 3,265 km<sup>2</sup>. Subsequently elements were added for dams and irrigation schemes. Results indicate that full implementation of all the schemes constructed or planned would cause flooding to be less than 375 km<sup>2</sup> for 60% of the time and groundwater storage to fall by over 5,500 10<sup>6</sup> m<sup>3</sup>. It is possible to define an operating regime for the basin's hydraulic structures which could

provide artificial floods and enable a distribution of water between formal irrigation, small scale irrigators, the wetlands and downstream users. This regime would provide assured flooding, of around 1,000 km<sup>2</sup> each year, and a reduced loss of groundwater storage. Such a sustainable development scheme could offset decades of piecemeal development and bring a philosophy which emphasizes water use throughout the basin not just in irrigation in the upper reaches.

**Barbier EB, 1996**

Valuing Floodplain Benefits: Economic and Hydrological Studies Conducted at the Hadejia-Nguru Wetlands Conservation Project, Nigeria

IUCN Wetlands Programme Newsletter No. 14

**Summary:**

The economic valuation of wetlands is a topic that, in the past, has received little attention. Critically, this issue has usually been overlooked in the more "classical" cost-benefit approach adopted for purposes of project evaluation. As a direct consequence of the failure to incorporate an economic assessment/evaluation of areas downstream of proposed hydropower developments prior to construction, many such projects have resulted in significant downstream social and economic problems. The importance of this topic should not be underestimated. Barbier writes:

*"Throughout Africa and other developing regions, river basin projects have the specific aim of diverting seasonal river flows in arid and drought-prone savannah environments for so-called development uses - irrigation schemes, urban water supply, industrial use and hydroelectricity. However, in semi-arid Africa, the natural floodplains formed by seasonal river flows have a strategic economic importance out of all proportion to their size. In many instances the uses of the wetlands - for agriculture, fishing,*

*grazing, resource harvesting, water supply and other benefits - are integrated with that of surrounding drylands. Thus, the floodwater feeding these "wetlands within drylands" is rarely wasted. As a consequence, upstream river basin developments that divert floodwater away from these critical wetlands may have considerable impact on the economic benefits they provide to local communities. Unfortunately, assessment of these impacts is generally not undertaken or incorporated in decisions concerning whether to proceed with upstream water developments. The prevailing assumption is that the water is essentially 'free', which in economic terms means that the opportunity cost of diverting river flow to upstream development projects is negligible.*

*A number of hydrological and economic studies in recent years conducted through the auspices of the Hadejia-Nguru Wetlands Conservation Project (HNWCP) in northern Nigeria is providing detailed evidence for the first time of the consequences (or costs), of diverting water from a natural floodplain. The HNWCP is located in the heart of the Hadejia-jama'are floodplain, which is created where the Hadejia and jama'are Rivers converge to form the Komadugu Yobe River which drains into Lake Chad. Although referred to as wetlands, much of the floodplain is dry for some or all of the year. In recent years, the maximum extent of flooding has declined from between 250,000 to 300,000 ha in 1960s and 1970s to around 70,000 to 100,000 ha more recently. Hydrologists have directly linked this reduced flooding to upstream water developments, principally the building of dam projects for irrigation. The first round of studies sponsored by HNWCP established both preliminary hydrological modelling of the river basin and floodplain, including initial analyses of the impacts of upstream developments through flooding scenarios, and evidence of the socioeconomic importance of*

activities undertaken by local communities living in and nearby the floodplain. The results of these studies was recently published collectively by the IUCN Wetlands programme (*The Hadejia-Nguru Wetlands, 1993*, by Hollis, Adams and AminuKano).

As part of this earlier work, an economic valuation was conducted to assess the benefits of the Hadejia-jama'are wetlands, and thus the opportunity cost to Nigeria of its loss, by estimating some of the key direct use values the floodplain provides to local populations through crop production, fuel wood and fishing (Barbier, Adams and Kimmage 1993). To provide a comparison, the net agricultural benefits of a major upstream development project, the Kano River Irrigation Project (Phase 1), were also estimated. The results are summarised in Table 1. The net present values of a weighted aggregate of the agricultural, fishing and fuel wood benefits of the floodplain were estimated to be around US\$34 to US\$51 per ha, or around US\$9.6 to US\$14.5 per 103Ml of annual floodwater input into the wetlands.<sup>1</sup> In contrast, the net present value of the Kano Irrigation Project's agricultural benefits was estimated at US\$20-31 per ha, or around US\$0.03-0.04 per 103Ml of annual irrigation water use. Thus the economic valuation study was able to demonstrate not only that the floodplain yields significant benefits but also that, when compared to a typical large-scale development project, floodplain activities are much more "efficient" in their use of water.

A further round of hydrological and economic studies are currently being conducted with the support of HNWCP to improve our understanding of the impacts of water diversion on the Hadejia-Jama'are floodplain. This work forms the basis of a project funded by IUCN and WWF International to support a more hydrological-economic approach to valuing floodplain benefits, undertaken through the joint efforts of the Wetlands

Unit, the Geography Department, University College London and the Environmental Economics and Environmental Department, University of York. There are two main outputs envisioned by new this project element: first, by combining the analysis of existing economic and hydrological studies it is possible to provide an estimate of the likely economic consequences of all upstream irrigation projects in the Hadejia-Jama'are River Basin in terms of foregone floodplain benefits. In addition, it is possible to indicate the effects on floodplain benefits of introducing floodwater release regime for upstream dams. Second, hydrological studies of the floodplain indicate that one of its major functions may be to recharge shallow underground aquifers within and surrounding the wetland area. These aquifers are then utilised by local communities either as a source of domestic water supplies through hand-dug village wells or as small-scale irrigation for crops through borehole pumps. By combining the available hydrological evidence on the rate of local aquifer recharge attributable to the floodplain with economic analysis of the value to villagers of utilising this water for domestic use and irrigation, it is possible to estimate the economic effects of changes in flooding from upstream water developments on the ground water recharge function of the floodplain.

Although both of these hydrological-economic studies are yet to be completed, preliminary results of the likely economic impacts on floodplain agricultural, fuel wood and fishing benefits of different flooding regimes are instructive. For example, all the scenarios indicate that the construction of upstream dams and projects in the Hadejia-jama'are River Basin cannot generate sufficient benefits from additional irrigation schemes to justify the substantial losses in floodplain benefits downstream. However, the preliminary scenario analysis also shows

*that the loss of floodplain benefits could be reduced substantially if a regulated flooding regime particularly during the dry season were to be implemented for the major upstream dams. Although further work is required to improve this analysis, our initial results do emphasise the need to conduct hydrological and economical analysis of the impacts of large-scale water project developments downstream to include potential downstream impacts, especially on natural floodplains.*

*The second study of the economic value to local communities of the ground water recharge function of the floodplain will yield results later this year. Our approach has been to survey representative villages where households obtain domestic water solely from wells tapping into the shallow aquifer, and where hydrological evidence exists that recharge of these particular aquifers are due to changes in the flood extent of the wetlands. Two villages appear to meet these criteria - one in the south-west and the other in the north central area of the floodplain. In addition, a series of irrigated agricultural fields have been identified that also depend for water supplies solely on shallow aquifers that are recharged by the wetlands. By estimating the value of crop production affected by changes in water supply, it will be possible to determine the benefits of the ground water recharge function for this type of irrigated agriculture which is prevalent throughout the region. If successful, both of these valuation studies will provide the first conclusive evidence of the economic benefits of the hydrological ground water recharge function of a natural floodplain in the developing world.*

**Polet G, 1996**

Water Management Issues in the Hadejia-Jama'are-Yobe river basin, northern Nigeria

IUCN Wetlands Programme Newsletter

**Abstract:**

In 1987, the Hadejia-Nguru Wetlands Conservation Project (HNWCP) was established to draw attention to the unique ecology of the floodplain wetlands in the Hadejia-Jama'are-Yobe river basin of northern Nigeria, which lies in the semi-arid zone of West Africa. Since 1990, HNWCP has been managed by IUCN – The World Conservation Union in partnership with RSPB and the Nigerian Conservation Foundation, with the emphasis on the wise use of resources, notably surface water resources which maintain the economy and ecology of the area through annual inundation of floodplains. Over the years, the wetlands and the areas downstream have received less and less water, resulting in smaller floods. This affected the economy (flood rice farming, fishing, dry season grazing) and ecology of the area negatively. Hollis et al. (1993) showed that these impacts can be attributed to drought cycles and the construction of two major dams in the headwaters of the river basin.

The article describes water management problems in the Hadejia-Jama'are-Yobe river basin and discusses ongoing actions to mitigate the problems. It concentrates on the development of an operation plan for the dams, which includes wet season releases to maintain annual flooding of the Hadejia-Nguru wetlands, a proposed flow proportioning structure in the wetlands and efforts to improve co-ordination between different water users.

**Thomas DHL, 1996**

Fisheries tenure in an African floodplain village and the implications for management.

Human-Ecology-New-York. 1996, 24: 3, 287-313.

**Abstract:**

This paper explores property regimes operating in the Hadejia-Jama'are

floodplain fishery, Nigeria, with a focus on a case-study village (Dagona). Private, communal property, and open-access tenure regimes exist. The physical characteristics of the resources under each of these categories are differentiated. The economic cost of making resources more exclusive appears to be a key factor affecting tenure. However, the social benefits of communal access are also extremely important. In a risky environment that is characterized by spatial and temporal variation in the distribution of resources, maintaining rights of access to a wide geographical portfolio of resources is an important consideration. This is especially true considering recent environmental changes in the floodplain caused by dams and drought. This suggests that recommendations to improve productivity of the fishery by making access more exclusive may not maximize overall benefits from the fishery, since gains in productivity may be outweighed by losses in social benefits.

biodiversity; the importance of considering sustainability at different levels; the work of development demands skills that are different from those required by conventional conservation projects; and finally that the integration of environmental conservation and development, though essential, is far from easy to do.

**Adams WM; Thomas DHL, 1996**

Conservation and sustainable resource use in the Hadejia-Jama'are Valley, Nigeria.

Oryx. 1996, 30: 2, 131-142

***Abstract:***

The Hadejia-Nguru Wetland Conservation Project in Nigeria grew out of a concern for wildlife, particularly wetland birds, but has expanded to address issues of environmental sustainability and economic development at both the local and the regional scale. An assessment of the achievements of the project's approach is presented through a case study. Sustainable development is highlighted as a legitimate, and locally critical, element in wildlife conservation. Four conclusions are drawn from the study: the importance of making the link between conventional wildlife conservation, ecosystem function and human use, and particularly the recognition of the economic dimensions of

## 1.6 ITEZHI-TEZHI DAM & KAFUE FLATS, ZAMBIA

- Storage for downstream Hydropower scheme at Kafue Gorge
- Some recent work has considered how releases might be timed more effectively in order to meet not only the irrigation demands of sugar producers and hydropower demands, but also to provide some artificial flooding of the wetlands of the Kafue flats.

Handlos, WL; Williams, GJ (editors). 1984

Development on the Kafue Flats: the last five years.
1984, vi + 78pp. [Lusaka, Zambia]; Kafue Basin Research Project, University of Zambia.

### *Abstract:*

Six papers given at a seminar entitled 'Development on the Kafue Flats - the last five years', held at the University of Zambia in April 1983, are presented. (1) The effects of dam construction on flooding of the Kafue Flats, presents an interim report on a study of the hydrological changes caused by the construction of dams at Kafue Gorge and Itezhi-tezhi. (2) Hydrological changes in the Kafue Basin, examines changes induced by man made interventions such as urbanization, mining installations and forest felling. (3) Development of irrigation on the Kafue Flats - the last five years, examines the apparent commercial attractions of the proposals to develop irrigation and an overview of the actual development of irrigation on the Flat in the last few years. (4) The expansion of Nakambala and increasing water needs during the last few years, discusses the water requirements of sugar and cane on the Nakambala Sugar Estate. (5) Family Farms Limited - development activities

with people engaged in fishing along the Kafue River, examines the involvement of Family Farms Limited, a non-profit making Zambian company established in 1972, with fisheries. (6) A status report on the Kafue fishery.

Walter A. Sheppe, 1985

Effects of human activities on Zambia's Kafue Flats ecosystems
Environmental Conservation, Vol.12, No.1, Spring 1985.

### *Abstract:*

This article discusses man's impacts on the Kafue Flats in Zambia, in particular those resulting from the building of two dams on the Kafue River. The Flats are a floodplain of approximately 6,000 km<sup>2</sup>, 235 km long and 40 km wide. Through the Flats meanders the Kafue River, one of the main tributaries of the Zambezi River. Man's effects on the Flats' ecosystems result from hunting, fishing, mere human presence, cattle-herding, agriculture and dam-building.

Sheppe writes:

"The life of the Flats is dominated by the alternating wet and dry seasons, and by the annual floods, before the dams were built the river level began to rise slowly in December and reached its crest after the end of the rains - typically in May, when most of the floodplain was under several metres of water. The level then dropped slowly until the next flood began. Because of this flood regime, the Flats were alternately a large lake and a dry grassland. The floods excluded almost all trees, and the vegetation was largely of grasses. Because of the abundant water, the floodplain vegetation was the most productive in the region, supporting large populations of a variety of animals."

Wildlife in the Flats included: lechwe, zebra, wildebeest, hippopotamus, crocodiles, sitatunga, several kinds of carnivores and small mammals, a large fishery and 400 species of birds, including: 125 waterbirds, the world's

largest population of Wattled Cranes, Fish Eagles, darters and jacanas.

In reviewing the literature on the Kafue Flats, Sheppe states:

"Two facts stand out. First our understanding of the basin is still inadequate for satisfactory protection and management of its resources and second, what we do know has had little effect on policy decisions. The construction of the power projects was approved without regard to its probable environmental effects, and its design and operation have been based almost entirely on a desire to produce the greatest possible amount of power, without regard to other interests."

Two dams have been built on the Kafue River. One, the Gorge Dam with a 900 MW capacity, is located immediately below the floodplain and was completed in 1972. Most of the dam's storage reservoir is located in the Flats, where the terrain results in a large surface area and low storage capacity. Because of the low storage capacity, the Itezhitzezi Dam was built immediately above the Flats in 1977. Sheppe notes that the Flats' ecosystems are "just beginning to become adapted to the hydrological changes produced by the dams." Nevertheless they have had a marked effect on the floodplain, reducing the amount of land that is seasonally flooded and maintaining a permanent lake over much of the eastern section. For example:

"During a 'normal' year, before the dam (Itezhitzezi) was built, flow in the western flats ranged from 30 to 1,400 cumecs (cubic metres per second), with recorded extremes of 10 and 2,700 cumecs. In an effort to produce some semblance of an annual flood, 300 cumecs are now released briefly each March; but this rate seems trivial in comparison to the 'normal' maximum of 1,400 cumec."

By 1983, the lush grasses that depended on the annual flood had been replaced by permanent open water in the lower elevations, and, on the upper elevations, a sparse cover of low grasses being invaded

by woody plants. Lechwe population had declined from 80,000 in 1975 to 41,000 in 1982; populations of other herbivores and carnivores had also been reduced; and herbivorous floodplain fish and fish eating bird populations had declined.

#### Chabwela, HN; Siewela, AA. 1986

The vegetative structure of the Kafue Flats north bank after the construction of the dams.

Proceedings, 7th international symposium on aquatic weeds. 1986, 61-72.

#### **Abstract:**

Kafue Flats are located in S. Zambia along the Kafue River. Their vegetation is dominated by *Acroceras macrum*, *Setaria sphacelata*, *Vossia cuspidata* and *Oryza barthi*. Clumps of *Vetiveria nigriflora* and *Phragmites australis* are common, but herbaceous cover is dominant in the abandoned water channels. Woody vegetation is confined to areas occasionally flooded. Kafue Flats have been grazing grounds for cattle and are important for wildlife reserve and fisheries, but the alteration of flood patterns caused by the 2 dams recently completed is believed to have an effect on plant composition and distribution.

#### Ellenbroek, GA; Werger, MJA. 1986

Canopy structure and production of four floodplain grassland communities at Kafue, Zambia.

Rangelands: a resource under siege. Proceedings of the 2nd International Rangeland Congress, Adelaide, Australia, 13 May 1984. 1986, 42-43; Canberra, Australia; Australian Academy of Science.

#### **Abstract:**

The relationships between habitat, grazing regime, production and canopy structure of 4 major grassland communities ((a) *Vossia cuspidata* *Echinochloa scabra* floodplain grassland, (b) *Paspalidium*



obtusifolium water meadow, (c) *Panicum repens/Leersia denudata* water meadow and (d) *Panicum aff. porphyrrhizos/Setaria sphacelata* 'dry' grassland) were studied. Max. aboveground phytomass varied for the different communities; (a) and (b) reached max. DW values of approx 2 kg/m<sup>2</sup>, (c) and (d) approx. 0.5 kg/m<sup>2</sup>. In (a) the aboveground vegetation reached a height of 80 cm and leaves were approx. equally distributed over the 1st 60 cm above the water surface with little penetration of light down to the water level. Vegetation was less dense in (b), leaves were smaller on av. than in (a) and were strongly concentrated in a thin layer above the water surface so that only a small percentage of PAR penetrated into the water. LAI was low in (c), and much of the PAR penetrated into the water; highest LAI was measured just below the water surface. In (d) the leaves were concentrated within 40 cm above the ground; much PAR penetrated into the canopy and reached soil level. The results are discussed in relation to the best plant strategy consistent with reaching max. primary production. Relationships between habitat, grazing regime, production and canopy structure are considered.

**Ellenbroek, GA. 1987**

Ecology and productivity of an African wetland system. The Kafue Flats Zambia.

1987, 267 pp. Dordrecht, Netherlands; Dr W. Junk Publishers.

**Abstract**

This book, volume 9 in the Geobotany Series, gives an account of a vegetation study on the Kafue Flats in S. Zambia. The main subjects are phytosociology, diversity, vegetation structure and productivity of the grasslands. The clear zonation of the vegetation is largely determined by the annual flooding pattern. The 3 distinct termitaria grassland types are *Panicum sp. aff. porphyrrhizos/Setaria*

*sphacelata*, *Eragrostis inamoena* and *S. incrassata* (including *Hyparrhenia rufa* grassland in the transition zone to woodland). Based on their species compositions and diversity calculations, relevés of the vegetation on termitaria and of alkaline grassland associated with hot springs are presented as 3 types of plant community (littoral zone, non-wooded and wooded termitaria). The deeply flooded *Vossia cuspidata/Echinochloa scabra* grassland is protected from intense grazing by lechwe [*Kobus leche kafuensis*] during periods of flooding. The *Panicum repens/Leersia denudata* water meadow is grazed throughout flooding and submergence offers the only protection from grazing. The deeper flooded *Paspalidium obtusifolium* water meadows provide grazing for lechwe during the rainy season and the period of shallow flooding. They are also extensively used by waterfowl when flooded and grazed by zebra and wildebeest in the dry season. In the termitaria zone the structure of the grasslands is largely determined by annual fires. Other topics covered are ecology of termitaria grasslands including belowground plant structures, decomposition and other biotic and abiotic environmental conditions.

**Jeffery, RCV; Chooye, DM. 1991**

The people's role in wetlands management: the Zambian initiative.

Landscape-and-Urban-Planning. 1991, 20: 1/3, 73-79.

**Abstract**

The WWF-Zambia Wetlands Project is an established project of the Department of National Parks and Wildlife Service under the Zambia Ministry of Tourism. The project is supported by the World Wide Fund for Nature International (WWF-I) in association with the International Union for the Conservation of Nature and Natural Resources (IUCN). The core project areas are the Kafue Flats and

Bangweulu Swamps wetlands, areas rich in fish and wildlife resources. The Kafue Flats are also important for hydro-electric power generation, agricultural irrigation, urban water supply, and natural grazing for traditional cattle. After years of neglect and the exclusion of the aspirations and interests of local people, the WWF-Zambia Wetlands Project was established in order to integrate local people with the management, conservation and sustainable development of the project areas. It is expected that this approach will lead to increasing benefits for the local communities which will in turn provide greater incentives for the proper management of the areas. The two central themes of the project, sustainable natural resource management and community development, are thus being woven together. This is being done by establishing a formal infrastructure of community development units based on existing, functioning traditional systems of chiefdoms. These are represented by local authorities which are linked to central Government through district councils, the project and other line departments active in the project areas. A system is evolving through the National Parks and Wildlife Service's Wildlife Conservation Revolving Fund whereby a proportion of funds generated in the project areas are returned to the local communities (the Admade Programme). It is intended that sufficient revenues will be generated eventually to support local community development initiatives, and assist central Government with its natural resource management responsibilities by employing local community members to support activities in the field. The project is still in the initial stage of a controlled experiment in wetlands resource management. Whilst many improvements in the project's approach are anticipated in the years to come, it has already reopened the door for local communities to participate in and benefit from the management of their traditional resources.

Gaudet, J.J. 1992

Structure and function of African floodplains.

J. E.A. Nat. Hist. Soc. & National Museum. 82:199, p.132

**Abstract:**

In Africa, floodplains often cover enormous areas. They represent a formidable dry season refuge for the indigenous flora and fauna, but at the same time they have a large potential for the intensive, highly productive agriculture and hydropower production so desperately needed in Africa. The main topographic features of the larger floodplains are reviewed in this paper, along with a general insight into water relations, nutrient dynamics, productivity, species distribution and changes in vegetation induced by present management practice. The question is raised of whether floodplains will survive in the face of development, and a call is made for alternative management strategies.

**Summary:**

The high rate of production in floodplains is certainly a factor in the overall productivity of these areas, especially in Africa where they support large numbers of domestic and wild animals, e.g. lechwe (*Kobus*) in the Kafue River floodplains (Werger & Ellenbroek, 1980). Another factor here is the quality of floodplain grasses. Van Rensberg (1971) found the Kafue flats floodplain grasses were "grasses of high fodder quality, containing a relatively high content of crude protein. They are also highly palatable, even when dry." In contrast, grass species from non-flooded areas lose their palatability on drying. Thus even in regions of similar grass production, the floodplain species will always be more attractive to herbivores.

The most impressive aspect of floodplains under normal conditions is the integration of physical and biological components

within the system. Welcome (1979) commented on this integration: "The traditional integrations of biological and human activities which make up the ecology of the floodplain river can only work if there is a community of micro-organisms, plants and animals which are adapted to the particular frequency of the environmental event which is fluctuating - in this case the flood."

However, because of their high rate of natural production, floodplains are attractive to developers and in many places in Africa, floodplains are being brought under management.

An example is the case of the Kafue flats. Prior to the construction of the Kafue Gorge dam, the Kafue flats showed a classic floodplain profile and function. They had a gentle slope progressing from west to east with a loss of only 6 m elevation over 193 km. The soils in the flats are impervious clays. The Kafue river channel meanders over the flats and divides into occasional branches. The main river is bordered by natural levées so that when the river is running full, the water in the channel may be a metre higher than the surrounding land. Eventual overtopping of levées, flooding, subsequent natural drainage and drying completed the annual cycle (White, 1973). Two dams were planned in order to achieve control over the Kafue river. The first, Kafue Gorge dam would dam the river below the flats and would impound enough water to allow hydropower production during the subsequent four years until a second dam could be erected upstream above the flats. This dam (the Itzhitezhi dam) would provide enough control over the whole river and floodplain system so that annual flooding-drying cycles could still be achieved within the floodplain. However, there would be a four year period between construction of the dams, during which time 2000 km of floodplain would be inundated. This region to be inundated supported an *Oryza* floodplain grassland,

where the principal species normally produced enough new growth each year to keep pace with the rising flood. The tips of the leaves and the inflorescence of *Oryza* must be maintained above the water level or it will die back. White (1973) predicted that four years of inundation would disrupt the normal cycle and that over such a long period death and decomposition of *Oryza* would result. He also cautioned that the open water expanse would be taken over by sudd-forming species with the result that the floodplain species would later require a very long period to be re-established.

White (1973) recommended that much of the annual flooding-drying cycle of the floodplains be maintained as possible over the 4-year period. Subsequently, the first dam was closed in 1972 and it was decided to maintain the floodplain cycles as much as possible. However, during the dry season in 1973 the Kafue river receded to one of its lowest recorded levels. The floodplain drained except for large lagoons, and the whole region was burned. Because of the expected increase in demand for water following this drought, and the need to have a larger storage for the subsequent year, it was decided to store more water. Thus, following the 1973-74 rains, the storage level was allowed to rise 1.2 m above normal. As a result, 2,200 km of the floodplain was flooded (Magadza, 1977). The *Oryza* grass died off and a rapid growth occurred of sudd-forming species such as *Vossia cuspidata* in shallow water and *Aeschynomene elaphroxylon* in open water.

The second dam was finally closed in 1977, with the result that the flooded area became smaller during the peak wet season, but during the dry season the inundated region remained permanently flooded (Werger & Ellenbroek 1980). These effects were not predicted by the early models of the dam operations (White 1973). In addition, the second dam developed structural faults due to

geological activity and subsequently had to be drained. At present over 40% of the original Kafue flats floodplain still remain inundated with little hope of any change in the future.

Are there any development alternatives? In the case of the Kafue flats, even if the Itzhitezhi dam is put back into operation and even if it operated in tandem with the Kafue Gorge dam, the floodplains may still not survive. The floodplain here needs an annual, "close to normal", flood cycle. If this is to be achieved the two dams must be regulated in a careful, regular fashion which based on past experience, is obviously difficult to achieve.

### 1.7 LOGONE RIVER, CAMEROON

- Main purpose: Irrigation
- Construction of barrage to create Lake Maga for irrigation of Semry II irrigation project.
- River formerly inundated 600,000 ha, sustaining an important fishing industry and providing pasture for cattle, sheep and goats. After construction of barrage, fish yields fell by 90%, and pasture land was reduced dramatically.
- It was found that artificial flood releases are possible, using excess water in Lake Maga. A number of alternative schemes are being considered.

### 1.8 FURTHER REFERENCES TO CONTROLLED RELEASE FROM RESERVOIRS

Armitage, PD; Blackburn, JH. 1990.

Environmental stability and communities of Chironomidae (Diptera) in a regulated river.
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Regulated-Rivers:-Research-and-Management. 1990, 5: 4, 319-328
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### Abstract:

Changes in the faunal composition and density of communities of chironomid larvae were studied over a 4-year period in a newly regulated stream in northern England and compared with those in an adjacent unregulated stream, with a view to examining 'stability' in contrasting environments. A total of 68 chironomid taxa were recorded from all sites. Faunal diversity was lowest closest to the dam and highest in the unregulated site. Within the study period, values of H were highest in the 4th year of study (5 years after dam closure). Species increments were tending to level out at the 3 totally regulated sites whereas at the partially regulated and unregulated sites new taxa continued to be recorded in samples. Clustering techniques and similarity indices clearly separated the study sites based on the composition of the chironomid fauna and there were indications that the unregulated sites were more variable in faunal composition between years than the regulated sites. The data are used to develop a conceptual model of fluctuations in faunal parameters under steady or reduced flow regimes. It is suggested that environmental stability brought about by regulation has structured the composition of the chironomid community and further that the changes occur very rapidly after impoundment. The model identifies key areas of faunal change and the question of environmental stability is discussed in relation to the scale of observation.

Brammer, H. 1990

Floods in Bangladesh. II. Flood mitigation and environmental aspects.
Geographical-Journal. 1990, 156: 2, 158-165.

### Abstract:

The devastation and suffering caused by the Bangladesh flood disasters in 1987 and 1988 stimulated major aid donors to

examine possible ways to help the Government of Bangladesh find a lasting solution to the country's chronic flood disaster problem. A UNDP-funded flood policy study recommended the preparation of a National Flood Master Plan under which the Ganges, Brahmaputra and Meghna rivers would be embanked to provide controlled flooding on adjoining flood plain areas. Studies of river morphology, river training techniques, mathematical modelling, and land and water management with controlled flooding will be taken up in 1990 under a World Bank coordinated Flood Action Plan. Alternatives to the embankment strategy considered by a USAID-funded team include upstream water storage in the Himalayas, basin storage on the flood plains and drawn-down of groundwater beneath flood plains to absorb excess monsoon rainfall and run-off. A UNDP-funded Agriculture Sector Review advocated continued priority for small-scale irrigation development to increase crop production rapidly in the safer dry season. There is no evidence that environmental degradation in the Himalayas or a 'greenhouse'-induced rise in sea level have aggravated floods in Bangladesh.

**Morgan, RP, et. al. 1991**

Effects of flow alteration on benthic macroinvertebrate communities below the Brighton Hydroelectric Dam.

Journal-of-Freshwater-Ecology. 1991, 6: 4, 419-429

**Abstract:**

Installation of hydroelectric power at Brighton Dam on the Patuxent River (near Olney, Maryland, USA) in December 1985 was accompanied by a revised (vs. pre-operation) flow release schedule intended to reduce the amount of time downstream macroinvertebrates were exposed to extreme high and low flows and to eliminate rapid changes in flow between these extremes. To assess

whether the flow regime was effective at protecting downstream biota, benthic macroinvertebrate populations were monitored for 20 months before and 23 months after the revised flow regime was implemented. Changes in invertebrate abundance below the dam were tested using an analysis of covariance, employing abundance above the dam as a covariate to account for seasonal and among-year variation. The revised flow regime resulted in a 35% reduction in low flows (defined as flows less than half the average annual flow) and a 25% reduction in high flows (defined as greater than twice the average annual flow). Benthic macroinvertebrates responded to this improvement in the flow pattern with a doubling in total density at the downstream sites. The altered flow regime also resulted in increased abundance at below dam stations for 6 of the 11 taxa that were analysed individually as well as a higher quality invertebrate community at the downstream station nearest the dam (measured by the Hilsenhoff index). Careful planning of flow modification associated with hydroelectric operations was effective not only at protecting, but also enhancing the downstream biota.

**Orlob, GT. 1991**

San Joaquin salt balance: future prospects and possible solutions.

The economics and management of water and drainage in agriculture [edited by Dinar, A.; Zilberman, D.]. 1991, 143-167. Dordrecht, Netherlands; Kluwer Academic Publishers.

**Abstract:**

The San Joaquin River Basin in California (USA) is presently in a state of salt imbalance with salt loads derived by natural inflow, importations, and accretions within the basin exceeding the loads carried from the basin by hydrologic outflow and extrabasin transfers. Trends in the rates of accretion and excretion parallel the development of the basin's

water resources for agricultural use. Accompanying this development there has been a progressive depletion of the natural outflow of the San Joaquin River, a principal tributary of the Sacramento-San Joaquin Delta estuarine system, and degradation of the quality of water available to users. In the lower river, this degradation has been mitigated in recent years by releases of high quality water impounded by New Melones Dam on the Stanislaus River. Supplies for water quality control from this source are limited and may not be sufficient to meet quality and flow targets in the future in the face of competing demands and continuing degradation of quality in the San Joaquin River. The historical development of salt loading in the basin from 1930 to 1989 is traced by means of a basinwide salt balance accounting of principal accretions and excretions. Alternative scenarios of water quality control, and including reallocation of yield from east side reservoirs, seasonal storage of saline drainage in groundwater systems, and control of imported salt loads, are explored.

**Maheshwari BL, Walker KF, Memahon TA, 1995**

Effects of regulation on the flow regime of the River Murray, Australia.		
Regulated	Rivers-Research	&
Management 1995 Apr;10(1):15-38		

**Abstract:**

The flow regime of the River Murray has changed markedly over the last century, and especially the last 50 years, through increased diversions, construction of

dams, weirs and levees and changes in operational procedures. A model developed by the Murray-Darling Basin Commission is used to compare simulated natural (unregulated) flows at eight stations with those at seven consecutive stages in the development of regulation. Monthly and annual average flows and coefficients of variation and skewness were computed, and the flow-duration, peak-flow and low-flow characteristics curves plotted. The results confirm that average monthly and annual flows are now considerably lower than those which prevailed under natural conditions. The seasonal distribution of flows has changed in the upper Murray, owing to the influence of dams. Flow-duration characteristics now vary considerably along the river, whereas there was little change under natural conditions. The effect of regulation on flow-duration characteristics is minimal at Albury and becomes more pronounced downstream; it is most apparent in regard to flows exceeded 20-80% of the time. The magnitude of average annual hoods (annual exceedance probability 50%) has been reduced by over 50% at all stations, but big floods (average recurrence interval 20 years or more) are little affected. Further, the low flows for a given annual non-exceedance probability are higher under regulated conditions than those under natural conditions. These changes have profound implications for communities of native plants and animals in both riverine and floodplain environments, and also for the long-term utility of the river as a resource.

## 2. SEDIMENT, & WATER QUALITY

### 2.1 SEDIMENTATION AND SEDIMENT TRANSPORT

#### 2.1.1 Kenya

**Barber, RG. 1983**

The magnitudes and sources of soil erosion in some humid and semi-arid parts of Kenya, and the significance of soil loss tolerance values in soil conservation in Kenya.

Soil and water conservation in Kenya [edited by Thomas, D.B.; Senga, W.M.]. 1983, 20-46. Nairobi, Kenya; Institute for Development Studies & Faculty of Agriculture, University of Nairobi.

**Abstract:**

Data are presented for five sub-catchments of the Upper Tana River and for the Liuni catchment in Machakos District.

**Wain, AS. 1983**

Athi river sediment yields and significance for water resources developments.

Soil and water conservation in Kenya [edited by Thomas, D.B.; Senga, W.M.]. 1983, 276-293. Nairobi, Kenya; Institute for Development Studies & Faculty of Agriculture, University of Nairobi.

**Abstract:**

Sediment yield data are presented for the Upper and Middle Athi basins.

**Alfredsson, E; Fridstrand, K; Larsson, H; Odin, M. 1988**

Dam protection on grazing land in Kwale district, Kenya.

Arbetsrapport, U-Landsavdelningen, Sveriges-Lantbruksuniversitet. 1988, No.

97, I, 101 pp.

**Abstract:**

This paper contains the results from a survey of physical geography and land use made in four dam catchments in the Hinterland of Kwale District, Kenya, in October and November 1987. The conclusion of the study is that in Kwale Hinterland a degradation of land is taking place in the shape of increasing areas of unproductive impenetrable thornshrub. This rapid increase of thornbushes is not natural and is caused by human activities through their livestock, either by overgrazing or undergrazing. Soil conservation measures for the surveyed dam catchments are given and the measures are concentrated to the dam site, the water courses and the areas of high erosion hazard. The protection measures proposed in this paper are very important, not only to reduce the amount of sediment reaching the dam, but also to stop the spread of thornshrub.

**Alfredsson, E; Fridstrand, K; Larsson, H; Odin, M, 1988**

Manual for dam protection on grazing land in Kwale District, Kenya.

Arbetsrapport, U-Landsavdelningen, Sveriges-Lantbruksuniversitet. 1988, No. 97, II, 97 pp.

**Abstract:**

This manual describes how to map high erosion hazard areas in dam catchments using aerial photographs. Suitable protection measures for preservation of these areas are presented. The manual was produced for the semiarid Kwale Hinterland, Kenya.

**Ongwenyi, GS; Kithiia, SM; Denga, FO. 1993**

An overview of the soil erosion and sedimentation problems in Kenya. In: Sediment problems: strategies for monitoring, prediction, and control:

Proceedings of an international symposium held at Yokohama, Japan, 19-21 July 1993 [edited by Hadley, R. F.; Mizuyama, T.]. 217-224. IAHS Publication No. 217. Wallingford, UK; IAHS Press.

**Abstract:**

Soil erosion and sedimentation, by-products of surface water runoff, reduce soil fertility and the life of reservoirs. The significance of soil and sedimentation problems in Kenya is reviewed. Soil erosion had been identified as an environmental problem by 1935 and sediment yield monitoring was initiated between 1948 and 1965. There was a marked increase in soil loss between 1985 and 1991 with the highest rates of soil loss on the steep slopes of Mt. Kenya. Soil erosion rates were very low in areas of undisturbed forests. Soil loss due to running water and wind was greatest in marginal and semiarid areas due mainly to overstocking by livestock and wildlife. Suspended sediment transport in the upper Tana river above the Kamburu dam increased rates of sedimentation in the reservoirs. Deforestation and land use changes associated with erosion have caused nutrient losses from the topsoil and productivity of the land as well as siltation of the reservoirs.

**Bryan, RB; Schnabel, S. 1994**

Estimation of sedimentation rates in the Chemeron reservoir.

Soil erosion, land degradation and social transition: geocological analysis of a semi-arid tropical region, Kenya [edited by Bryan, R. B. (Editor)]. 1994, 231-248; Cremlingen-Destedt, Germany; Catena Verlag.

**Abstract:**

The life span of a reservoir in Kenya was estimated. The Chemeron dam, completed in 1985, provides reservoir capacity of 4.58 million m<sup>3</sup>. Water supply from the reservoir has transformed land use on the

Njemps flats, providing for irrigated vegetable and cereal cultivation. The Chemeron catchment is 81km<sup>2</sup>, with average rainfall ranging from 650 to 1300 mm/yr. No reliable sediment yield estimates were available before construction, but rough sedimentation estimates indicated a possible lifespan as low as 26 yrs. Erosion studies carried out since dam construction, and all available soil loss information from the catchment with estimates for bank erosion and road and paths, give an annual sediment production of 432,895 t. Using the best available sediment delivery ratios and reservoir trap efficiencies a current sedimentation rate of 87,597 t/year is estimated, which would fill 1.91% of available capacity. This gives a reservoir life span of 85 yrs. Development of the forested area of the catchment would reduce reservoir lifespan to 43 yrs.

**2.1.2 Elsewhere**

**Pazwash, H. 1982**

Erosion and sedimentation effects of reservoirs.

Proceedings, 1982 Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation [edited by Graves, D.H.]. 1982, 457-461. Lexington, Kentucky, USA; University of Kentucky.

**Abstract:**

Construction of a dam in a basin results in trapping a major portion of sediment carried by a stream (also called "sediment yield of a basin") and causes severe erosion of the river channel downstream. These effects are exemplified by a case study which reveals the dangers involved in using empirical formulae to estimate the sediment yield of a basin.

**Bhalla, JK; Rajpal, KL. 1989**

Bhakra dam reservoir: sedimentation problem and remedial measures.



Indian-Journal-of-Power-and-River-Valley-Development. 1989, 39: 1/2, 23-26, 22.

**Abstract:**

Bhakra reservoir extends over 168.35 sq. km. at full reservoir elevation. After construction of the dam and creation of the water storage, silt is rarely found below the dam. Since the rate of siltation has been more than that anticipated at the time of designing the project, the Bhakra Beas Management Board is highly concerned about this problem. The Committee constituted by the Ministry of Energy in 1981 suggest measures for controlling the soil erosion in the catchment area of Sutlej. The Committee finalised a work plan and recommended a five year plan estimated to cost about RS. 14 crores (1 crore = 10 million rupees). The recommendations are briefly discussed.

**Smith, SE. 1990**

A revised estimate of the life span for Lake Nasser.

Environmental-Geology-and-Water-Sciences. 1990, 15: 2, 123-129.

**Abstract:**

One of the chief constraints to the development of a reliable estimate of the potential life span of Lake Nasser (Egypt and Sudan) has been the lack of sufficient historical data. Enough information has been collected since the reservoir's formation in 1964 to permit a realistic assessment. The reliability of the current official estimate for Lake Nasser was assessed. An improved estimate was made by applying appropriate modifications and additional data to the official estimate. The time forecasted for sedimentation of the reservoir by the official estimate is 362 years, somewhat less than the original design life of 500 years. By taking into account changes in the hydrological regime of the Nile after 1964 and a compaction factor, an estimate of 535

years was made. This additional time is significant for decision rules governing the operation of the Aswan High Dam.

**Elsheikh, S; Kaikai, A; Andah, K. 1991**

Intensive sediment transport from the upper Nile basin and water resources management in Sudan.

Hydrology for the water management of large river basins [edited by Ven, F. H. M. van de; Gutknecht, D.; Loucks, D. P.; Salewicz, K. A.]. IAHS-Publication. 1991, No. 201, 291-300. Wallingford, U.K.; International Association of Hydrological Sciences.

**Abstract:**

Most water resource projects in Sudan are situated at the Blue Nile and the Atbara subcatchments of the Nile basin. Both rivers come from Ethiopia and carry large amounts of sediment. The siltation process at the Roseires dam on the Blue Nile was examined using available data on Blue Nile streamflow and sediment concentration measurements. The results of the linear and quadratic regression relationships between stream flow data and sediment loads were compared to the bathymetric surveys of 1976 and 1981. This showed that the linear regression was a better model for future prediction of the annual suspended sediment load. The annual sediment deposition rate was dependent on the length of low flow periods between flood events.

**Hassanzadeh Y. 1995**

The removal of reservoir sediment.

Water-International. 1995, 20: 3, 151-154.

**Abstract:**

Reservoir silting is explained and the design of precise measures to maintain or improve this situation are discussed. Estimation of sediment yield is a complicated problem. Reasonable results were obtained in Iran by applying the chasse (flushing) method for Sefid Rud

Dam. A 1800 million m<sup>3</sup> reservoir had originally been created at the end of construction of the high dam in 1961 but sediments silted  $\approx$ 800 million m<sup>3</sup> of the reservoir capacity by 1981. During eight years of flushing operations,  $\approx$ 300 million m<sup>3</sup> of sediments were removed from the reservoir through five bottom outlets at riverbed level. These outlets can be used for irrigation water intake when none of the five turbines, with 165 m<sup>3</sup> per second total installed capacity, were operating. The outlets are evenly distributed along the base of the dam. The total discharge of these outlets at the reservoir normal water level (RNWL) is  $\approx$ 980 m<sup>3</sup>/s. Erosion contributes significantly to the amount of solids in runoff from the reservoir. Measurement of erosion can be carried out by: (1) metering of solid discharge; and (2) measurement of sedimentation in the reservoir. Both procedures were used in Iran.

**Ibanez-C; Prat-N1996**

Changes in the hydrology and sediment transport produced by large dams on the lower Ebro river and its estuary.

Regulated-Rivers. 1996, 12: 1, 51-62.

**Abstract:**

The mean annual flow of the lower Ebro river, Spain, and the causes of its changes, were studied. Permanent low river flows from July 1988 to April 1990 caused the continuous presence of a salt wedge for 18 months. Historical data for sediment transport in the Ebro river are scarce and incomplete. Limited data before the construction of reservoirs allowed only an estimate of the order of magnitude of annual suspended transport. Before the construction of large reservoirs in the lower Ebro at the end of the 1960s, sediment transport was  $\approx$ 1.0 X 10<sup>7</sup> Mt/yr. This was reduced to  $\approx$ 0.3 X 10<sup>6</sup> Mt/yr after construction of the dam. Currently, this amount ranges from 0.1 to 0.2 X 10<sup>6</sup> Mt/yr, which represents a reduction of

more than 99% in sediment transport. On a seasonal scale, the effects of the dams have been the standardization of the river flow and the virtual suppression of peaks in sediment transport. In the estuary, the salt wedge dynamics changed and its presence increased. River regulation and hydropower generation also changed the hydrology of the river on a daily scale. The effect of local storms on the river flow and the sediment transport has been suppressed. At present, these changes are related to hydropower generation.

**2.2 EUTROPHICATION & WATER QUALITY**

**Kutas, T; Herodek, S. 1987**

Effects of load reductions on the water quality of a large shallow lake.

Ecological-Modelling. 1987, 39: 1/2, 85-99

**Abstract:**

Eutrophication has threatened the viability for recreation of Lake Balaton, Hungary. A deterministic model (a system of differential equations) was constructed to study and simulate the process. The four basins of the lake are described by the same model and the models of basins are concatenated by hydrological throughflow. The one-basin model with its ten state variables describes the main mass transport processes in the pelagic zone of the lake and in the sediment, as the lake is shallow. The model can simulate seasonal changes and forecast the effect of some measures on water quality in the short term. The simulation runs show that the measures can be effective when the phosphorus-removing water-dam systems involved in tertiary treatment of sewage water are fully operational.

**Bouwman, H; Coetzee, A; Schutte, CHJ. 1990.**

Environmental and health implications

of DDT-contaminated fish from the Pongolo flood plain.

Journal-of-African-Zoology. 1990, 104: 4, 275-286.

**Abstract:**

DDT is used for indoor malaria control in the northern part of KwaZulu, South Africa. Three fish species (*Hydrocynus vittatus*, *Oreochromis mossambicus* and *Eutropius depressirostris*) that are used by the local population as an important source of protein were sampled (in November 1986 and May 1987) from the pan system associated with the Pongolo River that flows through the area. Generally low levels of DDT were observed in fillet samples. No significant variations in levels of DDT in fish were observed before and after application of DDT. The levels do not pose a health hazard to the local population, but possible deleterious effects to species in higher trophic levels (such as the African fish eagle and crocodile) could not be ruled out and a survey is suggested. The piscivorous tigerfish (*H. vittatus*) had the highest levels. Significantly higher DDT, DDE, DDD and sigmaDDT concentrations were found in *O. mossambicus* and *E. depressirostris* from the Mzinyeni pan, where a malaria control camp is situated on the shore, than in the same species collected from 3 other pans. As the percentage DDT in fish from Mzinyeni did not differ significantly from those of the other 3 pans, the higher levels do not indicate recent contamination of the Mzinyeni pan.

**Palmer, RW; O'Keeffe, JH. 1990**

Downstream effects of impoundments on the water chemistry of the Buffalo River (Eastern Cape), South Africa.

Hydrobiologia. 1990, 202: 1-2, 71-83

**Abstract:**

The downstream effects of impoundments on the chemistry of pristine and polluted stretches of the Buffalo River were

investigated in the context of the Serial Discontinuity Concept. Impoundments which received water from a near-pristine upper catchment caused alterations of the water quality which were consistent with the Serial Discontinuity Concept, and recovery to riverine conditions was within 2.6 to 18.4 km of the dam, depending on flow. Impoundments which received agricultural runoff and urban effluents generally caused an improvement in the water quality if the downstream reaches (with the exception of nitrate concn, which were higher in the tailwaters compared to inflowing water). Impoundments with polluted inflows therefore usually 'reset' the river towards its natural condition, rather than acting as perturbations. This represents a reversal of the Serial Discontinuity Concept described for pristine rivers. The downstream effects of impoundments on water chemistry therefore depend on the relative impact of other catchment perturbations. These disturbances become more severe during low flow, and it is during this time that the impoundments have the greatest effect on the river.

**Al-Salem, SS. 1992.**

Industrial wastewater treatment and its environmental impact on the Zarqa river.

Water-Science-and-Technology. 1992, 25: 1, 61-68

**Abstract:**

The Zarqa river basin provides most of Jordan's surface and groundwater, and most of its industries are located therein. A summary of an industrial waste water survey is presented, with quantity and quality of the discharges and methods of disposal. Compliance with the effluent standard and the effect on the environment is discussed. It is concluded that there is contamination of surface water and potential contamination of groundwater, the river bed and soils adjacent to the river. The existing regulation, standard and practices in industrial wastewater

management are reviewed and new principles are proposed for adoption in setting a sustainable policy in waste water management.

**Chutter, FM; Rossouw, JN. 1992**

Managing phosphate and algae in Hartbeespoort Dam. SA-Waterbulletin. 1992, 18: 3, 16-19.
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**Abstract:**

Water quality improvements in the Hartbeespoort Dam, South Africa, have resulted from the imposition of a 1 mg/litre limit on phosphates in effluents. In 1988/89, the phytoplankton of the reservoir was not dominated by *Microcystis* for the first time since close observation of water quality began in 1980. The reasons for the improvement are under investigation and long-term trends are discussed. It is recommended that the phosphate standard should not be relaxed. A further reduction in the phosphorus load is expected to achieve a further improvement in water quality.

**Meyer, DH; Rossouw, JN. 1992**

Development of the reservoir eutrophication model (REM) for South African reservoirs. Water-SA. 1992, 18: 3, 155-164.
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**Abstract:**

The REM is commonly used to simulate the trophic status of South African reservoirs. Uncertainty analysis is usually not included in such modelling which is unfortunate because a false sense of model accuracy may result. Uncertainty analyses conducted suggest that the conventional REM is too simple and too inflexible to characterize the behaviour of individual South African reservoirs accurately. A more accurate reservoir specific eutrophication model (RSEM) has therefore been developed. The RSEM is

more complicated in that it takes account of more variables and has to be calibrated individually for each reservoir. But the improvement in model accuracy, for predicting both historical and future data justifies this complication. In the case of Hartbeespoort Dam the newly developed RSEM has been compared with the conventional REM using Monte Carlo simulation which was designed to test the effect of a 20% decline in the inflow of point source phosphorus. The RSEM predicts that the effect of this management strategy is an av. reduction in chlorophyll of 25%. The REM predicts only an av. 7% reduction in chlorophyll.

### 2.3 SALINIZATION

(see also under Aswan Dam)

**Waite, PJ. 1979**

Abary River, Guyana. Salinity prediction model. Report, Hydraulics Research Station. 1979, No. OD 20, 25 pp.
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**Abstract:**

A one-dimensional model of the high water slack distribution of salinity has been used to simulate salinity movement in the Abary River, Guyana. The collection of data and its processing for use in the model is described. The model proving and verification procedures are outlined. A method is developed which uses the one-dimensional model to assist the operators of a reservoir with planning the release of water down the river to control the salinity in the estuary. This method is incorporated in a computer program which uses historical rainfall, planned crop areas and crop water requirements to simulate the operation of the reservoir, including water releases for irrigation, salinity control and flood control.

**Flugel, WA; Klenzle, S. 1989.**

Hydrology and salinity dynamics of the Breede river, Western Cape Province, Republic of South Africa.

IAHS-Publication. 1989, No. 182, 221-228.

**Abstract:**

The water quality of the irrigation supply in the Breede river, South Africa, is deteriorating due to the inflow of saline irrigation return flow. The salinity of the river is reduced during the irrigation season by releases from the Brandvlei dam. The salinity dynamics of the Breede river were evaluated between Brandvlei dam and weir 5 at the end of the systems. Hydrochemical fingerprinting and data on irrigation practices were used to determine time trends of the salinization process. Results indicated that a change from flood to trickle irrigation would improve irrigation efficiency. This would increase the salt concn but, due to a lower return flow, less salt would enter the receiving river.

**Hart, BT; Bailey, P; Edwards, R; Hortle, K; James, K; McMahon, A; Meredith, C; Swadling, K., 1990**

Effects of salinity on river, stream and wetland ecosystems in Victoria, Australia.

Water-Research-Oxford. 1990, 24: 9, 1103-1117.

Centre for Stream Ecology, Chisholm Inst. Technol., Melbourne, Australia.

**Abstract:**

Salinity is a growing problem in many parts of the world. In Australia both dryland salinity and salinity in irrigation regions are serious problems. Options being considered to control the latter involve pumping the groundwater to lower the watertable; however, this requires disposal of a saline wastewater, probably into local streams or wetlands. A previous review by the authors covered the lethal

and sub-lethal effects of salinity on individual species within the following groups of aquatic organisms: microbes (mainly bacteria), macrophytes and micro-algae, riparian vegetation, invertebrates, fish, amphibians, reptiles and mammals and water birds. That review concentrated on Australian information, information it is argued that will be more typical of the effects occurring over a large part of the world than data from the better watered areas of North America and Europe. This paper uses these data on individual species to determine the possible effects of saline wastewater discharges on aquatic ecosystems, in particular lowland rivers and streams and wetlands. In these freshwater systems, the macroinvertebrates and plants (riparian vegetation, macrophytes and micro-algae) were assessed to be the most salt sensitive biological communities, with direct adverse biological effects likely to occur when salinity is increased to around 1000 mg/litre. More subtle sub-lethal and indirect effects possibly occur at salinities below this: however the scientific data are not presently available to assess the extent that this might occur. A set of guidelines for assessing the possible biological effects in particular salt-affected rivers, streams or wetlands is developed.

### 3. OTHER HYDROPOWER & IRRIGATION PROJECTS

#### 3.1 THE ASWAN HIGH DAM, EGYPT

Lavergne, M. 1982

Egyptian agriculture 10 years after the completion of the Aswan Dam.

Bulletin-du-Centre-de-Documentation-et-d'Etudes-Juridiques, Economiques-et-Sociales. 1982, No. 14, 112-130; bibl.

**Abstract:**

10 years after the completion of the Aswan dam the paper draws up a negative balance of its effects on agriculture: inadequate agricultural production, decline in soil fertility, difficulty in improving desert land. The role of the agricultural cooperatives is also discussed.

Ibrabim, F. 1984

The Aswan high dam - an ecological catastrophe?

Geographische-Rundschau. 1984, 36: 5, 236-242.

**Abstract:**

When the Aswan dam was completed in 1971 at a cost of DM 4300 million it was hoped that control of the Nile waters would provide irrigation throughout the year and make cultivation possible on greatly extended areas as well as being a source of hydroelectric power. In practice the disturbance of the age old natural system, where the seasonal floodwaters deposited layers of fertile mud along the valley banks and into the delta, has produced many unforeseen problems. Although the artificial irrigation system has been completed and the dam protects against flood and drought, the total cultivated areas has actually fallen slightly since 1970. There are problems with

drainage and salting through rising groundwater; the lack of the nutrient rich mud has meant that much higher expenditure on fertilizers has been necessary. In addition the mud provided the raw materials for the mud bricks for building peasants' houses and they are now using topsoil from their fields for this purpose. There has also been land erosion at the seaward end of the delta where material eroded is no longer being replaced and the desert is encroaching on the fertile Nile Valley. Electricity production is only about one fifth of hoped for levels and the dam itself is filling up with mud.

Khalil, JB; Hanna, FS. 1984

Changes in the quality of Nile water in Egypt during the twenty-five years, 1954-1979.

Irrigation-Science. 1984, 5: 1, 1-13

**Abstract:**

The total soluble salt content of Nile water at Giza increased significantly by 29% after the construction of the Aswan High Dam. This was mainly due to the seepage of drainage water from cultivated land of the Nile Valley. The SO<sub>4</sub><sup>-</sup>, Cl<sup>-</sup>, K<sup>+</sup>, Na<sup>+</sup> and Mg<sup>++</sup> content increased significantly during the period of study, but the increase in pH, HCO<sub>3</sub><sup>-</sup> and Ca<sup>++</sup> contents was not significant. The suspended matter content decreased significantly by 94% from 1964 to 1979. The silica content increased significantly, but the decrease in oxygen content was not significant. No obvious variations were detected in chloride content, total alkalinity and total hardness during the study period. According to the ionic coefficients ratios and the geochemical classification, Nile water currently can be evaluated as excellent for irrigation purposes and good or highly satisfactory for domestic purposes.

Wolff, P. 1986

Nile mud and its influence on the fertility of the arable lands of Egypt.

Tropenlandwirt. 1986, 87: September, 143-161.

**Abstract:**

In spite of the many benefits of the Aswan High Dam, it is claimed to be an ecological and financial disaster. The loss of fertility to the "old lands" by trapping sediments is often quoted together with the fact that with this loss chemical fertilizers would be needed. The author concludes, that the fertility provided by the Nile mud was very small and could not cope with the increase in cropping intensity. More significant to the nutrient requirement of the "old lands" is the increase in yield through regular availability of an adequate supply of irrigation water, the growing of two or more crops per year and the resulting high levels of production with consequent increases in nutrient withdrawal. This requires replacement and supply of adequate amounts of the major elements and probably is a major contributing factor to the need for a number of trace elements in recent years. Increased production has an effect many times greater than the loss of sediment.

Abu-Zeld, M. 1987

Environmental impact assessment for the Aswan High Dam.

Environmental impact assessment for developing countries [edited by A.K. Biswas and Q. Geping]. 1987, 168-190; Natural Resources and the Environment Series Vol. 19, OQEH. London, UK; Tycooly International for United Nations University.

**Abstract:**

The chapter explains the need for the construction of the Aswan High Dam, briefly describes the dam and its reservoir, and discusses its major environmental impacts. Since the construction of the

Aswan High Dam there have been a number of plans drawn up by various agencies for the economic development of the region along the shores of the reservoir. This includes the establishment of human settlements (e.g. irrigation, land reclamation), industrial development, and tourism and recreational programmes. The risk is that such development schemes will affect water quality and the aquatic ecosystem of the reservoir. Furthermore, the deterioration of the quality of the reservoir will affect downstream river uses, since the reservoir is the only source of Nile water in Egypt. A serious consequence could be the propagation of schistosomiasis and the northward migration of the malaria mosquito vector from Sudan. The small vectors from both types of schistosomiasis have already been found in the reservoir. The assumption is that fishermen brought the disease with them to the region. Policy-makers should consider the alternative of keeping the reservoir area largely free from human activities, i.e. as a restricted and protected area, in an attempt to avoid possible pollution problems and the spreading of water-borne diseases. Alternative plans for the development of the shores of the reservoir should incorporate more realistic assessments of the environmental impacts and the cost of pollution control.

Wolff, P. 1987

The problem of drainage and its solution in the Nile Valley and Nile Delta.

Natural-Resources-and-Development. 1987, 25, 62-73

**Abstract:**

Although the need for further drainage facilities was foreseen when the Aswan High Dam was planned, these facilities have been provided with much delay, resulting in high water tables and soil salinization. The success of pilot projects led to the launch of a nationwide programme in 1971. The calculation of drain spacing and the use made of PVC

tubes are discussed. Drainage has improved both the salt balance of the soil and crop yields. The need for maintenance is stressed.

**Abu-Zeid, M. 1989**

Environmental aspects of the Aswan High Dam.

International-Journal-of-Water-Resources-Development. 1989, 5: 3, 147-157.

**Abstract:**

The Aswan High Dam has now been operational for 20 years. The environmental impacts of the dam based on data collected over this time are reviewed. It is concluded that the positive benefits of the dam (such as increased irrigated area, increased crop production, improved reliability of irrigation water and better protection from floods and droughts) clearly outweigh the adverse impacts (such as lowered river levels, bank erosion, changed water quality, siltation in Lake Nasser, the need for more extensive field drainage, and the loss of Nile silt added to the land).

**Amer, MH; Abu-Zeid, M. 1989**

History of land drainage in Egypt.

Land drainage in Egypt [edited by Amer, M.H. and Ridder, N.A. de]. 1989, 43-66. Cairo, Egypt; Drainage Research Institute. Drainage Res. Inst., PO Box 13621/5, El Kanater, Cairo, Egypt

**Abstract:**

The Aswan High Dam has enabled all Egypt's agricultural land to be brought under continuous irrigation, but has also resulted in the need for extensive sub-surface drainage to prevent waterlogging and soil salinization. The various factors in implementing the drainage installation programme are described, such as soils, land resources, and cropping patterns. Egypt's drainage problems are due in part to seepage from the extensive irrigation network as well as continuous irrigation.

Details are given of the main drainage network and field drainage policy.

**Smith, SE. 1990**

A revised estimate of the life span for Lake Nasser.

Environmental-Geology-and-Water-Sciences. 1990, 15: 2, 123-129

**Abstract:**

One of the chief constraints to the development of a reliable estimate of the potential life span of Lake Nasser (Egypt and Sudan) has been the lack of sufficient historical data. Enough information has been collected since the reservoir's formation in 1964 to permit a realistic assessment. The reliability of the current official estimate for Lake Nasser was assessed. An improved estimate was made by applying appropriate modifications and additional data to the official estimate. The time forecasted for sedimentation of the reservoir by the official estimate is 362 years, somewhat less than the original design life of 500 years. By taking into account changes in the hydrological regime of the Nile after 1964 and a compaction factor, an estimate of 535 years was made. This additional time is significant for decision rules governing the operation of the Aswan High Dam.

**Abdelbary, MR (Editor). 1992**

River regime of the Nile in Egypt.

1992, xxxvi + 356 pp. Hull, Canada; Canadian International Development Agency (CIDA). Nile Research Institute, Water Research Centre, El Qanater 13621, Egypt

**Abstract:**

This publication documents the changes in the river Nile within Egypt since the construction of the Aswan High Dam (AHD). Conditions prior to and since the construction of the AHD were examined and changes analysed with respect to aggradation, bank erosion, degradation, geomorphology, hydraulic properties, plan



form, river geometry, resistance to flow, sediment load and water level profiles.

**Abdel-Dayem, S; Abu-Zeid, M. 1992**

Salt load in irrigation and drainage water in the Nile Delta.

Proceedings of the African Regional Conference on Technologies for Environmentally Sound Water Resources Development, Alexandria, 1991. 1992, Vol. 2, 131-142. Wallingford, UK; HR Wallingford Ltd.

**Abstract:**

Irrigation water in Egypt is mainly provided from the Nile River. With the increase in population and the pressing need for meeting food requirements, the country has launched programmes for intensification and expansion in agriculture. Having a fixed share of the River Nile flow, the country has to seek other possibilities of providing future water requirements. This paper deals with the impacts of re-using agricultural drainage water for irrigation on the salt balance of the Nile Delta during the period 1984-89 and discusses implications on current and future water management policies. The Nile water is of high quality, its salinity is about 250 ppm. Following strict control on releases from the High Aswan Dam and main distribution structures in 1988, the quality of agricultural drainage water in the Delta dropped in the following year from an average of 865 ppm to 1300 ppm. The utilization of agricultural drainage water is to be increased from the present 4.7 billion cubic metres to 7 billions by the year 2000. This water will be used either directly, or after mixing with Nile water. The latter practice will increase the salt-input to the agricultural lands and require an additional leaching fraction which should be drained out of the system to maintain the salt balance. The drainage system in the Nile Delta is designed to achieve this goal. Recent monitoring indicated a reduction in the quantity of

available water as well as an increase in salinity. This has raised some concerns about the future salt balance of the Nile Delta.

**Biswas AK, 1992**

The Aswan High Dam revisited.

Ecocodecision. 1992, No. 6, 67-69.

**Abstract:**

The Aswan High Dam is often considered to be an environmental catastrophe - on the basis of predictions made some two decades ago. But an objective evaluation of the dam's impact clearly indicates that in fact it has been overwhelmingly positive. The huge costs of building the dam are estimated to have been recovered within only two years through increases in agricultural production and hydropower generation. The dam also proved its value to the country's economy through years of sustained drought and potentially catastrophic floods. Although there are environmental problems resulting from the dam's construction, many - including riverbed erosion and the effects on fishing - have proved much less severe than at first feared. Others, such as an increase in waterborne diseases, have been shown to be mainly due to lack of sanitation. In short, the Aswan High Dam is now due for reassessment: it deserves great credit for its remarkable contribution to Egypt's socio-economic development.

**Figure 1 Kainji Lake, Nigeria**

**Pearce, F. 1994**

High and dry in Aswan.
New-Scientist. 1994, 142: 1924, 28-32.

**Abstract:**

The benefits and costs of the Aswan dam in Egypt are reviewed. Construction of the dam, 4 km long, and >100 m high began in 1960. The dam has allowed double and triple cropping on the Nile floodplain, mitigated the effect of variable rainfall on agriculture and provides 10% of Egypt's electricity. The dam's reservoir displaced > 100 000 Nubians. Silt is no longer deposited with the annual floods although the effect that this has on fertility is disputed. The lack of silt and increased erosive power of the Nile means that the delta is being eroded. Salinization is also occurring. Further plans discussed include the construction of a canal through the Sudd wetlands in Sudan to reduce evaporation losses. If dams were constructed in the highlands of Ethiopia there would be less evaporation losses than at Aswan, and the hilly terrain would allow for deeper reservoirs.

**Fanos AM, Khafagy AA, Dean RG, 1995**

Protective works on the Nile Delta coast.
Journal of Coastal Research 1995 Spr;11(2):516-528

**Abstract:**

The Nile Delta Coast is a dynamic system which in historic times was in equilibrium or experienced an excess of sediment due to the large quantities of sediments discharged to the Mediterranean Sea through the various Nile branches. With the construction of the nine barrages (dam) along the main course of the river commencing at the beginning of the 20th century, the Nile Delta coastal zone has exhibited a sediment deficit and thus

erosion, especially around the three main headlands, i.e., Rosetta, El Burullus, and Damietta. This erosion has been particularly alarming since the construction of the Aswan High Dam in 1964, which trapped essentially all the flood sediments in its storage basin. Erosion is not the only trouble affecting the Delta coast. High rates of easterly longshore transport which cause shoaling of the Nile mouths and the outlets of the northern lagoons are also a serious problem; they directly affect coastal navigation and the eco-system of the lakes and consequently fish production. The aims of this paper are as follows: (1) to present a brief review of the major existing coastal problems along the Nile Delta Coast, and (2) to provide a general description of the protective measures that have been implemented in the coastal zone to address these problems.

### 3.2 KAINJI LAKE, NIGERIA

Ayeni, JSO; Roder, W; Ayanda, JO.  
1994

The Kainji Lake experience in Nigeria. World-Bank-Technical-Paper. 1994, No. 227, 111-124. Washington, D.C., USA.
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**Abstract:**

The creation of Kainji Lake and the consequent resettlement of 44,000 people was the single largest project of Nigeria's first development plan (1962-68). Of its total cost of 80 million (Sterling), one quarter was required for the resettlement effort. The primary purpose of the dam was to generate electricity to supply industrial, commercial and domestic users. In addition, it was expected to achieve three other objectives: to store water for flood control and for irrigation; to improve navigation on the river by submerging obstacles such as rocks and rapids; to increase the catch of fish in the man-made lake environment. The majority of people who were displaced were peasant farmers, fishermen or nomadic pastoralists. The paper describes the Kainji Lake Resettlement Scheme, and its policy of cash compensation and replacement housing. The impacts of resettlement are analysed, which suggest that the resettlement had been a resounding success. The flora and fauna of the area are looked at, followed by agriculture, pastoralism, and fisheries. Nine points are made in conclusion, based on the lessons learned from the project, and the knowledge that, ideally, is required. The primary objective has not been achieved in that only eight out of twelve turbines have been installed, plans for Kainji failed to provide specific proposals to achieve the expected irrigation benefits and the increase in road and rail transport made the project to increase barge transport worthless.

However, the resettlement scheme was a success because it aimed at replacement of lost villages, and left people undisturbed in their social, economic, and cultural life.

### 3.3 AKOSOMBO DAM, VOLTA RIVER, GHANA

Chisholm, NG. 1983

Response of some rural communities in south-east Ghana to economic recession 1982.
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Cambridge-African-Monographs, African-Studies-Centre, University-of-Cambridge. 1983, No. 2, 73pp. OAE.
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**Abstract:**

The monograph presents the results of a research project which investigated the effects of economic recession on rural communities in the vicinity of the artificially created Lake Volta. The economic activities of communities downstream of the lake were disrupted, but new opportunities were created which could be exploited. Many people migrated to this region, at first only seasonally, to take advantage of improved fishing. In the area below the Akosombo Dam, adjustments to changed conditions have included large flows of remittances from migrants which to some extent compensate for low incomes gained from reduced level of economic activity in the area. Some families have already suffered absolutely and the larger settlements have declined socially due to demographic imbalance. The spread of bilharzia in the area has caused further deterioration. The Volta Delta's specific social, economic and demographic conditions are unique, but the principle ruling economic organization, ecological adaption to physical resources has been identified as a common theme throughout the communities studied. The shallot industry typifies this principle but it can also be observed in salt collecting, mat and basket

making, gin distilling, lagoon fishing, etc. Sea fishing has become more capital intensive and dependent on external inputs but still represents development of an indigenous structure, particularly in regard to labour organization and distribution between labour and capital to permit resource exploitation.

**Odei, MA, 1983**

The effect of the Volta dams (at Akosombo and Kpong) on the ecology of schistosomiasis transmission in the lower Volta and its estuary in Ghana.
Bulletin-de-l'Institut-Fondamental-d'Afrique-Noire, A-Sciences-Naturelles. 1983, 45: 3-4, 195-207

**Abstract:**

The construction of the Akosombo dam in 1964 and later the Kpong dam in 1981 across the River Volta in Ghana has created ecological conditions downstream and in the Volta estuary which have enhanced the invasion and proliferation of aquatic weeds, submerged, emergent and floating and the intermediate hosts of schistosomiasis, *Bulinus* and *Biomphalaria* and also of *Lymnaea*. The intensive water-contact activities of the riparian communities who are mainly fishermen and clam-diggers have resulted in the establishment and transmission of urinary and intestinal schistosomiasis, due to *Schistosoma haematobium* and *S. mansoni*, respectively, in the River Volta itself and in the Volta estuary almost at the sea coast.

**Tamakloe, MA, 1994**

Long-term impacts of resettlement: the Akosombo Dam experience.
World-Bank-Technical-Paper. 1994, No. 227, 99-110. Washington, D.C., USA.

**Abstract:**

It is important to discuss the impact of resettlement wherever it occurs, for there are lessons to be learned from resettlement projects which are relevant to integrated

rural development processes. In this paper, the main policy guidelines and strategies adopted for the Akosombo Dam Resettlement Scheme, Ghana, are discussed, followed by an outline of the implementation of the resettlement policy and programmes. Impacts of the various programmes on the resettlers are identified, and lessons drawn for future settlement policy and planning. The Volta River Project (VRP) at Akosombo led to the formation of a lake which covered 4% of the total land area of Ghana. The Volta River Development Act made provision for compensation to be paid, but was generally found to be inadequate. The paper looks at the human settlements that were destroyed by the creation of the dam, and the housing, farming and fishing programmes that were established. The long term impacts of resettlement are discussed, for example the creation of inter-tribal conflict between Twi-speaking Kwahu peoples of Apaaso and Dunkumang over the status and roles of different hierarchies of traditional authority. Ecological changes, health problems downstream, economic impacts, migration and the development of irrigated agriculture are discussed. Three specific recommendations are made: that there is a need to broaden the feasibility studies carried out in planning for resettlement; that a high-level coordinating body consisting of representatives from government, sector agencies, researchers, scientists, local people, and the dam authority is essential; and that it is necessary for all development agencies to have a proper perspective in the possible impacts of the project.

**Schmidt-Kallert, E, 1990**

The Volta reservoir in Ghana - a review.
Applied-Geography-and-Development. 1990, No. 35, 77-93

**Abstract:**

The Akosombo Dam was built over the 1952-56 period, creating the Volta Reservoir over an area of 8515 sq km. The advantages of the reservoir were planned to be: development of a vertically interlinked aluminium industry; electrification in rural and urban areas; utilization of the reservoir for large scale irrigated farming; development of a fleet of ships for navigation; and newly-created settlements which were to be the forerunners of modernization. The expected benefits for the economy have not been realized: the vertically interlinked aluminium industry only exists in fragments; nothing has become of the planned electrification; and inland water transport is well below expected level. Resettlement fell behind schedule and has not been successful: delays in the implementation of agricultural programmes have triggered waves of emigration; there have been changes in the climate and vegetation, and a decrease in precipitation; and a spread of river blindness and bilharziasis.

**3.4 THREE GORGES DAM, YANGTZE RIVER, CHINA**

**Fearnside, PM. 1988**

China's Three Gorges Dam: "fatal" project or step toward modernization?

World-Development. 1988, 16: 5, 615-630

**Abstract:**

China's plans for the Three Gorges Dam on the Yangzi River imply costs that go far beyond the dam's substantial monetary price. The consequences would be catastrophic should the dam fail as a result of warfare, earthquakes, or other causes. Resettlement of population displaced by the reservoir, especially farmers, represents a formidable obstacle in the land around the reservoir site.

Resettlement could affect minority groups if population is moved to border areas. The reservoir would sacrifice cultural landmarks. Erosion and reservoir siltation may impede navigation within a few years and, in the longer term, will reduce storage volume. Impacts on natural habitats and human structures downstream of the dam include a variety of changes caused by greater streamflow at the low-water period and by reduced sediment load. The major justification for building the dam is flood control; alternatives include reforestation of the watershed, smaller dams on upper tributaries, and reversing the movement of population to dangerously exposed areas along the middle and lower Yangzi. Electricity could be produced more cheaply and quickly from smaller dams elsewhere. Energy conservation and population control are more cost effective ways of increasing per caput power supply. Installation of infrastructure for construction at the dam site before impact assessment is complete raises doubts about the place of environmental evaluation in China's decision process.

**Long, L. 1990**

Major impacts of the Three Gorges project on the Yangtze, China.

International-Journal-of-Water-Resources-Development. 1990, 6: 1, 63-70

**Abstract:**

The aims of the Three Gorges dam project are to: protect the densely populated areas of the Yangtze's middle and lower reaches from flooding; to generate hydro-electricity and to improve navigation between Changqing and Yichang. The paper gives information on the various environmental impacts the project will have both upstream and downstream of the dam. These are divided into beneficial and adverse impacts and are considered with respect to human, biological and physical aspects.

**Edmonds, LE, 1992**

The Sanxia (Three Gorges) Project: the environmental argument surrounding China's super dam.

Global-Ecology-and-Biogeography-Letters. 1992, 2: 4, 105-125.

**Abstract:**

The Sanxia (Three Gorges), the world's largest dam, was formally approved in 1992. This article looks at the background to the project and the arguments surrounding construction and financing. Approval was expedited by the Tiananmen Incident of 1989 and the flooding on the Chang (Yangtze) River during 1991. Advocates of the dam admit that there are still some technical uncertainties. Given that it is highly unlikely that the dam will serve its proposed functions of flood control, energy generation, navigation improvement, and increased water supply, it is recommended that the Chinese should avoid the irreparable ecological damage and the economic risk from such another grandiose project. Instead of a large dam, smaller scale projects and basic conservation measures are likely to have more positive environmental, economic, and political consequences.

**Hipel, KW. 1992**

Multiple objective decision making in water resources.

Water-Resources-Bulletin. 1992, 28: 1, 3-31.

**Abstract:**

The controversy caused by the proposed construction of the Three Gorges dam on the Yangtze river in China highlighted the need for a general methodological approach for solving decision making problems. The latest developments in multiple objective decision making that could be applied to water resources management are reviewed. Attributes for categorizing decision making techniques are given. The major contributions of the

multiple objective decision making papers are reviewed. The effectiveness of using the multiple objective decision making process in water resources management is illustrated.

**Freeberne, M, 1993**

The Three Gorges Project and mass resettlement.

International-Journal-of-Water-Resources-Development. 1993, 9: 3, 337-351.

**Abstract:**

In April 1992, the National People's Congress in Beijing approved the Three Gorges project. Once built, the dam will generate hydroelectric power, check flooding and improve navigation and water supply along the Changjiang (Tangtze). If the construction problems have been solved and investment funds are available, there remains concern about the potential environmental impact and the need compulsorily to resettle over one million people.

**3.5 TUCURUI, AMAZONIA, BRAZIL**

**Monosowski, E. 1986**

Brazil's Tucurui Dam: development at environmental cost.

The social and environmental effects of large dams. Volume 2: case studies [edited by Goldsmith, E.; Hildyard, N.]. 1986, 191-198. Camelford, Cornwall, UK; Wadebridge Ecological Centre.

**Abstract:**

Tucurui reservoir is the largest manmade lake ever built in a tropical rain forest. Its environmental impacts will be difficult to assess, because the Amazonian ecosystems are very complex and diverse, and very little is known about them. In addition, the gradual opening up of the area, further stimulated by major development projects, is beginning to

cause profound environmental changes throughout the region. If neglected, these environmental impacts could have extremely negative effects, even endangering the Tucuruí power project or, in the long run, the Grande Carajas Development Programme (GCDP). The Tucuruí dam, part of the GCDP, will create a reservoir of 2160 km<sup>2</sup> and will have a final installed capacity of 8000 MW.

**Barrow, C. 1988**

The impact of hydroelectric development on the Amazonian environment: with particular reference to the Tucuruí project.

Journal-of-Biogeography. 1988, 51: 1, 67-78.

**Abstract:**

Brazil has begun to exploit the hydroelectric potential of Amazonia. The Tucuruí Dam is the first of many large hydroelectric projects planned for Amazonian Brazil to be completed. Without doubt, the environmental impact assessment studies carried out at Tucuruí have great value for planning future Amazonian (and other humid tropical) hydroelectric projects. A review of information on the environmental impacts of the Tucuruí Project is presented, together with observations made during field visits to the Tocantins Basin and Belem region in 1981, 1983 and 1985. It is concluded that there is a need for more study of impacts downstream of Tucuruí, also for some assessment of the effects of increasing the number of turbines operating there, and for an examination of why some predicted difficulties have not in practice been avoided. An attempt is made to gather together the available information on other hydroelectric projects under construction or proposed for construction in Amazonian Brazil.

**3.6 BALBINA DAM, AMAZON AND PARA RIVERS, BRAZIL**

**Baird, D. 1988**

Balbina filling feeds eco debate.

World-Water. 1988, 11: 8, 40-43.

**Abstract:**

Brazil's newest hydroelectric project, the Balbina plant in Amazonia, is investigated and the strong environmental debate surrounding it discussed. The 3,264 m-long dam will create a reservoir swamping 1,600 km<sup>2</sup> of tropical rain forest.

**Marin, RA; Hoyos, JLB; Rovero, EL; Weigel, P; Magalhaes, A; Costa, VA; Nogueira, MF. 1993**

Hydroelectric power: knowledge and environmental impact.

1993, 174pp. Serie Universidade e Meio Ambiente. Belem, Brazil; Universidade Federal do Para, Nucleo de Meio Ambiente.

**Abstract:**

Aspects of the environmental and social impacts of large dams in Brazil (on the Amazon and Para rivers) are discussed in five papers. E. L. Rovero outlines the inadequacies of the evaluation process for environmental impacts of large dams in Brazil and proposes the inclusion of an environmental dimension to planning such dams. This would entail public participation in decision making. Some analytical parameters for the evolution of technical transfer are provided by P. Weigel in a paper focused on the Balbina dam; a role for 'regional science' is projected. The case of the impact of a large dam upon an indigenous people is described by A. Magalhaes, in a paper which argues that in view of the major impacts upon such people (both physical, upon their environments and economic and social impacts), public policy must be sensitive to new difficulties and needs. V. A. Costa has undertaken psychological

surveys of the mental health of those whose land was expropriated for the construction of a large dam, in an attempt to provide a framework for a discussion of health and change. The final paper (M. F. Nogueira et al.) looks at alternatives to large dams: the use of small stations powered either by diesel or water-driven turbines, is a viable way of maintaining populations in the rural areas; impacts on local populations and the environment are outlined.

### 3.7 MAHAWELI GANGA HYDROELECTRIC & IRRIGATION PROJECT

Alexis, L; Goldsmith, E; Hildyard, N. 1984

The damnation of paradise - Sri Lanka's Mahaweli project; The social and environmental effects of large dams; The myth of the benign superdam; The politics of damming.

Ecologist. 1984, 14: 5/6, 206-216; 1-16; 217-220; 221-231

#### *Abstract:*

Four articles examine the economic, social and environmental effects of the building of large-scale dams; they are based on contributions to a recent major study edited by E. Goldsmith and N. Hildyard, also Abstracted. (1) The damnation of paradise - Sri Lanka's Mahaweli project (L. Alexis) discusses the Sri Lankan governments multi-billion dollar, five dam project believed to be the large-scale technological solution to Sri Lanka's increasing food and employment requirements. The project has already destroyed much of the country's dwindling forest cover, threatening ecological stability, and reports from the resettlement schemes portray a picture of social misery and malnutrition. (2) A briefing document, The social and environmental effects of large dams, reviews the adverse effects of

large dams and water projects focusing on resettlement problems, water-borne diseases, flood control, the connection between earthquakes and dams and the extent of salinization and sedimentation. (3) The myth of the benign superdam, in which it is argued that large dams are inevitably destructive with costs far outweighing benefits, and (4) The politics of damming, in which examples are provided of prestige damming projects begun because political considerations have overridden ecological and social concerns.

Alexis, L. 1986.

Sri Lanka's Mahaweli Ganga Project: the damnation of paradise.

The social and environmental effects of large dams. Volume 2: case studies [edited by Goldsmith, E.; Hildyard, N.]. 1986, 276-290. Camelford, Cornwall, UK; Wadebridge Ecological Centre.

#### *Abstract:*

The Accelerated Mahaweli Ganga Hydroelectric Irrigation Project is a huge multipurpose scheme, comprising five separate dam projects, introduced as the lynch-pin of the United National Party's development policy in 1977. To get a clearer picture of the tremendous effect of the Accelerated Mahaweli Project on the Mahaweli Ganga River's numerous, complex ecosystems, the course of the river is traced, examining some of the impacts caused by each of the projects in the overall scheme. In the desperate search for a large scale technological solution to Sri Lanka's increasing food and employment requirements, the government has overlooked many low cost, low impact schemes. Indeed, it is suggested that the saddest aspect of the Mahaweli Scheme is that it is unnecessary. There exists an alternative strategy for increasing food production while preserving the traditional ways of life.



Johansson, D. 1989.

The Kotmale environment. A study of the environmental impact of the Kotmale Hydropower Project in Sri Lanka.

SIDA-Evaluation-Report-series, Swedish-International-Development-Authority. 1989, No. 1989/1, 78pp.

**Abstract:**

A study was carried out to evaluate the environmental impact of the Kotmale Hydro Power project in Sri Lanka, which uses the country's main river, the Mahaweli Ganga, for power generation and irrigation. The report is divided into six sections: (i) introduction; (ii) the catchment; (iii) the reservoir; (iv) the reservoir environment; (v) soil movement in the periphery; and (vi) the downstream environment. The area of the project suffers from soil mass movements, water regulation and land use problems, some caused by the project and some natural to the area. It is suggested that road construction and detailed land use planning be undertaken in order to drain the valley slopes and reduce silting of the reservoir.

### 3.8 CHICO RIVER BASIN DEVELOPMENT PROJECT, PHILIPPINES

Drucker, C. 1986.

Dam the Chico: hydro development & tribal resistance in the Philippines.

The social and environmental effects of large dams. Volume 2: case studies [edited by Goldsmith, E.; Hildyard, N.]. 1986, 304-313. Camelford, Cornwall, UK; Wadebridge Ecological Centre.

**Abstract:**

In 1973 the Philippines government announced an ambitious plan to develop the hydropower resources of the mountainous interior of Luzon, the archipelago's principal island. The Chico

River Basin Development Project called for the construction of five dams: four large impoundments and a smaller diversion dam to irrigate 52 000 ha of downstream agricultural land. 12 years later, the Chico Project is in total disarray. One of the power dams has been cancelled; the other three have been postponed at least until the 1990s; the irrigation dam is under construction, but in a dramatically scaled-down version. The Philippines Martial-Law government made numerous attempts to get the dam project under way, over the strenuous objections of the Chico region's indigenous, tribal inhabitants. The dams would inundate ancestral lands and threaten the tribal peoples' traditional way of life. Their opposition has, over the past decade, escalated into an armed, bloody struggle that the government must somehow resolve before the dam projects may proceed. One of the tribal peoples' principal allies in this confrontation is a nationwide revolutionary movement, which provides arms and guerrilla training.

### 3.9 ATBARA RIVER, SUDAN

Abusin, ME. 1985

Planners' and participants' perceptions of development in the semi-arid lands of Sudan: a case study of the Khasm el Girba scheme.

Natural resources and rural development in arid lands: case studies from Sudan [edited by Davies, H.R.J.]. 1985, 60-80. Tokyo, Japan; United Nations University.

**Abstract:**

A most important factor encouraging or discouraging the acceptance of innovations in the arid lands of Sudan has been the degree to which participants in the process have been able to identify with the proposed development. Although some of the unexpected results should

have been foreseen, the main reason why they were not is shown to be in the assumption that 'development' means the same to everyone and that people's reactions can be dependably predicted on the basis of experience elsewhere, especially when the blueprint for irrigation scheme development has been adopted. This was the case with the Khashm el Girba irrigation scheme in eastern Sudan, involving the use of 500 000 feddans of land west of the Atbara River for irrigation by gravity flow from a dam across the river in 1964. The model for the development was the analagous Gezira irrigation scheme covering some 2

**Mensching, H; Ati, HI; Glaser, B; Portge, KH. 1988**

Investigations of changes in the ecology and land use of the lower Atbara area, Sudan. A preliminary report. (in German)
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Erde. 1988, 119: 3, 193-202
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**Abstract:**

The Lower Atbara region was ecologically balanced prior to the construction of the Khashm el Girba dam and the start of drought conditions in about 1960. It has since then developed into an area severely affected by desertification. The resulting economic problems of the region are indicated by the high rate of emigration. Due to low rainfall, the riverine population could not practise rainfed cultivation in the Northern Butana. For the same reason, the nomads were forced to leave their traditional grazing areas, especially those north of the river Atbara. Thus, human and animal pressure started to increase along the river banks. At the same time, the construction of the dam caused a reduction in the annual rate of discharge and confined the seasonal run-off to a shorter period of time, thus resulting in the breakdown of the traditional land use system. Due to the Atbara's increased lateral erosion, the arable land along the river banks,

million feddans in a similar general region in central Sudan. The report deals with the varying attitudes, aspirations, and perceptions of planners and officials on the one hand and the various groups of settlers on the other. The main conclusion is that the various groups have widely different viewpoints and, unless these can be brought more closely together, the scheme is unlikely to achieve a high degree of success. The main lesson for arid-land development is the overriding need for a full assessment of the perceptions of the participants if success is to be achieved and waste minimized.

traditionally used for irrigated cultivation, was lost to a great extent. In consequence, fodder crop production was considerably reduced, leading to a marked decline in the number of livestock raised by the resident population. Thus the traditional land use system lost part of its diversity, having been perfectly adapted to the unstable climatological and ecological conditions. In addition, the loss of arable land due to erosion and the implementation of expensive irrigation systems resulted in changes in land tenure systems. Generally declining standards of living and the increasing proportion of landless make emigration seem the only alternative.

**Ati, HAA. 1992**

The damming of the River Atbara and its downstream impact.
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African river basins and dryland crises [edited by Darkoh, M.B.K.]. 1992, 21-43. Uppsala, Sweden; Research Programme on Environment and International Security, Uppsala University.
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**Abstract:**

This paper examines the major ecological changes that the Khashm el Girba Dam in Sudan has brought about in the area downstream over the last three decades and their social and economic

implications. Prior to the construction of the dam, the lower Atbara economy was predominantly agricultural, largely dependent on irrigation from the Atbara river. Four types of cultivation were known in the area: Gerf cultivation on the river banks (flood irrigation), Karu cultivation which makes use of irrigation by means of water wheels and pumps, Magat cultivation of the river bed when the river dries up into pools, and Atmur rainfed cultivation in some parts of the Atbara basin. Agriculture was characteristically subsistence, depending on the seasonality of the river and the unreliable rainfall. Nomadic activity was concentrated in the south-eastern part of the area, with fishing and wood collecting being other subsidiary economic activities. The ecological changes caused by the dam under a steadily declining rainfall situation in the area since the 1950s include the following: severe drop in the amount of water passing downstream, erosion of the river channel, siltation, deforestation, disturbance of the breeding and feeding systems of the fish population and a sequential process of environmental degradation. Agriculture is the economic activity most affected by the changes that occurred as a result of the Khasm El Girba dam construction. The reduced water supply downstream has affected the acreage of cultivated land and brought tremendous changes in tenorial and production systems. The ecological and economic changes also had their repercussions on other traditional livelihood systems and the population's income levels and distribution. The gap between the rich and the poor has widened. Unemployment, underemployment and out-migration are occurring at a scale never known before in the area. The paper serves to illustrate the disastrous consequences of planning dams without considering their downstream impact.